DRAFT ENGINEERING EVALUATION AND COST ANALYSIS

Arkema Early Action

Prepared for
Legacy Site Services LLC
468 Thomas Jones Way
Suite 150
Exton, PA 19341

Prepared by

integral consulting inc.
319 SW Washington Street
Suite 1150
Portland, OR 97204

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ACRONYMS AND ABBREVIATIONS

AOC	Administrative Order on Consent
AOPC	area of potential concern
ARAR	applicable or relevant and appropriate requirement
BERA	baseline ecological risk assessment
bgs	below ground surface
BHHRA	baseline human health risk assessment
bml	below mudline
BMP	best management practice
CAD	confined aquatic disposal
CDF	confined disposal facility
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980
cfs	cubic feet per second
COC	chemical of concern
COI	constituent of interest
CPT	cone penetration test
CWA	Clean Water Act
DDD	dichloro-diphenyl-dichloroethane
DDE	dichloro-diphenyl-dichloroethene
DDT	dichloro-diphenyl-trichloroethane
DDx	total of 2,4′- and 4,4′-DDD, DDE, DDT
DEQ	Oregon Department of Environmental Quality
dw	dry weight
EE/CA	engineering evaluation and cost analysis
ENR	enhanced natural recovery
EPA	U.S. Environmental Protection Agency
EVS	Environmental Visualization Software
FPM	floating percentile model

FS	feasibility study
GAC	granular activated carbon
GRA	general response action
GWET	groundwater extraction and treatment
IR	ingestion rate
LTMRP	long-term monitoring and reporting plan
LSS	Legacy Site Services LLC, agent for Arkema Inc.
LWG	Lower Willamette Group
MCL	maximum contaminant level
MNR	monitored natural recovery
MQ	mean quotient
NAVD	National Geodetic Vertical Datum of 1988
NCP	National Contingency Plan
NTCRA	non-time-critical removal action
PCB	polychlorinated biphenyl
NRWQC	national recommended water quality criteria
O&M	operation and maintenance
OAR	Oregon Administrative Rules
OC	organic carbon
OCDD	octachlorinated dibenzo-*p*-dioxin
OLW	ordinary low water
PCDD/F	polychlorinated dibenzo-*p*-dioxin/furan
PCDF	polychlorinated dibenzofuran
PRG	preliminary remediation goal
RAA	removal action area
RAAC	removal action area characterization
RAL	remedial action level
RAO	removal action objectives
RCRA	Resource Conservation and Recovery Act
RG	remediation goal

RI	remedial investigation
RM	river mile
RP	Rhône Poulenc
SCM	source control measure
SMA	sediment management area
SOW	Statement of Work
SPT	standard penetration test
SQG	sediment quality guideline
SQV	sediment quality value
SWAC	spatially weighted average concentration
TBC	To Be Considered
TCLP	toxic characteristic leaching potential
TEQ	toxic equivalent concentration
TIR	thermal infrared imaging
TMDL	total maximum daily load
TZW	transition zone water
USACE	U.S. Army Corps of Engineers
USC	United States Code
WQS	water quality standards

1 INTRODUCTION

This engineering evaluation and cost analysis (EE/CA) was prepared in support of a non-time-critical removal action (NTCRA) for the Arkema Inc. facility in Portland, Oregon (Figure 1-1), under the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA). The EE/CA is required by the Administrative Order on Consent (AOC) Statement of Work (SOW) between U.S. Environmental Protection Agency (EPA) and Arkema, effective June 27, 2005 (Docket No. CERCLA 10-2005-0191). The report content is pursuant to the AOC SOW, the May 23, 2008 and August 31, 2011 Final Decision on Disputes from Daniel Opalski, Director, EPA Office of Environmental Cleanup (Opalski Decision; USEPA 2008; Opalski 2011), and subsequent written agreements between EPA and Legacy Site Services LLC (LSS), agent for Arkema. This report partially fulfills the requirements under Section 3 of the AOC SOW.[1]

Consistent with the AOC SOW for the Arkema NTCRA, this EE/CA was prepared following EPA's *Guidance for Conducting Non-Time-Critical Removal Actions under CERCLA* (USEPA 1993). This EE/CA report follows the preparation of the final removal action area characterization (RAAC) report (Integral and ARCADIS 2011) that filled data gaps identified in the EE/CA work plan (Parametrix 2007) and work plan addendum (Integral 2008).

The Arkema NTCRA site is part of the Portland Harbor Superfund site. The EPA-directed horizontal removal action area (RAA) for the Arkema site is located within a portion of sediment management area (SMA) 14 of the Portland Harbor site (Figure 1-2). SMA 14 was derived from area of potential concern (AOPC) 14, which was one of many AOPCs identified for the Portland Harbor feasibility study (FS). In layout, SMA14 and AOPC 14 are very similar and the use of these two terms in this document is interchangeable when defining this subarea of the Portland Harbor site. In accordance with the AOC SOW, this EE/CA provides a robust evaluation of alternatives within the Arkema RAA only; however, the analysis in this EE/CA report was developed to be consistent with the Portland Harbor FS approach and to ultimately support EPA's selection of an alternative and the preparation of design reports for the portion of the Portland Harbor site that includes SMA 14 and the Arkema RAA.

This EE/CA relies in part, on the draft final Portland Harbor remedial investigation (RI; Integral et al. 2011), including the draft final baseline human health risk assessment (BHHRA; Kennedy/Jenks Consultants 2011) and draft final baseline ecological risk assessment (BERA; Windward 2011). In accordance with EPA's direction, this EE/CA document was developed to be consistent with the alternative evaluation approaches within the draft Portland Harbor FS (Anchor QEA et al. 2012).

[1] Section 3 of the AOC SOW also includes the second and final drafts of the EE/CA report (if requested by EPA).

1.1 REGULATORY FRAMEWORK

The NTCRA for the Arkema RAA is being conducted under CERCLA, 42 United States Code (USC) §§ 9601 *et seq*. (as amended). CERCLA Section 121 (d) requires that a cleanup 1) be protective and, 2) if a hazardous substance will remain on the site, attain a level of cleanup that complies with any legally applicable or relevant and appropriate requirement (ARAR). ARARs are presented in Section 3.2.

As previously noted, the Arkema NTCRA RAA is part of the Portland Harbor site. In 2000, EPA added the Portland Harbor site to the National Priorities List pursuant to CERCLA. The Portland Harbor site study area currently encompasses approximately 10 miles (river mile [RM] 1.9 to 11.8) of the Willamette River in Portland, Oregon. In fall 2001, EPA and 10 parties, including Arkema, entered into an AOC (CERCLA-10-2001-0240) for the Portland Harbor site. The draft RI/FS documents characterized the nature and extent of contamination, assessed the ecological and human health risks at the Portland Harbor site, and evaluated the feasibility of remedial alternatives for the site. These documents are currently under review by EPA.

1.2 SITE DESCRIPTION AND HISTORY

The following sections briefly describe the physical attributes of the Arkema site, the operational history of the site, the Willamette River hydrology, and the geology and hydrogeology of the site. Additional information is presented in the EE/CA work plan (Parametrix 2007), the Upland RI report (ERM 2005), and the final RAAC report (Integral and ARCADIS 2011).

1.2.1 Physical Site Description

The Arkema site is located in Portland, Oregon, on the southwest bank of the lower Willamette River between approximate RM 6.9 and 7.6 (Figure 1-1). The upland portion of the site encompasses approximately 54 acres of land. All of the site buildings have been demolished except for the office building. The EE/CA NTCRA is primarily focused on the in-water portion of the site.[2] However, elements of the EE/CA removal action will integrate portions of the riverbank above mean high water (+13.3 ft National Geodetic Vertical Datum of 1988 [NAVD88]) to the top of bank to facilitate engineering and planning for construction of potential riverbank source control measures (SCMs) in those areas. The remainder of the riverbank will be addressed, as needed, directly with the Oregon Department of Environmental Quality (DEQ) in accordance with the AOC between Arkema and DEQ dated October 31, 2008.

In-water access to the Arkema facility was historically provided from three docks—from upstream to downstream—the Salt Dock, Dock 1, and Dock 2 (Figure 1-3). Dock 1 was

[2] The in-water portion of the site below mean low tide is leased from the Oregon Division of State Lands.

originally constructed in the 1940s and consists of a pier section that runs perpendicular to the river, and a dock section that runs parallel to the river, both with a timber walkway hung from the bottom of the dock. Dock 2 was originally constructed in the late 1950s and early 1960s and has the same configuration and walkways as Dock 1, with the exception that the adjacent dolphins are timber piles and stairs lead under the dock to a small platform, which provides access to barges at low-river-stage elevations. The Salt Dock was built in the 1960s to support a conveyor belt system used to offload salt products from ships to the facility.

The site is bounded to the south (upstream) by the Bird Inc./CertainTeed roofing products facility and the Willbridge petroleum storage terminal (consisting of Kinder Morgan, Chevron, and ConocoPhillips). To the north (downstream), the site is bounded by a City of Portland sewer right-of-way that includes a discharge pipe from the currently operating groundwater remediation system located on the former Rhône Poulenc (RP) site as well as numerous historical discharge pipes and pathways associated with RP discharges from their facility and their associated historical discharges to the Willamette River via Doane Lake (Slater 2010). The City of Portland right-of-way is located immediately south of the BNSF Railroad Bridge (Figure 1-2).

1.2.2 Arkema Site Operational History

Inorganic chemicals were manufactured at the Arkema site from 1941 until 2001, when the facility was closed and chemical manufacturing was discontinued. For most of the site's history, the chemical activities involved electrolytic decomposition of brine solutions to manufacture inorganic chemicals, including sodium chlorate, chlorine, sodium hydroxide, hydrogen, and hydrochloric acid. Other chemical manufacturing processes during the site's operational history included the production of dichloro-diphenyl-trichloroethane (DDT) from 1947 to 1954, and ammonium perchlorate from 1958 to 1962 (ERM 2005).

The Acid Plant area is located on the upland portion of the site between Docks 1 and 2 (Figure 1-3). The Acid Plant area was used in the manufacturing of DDT, magnesium chloride hexahydrate, ammonium perchlorate, solid sodium hydroxide, a grass defoliant, sodium orthosilicate, and hydrochloric acid. The Chlorate Plant area is located on the upland portion of the site between Dock 1 and the Salt Dock (Figure 1-3). The Chlorate Plant area was used primarily to manufacture sodium chlorate and potassium chlorate.

Figure 1-3 also shows the locations of several other former site facilities. A more detailed description of the operational history is presented in the EE/CA work plan (Parametrix 2007) and the Upland RI report (ERM 2005).

1.2.3 Willamette River Hydrology

River stage and currents at the Portland Harbor site are influenced by hydrologic conditions in both the Willamette and Columbia rivers, and are further affected by the operations of federal and non-federal dams along these two rivers. Tidal fluctuations of up to approximately 3 ft per day were observed at the Arkema site during the 2009 EE/CA sediment investigation. A period of relatively high Willamette River stage occurs from late May through June when the Willamette River discharge to the Columbia River is restricted by high flows in the Columbia River that are associated with the spring freshet, as a result of snowmelt in the much larger Columbia River watershed (Anchor QEA et al. 2012). Under certain river stage, flow, and flood tidal conditions, typically in the late summer and fall, the influence of the Columbia River causes periodic slack water and flow reversals in the lower portion of the Willamette River (Anchor QEA et al. 2012).

Average annual mean discharge in the Willamette River during the water years[3] 1973 through 2007 was approximately 33,000 cubic ft per second (cfs) measured at the Morrison Bridge (near RM 12.8) in Portland (Anchor QEA et al. 2012). Late summer discharge levels were typically less than 10,000 cfs and December/January averages approached 100,000 cfs. Most of the Willamette River discharge is from upstream flow sources. A detailed review and discussion of flows on the lower Willamette River are provided in the draft final Portland Harbor RI (Integral et al. 2011) and Portland Harbor FS (Appendix La, Sediment Transport Modeling) (Anchor QEA et al. 2012). It is interesting to note that the Portland Harbor RI report documented that DDx compounds are the only constituents of interest (COIs) from upstream sources that increase in concentration during higher Willamette River flows.

1.2.4 Geology and Hydrogeology

The following sections briefly describe the upland and in-water geology and hydrogeology. Additional details are presented in the Upland RI report (ERM 2005), EE/CA work plan (Parametrix 2007), and final RAAC report (Integral and ARCADIS 2011).

1.2.4.1 Upland Geology

Results of the Arkema Upland RI indicated the following regarding upland site geology (ERM 2005; Integral 2004):

- The surficial geology at the site is characterized by fill and alluvial deposits of the Willamette River.

[3] A water year is defined as the 12-month period beginning October 1 and continuing through September 30 of the following year.

- The eastern portion of the upland site, generally between Docks 1 and 2, has been filled with debris consisting of asphalt, concrete, pipe, soil, and fill from other sources (e.g., City of Portland). These materials occur from the surface to depths of approximately 25 ft below ground surface (bgs). The area from Dock 1 to the upstream end of the property was filled primarily with materials dredged to accommodate the Salt Dock. Figure 1-3 shows the approximate extent of fill adjacent to the site.
- The native soil profile is generally characterized by laterally discontinuous, alternating layers of dark gray-brown sand with various amounts of silt and thinner silt layers with various amounts of fine sand. The layers vary from massive to finely laminated.
- Underlying the deepest silt layer, at a depth of approximately 35 ft bgs[4], is a black sand layer adjacent to the river in the Acid Plant area, and dark gray-brown sand layer in the southern end of the Arkema site (Figure 1-3).
- Columbia River Basalt is present below the fill and alluvium at the upland portion of the site at depths of 49 to 55 ft bgs.

A conceptual cross section that links the upland and in-water portions of the site is presented in Figure 1-4. Detailed cross sections that show the uplands and the in-water portion of the site are provided in Figures 3-6 through 3-9 of the EE/CA work plan (Parametrix 2007). Cross sections that include the eastern upland portion of the site and extend into the Willamette River are provided in the Upland RI report (ERM 2005).

1.2.4.2 In-Water Geology

With increasing distance from the shoreline (eastward), sediment overlying the basalt becomes finer grained, the thickness of the sediment layer diminishes, and sand horizons become more limited in vertical extent. The increased thickness of sediment on the landward side of the docks is likely due to several factors, including increased deposition because of the sheltering effect of the docks, natural deposition/sedimentation, and filling activities in the vicinity of the docks. In general, the sediment represents a fining upward sequence (i.e., coarser sediments at the bottom and finer sediment at the top of the sequence) and becomes thinner toward the east, which is what can be expected in a depositional area such as the Arkema RAA and SMA 14.

Thin layers (i.e., less than 1 ft thick) of sand and silt were observed in a number of boreholes and are shown on the cross sections. Although available data suggest that many of these layers are discontinuous, some of these horizons may, nonetheless, serve as important controls on the distribution of COIs (Integral 2003). Some of these layers appear to dip to the east, consistent with the slope of the basalt surface.

[4] The deepest silt layer is continuous throughout the Acid Plant area and somewhat discontinuous in the Chlorate Plant area toward the river.

The top of the underlying basalt surface was encountered during the 2009 EE/CA investigation at elevations ranging from –9.8 ft (WB-52) to –45.8 ft (WB-56b) NAVD88 (Integral and ARCADIS 2011). A basalt surface contour map is provided in Figure 3-6 of the final RAAC report (Integral and ARCADIS 2011). The basalt surface generally slopes to the east between Docks 1 and 2 and to the south between Dock 1 and the Salt Dock.

1.2.4.3 Upland Hydrogeology

Groundwater occurs in fill materials and in four distinct groundwater zones beneath the site, shallow, intermediate, deep, and basalt. In general, the depth to groundwater increases from west to east across the site (from NW Front Avenue toward the Willamette River). A summary of the four groundwater zones and their characteristics is presented in the Upland RI report (ERM 2005). Vertical hydraulic gradients between groundwater zones are primarily downward, with occasional upward gradients observed for well pairs near the Willamette River. Shallow groundwater at the site is likely recharged by precipitation that infiltrates at and to the west of the site.

The silt horizons (aquitards) separating the groundwater zones vary in thickness from approximately several inches to 5 feet. The distinct groundwater zones have been observed in most parts of the site, with the exception of the southeastern portion. In that area, downgradient of the Chlorate Plant area, the silt aquitard tends to become discontinuous, and the shallow and intermediate groundwater zones tend to coalesce. The intermediate groundwater zone is confined or semiconfined beneath the four uppermost alternating sand and silt layers (ERM 2005). The deep groundwater zone is confined. The basalt groundwater zone is confined beneath the alluvial deposits at the site.

The elevation of the shallow groundwater surface fluctuates seasonally, rising during periods of high rainfall and infiltration, and decreasing during mid-to-late summer and low rainfall periods. Shallow groundwater in proximity to the Willamette River rises in direct response to large increases in Willamette River stage (e.g., during a flood). In general, these short-term perturbations do not affect shallow groundwater flow directions, with the exception of short-term groundwater flow reversals very close to the river.

A tidal influence study conducted at the site in February 1999 provided a general understanding of the effects that tidal and river stage fluctuations in the Willamette River have on the groundwater flow system at the site (ERM 2005). The shallow-zone groundwater levels were not affected by the fluctuations in the river, whereas intermediate- and deep-zone groundwater levels exhibited some influence from the Willamette River tidal fluctuations up to 300 ft from the river. Results of the tidal influence monitoring suggest that Willamette River fluctuations are propagated inland as pressure waves through the semi-confined/confined intermediate and deep groundwater zones, but do not significantly alter the groundwater flow system at the site.

1.2.4.4 Transition Zone Water

Groundwater discharge was evaluated in the river adjacent to the Arkema site during the Portland Harbor groundwater pilot study using thermal infrared imaging (TIR), the Trident Probe, and the UltraSeep® system. Pressure transducers were deployed in upland wells in the Chlorate Plant area and the Acid Plant area to measure groundwater elevations during the UltraSeep investigation. Groundwater discharge was also evaluated during the Round 2 Groundwater Pathway Assessment using the UltraSeep system.

The following sections briefly describe the results of the TIR imaging, Trident probe, and UltraSeep system studies. Additional details are presented in the EE/CA work plan (Parametrix 2007).

TIR Imaging

TIR imaging is a distributed groundwater mapping technique that relies on a temperature difference between surface water and groundwater (Integral 2005a). The images produced by the survey have a high resolution, with a ground surface pixel size of 1.5 m^2 and temperature differential increments of 0.2°C. The TIR survey did not positively identify any groundwater discharge areas at the Arkema site or any other areas surveyed, but it did identify a number of point sources (i.e., known outfalls). The utility of the TIR survey in identifying groundwater seepage areas was limited; the primary—but not sole—confounding factor was thermal stratification of the river.

Trident Probe Survey

The Trident Probe is a direct-push system equipped with temperature, conductivity, and water sampling probes (Integral 2005a). The Trident Probe operates as a point measurement system that records the contrast in temperature and conductivity between surface water and transition zone water (TZW). Multiple point measurements are combined to develop a qualitative map of groundwater discharge zones. Interpretation of the Trident Probe temperature results requires consideration of tidal influences, sediment texture, and stratigraphy. Because of tidal influences on the system, flux at the sediment-water interface can alternate between positive and negative over the course of each tidal cycle (Integral 2005b).

Temperature differences between surface water and sediment 60 cm below mudline (bml) generally increased with distance from the shore. In addition, silty sediment generally displayed greater temperature differences than sandy sediment, likely because tidal mixing effects are reduced in zones of lower permeability sediments. A strong conductivity signal was observed at the site. The high conductivity readings may be associated with groundwater discharge due to the relatively high conductivity of groundwater in portions of the Arkema site (Integral 2005b).

The single events measured in the Trident Probe study may not represent long-term groundwater seepage, cannot provide data on seasonal variations, and cannot capture alterations between positive and negative flux due to the tidal cycle. However, the Trident study was able to provide information related to the mapping of fine- and coarse-grained sediment, which is important for identifying preferred areas of groundwater discharge.

UltraSeep Survey

The UltraSeep is an automated seepage meter that uses an ultrasonic flow meter to measure flux as a function of time over the period of deployment. It produces direct quantitative measurements, even at very low seepage rates. The unit rests on the sediment surface, requiring diver deployment and retrieval.

The UltraSeep system was deployed at three locations at the Arkema site in November 2004, two in the area downgradient of the former Acid Plant area and one in the area downgradient of the former Chlorate Plant area (Integral 2005a). At all three UltraSeep locations, both positive and negative seepage rates were observed over the 24-hour (minimum) period that seepage was measured. The scale of specific discharge, as measured in all three deployments, indicates low seepage rates, on the order of a few centimeters per day. The magnitude of both the peak positive and negative seepage rates can be related to sediment texture at each deployment location. The location with the highest discharge (maximum reading 6.11 cm/day) was station CP07B, a sandy area. Station AP04B, a sandy silt area, exhibited the second highest specific discharge (maximum reading 1.97 cm/day). Finally, the lowest discharge (maximum reading 0.47 cm/day, an overall negative value indicating water flowing into the sediment, though many of the measurements were near the limits of detection for the meter) was observed at station AP04D, a fine silt location.

The UltraSeep system was deployed for approximately 24 hours at 11 locations at the Arkema site in 2005. Near the shoreline, sandy and silty-sand locations displayed higher discharge rates relative to other locations, with average specific discharge rates of 4.0, 3.1, 7.0, and 2.1 cm/day (Integral 2006). The maximum specific discharge rates recorded at these locations were 16.0, 17.4, 31.5, and 3.1 cm/day. The average specific discharge rate at the remaining locations was low (<0.5 cm/day). In general, the nearshore sand and silty-sand sediment was found to have higher relative discharge rates, consistent with site stratigraphy and the conceptual model of shallow groundwater flow (Integral 2006). The seepage meters farthest offshore, located slightly offshore of the dock structures, showed near-zero average discharge rates (ranging from 0.5 to –1.2 cm/day).

The results of the UltraSeep surveys indicate that, although the specific discharge rates fluctuate between positive and negative values (i.e., groundwater discharge and recharge, respectively), a net positive discharge was recorded at most stations, but the magnitude of specific discharge was generally small.

1.3 NATURE AND EXTENT OF COIS IN GROUNDWATER

The last site-wide groundwater monitoring event was conducted in August 2009 (ERM 2010b). In general, the results of the August 2009 site-wide groundwater monitoring event confirmed the previously determined extent of COIs in the former Acid Plant area and the Chlorate Plant area for COIs such as perchlorate, chloride, chlorobenzene, DDx, and hexavalent chromium. These COIs are predominately localized in groundwater underlying Lot 4 (Figure 1-3), and their northernmost extent is bounded by the proposed groundwater SCM (Figure 1-5). Additional details, including maps depicting COIs in groundwater, are provided in the site-wide groundwater monitoring report (ERM 2010b).

1.4 UPLAND SOURCE CONTROL MEASURES

SCMs are currently being implemented on the upland portion of the site for stormwater and groundwater. The following sections briefly describe these SCMs. Additional details on the upland SCMs are presented in the stormwater SCM design report (Integral 2011) and the groundwater SCM design report (ERM 2011).

1.4.1 Stormwater SCM

The stormwater SCMs consist of collecting site stormwater, conveying it to a stormwater detention basin, equalizing the storm volume, providing primary solids removal through sedimentation in the basin, and providing second stage treatment through sand and/or a sand amended with carbon filtration system. The treated stormwater will be discharged to the river through Outfall 004. Figure 1-5 shows the configuration of the stormwater treatment system. Other elements of the stormwater SCMs include temporary capping of selected areas of the site that contain COIs in exposed surficial soil and decommissioning of a majority of the existing stormwater conveyance piping.

The stormwater SCMs are considered an interim action that are being applied in advance of the site-wide feasibility study and selection of a final site remedy that addresses COIs in soil, groundwater, and stormwater in the upland portions of the site. Thus, all SCMs implemented as part of this design are considered temporary in nature. The final upland site remedy is anticipated within approximately the next five years.

1.4.2 Groundwater SCM

The groundwater SCM will consist of the installation of a groundwater barrier wall and a groundwater extraction and treatment (GWET) system. The groundwater barrier wall will physically separate the affected upland portions and in-water portions of the site and will be located near the top of the bank. The barrier wall will be aligned approximately from Dock 2

to the southern portion of the Salt Dock (Figure 1-5). The groundwater barrier wall will be constructed using a bentonite slurry and will extend to the top of basalt bedrock.

The GWET will maintain hydraulic control to prevent groundwater from moving around, over, or under the barrier wall. The GWET system will consist of 23 extraction wells located just upgradient of the groundwater barrier wall (Figure 1-5). The extraction wells will be screened in the shallow (13 wells) and intermediate (9 wells) groundwater zones. The groundwater will be treated using a number of physical, chemical, and biological processes to remove COIs and the treated groundwater will be discharged to the river through Outfall 004.

A conceptual cross section that depicts the groundwater SCM and shows the upland and in-water portions of the site is presented in Figure 1-4.

1.5 REMEDIAL MEASURES SEQUENCING

The appropriate sequencing of remedial measures for the uplands, RAA, and Portland Harbor is critical to maximize the effectiveness of the remedial measures and minimize the potential for recontamination. The phases of work under DEQ and EPA direction are anticipated to occur in the following sequence:

1. Construction of the upland SCMs (DEQ lead). Construction began on the stormwater SCMs in the spring of 2012 and is anticipated to be completed in early 2013.
2. Construction of the upland groundwater SCMs (DEQ lead). Construction of the groundwater SCMs is scheduled to begin in summer of 2012 and is anticipated to be completed in 2013.
3. Arkema sediment NTCRA (i.e., the subject of this EE/CA), including adjacent riverbank soils (EPA lead).
4. Portland Harbor site sediment remedy (EPA lead) in AOPC 14.

1.6 REPORT ORGANIZATION

The remainder of this report is organized as follows:

- Section 2: Removal Action Area Characterization – This section briefly presents the nature and extent of contamination, geotechnical properties, and surface debris in the RAA.
- Section 3: Identification of Removal Action Scope and Objectives – This section presents the removal action scope and objectives, ARARs, and the RAA.
- Section 4: Post-Removal Action Recontamination Assessment – This section presents the upland source control strategy and post-NTCRA recontamination issues.

- Section 5: Identification and Protection of Cultural Resources – This section presents a summary of the evaluation of cultural resources at the Arkema site.
- Section 6: Identification and Evaluation of Removal Action Technologies – This section identifies the removal action technologies that will be assessed for the Arkema NTCRA.
- Section 7: Identification and Analysis of Removal Action Alternatives – This section identifies and evaluates removal action alternatives for the Arkema NTCRA.
- Section 8: Comparative Analysis of Removal Action Alternatives – This section compares the removal action alternatives for the Arkema NTCRA.
- Section 9: Recommended Removal Action Alternative and Implementation – This section recommends a removal action alternative and discusses the implementation of the alternative.
- Section 10: References – References cited in the document.
- Appendix A: Sediment Data Screening
  - Appendix A1: Evaluation of Mean Quotient Values as Remediation Goals for Benthic Toxicity in AOPC 14 Memorandum – This memorandum evaluates the suitability of using mean quotient (MQ) values as remediation goals for benthic toxicity within AOPC 14, of which the RAA is a part.
  - Appendix A2: AOPC 14-Specific Sediment Quality Values Memorandum – This memorandum presents the methodology for developing AOPC 14-specific sediment quality values (SQVs) used to screen sediment samples within the EPA-directed horizontal RAA boundary.
  - Appendix A3: Data Screening Results – This appendix presents the sediment data within the EPA-directed horizontal RAA boundary screened against some EPA-directed Portland Harbor preliminary remediation goals (PRGs), remediation goals (RGs), remedial action levels (RALs)[5], RM 7-8 specific RALs, and AOPC 14-specific sediment quality guidelines (SQGs).
- Appendix B: Biological Assessment – This appendix presents a draft biological assessment and essential fish habitat assessment for the Arkema NTCRA.
- Appendix C: Clean Water Act 404(b)(1) Evaluation – This appendix presents a preliminary draft Clean Water Act (CWA) 404(b)(1) evaluation for the Arkema NTCRA.
- Appendix D: Cultural Resources Evaluation – This appendix presents an evaluation of cultural resources at the Arkema facility.

[5] Note that some PRGs, RGs, and RALs were directed by EPA without benefit of the results of the draft risk assessments as neither the human health nor the ecological risk assessments had been completed (or accepted by EPA and its partners) which could inform a formal risk management evaluation for the purpose of establishing sediment remedial objectives at this site.

- Appendix E: Cost Estimate Details – This appendix presents the details of the cost estimates generated as part of this EE/CA.
- Appendix F: Riverbank Alternatives Evaluation – This appendix presents an evaluation of riverbank erodible soil SCM alternatives.
- Appendix G: Supporting Documents – This appendix presents selected materials from other reports.
    - Appendix G1: Draft Feasibility Study Figures – This appendix presents figures from the Portland Harbor FS (Anchor QEA et al. 2012) with estimated removal action levels for DDT, DDE, and 2,3,4,7,8-PCDF.
    - Appendix G2: ERM Data Gaps Assessment Work Plan – This appendix presents a work plan detailing the source and character of PCDD/Fs in the vicinity of the Arkema site (ERM 2009).
    - Appendix G3: Doane Lake Memorandum – This memorandum presents a detailed description of Rhone Poulenc pesticide/herbicide production, waste handling practices, and connections to the Willamette River (Slater 2010).
- Appendix H: Recontamination Assessment – This appendix provides detail on the recontamination assessment that is summarized in Section 4 of this EE/CA report.

2 REMOVAL ACTION AREA CHARACTERIZATION

The following sections describe the nature and extent of contamination and present a streamlined evaluation of risk within the EPA-directed horizontal RAA boundary[6] (Figure 1-5). Sediment geotechnical properties, sediment leaching properties, and the nature of surface debris in the vicinity of the EPA-directed horizontal RAA boundary are also presented. Initially, an overview of Portland Harbor and area-specific specific EPA-directed PRGs, RGs, RALs[7], and AOPC 14-specific SQGs is provided.

2.1 OVERVIEW OF PORTLAND HARBOR PRGS/RGS/RALS AND AOPC 14 SQGS

This section provides an overview of the draft Portland Harbor and area-specific EPA-directed PRGs/RGs/RALs and AOPC 14-specific SQGs. Additional information specific to the basis of each PRG and RG for a given COI is presented in Section 2.2. These Portland Harbor, area-specific and EPA-directed PRGs, RGs and RALs are then screened against the Arkema EE/CA data set as described in Section 2.2.

2.1.1 Portland Harbor PRGs

Initially, sediment PRGs were developed for the draft Portland Harbor FS (Anchor QEA et al. 2012) based on the results of the Portland Harbor site draft final BHHRA (Kennedy/Jenks 2011) and the draft final BERA (Windward 2011). The term PRG was applied to the following three cases in the draft Portland Harbor FS report:

- Development of goals that occurred prior to initiation of the draft FS writing in early 2011, representing a preliminary stage in the iterative process of RG development
- Goals that are not sufficiently refined to be defined as RGs
- Goals for non-COIs.

Sediment PRGs are available for all EPA-directed RAA COIs (Table 2-1). In some cases, more than one PRG is presented for a given EPA-directed COI based on the receptor (i.e., human or ecological) and risk level (human health receptors only). The exposure areas for the PRGs are based on either the entire Portland Harbor site, one river mile, or on a point-by-point basis.

[6] The horizontal RAA boundary, as directed by EPA, is the 5 mg/kg DDx contour in the EVS model that was presented in the final RAAC report. The horizontal RAA boundary will be used to evaluate EE/CA alternatives for the RAA. COIs outside of the horizontal RAA boundary will be addressed if necessary as part of the Portland Harbor site remedy.
[7] Note that some PRGs, RGs, and RALs were directed by EPA and were not endorsed by the LWG or LSS.

The broad list of sediment PRGs was refined into a smaller list of "focused" PRGs by EPA (2010a) for use in the draft FS as part of an EPA risk management decision (Anchor QEA et al. 2012). The focused PRGs directed by EPA encompass a number of COIs with a variety of exposure pathways, ingestion rates, and risk levels. EPA has not provided the rationale for their selection of the focused PRGs, and the Lower Willamette Group (LWG) did not endorse the focused PRGs as necessarily representing the most appropriate set of PRGs for use in the draft FS report (Anchor QEA et al. 2012). One example cited in the draft FS report was EPA's directed mixing of risk management goals for human health cancer risk for different chemicals under the same exposure scenario, which is inappropriate because it does not effectively result in the reduction of risk. For example, if excess cancer risk via fish consumption is managed to a risk level of 10^{-4} for total polychlorinated biphenyls (PCBs) and 10^{-6} for dichloro-diphenyl-dichloroethene (DDE), then cleanup of sediment to the goal of 10^{-6} for DDE will not result in any appreciable reduction of excess risk of cancer because residual PCBs would remain at the higher 10^{-4} risk level. Therefore, LSS believes it would be most appropriate to use a single measure of 10^{-4} excess cancer risk to establish human health risk management levels for all Portland Harbor COIs.

2.1.2 Portland Harbor RGs

RGs were developed in the draft Portland Harbor FS report for harbor-wide use. RGs represent numerical goals that have been sufficiently refined for use on a site-wide, river-mile, or point-by-point basis depending on the particular COI and receptor of concern. RGs that were developed for receptors with site-wide or river-mile exposure units are expressed as spatially weighted average concentrations (SWACs) in surface sediments (0–1 ft bml). RGs are primarily discussed in the draft FS in terms of ranges because they are chemical and receptor specific and because there are considerable sensitivities and/or uncertainties in their determination. RGs that were developed for the EPA-directed RAA COIs are listed in Table 2-1.

2.1.3 Portland Harbor RALs

RALs were developed for the harbor-wide area and presented in the draft Portland Harbor FS report. RALs are point concentrations that exceed RGs (even the EPA-directed RGs) and require remediation. RALs were developed for selected "bounding" indicator chemicals in the draft Portland Harbor FS with the specific understanding that remediation of these COIs would also address the remaining contaminants posing potentially unacceptable risk, potentially including risk to the benthic community[8] (Anchor QEA et al. 2012). These indicator chemicals are considered "bounding" because their distribution generally encompasses the spatial extent of all contaminants posing potentially unacceptable risks identified in the baseline risk assessment (Anchor QEA et al. 2012). This streamlined approach is intended to identify areas

[8] Instead of a single bounding chemical indicator, the draft FS recommends a composite chemical indicator (the mean quotient) as the metric for managing potential risks to the benthic community.

that may require remediation without conducting an evaluation of every contaminant potentially posing an unacceptable risk at the site.

The draft Portland Harbor FS developed RALs for five of the EPA-directed RAA COIs (Table 2-1): total[9] dichloro-diphenyl-dichloroethane (DDD), total DDE, total DDT, total PCBs, and 2,3,4,7,8-polychlorinated dibenzofuran (PCDF). The RAL for total DDE is based on human health risk via the consumption of large home range fish and a site-wide exposure area. All of the remaining RALs are based on human health risk via consumption of smallmouth bass and a 1-RM exposure area. The RALs in Table 2-1 are expressed as a range of concentrations and are categorized according to the methodology adopted the draft Portland Harbor FS (see Table 4.4-1 in Anchor/QEA et al. 2012):

- RAL-B – RALs very high in the zone of maximum incremental reduction
- RAL-C – RALs within the zone of maximum incremental reduction (first increment)
- RAL-D – RALs within the zone of maximum incremental reduction (second increment)
- RAL-E – RALs within the zone of maximum incremental reduction (third increment)
- RAL-F – RALs within the zone of minimal change.

The chemical-specific RALs developed in the draft Portland Harbor FS are based on human health risks, but cover a wide range of concentrations to accommodate potential risk to most ecological receptors with the exception of the benthic community. The draft FS recommends a composite chemical indicator (the MQ) as the metric for managing potential risks to the benthic community. Consequently, RGs and RALs for the benthic community are addressed separately.

As with the RGs, the level of risk used to develop RALs for individual COIs was inconsistently applied at the direction of EPA in the draft Portland Harbor FS. For example, the RALs developed for 2,3,7,8-PCDF and total PCBs are based on a PRG representing exposure to smallmouth bass over 1 RM with a cancer risk of 10^{-4}. Consequently, the RAL in each case should represent the upper (post-remedial) point concentration that will yield a SWAC equal to the PRG. However, the RAL for 2,3,4,7,8-PCDF is equal to its PRG[10] and, therefore, cleanup of areas with 2,3,4,7,8-PCDF RAL exceedances will result in a SWAC that is far below the PRG. For example, based on figures provided in Appendix Da of the draft FS report, a RAL of 1.75 µg/kg (1,750 pg/g) should yield a SWAC equal to the PRG of 0.02 µg/kg (20 pg/g) for RM 7–8 (Appendix G). Consequently, a RAL for 2,3,7,8-PCDF in the range of 1–2 µg/kg (1,000–2,000 pg/g) for RM 6.5–7.5 would be consistent with a 10^{-4} risk management goal based on exposure via consumption of smallmouth bass and will be evaluated in this EE/CA. EPA directed the LWG to use RALs of 10 and 20 pg/g, which are at or below the corresponding PRG, which is clearly an error as RALs should be greater than the respective PRG.

[9] The draft Portland Harbor FS report uses "sum" instead of "total". These terms are equivalent.
[10] Compare PRGs in Table 2 of Appendix Da with RALs in Tables 4.4-1 and 7.1-1 in the main test of the draft FS.

Another inconsistency exists in the risk management goals established for other EPA-directed COIs. RALs for PCBs and 2,3,7,8-PCDF are based on a cancer risk goal of 10^{-4}, and the RAL developed for total DDE is based on a EPA-directed PRG with a cancer risk goal of 10^{-6}. The risk goal for DDE is far below that for PCBs and PCDF and, therefore, is well beyond the point of diminishing returns with respect to making a significant incremental contribution to overall risk reduction. Consequently, for this EE/CA, LSS does not apply the inconsistent cancer risk levels directed by EPA to the LWG.

Based on the results of the BHHRA, potential cancer risks via consumption of large home range fish, which represent site-wide exposure, and via consumption of smallmouth bass, which represent 1-RM exposure, are already below the target risk level of 10^{-4} for total DDT, total DDD, and total DDE. Accordingly, these constituents do not require remediation to a 10^{-4} risk level within the Portland Harbor site.

A cancer risk goal of 10^{-5} via consumption of smallmouth bass, as an additional measure of conservancy, was also evaluated for development of AOPC 14-specific RALs for DDD, DDE, and DDT. Based on the draft FS (Appendices Da and Db in Anchor QEA et al. 2012), the 10^{-5} PRG for DDD is greater than the existing SWAC for DDD. Consequently, the 10^{-5} target risk goal for DDD is met and a RAL is not proposed. The 10^{-5} PRG for DDE (8.8 µg/kg) yields a RAL of approximately 400 µg/kg for RM 7–8 (Appendix G). As a result, RALs in the range of 300–500 µg/kg are considered appropriate for RM 6.5–7.5. The 10^{-5} PRG for DDT (120 µg/kg) yields a RAL of approximately 6,000 µg/kg for RM 7–8 (Appendix G). Consequently RALs in the range of 4,000–7,000 µg/kg are considered appropriate for RM 6.5–7.5. Based on the draft FS (Table 2 in Appendix Da), both DDE and DDT already meet their respective 10^{-5} target risk levels in the Portland Harbor on a site-wide basis. Because both 10^{-4} and 10^{-5} target risk levels are already met on a site-wide basis, they were selected for development of alternative RALs for RM 6.5–7.5 that could provide incremental risk reduction for AOPC 14 that is consistent with risk goals for other substances present at the site. An RAL of 6,000 µg/kg for DDT was selected with the objective of meeting a 1-RM SWAC equal to the 10^{-5} PRG of 120 µg/kg. For DDE, a RAL of 400 µg/kg was selected to meet the 1-RM SWAC for RM 6.5–7.5. These RALs are based on a cancer risk level that is consistent with that used to develop RALs for several other COIs at the Portland Harbor site, and is more conservative than the 10^{-4} risk level used for PCBs.

2.1.4 AOPC 14-Specific Sediment Quality Guidelines for the Benthic Community

The primary line of evidence that was used to judge potential risk to the benthic community in Portland Harbor was harbor-specific empirical toxicity testing with the amphipod *Hyalella azteca* and the midge *Chironomus dilutus*, where both a survival and a growth (biomass) endpoint were measured in each test. Whether sediments used in each test were considered toxic was based on survival and growth of the organisms in test sediments compared with those in sediments used in laboratory controls or from reference areas. Sediment chemistry was also measured at

each of the sediment toxicity test locations. Sediment toxicity and sediment chemistry results for Portland Harbor were combined using both logistic regression model and floating percentile model (FPM) to derive harbor-specific SQGs, which are chemical-specific expressions of potential toxicity. By either method, the resulting SQGs are chemical-specific values that are intended to judge risk at locations where toxicity testing was not conducted, but where sediment chemistry was measured. Consequently, each location can yield multiple hazard quotients—one for each chemical-SQG pair.

To reduce complexity and to facilitate spatial interpretation of potentially affected areas, the MQ method was adopted in the RI and FS for the Portland Harbor site to integrate multiple, chemical-specific hazard quotients[11], which are based on comparisons of SQGs to sediment chemistry concentrations. Individual MQs are determined by calculating the hazard quotient for each chemical-SQG pair in a sample, summing the quotients for that sample, and then dividing by the number of quotients. Sample MQs exceeding 0.7 were considered toxic. However, there are numerous limitations to this approach which preclude its meaningful use as an AOPC-specific RG (see memorandum in Appendix A1). The generic MQ threshold for toxicity is neither harbor-specific nor AOPC 14-specific. Because the MQ approach is based on FPM SQGs, it is subject to the limitations of the FPM method, which is not AOPC 14-specific and which excludes potential contribution of conventional substances (e.g., sulfides) as contributors to risk.

The harbor-wide SQGs derived in the BERA for Portland Harbor (Windward 2011) and the probable effects concentrations proposed as PRGs by EPA (2010) are not reliable for use in establishing benthic injury thresholds for AOPC 14 because they predict benthic toxicity at significantly higher rates than actually observed in toxicity tests performed in AOPC 14. An alternative approach to MQ values was adopted to establish site-specific SQGs for benthic toxicity within AOPC 14 that could be used as PRGs, could facilitate definition of RALs, and provide the basis for injury threshold levels for total DDx (i.e., the sum of 2,4′- and 4,4′-DDD, DDE, and DDT) compounds (Appendix A2). Consequently, the following site-specific SQGs were derived for DDx compounds based on a predicted reliability of 75 percent[12] for paired toxicity test and chemistry data obtained for AOPC 14:

- DDD – 1,680 μg/kg dry weight (dw)
- DDE – 750 μg/kg dw
- DDT – 5,800 μg/kg dw
- Total DDx – 8,200 μg/kg dw.

[11] A hazard quotient is calculated by dividing a sample contaminant concentration by its respective SQG.
[12] The 75 percent reliability level is consistent with the approach described by Long et al. (1995, 1998) and MacDonald et al. (2000).

The role of other chemicals, such as polycyclic aromatic hydrocarbons, and the potential confounding effect of conventional sediment quality parameters, such as sulfides, ammonia, grain size, and organic carbon, were also evaluated relative to the toxicity tests performed in AOPC 14. Toxicity units for these substances and for DDx compounds were used to distribute potential injury among the various chemicals associated with toxicity. Because benthic toxicity is evaluated on a point-by-point basis, these values can be conservatively used as both RGs and RALs for the site.

2.2 NATURE AND EXTENT OF CONTAMINATION AND STREAMLINED RISK EVALUATION

The following sections present the nature and extent of contamination in sediment within the EPA-directed horizontal RAA boundary and a streamlined evaluation of site-specific relevant and appropriate risk. The EPA NTCRA guidance requires a streamlined risk evaluation that is intermediate in scope between the limited risk evaluation undertaking for emergency removal actions and the conventional baseline assessment normally conducted for remedial actions (USEPA 1993). Human health and ecological risk evaluations have been conducted on the upland portion of the Arkema site, which includes the riverbank area.[13] As previously noted, a BHHRA and BERA have been conducted for the Portland Harbor site[14], which includes the EPA-directed RAA of the Arkema NTCRA. Sediment data within the EPA-directed horizontal RAA boundary were thus screened against Portland Harbor PRGs and RALs to utilize site-specific values from the Portland Harbor FS that align this EE/CA with the Portland Harbor process.

A summary of the EPA-directed Portland Harbor PRGs, RGs, RALs, RM 7–8 RALs, and AOPC 14 SQGs used in this evaluation is presented in Table 2-1. Table 2-1 also identifies the source of each of these values. Summary statistics are presented in Table 2-2. Appendix A1 presents a memorandum providing the methodology for developing AOPC 14-specific SQVs used to screen sediment samples within the EPA-directed horizontal RAA boundary. Appendix A3 presents the sediment data within the EPA-directed horizontal RAA boundary screened against EPA-directed Portland Harbor PRGs, RGs, RALs, RM 7-8 RALs, and AOPC 14-specific SQGs in Table 2-1.

The LWG presented an Oregon hot spot evaluation for sediments in the draft Portland Harbor FS report. No potential hot spots were identified at the Portland Harbor site (Anchor QEA et al. 2012). Accordingly, a hot spot evaluation for sediments within the EPA-directed horizontal RAA boundary was not deemed necessary for the EPA-directed horizontal RAA boundary. The riverbank area adjacent to the EPA-directed horizontal RAA boundary was not included in the

[13] LSS is currently addressing DEQ comments on the upland ecological risk assessment. The human health risk assessment has been finalized.
[14] The draft final BHHRA and BERA reports are currently undergoing EPA review.

LWG's Oregon hot spot evaluation. An Oregon hot spot evaluation for the riverbank area will be prepared in accordance with the Consent Order, pending DEQ approval of the Hot Spot Evaluation Update (ERM 2012). In the interim, an evaluation of riverbank soil SCM alternatives was conducted and is presented in Appendix F. The recommended riverbank SCM is included in the alternatives in this EE/CA report.

2.2.1 DDx

The following sections present the data screening results and distribution of DDx within the EPA-directed horizontal RAA boundary. The 2011 Opalski decision included direction to incorporate at least the PRGs available from the harbor-wide RI/FS process in evaluating the impacts of dredging and/or taking other removal actions to a range of concentrations vertically (Opalski 2011). In addition, the 2011 Opalski decision also provided direction to evaluate the implications of dredging to the extent of 5 mg/kg DDx vertically. The 5 mg/kg DDx value was based on a preliminary mass/volume breakpoint analysis. In order to align this EE/CA with the Portland Harbor FS, RALs based on the Portland Harbor BHHRA were considered in this EE/CA as discussed in Section 2.1.3. The RALs for DDE and DDT that were considered in this EE/CA include DDx concentrations in the range of 5 mg/kg.

2.2.1.1 Specific Portland Harbor PRGs and RM 7–8 RALs

As discussed in Section 2.1, PRGs were directed by EPA for total DDD, total DDE, total DDT, and total DDx in the draft Portland Harbor FS report (Anchor QEA et al. 2012). These PRGs are presented in Tables 3.5.2, 3.5.4, and Appendix Da of the draft Portland Harbor FS report (Anchor QEA et al. 2012). This section presents the specific PRGs that the sediment data were screened against.

Sediment data were screened against the following PRGs for total DDD:

- PRG-1 – 0.900 mg/kg (Human receptors, adult fish consumption, smallmouth bass, low ingestion rate [IR], 10^{-4} risk [exposure area: 1 RM])
- PRG-2 – 0.089 mg/kg (Human receptors, adult fish consumption, smallmouth bass, low IR, 10^{-5} risk [exposure area: 1 RM])
- PRG-3 – 0.028 mg/kg (Ecological receptors, benthic probable effects concentration SQG [exposure area: point-by-point]).

Sediment data were screened against the following PRGs and RM 7–8 RAL for total DDE:

- PRG-1 – 0.100 mg/kg (Human receptors, adult fish consumption, smallmouth bass, low IR, 10^{-4} risk [exposure area: 1 RM])

- PRG-2 – 0.0088 mg/kg (Human receptors, adult fish consumption, smallmouth bass, low IR, 10^{-5} risk [exposure area: 1 RM])
- PRG-3 – 0.0313 mg/kg (Ecological receptors, benthic permissible exposure level SQG [exposure area: point-by-point])
- PRG-4 – 0.00302 mg/kg (Human receptors, adult fish consumption, large home range, single species, low IR, 10^{-6} risk [exposure area: site]). This value is also an RG.
- RM 7–8 RAL – 0.4 mg/kg (Based on 10^{-5} risk, adult fish consumption, smallmouth bass. Estimated from RAL plots for RM 7–8 in Appendix Db, draft Portland Harbor FS report).

Sediment data were screened against the following PRGs and RM 7–-8 RAL for total DDT:

- PRG-1 – 1.20 mg/kg (Human receptors, adult fish consumption, smallmouth bass, low IR, 10^{-4} risk [exposure area: 1 RM])
- PRG-2 – 0.120 mg/kg (Human receptors, adult fish consumption, smallmouth bass, low IR, 10^{-5} risk [exposure area: 1 RM])
- PRG-3 – 0.0629 mg/kg (Ecological receptors, benthic probable effects concentration SQG [exposure area: point–by-point])
- RM 7-8 RAL – 6.0 mg/kg (based on 10^{-5} risk, adult fish consumption, smallmouth bass. Estimated from RAL plots for RM 7–8 in Appendix Db, draft Portland Harbor FS report).

Sediment data were screened against the following PRG for total DDx:

- PRG-1 – 0.218 mg/kg (Ecological receptors, benthic FPM high SQG [exposure area: point-by-point])[15].

2.2.1.2 Data Screening Summary

More than 550 sediment samples have been analyzed for total DDD, total DDE, total DDT, and total DDx[16] adjacent to the Arkema site. Of these samples, 287 are located within the EPA-directed horizontal RAA boundary. A summary of PRG and RAL exceedances is presented in Table 2-2.

Total DDD was detected in 93 percent of the samples at concentrations ranging from 0.000130 to 1,200 mg/kg with a median detected concentration of 0.270 mg/kg. Detection limits ranged from 0.00015 to 0.13 mg/kg with a median of 0.000170 mg/kg.

[15] This PRG was not recommended in the draft final Portland Harbor BERA. The PRG was screened in response to a comment from EPA on the draft RAAC report.
[16] Selected historical sediment samples were only analyzed for the 4,4 isomers of these compounds.

Total DDE was detected in 72.5 percent of the samples at concentrations ranging from 0.0000860 to 24 mg/kg with a median detected concentration of 0.0615 mg/kg. Detection limits ranged from 0.0000450 to 7.5 mg/kg with a median of 0.0003 mg/kg.

Total DDT was detected in 91.6 percent of the samples at concentrations ranging from 0.00015 to 4,500 mg/kg with a median detected concentration of 0.480 mg/kg. Detection limits ranged from 0.000140 to 0.4 mg/kg with a median of 0.000285 mg/kg.

Total DDx was detected in 95.1 percent of the samples at concentrations ranging from 0.00032 to 4,800 mg/kg with a median detected concentration of 0.860 mg/kg. Detection limits ranged from 0.000150 to 0.016 mg/kg with a median of 0.000285 mg/kg.

2.2.1.3 Distribution of DDx

As noted in the final RAAC report, Environmental Visualization Software (EVS) was used to create a model of DDx in sediment data within the preliminary RAA boundary at the site.[17] The model incorporated EE/CA investigation and historical DDx sediment data (Integral and ARCADIS 2011). The EVS DDx model contains more than 550 DDx sediment sample results in the preliminary RAA area. Of these samples, 287 are located within the EPA-directed horizontal RAA boundary.

Figure 2-1 presents the horizontal extent of the 0.218 mg/kg (DDx PRG), 8.2 mg/kg (AOPC 14-specific SQG), and 75 mg/kg (approximate mass-based breakpoint) DDx contours for the nominal boundary using the final RAAC report EVS model[18] within the EPA-directed horizontal RAA boundary. The 8.2 mg/kg DDx boundary covers the area between Docks 1 and 2 with a small strip extending upstream of Dock 1 and some small discontinuous areas downstream of Dock 2 (Figure 2-1). The 0.218 mg/kg DDx boundary is similar to the 8.2 mg/kg DDx boundary, except for the area downstream of Dock 2. The 0.218 mg/kg DDx boundary downstream of Dock 2 is larger than the 8.2 mg/kg DDx boundary, especially immediately downstream of Dock 2 and in the discontinuous areas downstream of Dock 2.

Figure 2-1 also presents a cross section that overlays the lower vertical extent of the 0.218 mg/kg, 5 mg/kg, 8.2 mg/kg, and 75 mg/kg contours. The highest DDx concentrations in sediment are between Docks 1 and 2 at a depth of approximately 10 ft bml. The 0.218 mg/kg vertical contour generally extends downward to within 5–10 ft of basalt bedrock, from the downstream portion of Dock 1 to the northern portion of the EPA-directed horizontal RAA boundary. The 0.218 mg/kg DDx vertical boundary is at a shallower depth upstream of Dock 1

[17] At the request of EPA, the DDx data in the EVS model do not include EPA's split sample data from the 2009 EE/CA characterization investigation. These data were rejected by EPA during their data validation process. The reason for this rejection has not been provided. LSS notes that EPA DDx data were variable but in some cases were up to 2 orders of magnitude lower than LSS' data presented herein.
[18] This model used an anisotropy ratio of 15, consistent with previous agreements with EPA.

(Figure 2-1). This cross section clearly shows that the detected DDx sediment areas downstream of Dock 2 have a limited vertical extent and are not contiguous. Note that as a result of the sample spacing downstream of Dock 2, there is higher variability in the EVS model in this area and, therefore, there is some uncertainty as to whether these discrete "islands" downstream of Dock 2 are laterally discontinuous[19].

2.2.2 PCDD/Fs

The following sections provide background on the Portland Harbor PRGs for 2,3,4,7,8-PCDF and describe the data screening results and distribution of polychlorinated dibenzo-*p*-dioxins/furans (PCDD/Fs) within the EPA-directed horizontal RAA boundary.

2.2.2.1 Background on the Portland Harbor PRG

Some of the contaminants posing potentially unacceptable risk identified in the human health and ecological risk assessments (Kennedy/Jenks Consultants 2011; Windward 2011, respectively) are mixtures of multiple contaminants that incorporate both concentration and toxicity information for each individual contaminant (i.e., bird PCB toxic equivalent concentration [TEQ], bird dioxin/furan TEQ, mammal PCB TEQ, and mammal dioxin/furan TEQ). The relationships between concentrations of these mixtures in sediments, water, and tissue are complex and difficult to use in setting PRGs and RALs. Consequently, at EPA's direction, the LWG used a single surrogate chemical to represent each mixture:receptor pair (Anchor QEA et al. 2012, Appendix D). Selection of a single contaminant as a surrogate for these mixtures allows the use of biota-sediment relationships in development of PRGs. For dioxin TEQ in birds and mammals, data on concentrations of TEQ and concentrations of the individual TEQ constituents (unadjusted for toxicity) were evaluated to identify an individual surrogate compound for each TEQ. Based on this evaluation, EPA-directed LWG to use 2,3,4,7,8- PCDF as the surrogate for dioxin TEQ in both birds and mammals. LWG then used a regression relationship to convert a dioxin TEQ concentration in tissue to its 2,3,4,7,8-PCDF surrogate concentration in tissue. The surrogate concentration in tissue was then used in a food web model to estimate a sediment PRG that is also expressed as 2,3,4,7,8-PCDF. Although the calculated PRG is expressed as a concentration of the surrogate 2,3,4,7,8-PCDF, it is representative of dioxin TEQ.

For the Arkema EE/CA, the 2,3,4,7,8-PCDF PRG is recommended for screening sediment data because it is a surrogate value that is representative of potential risk of dioxin TEQ to semi-aquatic birds and mammals. This approach is consistent with the Portland Harbor FS and meets the intent of the 2011 Opalski decision that requires the use of "…SLVs for COIs where PRGs are not available…." Since 2,3,4,7,8-PCDF is being used as a surrogate PRG for total TEQ

[19] Note, however, that the "islands" downstream of Dock 2 are smaller in the EVS model using the rejected EPA split sediment data in place of the corresponding LSS data.

in the Portland Harbor, there is no need for an SLV for total TEQ. Nor is there need for a dioxin TEQ SLV for benthic receptors since dioxin TEQ was not identified as a chemical of concern for AOPC 14 (Windward 2011). EPA's direction to use 2,3,4,7,8-PCDF as a surrogate PRG also appears to be site-specific to AOPC 14.

Sediment data were screened against the following PRGs and RM 7–8 RAL for 2,3,4,7,8-PCDF:

- PRG-1 – 56 pg/g (Ecological receptors, mink, multi-species diet [exposure area: 1 RM])
- PRG-2 – 54.1 pg/g (Ecological receptors, bird dietary assessment, sandpiper, worms [exposure area: beach type]). This value is also an RG.
- PRG-3 – 20.5 pg/g (Human receptors, adult fish consumption, smallmouth bass, low IR, 10^{-4} risk [exposure area: 1 RM]). This value is also an RG.
- RM 7–8 RAL – 1,750 pg/g (Based on 10^{-4} risk, adult fish consumption, smallmouth bass. Estimated from RAL plots for RM 7–8 in Appendix Db, draft Portland Harbor FS report).

2.2.2.2 Data Screening Summary

As discussed in the previous section, the 2,3,4,7,8-PCDF was screened and used as a surrogate for all PCDD/F compounds, consistent with the draft Portland Harbor FS. A total of 66 sediments samples were analyzed for 2,3,4,7,8-PCDF within the EPA-directed horizontal RAA boundary. 2,3,4,7,8-PCDF was detected in 78.8 percent of the samples ranging from 0.100 to 28,000 pg/g with a median detected concentration of 68.8 pg/g. Detection limits ranged from 0.005 to 0.65 pg/g with a median of 0.0835 pg/g.

2.2.2.3 Distribution of PCDD/Fs

As noted in the final RAAC report, EVS was used to create a model of total PCDD/Fs in sediment data within the preliminary RAA boundary. The model incorporated EE/CA investigation and historical total PCDD/F sediment data (Integral and ARCADIS 2011). The EVS PCDD/F model contains more than 100 total PCDD/F sediment sample results. Of these samples, 66 are located within the EPA-directed horizontal RAA boundary.

Figure 2-2 presents the horizontal extent of the 36,000 pg/g PCDD/F contour and the vertical extent of total PCDD/Fs in sediments within and adjacent to the EPA-directed horizontal RAA boundary. The highest total PCDD/F concentrations are present in the area between Docks 1 and 2, similar to that of DDx (compare Figures 2-1 and 2-2). The vertical distribution of total PCDD/Fs, however, differs from the vertical distribution of DDx. Based on the EVS model analysis, the highest concentrations of PCDD/Fs extend to the sediment surface, as opposed to DDx, which is found at approximately 10 ft bml. One potential factor that may bias this analysis for total PCDD/Fs is that the PCDD/F distribution between Docks 1 and 2 is based on

the waste characterization samples, which were composites of larger sample intervals from boreholes between the docks (i.e., samples representing 6–12 ft sediment sample intervals). Concentrations of total PCDD/Fs immediately upstream of Dock 1 and downstream of Dock 2 are generally within the range of 100 to 1,000 pg/g, which is less than the RM 7–8 RAL of 1,725 pg/g (Figure 2-2).

2.2.2.4 PCDD/F Sources

The source and character of PCDD/Fs was addressed extensively in the data gaps work plan (ERM 2009; Appendix G2) and data gaps investigation for the upland portion of the Arkema site (ERM 2010a). Samples of upland soil and groundwater, and sediment immediately offshore in the Willamette River, were analyzed, and a homologue pattern consisting primarily of PCDF homologues was consistently found in areas where onsite sources of PCDFs were suspected. The PCDF-dominated homologue pattern for the Arkema samples generally has a peak in the penta-CDF or hexa-CDF homologue range. LSS believes that certain chlorinated furans may be incidental by-products of historic chlor-alkali production technology involving the use of Gibbs cells at the site. The source of such compounds is believed to be the chlorination of precursor furans associated with coal tar used on Gibbs cell tops. A "background" (typically observed in urban waterways) signature much higher in octachlorinated dibenzo-*p*-dioxin (OCDD), and a range of PCDD/PCDF congeners are observed throughout the upland and in-water areas surrounding the site. This homologue signature is common for "urban background" sources, such as municipal waste streams and diesel-fuel engine combustion (USEPA 2006). The PCDD/F homologue signatures that are found upstream and downstream of the site are likely the result of documented aerial deposition of PCDD/F from these urban background sources and other nearby PCDD/F sources, such as the remnants from the historical discharge of the RP Agent Orange and other pesticide/herbicide production process wastes observed by the Railroad Bridge. A detailed description of RP pesticide/herbicide production, waste handling practices, and connections to the Willamette River is presented in the memorandum titled *Review and Evaluation of Historical Source Information and Assessment of Historical Connections to Doane Lake, Doane Creek, and Saltzman Creek* (Slater 2010; Appendix G3).

Site sediment data also show a relationship between "background", PCDD-dominated, homologue patterns and the PCDF-dominated homologue pattern associated with the Arkema site. Figure 2-3 presents pie charts showing the fraction of PCDD and PCDF homologues in each sediment sample at or near the Arkema site, with the proportional PCDD homologue sum in red, and the proportional PCDF homologue sum in blue. Figure 2-3 generally shows that the PCDD/F sources upgradient of the Arkema portion of the Willamette River are primarily PCDD-dominated.

Figure 2-4 shows the homologue plots for selected sediment samples within and adjacent to the EPA-directed horizontal RAA boundary, with the PCDD homologues in red (from tetra-CDD to OCDD, left to right) and PCDF homologues in blue (from tetra- to octachlorodibenzofuran, left

to right). Figure 2-5 shows homologue plots for selected sediment samples both upstream and downstream of the horizontal RAA boundary. Although the homologue signatures upstream and downstream of the Arkema site are not identical, inspection of Figures 2-4 and 2-5 generally shows dominance in the PCDD-dominated homologue signature in upgradient and downgradient samples with OCDD, followed by hepta-CDD, generally the dominant CDD homologues indicative of the "urban background" homologue pattern. The homologue signatures observed in the sediment samples collected between Docks 1 and 2 and downstream of Dock 2 likely do, however, represent mixtures from multiple sources. Between Docks 1 and 2, the PCDF-dominated signature with a peak at penta-CDF and hexa-CDF is evident. However, this homologue signature transforms back to the "urban background" pattern at depth below about 20 ft bml and downstream of Dock 2. Downstream of Dock 2, other atypical homologue patterns arise that are not attributable to either the "urban background" signature or the PCDF-dominated site pattern. For example at WB-65-10-15, the sample is dominated by tetra- and penta-CDD and tetra- and penta-CDF compounds, which suggests a distinct and separate source of PCDD/Fs at this location (e.g., perhaps discharge of an offsite upgradient groundwater plume migrating beneath the Arkema facility), Doane Lake, or other nearby sources, such as the remnants from the historical discharge of the RP 2-4D and 2,4,5-T (which were used as Agent Orange) and other pesticide/herbicide production process wastes observed by the Railroad Bridge (Slater 2010). This pattern is also observed in other sediment samples (e.g., C332, C333, C335) located near Outfall 22b, by the Railroad Bridge (Figure 2-5). The location of these samples and fingerprints that are different than those adjacent to the Arkema site appear to indicate the nearby RP stormwater outfall is the likely source of these CDDs/CDFs (ERM 2009).

Additional known or suspected sources of CDDs/CDFs in the vicinity of the Arkema site, including the numerous City-owned CSOs, were presented in the data gaps work plan (EMR 2009). Possible transport pathways from these sites to surrounding sites include groundwater migration, air deposition, and surface water runoff. The currently known list includes the following facilities (ERM 2009):

- Wacker Siltronic Corp. (7200 NW Front Avenue)
- Gould Inc./NL Industries (5909 NW 61st Avenue)
- Schnitzer Investment/Doane Lake (6529 NW Front Avenue)
- McCormick and Baxter (6900 N Edgewater Street)
- GenStar Roofing Products/Certainteed Roofing (6350 NW Front Avenue)
- Kinder Morgan Willbridge Terminal (5924 NW Front Avenue).

2.2.3 Other EPA-Directed COIs

EPA has directed additional chemicals as COIs for further evaluation in the EE/CA. These additional EPA-directed COIs consist of total chlordanes, lindane (gamma-hexachlorocyclohexane), hexachlorobenzene, PCBs, and tributyltin (Sheldrake 2011). However, there is no evidence or history of spills of any of the EPA-directed COIs on the Arkema site, so inclusion of these COIs is wholly unsupported. Therefore, the EPA-directed evaluation of these COI must be based on harbor-wide detections.

2.2.3.1 Total Chlordanes

As discussed in Section 2.1, PRGs were developed for total chlordanes in the draft Portland Harbor FS report (Anchor QEA et al. 2012). These PRGs are presented in Table 3.5-2, Table 3.5-4, and Appendix Da of the draft Portland Harbor FS report (Anchor QEA et al. 2012). Sediment data were screened against the following PRGs for total chlordanes:

- PRG-1 – 830 µg/kg (Human receptors, adult fish consumption, smallmouth bass, low IR, 10^{-4} risk [exposure area: 1 RM])
- PRG-2 – 83 µg/kg (Human receptors, adult fish consumption, smallmouth bass, low IR, 10^{-5} risk [exposure area: 1 RM])
- PRG-3 – 1.87 µg/kg (Human receptors, fish consumption, large home range, single species, high IR, low bioaccumulation, 10^{-6} risk [exposure area: site]).

Total chlordanes have been analyzed in 88 sediment samples within the EPA-directed horizontal RAA boundary. Total chlordanes were detected in 39.8 percent of the samples at concentrations ranging from 0.33 µg/kg to 1,100 µg/kg with a median detected concentration of 25 µg/kg.

Figure 2-6 presents total chlordane data for sediment in the EPA-directed horizontal RAA boundary. While selected samples collected between Docks 1 and 2 have elevated detection limits, the vast majority of the detection limits were in the range of 0.001 to 0.1 mg/kg total chlordane, which is well below the PRG-Alt value of 630 µg/kg. A number of detection limits were below the PRG-1 value of 1.87 µg/kg, particularly in samples just west of Docks 1 and 2, in deeper sediments between Docks 1 and 2, and downstream of Dock 2.

Figure 2-6 shows that while there are sporadic detections of total chlordanes at the site, there is no evidence of a source of total chlordanes at the Arkema site and, in fact, most of the sediment samples that have detections are collocated or are very near samples where total chlordanes were not detected at a lower detection limit. This indicates that the total chlordane detections are sporadic. This is consistent with the historical urban use of the river and with the conceptual site model that indicates this area is depositional and shows there are no chlordane

sources at the Arkema site because chlordane was never manufactured, handled, or stored at the facility.

2.2.3.2 Lindane (gamma-Hexachlorocyclohexane)

A PRG for lindane was not recommended in the draft final Portland Harbor BERA. The following PRG was screened in response to a comment from EPA on the draft RAAC report:

- PRG-1 – 1.38 µg/kg (Ecological receptors–benthic SQG [exposure area: point-by-point]).

Lindane has been analyzed in 98 sediment samples within the EPA-directed horizontal RAA boundary. Lindane was detected in 4.1 percent of the samples at concentrations ranging from 1.22 to 430 µg/kg with a median detected concentration of 87.5 µg/kg.

Figure 2-7 presents lindane data for sediments within the EPA-directed horizontal RAA boundary. While some samples collected between Docks 1 and 2 have elevated detection limits, numerous samples had detection limits below the PRG-1 value of 1.38 µg/kg—particularly samples from just west of Docks 1 and 2, in deeper sediments between Docks 1 and 2, and downstream of Dock 2. This indicates that lindane detections are sporadic and are consistent with the historical urban use of the river and the conceptual site model that indicates this area is depositional and shows there are no lindane sources at the Arkema site. Lindane was never manufactured, handled, or stored at the Arkema facility.

2.2.3.3 Hexachlorobenzene

As discussed in Section 2.1, PRGs were developed for hexachlorobenzene in the draft Portland Harbor FS report (Anchor QEA et al. 2012). These PRGs are presented in Tables 3.5-2, 3.5-4, and Appendix Da of the draft Portland Harbor FS report (Anchor QEA et al. 2012). For hexachlorobenzene, the sediment data were normalized to organic carbon (OC) to be consistent with the PRG units. Sediment data were screened against the following PRGs for hexachlorobenzene:

- PRG-1 – 37 mg/kg-OC (Human receptors, fish consumption, large home range, single species, low IR and bioaccumulation, 10^{-4} risk [exposure area: site])
- PRG-2 – 3.7 mg/kg-OC (Human receptors, fish consumption, large home range, single species, low IR and bioaccumulation, 10^{-5} risk [exposure area: site]).

Hexachlorobenzene has been analyzed in 80 sediment samples within the EPA-directed horizontal RAA boundary. Hexachlorobenzene was detected in 56.2 percent of the samples at concentrations ranging from 0.0196 to 639 mg/kg-OC with a median detected concentration of 0.444 mg/kg-OC. Detection limits for undetected samples range from 0.0414 to 361 mg/kg-OC

with a median of 9.09 mg/kg-OC. The majority of the detection limits were below the PRG-1 (37 mg/kg-OC).

Figure 2-8 presents hexachlorobenzene data for sediments within the EPA-directed horizontal RAA boundary. PRG-2 exceedances were detected in shallow sediment samples between and just west of Docks 1 and 2 (Figure 2-8). The data show that hexachlorobenzene detections in site sediment are sporadic. Arkema site knowledge indicates this area is depositional and the conceptual site model shows that there are no hexachlorobenzene sources at the Arkema site. Hexachlorobenzene was never manufactured, handled, or stored at the Arkema facility.

2.2.3.4 Total PCBs

As discussed in Section 2.1, PRGs were developed for total PCBs in the draft Portland Harbor FS report (Anchor QEA et al. 2012). These PRGs are presented in Tables 3.5-2, 3.5-4, and Appendix Da of the draft Portland Harbor FS report (Anchor QEA et al. 2012). Sediment data were screened against the following PRGs for total PCBs:

- PRG-1 – 0.5 mg/kg (Ecological receptors, FPM high SQG [exposure area: point-by-point])
- PRG-2 – 0.0295 mg/kg (Human receptors, adult fish consumption, smallmouth bass, low IR, 10^{-4} risk [exposure area: 1 RM]). This value is also an RG.

Total PCBs have been analyzed in 62 sediment samples within the EPA-directed horizontal RAA boundary. Total PCBs were detected in 24.2 percent of the samples at concentrations ranging from 32 μg/kg to 1,200 μg/kg with a median detected concentration of 120 μg/kg.

Detection limits for undetected samples range from 1.2 to 150,000 μg/kg with a median of 78 μg/kg. The majority of the elevated detection limits were from the 2009 EE/CA investigation waste characterization boreholes between Docks 1 and 2 that were analyzed by LSS (i.e., WB-35, WB-36, WB-37, WB-39, and WB-42; Figure 2-9). EPA's contractor, CDM, collected and analyzed split samples for two of the waste characterization borehole samples and had detection limits three orders-of-magnitude lower than the corresponding samples that LSS analyzed (compare WB35 with WB35_1 and WB42 with WB42_1). Although the elevated detection limits can add some uncertainty to the characterization of total PCBs at the site, a comparison of the LSS and EPA split sample results indicates that the elevated detection limits do not necessarily relate to elevated PCB concentrations in the samples.

Figure 2-9 presents total PCB data for sediments within the EPA-directed horizontal RAA boundary. The majority of the detected PCB concentrations in subsurface sediments are located just to the east of Docks 1 and 2. A few detected PCB concentrations in surface sediments are located upstream of Dock 1 and downstream of Dock 2 (Figure 2-9). The data show that PCB detections in site sediment are sporadic and consistent with the historical urban and industrial use of the river. Arkema site knowledge and the conceptual site model show that this area is

depositional, and there are identified and well-documented PCB sources upstream. Importantly, there are no PCB sources from the Arkema site to the river.

2.2.3.5 Tributyltin

As discussed in Section 2.1, PRGs were developed for tributyltin in the draft Portland Harbor FS report (Anchor QEA et al. 2012). These PRGs are presented in Tables 3.5-2, 3.5-4, and Appendix Da of the draft Portland Harbor FS report (Anchor QEA et al. 2012). For tributyltin, sediment data were normalized to OC to be consistent with the PRG units. Sediment data were screened against the following PRGs for tributyltin:

- PRG-1 – 24.4 mg/kg-OC (Ecological receptors, tissue residue assessment, benthic worms [exposure area: point-by-point]).

Tributyltin was analyzed in 16 sediment samples within the EPA-directed horizontal RAA boundary and was only detected in one sample at a concentration that was below the PRG-1. Detection limits for undetected samples range from 0.583 to 21.3 mg/kg-OC with a median detection limit of 5.42 mg/kg-OC. All of the detection limits were below PRG-1 for tributyltin.

Figure 2-10 presents tributyltin data for sediments within the EPA-directed horizontal RAA boundary. The single detected tributyltin value is located just southwest of Dock 1. Arkema site knowledge and the conceptual site model show that this area is depositional. There are former and active shipyard facilities upstream, and there are no tributyltin sources at the Arkema site. Tributyltin was never manufactured, handled, or stored at the facility.

2.3 GEOTECHNICAL AND LEACHING PROPERTIES IN THE RAA

Geotechnical and contaminant leaching properties of sediments adjacent to the Arkema site are discussed in the following sections.[20] Multiple studies have included analysis of samples collected from sediment at the Arkema site; however, the scope and complexity of these analyses varied. Informative data was gathered as a result of studies in the late 1990s and early 2000s; however, more detailed sampling and analysis was prescribed under the EE/CA work plan (Parametrix 2007) and described in detail in the final RAAC report (Integral and ARCADIS 2011).

2.3.1 Geotechnical Testing Prior to the 2009 EE/CA Investigation

Multiple studies from 1997 to 2004 provided only select information regarding geotechnical properties of the sediment and soil. Only grain size analysis was performed on sediment

[20] The geotechnical data presented in this section includes some data collected outside the EPA-directed horizontal RAA boundary. These data are considered representative of the area within the EPA-directed horizontal RAA boundary.

collected from 1997 to 1998 (Weston 1998). During the Portland Harbor RI/FS activities, the following analysis was performed on sediments collected offshore of the Arkema facility:

- Grain size and percent moisture on all samples collected
- Specific gravity on 71 samples, from 41 sample locations
- Liquid limit, plastic limit, and plasticity index on 5 samples from 5 sample locations.

Highlights of the above analytical results include the following (Integral 2004):

- Atterberg limits indicate medium to high compressibility/plasticity
- 36.5 percent average moisture of all samples (n=77)
- Silty sands (SM) and sandy silts (ML).

Since the sediment samples described above were rather shallow (less than 5 ft bml) and detailed analysis was rather limited, additional investigation was proposed in the EE/CA work plan (Parametrix 2007) to be able to complete the engineering evaluation.

2.3.2 Geotechnical Testing Results from 2009 EE/CA Investigation

In general, the data collected during the geotechnical investigation is divided into the following categories:

- Generalized subsurface conditions, as observed in geotechnical explorations, and soil descriptions provided via chemistry boring logs
- *In-situ* test data consisting of cone penetration test (CPT) and standard penetration test (SPT) data
- Laboratory test results.

The following sections provide highlights of available geotechnical data.

2.3.2.1 Generalized Subsurface Conditions

Multiple geologic units were identified in the in-water geotechnical explorations and chemistry boreholes. The two predominant units are briefly described below:

River Sediment

- Generally consisting of two sediment types: very soft to soft organic silt and silt, and very loose to loose sand with various amounts of silt.
- Gravel layers, containing various amounts of sand and silt, were encountered in a few of the boreholes (typically directly overlying the basalt bedrock). These gravel layers were

predominantly less than 3 ft thick in the geotechnical boreholes; exceptions are discussed in the final RAAC report (Integral and ARCADIS 2011).

- Stratigraphy varies significantly across the site in terms of the layering of the sand and silt units. Generally, the following typical sediment profiles were encountered: predominantly sand, predominantly silt, significant sand layer over silt deposit, significant silt layer over sand deposit.

Columbia River Basalt Group Bedrock

- Basalt bedrock was encountered in all of the boreholes at depths ranging from approximately 4 to 49 ft bml. A basalt elevation map and sediment thickness map are provided in the final RAAC report (Integral and ARCADIS 2011).
- Fracturing and weathering generally decreased with depth. Rock quality parameters and detailed descriptions of the cores are provided on the boring log for SPT-1 in Appendix C of the final RAAC report (Integral and ARCADIS 2011).

2.3.2.2 Geotechnical *In-Situ* Test Data

In-situ testing consisted of CPTs and SPTs performed in the geotechnical borings. The final RAAC report provides the SPT results (N-values) on geotechnical borehole logs and the CPT results on CPT logs (Appendix C, Integral and ARCADIS 2011), as well as a discussion of the information provided by each of these methods (Section 3.2.2, Integral and ARCADIS 2011).

2.3.2.3 Geotechnical Laboratory Test Data

Geotechnical testing was performed in general accordance with ASTM test methods (ASTM 2009a, b). The ASTM designations and detailed summary of results are provided in the final RAAC report (Integral and ARCADIS 2011). All laboratory testing was performed by Kleinfelder, and their test reports are provided in Appendix G of the final RAAC report (Integral and ARCADIS 2011).

2.3.2.3.1 Index Property Data

A summary of the index property data includes:

- The fine grain sediment that was encountered in the geotechnical boreholes was predominantly classified as organic silt of high plasticity.
- Moisture contents of up to 203% were recorded, consistent with the presence of organic material in the samples. Organic contents ranged from 4.6 to 9.2%.

2.3.2.3.2 Testing on Relatively Undisturbed Sediment Samples

Consolidation and hydraulic conductivity testing were performed on relatively undisturbed sediment samples; testing procedures and data are outlined in the final RAAC report (Integral and ARCADIS 2011). In summary:

- Consolidation test results on SPT-2 at a depth of 22.5 ft yielded a recompression index of 0.150, a compression index of 0.03, and an estimated pre-consolidation pressure of 3,900 pcf
- Hydraulic conductivity values ranged from 4.5×10^{-9} to 8.5×10^{-7} cm/sec (at 20°C) for SPT-1 (sample depth 13–15 ft) and SPT-2 (sample depth 20.5–22.5 ft), respectively.

2.3.2.3.3 Rock Strength Test Data

Point load tests and unconfined compressive strength tests were performed on core SPT-1. Summary results of these tests include:

- $I_{s(50)}$ [corrected point load strength index] values ranging from 229.21 to 853.61psi at depths of 30 to 31.5 ft and 37 to 39 ft, respectively
- σ_{uc} [uniaxial compressive strength] values ranging from 5,616 to 20,913 psi at depths of 30 to 31.5 ft and 37 to 39 ft, respectively
- Compressive stress values ranging from 3,500 psi (with axial strain of ~0.004 inch/inch) up to 22,000 psi (with axial strain of ~0.012 inch/inch) at depths of 30 to 31.5 ft and 37 to 39 ft, respectively.

Additional details regarding these test procedures are provided in the final RAAC report (Integral and ARCADIS 2011).

2.3.3 Waste Characterization Testing

The following sections provide toxic characteristic leaching potential (TCLP) and asbestos testing results that may have implications for waste disposal handling and costs.

2.3.3.1 Toxicity Characteristic Leaching Procedure Testing

In order to properly manage the contaminants present and identified via sediment sampling at the Arkema site, federal regulations (40 CFR §261.24) require an understanding of the potential for contaminant mobility in landfill conditions. The TCLP procedure is one method for simulating leaching potential. A total of 14 samples were analyzed for TCLP as part of the 2009 EE/CA investigation (Integral and ARCADIS 2011). The following is a summary of the TCLP results:

- Herbicides were not detected.
- Multiple metals were detected.
  - The TCLP regulatory limit was exceeded only for lead in a single sample, ARK-WB-39 from 0 to 8 ft bml, at a concentration of 11 mg/L (lead TCLP regulatory limit is 5 mg/L).

- gamma-Hexachlorocyclohexane (the only pesticide detected).
  - No samples exceeded the corresponding TCLP regulatory limit.
- Phenols were not detected.
- Hexachlorobutadiene and 1,4-dichlorobenzene were detected.
  - No samples exceeded the corresponding TCLP regulatory limits.
- Several volatile organic compounds were detected.
  - Two volatile organic compounds were detected above TCLP regulatory limits. Benzene (TCLP limit of 0.5 mg/L) was detected in one sample location, ARK-WB-37 from 0 to 6 ft bml, at a concentration of 0.6 mg/L. Tetrachloroethene (TCLP limit of 0.7 mg/L) was also detected in a single sample location, WB-42 from 6 to 14 ft bml, at a concentration of 0.75 mg/L.

2.3.3.2 Asbestos

Asbestos results are presented because of possible implications for waste handling, safety, disposal, and costs. Data for samples analyzed for asbestos are presented in the final RAAC report (Integral and ARCADIS 2011).

Asbestos was detected in 8 of the 14 sediment samples in which it was analyzed by LSS, at concentrations ranging from 0.1 to 0.4 percent, with a median value of 0.3 percent (Integral and ARCADIS 2011). Chrysotile was detected in all 4 of the split sediments analyzed by the EPA for asbestos, ranging from a trace to 4.5 percent.

The discrepancy between the LSS analytical results and the EPA split analytical results for asbestos was discussed in correspondence between LSS and EPA. The data quality review of the quantitative analysis for the LSS results verified the accuracy of the point-count quantitation method used in the analysis of the LSS asbestos samples. EPA provided their data quality review for their analyses, which indicated that the asbestos quantitation combined both volumetric and weight quantitation methodologies for different asbestos size fractions. Based on LSS' review of both LSS' and EPA's analytical reports and data, no further asbestos analyses are required at this time and the LSS asbestos quantitation is deemed sufficient for assessing asbestos concentrations in sediment in the EPA-directed horizontal RAA. However, additional asbestos data may be collected during the remedial design process to address any uncertainties with respect to asbestos waste handling and disposal.

2.4 SURFACE DEBRIS IN THE RAA

In 2009, a visual surface debris survey was conducted to catalog and identify the locations of outfalls, pilings, concrete, and other debris within the preliminary RAA boundary. The visual

surface debris survey results are detailed in the final RAAC report (Integral and ARCADIS 2011). A brief summary of the surface debris observed on the riverbank and in-water portions of the site is provided below:

- Downstream of Dock 2 – The northern portion of this area includes a piling field from a historical dock. Miscellaneous concrete debris, metal debris, and some logs were also observed in this area. In addition, one active outfall and associated Parshall flume (Outfall 004) and an inactive historical outfall were observed in this area.
- Between Dock 1 and Dock 2 – The surface debris in this area consists primarily of concrete, historical pilings and dolphins, metal debris, logs, and other miscellaneous debris. Blackberry bushes were particularly thick in this area, which limited the amount of surface debris visible during the survey. Two active outfalls and associated Parshall flumes (Outfalls 002 and 003) were also observed in this area.
- Between Dock 1 and Salt Dock – The debris in this area consists primarily of concrete debris, with smaller amounts of scrap metal, logs, pilings, and a few dolphins also observed in this area. In addition, one active outfall and associated Parshall flume (Outfall 001) were observed in this area.

3 IDENTIFICATION OF REMOVAL ACTION SCOPE AND OBJECTIVES

The following sections present the identification of the removal action scope and removal action objectives (RAOs).

3.1 NTCRA SCOPE AND OBJECTIVES

The following sections present the NTCRA scope and RAOs.

3.1.1 Scope and Objectives of the Arkema NTCRA

This EE/CA was prepared following EPA's *Guidance for Conducting Non-Time Critical Removal Actions under CERCLA* (USEPA 1993). The EE/CA is based on a data set that includes historical site characterization data, as well as additional data collected in 2009 for the Arkema EE/CA.[21] The following are the EE/CA objectives (USEPA 1993):

- Identification of removal action scope, goals, and objectives (presented in this section)
- Identification and analysis of removal action alternatives (presented in Section 7)
- Comparative analysis of removal action alternatives (presented in Section 8)
- Recommendation of removal action alternative (presented in Section 9).

In addition to following EPA's NTCRA guidance (USEPA 1993), to meet with EPA's request, this EE/CA was also developed to be in accordance with the draft Portland Harbor FS. The EE/CA process included refinement of the RAOs; use of Portland Harbor-specific PRGs, RGs, and RALs; development of removal action technologies and alternatives consistent with the draft Portland Harbor FS report; and other actions to be consistent with the draft Portland Harbor FS.

3.1.2 Removal Action Objectives[22]

The following sections describe the Arkema NTCRA RAOs presented in the 2005 AOC SOW, the Portland Harbor FS RAOs (Anchor QEA et al. 2012), and the subsequently revised Arkema NTCRA RAOs that are consistent and aligned with the overall Portland Harbor FS RAOs and process. These various RAOs are summarized in Table 3-1.

[21] The 2009 EE/CA site characterization results were presented in the final RAAC report (Integral and ARCADIS 2011).
[22] The 2005 Arkema AOC SOW uses the phrase "removal action objectives" to describe the objectives. The draft Portland Harbor FS uses the phrase "remedial action objectives." These phrases are considered synonymous.

3.1.2.1 Arkema Removal Action RAOs

The following Arkema NTCRA RAOs were provided in the SOW of the AOC, dated June 27, 2005. RAO numbers were not presented in the SOW, but are included here for reference.

- **RAO 1**: Reduce human health risks to acceptable levels from direct contact with and incidental ingestion of chemicals of concern (COCs) in sediments and riverbank within the RAA.
- **RAO 2**: Reduce COC concentrations in sediments and riverbank within the RAA to levels that will result in acceptable risks to humans that eat fish and shellfish from the Willamette River.
- **RAO 3**: Reduce human health risks to acceptable levels from direct contact with and incidental ingestion of water with COCs within the RAA.
- **RAO 4**: Reduce ecological risks from contact with and ingestion of COCs in sediments or riverbank material or prey within the RAA to acceptable levels.
- **RAO 5**: Reduce ecological risks to acceptable levels from contact with and ingestion of water with COCs within the RAA.
- **RAO 6**: Eliminate the potential for migration of contaminants at unacceptable levels from the RAA to the Willamette River.
- **RAO 7**: Reduce contaminant flux from uplands, riverbank, and sediments so that recontamination of any sediment or riverbank caps put in place does not occur.

3.1.2.2 Portland Harbor FS RAOs

A total of eight RAOs were presented in the Portland Harbor FS; four were based on human health risk and four were based on ecological risk. The human health risk RAOs are as follows (Anchor QEA et al. 2012):

- **RAO 1 – Sediments:** Reduce to acceptable levels human health risks from exposure to contaminated sediments resulting from incidental ingestion of and dermal contact with sediments, and comply with identified ARARs.
- **RAO 2 – Biota Ingestion:** Reduce to acceptable levels human health risks from indirect exposures to COCs through ingestion of fish and shellfish that occur via bioaccumulation pathways from sediment and/or surface water and comply with identified ARARs.
- **RAO 3 – Surface Water:** Reduce risks from COCs in surface water at the Site to acceptable exposure levels that are protective of human health risks from ingestion of, inhalation of, and dermal contact with surface water; protect the drinking water beneficial use of the Willamette River at the Site; and comply with identified ARARs.

- **RAO 4 – Groundwater:** Reduce to acceptable levels human health risks resulting from direct exposure to contaminated groundwater and indirect exposure to contaminated groundwater through fish and shellfish consumption, and comply with identified ARARs.

The ecological risk RAOs are as follows:

- **RAO 5 – Sediments:** Reduce to acceptable levels the risks to ecological receptors resulting from the ingestion of and direct contact with contaminated sediments and comply with identified ARARs.
- **RAO 6 – Biota (Prey) Ingestion:** Reduce to acceptable levels risks to ecological receptors from indirect exposures through ingestion of prey to COCs in sediments via bioaccumulation pathways from sediment and/or surface water and comply with identified ARARs.
- **RAO 7 – Surface Water:** Reduce risks from COCs in surface water at the Site to acceptable exposure levels that are protective of ecological receptors based on the ingestion of and direct contact with surface water and comply with identified ARARs.
- **RAO 8 – Groundwater:** Reduce to acceptable levels the risks to ecological receptors resulting from the ingestion of and direct contact with contaminated groundwater and indirect exposures through ingestion of prey via bioaccumulation pathways from groundwater, and comply with identified ARARs.

A detailed discussion of the considerations for each RAO is presented in Section 3 of the draft Portland Harbor FS report (Anchor QEA et al. 2012).

3.1.2.3 Revised Arkema Removal Action RAOs

The Arkema removal action RAOs presented in the SOW of the AOC (dated June 27, 2005) were modified herein to more closely align the Arkema removal action with the Portland Harbor FS. This revision addresses EPA's direction to align the Arkema NTCRA with the harbor-wide RI/FS process, and is also supported by the 2011 Opalski Decision (Opalski 2011).

The following is a list of the revised Arkema removal action RAOs and discussion of how the performance of the RAOs will be assessed consistent with the Portland Harbor FS:

- **Revised RAO 1**: Reduce human health risks to acceptable levels from direct contact with and incidental ingestion of chemicals of concern (COCs) in sediments and riverbank soil within the RAA.

This RAO is consistent with Portland Harbor FS RAO 1 (see Section 3.1.2.2). The performance of RAO 1 will be assessed against EPA-directed Portland Harbor RGs for total DDE, total PCBs,

and 2,3,4,7,8-PCDF, and Portland Harbor focused PRGs for total DDD, total DDT, gamma-hexachlorocyclohexane, total chlordanes, and tributyltin (Anchor QEA et al. 2012).

- **Revised RAO 2**: Reduce COC concentrations in sediments and riverbank soil within the RAA to levels that will result in acceptable risks to humans that eat fish and shellfish that occur via bioaccumulation pathways from sediments from the Willamette River.

This RAO is consistent with Portland Harbor FS RAO 2. The performance of RAO 2 will be assessed against Portland Harbor RGs for total DDE, total PCBs, and 2,3,4,7,8-PCDF, and Portland Harbor focused PRGs for total DDD, total DDT, gamma-hexachlorocyclohexane, total chlordanes, and tributyltin (Anchor QEA et al. 2012).

- **Revised RAO 3**: Reduce human health risks to acceptable levels from direct dermal contact with and incidental ingestion of surface water with COCs within the RAA.

This RAO is consistent with Portland Harbor FS RAO 3. The performance of RAO 3 will be assessed against Oregon water quality standards (WQS), federal national recommended water quality criteria (NRWQC), and maximum contaminant levels (MCLs) for indicator chemicals listed in Appendix C of the draft Portland Harbor FS report (Anchor QEA et al. 2012). Consistent with the draft Portland Harbor FS, in cases where WQS/NRWQC are below background, upstream background concentrations will be used for comparisons to site data. The Portland Harbor "bounding" indicator chemicals that are EPA-directed RAA COIs consist of total PCBs, 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT.

- **Revised RAO 4a**: Reduce ecological risks from direct contact with and ingestion of COCs in sediments or riverbank material within the RAA to acceptable levels.
- **Revised RAO 4b:** Reduce ecological risks from indirect exposure to COCs in sediment via bioaccumulation in prey within the RAA to acceptable levels.

This two-part RAO is consistent with Portland Harbor FS RAOs 5 and 6. The RAO was broken into two parts (i.e., a and b) because the exposure routes are different. The performance of RAOs 4a and 4b will be assessed against EPA-directed Portland Harbor RGs for total DDE, total PCBs, and 2,3,4,7,8-PCDF, and EPA-directed Portland Harbor focused PRGs for total DDD, total DDT, gamma-hexachlorocyclohexane, total chlordanes, and tributyltin in surface soils and sediments (0–30 cm bml). In addition, the performance of RAO 4a will be assessed against AOPC 14 SQGs for total DDT, total DDE, and total DDD.

- **Revised RAO 5**: Reduce ecological exposure to acceptable risk levels from contact with and ingestion of surface water with COCs within the RAA.

This RAO is consistent with Portland Harbor FS RAOs 5 and 7. Although this RAO is being achieved for the harbor-wide site, performance of RAO 5 for the Arkema NTCRA will be assessed against Oregon WQS, federal NRWQC, and MCLs for indicator chemicals listed in Appendix C of the draft Portland Harbor FS report (Anchor QEA et al. 2012). Consistent with

the draft Portland Harbor FS, in cases where WQS/NRWQC are below background, upstream background concentrations will be used for comparisons. The Portland Harbor indicator chemicals that are EPA-directed RAA COIs consist of total PCBs, 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT.

- **Revised RAO 6**: Eliminate the potential for migration of contaminants at unacceptable levels from the RAA to the Willamette River.

This RAO is specific to the Arkema removal action. Short-term and long-term monitoring will be implemented once the NTCRA is completed to assess the performance of RAO 6. For sediments, the performance of RAO 6 will be assessed against EPA-directed Portland Harbor RGs for total DDE, total PCBs, and 2,3,4,7,8-PCDF, and EPA-directed Portland Harbor focused PRGs for total DDD, total DDT, gamma-hexachlorocyclohexane, total chlordanes, and tributyltin in surface soils and sediments (0–30 cm bml). For potential groundwater migration, the performance of RAO 6 for the Arkema NTCRA will be assessed against Oregon WQS, federal NRWQC, and MCLs for indicator chemicals listed in Appendix C of the draft Portland Harbor FS report (Anchor QEA et al. 2012). Consistent with the draft Portland Harbor FS, in cases where WQS/NRWQC are below background, upstream background concentrations will be used for comparisons. The Portland Harbor indicator chemicals that are EPA-directed RAA COIs consist of total PCBs, 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT.

- **Revised RAO 7**: Reduce contaminant flux from uplands, riverbank, and sediments so that recontamination of any sediment or riverbank caps put in place does not occur.

This RAO is specific to the Arkema removal action. The performance will be assessed differently for sediments than stormwater and TZW. For sediments, the performance of RAO 7 will be assessed against Portland Harbor RGs for total DDE, total PCBs, and 2,3,4,7,8-PCDF, and Portland Harbor focused PRGs for total DDD, total DDT, gamma-hexachlorocyclohexane, total chlordanes, and tributyltin in surface soils and sediments (0–30 cm below mudline). For stormwater and TZW, the performance of RAO 7 for the Arkema NTCRA will be assessed against Oregon WQS, federal NRWQC, and MCLs for indicator chemicals listed in Appendix C of the draft Portland Harbor FS report (Anchor QEA et al. 2012). Consistent with the draft Portland Harbor FS, in cases where WQS/NRWQC are below background, upstream background concentrations will be used for comparisons. The Portland Harbor indicator chemicals that are EPA-directed RAA COIs consist of total PCBs, 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT.

Portland Harbor RAOs 4 and 8 are not directly addressed by the revised Arkema RAOs. These Portland Harbor RAOs address groundwater exposure to human and ecological receptors, respectively. Note that construction of the Arkema groundwater SCM is being initiated in summer 2012 and will be fully implemented prior to the construction of the Arkema NTCRA. The groundwater SCM will consist of a groundwater barrier wall and a pump and treat system immediately upgradient of the barrier wall. This system is designed to capture and treat

upland groundwater. The TZW pathway will be assessed once the groundwater SCM has been implemented and data are available to assess the post-groundwater SCM effectiveness.

3.1.3 Other Objectives

EPA directed the LWG to evaluate Portland Harbor site-wide management goals in the draft Portland Harbor FS to ensure a successful remedy and integration with other regulatory mechanisms including, but not limited to, State of Oregon Water Quality and Environmental Cleanup programs (Anchor QEA et al. 2012). These management goals could potentially be applied to the Arkema NTCRA. Per EPA direction (USEPA 2009), specific numeric RGs were not developed for these management goals in the draft FS (Anchor QEA et al. 2012). Management goals are not RAOs and, therefore, the effectiveness of remedial alternatives will not be directly determined by comparison to management goals.

EPA directed the LWG to discuss the following Portland Harbor site-wide management goals in the draft FS:

- **Management Goal 1:** Ensure sediment cleanup activities consider, complement, and are compatible with, upland and upstream source control efforts designed to prevent recontamination by COCs in groundwater, stormwater, soil erosion, upstream sources, and overwater activities at the Site and are consistent with the RAOs for the Site; and allow in-water remedies at the Site to proceed in a timely manner.
- **Management Goal 2:** To the maximum extent practicable, minimize the long-term transport of COCs in the Willamette River from the Site to the Columbia River and the Multnomah Channel.
- **Management Goal 3:** Clean up contaminated sediments in a manner that promotes habitat that will support a healthy aquatic ecosystem and the conservation and recovery of threatened and endangered species.

Details on the management goals are presented in Section 3 of the draft Portland Harbor FS report (Anchor QEA et al. 2012).

3.2 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

This section discusses potential ARARs for the Arkema NTCRA. The ARARs discussed in this section are evaluated for the mix of technologies found in the various remedial alternatives developed in this EE/CA. Final ARAR determinations will be made by EPA during the preparation of the record of decision. A summary of potential ARARs is presented in Table 3-2.

Section 121(d) of CERCLA requires remedial actions to generally comply with all applicable or relevant and appropriate federal environmental or promulgated state environmental or facility

siting laws, unless such standards are waived. "For the purposes of identification and notification of promulgated state standards, the term promulgated means that the standards are of general applicability and are legally enforceable" (National Contingency Plan [NCP], 40 CFR 300.400[g][4]). If the most suitable remedial alternative does not meet an ARAR, EPA may waive the ARAR.

"Applicable requirements", as defined in 40 CFR 300.5, are:

> "those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstances found at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable."

"Relevant and appropriate requirements," also defined in 40 CFR 300.5, are:

> "those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws, that, while not 'applicable' to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. Only those state standards that are identified in a timely manner and are more stringent than federal requirements may be relevant and appropriate."

In addition to ARARs, advisories, criteria, or guidance may be identified as To Be Considered (TBC) for a particular release. As defined in 40 CFR 300AOO(g)(3), the TBC category "consists of advisories, criteria, or guidance developed by the U.S. Environmental Protection Agency, other federal agencies, or states that may be useful in developing CERCLA remedies." TBCs are non-promulgated advisories or guidance that are not legally binding and do not have the status of potential ARARs.

Under CERCLA 121 (e), federal, state, or local permits need not be obtained for remedial actions which are conducted entirely on-site. "On-site" is defined as the "areal extent of contamination and all suitable areas in very close proximity to the contamination necessary for implementation of the response action" (40 CFR 300.5). Although a permit would not have to be obtained, the substantive (non-administrative) requirements of the permit must be met. Remedial activities performed off-site would require applicable permits.

Potential ARARS and TBCs for the Arkema NTCRA, consistent with those presented in the Portland Harbor draft FS (Anchor QEA 2012a), are presented in Table 3-2.

3.2.1 ARARs

Potential ARARs are divided into the following categories:

- Chemical-specific requirements: These are health- or risk-based concentration limits or ranges for contaminants in different media.
- Location-specific requirements: These are restrictions on activities based on the characteristics of a site or its immediate environment.
- Performance, design, or other action-specific requirements: These are controls or restrictions on particular types of activities, such as the CWA regulations on discharges or dredged and fill material entering into waters of the United States.

3.2.2 Chemical-Specific Requirements

The RAOs identify sediment, surface water, and groundwater as media of concern at the Arkema site. Although there are no promulgated federal or Oregon ARARs providing numerical standards for contaminants in sediment, both federal and Oregon standards and criteria are available for surface water and groundwater.

In addition to Oregon WQS (Oregon Administrative Rules [OAR] 340-041-0340), EPA has identified federal NRWQC developed to protect ecological receptors and human consumers of fish and shellfish as potential relevant and appropriate requirements. With respect to application of NRWQC, EPA directed the LWG to compare the NRWQC to the Oregon WQS. If there is no Oregon WQS and there is a NRWQC, comparisons should be made to the NRWQC. If the Oregon WQS have not been updated to reflect the most recent NRWQC, then comparisons should be made to the NRWQC. However, if the Oregon WQS is adopted after the most recent NRWQC, but is less stringent due to waterbody-specific reasons, EPA may determine that the NRWQC is not relevant and appropriate as long as the remedy will be protective using the Oregon promulgated standard (USEPA 2010b). Specific Oregon WQS and federal NRWQC and other chemical-specific ARAR numeric values are provided in the Portland Harbor draft FS (Anchor QEA 2012a).

Oregon Hazardous Substance Remedial Action Rules [OAR 340-122-0040(2)(a) and (c), 0115 (3),(32) and (51)] set standards for the degree of cleanup required, and establish acceptable risk levels for humans and protection of ecological receptors, at the individual level for threatened or endangered species and the population level for all others. OAR 340-122-0040 requires that hazardous substance remedial actions achieve one of three standards: 1) acceptable residual risk levels as defined in OAR 340-122-0115 and as demonstrated by a residual risk assessment, 2) generic soil numeric cleanup levels, or 3) background levels in areas where hazardous

substances occur naturally. Oregon Hazardous Substance Remedial Action Rules (OAR 340-122-0115) define the following acceptable risk levels:[23]

- 1 in 1,000,000 (1×10^{-6}) lifetime excess cancer risk for individual carcinogens (e.g., benzo(a)pyrene)
- 1 in 100,000 (1×10^{-5}) cumulative lifetime excess cancer risk for multiple carcinogens (e.g., total PCBs)
- A hazard index[24] of 1.0 for noncarcinogens
- For populations of ecological receptors, a 10 percent or less chance that more than 20 percent of the total local population will be exposed to an exposure point value greater than the ecological benchmark value for each COC and no other observed significant adverse effects on the health or viability of the local population
- For individuals of species listed as threatened or endangered, a toxicity index less than or equal to 1.

EPA's target range for managing cancer risk is 1×10^{-4} to 1×10^{-6}, and the level for noncancer risk is a hazard quotient of 1. While the target risk levels in the Oregon Administrative Rules for noncarcinogens and for the protection of ecological receptors are similar to those of the NCP, the Oregon Administrative Rules for individual and multiple carcinogens are somewhat different than those under the NCP, which are nevertheless protective.

3.2.3 Location-Specific Requirements

Location-specific ARARs are restrictions placed on the concentration of hazardous substances or the conduct of activities solely because they are in specific locations. Some examples of specific locations include floodplains, wetlands, historic places, and sensitive ecosystems or habitats.

3.2.4 Action-Specific Requirements

Action-specific ARARs are usually technology- or activity-based requirements or limitations on actions taken with respect to hazardous wastes. These requirements are triggered by the particular remedial activities that are selected to accomplish a remedy. Because there are usually several alternative actions for any site remediation, a variety may apply. These action-specific requirements do not in themselves determine the remedial alternative; they instead

[23] OAR 340-122-0115 also provides separate "acceptable risk levels" for probabilistic risk assessments for human health and for individual ecological receptors listed as threatened or endangered, which are not addressed in these bullets.
[24] A hazard index represents the sum of individual contaminant hazard quotients.

indicate how a selected alternative must be achieved. Several select action-specific ARARs important to this EE/CA are briefly described below.

Under the State of Oregon's Environmental Cleanup Law, Oregon hot spots are defined as hazardous substances that are present in high concentrations, are highly mobile or cannot be reliably contained, and that would present a risk to human health or the environment exceeding the acceptable risk level if exposure to these materials were to occur (ORS 465.315(2)(b)) (see also, OAR 340-122-115(32)).

CWA Section 404 regulates the discharge of dredged or fill material into navigable waters, with the exception of incidental fallback associated with dredged materials. This ARAR is applicable to cleanup actions in the Willamette River. Appendix C provides a summary of the Section 404(b)(1) analysis of each of the alternatives and their consistency with the determinations provided for the Portland Harbor site-wide remedial alternatives evaluated in the Portland Harbor draft FS (see Appendix M to the Portland Harbor draft FS; Anchor QEA 2012a). The final determination of mitigation requirements will be made during remedial design; however, for the purposes of this EE/CA evaluation, the mitigation estimate developed for the LSS sediment management area in the Portland Harbor draft FS is incorporated into the EE/CA CWA evaluation of alternatives. The level of mitigation was considered to be a component of the proposed action, as it was then evaluated for Endangered Species Act compliance in the Arkema draft biological assessment (Appendix B).

Section 7 of the Endangered Species Act requires that federal agencies consult with National Marine Fisheries Service and the U.S. Fish and Wildlife Service to ensure that action "authorized, funded or carried out by such agency is not likely to jeopardize the continued existence of any threatened or endangered species" or result in adverse modification of species' critical habitat (16 USC § 1536(a)(2)). Five species of listed salmonids are known to use the lower Willamette River as a rearing and migration corridor. Moreover, eight listed salmonid species, three additional listed fish species, and one listed mammal species are known to occur in the lower Columbia River near the confluence with the Willamette River. Because these listed species are present at and near the site, a draft biological assessment was prepared and is included as Appendix B. This draft biological assessment is based upon the information and findings presented in the Portland Harbor draft biological assessment, which includes consideration of impact avoidance and minimization, and voluntary conservation measures.

The Federal Emergency Management Act floodplain ARAR requires that any action that encroaches on the floodways of United States waters (such as sediment cleanup) cannot cause an increase in the water surface elevation of the river during a 100-year flood event.

3.2.5 ARAR Waivers

If it is found that the most suitable remedial alternative does not meet an ARAR, the NCP provides for waivers of ARARs under certain circumstances. According to 40 CFR 300.430(f)(1)(ii)(C):

> "An alternative that does not meet an ARAR under federal environmental or state environmental or facility siting laws may be selected under the following circumstances:
>
> 1. The alternative is an interim measure and will become part of a total remedial action that will attain the applicable or relevant and appropriate federal or state requirement;
> 2. Compliance with the requirement will result in greater risk to human health and the environment than other alternatives;
> 3. Compliance with the requirement is technically impracticable from an engineering perspective;
> 4. The alternative will attain a standard of performance that is equivalent to that required under the otherwise applicable standard, requirement, or limitation through use of another method or approach;
> 5. With respect to a state requirement, the state has not consistently applied, or demonstrated the intention to consistently apply, the promulgated requirement in similar circumstances at other remedial actions within the state; or
> 6. For Fund-financed response actions only, an alternative that attains the ARAR will not provide a balance between the need for protection of human health and the environment at the site and the availability of Fund money to respond to other sites may present a threat to human health and the environment."

The EPA Office of Solid Waste and Emergency Response Directive 9234.2-25 guidance titled *Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration* (USEPA 1993), although specific to groundwater, is the primary guidance for technical impracticability waivers (TI guidance).

3.3 REMOVAL ACTION AREA

The horizontal RAA boundary, as directed by EPA, is the 5 mg/kg DDx contour in the EVS model that was presented in the final RAAC report (Figure 1-5). The horizontal RAA boundary

was used to evaluate EE/CA alternatives at the site. EPA-directed COIs that are present outside of the horizontal RAA boundary will be addressed as part of the Portland Harbor site remedy.

The vertical limits of the RAA were not defined in the final RAAC report. Per the 2011 Opalski Decision and other correspondence from EPA, the vertical limits of the RAA are to be determined through the evaluation of alternatives in this EE/CA document. The 2011 Opalski decision stated the following:

> "LSS is to follow the direction provided by EPA to incorporate at least the PRGs available from the harbor-wide RI/FS process, and SLVs for COIs where PRGs are not available, in evaluating the impacts of dredging and/or taking other removal actions to a range of concentrations vertically. Consistent with my prior dispute decision, LSS shall also include an evaluation of implications of dredging to the extent of 5 ppm DDx vertically. LSS also may evaluate implications of active removal to other concentrations, including concentrations that may be derived primarily from a mass to volume relationship."

As discussed in Section 2.1, LSS has identified RALs for DDT (6 mg/kg), DDE (0.4 mg/kg), and 2,3,4,7,8-PCDF (1,750 pg/g) for the RAA. Because DDx is the primary COI for the removal action (Parametrix 2007), DDT and DDE were the initial and primary basis for defining the vertical boundary of the RAA and in evaluating the lateral and vertical extent of various removal action technologies (e.g., dredging, capping, monitored natural recovery [MNR]) when assembling remedial alternatives. As described below, the horizontal and vertical boundaries defined by the combined extent of DDT and DDE RAL exceedances encompass the vast majority of sediment impacted by DDx and other EPA-directed COIs in both surface sediments and at depth. Use of the DDT and DDE RALs for defining the horizontal and vertical extent of various removal action components during removal action alternative development is appropriate because:

- Alternatives (e.g., capping, dredging) that result in a clean sediment surface across the area where pre-removal action surface sediments exceed RALs, achieve a significant reduction in the SWAC for EPA-directed COIs that are present at locally elevated concentration at the RAA (e.g., DDx, furans); and thus substantively improves conditions relative to PRGs that are regionally (e.g., Portland Harbor site-wide or RM) based.

- The DDT and DDE RALs encompass the most highly contaminated sediment in the RAA, and thus the boundaries defined by these RALs provide a reasonable basis for establishing areas and volumes where removal alternatives achieve the greatest effect in terms of mass removal and risk reduction.

Based on the data presented in Section 2.2, the COI distribution can be sorted into two general areas within the EPA-directed horizontal RAA boundary (Figure 3-1):

- **Area 1.** The first area is generally between Docks 1 and 2 (Figure 3-1), and is defined by a relatively contiguous area of sediment impacts that exceed the DDT and DDE RALs at any depth, and a few isolated "islands" where COIs were detected predominantly at depth. In general, the highest concentrations of DDx, furans, and some other EPA-directed COIs occur within the footprint of contiguous sediment impacts of Area 1, and this area encompasses the estimated extent of sediments that exceed the RAL for 2,3,4,7,8-PCDF. Area 1 corresponds to the area where the majority of COI mass resides both in surface and subsurface sediment.

- **Area 2.** The second area consists of relatively isolated islands of sediment downstream of Dock 2 characterized by sporadic and low DDx concentrations at depth. DDx concentrations are not above RALs in surface sediments in this area, and the other EPA-directed COIs are generally not elevated in this portion of the RAA.

Figures 3-2 and 3-3 present the samples in which detected total DDE and DDT concentrations exceed the Arkema RALs within the EPA-directed horizontal RAA boundary. The highest concentrations of DDx are located in Area 1. Approximately 90 percent of the total DDx mass within the footprint of the EPA-directed horizontal RAA boundary is located within the horizontal boundary defined by the 75 mg/kg DDT concentration, which encompasses an approximate 1.3-acre footprint within Area 1.

There are some RAL exceedances at depth distributed throughout Areas 1 and 2. The highest DDx concentrations are generally present above a depth of 15 ft bml in both Areas 1 and 2. It is estimated that nearly 80 percent of the DDx mass is present in the top 15 ft of sediments within the EPA-directed horizontal RAA boundary. The few RAL exceedances in Area 2 are generally located at least 2 ft bml. Figures 3-4 and 3-5 present the surface sediment samples (0–1 ft) in which total DDE and/or DDT was detected at concentrations exceeding the Arkema RALs. There are no RAL exceedances in surface sediment samples collected from Area 2. All but one of the RAL exceedances detected in surface samples are within the area of relatively contiguous sediment impacts in Area 1. With the exception of total DDE in one surface sediment sample collected from station G366 at the upstream end of the site, RAL exceedances were limited to samples collected at depth in the isolated islands of impacted sediments associated with Area 1.

As shown in Figure 3-6, detection of 2,3,4,7,8-PCDF above the RAL is limited to samples collected within Area 1. The vast majority of the 2,3,4,7,8-PCDF RAL exceedances occur at depths of less than 15 ft bml. As shown in Figure 3-7, there was only one detected RAL exceedance for 2,3,4,7,8-PCDF in surface sediment samples within the EPA-directed horizontal RAA boundary. This detection occurred in Area 1 and is within the extent of contiguous surface sediment which exceeds the DDE and/or DDT RALs. Based on these data, removal

action alternatives developed based on the extent of DDE and DDT RAL exceedances in Area 1 will address the vast majority of the RAL exceedances for 2,3,4,7,8-PCDF.

In summary, the horizontal RAA boundary, as directed by EPA, is the 5 mg/kg DDx contour in the EVS model that was presented in the final RAAC report and is used to evaluate the EE/CA alternatives in later sections of this report. The vertical boundary, which was left undefined in the final RAAC report, was assessed by defining AOPC-specific RALs that were based on the Portland Harbor FS and that address the EPA-directed RAA COIs. Two areas, both laterally and vertically, within the horizontal RAA boundary were identified: Area 1 is generally between Docks 1 and 2, and is defined by a relatively contiguous area of sediment impacts that exceed the DDT and DDE RALs at any depth (i.e., surface and subsurface) and a few isolated areas where COIs were detected in isolated samples predominantly at depth; the highest concentrations of DDx, furans, and some other EPA-directed RAA COIs; and where the majority of DDx and other EPA-directed RAA COI mass resides both in surface and subsurface sediment. Area 2 consists of isolated areas downstream of Dock 2 where DDx was sporadically detected at low concentrations relative to Area 1. RAL exceedances occur only in samples collected at depth from Area 2, and other EPA-directed RAA COIs are generally not elevated in this area. Area 1 and Area 2 are used in the assessment of EE/CA alternatives both laterally and vertically in later sections of this report.

4 POST-REMOVAL ACTION RECONTAMINATION ASSESSMENT

The long-term effectiveness of the planned Arkema NTCRA relies on the identification, characterization, and control of potential recontamination sources and pathways that may exist after completion of the removal action. To assess this future recontamination potential, this section provides the following:

- An overview of the source control strategy
- A discussion of potential recontamination sources and pathways and a semi-quantitative evaluation of the potential for these sources/pathways to contribute to the recontamination of post-NTCRA sediments
- Recommendations for multi-media monitoring to ensure long-term protectiveness of the remedy.

4.1 SOURCE CONTROL STRATEGY

The source control strategy for the Arkema site is governed by the strategy that has been outlined for Portland Harbor, where a successful harbor-wide remedy includes the implementation of effective in-water remedies and upland SCMs (Anchor QEA et al. 2012). Upland source controls are regulated and determined by DEQ working with responsible parties along the river and adjoining drainage basin. DEQ's objective is to minimize the potential for unacceptable recontamination of remediated sediments. Because ongoing sources to the river via groundwater, stormwater, soil erosion, and overwater activities at, offsite, and upstream from the site could impact sediment following remediation, upland source control activities need to be implemented in a time frame that is consistent with the harbor-wide remedy. The draft Portland Harbor FS assumes sources will be controlled under the DEQ program at the time of the sediment remedy and does not attempt to determine acceptable levels of upland sources, source controls, or targets for specific source control efforts. Instead, the draft Portland Harbor FS evaluates the extent to which currently known sources may be expected to contribute to sediment recontamination. The remainder of this section conducts a similar evaluation, in the context of the Arkema EE/CA.

4.2 POTENTIAL RECONTAMINATION SOURCES AND PATHWAYS

4.2.1 Groundwater

Groundwater containing volatile organic compounds, metals, furans, and DDx has been identified in the Arkema RAA (Anchor QEA et al. 2012). An SCM to control this groundwater has been selected, and includes a groundwater containment system consisting of an upland bentonite barrier wall, and a groundwater treatment system with groundwater extraction and treatment in a multi-media *ex-situ* physical, chemical, and biological treatment system (Figure 1-5). This groundwater SCM is scheduled to be constructed beginning in the summer of 2012 and be operational by 2013.

The groundwater SCM is intended to prevent flux of COIs in groundwater from the site to the Willamette River. This will be achieved by maintaining an inward hydraulic gradient from the Willamette River. Any COIs potentially leaching from soil to groundwater on the riverward side of the groundwater barrier wall, including the RAA riverbank area, will tend to flow away from the river, thus containing any potentially highly mobile areas with high concentrations (ERM 2012).

4.2.2 Stormwater

Stormwater runoff from the Arkema site has been identified as a source of DDx to the RAA. Levels of DDx in the runoff exceed screening levels for ambient water quality criteria (Appendix Q, Anchor QEA et al. 2012). Stormwater SCMs are in progress and include abandonment of the existing stormwater collection system, construction of a new stormwater conveyance system including a detention basin and sand filter, and soil capping, as well as best management practices (BMPs). Construction of the stormwater collection and treatment system is underway and scheduled for completion in January 2013. The potential for recontamination of future remediated sediments following completion of the treatment system was evaluated and indicated minimal recontamination (Integral 2011).

4.2.3 Riverbank Soils

Arkema bank erosion has been identified as a potential onsite source of COIs to the Willamette River (Appendix F). Historical upland and offsite activities, deposition of river sediments, and placement of dredge materials may have led to DDx, furans, and metals in Arkema's riverbanks (Anchor QEA et al. 2012). A screening evaluation of available data concluded the bank area between the site's docks is a high priority for measures to control bank erosion as a potential pathway of DDx to the RAA (Appendix F). SCMs for this portion of the riverbank are, therefore, included in the alternatives developed for this EE/CA. The remainder of the riverbank will be addressed as part of the ongoing RI/FS for the upland Arkema property.

4.2.4 Upstream Sources

Tributaries to the Willamette River, as well as the main stem Willamette River which runs through the agricultural Willamette Valley, may adversely affect COI concentrations in the Arkema RAA following sediment remediation. DEQ placed Johnson Creek, which enters the Willamette River at RM 18.9, on Oregon's 303(d) list of impaired waters due to exceedances of water quality standards for DDT, PCBs, and other COIs (Portland Bureau of Environmental Services 2005). Historical agricultural use of pesticides has likely been the primary source of DDT for Johnson Creek. As a result of these historical sources, DEQ has established a total maximum daily load (TMDL)and waste load allocation in an attempt to control DDT inputs to Johnson Creek and the downstream watershed including the area of the Arkema site. In Johnson Creek, DEQ found that DDT persists in the watershed as a result of historic agricultural pesticide use. For Johnson Creek, DEQ's DDT TMDL was a 77 percent reduction in DDT for urban stormwater and 94 percent reduction for non-point sources. For non-point sources, DEQ also chose 15 mg/L total suspended solids as a surrogate for DDT removal because DDT and total suspended solids concentrations are correlated in Johnson Creek flows. Although these reductions would not achieve the water quality criteria for fish consumption, DEQ stated that they expected these TMDLs to achieve the chronic ambient water quality criteria for the protection of aquatic life. The Arkema recontamination analysis examines the impact of potential ongoing upstream sources of COIs, including those from tributaries, as well as potential future conditions in which these sources are controlled.

4.2.5 In-waterway Sediment Transport and Deposition

A mathematical mass balance model, SEDCAM (Jacobs et al. 1988), was applied to evaluate potential recontamination from upstream as well as upland sources (Appendix H). SEDCAM predicts surficial sediment contaminant concentrations over time, and the model assumes that the source inputs of sediments are fully mixed within the surficial layer over the area of potential recontamination. Model inputs include sediment concentrations of incoming (upstream) sediments, sediment load and concentration in the stormwater discharge from the site, initial surficial sediment concentration over the area of potential recontamination, and sedimentation rate. Model input parameters were developed from available site data. Where parameters were uncertain, a range of values were evaluated to provide a bounding estimate of potential sediment concentrations.

Model results for all analytes indicate that there will be some recontamination following the removal action from upstream load scenarios. An estimated sedimentation rate of 3.3 cm/yr would result in predicted surficial concentrations below all Portland Harbor site RALs and PRGs for the three DDx isomers. The model results suggest that the extent of the recontamination and the achievement of the remedial goals will depend on the upstream sediment COI concentrations, ongoing net sedimentation rate in the RAA, and the implementation of upstream source control measures.

4.3 SUMMARY AND MONITORING RECOMMENDATIONS

All of the potential individual recontamination pathways that originate at the Arkema site have a relatively low likelihood of increasing the contaminant concentrations in RAA sediments following the NTCRA. The greatest potential for recontamination is from upstream sources, including urban runoff, of DDx (e.g., Johnson Creek tributary) and other COIs.

Impacted groundwater remaining in the upland portion of the site will be contained and treated—substantively reducing/eliminating advective discharge of impacted groundwater from the upland areas to the RAA. The groundwater monitoring program (ERM 2010c) conducted following implementation of this SCM is anticipated to verify that groundwater will not be a source of recontamination to the post-NTCRA RAA.

The stormwater SCMs will treat stormwater discharges from the upland portion of the site. The Arkema SCM design report (Integral 2011) conducted a recontamination assessment using the SEDCAM (Jacobs et al. 1988) mathematical mass balance model. This assessment concluded that following SCM implementation, site stormwater discharge is unlikely to result in unacceptable risk and is thus unlikely to necessitate additional remediation activities (Integral 2011). The stormwater sampling program to be implemented following implementation of the SCMs will be used to verify that stormwater is not a source of recontamination to the post-NTCRA RAA.

SCMs for a targeted portion of the riverbank are included in this EE/CA. Specific performance monitoring recommendations for the selected remedy will be developed as part of remedial design, and will likely include a combination of visual monitoring and nearshore sediment sampling. As stated above, the remainder of the riverbank is being addressed as part of the ongoing RI/FS for the upland Arkema property, and specific performance monitoring requirements will be developed in conjunction with that process.

Potential recontamination from transport and deposition of contaminated sediment elsewhere (e.g. , from cleanup activities elsewhere in Portland Harbor and upstream) have been determined to be medium to low, contingent on, among other things, the implementation of upstream SCMs. The design phase of the NTCRA will include the design of a post-NTCRA stormwater, groundwater, and sediment monitoring program to verify that post-NTCRA recontamination of sediments within the Arkema RAA does not occur. Monitoring results will be used to evaluate the potential for recontamination to result in unacceptable risks, and identify the need for further evaluation of potential sources and pathways. As the FS process for Portland Harbor develops, the overall timing and sequencing of in-water work, relative to the implementation of this, and other, early actions should be considered. The single greatest potential for recontamination is from upstream sources of DDx and other COIs, such as from the mainstem of the Willamette River and from the Johnson Creek tributary.

5 IDENTIFICATION AND PROTECTION OF CULTURAL RESOURCES

As required by the AOC, a cultural resources evaluation was conducted for the Arkema NCTRA site. A summary of the evaluation results is provided here and the complete report (Ogle and Ellis 2012) can be found in Appendix E.

A comprehensive cultural resource analysis conducted previously for the Portland Harbor site (Ellis et al. 2005) designated the lower Willamette River, including the Arkema site, as a low-probability area for the occurrence of cultural resources. Willamette Cultural Resources Associates, Ltd. (WillametteCRA) conducted a site-specific follow-up study of the Arkema NCTRA site, which consisted of a records review and a site reconnaissance survey. The records review identified previous studies in the vicinity of the project area, but none of them occurred on the Arkema property. Archaeological sites reported in the vicinity have largely been destroyed or buried by modern development, and little evidence remains of prehistoric activity in the area. The Arkema property has been heavily altered from its original condition by years of industrial activity and the addition of artificial fill to extend the shoreline into the river channel.

WillametteCRA conducted a pedestrian survey of accessible shoreline of the Arkema NCTRA site (Appendix E, Figure 2); construction activities related to the stormwater SCMs and structural remains (e.g., concrete pads) precluded survey of the remainder of the Arkema property. The shoreline area in the southeastern and central portion of the survey is largely covered by steep fill material and modern fill debris. The northwestern portion consists of a flat sandy beach, and small sandy beaches are also located in the central area. No archaeological remains were identified during the survey. The sandy beaches would have a greatest potential to contain archaeological resources; however, these beaches are likely the result of very recent alluvium, which has buried the older shoreline. WillametteCRA (Ogle and Ellis 2012) indicated that it is unlikely that the Arkema NCTRA site contains intact archaeological deposits, and because of the degree of industrial development at the site, if cultural resources are present, they are unlikely to retain enough integrity to be eligible for listing on the National Register of Historic places.

Three docks are located on the Arkema NCTRA site (Dock 1, Dock 2, and the Salt Dock; Figure 1-5). Historical aerial photographs indicate the docks are 50 years old or older; however, given that similar docks are common on the lower Willamette River, that the two oldest docks (Dock 1 and Dock 2) have been modified over time, and that the docks lack significant historical association, WillametteCRA (Ogle and Ellis 2012) recommended that the docks are not eligible for listing in the National Register of Historic Places. No additional cultural resources investigations were recommended for the Arkema NCTRA.

Based on the results of the cultural resources analysis, the Arkema NCTRA is unlikely to affect cultural resources.

6 IDENTIFICATION AND EVALUATION OF REMOVAL ACTION TECHNOLOGIES

This section identifies and evaluates technologies to be considered for their applicability to the Arkema NTCRA. In accordance with EPA's guidance for remediation of contaminated sediments (USEPA 2005d), the evaluation contained herein considers a range of potentially applicable technologies and selected innovative technologies (e.g., *in situ* treatment). This evaluation is based on available site-specific information summarized in this report and considers applicable analyses and conclusions from the Portland Harbor draft FS (Anchor QEA et al. 2012). The evaluation focuses on demonstrated technologies appropriate for the size and conditions of the RAA, and the anticipated time frame for implementing the remedy. Generally, technologies that were screened and eliminated in the Portland Harbor draft FS are not discussed in this screening.

Removal action technologies considered for the Arkema NTCRA fall into the following general response action (GRA) categories:

- No Action
- Monitored Natural Recovery and Enhanced Natural Recovery
- Removal
- Containment
- Treatment
- Disposal
- Institutional Controls

Technologies within each GRA that are considered to be applicable for the Arkema NTCRA are briefly discussed and evaluated in the following subsections. Consistent with EPA guidance (USEPA 1993), the technologies are evaluated based on effectiveness, implementability, and cost. These criteria are discussed in greater detail in Section 7.

6.1 NO ACTION

The No Action GRA leaves the RAA in its current condition and assumes no further intervention will occur. As discussed in Section 2.1.3 above, the results of the BHHRA show potential cancer risks via consumption of large home range fish, which represent site-wide exposure, and via consumption of smallmouth bass, which represent 1-RM exposure, are already below the target risk level of 10^{-4} for total DDT, total DDD, and total DDE. Further, based on the draft FS (Table 2 in Appendix Da, Anchor QEA et al. 2012), both DDE and DDT

already meet their respective 10^{-5} target risk levels in the Portland Harbor on a site-wide basis. Accordingly, the results of this analysis conservatively indicate no further action is required to achieve 10^{-4} risk level goal for these constituents.

Although No Action would not achieve all the RAOs for the RAA, its consideration is required to serve as a basis for comparison for the removal alternatives retained for further analysis.

6.2 MONITORED NATURAL RECOVERY AND ENHANCED NATURAL RECOVERY

6.2.1 Description and Applicability

MNR is a risk management approach that identifies, quantifies, and relies upon natural environmental processes (e.g., natural deposition of cleaner sediments, bioturbation) to permanently reduce exposure and potential risks associated with contaminated sediments. Enhanced natural recovery (ENR) typically involves the placement of a thin layer of clean sand or sediments over areas with relatively low contaminant concentrations to speed up or enhance the natural recovery processes already demonstrated to be occurring at a site. The recovery of the system is controlled by physical, biological, and chemical processes (USEPA 2005a).

A review of site conditions and local fate and transport processes provides a characterization of the potential effectiveness of MNR as a remedy. As described further below, natural recovery will occur at the site as a result of deposition of cleaner sediments transported to the site from upriver. MNR and ENR technologies are potentially applicable in areas where COIs are present at depth as a result of natural recovery, in combination with other response actions, and/or in addressing thin deposits of residual contaminated sediments that may remain following a more intrusive remedy such as dredging (i.e., dredge residuals).

Lastly, natural recovery processes will occur at the site. Therefore, it is important to understand the mechanisms that drive these processes and the resulting effects of these processes on any remedy as these processes will be occurring regardless of which remedy is implemented.

6.2.2 Evaluation

Existing local and regional data provide an understanding of historical and ongoing fate and transport processes that may support natural recovery, where the dominant recovery process is expected to be burial. Sediment deposition rates, sediment contaminant profiles, measurements of sediment stability, and evaluations of ongoing sources and SCMs may be used to characterize a site's natural recovery processes (Magar et al. 2009).

The following presents a preliminary qualitative analysis of MNR potential at the Arkema site based in large part on the findings of the Portland Harbor MNR evaluation, as well as data specific to the RAA.

6.2.2.1 Sediment Surface and Subsurface Contaminant Concentrations

The vertical distribution of sediment contaminant concentrations at the Arkema site provides a strong line of evidence that substantial natural recovery has occurred since the time of contaminant release. Peak concentrations of COIs occur well below the sediment surface, with a declining COI concentration profile from the peak concentration at depth to the sediment surface. Eight sediment cores[25] collected in the vicinity of the RAA were used to assess DDx concentration profiles with depth. In these cores, the peak DDx concentrations were observed at depths ranging from approximately 2 to 10 ft bml. These findings indicate a long-term, depositional environment and an average local deposition rate of 3.3 cm/year in the RAA (Integral 2011). These results are consistent with the conclusions of the Portland Harbor MNR evaluation and with other lines of evidence discussed below. Significantly, nearshore sediment cores[26] also exhibit peak DDx contamination at depths greater than 2 ft, which provides evidence of deposition in nearshore shallow areas not fully evaluated by the Portland Harbor MNR evaluation, because the LWG did not have the ability to incorporate these recent site specific findings available to LSS.

Observations made using RAA sediment core DDx data are also consistent with temporal trends observed in RM 7 to 8 surficial sediments collected for the Portland Harbor RI and FS (Anchor QEA et al. 2012). Surficial sediments collected in this river segment west of the navigation channel from 1997 to 2007 exhibited decreasing DDE levels, indicating natural recovery via sedimentation has occurred for this contaminant over those years (Figure 6.2-17, Anchor QEA et al. 2012). These results also indicate an absence of significant ongoing sources of DDx from the Arkema site to this segment of the Willamette River.

6.2.2.2 Surface Sediment Grain Size

The grain size pattern of surficial sediments provides an indication of the river bed's energy regime and stability; low energy depositional environments tend to be dominated by fine-grained sediments such as silts and clays. Sampled areas with surficial grain size distribution of greater than 40 percent fines were categorized as having high potential for natural recovery in the Portland Harbor FS weight-of-evidence approach (Anchor QEA et al. 2012). Available grain size data for the RAA's surficial sediments (samples taken from the surface to a depth of up to 1 ft) had an average of 62 percent fines, which indicates the RAA is located in a low-energy environment where sediment deposition is favored. RAA nearshore and bank areas had lower

[25] Data for sediment cores WB-9, WB-36, WB-48, WB-50, WB-51, WB-52, WB-53, and WB-66 are presented in the final RAAC report (Integral and ARCADIS 2011).
[26] Includes boring locations WB-42, WB-46, WB-47, WB-52, WB-55, and WB-64 (Integral and ARCADIS 2011).

percentages of fines, suggesting that these areas may be subject to higher energy due to wave and wake action. As a result, natural recovery in these areas may be less effective without enhancement (Figure 2.1-3, Anchor QEA et al. 2012).

6.2.2.3 Bathymetric Survey Data

Several site-wide bathymetry surveys have been performed as part of the Portland Harbor RI. A comparison of 2002 and 2009 surveys characterizes bathymetric changes and allows for the calculation of corresponding sedimentation rates over the 7-year period (Anchor QEA et al. 2012). An average of the sedimentation rate for each AOPC is presented in the draft Portland Harbor FS (Figure 6.2-3, Anchor QEA et al. 2012); the average deposition rate in AOPC 14, of which the RAA is a part, was approximately 1.5 cm/yr (Figure 6.2-3, Anchor QEA et al. 2012).

6.2.2.4 Ongoing Sources

The extent to which sediment deposition supports MNR is controlled in part by ongoing sources that may contain elevated contaminant concentrations. Documentation of source control evaluations and measures is a primary line of evidence to be considered in sediment investigations (Magar et al. 2009). Potential sources of contaminants and their corresponding SCMs were evaluated for each AOPC as part of the Portland Harbor FS (Appendix Q, Anchor QEA et al. 2012).

Water column and sediment trap data were used to estimate incoming suspended sediment concentrations to the Portland Harbor site. Sediment from traps placed at RM 11 and 16 and particulates from water column samples collected during high and low flows were analyzed for total PCBs and DDE (Anchor QEA et al. 2012). The DDE concentrations in the sediment trap and particulate samples were generally comparable with the SWACs of each AOPC's surficial sediment, except for AOPCs 19, 14, and 9U, where SWACs were higher (Figure 6.2-7, Anchor QEA et al. 2012). AOPC 14 had the highest average surficial sediment DDE SWAC. Estimated total PCBs levels in suspended sediments were on average an order of magnitude lower than average surficial sediment concentrations for each Portland Harbor site AOPC (Figure 6.2-5, Anchor QEA et al. 2012). These data are largely from sampling points near the upstream boundary of the Portland Harbor site and may not accurately represent contaminant levels on incoming sediment particles to the RAA. However, the trends observed in these comparisons suggest that surficial sediment concentrations of DDx and PCBs would be expected to decrease with time in depositional areas barring the influx of other sources. Further, SCMs are expected to be implemented upstream of the Arkema site as part of the Portland Harbor remedial action and other cleanup activities. As a result, contaminant levels can be expected to decrease on incoming sediment particles to the RAA.

Bank erosion, groundwater discharge, and stormwater discharge have been identified as potential onsite sources of COIs from the Arkema site to the Willamette River (Appendix Q,

Anchor QEA et al. 2012). Historical upland activities, deposition of river sediments, and placement of dredge materials may have led to DDx, furans, and metals contamination in Arkema's riverbanks (Anchor QEA et al. 2012). Screening levels are exceeded for several contaminants in the banks between the site's docks. As noted previously, AOPC 14 is depositional. It is therefore reasonable to conclude that, because the bank soil tends to be coarse grained, transport of materials derived from bank erosion would be limited and likely confined to nearshore areas within the RAA. A screening evaluation of available data concluded the bank area between the site's docks is high-priority for measures to control bank erosion and is a potential pathway of DDx to the RAA (Appendix F). SCMs for this portion of the riverbank are therefore included in the alternatives developed for this EE/CA. The remainder of the riverbank will be addressed as part of the ongoing RI/FS for the upland Arkema property.

Groundwater containing VOCs, metals, furans, and DDx has been identified in the uplands portion of the site and extending to Area 1 of the RAA (Anchor QEA et al. 2012). An SCM to control this has been selected and includes a groundwater containment system, consisting of an upland bentonite barrier wall, a groundwater extraction system, and a multi-media *ex situ* physical, chemical, and biological groundwater treatment system. This groundwater SCM is scheduled to be constructed beginning in the summer of 2012 and be operational by 2013.

Stormwater discharge from the Arkema site has been identified as a potential source of DDx to the RAA. Levels of DDx in the stormwater discharge exceed screening levels for ambient water quality criteria (Appendix Q, Anchor QEA et al. 2012). Stormwater SCMs are in progress and include abandonment of the existing stormwater collection system, construction of a new stormwater conveyance system including a detention basin and sand filter, and soil capping, as well as BMPs. Construction of the stormwater collection and treatment system is underway and scheduled for completion in January 2013. The potential for recontamination of future remediated sediments following completion of the treatment system was evaluated and indicated minimal recontamination, with estimated sediment concentrations well below standards (Integral 2011).

6.2.2.5 Physical Conditions

The effectiveness and implementability of MNR and ENR will be influenced by wave action as well as vessel and dredging activity. Water velocity from vessel propellers, or "propwash", was evaluated for each AOPC as part of the Portland Harbor FS (Anchor QEA et al. 2012). Surveys of current vessel operations were used to estimate potential surface sediment mixing and scour depths due to propwash forces. AOPC 14 reported no vessel activity as its docks are currently inactive and propwash was assumed to not affect sediment stability in the RAA (Anchor QEA et al. 2012).

Wave erosion generated by wind and vessel wake could impede natural recovery in the RAA's nearshore area. A wave zone based upon surface sediment elevation was defined for the

Portland Harbor; the RAA's nearshore sediments are in this zone and could be disturbed by wave and wake action (Figure 5.4-1c, Anchor QEA et al. 2012). Also, maintenance dredging activities could disrupt natural recovery in AOPC 14, as future maintenance dredge areas were identified at the eastern end of Arkema's docks; however, these areas are outside of the RAA (Figure 5.4-1c, Anchor QEA et al. 2012).

6.2.2.6 Conclusions

A qualitative assessment of site-specific data and review of the draft Portland Harbor FS MNR evaluation indicate that natural recovery is occurring in AOPC 14 and, specifically, within the RAA. Multiple lines of evidence indicate that the RAA is depositional and declining surficial sediment DDx concentrations demonstrate that natural recovery is occurring in this segment of the Willamette River. A review of potential ongoing sources and pending SCMs indicates upstream sediment input is expected to continue to improve in quality, providing sediments suitable for natural recovery.

Based on the preliminary analysis presented herein, MNR is a viable approach for addressing portions of the RAA—particularly those areas where deposition is occurring and surface sediment concentrations are below RALs. ENR potentially could also be implemented in higher concentration areas of the RAA where natural recovery is known to be occurring. Thin layer placement of suitable sand could provide immediate benefits in risk reduction and speed up the natural recovery process. Further, the added sand could be amended with active materials (e.g., granular activated carbon [GAC]) to bind potentially mobile contaminants, if necessary.

MNR and ENR are potentially effective, implementable, and cost effective; and are retained for assembly into removal action alternatives. These technologies will become increasingly effective as additional upstream SCMs are implemented.

6.3 REMOVAL

6.3.1 Description and Applicability

As a general response action, removal refers to technologies for the physical excavation of material from the waterway. The excavated material would then need to be handled through disposal technologies. As it applies to the Arkema NTCRA, removal technologies could be used to satisfy a range of potential design objectives:

- **Minimizing changes to shallow, nearshore riparian habitat**. This objective could apply to the nearshore area where capping without prior removal would raise shallow, riparian habitat elevations.

- **Accommodating outfall drainage**. This objective applies to the immediate area adjacent to the existing outfalls and associated diffuser structures, where capping without prior removal may obstruct the flow of water.
- **Removing material with the highest concentrations of contaminants**. This objective could apply to the area between Docks 1 and 2, where total DDx concentrations in sediments are comparatively high.
- **Removing all contaminated material and leaving a clean surface**. As discussed in Section 7, this objective was considered for applicability throughout the RAA. However, site limitations (including slope stability, outfall protection, and depth of contamination) limit the feasibility of complete removal of all contaminated material throughout the RAA. Complete removal would also require extensive backfilling to return the site to original grades to minimize changes to habitat. Furthermore, following implementation of SCMs, extensive removal of minimally impacted sediments extending to depths beyond 10 to 15 ft bml would not present significant reduction in risk relative to more shallow removal and/or containment.

With the exception of the No Action alternative, the assembled alternatives incorporate varying degrees of removal combined with other general response actions. Alternatives that satisfy the RAOs and are protective of human health and the environment may not necessarily incorporate all of the removal objectives described above.

Removal technologies for the RAA can be implemented using two general construction technologies:

- Construction "in-the-dry," typically using land-based construction equipment from the upland side of the site (referred to as "excavation" for the purposes of this EE/CA)
- In-water construction, typically using floating equipment (referred to as "dredging" for the purposes of this EE/CA).

Generally, excavation will be used as practicable, within the range of available water elevations during the construction time frame. Excavation will generally be used on embankments and elevations above approximately 5 ft NAVD88, which is defined as ordinary low water (OLW) for consistency with the draft Portland Harbor FS (Anchor QEA et al. 2012). Dredging will be used throughout the remainder of the RAA where conventional excavation techniques become technically impracticable. These two construction technologies are discussed in the following subsections.

6.3.2 Excavation

Excavation would be accomplished with typical earthmoving equipment and would generally occur in-the-dry, during periods of low-water conditions. Excavation would be used on the

riverbank (above elevation +13 ft NAVD88) and potentially extend to portions of the sediment RAA above approximately 5 ft NAVD88 (OLW). (The ability to excavate at and near the toe of the riverbank depends on the bottom elevation of the cut, which varies among the alternatives discussed in Section 7.) Completing excavations from the land (and in-the-dry or with minimal inundation) provides several advantages as compared to working in the water:

- Operators can see the work area and accurately place the bucket to ensure complete removal to the design limits.
- Operators and oversight staff can see the excavated face and adjust the depth of excavation based on observed conditions.
- Material is maintained and removed in a relatively intact state, reducing the potential for creating a liquefied mix of sediment and water that can be difficult to capture in the excavator bucket.
- The potential for offsite transport in the water column is minimized, as minimal impacted material enters the water column.
- Some construction could potentially be completed in-the-dry during periods when in-water work is prohibited due to ecological or other considerations.

In some cases, the ability to work completely in-the-dry would be limited by the practical ability to time the available low-water periods within the construction window. The design may identify certain areas where excavation in-the-dry is required. In other areas, working in-the-dry would not be an absolute requirement but would be identified as a preferred method to be implemented as practicable. The contractor would propose detailed work schedules and methods in its work plan, which would require approval by EPA.

Allowable in-water construction windows will be determined by EPA in consultation with NOAA Fisheries, U.S. Fish and Wildlife Service, Oregon Department of Fish and Wildlife, and Tribes. EPA may allow excavation below ordinary high water outside the established in-water construction window if the work is effectively completed in-the-dry while water levels are generally low.

Excavation would be completed with typical earthmoving equipment (e.g., excavators, front-end loaders, and dump trucks). Specially equipped long-reach excavators and low-ground pressure equipment may be appropriate to access lower elevation areas. Excavated material would be placed in properly lined trucks and transported onsite or over city streets to selected disposal or intermodal transfer facilities. Alternatively, excavated material could be loaded onto haul barges, as described for dredging in the following subsection.

6.3.3 Dredging

For mechanical dredging, a barge-mounted excavator or derrick would use a bucket to remove material from the bed and place it into a haul barge. The dredged material would be dewatered on the haul barge using BMPs, such as sideboards for bulk containment and filter fabric and drainage systems to limit turbidity releases to the waterway, so as to maintain compliance with the water quality criteria established for the project. The dredged material would be moved in the haul barge to a waterfront location for offloading, possible additional dewatering, and transport to a selected disposal or intermodal transfer facility.

Conventional dredging methods advance each dredge cut at a constant dredge elevation within a discrete area. Dredging of sloped areas is normally completed with a series of stair-step cuts. The removal of a sloping layer is thus achieved by completing a series of horizontal bench cuts into the slope. The actual dredging pattern for slopes would be established by the selected removal action contractor to match the capabilities of the dredging equipment. Mechanical dredging technology process options include conventional clamshell buckets, environmental dredge buckets, and articulated, hydraulic arm dredges. All process options are retained in this EE/CA for use, as needed, during construction to achieve the remedial objectives by the removal action design.

Hydraulic dredging is not considered practicable for this removal action because of the presence of debris, the significant volume of water generated by the method and the relatively small size of the project. If hydraulic dredging were used, a comparatively large processing site would have to be developed nearby to dewater the dredge spoils before transporting the solids to a selected disposal or intermodal transfer facility. Development of a processing site would pose implementability concerns and substantially raise costs. Additionally, the presence of significant debris at the RAA would certainly impede and/or damage the dredge, reducing efficiency, resuspending more material into the water column, and generating greater amounts of process water. This would increase costs, extend schedules, and require adjunct mechanical dredging to remove the debris.

6.3.4 Removal Best Management Practices

Short-term water quality impacts and residuals generation have the potential to occur during removal construction activities. These construction impacts can be mitigated to some degree using operational and barrier control BMPs. The following sections provide an overview of the range of water quality and dredge residual BMPs that have been implemented for environmental dredging projects both regionally and nationally, and discuss the potential applicability of these BMPs for the RAA.

While it is appropriate to identify and evaluate potentially applicable BMPs in this EE/CA, the final selection and design of BMPs for the Arkema removal action will occur during the design

and implementation phases of the cleanup, based on anticipated water quality performance criteria to be set forth in the Section 401 water quality certification. It is also important to recognize that regardless of the selected BMPs, a certain degree of sediment resuspension and loss from the RAA may be expected to occur during sediment removal. Accordingly, the BMP strategy needs to anticipate any such losses and include appropriate monitoring and response actions.

6.3.4.1 Operational Controls

Operational controls involve the implementation of constraints on the operation of the equipment to reduce the potential for resuspension and loss of contaminated sediments during dredging and other in-water construction activities. For environmental mechanical dredging, the representative process option considered to be appropriate for this EE/CA entails typical operational control BMPs including, but not limited to, the following:

- Removal of known surface and shallow debris prior to dredging
- Use of appropriate dredge buckets to accommodate anticipated site conditions (e.g., soft sediment, debris, hard digging, etc.) while reducing any sediment resuspension to the extent practicable
- Maintaining stable dredge cut slopes by specifying shallow top to bottom cuts and preventing deep box cuts
- Control of depth of cut to prevent over excavation and the possible release of residuals by overfilling
- Controlling the rate of dredge bucket descent and retrieval
- Limiting operations during relatively high water velocity conditions
- Preventing "sweeping" of bottom sediments with the dredge bucket to achieve specified dredge grades
- Preventing stockpiling of dredge material on the river bottom
- Preventing overfilling of dredge buckets through continuous observation
- Requiring the slow release of excess bucket water at the water surface
- Preventing over-filling of barges to minimize spillage from barges
- Separating sediment solids from barge return water through filtration.

While the effectiveness of operational controls in improving water quality can be difficult to assess (USACE 2008a, 2008b), several regional projects have demonstrated the effectiveness of specific operational controls (Anchor and Windward 2005; Foth and Van Dyke 2001; Anchor QEA 2009). For example, the Phase 1 Removal Action at Terminal 4 used a series of operational controls that were modified in response to water quality monitoring results, effectively

controlling turbidity without the use of engineered barrier controls. Another recent example, implemented by Arkema, is the Head of the Hylebos Waterway in Tacoma, Washington. This project removed approximately 500,000 cy of sediments using mechanical dredging technologies, and successfully satisfied water quality standards through use of a similar suite of operational BMPs (Webb and Fugelvand 2007). Similarly, for the recently completed Slip 4 Early Action in the Lower Duwamish Water, the contractor developed an innovative method to capture and filter decant water during gravity dewatering from its material barge, significantly reducing the amount suspended sediment discharged back to the waterway (Integral 2012).

In selecting operational controls, it is important to consider the potential impacts such controls could have on dredge production rates and the overall project duration (USACE 2008a). Further, site-specific conditions must be considered in selecting removal BMPs. Low water conditions typically occur during the in-water work period (July 1 through October 31). This in-water work period is characterized by lower river discharge and lower velocities, as well as by tidal-induced flow effects, including current reversal and associated slack water conditions. The low-flow conditions and tidal effects coinciding with the in-water work period are advantageous in reducing the potential for generation and migration of suspended particulates during dredging.

6.3.4.2 Barrier Controls

Engineered barrier controls that have been used for environmental dredging and capping projects include silt curtains/silt screens and rigid containment (e.g., sheetpiles or cofferdams) (USACE 2008a). A summary of project experience and advantages and disadvantages related to these engineered controls is discussed in the following section. A comprehensive evaluation of these engineered controls is also presented in the draft Portland Harbor FS (Anchor QEA et al. 2012).

Silt Curtains/Screens

Silt curtains can be effective in reducing surface water turbidity and retaining suspended sediment in relatively quiescent, low-energy environments (Francingues and Palermo 2005). However, their application in moderate- or high-energy settings can be difficult, often requiring extensive structural reinforcement and frequent repair and maintenance. In addition, it is not possible to completely contain turbid water within such systems, as they cannot be reliably sealed to the river bottom due to structural and hydraulic constraints. Water also discharges around the curtains when they are opened to allow the necessary passage of work equipment. Based on studies conducted by the U.S. Army Corps of Engineers (USACE) (Bridges et al. 2010) and Alcoa (Connolly et al. 2007), there is considerable uncertainty as to whether silt curtains are effective in retaining contaminants within the curtain footprint during dredging, and contaminants may also be released upon removal of the curtain. In addition, concentrated flow beneath silt curtains can result in localized scour and downstream sediment transport and water quality impacts.

Silt curtain implementability concerns have also been documented on several projects, including the Lower Grasse River (Connolly et al. 2007), San Jacinto River (Anchor QEA 2011) and other environmental dredging projects (USEPA 2005a). Silt curtain use during sediment removal on the upper Trenton Channel in the Detroit River (Erickson et al. 2007) reportedly worked well for depths up to 27 ft in currents of approximately 2.4 ft per second, but this system required extensive structural reinforcement using pilings placed at 10-ft intervals along the curtain alignment. Implementability concerns are exacerbated in deeper water, such as conditions across much of the RAA, because deeper curtains can act as a bigger "sail" during high river velocity conditions, which can be extremely difficult to effectively anchor. In the event of unintended movement, the displaced curtains can also become a hazard to navigation, can block access to the work area, and need to be repositioned or re-anchored. As a result, the use of silt curtains can significantly reduce overall dredge production rates and prolong the duration of the project.

Because of the extensive structural elements that would be required, it is anticipated that the effort to install a silt curtain at the RAA would utilize a significant portion of the available in-water construction work window, thus extending the duration of the project to two or more construction seasons. Accordingly, the silt curtain system would need to be designed to accommodate both summer low-flow conditions and spring high-flow conditions.

Rigid Containment

Rigid containment barriers (e.g., sheetpiles or cofferdams) have been used to contain resuspended sediment during environmental dredging operations in high-energy environments. While several case studies have demonstrated reductions of dredging-related releases outside of the sheetpile-enclosed area, release of contaminants beyond the barrier still occurs in practice as it not possible construct a completely water-tight barrier. For example, during the Hudson River Phase 1 environmental dredging project, it was estimated that roughly 1 percent of the contaminant mass in the dredged sediment was released through the barrier, largely due to leakage through ports at the interlocks (Anchor QEA and ARCADIS 2010).

The variable geologic and debris conditions that occur at the RAA, along with dynamic river forces, may pose similar technological challenges that could lead to separation of the barrier interlocks. Further, required barrier design features to accommodate hydraulic forces (e.g., pressure equalization ports) would also allow release of resuspended sediment.

In high-energy environments, the use of rigid containment barriers can also have unintended and undesirable environmental consequences. For example, relatively deep scour of sediments outside of sheetpile enclosures can easily occur in mid- to high-energy environments. Such scour can lead to potential water and sediment quality impacts, and the loss of lateral support at the toe of the sheetpile can result in instability and possible failure of the enclosure. Because these types of unintended consequences result from localized flow conditions that are transient

in nature, they can be difficult to predict and can occur at any time during or after installation of the containment structure. Another potential undesirable consequence associated with rigid containment structures is the accumulation and concentration of dissolved-phase contaminants in the water column within the structure (Anchor QEA and ARCADIS 2010). Removal of rigid barriers can also have undesirable consequences, as sediment adhering to the piling can be resuspended into the water column during pile pulling, resulting in potential impacts to adjacent and downstream areas.

As part of the Gasco Early Action, Anchor (2005) reported that sheetpiles 1) would lead to penetration of contamination along the wall configuration to much deeper depths and leave stranded contamination following removal of the sheetpiles; 2) would greatly increase the construction duration and related impacts; 3) would not lead to the complete containment of nonaqueous-phase liquid and dissolved contaminant releases from the containment area; 4) would temporarily impound a large volume of water in which construction activities could create substantially concentrated contaminant loads, which could cause adverse impacts upon release when containment is removed; and 5) would potentially create health and safety risks for construction workers.

An assessment of sediment thickness, depth to bedrock and water level conditions for the RAA indicate a cantilevered rigid barrier would require king piles embedded in the bedrock underlying the sediment to provide the lateral support for low-water conditions over the summer and fall in-water work window. However, construction of a rigid containment system at the RAA would extend the overall duration of the project to multiple construction seasons, necessitating design for high-water conditions through the winter flood and spring freshet seasons. A cantilevered wall system is technically impracticable during these seasons due to the high water and flow conditions that occur at the depths needed to contain the removal area and accommodate equipment operations. As a result, a far more extensive containment barrier foundation, such as a cellular cofferdam structure, would be required. However, such a system is not technically practicable for this site

Summary

In summary, there would be limited if any water quality benefit from deploying barrier controls, particularly in light of their implementability constraints and disproportionate impacts on the project schedule and cost. As described above, the final selection and design of BMPs for the Arkema removal action will occur during the design and implementation phases of the project, based on water quality performance criteria set forth in the Section 401 water quality certification. In this EE/CA, mitigation of potential water quality impacts is included through use of operational control BMPs, which are accounted for in cost development through adjustment of dredging unit rates.

6.3.5 Evaluation

Excavation and mechanical dredging technologies are effective, implementable, and cost-effective, and are retained as components of active remediation alternatives. Mechanical dredging is favored over hydraulic dredging at the RAA for the following reasons:

- **Disposal.** Mechanical dredging is best suited to landfill disposal because it avoids the addition of large volumes of water associated with hydraulic dredging.
- **Debris.** A mechanical dredge is more capable of handling the variety of debris known to be present at the RAA, especially when compared to a small (8- to 10-inch pipeline) hydraulic dredge that might be used for a project the size of the Arkema NTRCA.
- **Water Management.** Mechanical dredging generates much less water than hydraulic dredging. The size of the upland facility and infrastructure required to manage the water associated with even a small hydraulic dredge would be considerable, and the local sewer system may not be able to handle the dewatering process water.
- **Equipment Availability.** Mechanical dredging is completed with common marine/upland construction equipment, while hydraulic dredging requires dedicated, specialized equipment. There are more equipment options and a greater number of local contractors who are experienced with mechanical dredging.

Hydraulic dredging is rejected based on limited effectiveness in the presence of debris, and implementability and cost concerns associated with the required upland dewatering facility. Diver-operated hydraulic dredging is not considered practicable for this project due to these same concerns, in addition to concerns over the substantially increased risk to workers during the cleanup.

As part of the design process, BMPs will be defined to reduce the potential for sediment resuspension and water quality impacts during dredging to ensure compliance with the anticipated water quality certification threshold criteria. The selected contractor will be required to include BMPs in their remedial action work plan submitted to EPA for review and approval.

6.4 CONTAINMENT

Containment is in-place physical isolation or immobilization of contaminants in sediment through *in situ* capping. Although certain technical guidance (Averett et al. 1990; USACE 1998) include aquatic disposal and confined disposal facilities (CDFs) in the containment category, these are discussed as disposal alternatives in this document.

Capping is an applicable containment technology for the RAA. Conventional sand caps and armored caps are applicable, and would be designed according to site-specific conditions using established EPA and USACE design procedures (USACE 1998).

Active, or reactive, cap technologies are specialty capping technologies that are typically applied for unique site conditions (such as presence of nonaqueous-phase liquid or high concentrations of highly soluble contaminants). As part of the draft Portland Harbor FS (Anchor QEA et al. 2012), a site-wide, screening level evaluation was performed to evaluate the contaminant mobility through sediment caps. This evaluation indicated that an active cap may be needed over the RAA to meet performance criteria due to the presence of highly mobile contaminants (chlorobenzene) at elevated concentrations in a groundwater plume. The site-wide evaluation assumed reduced groundwater Darcy velocities, representative of post-construction of the groundwater barrier wall and extraction system on the Arkema site. However, the evaluation did not consider the reduction in mass flux and concentrations that will occur following installation of the barrier wall and extraction system; rather the evaluation was based on the highest observed contaminant concentrations in TZW samples collected from across the Arkema site prior to groundwater SCM implementation. This assumption is inappropriate. An overly conservative comparison (ignoring water column mixing) indicates TZW contaminant concentrations were below water quality criteria for the majority of the sample locations at the Arkema site. Further, considerable temporal and spatial (both lateral and vertical) variation was observed in TZW contaminant concentrations. For example, at location AP04D, chlorobenzene concentrations measured two months apart varied by 3 orders of magnitude (Integral et al. 2011). At location AP03ATR, shallow chlorobenzene concentrations were an order of magnitude lower than the concentrations observed at depth. The potential for reductions in contaminant concentrations following implementation of the barrier wall and the observed variation in the available data warrant careful re-consideration in determining the design characteristics and extent of a cap required to achieve the remedial goals. The necessity for an active cap configuration for containment of site sediments can be evaluated as part of the removal action design, based on consideration of results from the performance monitoring program to be conducted following implementation of the groundwater SCM and other pre-design investigations that may be conducted, as needed.

Cap material for the Arkema NTCRA would be obtained from established borrow sources. Consistent with CWA Section 404 requirements, the capping material would be evaluated to verify that it is of suitable quality and appropriate for in-water use. The evaluation would include consideration of physical and chemical properties of the material, as appropriate. All cap materials would have chemical concentrations below RALs.

Armoring requirements would also be determined in design. Armored caps are required where erosive forces (i.e., shear stresses) on cap particles would be sufficient to move typical sand cap particles. Areas of the RAA with erosive forces that may require armoring include:

- Bank caps where even minor wave action on steep slopes creates high shear stresses. (Armoring may also be required on the banks to improve overall stability of the existing slopes.)
- Areas near vessel operations, where propeller-wash flows across the cap surface.
- Areas immediately adjacent to the outfalls.

As described for removal technologies, caps can be placed using land-based or waterway-based equipment. Capping of banks and nearshore sediments (above approximately +5 ft NAVD88) would likely be completed with land-based earthmoving equipment (e.g., excavators, front-end loaders, and dump trucks). Suitable capping material would be imported to the site in dump trucks and/or on barges, and then placed as engineered fill over the soil and sediment. Placement of cap material in-the-dry allows equipment operators to see where the capping material is being placed to ensure that the required coverage and material thickness is achieved. However, use of barge-mounted equipment may be more practicable for some bank/nearshore areas due to site constraints (e.g., access); and numerous contractors in the region are experienced in the successful placement of caps on banks and in waterways using this approach.

In areas below +5 ft NAVD88 (the majority of the area within the RAA), capping would be accomplished with floating equipment similar to that used for mechanical dredging. A dredge would use a bucket to collect capping material from a haul barge and would spread the material on the bed of the waterway. In some areas, the positioning of floating equipment may be limited by water depths. Minimum drafts typically range from 5 to 15 ft depending on specific equipment.

6.4.1 Evaluation

Conventional sand caps and armored caps are effective, implementable, and cost-effective, and these are retained as components of active remediation alternatives. Active caps have also been determined to be effective, implementable, and cost-effective, and these are also retained. Different cap materials and configurations may be needed in different areas. As stated above, the final configuration of the cap (including thicknesses and materials) will be established in the removal design. In this EE/CA, the estimated cost for sediment caps is based on a conventional 1 ft filter layer amended with 2.5 percent (by mass) GAC. This is intended to conservatively represent a range of potential cap configurations (conventional to active).

6.5 TREATMENT

Treatment is the application of chemical or biological methods for reducing contaminant concentrations, mobility, or toxicity. This section provides a screening of treatment technologies which are potentially applicable to the Arkema NTCRA.

6.5.1 *In Situ* Treatment

The direct application or placement of sorbent amendments (e.g., GAC) is an *in situ* treatment technology that has been successfully demonstrated to reduce the bioavailability of contaminants, including PCBs, PAHs, dioxin/furans, DDx, and mercury (Ghosh 2011). The draft Portland Harbor FS (Anchor QEA et al. 2012) incorporates direct broadcasting of GAC as a representative process option for *in situ* technologies and retained, for future consideration, the broad range of other process options and reagents for potential evaluation during remedial design. Based on the evaluation for Portland Harbor, *in situ* treatment is retained, both as a stand-alone measure and in concert with other technologies (e.g., active capping or ENR) for potential consideration during remedial design, or as a potential contingency measure that may be employed following implementation (e.g., as part of a maintenance and monitoring program).

6.5.2 *Ex Situ* Treatment

Ex situ treatment refers to steps taken to reduce the toxicity, mobility, or volume of contamination after removal has occurred. The draft Portland Harbor FS summarizes a multi-year process conducted to evaluate and screen *ex situ* treatment of sediments for applicability to the Portland Harbor site (Anchor QEA et al. 2012). In conclusion, the draft FS retained stabilization and solidification for use as a potential method to reduce leaching of contaminants and as a treatment method to reduce sediment water content. Based on the extensive evaluation of *ex situ* treatment presented in Anchor QEA et al. (2012), this EE/CA retains stabilization and solidification as a technology to be considered during design and/or implementation as a measure to reduce sediment water content, as may be required to facilitate handling and/or transport.

6.6 DREDGE MATERIAL DISPOSAL

Disposal of excavated or dredged material could potentially occur either at established and permitted offsite facilities or at a constructed onsite disposal facility.

6.6.1 Offsite Disposal

Existing sampling information indicates the excavated and dredged material would be suitable for placement in a Resource Conservation and Recovery Act (RCRA) Subtitle D solid waste landfill. Transportation of excavated/dredged material to the landfill would be by truck, rail, barge or some combination depending on the selected landfill and removal action alternative. Additional information on the methods of transportation will be developed during design, but the final selection will be made during implementation, based on the contractor's specific construction approach. To the extent that truck transport is used, hauling of material from the

removal area to the disposal site would result in some increased truck traffic on NW Front Avenue and other arterial streets. During design, one or more transloading facilities will be identified based on their status at that time, including potential establishment of a facility at the Arkema site. Dredged material could be delivered to the identified sediment offloading facility via barge, while upland excavated material could be transported by barge, truck, or rail to a transfer facility operated by a landfill.

Disposal sites must be evaluated and approved by EPA before they are selected to receive materials originating from CERCLA sites. EPA's review includes assessing the site's compliance with RCRA permits and governing regulations. This agency evaluation of any proposed landfill disposal site will be consistent with the Off-Site Rule (40 CFR 200.440). This rule is intended to avoid having CERCLA waste contribute to present or future environmental problems by directing these wastes to sites determined to be environmentally sound. The Columbia Ridge Landfill near Arlington, Oregon, has established services to receive dredged sediment. This site is licensed as a Subtitle D (RCRA) commercial landfill, and has the ability to receive wet dredged sediment delivered to the landfill by rail. Waste Management Inc. operates the Columbia Ridge Landfill. In 2004, Waste Management completed significant upgrades at the landfill to allow offloading of rail cars loaded with soil and dredged material. This facility has been selected as a representative potential offsite disposal location for this EE/CA. All upland Subtitle D facilities identified by the draft Portland Harbor FS (Anchor QEA et al. 2012) are likely to be equally effective and have similar costs to this representative facility.

Disposal of excavated and dredged material in permitted RCRA Subtitle D landfills meets all state and federal requirements and uses reliable and demonstrated technologies. It is readily implemented and minimizes the amount of upland area and time required for material handling and loading. Offsite disposal at permitted landfills is considered effective, implementable, and cost-effective for RAA sediment.

6.6.2 Onsite Disposal

Onsite disposal involves consolidating the removed material in a containment cell constructed within the project boundaries. The draft Portland Harbor FS identifies several onsite disposal technologies as potentially applicable for site sediments (Anchor QEA et al. 2012). Upland onsite disposal involves placing removed material into a lined and capped embankment constructed away from the shoreline. In-water onsite disposal involves placing dredged material into a cell constructed in the aquatic environment. One example of in-water disposal involves placing dredged material into a submerged pit, which is then covered by a cap, referred to as confined aquatic disposal (CAD). Another example of in-water disposal involves placing dredged material into a permeable diked cell or impermeable sheet pile cofferdam cell extending from the shoreline that is then capped to create new uplands. This is referred to as a CDF or a nearshore CDF.

Implementation of onsite disposal technologies normally requires extensive site evaluations and design studies. Issues to be addressed include contamination transport and containment, long-term stability, land-use regulations, comparison to alternate technologies, and public acceptance. Development of an onsite disposal facility would require evaluations, design, permitting, and construction. At the Arkema site, a CAD is less practical than a CDF due to existing physical constraints (e.g., existing bathymetry) and potential impacts to the waterway. However, a nearshore CDF is effective, implementable, and potentially cost-effective for the Arkema NTCRA and is retained. The development of a nearshore CDF is potentially cost-effective for large volumes of disposed material, or in cases where constructing the facility could provide other benefits such as the creation of new industrial uplands or new habitat. Construction of a nearshore CDF may require mitigation under CWA Section 404. A nearshore CDF is retained for consideration in development of Arkema NTCRA alternatives.

The screening evaluation conducted in support of the draft Portland Habor FS (Anchor QEA et al. 2012) concluded three potential CDFs and one CAD, including the CDF proposed for the Arkema site, were effective and implementable disposal options, and were retained for development of FS alternatives. The potential CDF and CAD facilities at locations other than the Arkema site, including Swan Island and Terminal 4, are retained in this EE/CA as potential disposal options, to be considered further during design.

6.7 INSTITUTIONAL CONTROLS

The term "institutional controls" refers to non-engineering measures intended to ensure the protectiveness of the remedy and to affect human activities and ecological receptors in such a way as to prevent or reduce the potential for exposure to contaminated media (USEPA 2000). These controls may include elements such as fish consumption advisories, land use restrictions including easements or covenants, waterway use restrictions, or similar measures. Much of the information in this section is summarized from EPA guidance (USEPA 2000, 2003, 2004, and 2005b).

Institutional controls can play an important role when a cleanup is conducted and when it is too difficult or too costly to remove all contamination from a site (USEPA 2000). Institutional controls are rarely used alone to deal with contamination at a site. Typically, institutional controls are part of a larger cleanup solution and serve as a non-engineered layer of protection. Institutional controls are designed to keep people from using the site in a way that is not safe, thus, potentially jeopardizing protection of people and the environment. Institutional controls are normally used when some amount of contamination remains onsite as part of a cleanup remedy and when there is a limit to the activities that can safely take place at the site (i.e., the site cannot support unlimited use and unrestricted exposure). Institutional controls are also used to preserve the long-term protectiveness of the remedy.

According to EPA (2005c), institutional controls are generally divided into four categories:

- **Government Controls**—local laws or permits (e.g., county zoning, building permits)
- **Proprietary Controls**—property use restrictions based on private property law (e.g., easements and covenants)
- **Enforcement Tools**—documents that require individuals or companies to conduct or prohibit specific actions (e.g., environmental cleanup consent decrees, unilateral orders, or permits)
- **Informational Devices**—deed notices or public advisories that alert and educate people about a site.

The use of institutional controls at EPA cleanup sites is further described in EPA guidance (USEPA 2005b, 2004, 2000, 1999).

Institutional controls, by themselves, would not be protective of the environment or satisfy the RAOs for the RAA. Institutional controls are potentially applicable and are retained as potential components of alternatives that also include active cleanup. For example, on privately owned lands, restrictive covenants (a form of Proprietary Controls) can be effective in maintaining the long-term integrity of capping or other containment actions. For the purposes of this EE/CA, such Proprietary Controls are referred to as "land use restrictions."

Institutional controls are effective, implementable, and cost-effective, and are retained as a potential component of active remediation alternatives.

7 IDENTIFICATION AND ANALYSIS OF REMOVAL ACTION ALTERNATIVES

This section presents the removal alternatives identified for the RAA and evaluates each with regard to the following criteria (USEPA 1993):

- Effectiveness
  - Overall protection of human health and the environment
  - Achievement of RAOs
  - Compliance with ARARs
  - Reduction of toxicity, mobility, or volume through treatment
  - Short-term effectiveness
  - Long-term effectiveness and permanence
- Implementability
  - Technical feasibility
  - Availability
  - Administrative feasibility
- Cost
  - Capital cost
  - Present worth of long-term monitoring and maintenance
  - Total present-worth cost.

7.1 BASIS FOR REMOVAL ACTION ALTERNATIVE DEVELOPMENT

In Section 6, technologies within the general response action categories of MNR/ENR, Removal, Containment, Disposal, and Institutional Controls, were determined to be potentially applicable to the Arkema NTCRA. Consistent with the draft Portland Harbor FS (Anchor QEA et al. 2012), these technologies have been assembled into a set of removal alternatives that range from an emphasis on in-place containment to an emphasis on removal.

Key considerations were identified in developing the removal alternatives, including the following:

- Physical features such as outfalls, docks, and existing bathymetry:
  - One or more of the existing docks within the RAA footprint may be removed as part of the removal action. Dock 1 will likely be removed; however, Dock 2 may be retained to support both potential onsite transloading of dredged material during the removal action and to accommodate long-term site uses. For the purposes of estimating costs, it has been assumed both docks will be removed, with the understanding that additional costs associated with conducting removal actions in and around structures would be roughly equivalent to costs associated with dock demolition and disposal. A final decision regarding the use of the docks will be determined as part of removal action design.
  - Each of the existing outfalls will be protected from activities associated with the removal action to allow potential reactivation following implementation of the final upland remedy.
- Substantive requirements of CWA Section 404, including a goal of no net loss of aquatic habitat.
- Slope and structural stability considerations.
- The majority of the COI mass in sediments is co-located spatially (particularly for DDx and furans), although the depth of contamination can vary between COIs.
- The contaminant distribution can be delineated into two general areas within the EPA-directed RAA:
  - **Area 1.** The first area is generally between Docks 1 and 2 (Figure 3-1), and is defined by a relatively contiguous area of sediment impacts that exceed the DDT and DDE RALs at any depth, and a few isolated "islands" where COIs were detected predominantly at depth. In general, the highest concentrations of DDx, furans, and some other EPA-directed COIs occur within the footprint of contiguous sediment impacts of Area 1, and this area encompasses the estimated extent of sediments that exceed the RAL for 2,3,4,7,8-PCDF. Area 1 corresponds to the area where the majority of COI mass resides both in surface sediments and at depth; as a result, removal alternatives that focus on Area 1 result in considerable mass removal and/or isolation beneath an engineered cap.
  - **Area 2.** The second area consists of relatively isolated islands of sediment downstream of Dock 2 characterized by sporadic and low DDx concentrations at depth. DDx concentrations are not above RALs in surface sediments in this area, and the other EPA-directed COIs are generally not elevated in this portion of the RAA. Because DDx is largely buried by natural sediments in these areas and available data indicate the site is depositional, Area 2 is amenable to MNR/ENR.
- Because several of the EPA-directed COIs, such as DDx and furans, occur at locally elevated concentrations within the RAA (predominantly in Area 1), all of the removal

alternatives (except no action) result in a substantial reduction in the SWAC. For certain constituents (e.g., DDT and DDD), the post-removal action SWAC is predicted to be below 10^{-5} risk level PRGs.

- The upland barrier wall and groundwater recovery system will prevent substantive migration of groundwater contaminants from upland areas to site sediments, as well as greatly reduce or eliminate the rate and extent of discharge of groundwater to Area 1 (which is located downgradient of the barrier and recovery system). As a result, advective transport of dissolved-phase contaminants from any contaminated sediments that are left in place in this area will be minimal.
- Although groundwater discharge will not be substantially affected by the groundwater SCM for the portion of the RAA that is downriver of Dock 2 (including Area 2), this area is not downgradient of impacted groundwater at the Arkema site. Further, the sediment contamination in these areas is generally limited to low concentration DDx isomers which are characterized by very low aqueous mobility and, therefore, not mobilized by discharging groundwater.

As is discussed in the following sections, five primary alternatives have been developed for the RAA based on the RAOs identified in Section 3 and the technologies that were carried forward from the initial screening of technologies in Section 6. Each of the alternatives addresses the approximately 6.6-acre RAA directed by the EPA and defined in Section 3. Three of the alternatives include both an "integrated" option (denoted by an "i") that combines MNR/ENR with other active removal technologies, and a "removal" option (denoted by an "r"). This general approach and nomenclature is consistent with the draft Portland Harbor FS. The integrated option incorporates MNR/ENR within a maintenance and monitoring framework to address areas within the EPA-directed RAA where surface sediment concentrations are currently below RALs.

7.2 EVALUATION OF REMOVAL ACTION ALTERNATIVES

The following alternatives have been identified for the RAA and are evaluated in the subsections below:

- **Alternative 1** is No Action.
- **Alternative 2(i) Dredge to Facilitate a Cap and Optimized MNR –** Alternative 2(i) integrates a containment approach by capping and also utilizing MNR. Under this alternative, sediments within the majority of Area 1 would be dredged to accommodate an engineered cap of suitable materials, placed to return the sediment bed to grade. The banks would be regraded and capped. Removed materials would be disposed of in an offsite upland facility. MNR would be used to address the remainder of the RAA footprint, including portions of Area 1 where RAL exceedances are largely absent in

surface sediments and all of Area 2. A maintenance and monitoring program would be developed and implemented to monitor the cap and MNR performance, and provide protocols for response actions (e.g., incorporation of ENR or additional capping) should monitoring indicate a failure to meet the performance standards. However, surface sediments in areas identified for MNR already meet RALs, changes or response actions are considered to be highly unlikely.

- **Alternative 2(r) Dredge to Facilitate a Cap –** Alternative 2(r) is the same as Alternative 2(i) with the exception that the dredge and cap footprint would include the footprint where any sediments are present above the DDT and DDE RALs, regardless of depth (i.e., both Areas 1 and 2). The remainder of the RAA would be addressed by MNR/ENR under a maintenance and monitoring program as described in Alternative 2(i) above.

- **Alternative 3(i) Mass-Based Removal, Capping, and Optimized MNR** – This integrated alternative includes removal of the most highly contaminated sediments, capping, regrading of riverbanks, and MNR. Removed materials would be disposed of in an offsite upland facility. Engineered sediment caps would be constructed over the majority of the remainder of Area 1, including placement of engineered slope caps on the affected banks. MNR/ENR would be applied to address the remainder of the RAA footprint (including portions of Area 1 where RAL exceedances are largely absent in surface sediments and all of Area 2) under a maintenance and monitoring program, as described for Alternative 2(i).

- **Alternative 3(r) Mass-Based Removal and Capping —**Alternative 3(r) is the same as Alternative 3(i) except that sediments in the remainder of Area 1 (i.e., outside the mass removal area) and in all of Area 2, would be dredged to facilitate the placement of an engineered cap. Engineered slope caps would be placed on the affected banks. MNR/ENR would be applied to address the remainder of RAA footprint under a maintenance and monitoring program, as described for Alternative 2(r).

- **Alternative 4(i) Removal Focused and Optimized MNR –** This alternative includes dredging to a maximum depth of 15 ft within the majority of Area 1, based on practicality considerations and to minimize impacts to adjacent banks, and backfilled to original grades. The riverbanks would be excavated and regraded. In areas where dredging could not remove all contaminated materials, the backfill would be designed to function as a cap. Engineered slope caps would be constructed on the affected banks. Removed materials would be disposed in an offsite upland facility. MNR/ENR would be applied to the remaining RAA footprint (including portions of Area 1 where RAL exceedances are largely absent in surface sediments and all of Area 2) under a maintenance and monitoring program, as described for Alternative 2(i).

- **Alternative 4(r) Removal Focused** – Alternative 4(r) includes the greatest amount of dredging within the EPA-directed RAA among the alternatives. The alternative is the same as Alternative 4(i), except all material exceeding the DDE and DDT RALs would be dredged wherever reasonably feasible (combined footprint of Areas 1 and 2). MNR/ENR would be applied to the portion of the RAA footprint that is below the DDE and DDT RALs under a maintenance and monitoring program, as described for Alternative 2(r).

- **Alternative 5 Nearshore CDF** – This alternative includes dredging and in-place containment using a nearshore CDF. A nearshore CDF would be constructed to contain a portion of the EPA-directed RAA boundary in-place (i.e., constructed around a portion of the most highly contaminated material). The remaining RAA footprint exceeding the DDE and DDT RALs (combined footprint of Areas 1 and 2 outside of the CDF footprint) would be dredged to a maximum depth of 15 ft (as discussed for Alternative 4) and suitable backfill placed to return the site to original grades. Docks, piling, and debris would be removed. Outfall 4 would be protected, and outfalls which fall within the footprint of the CDF would be removed. In areas where dredging could not remove all contaminated materials, the backfill would be designed to function as a cap. Engineered slope caps would also be constructed in bank areas. MNR/ENR would be applied to the portion of the RAA footprint that is below the DDE and DDT RALs under a maintenance and monitoring program, as described for Alternative 2(r).

7.2.1 Alternative 1 – No Action

Alternative 1 would leave contaminated material within the RAA in its current condition and assumes no further action would occur. Under Alternative 1, no response activities or monitoring would occur.

7.2.1.1 Effectiveness

This alternative, however, would not be effective in protecting all human health or ecological receptors, would not attain all potential ARARs, and would not meet all RAOs.

The toxicity, mobility, and volume of contaminants would not be reduced under this alternative.

7.2.1.2 Implementability

This alternative is technically implementable; however, this alternative would likely not be acceptable to the regulatory agencies or stakeholders.

7.2.1.3 Cost

There are no costs associated with this alternative.

7.2.1.4 Evaluation of Alternative 1

Based on the results of the BHHRA, potential cancer risks via consumption of large home range fish, which represent site-wide exposure, and via consumption of smallmouth bass, which represent 1-RM exposure, are already below the target risk level of 10^{-4} for total DDT, total DDD, and total DDE. Accordingly, these constituents do not require remediation to a 10^{-4} risk level within the Portland Harbor site. A No Action alternative will satisfy a target risk level of 10^{-4} for total DDT, total DDD, and total DDE. However, for a target risk level of 10^{-5}, a No Action alternative will not satisfy all the removal action objectives and would not be protective of human health and the environment. This alternative is therefore eliminated from further consideration in this EE/CA.

7.2.2 Alternative 2(i) – Dredge to Facilitate a Cap and Optimized MNR

Alternative 2(i) is an integrated approach that emphasizes in-place containment of contaminants via capping and MNR (Figure 7-1). Sediment and bank soil would be removed to facilitate the placement of the cap. All removed materials would be disposed of offsite. The extent of removal would be based on achieving the following:

- Ensure no net change in existing site grades (elevations).
- Remove near-surface sediments in Area 1 and thereby eliminate RAL exceedances in surface sediments throughout the vast majority of the EPA-directed RAA and facilitating placement of an engineered cap over to physically isolate the remaining contaminate mass at the RAA.
- Improve conditions of bank areas in preparation for capping (including improving slope stability, removing debris, and preparing subgrade for cap placement).
- Accommodate outfall drainage.

Under Alternative 2(i), Area 1, including the portion of the EPA-directed RAA where surface (0-30 cm) sediment exceeds the DDT and DDE RALs at the 10^{-5} risk level, would be dredged to facilitate the placement of an engineered cap. Riverbank soil would be removed and regraded to facilitate an engineered slope cap, on the portion of the riverbank which intersects the EPA-directed RAA.

The remainder of the EPA-directed RAA (Area 2 and portions of Area 1 where RAL exceedances are largely absent in surface sediments) would be addressed by MNR. ENR may be applied in localized areas, if analysis during remedial design determines conditions exist and

are of significance to warrant ENR. A maintenance and monitoring program will be implemented following the remedy construction, such that additional measures (e.g., ENR, capping) may be implemented should monitoring indicate that MNR is not effective. This condition is highly unlikely to occur because DDx RALs are already being achieved in surface sediments in areas identified for MNR.

7.2.2.1 Bank Regrading and Capping

Riverbank that is generally co-located and adjacent to the EPA-directed RAA is included in this EE/CA. The riverbank is generally defined as the area between the top of bank (at or near 20.5 ft NAVD88, Ordinary High Water) and the edge of the Willamette River. For the purpose of this evaluation, the river's edge, or the toe of the slope, is defined at an elevation of +13 ft NAVD 88.

Approximately 1,250 linear ft of riverbank would be regraded, including removal and offsite disposal of debris and localized riverbank highly contaminated material if identified. Cutting and filling soil along the riverbank would create a more uniform slope from the top of bank to the toe that is more stable and resistant to erosion. The slope of the regraded riverbank would be similar to the existing slope, which ranges from 1.5:1 to 2:1 (horizontal:vertical). Following regrading, a suitable soil cover would be placed. For the purposes of this EE/CA, it is assumed that this cover layer would be 3-ft thick; however, the final cover thickness would be determined during the remedial design. The finished grade would be stabilized with rip rap, and fish-suitable habit in the lower portion of the cap.. The configuration of the riverbank regrading and capping is being developed in accordance with the pending update to the Hot Spot Evaluation (ERM 2012). Appendix F provides further detail and analysis of alternative remedial measures for the Arkema site riverbank.

7.2.2.2 Dredging

Under Alternative 2(i), sediment would be removed from Area 1 prior to cap placement to ensure no net change in existing elevation. For the purposes of this EE/CA, it is estimated sediment would be removed prior to placement of an assumed 3-ft thick cap, as described below.

7.2.2.3 Sediment Capping

Engineered sediment caps would be placed throughout the dredged area described above to physically isolate affected sediments not removed by dredging. The cap would be engineered to withstand scour and erosive forces (e.g. vessel and wind-wave induced forces). The cap will be placed around outfalls, which would be protected and maintained. Dredging and capping would be designed such that the final cap surface allows proper drainage from the existing outfall and diffuser structure.

The specific cap configurations would be determined in the design, in accordance with EPA and USACE guidance (USACE 1998). The caps would be designed for long-term seismic stability. For the purposes of this EE/CA, a nominal 3-foot cap thickness is assumed based on an understanding of site conditions, regional experience at similar sites and analyses conducted in support of the draft Portland FS (Anchor QEA et al. 2012). The cap is assumed to consist of a 1-ft thick filter layer (i.e., sand) and 2 ft of armoring. Although contaminant mobility (e.g., due to upwelling or diffusion) is expected to be insignificant due to the implementation of groundwater SCMs in 2012-3 and the immobility of the majority of the COIs, the cap may be amended in localized areas with GAC or similar active materials if remedial design analysis determines that such provisions are necessary.

7.2.2.4 Residuals Management

Excavation and dredging would be accomplished using operational BMPs to reduce the potential for resuspension and mobilization of contaminated sediments. However, following dredging or excavation, some disturbed, contaminated material often remains at the new surface and/or surrounding area outside the dredge prism (e.g., "residuals").

Under this alternative, none of the excavated/dredged areas would be left uncapped and not all excavations would be designed to expose a clean surface. Within a large portion of the RAA, residuals would be permanently contained by the designed cap, which would be placed after dredging and bank excavation is complete. Post-excavation samples would be collected on the exposed surfaces to document the nature of the material beneath the cap; however, over-dredging, or excavation to reach a clean surface is not a required contingency or management action. Confirmation samples would also be collected on top of all final cap surfaces and in the area immediately adjacent to the removal boundary to document post-remedy conditions. The design may also include provisions for thin-layer placement of suitable sand, and possibly activated carbon amendment, as a residuals management action to be implemented outside of areas which are capped.

7.2.2.5 Material Handling, Transport and Disposal

Dredged or excavated materials would be either loaded onto trucks or rail cars onsite and/or loaded onto conventional barges and moved offsite. The material from barges would be offloaded to either rail cars or trucks at a transloading facility in the project vicinity. One or more acceptable transloading facilities would be identified in the design.

All of the excavated and dredged material would be suitable for placement in a RCRA Subtitle D solid waste landfill. Excavated and dredged material (including non-recyclable debris) would be disposed of in a permitted RCRA Subtitle D landfill that meets state and federal requirements. The disposal site(s) would be evaluated and approved by EPA before they are

selected to receive materials originating from the site. Agency site review includes the site's compliance with RCRA permits and governing regulations.

Some debris (e.g., concrete, metals) may be candidate material for recycling; this material would be segregated, cleaned, and evaluated for recycling at an approved facility.

Imported cap materials would be delivered to the site primarily by barge. The contractor may elect to deliver some import materials (such as for bank capping) by truck.

7.2.2.6 Construction Approach

The design will include plans and specifications that are primarily performance-based, with specific requirements for excavation and capping grades/tolerances, materials, environmental protection, and sequencing of the work. (General sequencing is discussed further in Section 8). The contractor will be required to submit a remedial action work plan that details the proposed construction means, methods, and schedule. The contractor's work plan will be reviewed and approved by LSS and EPA.

To reduce resuspension and mobilization of contaminated sediments during construction, all in-water work would be conducted using BMPs that will be identified in the design specifications and in the remedial action work plans. In addition, all in-water work would be conducted and monitored in accordance with EPA's CWA Section 401 Water Quality Certification, which would specify allowable in-water work periods, water quality monitoring requirements and compliance criteria, and operational responses to any water quality exceedances. The contractor would be required to modify operations or employ other engineering measures (e.g., use different equipment or silt curtains) as needed to remain in compliance with water quality criteria.

Sediment removal would likely be accomplished by mechanical dredging. It is anticipated that bank excavation and capping would be accomplished with shore-based equipment and constructed during periods of low tide, as practicable. Capping of sediments would be completed using a combination of shore-based and floating equipment, to be determined during construction based on water level and required draft for the barges.

As described above, one or more of the existing docks may be removed within the RAA prior to dredging and capping. If removed, pilings would be removed intact, if possible, using either vibratory extraction, or dead-line pull methods. Pilings that can not be removed intact would be cut at, or near the mudline. The piling removal would follow procedures in EPA (2005c) guidance. Some inert debris embedded in the sediment would remain in place if it is determined it would not affect the function of the cap. Existing Outfalls 1 through 4 would be protected prior to placement of the cap.

For any dock, or outfall, structure left in-place, the dredge prism would be designed to minimize potential impacts to the structure. Cap materials would be placed beneath the dock using a conveyor, or other means. Specific requirements for mitigating limited overhead clearance and space limitations would be determined in design and equipment selections made during implementation.

7.2.2.7 Monitored Natural Recovery

The portion of the EPA-directed RAA Area 2 and fringe portions of Area 1 would be addressed by MNR. During the remedial design, an assessment would be completed to determine if localized application of ENR (e.g., thin layer capping with possible GAC amendment) is necessary.

The highest concentrations of COIs, if present, occur at depth in the areas where MNR would be applied (i.e., Area 2 and fringe portions of Area 1) and surface sediment concentrations are already below RALs. This profile suggests that natural recovery has occurred since the time of release. As described in Section 6.2, several lines of evidence indicate that the section of the Willamette River where the Arkema site is located is depositional and, thus, ongoing sediment deposition will result in continued natural recovery of sediment in these areas. A site-specific evaluation on natural recovery rates has not been completed for the Arkema site. Therefore, MNR would be applied within a maintenance and monitoring program designed to monitor RAA conditions over time following remedy implementation to ensure that MNR is performing as designed and, if not, implement additional response measures (e.g., ENR, capping) in areas where performance standards are not being met.

7.2.2.8 Institutional Controls

Institutional controls would be required under Alternative 2(i) because some contamination would remain onsite. Institutional controls would be employed as an additional measure to ensure the long-term protectiveness and integrity of the remedy, and would exist in perpetuity. The specific objectives of the institutional controls would be to:

- Prevent any uncontrolled disturbance, excavation, or construction that may compromise the cap integrity or impede natural recovery.
- Prevent any current or future land uses that could compromise the cap integrity or impede natural recovery.
- Require notification of the state and EPA prior to any redevelopment of the site, to ensure that the agencies concur that the development has been designed to avoid damage to the cap or affect natural recovery. If the cap must be disturbed as part of the activity, the notification would be required to include specific plans for appropriate

management of the construction and restoration of the cap, as applicable. The specific plans must be approved by EPA prior to implementation.

- Ensure that these restrictions will run with the land.

Consistent with Section 6.2.1 of the draft Portland Harbor FS (Anchor QEA et al 2012), a detailed institutional control plan is not prepared in this EE/CA and will be considered during remedial design. Costs of institutional controls are broadly estimated for use in this EE/CA based on the controls generally described above, in Section 6.7, and in the draft Portland Harbor FS.

7.2.2.9 Monitoring, Maintenance, and Reviews

A long-term monitoring and reporting plan (LTMRP) would be developed during the design that defines the specific monitoring activities and frequency of monitoring events. LSS would implement the requirements of this plan to ensure the long-term integrity and protectiveness of the remedy, and ensure that habitat benefits are not lost over the long term. Further, the plan will detail the process for contingency planning and response in the event that performance standards for the cap are not met. The need for maintenance of capped areas would be determined based on the results of the long-term monitoring. Finally, a maintenance and monitoring plan will be developed in conjunction with or as part of the LTMRP to monitor MNR effectiveness and to specify protocols to address any areas where performance standards are not met. Because this alternative would result in contaminants remaining onsite above levels that allow for unlimited use and unrestricted exposure, EPA would review the effectiveness of the remedy no less frequently than every five years.

7.2.2.10 Summary of Construction Quantities

The estimated volumes of bank excavation, dredging, and capping associated with Alternatives 2 through 5 are summarized in Table 7-1**.**

7.2.2.11 Evaluation of Alternative 2(i)

An initial evaluation of Alternative 2(i) is provided below. Section 8 includes a comparative analysis of all of the alternatives.

Effectiveness

Alternative 2(i) would be effective in removing and containing sediments with total DDx and other COIs within the EPA-directed RAA. Removal, capping, and MNR/ENR are proven technologies that have been successfully implemented in similar CERCLA sediment cleanup actions. Impacted material that remains in place at the RAA would be reliably contained by capping and MNR.

Other considerations related to the effectiveness of Alternative 2(i) are summarized below:

- Alternative 2(i) satisfies the RAOs by creating a post-construction surface that meets the RALs across the EPA-directed RAA and provides effective long-term containment of remaining contaminants.
- By meeting the RALs in surface sediments, Alternative 2(i) would be protective of human health and the environment.
- Alternative 2(i) would remove a total of approximately 33,000 cy of sediment and soil containing total DDx and other COIs, and dispose of this material in a permitted upland landfill approved by EPA.
- As is summarized in Table 7-2, predicted RM 6.5-7.5 SWACs following implementation of Alternative 2(i) are significantly reduced. Percent reduction in SWACs range from 25 to 55 percent for DDx and is 46 percent for 2,3,4,7,8-PCDF.
- Land use restrictions, long-term monitoring, and periodic reviews would ensure long term protection of human health and the environment.
- Alternative 2(i) could be implemented in compliance with all ARARs.
- Alternative 2(i) includes, if necessary, provisions for treatment to reduce the mobility of dissolved contaminants resulting from diffusive and advective processes.
- Alternative 2(i) can be implemented in one construction season, assuming typical BMPs are used, and the RAOs would be achieved upon completion of construction. The institutional controls could be fully implemented within approximately 1 year of construction completion.
- Engineering controls, BMPs, and other measures to ensure compliance with ARARs would control short-term risks during implementation. The potential for releases of material to the environment during construction would be minimal under Alternative 2(i), because a relatively small volume of contaminated material would be excavated/dredged and the area would subsequently be capped. Potential impacts resulting from release of dredging residuals would be identified and addressed through an appropriately designed water quality monitoring and post-dredge sediment sampling program.
- The potential for undetected release of residual contaminants left in place under the cap or at depth in sediments (e.g., from isolated erosional failure of the cap or native sediments in MNR areas) is small. In design, consideration would be given to long-term

function, including resistance to cap erosion due to propeller wash, or other wave/wake-induced forces.

- Long-term performance would be verified through monitoring and periodic reviews. Land use restrictions would also contribute to the long-term integrity of the caps by reliably minimizing the potential for future uncontrolled activities that could disturb the caps or impede natural recovery.
- Maintenance and monitoring protocols would be established such that appropriate response actions would be taken should monitoring indicate that a portion of the remedy is not achieving the performance standards.

Implementability

Based on the proven success of similar EPA Region 10 removal/capping projects, Alternative 2(i) can be reliably implemented using commonly available upland and marine construction equipment and materials. Excavated materials can be trucked, railed or barged offsite and imported material brought onsite with conventional trucking or barge equipment. For work on the riverbank, the contractor would schedule excavation and capping activities to take best advantage of low-flow and tide conditions to accomplish work in-the-dry. The remainder of the work (including most capping) would likely be completed using floating equipment and conventional marine construction methods, working at higher tides, as practicable, to provide the required draft for the barges.

Dredged or excavated materials would be loaded onto trucks or rail cars onsite or loaded onto conventional barges and moved offsite. The material from barges would be offloaded to rail cars or trucks at a transloading facility in the project vicinity or at the disposal facility.

Cost

The estimated removal action cost for Alternative 2(i) is detailed in Table 7-3. The total estimated costs include present-value operation and maintenance (O&M) costs estimated for 30 years, based on a 7 percent discount rate. Over the 30-year period, operation costs assume seven monitoring events, and maintenance costs assume five cap repair events. O&M costs were not projected beyond 30 years because their effect on net present value becomes diminishingly small.

7.2.3 Alternative 2(R) – Dredge to Facilitate a Cap

Alternative 2(r) parallels Alternative 2(i) with the exception that the footprint to be dredged and capped encompasses the entire area where sediment concentrations exceed the DDT and DDE RALs for a 10^{-5} risk level, regardless of depth (combined Areas 1 and 2; Figure 7-2). Alternative 2(r) places more emphasis on sediment removal than Alternative 2(i). MNR would be applied to address the remaining portion of the RAA outside of the cap footprint. A maintenance and

monitoring program would be implemented following the remedy construction, such that additional remedial measures, such as ENR or capping, may be applied should monitoring indicate that MNR is not effective. This, however, is unlikely since Area 2 surface sediments already meet RALs.

7.2.3.1 Bank Regrading and Capping

Riverbank regrading and capping would occur as described for Alternative 2(i).

7.2.3.2 Dredging

Dredging would occur as described for Alternative 2(i), with the exception that the dredging footprint would extend across both Areas 1 and 2.

7.2.3.3 Sediment Capping

Sediment capping would occur as described for Alternative 2(i), with the exception that the cap footprint would extend across both Areas 1 and 2.

7.2.3.4 Residuals Management

The strategy for management of residuals would be the same as described for Alternative 2(i).

7.2.3.5 Material Handling, Transport and Disposal

Material handling, transportation, and disposal would be as described for Alternative 2(i).

7.2.3.6 Construction Approach

The construction approach would be generally the same as described for Alternative 2(i).

7.2.3.7 Institutional Controls

Institutional controls would be implemented as described for Alternative 2(i).

7.2.3.8 Monitored Natural Recovery

MNR would be implemented as described for Alternative 2(i), with the exception that MNR would be applied to a smaller area (i.e., the area outside of Areas 1 and 2 and inside of the EPA-directed RAA; Figure 7-2).

7.2.3.9 Monitoring, Maintenance, and Reviews

Long-term monitoring, maintenance, and periodic reviews would be implemented as described for Alternative 2(i).

7.2.3.10 Summary of Construction Quantities

The estimated volumes of bank excavation, dredging, and capping associated with Alternatives 2 through 5 are summarized in Table 7-1**.**

7.2.3.11 Evaluation of Alternative 2(r)

An initial evaluation of Alternative 2(r) is provided below. Section 8 includes a comparative analysis of all of the alternatives.

Effectiveness

Alternative 2(r) would be effective in removing and containing sediments with total DDx and other COIs within the EPA-directed RAA. Removal, capping, and MNR/ENR are proven technologies that have been successfully implemented in similar CERCLA sediment cleanup actions. Impacted material that remains in place at the RAA would be reliably contained by capping and MNR.

Other considerations related to the effectiveness of Alternative 2(r) are summarized below:

- Alternative 2(r) satisfies the RAOs by creating a post-construction surface that meets the RALs across the EPA-directed RAA and provides effective long-term containment of remaining COIs.
- By meeting the RALs in surface sediments, Alternative 2(r) would be protective of human health and the environment.
- Alternative 2(r) would remove a total of approximately 39,000 cy of sediment and soil containing total DDx, and other COIs, and dispose of this material in a permitted upland landfill approved by EPA.
- As is summarized in Table 7-2, predicted RM 6.5-7.5 SWACs following implementation of Alternative 2(r) are significantly reduced. Percent reductions in SWACs are on the order of 27 to 55 percent for DDx and 46 percent for 2,3,4,7,8-PCDF. Land use restrictions, long-term monitoring, and periodic reviews would ensure long term protection of human health and the environment.
- Alternative 2(r) could be implemented in compliance with all ARARs.
- Alternative 2(r) includes, if necessary, provisions for treatment to reduce the mobility of dissolved contaminants as a result of diffusive and advective processes.

- Alternative 2(r) can be implemented in one construction season, assuming typical BMPs are used, and the RAOs would be achieved upon completion of construction. The institutional controls could be fully implemented within approximately 1 year of construction completion.
- Engineering controls, BMPs, and other measures to ensure compliance with ARARs would control short-term risks during implementation. The potential for releases of material to the environment during construction would be minimal under Alternative 2(r), because a somewhat lesser volume of contaminated material would be excavated/dredged and the area would subsequently be capped. Potential impacts resulting from release of dredging residuals would be identified and addressed through an appropriately designed water quality monitoring and post-dredge sediment sampling program.
- The potential for undetected release of residual contaminants left in place under the cap or at depth in sediment (e.g., from isolated erosional failure of the cap or native sediments in MNR areas) is very small. In design, consideration would be given to long-term function, including resistance to cap erosion due to propeller wash, or other wave/wake induced forces.
- Long-term performance would be verified through monitoring and periodic reviews. Land use restrictions would also contribute to the long-term integrity of the caps by reliably minimizing the potential for future uncontrolled activities that could disturb the caps or impede natural recovery.
- Maintenance and monitoring protocols would be established such that appropriate response actions would be taken should monitoring indicate that a portion of the remedy is not achieving the performance standards.

Implementability

Based on the proven success of similar EPA Region 10 removal/capping projects, Alternative 2(r) can be reliably implemented in a manner consistent with Alternative 2(i).

Cost

The estimated removal action cost for Alternative 2(r) is detailed in Table 7-3. The total estimated costs include present-value O&M costs estimated for 30 years, based on a 7 percent discount rate. Over the 30-year period, operation costs assume seven monitoring events, and maintenance costs assume five cap repair events. O&M costs were not projected beyond 30 years because their effect on net present value becomes diminishingly small.

7.2.4 Alternative 3(i) – Mass-Based Removal, Capping and Optimized MNR

Alternative 3(i) integrates mass-based, most highly contaminated sediment removal, capping, and MNR (Figure 7-3). Under Alternative 3(i), a majority of the sediment with within the 75 mg/kg DDx contour would be removed from the EPA- directed RAA (the footprint of which is entirely within Area 1). This area would be dredged to a maximum depth of 15 ft and the dredge prism backfilled with suitable material. The majority of the remaining portion of Area 1 sediment would be dredged to facilitate the placement of an engineered cap, including an engineered slope cap on the portion of the riverbank which intersects the EPA-directed RAA. The remainder of the EPA-directed RAA would be addressed by MNR. ENR may be applied in localized areas if deemed necessary during the remedial design. A maintenance and monitoring program would be implemented following the remedy construction, such that additional remedial measures, such as ENR or capping, may be applied should monitoring indicate that MNR is not effective. This however is unlikely since surface sediments in areas identified for MNR already meet RALs.

7.2.4.1 Docks, Debris and Outfall Removal

Existing docks, creosote-treated piling, debris and outfalls would be handled as described under Alternative 2(i).

7.2.4.2 Bank Regrading and Capping

Riverbank regrading and capping would occur as described for Alternative 2(i).

7.2.4.3 Dredging

Under Alternative 3(i), sediment containing the majority of the DDx mass within the EPA-directed RAA would be dredged to a practical maximum depth of 15 ft bml. In addition, the remainder of surface sediments within Area 1 would be dredged to facilitate placement of a cap. The dredging would occur as described for Alternative 2(i).

7.2.4.4 Sediment Capping

Engineered sediment caps would be placed in the footprint of the dredge prism described above to isolate any affected sediments beneath the dredge prism that are not removed, as described under Alternative 2(i) above.

7.2.4.5 Residuals Management

The strategy for management of residuals would be the same as described for Alternative 2(i).

7.2.4.6 Material Handling, Transport and Disposal

Material handling, transportation, and disposal would be as described for Alternative 2(i).

7.2.4.7 Construction Approach

The construction approach would be generally the same as described for Alternative 2(i).

7.2.4.8 Institutional Controls

Institutional controls would be implemented as described for Alternative 2(i).

7.2.4.9 Monitored Natural Recovery

MNR would be implemented as described for Alternative 2(i).

7.2.4.10 Monitoring, Maintenance, and Reviews

Long-term monitoring, maintenance, and periodic reviews would be implemented as described for Alternative 2(i).

7.2.4.11 Summary of Construction Quantities

The estimated volumes of bank excavation, dredging, and capping associated with Alternatives 2 through 5 are summarized in Table 7-1.

7.2.4.12 Evaluation of Alternative 3(i)

An initial evaluation of Alternative 3(i) is provided below. Section 8 includes a comparative analysis of all of the alternatives.

Effectiveness

Alternative 3(i) would be effective in removing and containing sediments with total DDx and other COIs within the EPA-directed RAA. Removal, capping, and MNR/ENR are proven technologies that have been successfully implemented in similar CERCLA sediment cleanup actions. Impacted material that remains in place at the RAA would be reliably contained by capping and MNR.

Other considerations related to the effectiveness of Alternative 3(i) are summarized below:

- Alternative 3(i) satisfies the RAOs by creating a post-construction surface that meets the RALs across the EPA-directed RAA and provides effective long-term containment of remaining COIs.

- By meeting the RALs in surface sediment, Alternative 3(i) would be protective of human health and the environment.
- Alternative 3(i) would remove a total of approximately 54,000 cy of sediment and soil containing total DDx, and other COIs, and dispose of this material in a permitted upland landfill approved by EPA.
- As is summarized in Table 7-2, predicted RM 6.5-7.5 SWACs following implementation of Alternative 3(i) are significantly reduced. Percent reduction in SWACs range from 27 to 55 percent for DDx and is 46 percent for 2,3,4,7,8-PCDF. Land use restrictions, long-term monitoring, and periodic reviews would ensure long-term protection of human health and the environment.
- Alternative 3(i) could be implemented in compliance with all ARARs.
- Alternative 3(i) can be implemented in one construction season, depending on required BMPs, and the RAOs would be achieved upon completion of construction. The institutional controls could be fully implemented within approximately 1 year of construction completion.
- Engineering controls, BMPs, and other measures to ensure compliance with ARARs would control short-term risks during implementation. Potential impacts resulting from release of dredging residuals would be identified and addressed through an appropriately designed water quality monitoring and post-dredge sediment sampling program.
- The potential for undetected release of residual COIs left in place under the cap or at depth in sediments (e.g., from isolated erosional failure of the cap or MNR areas) is small. In design, consideration would be given to long-term function, including resistance to cap erosion due to propeller wash, or other wave/wake-induced forces.
- Long-term performance would be verified through monitoring and periodic reviews. Land use restrictions would also contribute to the long-term integrity of the caps by reliably minimizing the potential for future uncontrolled activities that could disturb the caps or impede natural recovery.
- Maintenance and monitoring protocols would be established such that appropriate response actions would be taken should monitoring indicate that a portion of the remedy is not achieving the performance standards.

Implementability

Based on the proven success of similar EPA Region 10 removal/capping projects, Alternative 3(i) can be reliably implemented in a manner consistent with Alternative 2(i).

Cost

The estimated removal action cost for Alternative 3(i) is detailed in Table 7-3. The total estimated costs include present-value O&M costs estimated for 30 years, based on a 7 percent discount rate. Over the 30-year period, operation costs assume seven monitoring events, and maintenance costs assume five cap repair events. O&M costs were not projected beyond 30 years because their effect on net present value becomes diminishingly small.

7.2.5 Alternative 3(r) – Mass-Based Removal and Capping

Alternative 3(r) parallels Alternative 3(i) with the exception that the footprint of the dredge prism and cap encompasses Areas 1 and 2 (Figure 7-4). Alternative 3(r) places more emphasis on sediment removal than Alternative 3(i), and MNR would be applied only in areas of the EPA-directed RAA where sediments are below the DDT RAL across the entire sediment thickness. A maintenance and monitoring program would be implemented following the remedy construction, such that additional remedial measures, such as ENR or capping, may be applied should monitoring indicate that MNR is not effective. This, however, is unlikely since Area 2 surface sediments already meet RALs.

7.2.5.1 Bank Regrading and Capping

Riverbank regrading and capping would occur as described for Alternative 2(i).

7.2.5.2 Dredging

Under Alternative 3(r), sediment containing the majority of the DDx mass within the EPA-directed RAA would be dredged to a practical maximum depth of 15 ft bml. In addition, surface sediment would be dredged throughout the rest of Area 1 and Area 2 to facilitate placement of a cap. The dredging would occur as described for Alternative 2(i).

7.2.5.3 Sediment Capping

Engineered sediment caps would be placed in the footprint of the dredge prism described above, effectively isolating any affected sediments beneath the dredge prism that are not removed by dredging, as described under Alternative 2(i) above.

7.2.5.4 Residuals Management

The strategy for management of residuals would be the same as described for Alternative 2(i).

7.2.5.5 Material Handling, Transport and Disposal

Material handling, transportation, and disposal would be as described for Alternative 2(i).

7.2.5.6 Construction Approach

The construction approach would be generally the same as described for Alternative 2(i).

7.2.5.7 Institutional Controls

Institutional controls would be implemented as described for Alternative 2(i).

7.2.5.8 Monitored Natural Recovery

MNR would be implemented as described for Alternative 2(r).

7.2.5.9 Monitoring, Maintenance, and Reviews

Long-term monitoring, maintenance, and periodic reviews would be implemented as described for Alternative 2(i).

7.2.5.10 Summary of Construction Quantities

The estimated volumes of bank excavation, dredging, and capping associated with Alternatives 2 through 5 are summarized in Table 7-1.

7.2.5.11 Evaluation of Alternative 3(r)

An initial evaluation of Alternative 3(r) is provided below. Section 8 includes a comparative analysis of all of the alternatives.

Effectiveness

Alternative 3(r) would be effective in removing and containing sediment with total DDx and other COIs within the EPA-directed RAA. Removal, capping, and MNR/ENR are proven technologies that have been successfully implemented in similar CERCLA sediment cleanup actions. Impacted material that remains in place at the RAA would be reliably contained by capping and MNR.

Other considerations related to the effectiveness of Alternative 3(r) are summarized below:

- Alternative 3(r) satisfies the RAOs by creating a post-construction surface that meets the RALs across the EPA-directed RAA and provides effective long-term containment of remaining COIs.
- By meeting the RALs in surface sediments, Alternative 3(r) would be protective of human health and the environment.

- Alternative 3(r) would remove a total of approximately 59,000 cy of sediment and soil containing total DDx, and other COIs, and dispose of this material in a permitted upland landfill approved by EPA.
- As is summarized in Table 7-2, predicted RM 6.5–7.5 SWACs following implementation of Alternative 3(r) are significantly reduced. Percent reductions in SWACs are on the order of 27 to 55 percent for DDx and 46 percent for 2,3,4,7,8-PCDF. However, despite the additional volume of sediment, and corresponding COI mass, removed under this Alternative 3(r), the predicted SWAC concentrations are the same or not substantially different from Alternatives 2(i) and 2(r), which involve less removal. Land use restrictions, long-term monitoring, and periodic reviews would ensure long term protection of human health and the environment.
- Alternative 3(r) could be implemented in compliance with all ARARs.
- Alternative 3(r) can be implemented in one to two construction seasons, depending on required BMPs, and the RAOs would be achieved upon completion of construction. The institutional controls could be fully implemented within approximately 1 year of construction completion.
- Engineering controls, BMPs, and other measures to ensure compliance with ARARs would control short-term risks during implementation. Potential impacts resulting from release of dredging residuals would be identified and addressed through an appropriately designed water quality monitoring and post-dredge sediment sampling program.
- The potential for undetected release of residual contaminants left in place under the cap or at depth in sediment (e.g., from isolated erosional failure of the cap or MNR areas) is small. In design, consideration would be given to long-term function, including resistance to cap erosion due to propeller wash, or other wave/wake-induced forces.
- Long-term performance would be verified through monitoring and periodic reviews. Land use restrictions would also contribute to the long-term integrity of the caps by reliably minimizing the potential for future uncontrolled activities that could disturb the caps or impede natural recovery.
- Maintenance and monitoring protocols would be established such that appropriate response actions would be taken should monitoring indicate that a portion of the remedy is not achieving the performance standards.

Implementability

Based on the proven success of similar EPA Region 10 removal/capping projects, Alternative 3(r) can be reliably implemented in a manner consistent with Alternative 2(i).

Cost

The estimated removal action cost for Alternative 3(r) is detailed in Table 7-3. The total estimated costs include present-value O&M costs estimated for 30 years, based on a 7 percent discount rate. Over the 30-year period, operation costs assume seven monitoring events, and maintenance costs assume five cap repair events. O&M costs were not projected beyond 30 years because their effect on net present value becomes diminishingly small.

7.2.6 Alternative 4(i) – Removal Focused and Optimized MNR

Alternative 4(i) involves removal of sediment to a maximum depth of 15 ft across the majority of Area 1. MNR would be applied under a maintenance and monitoring approach to address the remainder of the EPA-directed RAA (Figure 7-5).

7.2.6.1 Bank Regrading and Capping

Riverbank regrading and capping would occur as described for Alternative 2(i).

7.2.6.2 Dredging

Under Alternative 4(i), sediment within Area 1 would be dredged to a practical maximum depth of 15 ft bml. The dredging would occur as described for Alternative 2(i).

7.2.6.3 Sediment Capping

Given the conceptual extent of removal, suitable backfill material would replace removed sediment. Backfill would primarily be designed to satisfy physical stability and habitat substrate considerations rather than chemical isolation. During design, areas which preclude dredging to the specified RAL due to engineering constraints (e.g., slope stability) may be identified. In these cases, engineered sediment caps would be used to physically isolate any affected sediments not removed by dredging, as described under Alternative 2(i) above.

7.2.6.4 Residuals Management

The strategy for management of residuals would be generally the same as described for Alternative 2(i).

7.2.6.5 Material Handling, Transport and Disposal

Material handling, transportation, and disposal would be as described for Alternative 2(i).

7.2.6.6 Construction Approach

The construction approach would be generally the same as described for Alternative 2(i).

7.2.6.7 Institutional Controls

Institutional controls would be implemented as described for Alternative 2(i).

7.2.6.8 Monitored Natural Recovery

MNR would be implemented as described for Alternative 2(i).

7.2.6.9 Monitoring, Maintenance, and Reviews

Long-term monitoring, maintenance, and periodic reviews would be implemented as described for Alternative 2(i).

7.2.6.10 Summary of Construction Quantities

The estimated volumes of bank excavation, dredging, and capping associated with Alternatives 2 through 5 are summarized in Table 7-1.

7.2.6.11 Evaluation of Alternative 4(i)

An initial evaluation of Alternative 4(i) is provided below. Section 8 includes a comparative analysis of all of the alternatives.

Effectiveness

Alternative 4(i) would be effective in removing and containing sediments with total DDx and other COIs within the EPA-directed RAA. Removal, capping, and MNR/ENR are proven technologies that have been successfully implemented in similar CERCLA sediment cleanup actions. Impacted material that remains in place at the RAA would be reliably contained by capping, suitable backfill, and MNR.

Other considerations related to the effectiveness of Alternative 4(i) are summarized below:

- Alternative 4(i) satisfies the RAOs by creating a post-construction surface that meets the RALs across the EPA-directed RAA and provides effective long-term containment of remaining COIs.
- By meeting the RALs in surface sediment, Alternative 4(i) would be protective of human health and the environment.
- Alternative 4(i) would remove a total of approximately 62,000 cy of sediment and soil containing total DDx, and other COIs, and dispose of this material in a permitted upland landfill approved by EPA.
- As is summarized in Table 7-2, predicted RM 6.5-7.5 SWACs following implementation of Alternative 4(i) are significantly reduced. Percent reductions in SWACs are on the

order of 25 to 55 percent for DDx and 46 percent for 2,3,4,7,8-PCDF. However, despite the relatively large volume, and corresponding COI mass, removed under this Alternative 4(i), the predicted SWAC concentrations are the same or not substantially different from Alternatives 2(i), 2(r), 3(i), or 3(r), all of which involve less removal. Land use restrictions, long-term monitoring, and periodic reviews would ensure long term protection of human health and the environment.

- Alternative 4(i) could be implemented in compliance with all ARARs.
- Alternative 4(i) includes provisions for treatment to reduce the mobility of dissolved contaminants through diffusive and advective processes, if necessary.
- Alternative 4(i) can be implemented in two to three construction seasons, depending on required BMPs, and the RAOs would be achieved upon completion of construction. The institutional controls could be fully implemented within approximately 1 year of construction completion.
- Engineering controls, BMPs, and other measures to ensure compliance with ARARs would control short-term risks during implementation. Potential impacts resulting from release of dredging residuals would be identified and addressed through an appropriately designed water quality monitoring and post-dredge sediment sampling program.
- The potential for undetected release of residual COIs left in place at depth in sediment (e.g., from isolated erosion in MNR areas) is small. In design, consideration would be given to long-term function, including resistance to cap erosion due to propeller wash, or other wave/wake-induced forces.
- Long-term performance would be verified through monitoring and periodic reviews. Land use restrictions would also contribute to the long-term integrity of the post-remedy sediment bed by reliably minimizing the potential for future uncontrolled activities that could disturb sediment or impede natural recovery.
- Maintenance and monitoring protocols would be established such that appropriate response actions would be taken should monitoring indicate that a portion of the remedy is not achieving the performance standards.

Implementability

Based on the proven success of similar EPA Region 10 removal/capping projects, Alternative 4(i) can be reliably implemented in a manner consistent with Alternative 2(i).

Cost

The estimated removal action cost for Alternative 4(i) is detailed in Table 7-3. The total estimated costs include present-value O&M costs estimated for 30 years, based on a 7 percent discount rate. Over the 30-year period, operation costs assume seven monitoring events, and

maintenance costs assume five cap repair events. O&M costs were not projected beyond 30 years because their effect on net present value becomes diminishingly small.

7.2.7 Alternative 4(r) – Removal Focused

Alternative 4(r) (Figure 7-6) parallels Alternative 4(i) with the exception that it would include the removal of sediments to a maximum depth of 15 ft across Areas 1 and 2. MNR would be applied under a maintenance and monitoring approach to address the remainder of RAA.

7.2.7.1 Bank Regrading and Capping

Riverbank regrading and capping would occur as described for Alternative 2(i).

7.2.7.2 Dredging

Under Alternative 4(r), sediment within Areas 1 and 2 would be dredged to a practical maximum depth of 15 ft bml. The dredging would occur as described for Alternative 2(i).

7.2.7.3 Sediment Capping

Sediment capping would be completed in the same general manner as described for Alternative 4(i).

7.2.7.4 Residuals Management

The strategy for management of residuals would be generally the same as described for Alternative 2(i).

7.2.7.5 Material Handling, Transport and Disposal

Material handling, transportation, and disposal would be as described for Alternative 2(i).

7.2.7.6 Construction Approach

The construction approach would be generally the same as described for Alternative 2(i).

7.2.7.7 Institutional Controls

Institutional controls would be implemented as described for Alternative 2(i).

7.2.7.8 Monitored Natural Recovery

MNR would be implemented as described for Alternative 2(r).

7.2.7.9 Monitoring, Maintenance, and Reviews

Long-term monitoring, maintenance, and periodic reviews would be implemented as described for Alternative 2(i).

7.2.7.10 Summary of Construction Quantities

The estimated volumes of bank excavation, dredging, and capping associated with Alternatives 2 through 5 are summarized in Table 7-1.

7.2.7.11 Evaluation of Alternative 4(r)

An initial evaluation of Alternative 4(r) is provided below. Section 8 includes a comparative analysis of all of the alternatives.

Effectiveness

Alternative 4(r) would be effective in removing and containing sediment with total DDx and other COIs within the EPA-directed RAA. Removal and MNR are proven technologies that have been successfully implemented in similar CERCLA sediment cleanup actions. Impacted material that remains in place at the RAA would be reliably contained by suitable backfill and MNR.

Other considerations related to the effectiveness of Alternative 4(r) are summarized below:

- Alternative 4(r) satisfies the RAOs by creating a post-construction surface that meets the RALs across the EPA-directed RAA and provides effective long-term containment of remaining COIs.
- By meeting the RALs in surface sediment, Alternative 4(r) would be protective of human health and the environment.
- Alternative 4(r) would remove a total of approximately 81,000 cy of sediment and soil containing total DDx, and other COIs, and dispose of this material in a permitted upland landfill approved by EPA. The following summarizes the predicted COI mass removal under Alternative 4(r).
- As is summarized in Table 7-2, predicted RM 6.5-7.5 SWACs following implementation of Alternative 4(r) are significantly reduced. Percent reductions in SWACs are on the order of 27 to 55 percent for DDx and 46 percent for 2,3,4,7,8-PCDF. Alternative 4(r) would involve the removal of the greatest volume, but not substantially more COI mass, of all the alternatives. More importantly, the predicted SWAC concentrations are the same or not substantially different from that predicted for the other alternatives.
- Land use restrictions, long-term monitoring, and periodic reviews would ensure long term protection of human health and the environment.

- Alternative 4(r) could be implemented in compliance with all ARARs.
- Alternative 4(r) includes provisions for treatment to reduce the mobility of dissolved contaminants through diffusive and advective processes, if necessary.
- Alternative 4(r) can be implemented in two to three construction seasons, depending on the required BMPs, and the RAOs would be achieved upon completion of construction. The institutional controls could be fully implemented within approximately 1 year of construction completion.
- Engineering controls, BMPs, and other measures to ensure compliance with ARARs would control short-term risks during implementation. Potential impacts resulting from release of dredging residuals would be identified and addressed through an appropriately designed water quality monitoring and post-dredge sediment sampling program.
- The potential for undetected release of residual COIs left in place at depth in sediment (e.g., from isolated erosion in MNR areas) is small. In design, consideration would be given to long-term function, including resistance to cap erosion due to propeller wash, or other wave/wake-induced forces.
- Long-term performance would be verified through monitoring and periodic reviews. Land use restrictions would also contribute to the long-term integrity of the post-remedy sediment bed by reliably minimizing the potential for future uncontrolled activities that could disturb the sediment or impede natural recovery.
- Maintenance and monitoring protocols would be established such that appropriate response actions would be taken should monitoring indicate that a portion of the remedy is not achieving the performance standards.

Implementability

Based on the proven success of similar EPA Region 10 removal/capping projects, Alternative 4(r) can be reliably implemented in a manner consistent with Alternative 2(i).

Cost

The estimated removal action cost for Alternative 4(r) is detailed in Table 7-3. The total estimated costs include present-value O&M costs estimated for 30 years, based on a 7 percent discount rate. Over the 30-year period, operation costs assume seven monitoring events, and maintenance costs assume five cap repair events. O&M costs were not projected beyond 30 years because their effect on net present value becomes diminishingly small.

7.2.8 Alternative 5 – Nearshore CDF

Alternative 5 centers on the creation of a nearshore CDF to partially contain contaminated sediments along the shoreline, generally in the nearshore area between Docks 1 and 2

(Figure 7-7). Outside of the CDF footprint, sediment would be dredged to a maximum depth of 15 ft bml within Areas 1 and 2. MNR would be applied under a maintenance and monitoring approach to address the remainder of the EPA-directed RAA boundary.

7.2.8.1 Docks, Debris and Outfall Removal

Existing docks, creosote-treated piling, debris and outfalls would be handled as described under Alternative 2(i).

7.2.8.2 Bank Regrading and Capping

Riverbank regrading and capping would occur as described for Alternative 2(i).

7.2.8.3 Dredging

Under Alternative 5, sediment within Area 1, outside of the CDF boundary, and in Area 2 would be dredged to a practical maximum depth of 15 ft bml. Suitable backfill would be placed within the dredge prism, as described for Alternative 4(i). The dredging would occur as described for Alternative 2(i).

7.2.8.4 Confined Disposal Facility

A nearshore CDF would likely be constructed utilizing a sheetpile wall which would be keyed into the upland barrier slurry wall to be constructed in support of the upland groundwater SCM. Following placement, consolidation, and dewatering of dredged sediment within the cell, an impermeable, engineered cap would be placed over the CDF to minimize infiltration of stormwater. As an additional containment measure, a system of groundwater extraction wells could be installed, if necessary based on a detailed analysis in the design phase, within the CDF footprint and connected to the GWET system to maintain an inward hydraulic gradient within the CDF. A feasibility-level screening of CDFs, including the conceptual CDF proposed for the Arkema site under this alternative, is presented in the draft Portland Harbor FS (Anchor QEA et al. 2012). In addition, LSS has conducted a separate CDF screening evaluation (ARCADIS 2010) for the Arkema RAA. This screening-level evaluation concluded there were no fatal flaws that would preclude implementation of a CDF at the Arkema site, and identified further technical considerations for design. The conceptual layout of this alternative is illustrated on Figure 7-7.

7.2.8.5 Residuals Management

The strategy for management of residuals would be generally the same as described for Alternative 2(i).

7.2.8.6 Construction Approach

The construction approach would be generally the same as described for Alternative 2(i), with the exception that docks would certainly be removed.

7.2.8.7 Institutional Controls

Institutional controls would be implemented as described for Alternative 2(i).

7.2.8.8 Monitoring, Maintenance, and Reviews

Long-term monitoring, maintenance, and periodic reviews would be implemented as described for Alternative 2(i).

7.2.8.9 Summary of Construction Quantities

The estimated volumes of bank excavation, dredging, and capping associated with Alternatives 2 through 5 are summarized in Table 7-1.

7.2.8.10 Evaluation of Alternative 5

An initial evaluation of Alternative 5 is provided below. Section 8 includes a comparative analysis of all of the alternatives.

Effectiveness

Alternative 5 would be effective in removing and containing sediment with total DDx and other COIs within the EPA-directed RAA. Removal, a CDF, and MNR are proven technologies that have been successfully implemented in similar CERCLA sediment cleanup actions. Impacted material that remains in place at the RAA would be reliably contained by the CDF, suitable backfill, and MNR.

Other considerations related to the effectiveness of Alternative 5 are summarized below:

- Alternative 5 satisfies the RAOs by creating a post-construction sediment surface that meets the RALs across the EPA-directed RAA and provides effective long-term containment of remaining COIs.
- By meeting the RALs in sediment, Alternative 5 would be protective of human health and the environment.
- Alternative 5 would remove a total of approximately 57,000 cy of sediment and soil containing total DDx, and other COIs, and dispose of this material in a nearshore CDF. Remaining impacted material would be reliably contained in-place beneath suitable

backfill or by MNR. The following summarizes the predicted COI mass removal under Alternative 5.

- As is summarized in Table 7-2, predicted RM 6.5–7.5 SWACs following implementation of Alternative 5 are significantly reduced. Percent reductions in SWACs are on the order of 27 to 55 percent for DDx and 46 percent for 2,3,4,7,8-PCDF. However, despite the large volume of sediment, and corresponding COI mass that would be removed under Alternative 5, the predicted SWAC concentrations are not substantially different from those predicted for the other alternatives. Land use restrictions, long-term monitoring, and periodic reviews would ensure long term protection of human health and the environment.
- Alternative 5 could be implemented in compliance with all ARARs.
- Alternative 5 includes provisions for treatment to reduce the mobility of dissolved contaminants through diffusive and advective processes, if necessary.
- Alternative 5 can be implemented in two to three construction seasons, and the RAOs would be achieved upon completion of construction. The institutional controls could be fully implemented within approximately 1 year of construction completion.
- Engineering controls, BMPs, and other measures to ensure compliance with ARARs would control short-term risks during implementation. Potential impacts resulting from release of dredging residuals would be identified and addressed through an appropriately designed water quality monitoring and post-dredge sediment sampling program.
- The potential for undetected release of residual contaminants left in place at depth in sediments (e.g., from isolated erosion in MNR areas) is small.
- Alternative 5 would permit future navigational use of the EPA-directed RAA by heavy tugs, and the CDF would be amenable for development into a dock/pier facility.
- The CDF cap would be designed for long-term function, and long-term performance would be verified through monitoring and periodic reviews.
- Land use restrictions would also contribute to the long-term integrity of the post-remedy sediment bed by reliably minimizing the potential for future uncontrolled activities that could disturb sediment or impede natural recovery.
- Maintenance and monitoring protocols would be established such that appropriate response actions would be taken should monitoring indicate that a portion of the remedy is not achieving the performance standards.
- Land use restrictions would also contribute to the long-term integrity of the CDF by reliably minimizing the potential for future uncontrolled activities that could disturb the cap.

Implementability

Based on successful demonstration of nearshore and upland CDFs at other sediment management sites within EPA Region 10, Alternative 5 can be reliably implemented using commonly available upland and marine construction equipment and materials. Imported material would be brought onsite with conventional trucking or barge equipment. For work on the riverbanks, the contractor would schedule excavation and capping activities to take best advantage of low water conditions to accomplish work in-the-dry. The remainder of the work (including CDF pile installation) would likely be completed using a combination of conventional marine and upland construction methods, as dictated by water level and the required draft for the barges. The major implementability issues with CDFs include compatibility with ongoing site uses, and future maintenance requirements. The concept for the Arkema site would incorporate new vessel berthing, and the layout provides separation from the navigation channel. Therefore, the CDF is not anticipated to impede vessel traffic. The retaining structure would require monitoring and maintenance over time to ensure its integrity. Finally, the construction of the CDF may result in unavoidable loss of habitat, although the conceptual layout places the CDF within the most impacted portion of the RAA. Potential losses would require offset by requirements for compensatory mitigation, as described in the draft Portland Harbor FS (Anchor QEA et al. 2012).

Cost

The estimated removal action cost for Alternative 5 is detailed in Table 7-3. The total estimated costs include present-value O&M costs estimated for 30 years, based on a 7 percent discount rate. Over the 30-year period, operation costs assume seven monitoring events, and maintenance costs assume five CDF cap repair events. O&M costs were not projected beyond 30 years because their effect on net present value becomes diminishingly small.

8 COMPARATIVE ANALYSIS OF REMOVAL ACTION ALTERNATIVES

This section presents a comparative analysis of the retained removal action alternatives for the Arkema NTCRA. Although the results of the BHHRA represent that the 1-RM exposure is already below the target risk level of 10^{-4} for total DDT, total DDD, and total DDE, so that these constituents do not require remediation to a 10^{-4} risk level within the Portland Harbor site, Alternative 1 (the no action alternative) was eliminated from consideration in Section 7. Therefore, Alternative 1 is not considered in this comparative analysis. Consistent with EPA (1993) guidance, the analysis is based on a comparison of effectiveness, implementability, and cost with regard to the following specific criteria:

- Effectiveness
- Overall protection of human health and the environment
- Achievement of RAOs
- Compliance with ARARs
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Long-term effectiveness and permanence
- Implementability
- Technical feasibility and availability
- Administrative feasibility
- Cost.

The following subsections analyze the alternatives based on the EPA criteria, including a relative ranking of the alternatives for each criterion. Section 9 presents a preferred alternative. A proposed schedule for implementation of the preferred alternative is also provided in Section 9.

8.1 EFFECTIVENESS

8.1.1 Overall Protection of Human Health and the Environment

All of the removal action alternatives would reduce potential risks to human health and the environment over the long term through a combination of removal of soil and sediment contaminated with DDx and other contaminants, and containment of remaining contaminated

soil and sediment with engineered caps or through natural recovery. Each alternative would achieve the RAOs and comply with all ARARs. Each alternative employs removal and capping technologies, coupled with MNR, which are reliable and proven technologies that have been used successfully in similar sediment cleanup actions at EPA Superfund sites.

Under each alternative, some COIs would remain onsite (contained beneath engineered caps, backfill material, or natural sediment). Each alternative would include monitoring and periodic reviews to verify long-term protection of human health and the environment. Each alternative would also include land use restrictions as an additional means of maintaining long-term protection of human health and the environment. The land use restrictions would contribute to the long-term integrity of the caps and natural sediments by reliably minimizing the potential for future uncontrolled activities that could disturb them.

8.1.2 Achievement of RAOs

Figure 8-1 illustrates the conceptual points of compliance which will be used to measure achievement of the RAOs. Each of the alternatives would equally satisfy the RAOs for the RAA by creating a post-construction surface that meets the DDT RALs, and the DDE and 2,3,4,7,8-PCDF RAL over the sediment surface; and by providing effective long-term containment of remaining material with engineered caps and/or through MNR.

In addition to the specific Arkema NTCRA RAOs, the NCP [40 CFR 300.415(c)] states that removal actions shall, to the extent practicable, contribute to the efficient performance of any anticipated long-term remedial action with respect to the release concerned. Each of the alternatives would be compatible with potential long-term remedial actions for Portland Harbor. Additionally, none of the alternatives is expected to preclude possible mitigation projects in nearby areas should such projects be identified in the future.

8.1.3 Compliance with ARARs

Consistent with the NCP, each of the alternatives would satisfy the substantive requirements of all ARARs. None of the alternatives would require waivers of any ARARs.

8.1.4 Long-term Effectiveness and Permanence

All of the removal alternatives include, to varying extents, dredging/excavation of sediments and soil impacted by DDx and other EPA-directed COIs, capping and/or backfill in the excavated areas, and MNR for the remaining area of the EPA-directed RAA. Alternative 5 also includes installation of a nearshore CDF. The primary differentiating factors between the remedies is the lateral and vertical extent of removal, and, in turn, the extent of isolation by capping/backfill and MNR. All of the removal alternatives substantially reduce the occurrence of DDT, DDE, and 2,3,4,7,8-PCDF in surface sediments at concentrations exceeding the RALs,

and achieve similar magnitude of reductions in SWACs relative to PRGs for EPA-directed COIs. Figures 8-2 summarizes the relative reduction in RM 6.5 to 7.5 SWACs for each EPA-directed COI for integrated and removal emphasis alternatives. Reductions for DDT, DDE, and 2,3,4,7,8-PCDF are significant, generally ranging from 25 to 55 percent. Figure 8-3 presents the relative reduction in AOPC 14 SWACs for EPA-directed COIs for integrated and removal emphasis alternatives. This presentation further illustrates the significant reductions in surface concentrations of COIs as a result of each removal alternative.

All of the alternatives leave contaminants in place in site sediments to varying degrees. Each of the alternatives relies on containment by engineered caps, suitable backfill, and natural sediment for reliable long-term physical isolation of contaminated sediments that would remain in the EPA-directed RAA. Under Alternatives 2(r), 3(r), 4(r), and 5, any remaining sediment exceeding the DDT or 2,3,4,7,8-PDCF RALs, and the majority of sediments exceeding the DDE RAL, would be isolated by an engineered cap, suitable backfill or a CDF. Alternatives 2(i), 3(i), and 4(i) rely on continued MNR for further isolation of sediment in Area 2 and isolated portions of Area 1, where surface sediment is currently below RALs and the relatively few subsurface sediment samples exceeding the RALs are currently isolated by a minimum of 30 cm of native sediment.

Caps and backfill would be designed to remain stable and provide long-term containment in accordance with EPA/USACE guidance, and would also be designed for long-term seismic stability. Multiple lines of evidence show that the site is depositional and the risk of erosion of engineered caps, backfill, and native sediment is small. Institutional controls, such as land use restrictions, would reliably minimize the potential for future uncontrolled activities that could result in localized erosion. Long-term reliability of the caps and backfill would be verified through LTMRP that requires periodic monitoring and repair of the cap/backfill area, if needed. MNR would be applied within a maintenance and monitoring framework developed during the remedial design, which would establish protocols to monitor natural recovery and to implement, as necessary, additional remediation measures (e.g., ENR, capping) should monitoring indicate that natural recovery is not achieving the removal action objectives. The long-term effectiveness would also be assessed through periodic reviews, no less frequently than every five years.

Under Alternatives 2(i) and 2(r), material containing DDx would remain. Under Alternative 2(r), the sediment exceeding the RALs below the 3-ft dredge prism in Areas 1 and 2 would be isolated under an engineered cap. There are currently no surficial sediment RAL exceedances and isolated small pockets of subsurface sediment exceeding the RALs in Area 2, which are currently isolated by approximately 30 cm native depositional sediment. Under Alternative 2(i), Area 2 would continue to be isolated by native sediment and no cap would be placed in this area. In general, Alternative 2(r) might have somewhat greater long-term effectiveness and permanence than Alternative 2(i) due to the greater degree of isolation by capping versus MNR; however, the difference in effectiveness and permanence is extremely small, as both the cap and

native sediment deposition are predicted to be stable and maintenance and monitoring protocols would be established such that timely and appropriate mitigation measures could be enacted should any sediment erosion be determined to occur.

Under Alternatives 3(i) and 3(r), a larger volume of sediment containing DDx and PCCD/F, compared to 2(i) and 2(r), would be removed prior to backfill and capping, providing potentially greater long-term effectiveness/permanence than Alternatives 2(i) and 2(r). Also, the mass-based removal under Alternative 3(i) and 3(r) would eliminate areas where comparatively high DDx and PCCD/F concentrations immediately underlie the cap. Remaining material that exceeds RALs would be contained under existing layers of cleaner sediment and/or backfill, which in turn would be contained by engineered cap materials. These cleaner sediment deposits beneath the cap would enhance the long-term cap performance by providing an additional barrier to any potential contaminant transport. As above for Alternative 2(i), the cap for Alternative 3(i) would not include Area 2 and portions of Area 1, where there are currently no or few surficial sediment RAL exceedances, subsurface sediment RAL exceedances are currently buried by a minimum of 30 cm of native sediment, and ongoing natural recovery is occurring. As such, Alternative 3(r) might have somewhat greater long-term effectiveness/permanence than Alternative 3(i) due to the greater degree of isolation by capping versus MNR; however, the difference in effectiveness and permanence is extremely small.

Under Alternatives 4(i) and 4(r), significantly more sediment volume would be removed; however, these alternatives would not remove appreciably more DDx/contaminant mass compared to Alternatives 2(i), 2(r), 3(i), 3(r), and 5; and, thus, Alternatives 4(i) and 4(r) potentially would achieve little greater long-term effectiveness and permanence. Some sediment exceeding the RALs would remain at depth beneath the footprint of the excavation (>15 ft bgs). This sediment would be isolated by 15 ft of backfill material. There are currently no surficial sediment RAL exceedances and subsurface sediment exceeding the RALs in Area 2 and portions of Area 1, where sediment RAL exceedances are currently buried by a minimum of 30 cm of native sediment and ongoing natural recovery is occurring. Under Alternative 4(i), these areas would not be dredged. As such, Alternative 4(r) might have somewhat greater long-term effectiveness/permanence than Alternative 4(i) due to the greater degree of isolation by capping versus MNR; however, the difference in effectiveness and permanence is extremely small.

Under Alternative 5, all sediment and soil exceeding RALs at a depth of 15 ft bml or less would either be dredged/excavated and placed in a CDF or isolated beneath the CDF due to its configuration. Remaining sediment exceeding RALs would be isolated by 15 ft of backfill material. Alternative 5 would have a greater level of long-term effectiveness and permanence than Alternatives 2(i), 2(r), 3(i), 3(r), and 4(i), but a somewhat lower level than Alternative 4(r) as impacted materials would remain onsite under Alternative 5.

8.1.5 Reduction of Toxicity, Mobility, or Volume through Treatment

The SCMs for groundwater, which include a barrier wall and groundwater extraction and treatment system, will greatly reduce the potential for any advective transport of EPA-directed COIs to cap and backfill materials in the vicinity of the Docks 1 and 2 (Area 1). Impacted sediments downriver of Dock 2 (Area 2) are not downgradient of upland groundwater impacts and are thus not affected by the groundwater SCMs. However, COIs in this area are largely limited to low mobility contaminants (DDx, 2,3,4,7,8-PCDF) which are unlikely to migrate with discharging groundwater. All of the alternatives include, as a contingency measure, provisions for localized inclusion of reactive media (e.g., GAC, organoclay) in cap/backfill materials or ENR, should contaminant mobility (e.g., through diffusion or groundwater upwelling) be determined to be of importance during remedial design or groundwater SCM performance monitoring.

8.1.6 Short-term Effectiveness

Alternatives 2(i) and 2(r) are anticipated to be completed in one construction season. Alternatives 3(i) and 3(r) are anticipated to require one to two construction seasons. Alternatives 4(i), 4(r), and 5 are likely to require three construction seasons; however, the time needed for construction may approach the limits of the in-water construction window. It is possible that an extension of the allowable period of in-water work would be required under Alternatives 4(i), 4(r), and 5 to achieve this. If needed, such an extension would be coordinated with the regulatory agencies. Under each alternative, institutional controls could be fully implemented within approximately 1 year of construction completion. Under each alternative, the RAOs would be achieved upon completion of construction.

None of the alternatives poses significant short-term risks to the community during implementation. Alternatives 2(i) and 2(r) pose the least potential short-term risks to the community, as these alternatives involve the least material transport, whereas Alternatives 4(i) and 4(r) have substantially greater transport requirements than the other alternatives. It is anticipated that most material transport would occur by barge, rail, or truck traffic through industrial areas for offsite disposal and/or importing suitable backfill. Risks to workers during implementation would be managed through standard engineering and safety controls.

Short-term risks to the environment during implementation would be limited through engineering controls, BMPs, and other measures to ensure compliance with ARARs (e.g., observance of fish windows). Under Alternatives 2(i) and 2(r), the potential for releases of material to the environment during construction would be minimal because a smaller volume of contaminated material would be excavated or dredged, and all surrounding areas would subsequently be capped. Alternatives 4(i), 4(r), 5, and, to a lesser extent, Alternatives 3(i) and 3(r), involve considerably larger dredge prisms, and there is a greater potential for impacts from dredging residuals as a consequence. Monitoring and contingency actions (potentially

including ENR) would be employed as needed to address residuals under any of the alternatives. Potential short-term impacts to water quality would be of greater duration under Alternatives 4(i), 4(r), and 5, as additional seasons of in-water work, including significantly more dredging, would be required.

Soil and sediment containing DDx are present in the riverbank. Each alternative would include measures to limit releases of contaminated materials from the banks during implementation. Bank excavations would proceed from the top of the bank downward, would occur in-the-dry (as practicable), and the excavated face would be capped soon after it is exposed.

For each alternative, the design would specify requirements for environmental protection during excavation, dredging, and capping activities.

8.2 IMPLEMENTABILITY

8.2.1 Technical Feasibility

Sequencing of the work would be critical for successful implementation of any alternative. Each alternative would be sequenced to limit the potential for water-borne sediment transport and recontamination of areas outside the removal boundary. The implementation of Alternatives 2(i), 2(r), 3(i), 3(r), 4(i), and 4(r) would likely be based on the following general sequencing:

- Removal of debris
- Excavation of riverbank
- Dredging of sediments
- Capping of the riverbank and sediments
- Implementation of contingency actions for residuals management, as required based on post-dredge sampling.

The implementation of Alternatives 5 would likely be based on the following general sequencing:

- Removal of docks, and debris
- Construction of nearshore CDF
- Dredging of sediments
- Dewatering of sediments within the CDF
- Capping of the CDF

- Implementation of contingency actions for residuals management, as required based on confirmation sampling.

The extended construction duration for Alternatives 4(i), 4(r), and 5 would necessitate some construction downtime and project delays. Under all of the alternatives, documentation sampling of excavated banks would be completed prior to cap placement; however, the bank capping could proceed before sample results were reported.

For work on the banks, the contractor would schedule excavation and capping activities to take best advantage of low water conditions to accomplish work in-the-dry as practicable. However, it may not be feasible to accomplish all of the bank work in-the-dry. The remainder of the work (including most dredging and capping) would be completed using floating equipment and conventional marine construction methods, working at higher water conditions, as needed, to provide the required draft for the barges.

Sequencing will be further addressed during design, including development of provisions to protect and monitor sediment quality in completed areas of the RAA from the impacts of subsequent work in adjacent areas.

While Alternatives 4(i), 4(r), and 5 can be reliably implemented, these alternatives require greater consideration of design, monitoring, and construction elements than Alternatives 2(i), 2(r), 3(i), and 3(r).

8.2.2 Availability

Each of the alternatives can reliably be implemented using commonly available upland and marine construction equipment and materials. Dredged or excavated materials would be either loaded onto trucks or rail cars onsite or loaded onto conventional barges and moved offsite. The material from barges would be offloaded to either rail cars or trucks at a transloading facility in the project vicinity. Imported material can be brought onsite with conventional trucking or barge equipment. Numerous local contractors are experienced in this type of work. The volume of contaminated sediments that would be shipped offsite for upland landfill disposal is not anticipated to impact the capacity of the receiving facilities, although this may depend on the sequencing of this action relative to other remedial actions within the harbor.

8.2.3 Administrative Feasibility

Arkema, through its agent LSS, will coordinate, as needed, to arrange access and staging areas during the work, implement land-use restrictions for long-term protection of the capped area, and provide easements allowing access for future long-term monitoring activities. Institutional controls that will limit any uncontrolled disturbance of capped areas will be developed as part of the design process, as described in Section 6. Although the specifics would vary among the

alternatives, the institutional controls are considered to be administratively feasible for each alternative. Alternative 5 has the lower administrative feasibility relative to the other alternatives.

8.3 COST

The estimated costs (NPV) for the removal alternatives are summarized in Table 7-3, and include long-term monitoring and maintenance costs for the capping and MNR components of the cleanup.

8.4 SUMMARY OF COMPARATIVE ANALYSIS

Table 8-1 presents a comparison of the removal alternatives. This analysis is summarized below, and the removal alternatives are ranked relative to one another for effectiveness, implementability, and cost:

- **Effectiveness:** Each alternative would provide overall protection of human health and the environment and can achieve the RAOs. Each alternative can be implemented in compliance with ARARs. Alternative 2(i), followed by Alternative 2(r), has the greatest short-term effectiveness as it would avoid potential impacts from disturbance and transport of the deeper buried contaminated sediments. Due to the greater amount of dredging and longer project duration, Alternatives 4(i), 4(r), and 5 would pose the greater short-term risk of recontamination caused by dredging and would have greater short-term water quality impacts during dredging. Alternative 3(i), followed by Alternative 3(r), strikes a balance between the removal-focused and containment-focused removal alternatives in terms of potential short-term risk. Each alternative would be effective in the long-term; however, Alternatives 2(i), 2(r), 3(i), and 3(r) would require somewhat greater maintenance over the long-term to ensure the integrity of the cap and for MNR. Each alternative would include institutional controls, long-term monitoring, and periodic reviews to ensure long-term protectiveness.

- **Implementability:** For overall implementability, Alternatives 2(i), 2(r), 3(i), and 3(r) rank highest, followed by Alternatives 4(i), 4(r), and 5. Each of the alternatives can reliably be implemented; however, Alternatives 4(i), 4(r), and 5 would require multiple construction seasons special consideration of design, monitoring, and construction elements.

- **Cost:** The cost evaluation considers capital costs and the net present value of long-term monitoring and maintenance costs. Alternative 2(i) followed by Alternative 2(r) are least costs, followed in order of increasing cost by Alternatives 3(i), 3(r), 4(i), 4(r), and 5.

9 RECOMMENDED REMOVAL ACTION ALTERNATIVE AND IMPLEMENTATION

The recommended alternative for the Arkema NTCRA is Alternative 2(i). Alternative 2(i):

- Is protective.
- Achieves site-specific RAOs.
- Complies with ARARs.
- Minimizes the potential for short-term contaminant release resulting from disturbance of contaminated sediments by emphasizing MNR and capping over dredging.
- Provides long-term effectiveness through partial removal, containment, and MNR.

Each of the alternatives assembled in this EE/CA provide nearly equivalent levels of long-term effectiveness and permanence; however, Alternatives 3(i), 3(r), 4(i), 4(r), and 5 have a greater potential for short-term impacts due to greater disturbance of contaminated sediments during dredging. Alternative 2(i) provides an emphasis on in-place containment over dredging and, therefore, minimizes the potential for short-term impacts resulting from the disturbance of contaminated sediment. Further, Alternative 2(i) emphasizes MNR in areas where there are currently no surficial sediment RAL exceedances and where impacts to subsurface sediments are isolated and occur at low-levels relative to areas of the site where dredging and capping will occur. Impacted subsurface sediment in these area are currently buried by native sediment and will continue to be buried by ongoing sediment deposition, eliminating the potential for disturbance of contaminated sediment in these areas.

Figure 9-1 presents the anticipated schedule for implementation of Removal Alternative 2(i) based on the Arkema EE/CA SOW. Remedy implementation and the scheduling of in-water construction activities will be coordinated within allowable construction windows. Proper sequencing within the RAA will involve removal of higher contaminated materials first in order to eliminate potential for recontamination of the remaining sediment area.

An LTMRP will be developed during the Arkema NTCRA design. Monitoring and maintenance of the RAA will be part of the post-NTCRA activities, and will involve periodic sampling of the cap and MNR surface sediments to verify ongoing compliance with the RAOs, and monitoring of site bathymetry to verify ongoing stability of cap surface. The plan will also include maintenance and monitoring provisions to repair or replace cap and MNR areas that fail to satisfy long-term performance requirements.

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FIGURES

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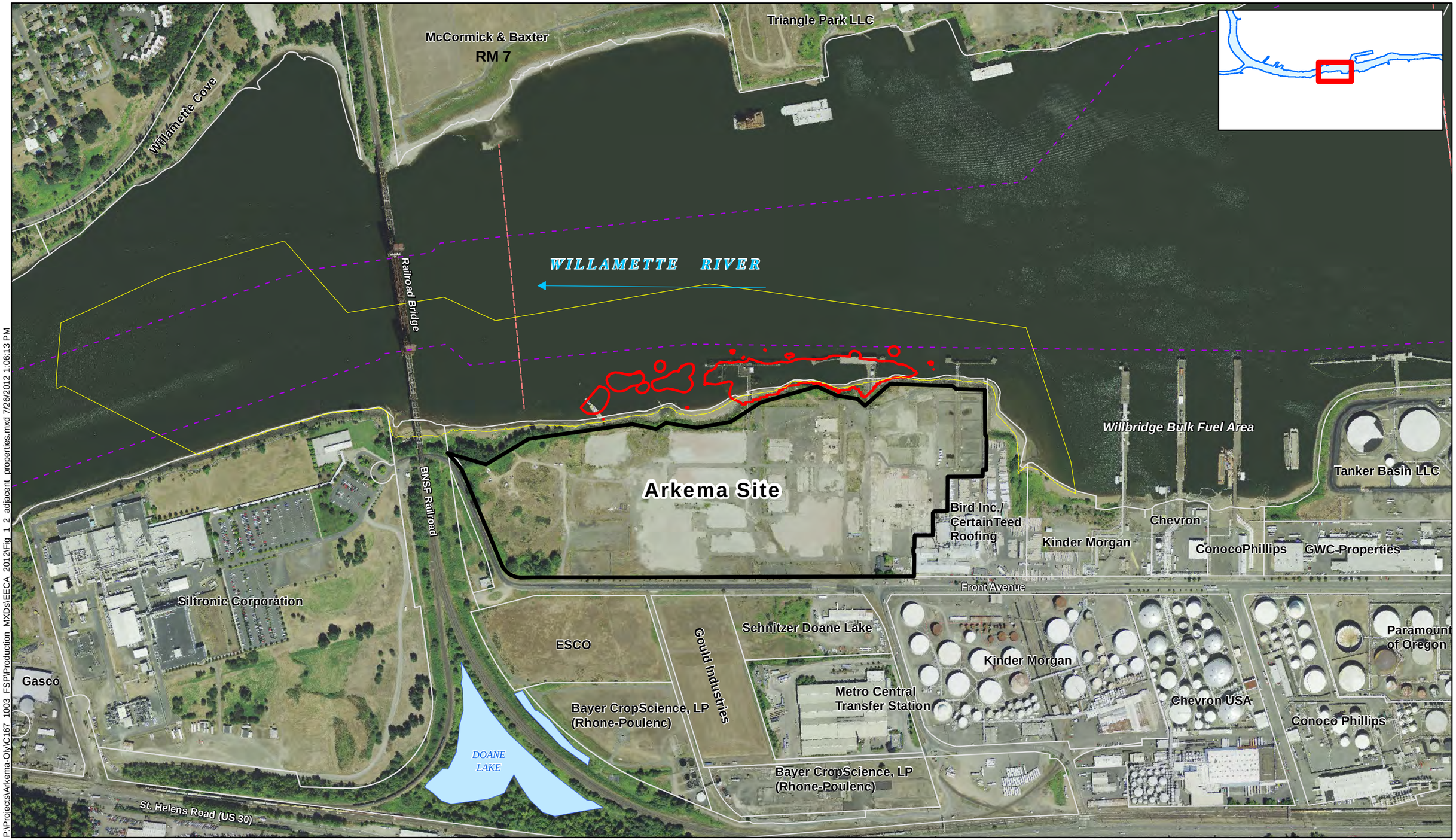
N

FEATURE SOURCES:
Property Boundaries and Transportation Features: Metro RLIS, 2010

0 0.75 1.5 3 Miles

DRAFT

Figure 1-1
Site Location
Arkema Early Action
Draft EE/CA Report



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integral consulting inc.

FEATURE SOURCES:
Aerial: Metro, 2007
Property Boundaries: Metro RLIS

0 250 500 Feet

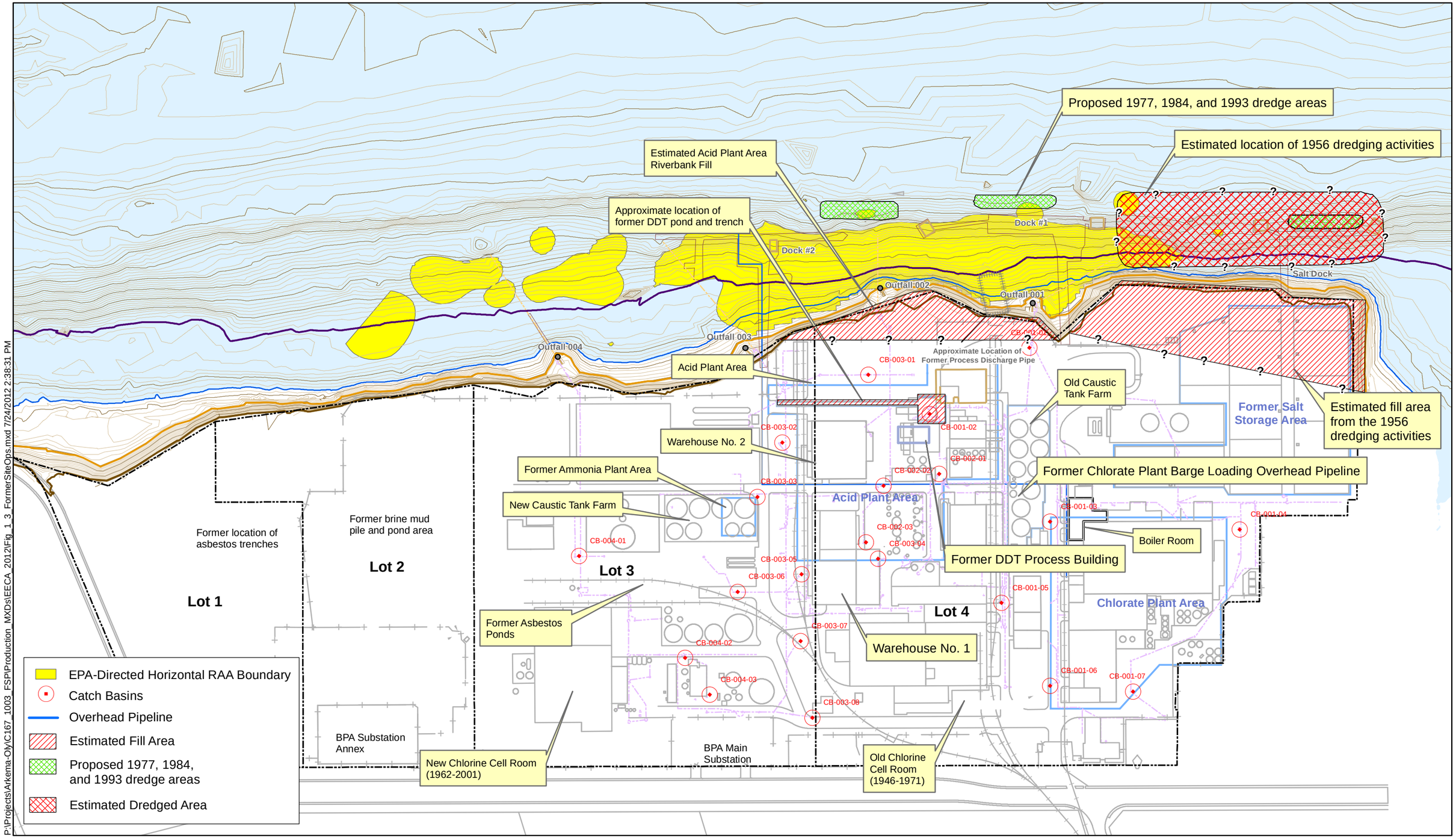
N

Map Features

- EPA-Directed Horizontal RAA Boundary
- Sediment Management Area 14
- River Miles
- Navigation Channel
- Waterfront Taxlots
- Doane Lake (Current)

DRAFT

Figure 1-2
Aerial Photograph and Adjacent Properties
Arkema Early Action
Draft EE/CA Report



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integral consulting inc.

FEATURE SOURCES:
Property Boundaries, OHW, TOB: 2007 DEA Topographic Survey
Navigation Channel: US Army Corps of Engineers
Elevation Contours: Areas Below +16 ft: 2004 Bathymetry and 2001 LiDAR;
Area above +16ft: 2007 DEA Topographic Survey

0 100 200 Feet

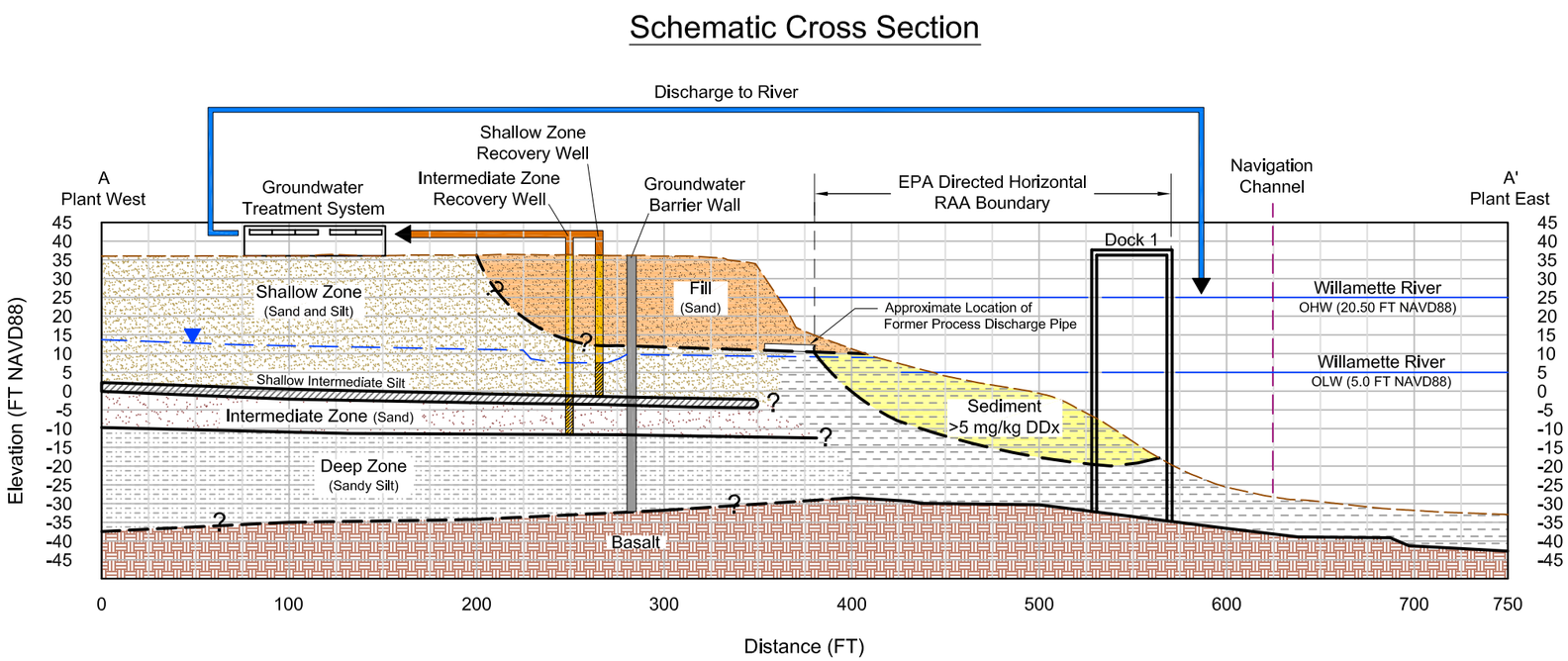
N

Map Features

- Property and Lot Boundary
- Navigation Channel
- Top of Bank
- +13 ft NAVD88
- Ordinary High Water (20.5 ft NAVD88)
- Ordinary Low Water (5 ft NAVD88)
- 5 ft Contour (NAVD88)
- 1 ft Contour (NAVD88)
- Docks and Structures
- Storm Drain
- Sewer Line
- River Edge

DRAFT

Figure 1-3
Dredge and Fill and Historical Uses at the Site
Arkema Early Action
Draft EE/CA Report



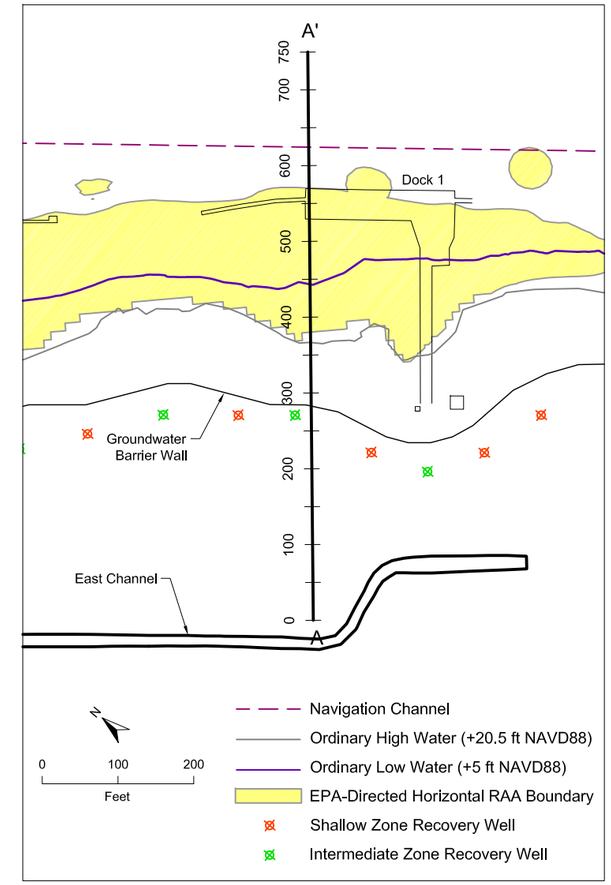


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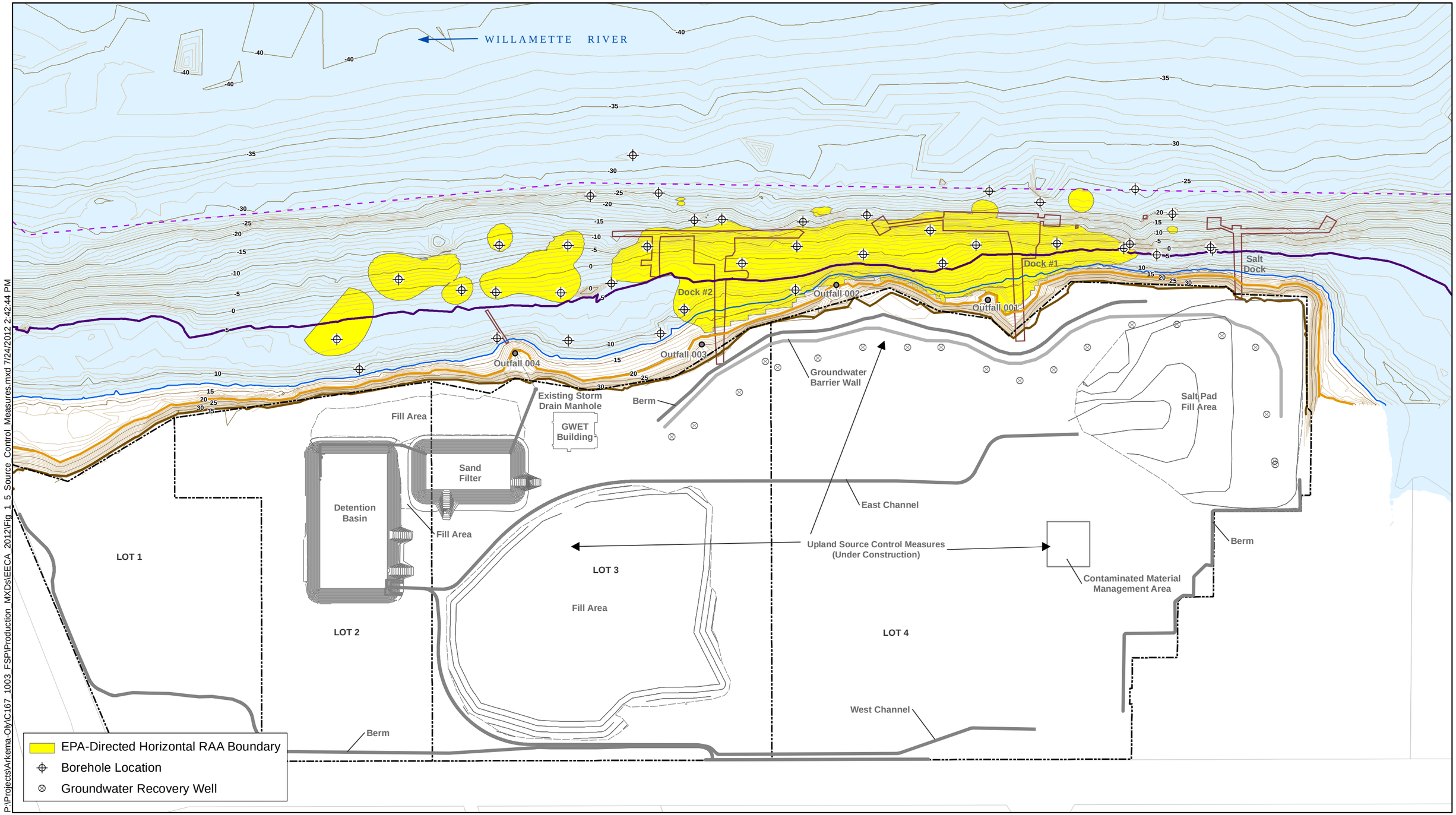
Figure 1-4
Conceptual Geologic Cross Section and
Conceptual Schematic of the Groundwater SCM
Arkema Early Action
Draft EE/CA Report



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integral consulting inc.

FEATURE SOURCES:
Property Boundaries, OHW, TOB: 2007 DEA Topographic Survey
Navigation Channel: US Army Corps of Engineers
Elevation Contours: Areas Below +16 ft: 2004 Bathymetry and 2001 LiDAR;
Area above +16ft: 2007 DEA Topographic Survey

0 100 200 Feet

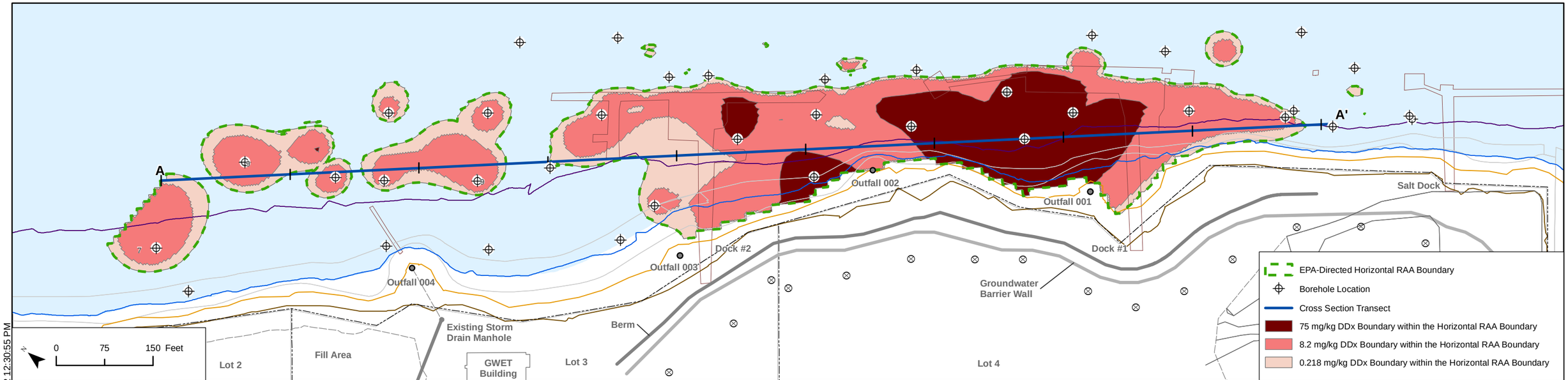
N

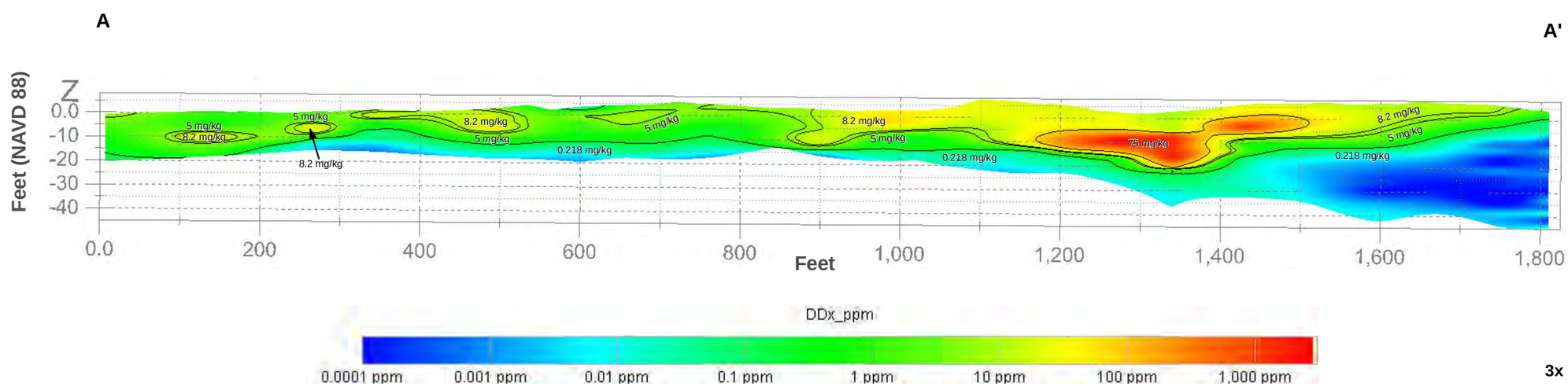
Map Features

- Property and Lot Boundary
- Navigation Channel
- Top of Bank
- +13 ft NAVD88
- Ordinary High Water (20.5 ft NAVD88)
- Ordinary Low Water (5 ft NAVD88)
- 5 ft Contour (NAVD88)
- 1 ft Contour (NAVD88)
- Docks and Structures
- River Edge

DRAFT

Figure 1-5
Source Control Measures
Arkema Early Action
Draft EE/CA Report





3x Vertical Exaggeration

All boundaries use 15 anisotropy.

ppm = mg/kg

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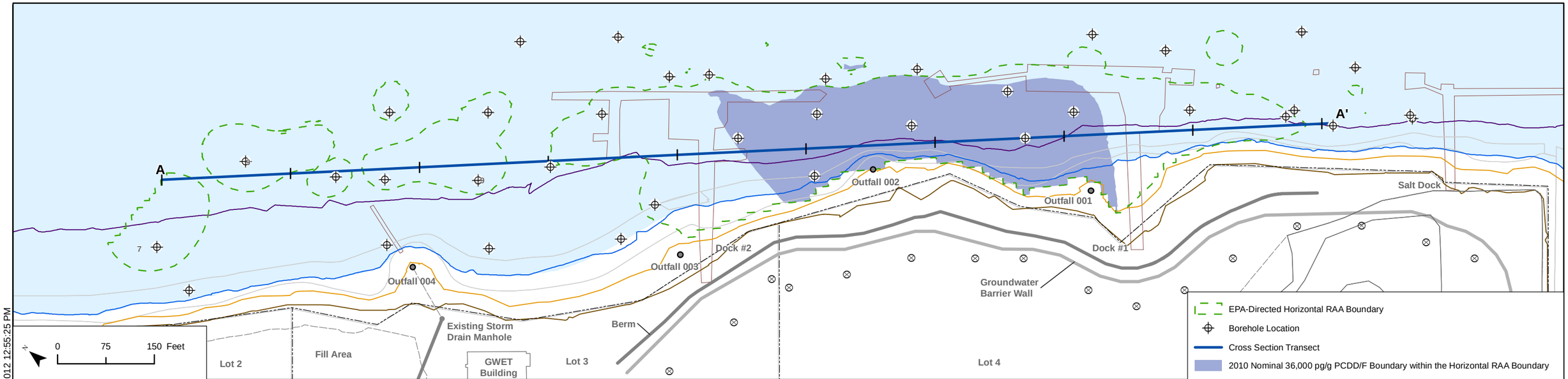
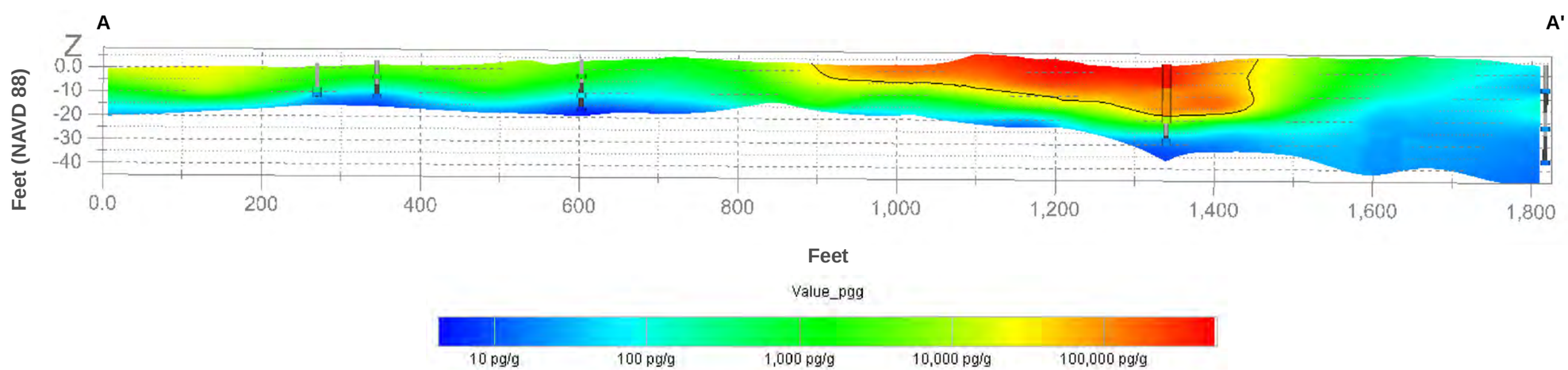
Map Features

- Property and Lot Boundary
- Groundwater Recovery Well
- Top of Bank
- +13 ft NAVD88
- Ordinary High Water (20.5 ft NAVD88)
- Ordinary Low Water (5 ft NAVD88)
- Docks and Structures
- River Edge

DRAFT

Figure 2-1
DDx Contours and Cross Section
within the EPA-Directed Horizontal RAA Boundary
Arkema Early Action
Draft EE/CA Report





3x Vertical Exaggeration

Boreholes within 20 feet of cross section transect are projected onto the profile.

All boundaries use 15 anisotropy.

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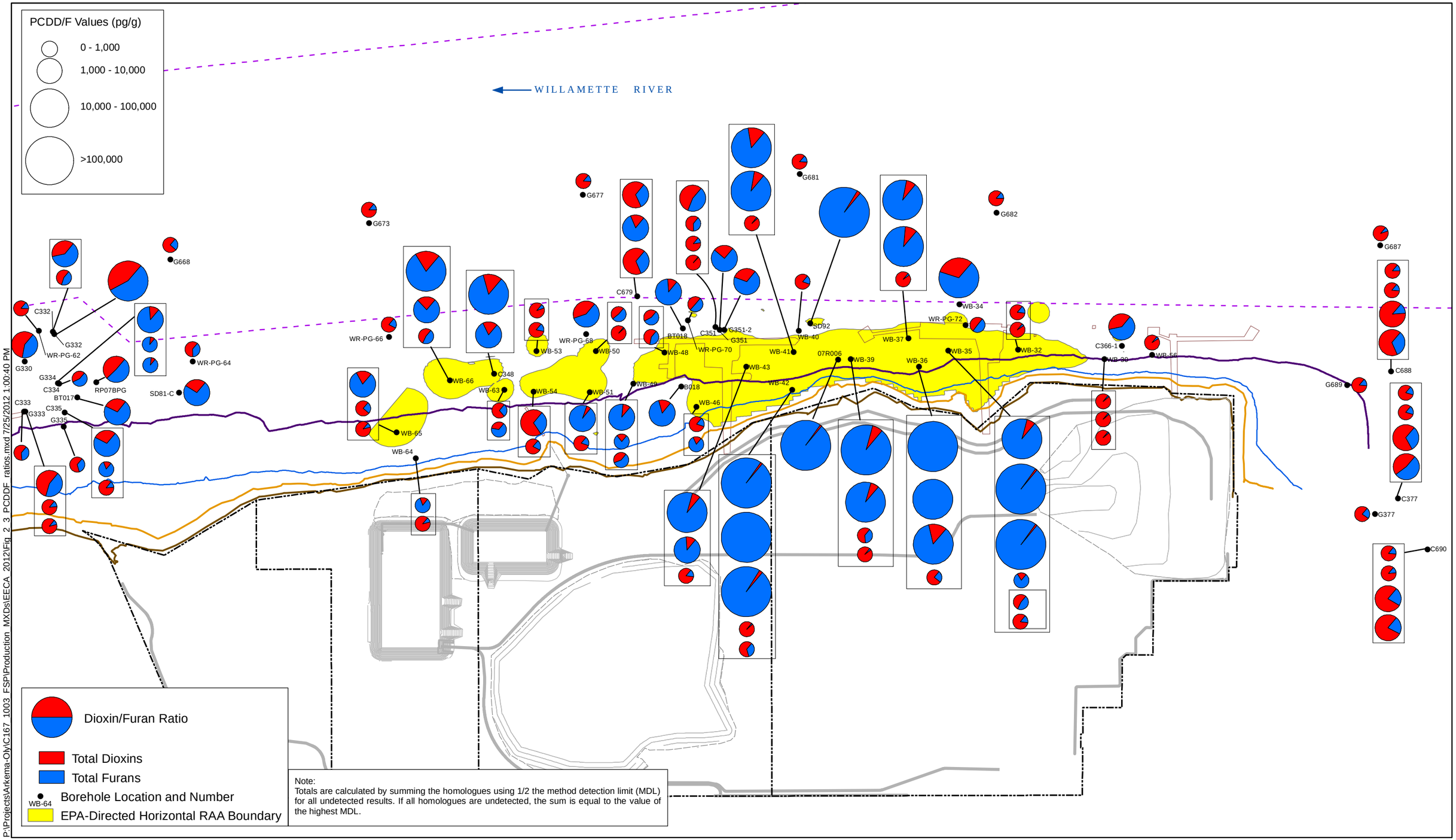
Map Features

- Property and Lot Boundary
- Groundwater Recovery Well
- Top of Bank
- +13 ft NAVD88
- Ordinary High Water (20.5 ft NAVD88)
- Ordinary Low Water (5 ft NAVD88)
- Docks and Structures
- River Edge

DRAFT

Figure 2-2
Total PCDD/F Contours
within the EPA-Directed Horizontal RAA Boundary
Arkema Early Action
Draft EE/CA Report



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FEATURE SOURCES:
Property Boundaries, OHW, TOB: 2007 DEA Topographic Survey

0 150 300 Feet

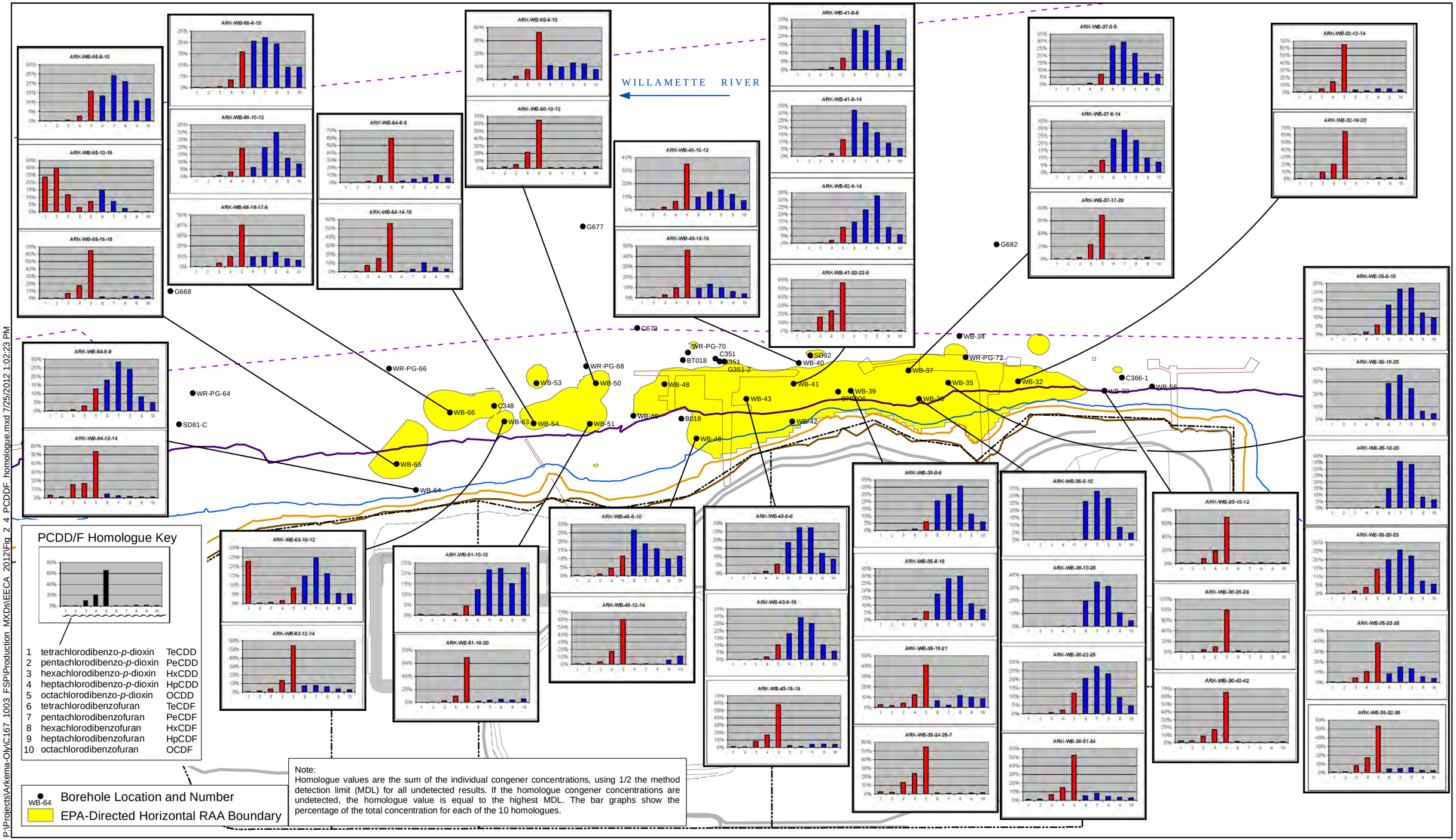
N

Map Features

- Property and Lot Boundary
- Navigation Channel
- Top of Bank
- +13 ft NAVD88
- Ordinary High Water (20.5 ft NAVD88)
- Ordinary Low Water (5 ft NAVD88)
- Docks and Structures

DRAFT

Figure 2-3
PCDD/PCDF Ratios in Sediment Samples
Arkema Early Action
Draft EE/CA Report



integral consulting inc.

FEATURE SOURCES:
Property Boundaries, OHW, TOB: 2007 DEA Topographic Survey

0 150 300 Feet

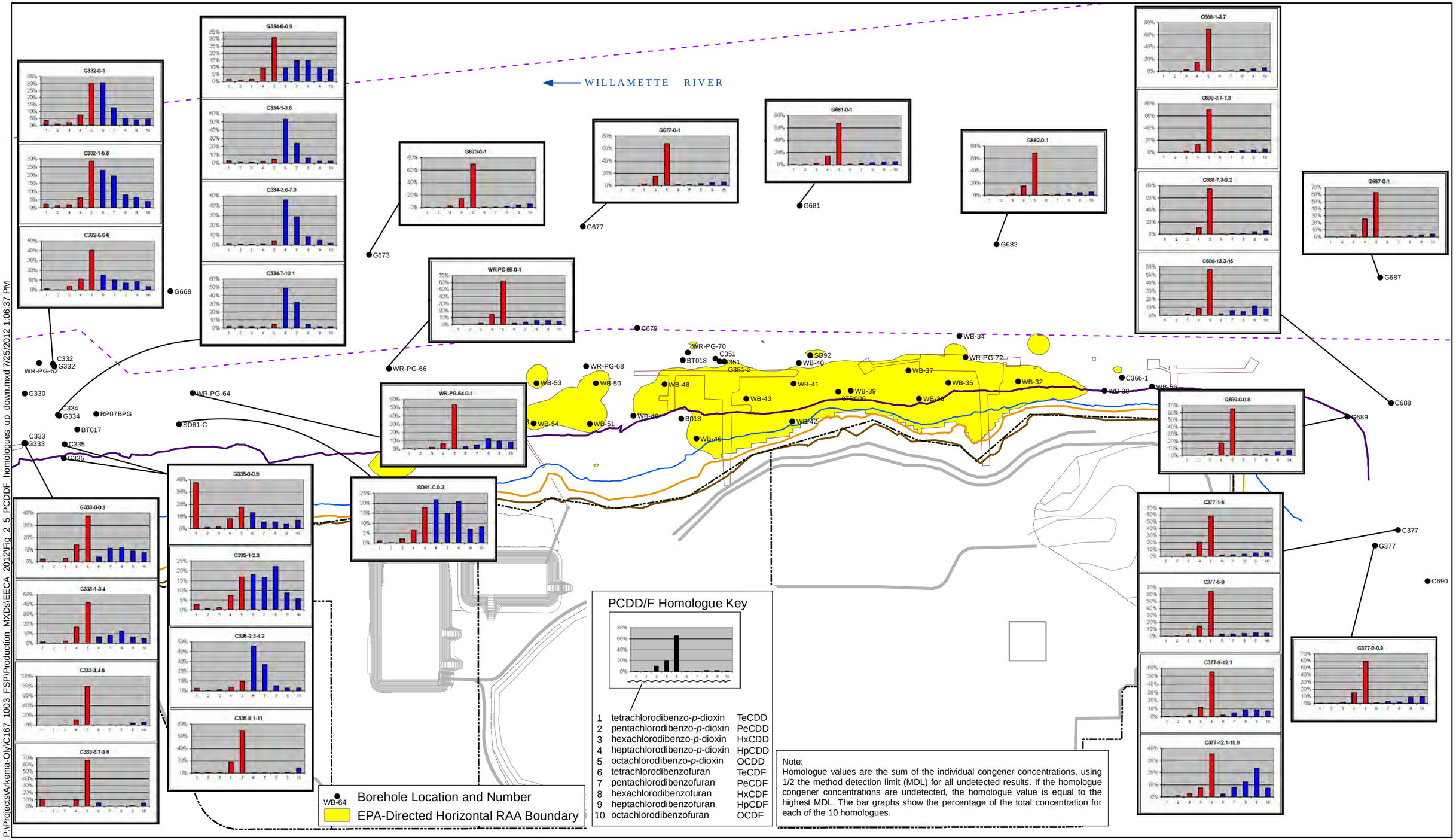
N

Map Features

- Property and Lot Boundary
- Navigation Channel
- Top of Bank
- +13 ft NAVD88
- Ordinary High Water (20.5 ft NAVD88)
- Ordinary Low Water (5 ft NAVD88)
- Docks and Structures

DRAFT

Figure 2-4
PCDD/F Homologue Plots for Sediment Samples
within and Adjacent to the EPA-Directed Horizontal RAA Boundary
Arkema Early Action
Draft EE/CA Report



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integral consulting inc.

FEATURE SOURCES:
Property Boundaries, OHW, TOB: 2007 DEA Topographic Survey

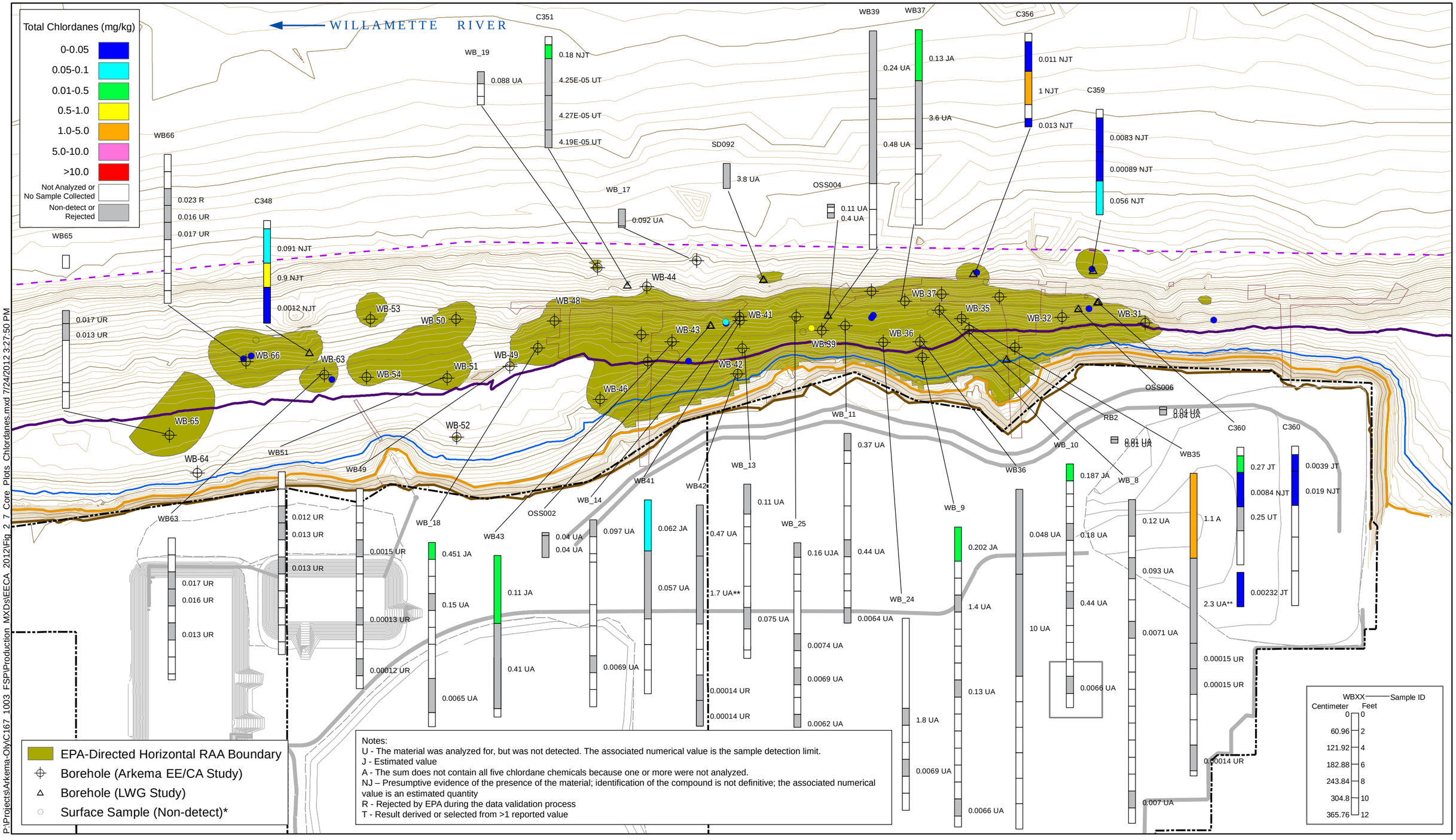
0 150 300 Feet

Map Features

- Property and Lot Boundary
- Navigation Channel
- Top of Bank
- +13 ft NAVD88
- Ordinary High Water (20.5 ft NAVD88)
- Ordinary Low Water (5 ft NAVD88)
- Docks and Structures

DRAFT

Figure 2-5
PCDD/F Homologue Plots for Sediment Samples
Upstream and Downstream of the EPA-Directed Horizontal RAA Boundary
Arkema Early Action
Draft EE/CA Report



integral consulting inc.

FEATURE SOURCES:
Property Boundaries, OHW, TOB: 2007 DEA Topographic Survey
Navigation Channel: US Army Corps of Engineers
Elevation Contours: Areas Below +16 ft: 2004 Bathymetry and 2001 LiDAR; Area above +16ft: 2007 DEA Topographic Survey
NOTE: Bottom of cores are generally placed at core sample station, if not possible a tag line indicates the sample location.

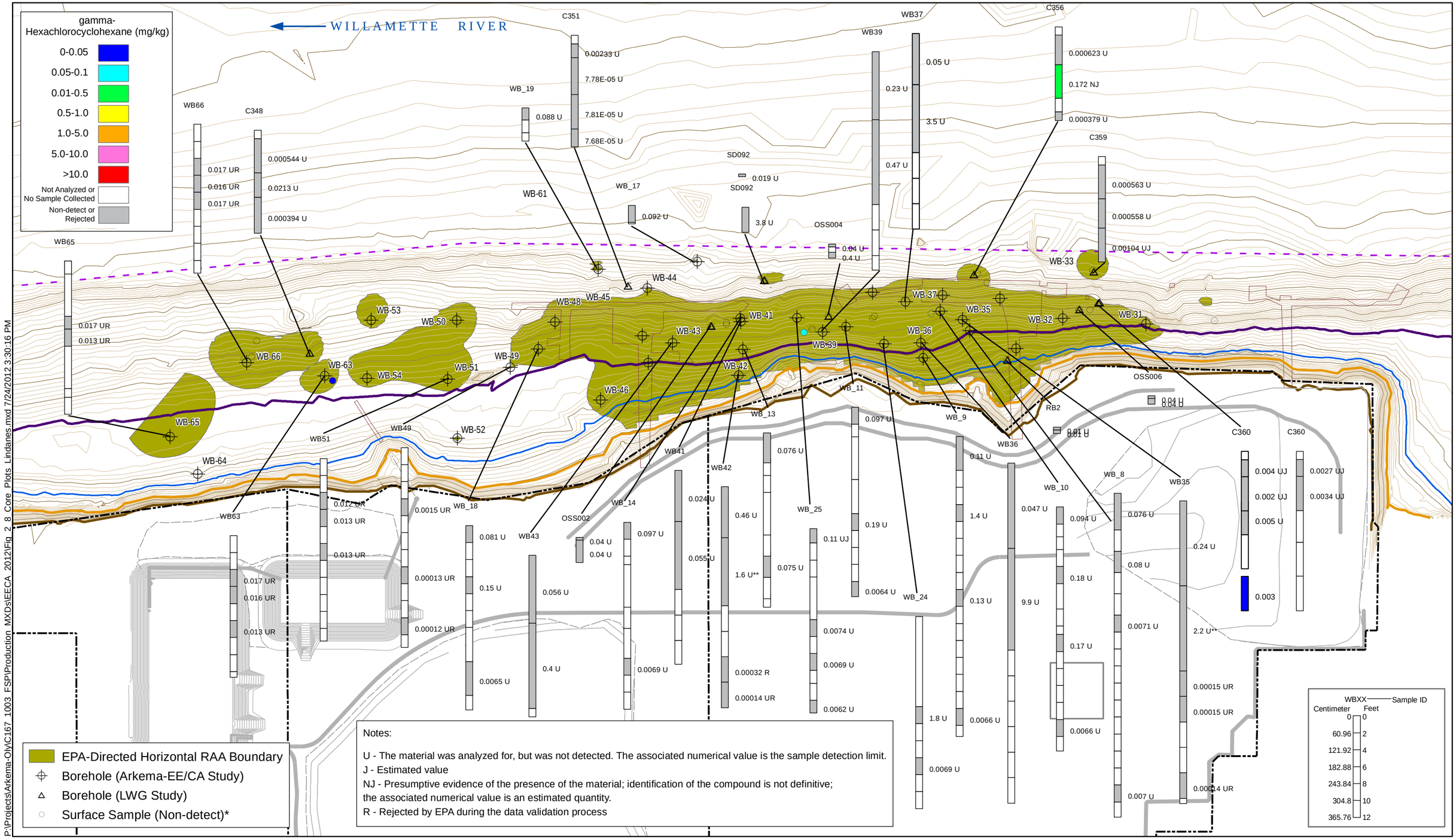
0 100 200 400 Feet

Map Features
- Property and Lot Boundary
- Navigation Channel
- Top of Bank
- +13 ft NAVD88
- Ordinary High Water (20.5 ft NAVD88)
- Ordinary Low Water (5 ft NAVD88)
- 5 ft Contour (NAVD88)
- 1 ft Contour (NAVD88)
- Docks and Structures

*Where total chlordanes are detected, symbol color represents total chlordane concentration.
**LSS and EPA both analyzed the sediment sample from this interval. The higher of the two values is shown.

DRAFT

Figure 2-6
Total Chlordane Sediment Data
within the EPA-Directed Horizontal RAA Boundary
Arkema Early Action
Draft EE/CA Report



integral consulting inc.

FEATURE SOURCES:
Property Boundaries, OHW, TOB: 2007 DEA Topographic Survey
Navigation Channel: US Army Corps of Engineers
Elevation Contours: Areas Below +16 ft: 2004 Bathymetry and 2001 LiDAR; Area above +16ft: 2007 DEA Topographic Survey
NOTE: Bottom of cores are generally placed at core sample station, if not possible a tag line indicates the sample location.

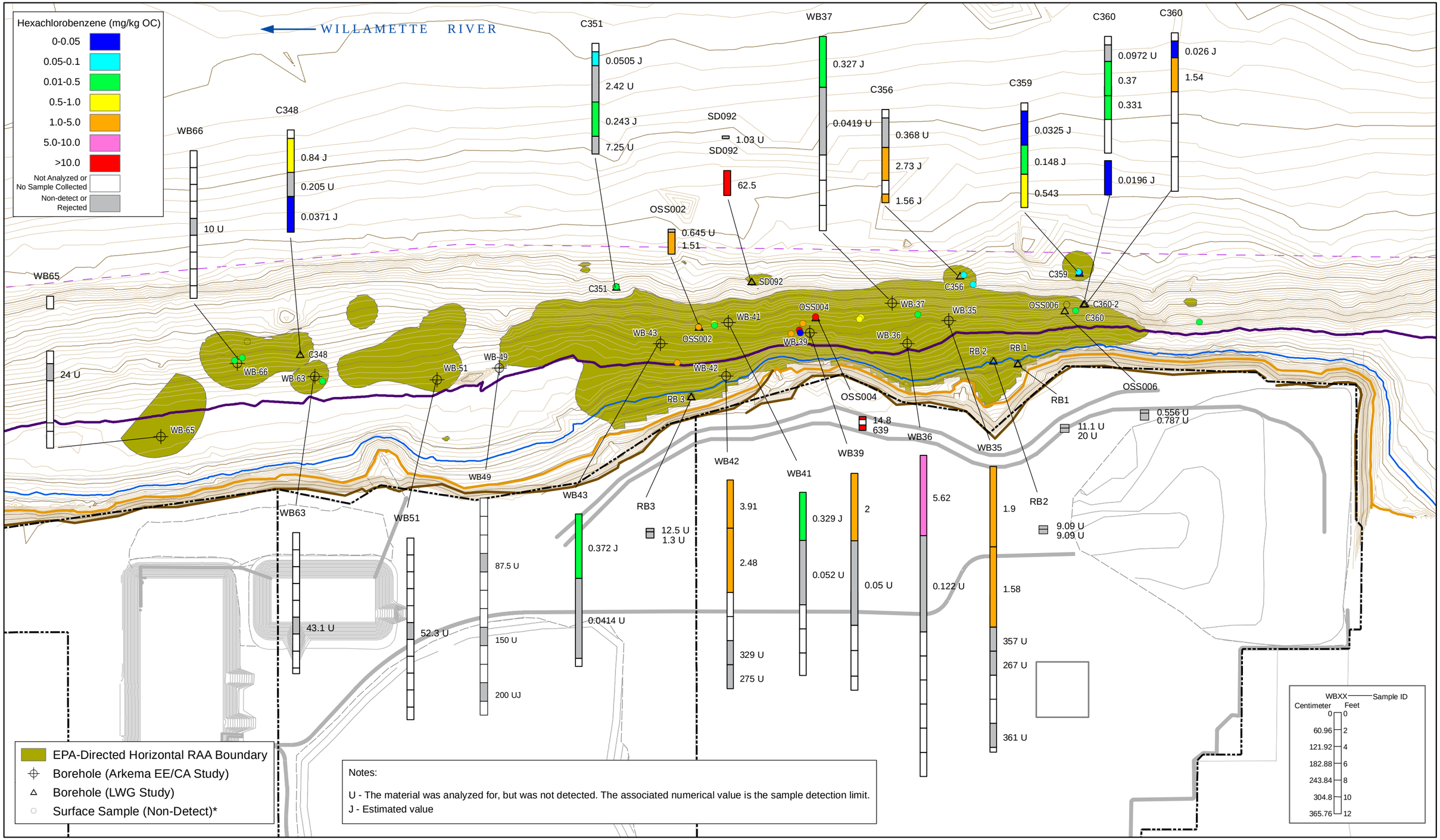
0 100 200 400 Feet

Map Features
- Property and Lot Boundary
- Navigation Channel
- Top of Bank
- +13 ft NAVD88
- Ordinary High Water (20.5 ft NAVD88)
- Ordinary Low Water (5 ft NAVD88)
- 1 ft Contour (NAVD88)
- 5 ft Contour (NAVD88)
- Docks and Structures

DRAFT

*Where gamma-hexachlorocyclohexane is detected, symbol color represents gamma-hexachlorocyclohexane concentration.
**LSS and EPA both analyzed the sediment sample from this interval. The higher of the two values is shown.

Figure 2-7
gamma-Hexachlorocyclohexane Sediment Data within the EPA-Directed Horizontal RAA Boundary
Arkema Early Action
Draft EE/CA Report



integral consulting inc.

N

FEATURE SOURCES:
Property Boundaries, OHW, TOB: 2007 DEA Topographic Survey
Navigation Channel: US Army Corps of Engineers
Elevation Contours: Areas Below +16 ft: 2004 Bathymetry and 2001 LiDAR;
Area above +16ft: 2007 DEA Topographic Survey

0 100 200 400 Feet

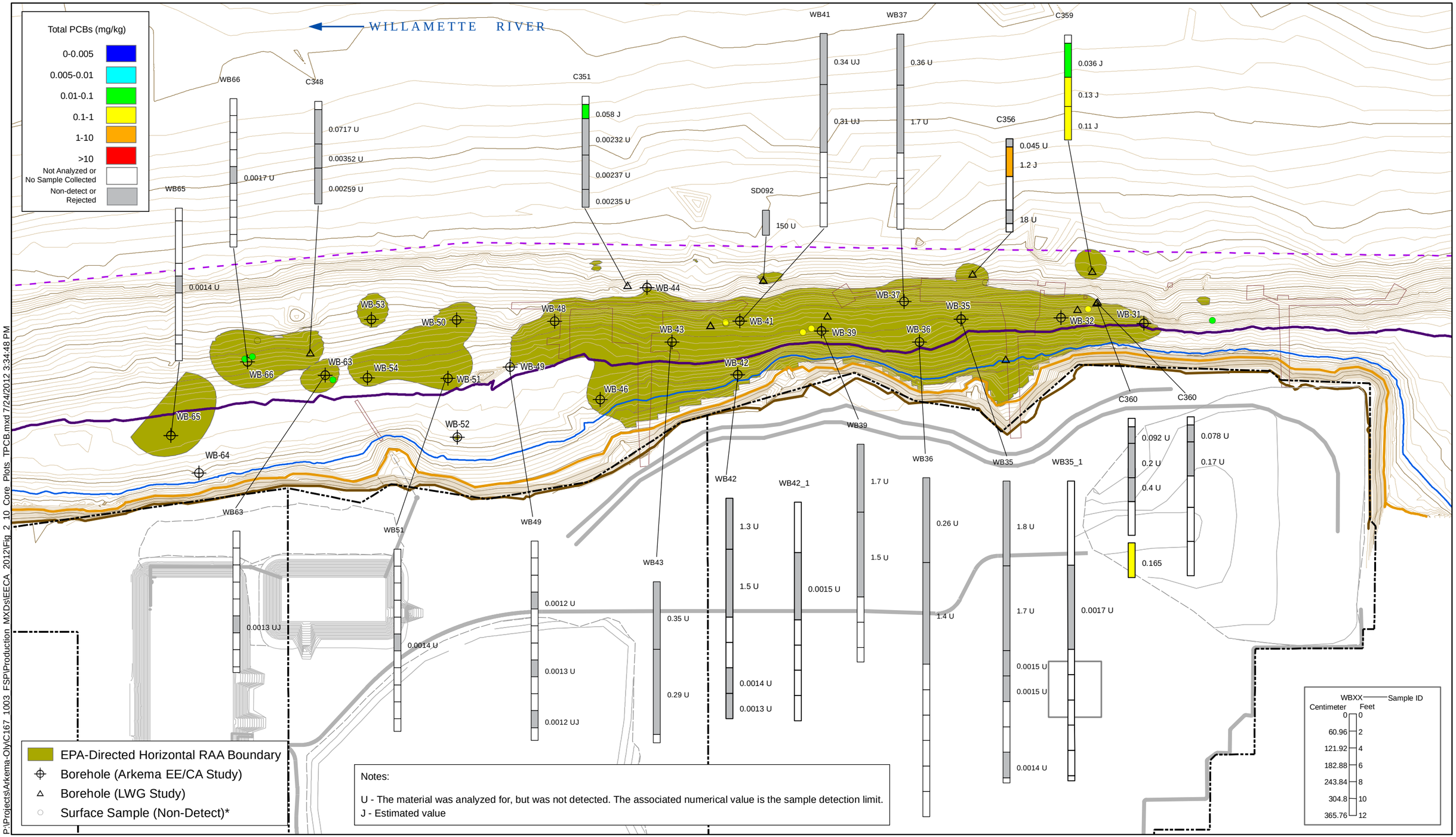
Map Features

- Property and Lot Boundary
- Top of Bank
- Navigation Channel
- +13 ft NAVD88
- Ordinary High Water (20.5 ft NAVD88)
- Ordinary Low Water (5 ft NAVD88)
- 5 ft Contour (NAVD88)
- 1 ft Contour (NAVD88)

*Where hexachlorobenzene is detected, symbol color represents hexachlorobenzene concentration.

DRAFT

Figure 2-8
Hexachlorobenzene Sediment Data
within the EPA-Directed Horizontal RAA Boundary
Arkema Early Action
Draft EE/CA Report



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integral consulting inc.

N

FEATURE SOURCES:
Property Boundaries, OHW, TOB: 2007 DEA Topographic Survey
Navigation Channel: US Army Corps of Engineers
Elevation Contours: Areas Below +16 ft: 2004 Bathymetry and 2001 LiDAR; Area above +16ft: 2007 DEA Topographic Survey
NOTE: Bottom of cores are generally placed at core sample station, if not possible a tag line indicates the sample location.

0 100 200 400 Feet

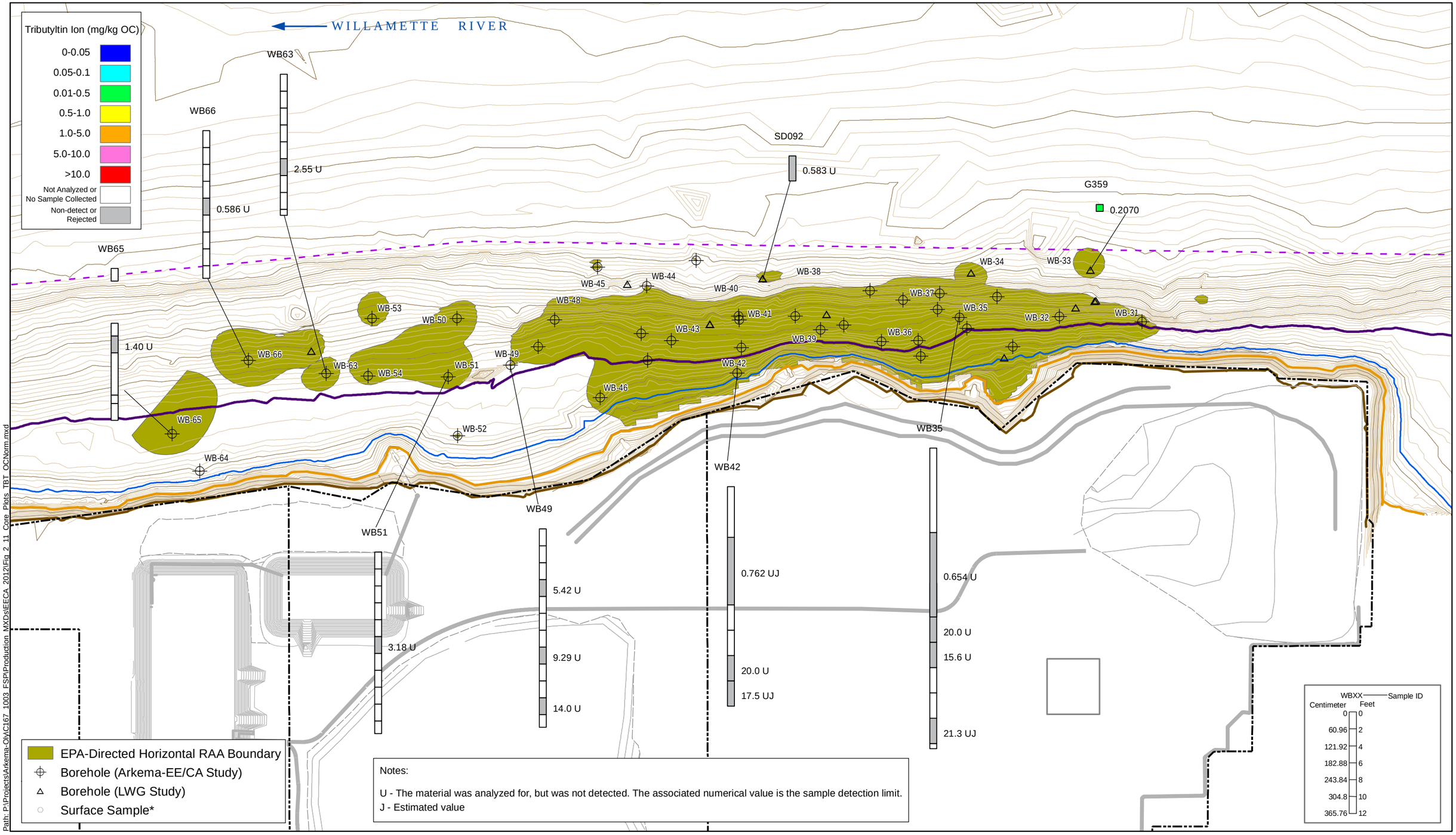
Map Features

- Property and Lot Boundary
- Navigation Channel
- Top of Bank
- +13 ft NAVD88
- Ordinary High Water (20.5 ft NAVD88)
- Ordinary Low Water (5 ft NAVD88)
- 5 ft Contour (NAVD88)
- 1 ft Contour (NAVD88)
- Docks and Structures

*Where total PCBs are detected, symbol color represents total PCBs concentration.

DRAFT

Figure 2-9
Total PCB Sediment Data within the EPA-Directed Horizontal RAA Boundary
Arkema Early Action
Draft EE/CA Report



integral consulting inc.

FEATURE SOURCES:
Property Boundaries, OHW, TOB: DEA Survey
Channel: US Army Corps of Engineers.
NOTE: Bottom of cores are generally placed at core sample station, if not possible a tag line indicates the sample location.

0 100 200 400 Feet

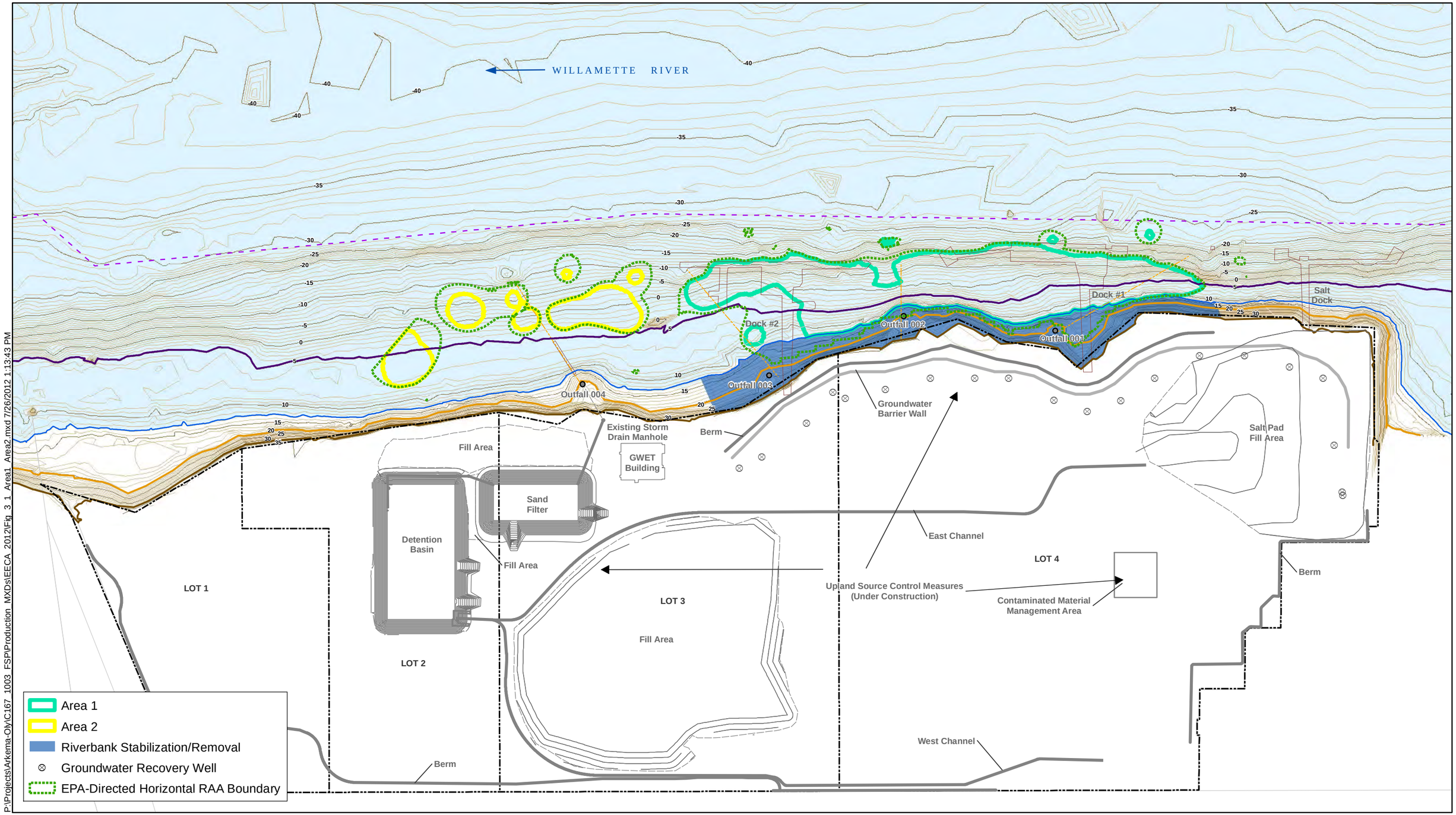
Map Features

- Property and Lot Boundary
- Navigation Channel
- Top of Bank
- +13 ft NAVD88
- Ordinary High Water (20.5 ft NAVD88)
- Ordinary Low Water (5 ft NAVD88)
- 5 ft Contour (NAVD88)
- 1 ft Contour (NAVD88)
- Docks and Structures

*Where tributyltin is detected, symbol color represents tributyltin concentration.

DRAFT

Figure 2-10
Tributyltin Sediment Data within the
EPA-Directed Horizontal RAA Boundary
Arkema Early Action
Draft EE/CA Report



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integral consulting inc.

FEATURE SOURCES:
Property Boundaries, OHW, TOB: 2007 DEA Topographic Survey
Navigation Channel: US Army Corps of Engineers
Elevation Contours: Areas Below +16 ft: 2004 Bathymetry and 2001 LiDAR;
Area above +16ft: 2007 DEA Topographic Survey

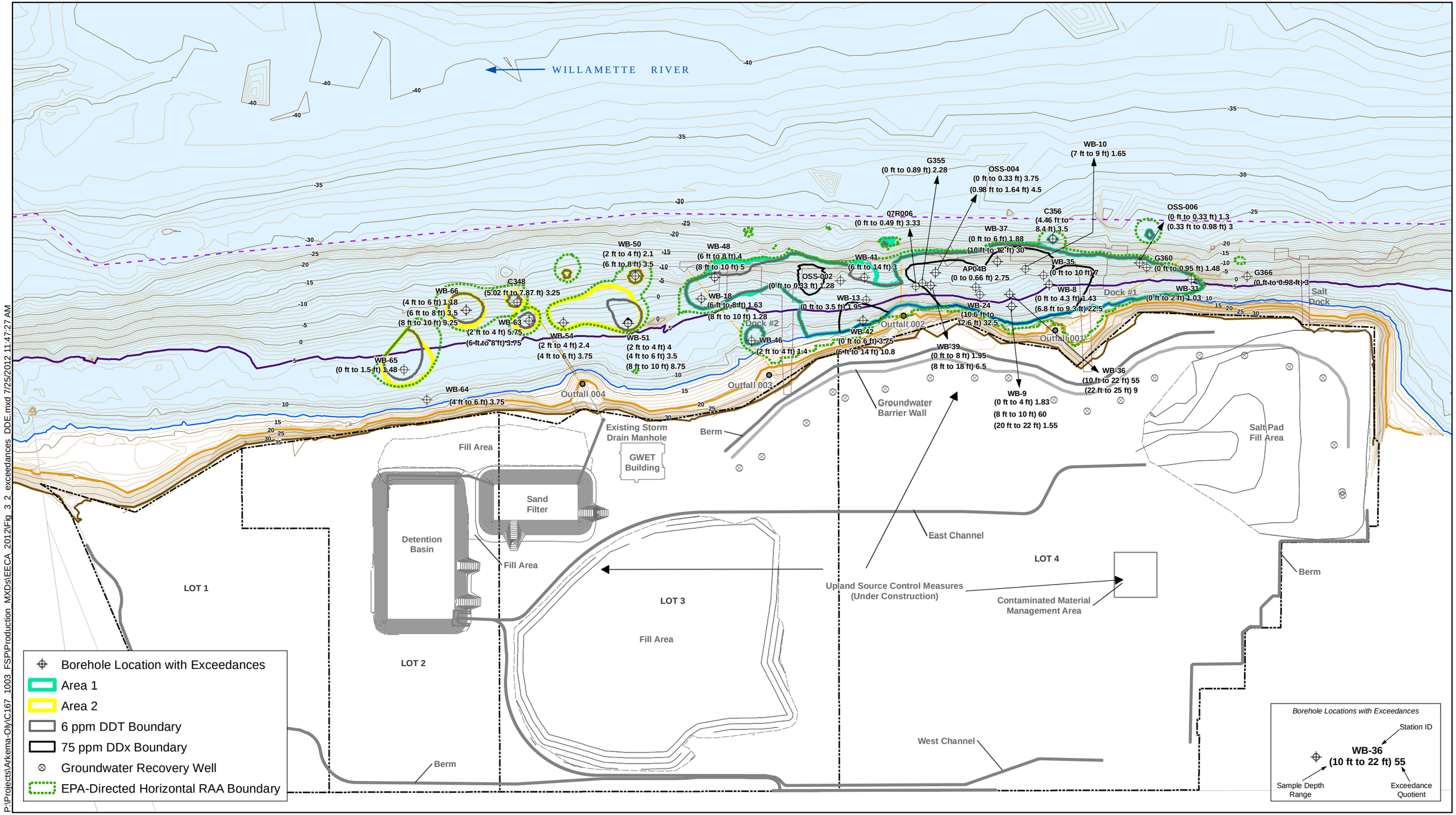
0 100 200 Feet

Map Features

- Property and Lot Boundary
- Storm Drain
- Navigation Channel
- Top of Bank
- +13 ft NAVD88
- Ordinary High Water (20.5 ft NAVD88)
- Ordinary Low Water (5 ft NAVD88)
- 5 ft Contour (NAVD88)
- 1 ft Contour (NAVD88)
- Docks and Structures
- River Edge

DRAFT

Figure 3-1
Areas 1 and 2
within the EPA-Directed Horizontal RAA Boundary
Arkema Early Action
Draft EE/CA Report



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integral consulting inc

FEATURE SOURCES:
Property Boundaries, OHW, TOB: 2007 DEA Topographic Survey
Navigation Channel: US Army Corps of Engineers
Elevation Contours: Areas Below +16 ft: 2004 Bathymetry and 2001 LiDAR;
Area above +16ft: 2007 DEA Topographic Survey

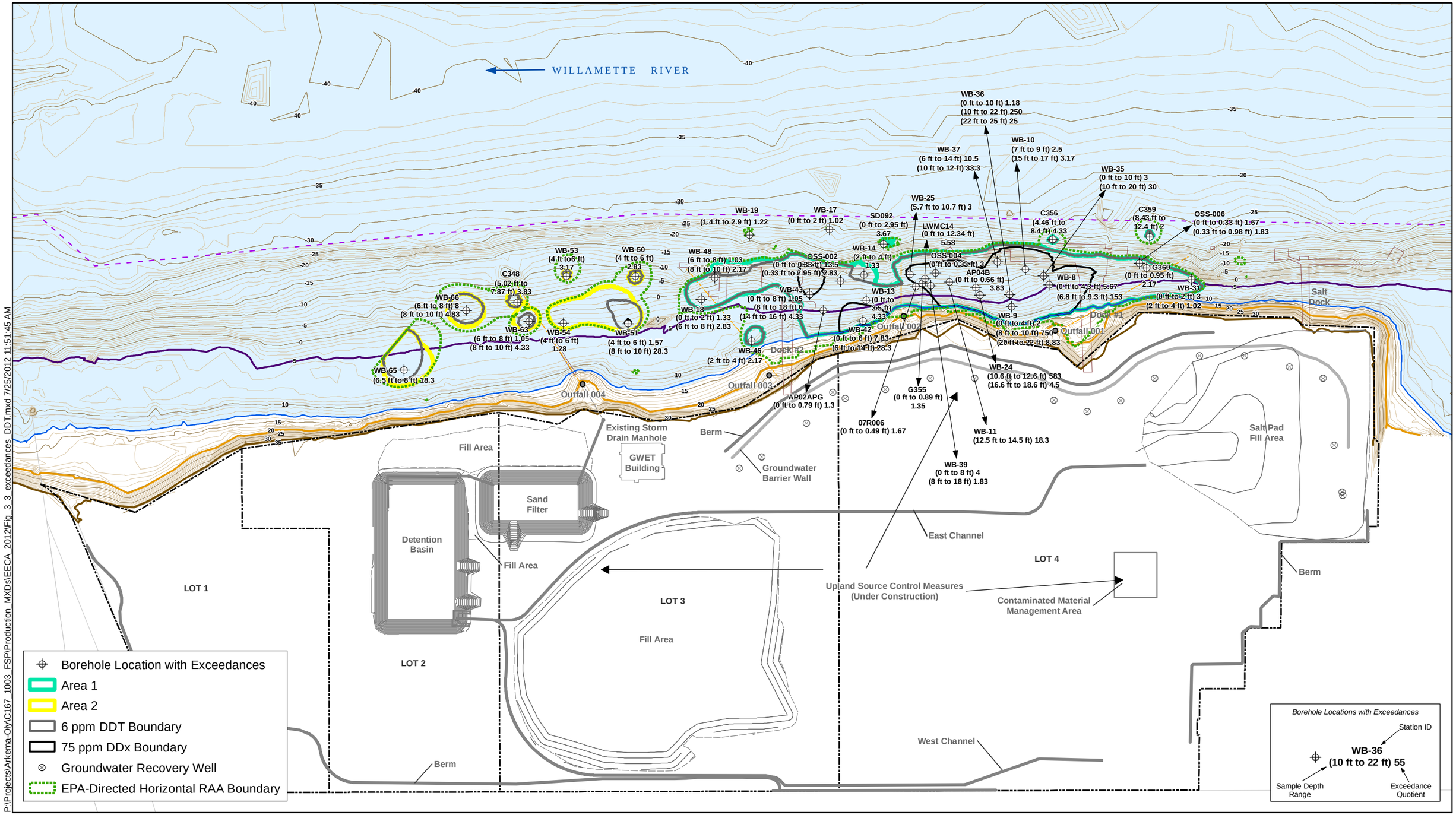
0 100 200 Feet

Map Features

- Property and Lot Boundary
- Storm Drain
- Navigation Channel
- Top of Bank
- +13 ft NAVD88
- Ordinary High Water (20.5 ft NAVD88)
- Ordinary Low Water (5 ft NAVD88)
- 5 ft Contour (NAVD88)
- 1 ft Contour (NAVD88)
- Docks and Structures
- River Edge

DRAFT

Figure 3-2
Total DDE RAL Exceedances in Surface and Subsurface Sediment
within the EPA-Directed Horizontal RAA Boundary
Arkema Early Action
Draft EE/CA Report



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integral consulting inc.

FEATURE SOURCES:
Property Boundaries, OHW, TOB: 2007 DEA Topographic Survey
Navigation Channel: US Army Corps of Engineers
Elevation Contours: Areas Below +16 ft: 2004 Bathymetry and 2001 LiDAR;
Area above +16ft: 2007 DEA Topographic Survey

0 100 200 Feet

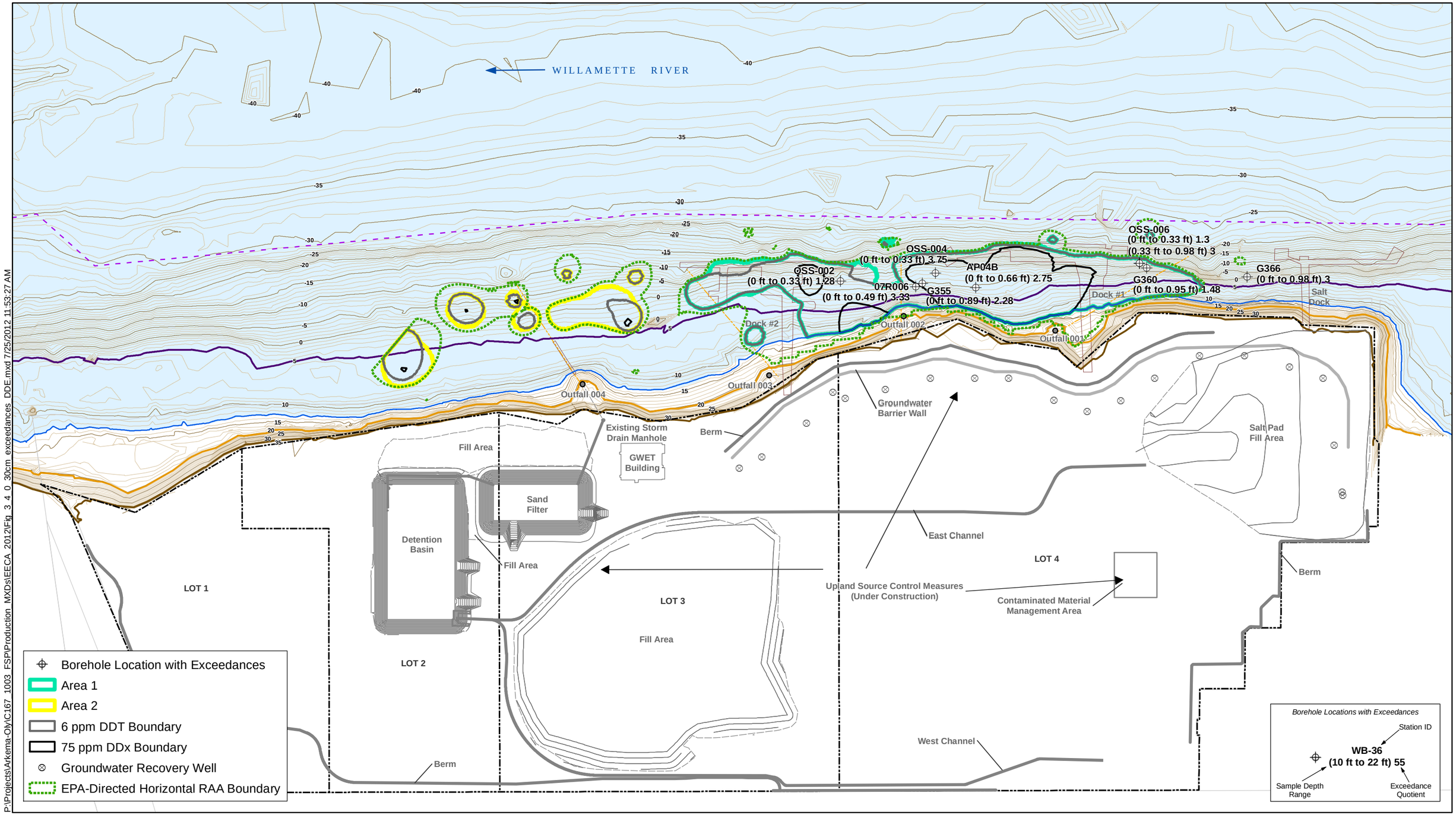
N

Map Features

- Property and Lot Boundary
- Storm Drain
- Navigation Channel
- Top of Bank
- +13 ft NAVD88
- Ordinary High Water (20.5 ft NAVD88)
- Ordinary Low Water (5 ft NAVD88)
- 5 ft Contour (NAVD88)
- 1 ft Contour (NAVD88)
- Docks and Structures
- River Edge

DRAFT

Figure 3-3
Total DDT RAL Exceedances in Surface and Subsurface Sediment
within the EPA-Directed Horizontal RAA Boundary
Arkema Early Action
Draft EE/CA Report



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integral consulting inc

FEATURE SOURCES:
Property Boundaries, OHW, TOB: 2007 DEA Topographic Survey
Navigation Channel: US Army Corps of Engineers
Elevation Contours: Areas Below +16 ft: 2004 Bathymetry and 2001 LiDAR;
Area above +16ft: 2007 DEA Topographic Survey

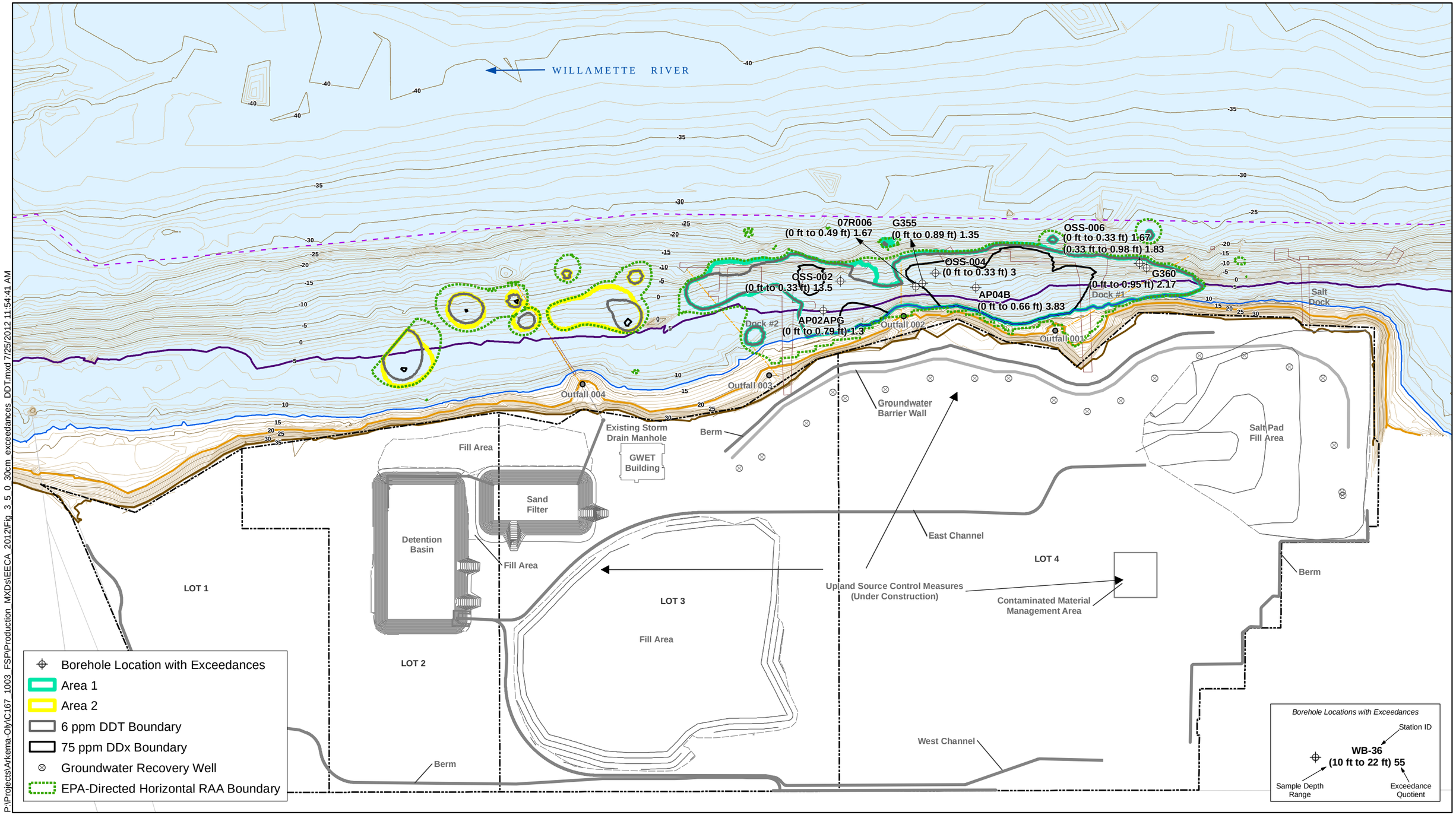
0 100 200 Feet

Map Features

- Property and Lot Boundary
- Storm Drain
- Navigation Channel
- Top of Bank
- +13 ft NAVD88
- Ordinary High Water (20.5 ft NAVD88)
- Ordinary Low Water (5 ft NAVD88)
- 5 ft Contour (NAVD88)
- 1 ft Contour (NAVD88)
- Docks and Structures
- River Edge

DRAFT

Figure 3-4
Total DDE RAL Exceedances in Surface Sediment within the EPA-Directed Horizontal RAA Boundary
Arkema Early Action
Draft EE/CA Report



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integral consulting inc.

FEATURE SOURCES:
Property Boundaries, OHW, TOB: 2007 DEA Topographic Survey
Navigation Channel: US Army Corps of Engineers
Elevation Contours: Areas Below +16 ft: 2004 Bathymetry and 2001 LiDAR;
Area above +16ft: 2007 DEA Topographic Survey

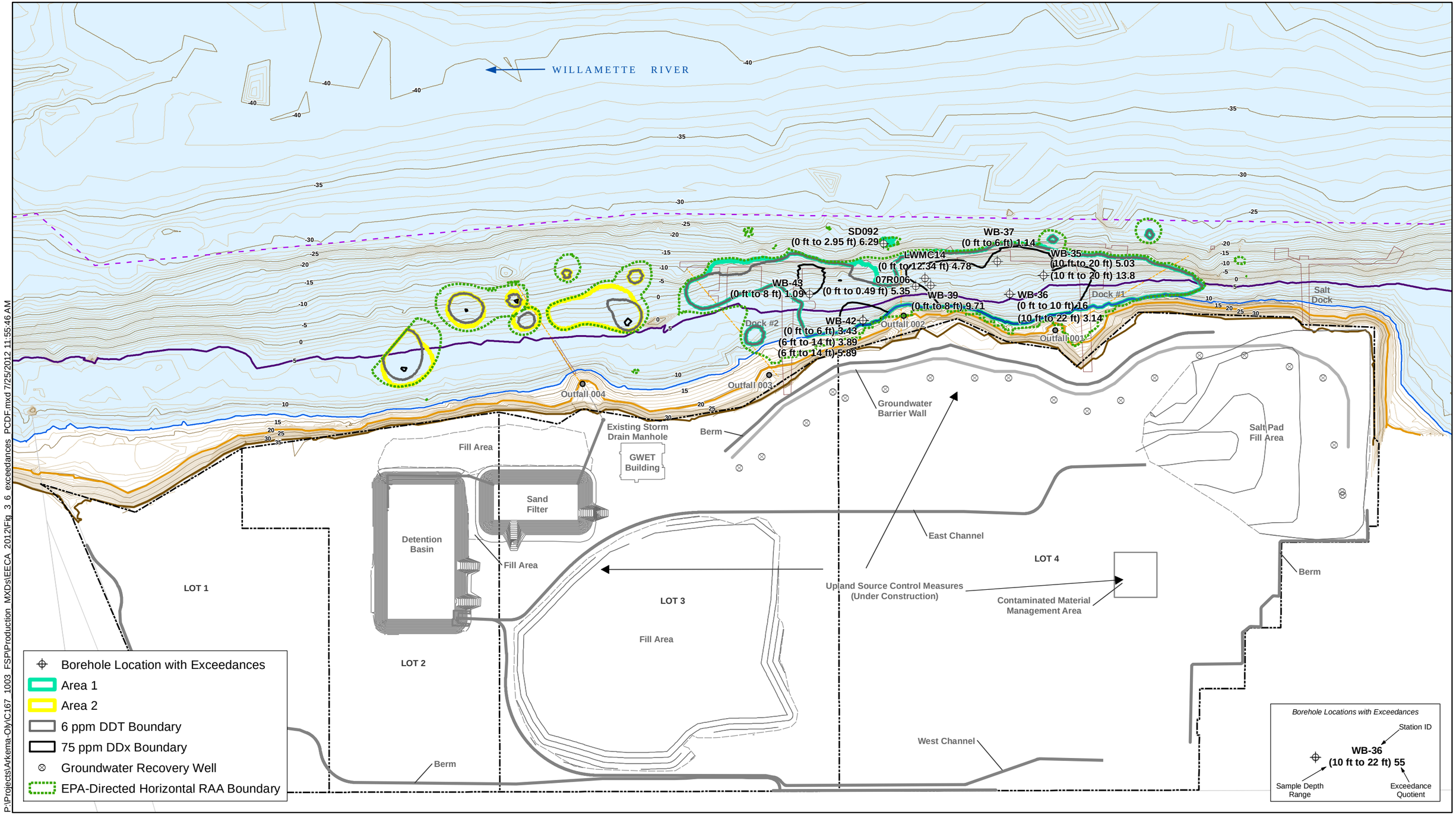
0 100 200 Feet

Map Features

- Property and Lot Boundary
- Storm Drain
- Navigation Channel
- Top of Bank
- +13 ft NAVD88
- Ordinary High Water (20.5 ft NAVD88)
- Ordinary Low Water (5 ft NAVD88)
- 5 ft Contour (NAVD88)
- 1 ft Contour (NAVD88)
- Docks and Structures
- River Edge

DRAFT

Figure 3-5
Total DDT RAL Exceedances in Surface Sediment within the EPA-Directed Horizontal RAA Boundary
Arkema Early Action
Draft EE/CA Report



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integral consulting inc

FEATURE SOURCES:
Property Boundaries, OHW, TOB: 2007 DEA Topographic Survey
Navigation Channel: US Army Corps of Engineers
Elevation Contours: Areas Below +16 ft: 2004 Bathymetry and 2001 LiDAR;
Area above +16ft: 2007 DEA Topographic Survey

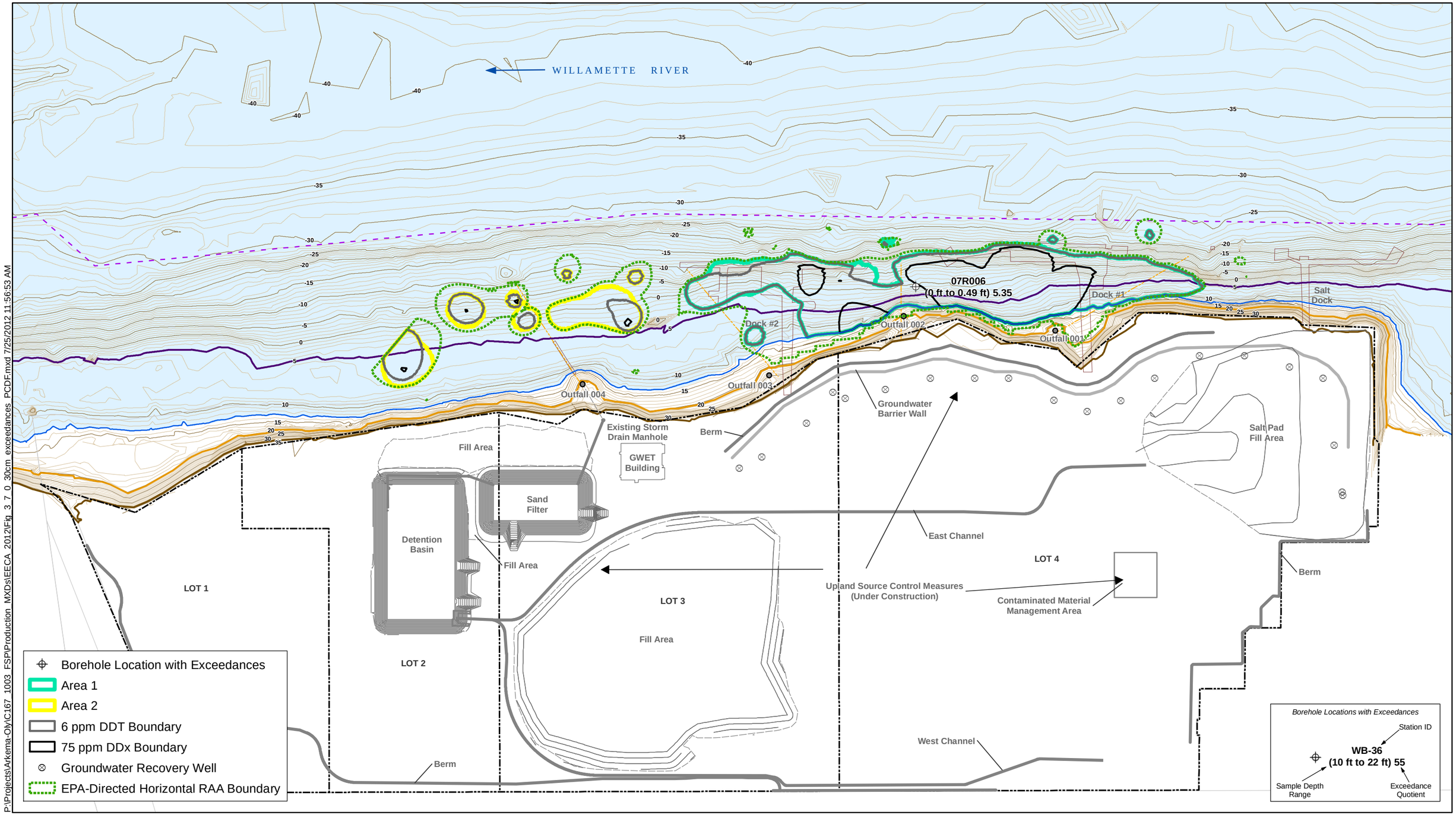
0 100 200 Feet

Map Features

- Property and Lot Boundary
- Storm Drain
- Navigation Channel
- Top of Bank
- +13 ft NAVD88
- Ordinary High Water (20.5 ft NAVD88)
- Ordinary Low Water (5 ft NAVD88)
- 5 ft Contour (NAVD88)
- 1 ft Contour (NAVD88)
- Docks and Structures
- River Edge

DRAFT

Figure 3-6
PCDF RAL Exceedances in Surface and Subsurface Sediment within the EPA-Directed Horizontal RAA Boundary
Arkema Early Action
Draft EE/CA Report



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integral consulting inc

FEATURE SOURCES:
Property Boundaries, OHW, TOB: 2007 DEA Topographic Survey
Navigation Channel: US Army Corps of Engineers
Elevation Contours: Areas Below +16 ft: 2004 Bathymetry and 2001 LiDAR;
Area above +16ft: 2007 DEA Topographic Survey

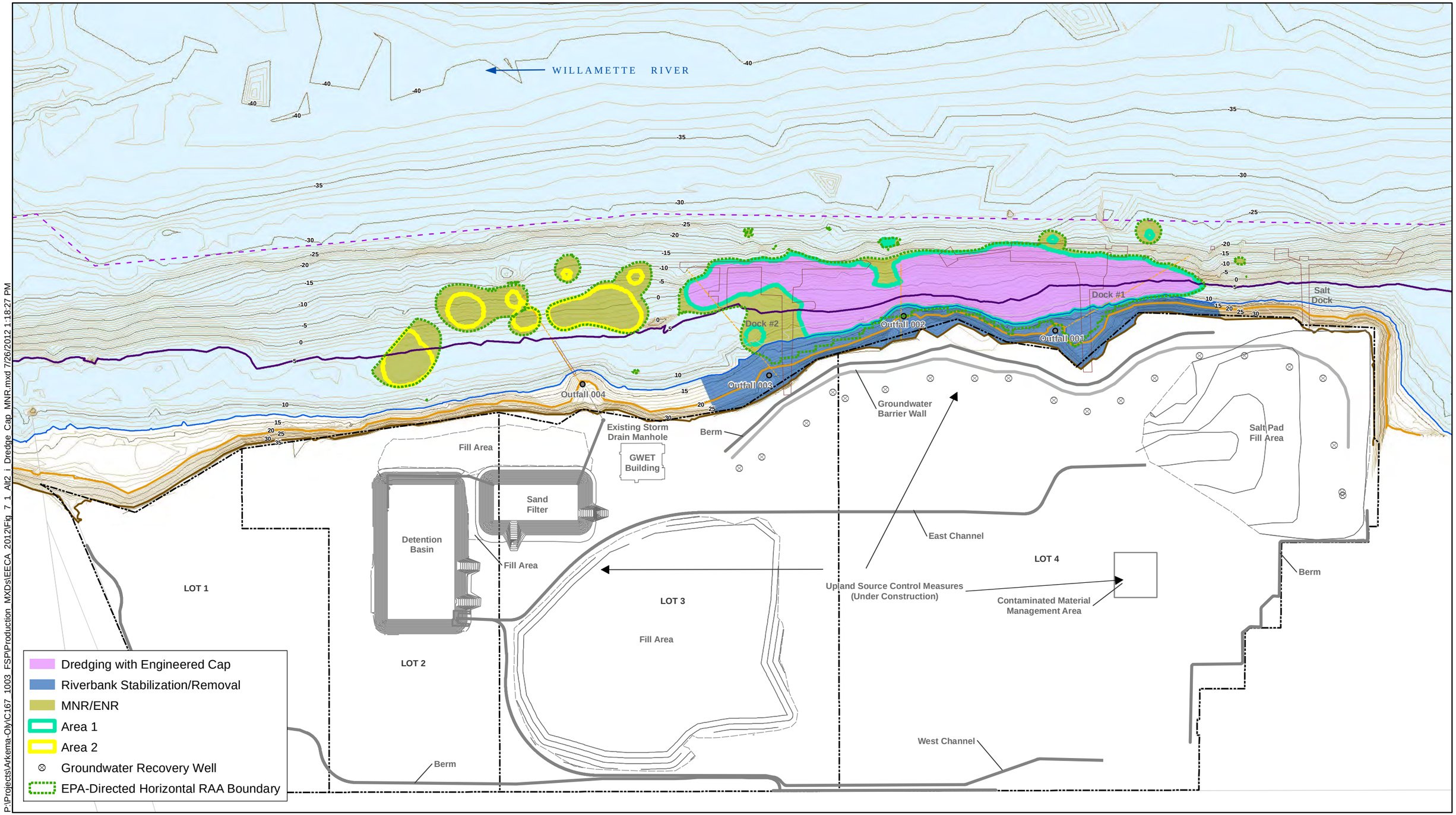
0 100 200 Feet

Map Features

- Property and Lot Boundary
- Storm Drain
- Navigation Channel
- Top of Bank
- +13 ft NAVD88
- Ordinary High Water (20.5 ft NAVD88)
- Ordinary Low Water (5 ft NAVD88)
- 5 ft Contour (NAVD88)
- 1 ft Contour (NAVD88)
- Docks and Structures
- River Edge

DRAFT

Figure 3-7
PCDF RAL Exceedances in Surface Sediment
within the EPA-Directed Horizontal RAA Boundary
Arkema Early Action
Draft EE/CA Report



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FEATURE SOURCES:
Property Boundaries, OHW, TOB: 2007 DEA Topographic Survey
Navigation Channel: US Army Corps of Engineers
Elevation Contours: Areas Below +16 ft: 2004 Bathymetry and 2001 LiDAR;
Area above +16ft: 2007 DEA Topographic Survey

0 100 200 Feet

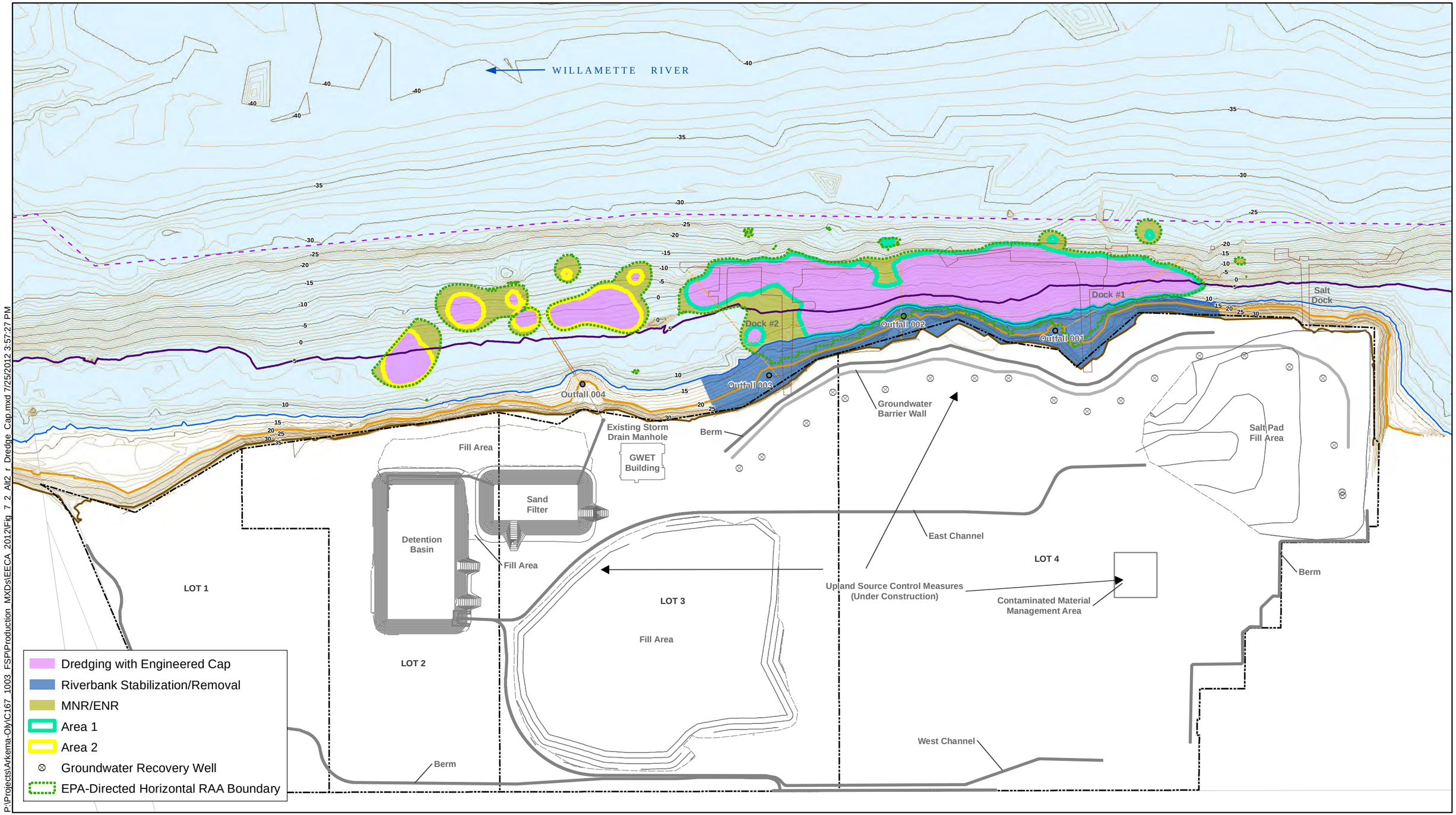
N

Map Features

- Property and Lot Boundary
- Storm Drain
- Navigation Channel
- Top of Bank
- +13 ft NAVD88
- Ordinary High Water (20.5 ft NAVD88)
- Ordinary Low Water (5 ft NAVD88)
- 5 ft Contour (NAVD88)
- 1 ft Contour (NAVD88)
- Docks and Structures
- River Edge

DRAFT

Figure 7-1
Alternative 2(i): Dredge to Facilitate a Cap and Optimized MNR
Arkema Early Action
Draft EE/CA Report



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FEATURE SOURCES:
Property Boundaries, OHW, TOB: 2007 DEA Topographic Survey
Navigation Channel: US Army Corps of Engineers
Elevation Contours: Areas Below +16 ft: 2004 Bathymetry and 2001 LiDAR;
Area above +16ft: 2007 DEA Topographic Survey

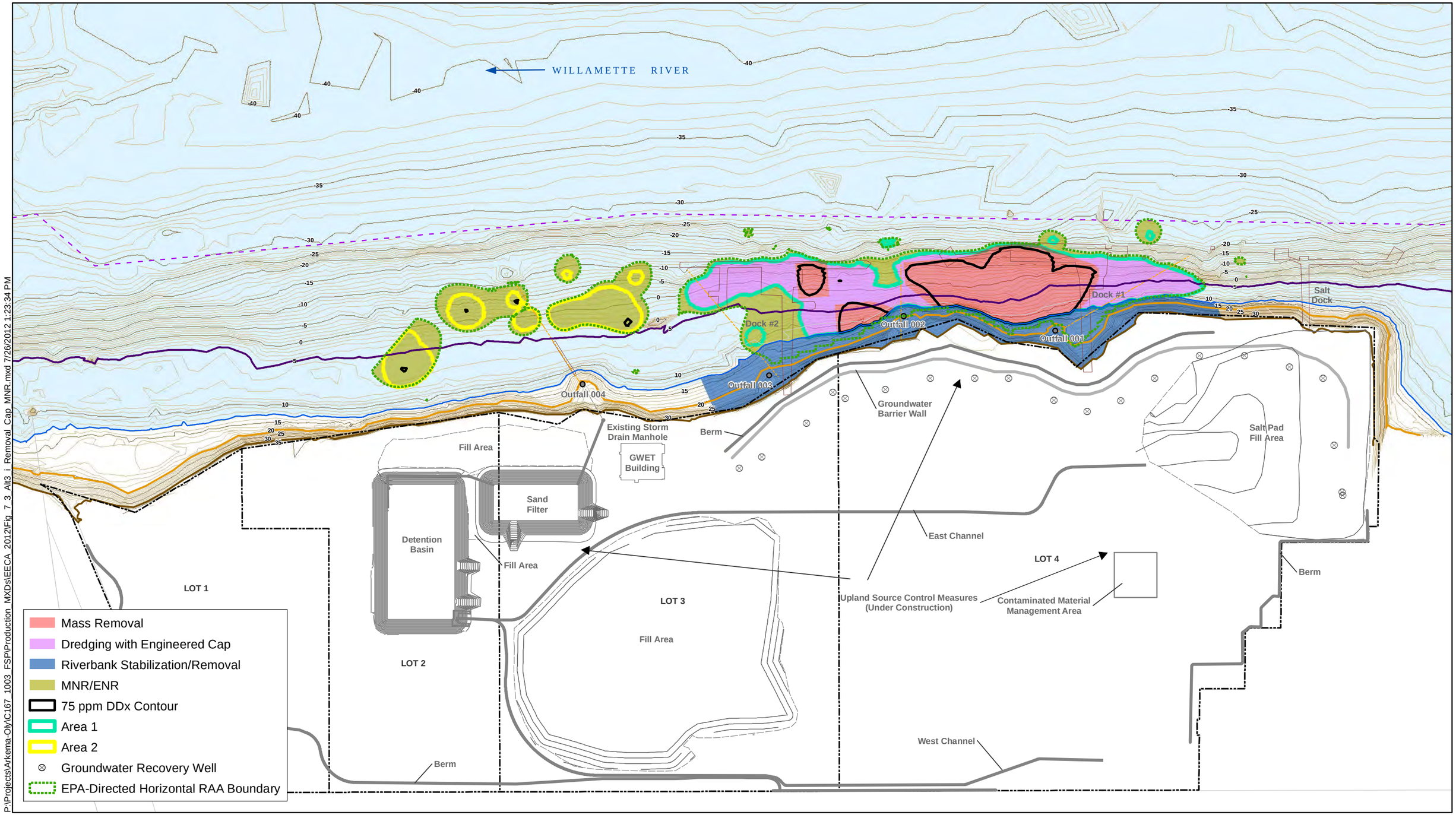
0 100 200 Feet

Map Features

- Property and Lot Boundary
- Storm Drain
- Navigation Channel
- Top of Bank
- +13 ft NAVD88
- Ordinary High Water (20.5 ft NAVD88)
- Ordinary Low Water (5 ft NAVD88)
- 5 ft Contour (NAVD88)
- 1 ft Contour (NAVD88)
- Docks and Structures
- River Edge

DRAFT

Figure 7-2
Alternative 2(r): Dredge to Facilitate a Cap
Arkema Early Action
Draft EE/CA Report



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FEATURE SOURCES:
Property Boundaries, OHW, TOB: 2007 DEA Topographic Survey
Navigation Channel: US Army Corps of Engineers
Elevation Contours: Areas Below +16 ft: 2004 Bathymetry and 2001 LiDAR;
Area above +16ft: 2007 DEA Topographic Survey

0 100 200 Feet

Map Features

- Property and Lot Boundary
- Storm Drain
- Navigation Channel
- Top of Bank
- +13 ft NAVD88
- Ordinary High Water (20.5 ft NAVD88)
- Ordinary Low Water (5 ft NAVD88)
- 5 ft Contour (NAVD88)
- 1 ft Contour (NAVD88)
- Docks and Structures
- River Edge

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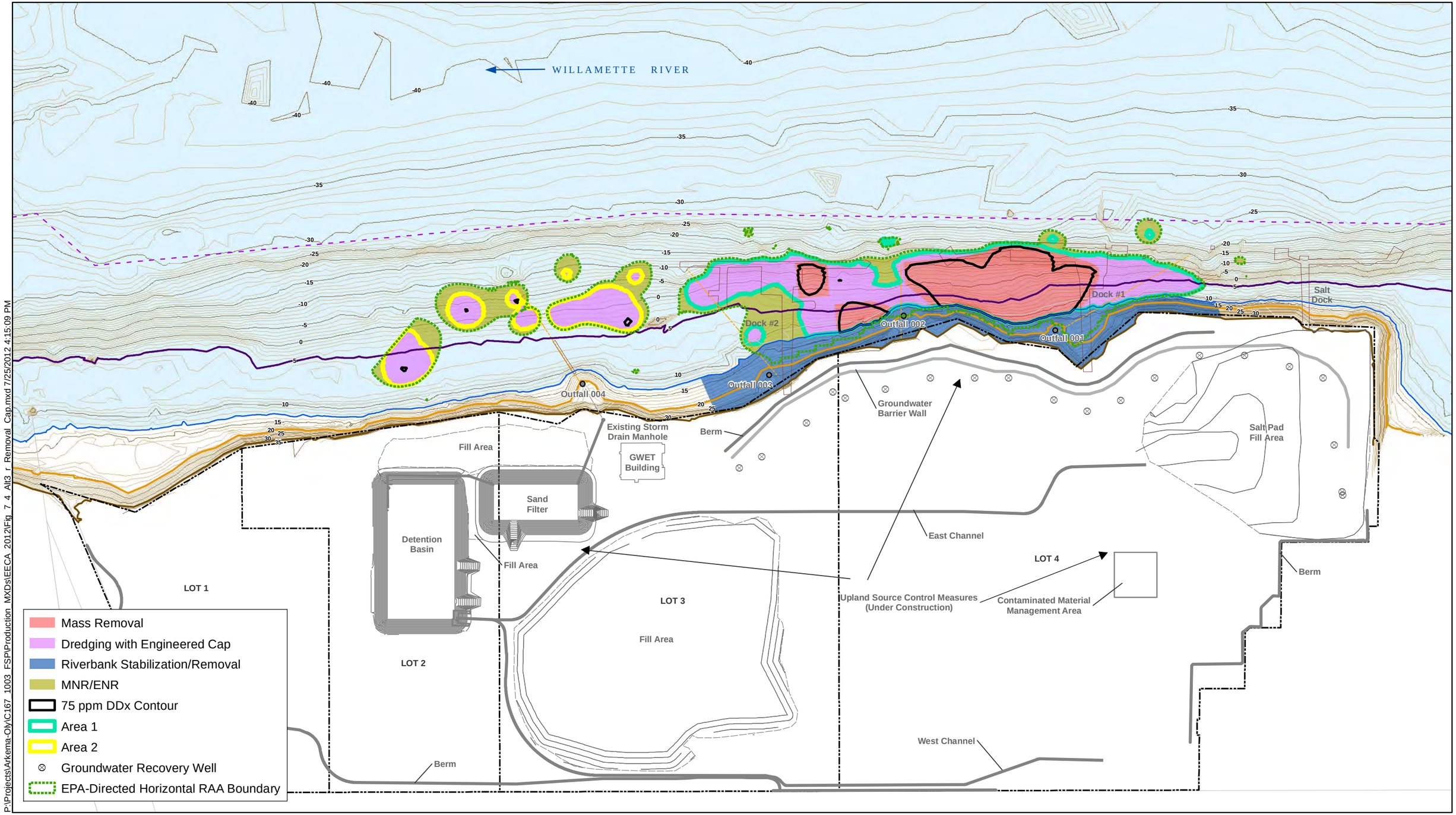
Figure 7-3
Alternative 3(i): Mass-Based Removal, Capping, and Optimized MNR
Arkema Early Action
Draft EE/CA Report



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FEATURE SOURCES:
Property Boundaries, OHW, TOB: 2007 DEA Topographic Survey
Navigation Channel: US Army Corps of Engineers
Elevation Contours: Areas Below +16 ft: 2004 Bathymetry and 2001 LiDAR;
Area above +16ft: 2007 DEA Topographic Survey

0 100 200 Feet

Map Features

- Property and Lot Boundary
- Storm Drain
- Navigation Channel
- Top of Bank
- +13 ft NAVD88
- Ordinary High Water (20.5 ft NAVD88)
- Ordinary Low Water (5 ft NAVD88)
- 5 ft Contour (NAVD88)
- 1 ft Contour (NAVD88)
- Docks and Structures
- River Edge

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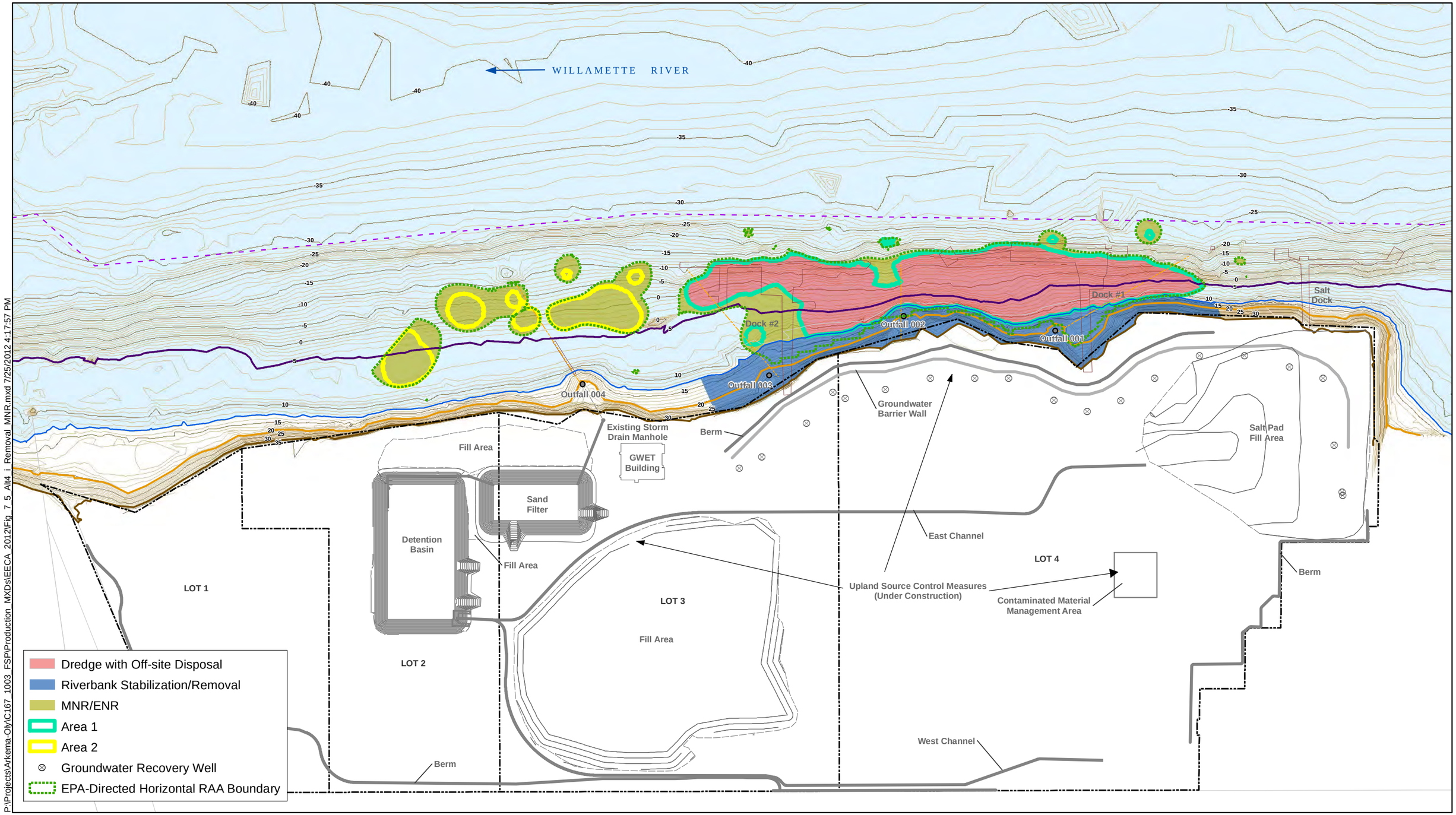
Figure 7-4
Alternative 3(r): Mass-Based Removal and Capping
Arkema Early Action
Draft EE/CA Report



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FEATURE SOURCES:
Property Boundaries, OHW, TOB: 2007 DEA Topographic Survey
Navigation Channel: US Army Corps of Engineers
Elevation Contours: Areas Below +16 ft: 2004 Bathymetry and 2001 LiDAR;
Area above +16ft: 2007 DEA Topographic Survey

0 100 200 Feet

Map Features

- Property and Lot Boundary
- Storm Drain
- Navigation Channel
- Top of Bank
- +13 ft NAVD88
- Ordinary High Water (20.5 ft NAVD88)
- Ordinary Low Water (5 ft NAVD88)
- 5 ft Contour (NAVD88)
- 1 ft Contour (NAVD88)
- Docks and Structures
- River Edge

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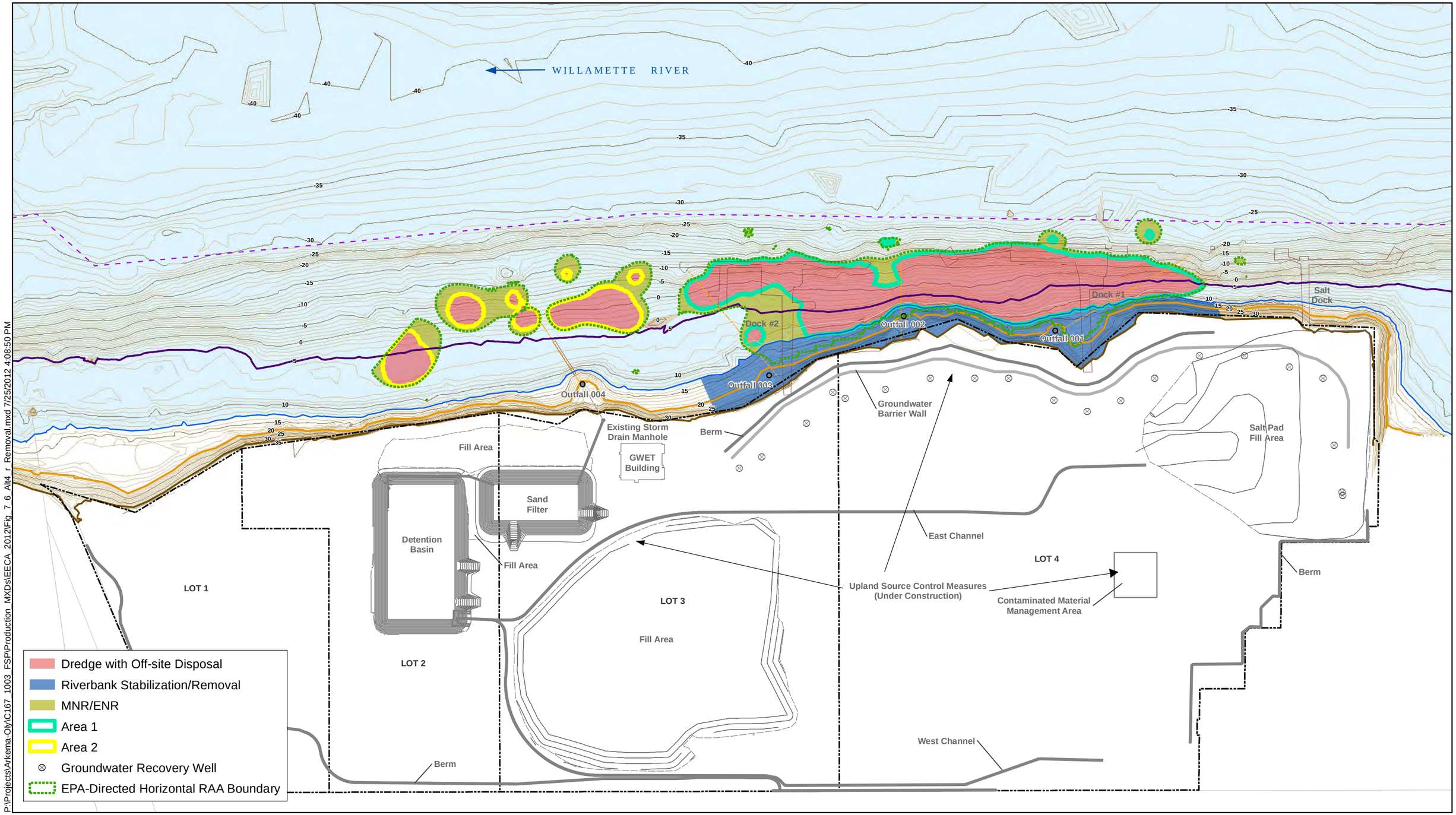
Figure 7-5
Alternative 4(i): Removal Focused and Optimized MNR
Arkema Early Action
Draft EE/CA Report



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integral consulting inc

FEATURE SOURCES:
Property Boundaries, OHW, TOB: 2007 DEA Topographic Survey
Navigation Channel: US Army Corps of Engineers
Elevation Contours: Areas Below +16 ft: 2004 Bathymetry and 2001 LiDAR;
Area above +16ft: 2007 DEA Topographic Survey

0 100 200 Feet

Map Features

- Property and Lot Boundary
- Storm Drain
- Navigation Channel
- Top of Bank
- +13 ft NAVD88
- Ordinary High Water (20.5 ft NAVD88)
- Ordinary Low Water (5 ft NAVD88)
- 5 ft Contour (NAVD88)
- 1 ft Contour (NAVD88)
- Docks and Structures
- River Edge

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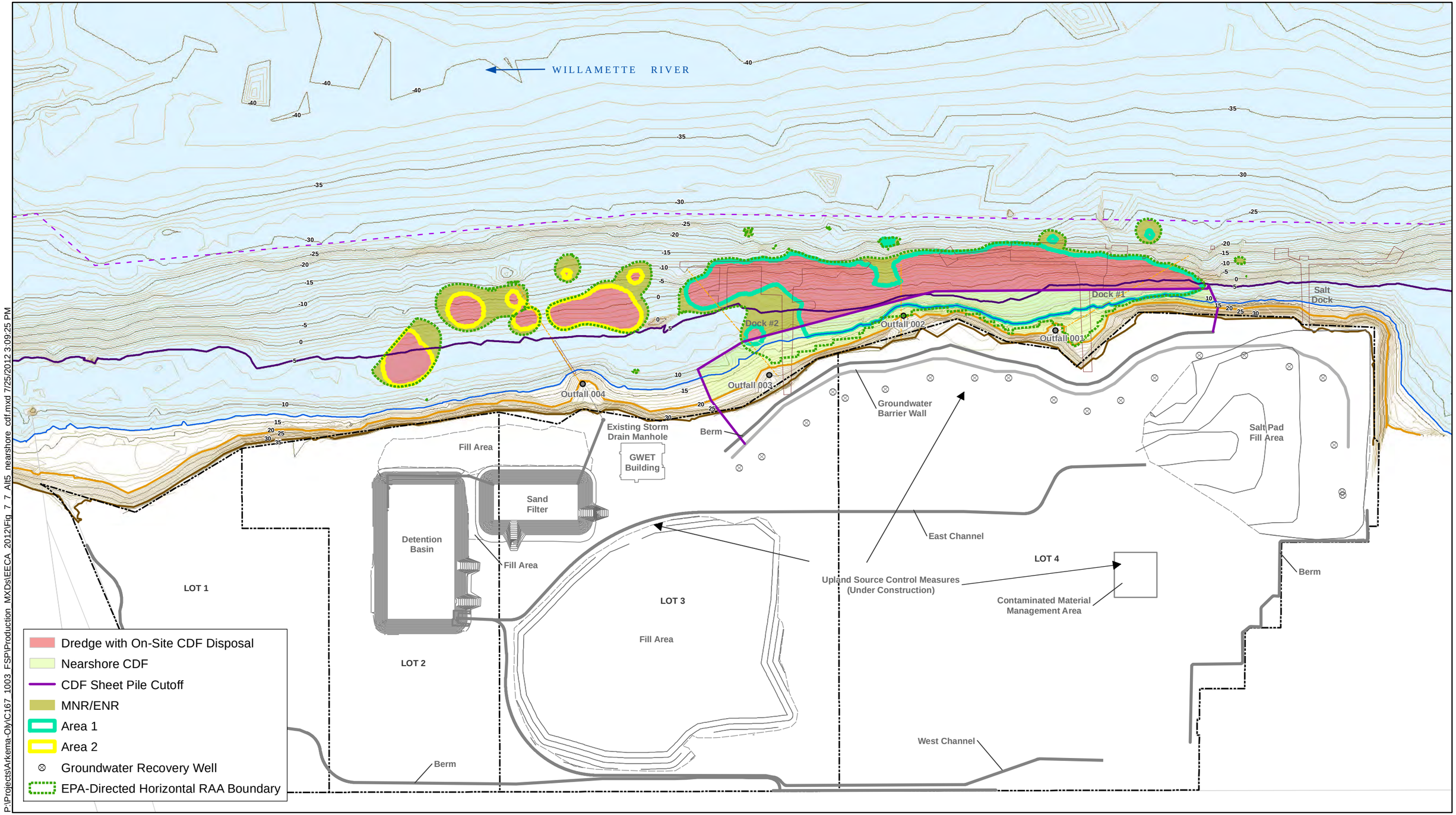
Figure 7-6
Alternative 4(r): Removal Focused
Arkema Early Action
Draft EE/CA Report



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FEATURE SOURCES:
Property Boundaries, OHW, TOB: 2007 DEA Topographic Survey
Navigation Channel: US Army Corps of Engineers
Elevation Contours: Areas Below +16 ft: 2004 Bathymetry and 2001 LiDAR;
Area above +16ft: 2007 DEA Topographic Survey

0 100 200 Feet

Map Features

- Property and Lot Boundary
- Storm Drain
- Navigation Channel
- Top of Bank
- +13 ft NAVD88
- Ordinary High Water (20.5 ft NAVD88)
- Ordinary Low Water (5 ft NAVD88)
- 5 ft Contour (NAVD88)
- 1 ft Contour (NAVD88)
- Docks and Structures
- River Edge

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Figure 7-7
Alternative 5: Nearshore CDF
Arkema Early Action
Draft EE/CA Report

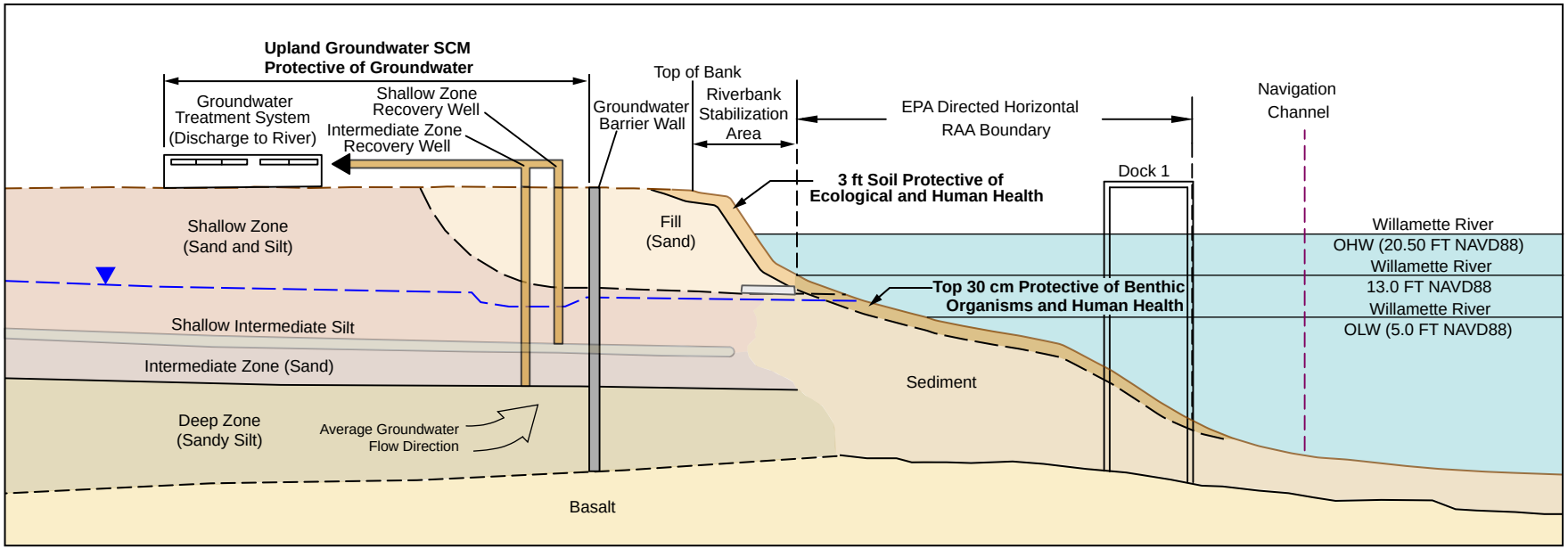

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Figure 8-1
Conceptual Points of Compliance
Arkema Early Action
Draft EE/CA Report

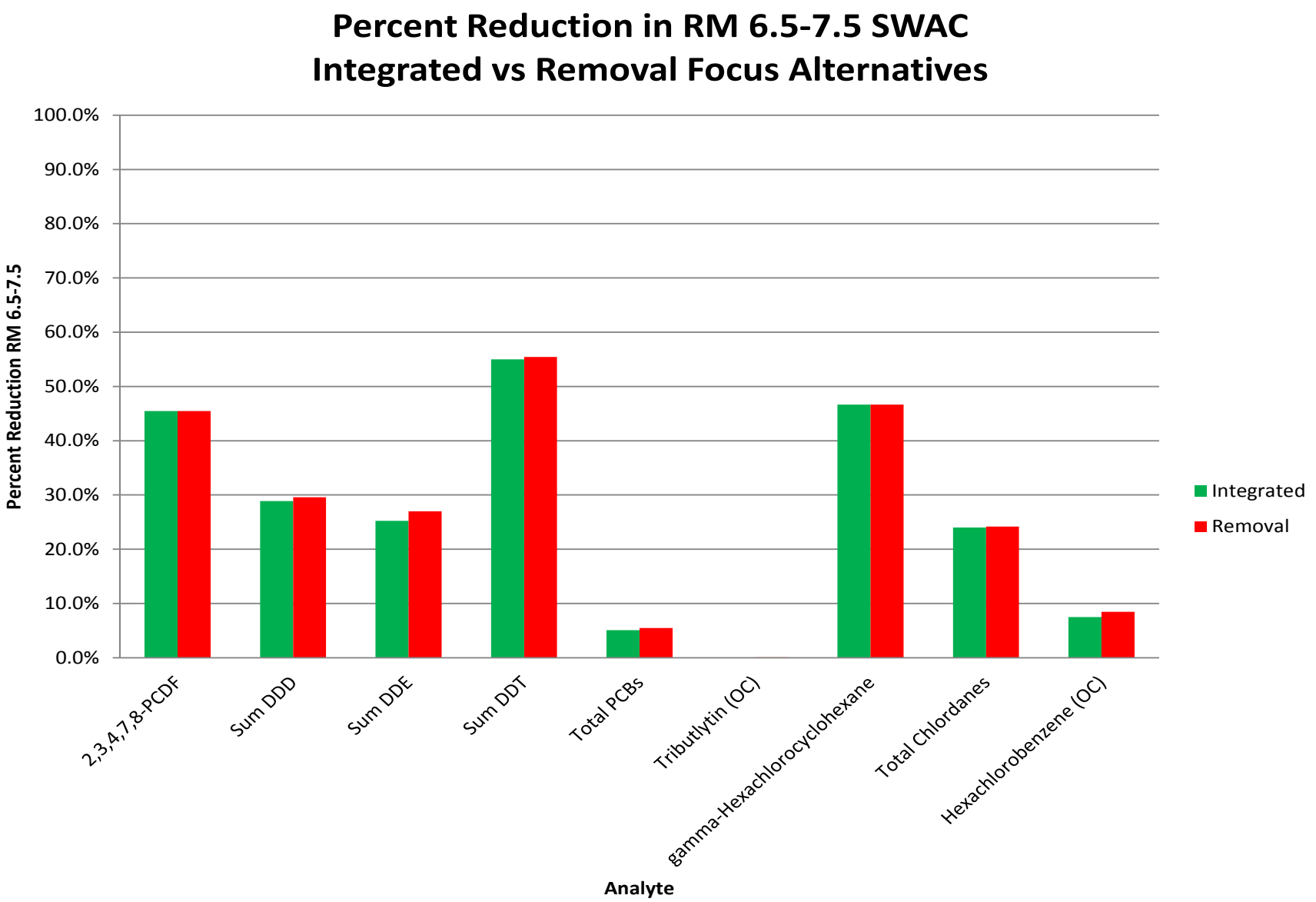

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Figure 8-2
Reduction in RM 6.5-7.5 SWAC for Integrated vs. Removal Focus Alternatives
Arkema Early Action
Draft EE/CA Report

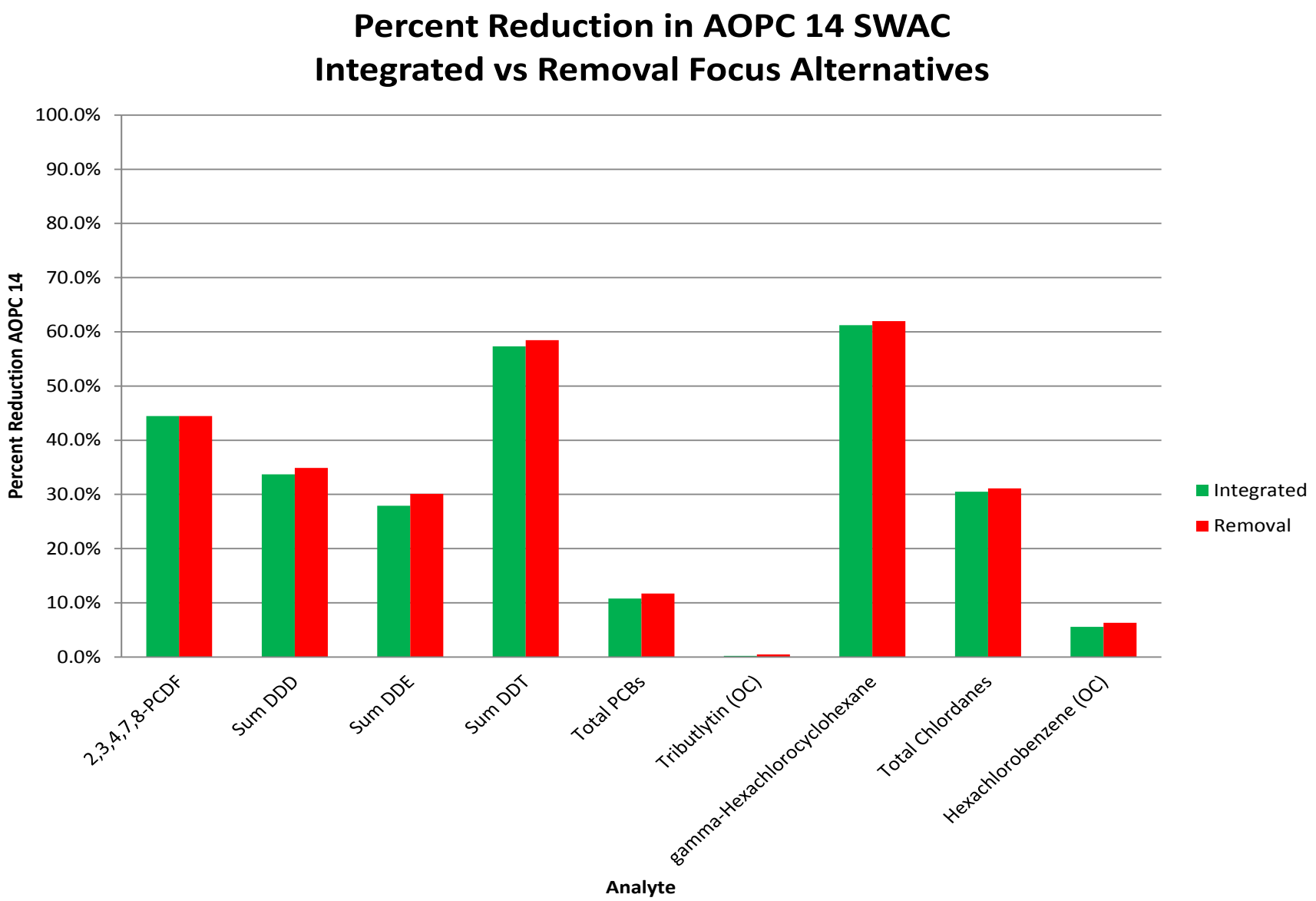

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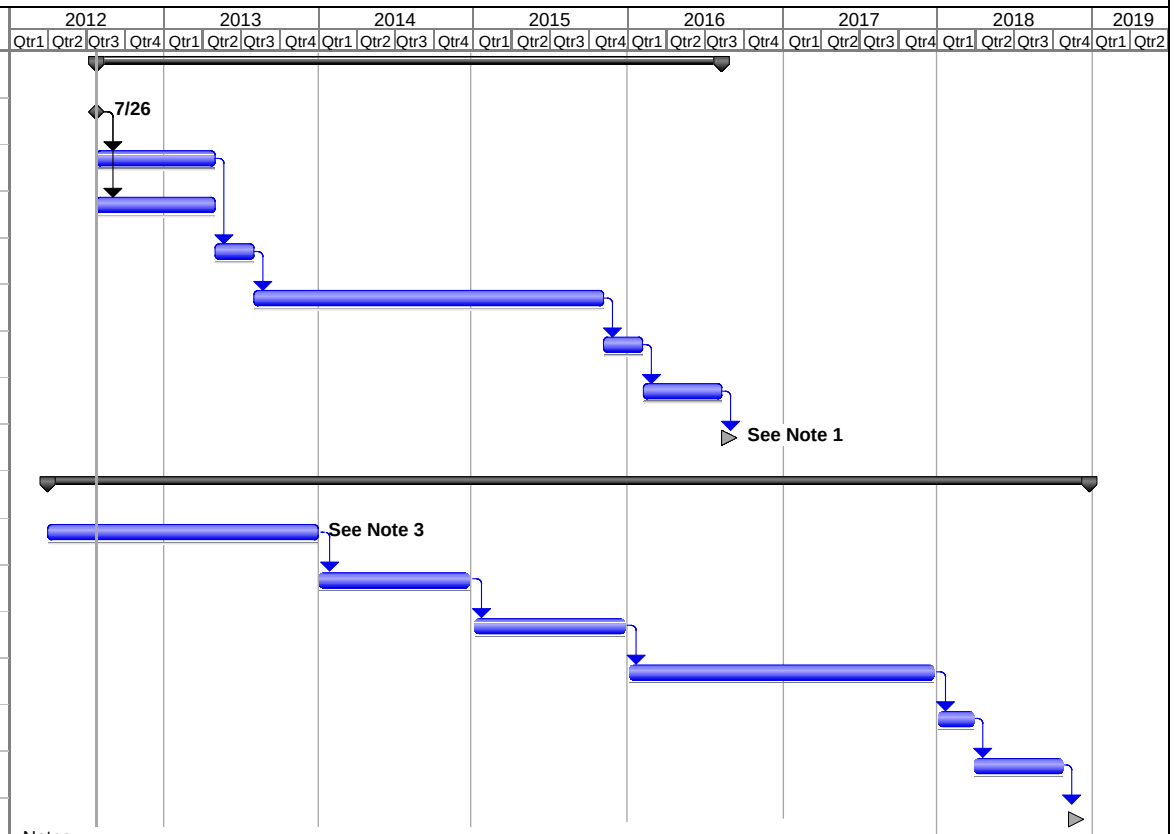
Figure 8-3
Reduction in AOPC 14 SWAC for Integrated vs. Removal Focus Alternatives
Arkema Early Action
Draft EE/CA Report

Estimated Arkema Early Action Schedule

ID	Task Name
1	**Estimated Arkema Early Action Schedule**
2	Submittal of First Draft EE/CA to EPA
3	Preparation and EPA Approval of Final EE/CA Report
4	Preparation and EPA Approval of Final BA & Section 404 Memo
5	Preparation and EPA Issuance of Action Memorandum
6	Preparation and EPA Approval of Final Design
7	Preparation and EPA Approval of Contractor(s)
8	Preparation and EPA Approval of RA Work Plan
9	Implementation of Removal Action (Note 1)
10	**Estimated Portland Harbor Schedule (Note 2)**
11	Preparation and EPA Approval of PH FS (Note 3)
12	EPA Issuance of PH ROD
13	EPA Issuance of Consent Orders
14	EPA Approval of PH Final Design(s)
15	EPA Approval of PH RA Contractor(s)
16	EPA Approval of PH RA Work Plan
17	Implementation of PH Removal Action



Notes:
1. Estimated Arkema Early Action implementation schedule is dependent on sequencing to be provided in the PH ROD.

2. A formal schedule for the Portland Harbor Superfund Site is not available. Major milestones, tasks and durations have been estimated.

3. Assumed duration includes reviews and associated comment response periods (including National Remedy Review Board, CSTAG, and public) and writing of the action memorandum (per EPA's 3-28-2012 letter).

Dates and duration of tasks are dependent on timing of agency review. It should be noted that this schedule does not include time incurred as a result of administrative delays (i.e., review delays, etc.).

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Figure 9-1
Arkema Early Action Schedule
Arkema Early Action
Draft EE/CA Report

TABLES

Table 2-1. Summary of Portland Harbor PRGs, RALs, and AOPC 14 SQGs

			Portland Harbor PRGs				AOPC 14 Specific	Portland Harbor RALs					RM 7–8 RALs
Analyte	CAS #	Units	PRG-1	PRG-2	PRG-3	PRG-4	SQG	RAL-B	RAL-C	RAL-D	RAL-E	RAL-F	RM 7–8 RALs[a]
2,3,4,7,8-Pentachlorodibenzofuran	57117-31-4	pg/g	56	54.1	20.5	--	--	--	--	--	20	10	1,750
gamma-Hexachlorocyclohexane	58-89-9	mg/kg	0.00138	--	--	--	--	--	--	--	--	--	--
Hexachlorobenzene	118-74-1	mg/kg-OC	37	3.7	--	--	--	--	--	--	--	--	--
Total Chlordanes (EE/CA)	TOTCHLDANEeeca	mg/kg	0.83	0.083	0.00187	--	--	--	--	--	--	--	--
Total DDD (EE/CA)	E17075011eeca	mg/kg	0.9	0.089	0.028	--	1.68	--	--	--	0.1	0.05	--
Total DDE (EE/CA)	E17075029eeca	mg/kg	0.1	0.0088	0.0313	0.00302	0.75	1	1	0.2	0.05	0.02	0.4
Total DDT (EE/CA)	E17075037eeca	mg/kg	1.2	0.12	0.0629	--	5.8	--	--	--	0.15	0.06	6.0
Total DDx (EE/CA)	E966176eeca	mg/kg	0.218	--	--	--	8.2	--	--	--	--	--	--
Total PCBs (EE/CA)	TOTPCBSeeca	mg/kg	0.5	0.0295	--	--	--	1	0.75	0.5	0.2	0.075	--
Tributyltin ion	36643-28-4	mg/kg-OC	24.4	--	--	--	--	--	--	--	--	--	--

Sources:

Analyte	PRG-1	PRG-2	PRG-3	PRG-4
2,3,4,7,8-Pentachlorodibenzofuran	Eco - mink multi-species diet (Exposure area: 1 RM). **This value is also an RG.**	Eco - bird dietary assessment - sandpiper worms (Exposure area: beach type). This value is also an RG. **This value is also a focused PRG.**	HH - adult fish consumption, small mouth bass, low IR, based on cancer risk =1E-4 (Exposure area: 1 RM). **This value is also an RG.**	--
gamma-Hexachlorocyclohexane	Eco benthic - PEL SQG (Exposure area: point-by-point).[b,c]		--	--
Hexachlorobenzene	HH - Adult fish consumption, single species diet, large home range fish, low IR, low BA, based on cancer risk =1E-4 (Exposure area: site).	HH - Adult fish consumption, single species diet, large home range fish, low IR, low BA, based on cancer risk =1E-5 (Exposure area: site).	--	--
Total Chlordanes (EE/CA)	HH – Adult fish consumption, small mouth bass low IR, based on cancer risk =1E-4 (Exposure area: 1 RM).[b]	HH – Adult fish consumption, small mouth bass low IR, based on cancer risk =1E-5 (Exposure area: 1 RM).[b]	HH - fish consumption - Large home range single species high IR, low BA, based on cancer risk =1E-6. (Exposure area: site). **Focused PRG.**	--
Total DDD (EE/CA)	HH - adult fish consumption, small mouth bass low IR, based on cancer risk =1E-4 (Exposure area: 1 RM).b	HH - adult fish consumption, small mouth bass low IR, based on cancer risk =1E-5 (Exposure area: 1 RM).[b]	Eco benthic - PEC SQG (Exposure area: point-by-point).[b]	--

Table 2-1. Summary of Portland Harbor PRGs, RALs, and AOPC 14 SQGs

Analyte	PRG-1	PRG-2	PRG-3	PRG-4
Total DDE (EE/CA)	HH - adult fish consumption, small mouth bass low IR, based on cancer risk =1E-4 (Exposure area: 1 RM).	HH - adult fish consumption, small mouth bass low IR, based on cancer risk =1E-5 (Exposure area: 1 RM).[b]	Eco - benthic - PEC SQG (Exposure area: point-by-point).	HH - adult fish consumption, large home range single species, low IR, low BA, based on cancer risk =1E-6 (Exposure area: site). **This value is also an RG.**
Total DDT (EE/CA)	HH - adult fish consumption, small mouth bass low IR, based on cancer risk =1E-4 (Exposure area: 1 RM).b	HH - adult fish consumption, small mouth bass low IR, based on cancer risk =1E-5 (Exposure area: 1 RM).[b]	Eco - Benthic PEC SQG (Exposure area: point-by-point).[b]	--
Total DDx (EE/CA)	Eco - Benthic PEC SQG (Exposure area: point-by-point).[b]	--	--	--
Total PCBs (EE/CA)	Eco - benthic - FPM high SQG (Exposure area: point-by-point).[b]	HH - adult fish consumption, small mouth bass, low IR, based on cancer risk =1E-4 (Exposure area: 1 RM). **This value is also an RG.**	--	--
Tributyltin ion	Eco - tissue residue assessment, benthic, worms (Exposure area: point by point).	--	--	--

Notes:

-- = not available
AOPC = area of potential concern
BA = bioaccumulation
BERA = baseline ecological risk assessment
DW = dry weight
Eco = ecological
EE/CA = engineering evaluation and cost analysis
EPA = U.S. Environmental Protection Agency
FPM = floating point model
FPRG = focused preliminary remediation goal
FS = feasibility study
HH = human health
IR = ingestion rate
LWG = Lower Willamette Group
NOAA = National Oceanic and Atmospheric Administration
OC = organic carbon
PEC = probable effects concentration
PEL = probable effects level
PRG = preliminary remediation goal
RAL = removal action level
RG = remediation goal
RM = river mile
SQG = sediment quality guideline
UPL = upper prediction limit

[a] This RAL was estimated based on 10^{-5} risk, adult fish consumption, small mouth bass. Estimated from RAL plots for RM 7-8 in Appendix Db, Draft Portland Harbor FS Report.
[b] Listed as FPRG by EPA in FS Table 3.5-2, but not recommended by LWG in FS Table 3.5-4.
[c] Not among the chemicals of concern with potentially unacceptable risk that were recommended for risk management in the draft final Portland Harbor BERA.

Table 2-2. Data Screening Results

										Portland Harbor PRGs			
										PRG-1		PRG-2	
Analyte	Units	Sample Count	Percent Detected	Minimum Non-Detected	Maximum Non-Detected	Median Non-Detected	Minimum Detected	Maximum Detected	Median Detected	Percent Detected Exceedances	Percent Non-Detected Exceedances	Percent Detected Exceedances	Percent Non-Detected Exceedances
Tributyltin ion	mg/kg-OC	16	6.20	0.583	21.3	5.42	0.207	0.207	0.207	0	6.20	--	--
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	66	78.8	0.00500	0.650	0.0835	0.100	28000	68.8	42.4	36.4	42.4	36.4
gamma-Hexachlorocyclohexane	mg/kg	98	4.10	0.0000770	9.90	0.0100	0.00122	0.430	0.0875	3.10	1.00	--	--
Total Chlordanes (EE/CA)	mg/kg	88	39.8	0.0000420	10.0	0.0920	0.000330	1.10	0.0250	3.40	36.4	13.6	26.1
Total DDD (EE/CA)	mg/kg	287	93.0	0.000150	0.130	0.000170	0.000130	1200	0.270	32.1	61.0	54.7	38.3
Total DDE (EE/CA)	mg/kg	287	72.5	0.0000450	7.50	0.000300	0.0000860	24.0	0.0615	32.8	39.7	49.1	23.3
Total DDT (EE/CA)	mg/kg	287	91.6	0.000140	0.400	0.000285	0.000150	4500	0.480	35.5	56.1	55.1	36.6
Total DDx (EE/CA)	mg/kg	287	95.1	0.000150	0.0160	0.000285	0.000320	4800	0.860	58.2	36.9	--	--
Hexachlorobenzene	mg/kg-OC	80	56.2	0.0414	361	9.09	0.0196	639	0.444	2.50	53.8	8.80	47.5
Total PCBs (EE/CA)	mg/kg	62	24.2	0.00120	150	0.0780	0.0320	1.20	0.120	4.80	19.4	24.2	0

Table 2-2. Data Screening Results

		Portland Harbor PRGs				AOPC 14 Specific		Portland Harbor RALs					
		PRG-3		PRG-4		SQG		RAL-B		RAL-C		RAL-D	
Analyte	Units	Percent Detected Exceedances	Percent Non-Detected Exceedances	Percent Detected Exceedances	Percent Non-Detected Exceedances	Percent Detected Exceedances	Percent Non-Detected Exceedances	Percent Detected Exceedances	Percent Non-Detected Exceedances	Percent Detected Exceedances	Percent Non-Detected Exceedances	Percent Detected Exceedances	Percent Non-Detected Exceedances
Tributyltin ion	mg/kg-OC	--	--	--	--	--	--	--	--	--	--	--	--
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	43.9	34.8	--	--	--	--	--	--	--	--	--	--
gamma-Hexachlorocyclohexane	mg/kg	--	--	--	--	--	--	--	--	--	--	--	--
Total Chlordanes (EE/CA)	mg/kg	35.2	4.50	--	--	--	--	--	--	--	--	--	--
Total DDD (EE/CA)	mg/kg	62.0	31.0	--	--	25.4	67.6	--	--	--	--	--	--
Total DDE (EE/CA)	mg/kg	41.5	31.0	55.1	17.4	12.5	59.9	10.8	61.7	10.8	61.7	24.7	47.7
Total DDT (EE/CA)	mg/kg	59.2	32.4	--	--	21.6	70.0	--	--	--	--	--	--
Total DDx (EE/CA)	mg/kg	--	--	--	--	23.7	71.4	--	--	--	--	--	--
Hexachlorobenzene	mg/kg-OC	--	--	--	--	--	--	--	--	--	--	--	--
Total PCBs (EE/CA)	mg/kg	--	--	--	--	--	--	3.20	21.0	4.80	19.4	4.80	19.4

Table 2-2. Data Screening Results

		Portland Harbor RALs				RM 7–8 RALs	
		RAL-E		RAL-F		RM 7–8 RALs	
Analyte	Units	Percent Detected Exceedances	Percent Non-Detected Exceedances	Percent Detected Exceedances	Percent Non-Detected Exceedances	Percent Detected Exceedances	Percent Non-Detected Exceedances
Tributyltin ion	mg/kg-OC	--	--	--	--	--	--
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	90.9	66.7	90.9	66.7	19.7	59.1
gamma-Hexachlorocyclohexane	mg/kg	--	--	--	--	--	--
Total Chlordanes (EE/CA)	mg/kg	--	--	--	--	--	--
Total DDD (EE/CA)	mg/kg	112	74.2	112	74.2	--	--
Total DDE (EE/CA)	mg/kg	82.2	62.7	82.2	62.7	17.4	55.1
Total DDT (EE/CA)	mg/kg	114	69.7	114	69.7	21.3	70.4
Total DDx (EE/CA)	mg/kg	--	--	--	--	--	--
Hexachlorobenzene	mg/kg-OC	--	--	--	--	--	--
Total PCBs (EE/CA)	mg/kg	22.6	25.8	22.6	25.8	--	--

Notes:
-- = not applicable
AOPC = area of potential concern
EE/CA = engineering evaluation and cost analysis
PRG = preliminary remediation goal
RAL = removal action level
SQG = sediment quality guideline

Table 3-1. Removal Action Objectives Summary

Arkema Removal Action AOC Statement of Work RAOs	Portland Harbor Draft FS RAOs (Anchor et al. 2012)	Arkema EE/CA Refined RAOs
RAO 1: Reduce human health risks to acceptable levels from direct contact with and incidental ingestion of chemicals of concern (COCs) in sediments and riverbank within the RAA.	**PH RAO 1 – HH Sediments:** Reduce to acceptable levels human health risks from exposure to contaminated sediments resulting from incidental ingestion of and dermal contact with sediments, and comply with identified ARARs.	**Refined RAO 1:** Reduce human health risks to acceptable levels from direct contact with and incidental ingestion of chemicals of concern (COCs) in sediments and riverbank soils within the RAA. <u>Performance of the RAO</u> The performance of RAO 1 will be assessed against Portland Harbor RGs for total DDE, total PCBs, and 2,3,4,7,8-PCDF and Portland Harbor focused PRGs for total DDT, total DDD, gamma-hexachlorocyclohexane, total chlordanes, and tributyltin (Anchor et al. 2012).
RAO 2: Reduce COC concentrations in sediments and riverbank within the RAA to levels that will result in acceptable risks to humans that eat fish and shellfish from the Willamette River.	**PH RAO 2 – HH Biota Ingestion:** Reduce to acceptable levels human health risks from indirect exposures to COCs through ingestion of fish and shellfish that occur via bioaccumulation pathways from sediment and/or surface water and comply with identified ARARs.	**Refined RAO 2:** Reduce COC concentrations in sediments and riverbank soil within the RAA to levels that will result in acceptable risks to humans that eat fish and shellfish that occur via bioaccumulation pathways from sediments from the Willamette River. <u>Performance of the RAO</u> The performance of RAO 2 will be assessed against Portland Harbor RGs for total DDE, total PCBs, and 2,3,4,7,8-PCDF and Portland Harbor focused PRGs for total DDD, total DDT, gamma-hexachlorocyclohexane, total chlordanes, and tributyltin (Anchor et al. 2012).
RAO 3: Reduce human health risks to acceptable levels from direct contact with and incidental ingestion of water with COCs within the RAA.	**PH RAO 3 – HH Surface Water:** Reduce risks from COCs in surface water at the Site to acceptable exposure levels that are protective of human health risks from ingestion of, inhalation of, and dermal contact with surface water; protect the drinking water beneficial use of the Willamette River at the Site; and comply with identified ARARs.	**Refined RAO 3:** Reduce human health risks to acceptable levels from direct dermal contact with and incidental ingestion of surface water with COCs within the RAA. <u>Performance of the RAO</u> The performance of RAO 3 will be assessed against Oregon WQS, federal NRWQC, and MCLs for indicator chemicals listed in Appendix C of the draft Portland Harbor FS report (Anchor et al. 2012). Consistent with the draft Portland Harbor FS, in cases where WQS/NRWQC are below background, upstream background concentrations will be used for comparisons. The indicator chemicals that are COIs at the site consist of total PCBs, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT.
NA	**PH RAO 4 – HH Groundwater:** Reduce to acceptable levels human health risks resulting from direct exposure to contaminated groundwater and indirect exposure to contaminated groundwater through fish and shellfish consumption, and comply with identified ARARs	Construction of the Arkema groundwater source control measure will be initiated in 2012 and will be fully implemented prior to the Arkema NTCRA. The groundwater source control measure will consist of a barrier wall and a pump and treat system. The TZW pathway will be assessed throughout the EE/CA process once the groundwater source control measure has been implemented and data are available to assess the post-groundwater source control measure TZW data.
RAO 4: Reduce ecological risks from contact with and ingestion of COCs in sediments or riverbank material or prey within the RAA to acceptable levels.	**PH RAO 5 – Eco Sediments:** Reduce to acceptable levels the risks to ecological receptors resulting from the ingestion of and direct contact with contaminated sediments and comply with identified ARARs	**Refined RAO 4a:** Reduce ecological risks from direct contact with and ingestion of COCs in sediments or riverbank material within the RAA to acceptable levels. **Refined RAO 4b:** Reduce ecological risks from indirect exposure to COCs in sediment via bioaccumulation in prey within the RAA to acceptable levels. <u>Performance of the RAO</u> The performance of RAOs 4a and 4b will be assessed against Portland Harbor RGs for total DDE, total PCBs, and 2,3,4,7,8-PCDF and Portland Harbor focused PRGs for total DDD, total DDT, gamma-hexachlorocyclohexane, total chlordanes, and tributyltin in surface soils and sediments (0-30 cm below mudline) (Anchor et al. 2012).
NA	**PH RAO 6 – Eco Biota (Prey) Ingestion:** Reduce to acceptable levels risks to ecological receptors from indirect exposures through ingestion of prey to COCs in sediments via bioaccumulation pathways from sediment and/or surface water and comply with identified ARARs.	See refined RAOs 4 and 5.

Table 3-1. Removal Action Objectives Summary

Arkema Removal Action AOC Statement of Work RAOs	Portland Harbor Draft FS RAOs (Anchor et al. 2012)	Arkema EE/CA Refined RAOs
RAO 5: Reduce ecological risks to acceptable levels from contact with and ingestion of water with COCs within the RAA.	**PH RAO 7** – **Eco Surface Water:** Reduce risks from COCs in surface water at the Site to acceptable exposure levels that are protective of ecological receptors based on the ingestion of and direct contact with surface water and comply with identified ARARs.	**Refined RAO 5:** Reduce ecological exposure to acceptable risk levels from contact with and ingestion of surface water with COCs within the RAA. <u>Performance of the RAO</u> Although this RAO is being achieved for the Harbor-wide site, performance of RAO 5 for the Arkema site will be assessed against Oregon WQS, federal NRWQC, and MCLs for indicator chemicals listed in Appendix C of the draft Portland Harbor FS report (Anchor et al. 2012). Consistent with the draft Portland Harbor FS, in cases where WQS/NRWQC are below background, upstream background concentrations will be used for comparisons. The indicator chemicals that are COIs at the site consist of total PCBs, 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT.
RAO 6: Eliminate the potential for migration of contaminants at unacceptable levels from the RAA to the Willamette River.	NA	**Refined RAO 6:** Eliminate the potential for migration of contaminants at unacceptable levels from the RAA to the Willamette River. <u>Performance of the RAO</u> Short-term and long-term monitoring will be implemented once the NTCRA is completed to assess the performance of RAO 6. <u>Sediments:</u> The performance of RAO 6 will be assessed against Portland Harbor RGs for total DDE, total PCBs, and 2,3,4,7,8-PCDF and Portland Harbor focused PRGs for total DDD, total DDT, gamma-hexachlorocyclohexane, total chlordanes, and tributyltin in surface soils and sediments (0-30 cm below mudline). <u>Groundwater:</u> The performance of RAO 6 for the Arkema site will be assessed against Oregon WQS, federal NRWQC, and MCLs for indicator chemicals listed in Appendix C of the draft Portland Harbor FS report (Anchor et al. 2012). Consistent with the draft Portland Harbor FS, in cases where WQS/NRWQC are below background, upstream background concentrations will be used for comparisons. The indicator chemicals that are COIs at the site consist of total PCBs, 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT.
RAO 7: Reduce contaminant flux from uplands, riverbank, and sediments so that recontamination of any sediment or riverbank caps put in place does not occur.	NA	**Refined RAO 7:** Reduce contaminant flux from uplands, riverbank, and sediments so that recontamination of any sediment or riverbank caps put in place does not occur. <u>Performance of the RAO</u> <u>Sediments:</u> The performance of RAO 7 will be assessed against Portland Harbor RGs for total DDE, total PCBs, and 2,3,4,7,8-PCDF, and Portland Harbor focused PRGs for total DDD, total DDT, gamma-hexachlorocyclohexane, total chlordanes, and tributyltin in surface soils and sediments (0-30 cm below mudline). <u>Stormwater and TZW:</u> The performance of RAO 7 for the Arkema site will be assessed against Oregon WQS, federal NRWQC, and MCLs for indicator chemicals listed in Appendix C of the draft Portland Harbor FS report (Anchor et al. 2012). Consistent with the draft Portland Harbor FS, in cases where WQS/NRWQC are below background, upstream background concentrations will be used for comparisons. The indicator chemicals that are COIs at the site consist of total PCBs, 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT.
NA	**PH RAO 8** – **Eco Groundwater:** Reduce to acceptable levels the risks to ecological receptors resulting from the ingestion of and direct contact with contaminated groundwater and indirect exposures through ingestion of prey via bioaccumulation pathways from groundwater, and comply with identified ARARs.	Construction of the Arkema groundwater source control measure will be initiated in 2012 and will be fully implemented prior to the Arkema NTCRA. The groundwater source control measure will consist of a barrier wall and a pump and treat system. The TZW pathway will be assessed throughout the EE/CA process once the groundwater source control measure has been implemented and data are available to assess the post-groundwater source control measure TZW data.

Notes

AOC	Administrative Order on Consent
ARAR	applicable or relevant and appropriate requirement
COC	chemical of concern
COI	contaminant of interest
Eco	ecological
EE/CA	engineering evaluation and cost analysis
FS	feasibility study
HH	human health
MCL	maximum contaminant level
NA	not available
NRWQC	National Recommended Water Quality Criteria
NTCRA	non-time-critical removal action
PCB	polychlorinated biphenyl
PCDF	polychlorinated dibenzofuran
PH	Portland Harbor
PRG	preliminary remediation goal
RAA	removal action area
RAO	remedial action objective
RG	remediation goal
TZW	transition zone water
WQS	water quality standard

Anchor et al. 2012. Draft Portland Harbor Feasibility Study.

Table 3-2. ARAR Summary

Regulation	Citation	Criterion/Standard	Applicability/Appropriateness
Federal ARARs			
Clean Water Act, Section 404 and Section 404(b)(1) Guidelines	33 USC 1344, 40 CFR Part 230	Regulates discharge of dredged and fill material into navigable waters of the United States.	Action-specific. Applicable to dredging, covering, capping, and designation and construction of in-water disposal sites and in-water filling activities in the Willamette River.
Clean Water Act	33 USC 1313, 1314 Most recent 304(a) list, as updated up to issuance of the ROD	Under Section 304(a), minimum criteria are developed for water quality programs established by states. Two kinds of water quality criteria are developed: one for protection of human health, and one for protection of aquatic life.	Chemical-specific and action-specific. Relevant and appropriate for cleanup standards for surface water and contaminated groundwater discharging to surface water if more stringent than promulgated state criteria. Relevant and Appropriate to short-term impacts to surface water from implementation of the remedial action that results in a discharge to navigable water, such as dredging and capping if more stringent than promulgated state criteria.
Clean Water Act, Section 401	33 USC 1341, 40 CFR Section, 121.2(a)(3), (4) and (5)	Any federally authorized activity which may result in any discharge into navigable waters requires reasonable assurance that the action will comply with applicable provisions of sections 1311, 1312, 1313, 1316, and 1317 of the Clean Water Act.	Action-specific. Relevant and Appropriate to implementation of the remedial action that results in a discharge to the river if more stringent than state implementation regulations.
Clean Water Act, Section 402	33 USC 1342	Regulates discharges of pollutants from point sources to waters of the U.S., and requires compliance with the standards, limitations and regulations promulgated per Sections 301, 304, 306, 307, 308 of the Clean Water Act.	Relevant and appropriate to remedial activities that result in a discharge of pollutants from point sources to the river if more stringent than state promulgated point source requirements.
Safe Drinking Water Act	42 USC 300f, 40 CFR Part 141, Subpart O, App. A. 40 CFR Part 143	Establishes national drinking water standards to protect human health from contaminants in drinking water	Chemical-specific. Relevant and appropriate as a performance standard for groundwater and surface water which are potential drinking water sources.
Resource Conservation and Recovery Act	40 CFR 260, 261	Establishes identification standards and definitions for material is exempt from the definition of a hazardous waste.	Action-specific. Applicable to characterizing wastes generated from the action and designated for off-site or upland disposal; potentially relevant and appropriate for use in identifying acceptance criteria for confined in-water disposal.

Table 3-2. ARAR Summary

Regulation	Citation	Criterion/Standard	Applicability/Appropriateness
RCRA – Solid Waste	40 CFR 257 Subpart A		RCRA Solid Waste requirements may be relevant and appropriate to remedial actions that result in upland or in-water disposal of dredged material. Requirements for the management of solid waste landfills may be relevant and appropriate to upland disposal.
Hazardous Materials Transportation Act	49 USC §5101 et seq. 40 CFR Parts 171-177		Hazardous Materials Transportation Act requirements are applicable to remedial actions that involve the transport of hazardous materials (i.e., dredged material).
Fish and Wildlife Coordination Act Requirements	16 USC 662, 663 50 CFR 6.302(g)	Requires federal agencies to consider effects on fish and wildlife from projects that may alter a body of water and mitigate or compensate for project-related losses, which includes discharges of pollutants to water bodies.	Action-specific. Potentially applicable to determining impacts and appropriate mitigation, if necessary, for effects on fish and wildlife from filling activities or discharges from point sources.
Magnuson-Stevens Fishery Conservation and Management Act	50 CFR Part.600.920	Evaluation of impacts to Essential Fish Habitat (EFH) is necessary for activities that may adversely affect EFH.	Location-specific. Potentially applicable if the removal action may adversely affect EFH.
Federal Emergency Management Act	44 CFR 60.3(d)(2) and (3)		FEMA flood rise requirements are considered relevant and appropriate requirements for remedial actions.
River and Harbors Act	33 USC 401 et seq. 33 CFR parts 320 to 323	Section 10 prohibits the unauthorized obstruction or alteration of any navigable water. Structures or work in, above, or under navigable waters are regulated under Section 10.	Action-specific. Applicable requirements for how remedial actions are taken or constructed in the navigation channel.
Clean Air Act	42 USC §7401 et seq.		Action-specific. Applicable to remedial activities that generate air emissions.
Toxic Substances Control Act	15 USC §2601 et seq.		Chemical-specific. TSCA requirements are applicable to contaminated material or surface water with PCB contamination.
Marine Mammal Protection Act	16 USC §1361 et seq. 50 CFR 216		Action-specific. Applicable to remedial actions that have the potential to affect marine mammals.

Table 3-2. ARAR Summary

Regulation	Citation	Criterion/Standard	Applicability/Appropriateness
Migratory Bird Treaty Act	16 USC §703 50 CFR §10.12	Makes it unlawful to take any migratory bird. "Take" is defined as pursuing, hunting, wounding, killing, capturing, trapping and collecting.	Action-specific. Applicable to remedial actions that have the potential to effect a taking of migratory birds.
National Historic Preservation Act	16 USC 470 et seq. 36 CFR Part 800	Requires the identification of historic properties potentially affected by the agency undertaking, and assessment of the effects on the historic property and seek ways to avoid, minimize or mitigate such effects. Historic property is any district, site, building, structure, or object included in or eligible for the National Register of Historic Places, including artifacts, records, and material remains related to such a property.	Action-specific. Potentially applicable if historic properties are potentially affected by remedial activities.
Archeological and Historic Preservation Act	16 USC 469a-1	Provides for the preservation of historical and archeological data that may be irreparably lost as a result of a federally approved project and mandates only preservation of the data.	Action-specific. Potentially applicable if historical and archeological data may be irreparably lost by implementation of the remedial activities.
Native American Graves Protection and Reparation Act	25 USC 3001-3013 43 CFR 10	Requires federal agencies and museums which have possession of or control over Native American cultural items (including human remains, associated and unassociated funerary items, sacred objects and objects of cultural patrimony) to compile an inventory of such items. Prescribes when such federal agencies and museums must return Native American cultural items. "Museums" are defined as any institution or state or local government agency that receives federal funds and has possession of, or control over, Native American cultural items.	Location-specific; action-specific. If Native American cultural items are present on property belonging to the Oregon Division of State Lands that is a part of the removal action area, this requirement is potentially applicable. If Native American cultural items are collected by an entity which is either a federal agency or museum, then the requirements of the law are potentially applicable.

Table 3-2. ARAR Summary

Regulation	Citation	Criterion/Standard	Applicability/Appropriateness
Endangered Species Act	16 USC 1531 et seq. 50 CFR 17	Actions authorized, funded, or carried out by federal agencies may not jeopardize the continued existence of endangered or threatened species or adversely to avoid jeopardy or take appropriate mitigation modify or destroy their critical habitats. Agencies are to avoid jeopardy or take appropriate mitigation measures to avoid jeopardy.	Action-specific. Applicable to remedial actions, that may adversely impact endangered or threatened species or critical habitat that are present at the site.
Executive Order for Wetlands Protection	Executive Order 11990 (1977) 40 CFR 6.302 (a) 40 CFR Part 6, App. A	Requires measures to avoid adversely impacting wetlands whenever possible, minimize wetland destruction, and preserve the value of wetlands.	Location-specific. Relevant and appropriate in assessing impacts to wetlands, if any, from the response action and for developing appropriate compensatory mitigation for the project.
Executive Order for Floodplain Management	Exec. Order 11988 (1977) 40 CFR Part 6, App. A 40 CFR 6.302 (b)	Requirements for Flood Plain Management Regulations Areas. Requires measures to reduce the risk of flood loss, minimize impact of floods, and restore and preserve the natural and beneficial values of floodplains.	Location-specific. Relevant and appropriate for assessing impacts, if any, to the floodplain and flood storage from the response action and developing compensatory mitigation that is beneficial to floodplain values.
National Flood Insurance Act and Flood Disaster Protection Act	42 USC 4001 et seq. 44 CFR National Flood Insurance Program Subpart A	Requirements for Flood Plain Management Regulations Areas. Requires measures to reduce the risk of flood loss, minimize impact of floods, and restore and preserve the natural and beneficial values of floodplains.	Location-specific. Relevant and appropriate for assessing impacts, if any, to the floodplain and flood storage from the response action and developing compensatory mitigation that is beneficial to floodplain values.
State ARARs			
Oregon Environmental Cleanup Law ORS 465.315.	Oregon Hazardous Substance Remedial Action Rules OAR 340-122-0040(2)(a) and (c), 0115(3),(32) and (51).	Sets standards for degree of cleanup required, including for oil and other petroleum products/wastes. Establishes acceptable risk levels for human health at 1x10-6 for individual carcinogens, 1x10-5 for multiple carcinogens, and Hazard Index of 1 for noncarcinogens; and protection of ecological receptors at the individual level for threatened or endangered species and the population level for all others. OAR 340-122-0040 and 0115(3).	Chemical-specific. A risk-based numerical value that, when applied to site-specific conditions, will establish concentrations of hazardous substances that may remain or be managed onsite in a manner avoiding unacceptable risk.

Table 3-2. ARAR Summary

Regulation	Citation	Criterion/Standard	Applicability/Appropriateness
	OAR 340-122-and (b), 340-122-0040(4) 0115(32)	For hot spots of contamination in water, requires treatment, if feasible, when treatment would be reasonably likely to restore or protect beneficial uses within a reasonable time. For hot spots contamination of sediments, requires treatment or excavation and offsite disposal of hazardous substances if treatment is reasonably likely to restore or protect such beneficial uses within a reasonable time.	Chemical-specific and action-specific. When contaminant concentrations fall within the definition of “hot spot” set forth in subpart 0115(32), treatment (including excavation and offsite disposal) of contaminated media to levels below such risk levels or beneficial-use impacts needs to be evaluated in the feasibility study.
Hazardous Waste and Hazardous Materials II	ORS 466.005(7) OAR 340-102-0011 - Hazardous Waste Determination	Defines "Hazardous Waste" and the rule contains the criteria by which anyone generating residue must determine if that residue is a hazardous waste.	Chemical-specific and action-specific. Specifies substantive requirements if remedial action will involve onsite treatment, disposal, or storage of RCRA-listed or characteristic hazardous waste. (Note: offsite treatment, storage, or disposal is subject to all administrative and substantive state requirements.)
	Identification and Listing of Hazardous Waste OAR 340-101-0033	Identifies additional residuals that are subject to regulation as hazardous waste under state law.	Action-specific. Specifies requirements if remedial action will involve onsite treatment, disposal, or storage of additional listed wastes.
Solid Waste: General Provisions	Specific regulatory references to be provided by DEQ	Substantive Requirements for the location, design, construction, operation, and closure of solid waste management facilities.	Action-specific. Applicable if upland disposal facility contemplated onsite for solid, nonhazardous, waste disposal, handling, treatment, or transfer. (Note: offsite transfer, treatment, handling, or disposal is subject to all administrative and substantive state requirements.)
	Solid Waste: Land Disposal Sites Other than Municipal Solid Waste Landfills, specific regulatory references to be supplied by DEQ	Requirements for the management of solid wastes at land disposal sites other than municipal solid waste landfills.	Action-specific. Applicable to the onsite management and disposal of contaminated sediment, soil, and/or groundwater.

Table 3-2. ARAR Summary

Regulation	Citation	Criterion/Standard	Applicability/Appropriateness
Water Pollution Control Act ORS 468B.048	Water Quality Standards OAR 340-041-0340, Table 20 and Table 33A	DEQ is authorized to administer and enforce Clean Water Act program in Oregon. DEQ rules designate beneficial uses for water bodies and narrative and numeric water quality criteria necessary to protect those uses. OAR 340-041-0340 designates and defines the beneficial uses that shall be protected in the Willamette Basin. For the purposes of state law, Table 20 are the applicable criteria, unless there is a corresponding criterion under Table 33A, in which case Table 33A is applicable. (Note: if Oregon promulgates new criteria prior to ROD, such new criteria will be ARAR).	Chemical-specific and action-specific. Applicable to any discharges to surface water from point sources, groundwater, overland flow of stormwater, and activities that may result in discharges to waters of the state, such as dredge and fill, de-watering sediments, and other remedial activities. Relevant and appropriate as performance standards for sites and where contaminants are left in place.
Water Pollution Control Act ORS 468B.048	Regulations Pertaining to NPDES Discharges Specific regulatory references to be supplied by DEQ	Effluent limitations and management practices for point-source discharges into waters of the state (otherwise subject to NPDES permit but for onsite permit exemption).	Chemical-specific and action-specific. Applies state water quality standards and effluent limitations to point-source discharges to the Willamette River.
	Certification of Compliance with Water Quality Requirements and Standards ORS 468b.035	Provides that federally-approved activities that may result in a discharge to waters of the state requires evaluation whether an activity may proceed and meet water quality standards with conditions, which if met, will ensure that water quality standards are met.	Action-specific. Applicable to implementation of the remedial action (e.g., dredging, capping, and construction of confined disposal facility) that may result in a discharge to waters of the state.
	Rules Governing the Issuance and Enforcement of Removal-Fill Authorizations within Waters of Oregon Including Wetlands OAR 141-085 0680, 141-085-0695, 141-085-0710, 141-085-0765	Substantive requirements for dredge and fill activities in waters of the state, including in designated Essential Indigenous Anadromous Salmonid Habitat.	Action-specific. Applicable to remedial action dredge and fill activities, capping, and riverbank remediation.

Table 3-2. ARAR Summary

Regulation	Citation	Criterion/Standard	Applicability/Appropriateness
Oregon Department of Fish and Wildlife Fish Management Plans for the Willamette River	OAR 635, div 500	Provides basis for in-water work windows in the Willamette River.	Action-specific. Potentially applicable to timing of implementation of the remedial action due to presence of protected species at the site.
Oregon Air Pollution Control ORS 468A et. seq.	General Emissions Standards OAR 340-226	DEQ is authorized to administer and enforce Clean Air program in Oregon. Rules provide general emission standards for fugitive emissions of air contaminants and require highest and best practicable treatment or control of such emissions.	Action-specific. Applicable to remedial actions taking place in on-site uplands. Could apply to earth-moving equipment, dust from vehicle traffic, and mobile-source exhaust, among other things.
Oregon Air Pollution Control ORS 468A et. seq.	Fugitive Emission Requirements OAR 340-208	Prohibits any handling, transporting, or storage of materials, or use of a road, or any equipment to be operated, without taking reasonable precautions to prevent particulate matter from becoming airborne. These rules for “special control areas” or other areas where fugitive emissions may cause nuisance and control measures are practicable.	Action-specific. Applicable to remedial actions taking place in on-site uplands. Could apply to earth-moving equipment, dust from vehicle traffic, and mobile-source exhaust, among other things.
Indian Graves and Protected Objects ORS 97.740-760		Prohibits willful removal of cairn, burial, human remains, funerary object, sacred object or object of cultural patrimony. Provides for reinterment of human remains or funerary objects under the supervision of the appropriate Indian tribe. Proposed excavation by a professional archeologist of a native Indian cairn or burial requires written notification to the State Historic Preservation Officer and prior written consent of the appropriate Indian tribe. Prohibits persons from excavating, injuring, destroying or damaging archeological sites or objects on public or private lands unless authorized.	
Archeological Objects and Sites ORS 358.905-955 ORS 390.235		Imposes conditions for excavation or removal of archeological or historical materials.	Location-specific and action-specific. Potentially relevant and appropriate if archeological material encountered.

Table 3-2. ARAR Summary

Regulation	Citation	Criterion/Standard	Applicability/Appropriateness
	Survival Guidelines OAR 635-100-0135	Survival Guidelines are rules for state agency actions affecting species listed under Oregon's Threatened or Endangered Wildlife Species law.	Action-specific and location-specific. Substantive requirements of Survival Guidelines relevant and appropriate to remedial activities affecting state-listed species.
Guidance for Assessing Bioaccumulative Chemicals of Concern in Sediment DEQ, 2007		Describes a process to evaluate chemicals found in sediment for their potential contribution to risk as a result of bioaccumulation. Provides alternative methods for developing sediment screening levels and bioaccumulation bioassay data.	To be Considered: in level of cleanup or standard of control that is protective.

Notes:
ARAR = applicable or relevant and appropriate requirement
CFR = Code of Federal Regulation
DEQ = Oregeon Department of Environmental Quality
EFH = Essential Fish Habitat
FEMA = Federal Emergency Management Agency
OAR = Oregon Administrative Rules
ORS = Oregon Revised Statute
NPDES = National Pollutant Discharge Elimination System
RCRA = Resource Conservation and Recovery Act
ROD = record of decision
USC = United States Code

Table 7-1. Summary of Quantities - Arkema NTCRA Removal Action Alternatives

Quantity	Alternative						
	2(i)	2(r)	3(i)	3(r)	4(i)	4(r)	5
Removal/ Disposal Volumes (cy) [a]							
Bank Excavation	11,000	11,000	11,000	11,000	11,000	11,000	-
Dredging	22,000	28,000	43,000	48,000	51,000	70,000	57,000
Total Volume Removed	33,000	39,000	54,000	59,000	62,000	81,000	57,000
Fill Volumes (cy)							
Sediment Caps	22,000	28,000	10,000	16,000	-	-	-
Riverbank Slope Cap[b]	11,000	11,000	11,000	11,000	11,000	11,000	-
Targeted Removal Backfill	-	-	32,000	32,000	51,000	70,000	57,000
Total Fill Volume	33,000	39,000	53,000	59,000	62,000	81,000	57,000
Areas (acres)							
Cap Area	2.9	3.7	1.4	2.2	0	0	0
MNR Area	2.1	1.3	2.1	1.3	2.1	1.3	1.2

Notes:

cy = cubic yard

MNR = monitored natural recovery

NCTRA = non-time-critical removal action

[a] All quantities are rounded to two significant figures. All removal volume estimates include a 6-inch overdepth allowance. 50% contingency applied to neatline volume estimates to accommodate dredge cut side slopes and refinements to dredge prism during design. For Alternatives 3 and 4, assumed maximum dredge depth of 15 ft and 3:1 cut slope from toe of riverbank (elev. +13 ft NAVD88) to bottom of dredge cut.

[b] Riverbank Slope Cap volume estimate includes re-use of bank soils, clean soil cover, riprap, and sand fill.

Table 7-2. SWAC Results for Alternatives 1 through 5

Chemical Group	Chemical	River Mile	Background[a]	Units	HH PRG: 10^{-4} Risk	HH PRG: 10^{-5} Risk	Eco PRG	Alt 1 (baseline)	Alt 2r	Alt 2i	Alt 3r	Alt 3i	Alt 4r	Alt 4i	Alt 5
Rivermile 6.5-7.5															
Dioxins	2,3,4,7,8-PCDF	6.5-7.5	0.0005	µg/kg dw	0.02			0.11	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Pesticides	Sum DDD	6.5-7.5	1.31	µg/kg dw	900	89		42.33	29.8	30.1	29.8	30.1	29.8	30.1	29.8
Pesticides	Sum DDE	6.5-7.5	1.72	µg/kg dw	100	8.8		16.52	12.06	12.35	12.06	12.35	12.06	12.35	12.06
Pesticides	Sum DDT	6.5-7.5	1.1	µg/kg dw	1200	120		163.75	72.94	73.67	72.94	73.67	72.94	73.67	72.94
PCBs	Total PCBs	6.5-7.5	17	µg/kg dw	29.5	-		77.03	72.8	73.11	72.8	73.11	72.8	73.11	72.8
Butyltin	Tributlytin (OC)	6.5-7.5	0.153	mg/kg-OC	-	-	24.1	4.375	4.371	4.373	4.371	4.373	4.371	4.373	4.371
SVOCs	gamma-Hexachlorocyclohexane	6.5-7.5	0.418	µg/kg dw	-	-	1.38	1.35	0.72	0.72	0.72	0.72	0.72	0.72	0.72
Pesticides	Total Chlordanes	6.5-7.5	0.698	µg/kg dw	830	83		5.58	4.23	4.24	4.23	4.24	4.23	4.24	4.23
SVOCs	Hexachlorobenzene (OC)	6.5-7.5	0.125	mg/kg-OC	37	3.7		0.401	0.367	0.371	0.367	0.371	0.367	0.371	0.367
Site-Wide															
Pesticides	Sum DDE	Site-Wide	1.72	µg/kg dw	470	45		4.03	3.61	3.64	3.61	3.64	3.61	3.64	3.61
SVOCs	Hexachlorobenzene (OC)	Site-Wide	0.125	mg/kg-OC	37	3.7		1.639	1.637	1.637	1.637	1.637	1.637	1.637	1.637
AOPC14															
Dioxins	2,3,4,7,8-PCDF	AOPC14	0.0005	µg/kg dw	-	-		0.27	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Pesticides	Sum DDD	AOPC14	1.31	µg/kg dw	-	-		98.93	64.4	65.6	64.4	65.6	64.4	65.6	64.4
Pesticides	Sum DDE	AOPC14	1.72	µg/kg dw	-	-		39.13	27.35	28.21	27.35	28.21	27.35	28.21	27.35
Pesticides	Sum DDT	AOPC14	1.1	µg/kg dw	-	-		413.13	171.6	176.3	171.6	176.3	171.6	176.3	171.6
PCBs	Total PCBs	AOPC14	17	µg/kg dw	-	-		95.5	84.3	85.2	84.3	85.2	84.3	85.2	84.3
Butyltin	Tributlytin (OC)	AOPC14	0.153	mg/kg-OC	-	-		1.745	1.737	1.741	1.737	1.741	1.737	1.741	1.737
SVOCs	gamma-Hexachlorocyclohexane	AOPC14	0.418	µg/kg dw	-	-		2.63	1	1.02	1	1.02	1	1.02	1
Pesticides	Total Chlordanes	AOPC14	0.698	µg/kg dw	-	-		11.73	8.08	8.15	8.08	8.15	8.08	8.15	8.08
SVOCs	Hexachlorobenzene (OC)	AOPC14	0.125	mg/kg-OC	-	-		1.33451	1.25	1.26	1.25	1.26	1.25	1.26	1.25

Exposure Area	Chemical	Human Health PRG Basis (Table 2, Appendix Da, Draft Portland Harbor FS Report)
River Mile	2,3,4,7,8-PCDF	HH, adult fish consumption, single species diet, smallmouth bass, low ingestion rate
River Mile	Sum DDD	HH, adult fish consumption, single species diet, smallmouth bass, low ingestion rate
River Mile	Sum DDE	HH, adult fish consumption, single species diet, smallmouth bass, low ingestion rate
Site-Wide	Sum DDE	HH, adult fish consumption, single species diet, large home range fish, low ingestion rate, low bioaccum rate
River Mile	Sum DDT	HH, adult fish consumption, single species diet, smallmouth bass, low ingestion rate
River Mile	Total PCBs	HH, adult fish consumption, single species diet, smallmouth bass, low ingestion rate
River Mile	Total Chlordanes	HH, adult fish consumption, single species diet, smallmouth bass, low ingestion rate
Site-Wide	Hexachlorobenzene (OC)	HH, adult fish consumption, single species diet, large home range fish, low ingestion rate, low bioaccum rate

Exposure Area	Chemical	Ecological PRG Basis (Table 3.5-2, Draft Portland Harbor FS Report)
Point by point	Tributlytin Ion (OC)	Eco, tissue residue assessment, bentic, worms
Point by point	gamma-Hexachlorocyclohexane	Eco, benthic PEL SQG (Note: This chemical is not among the COIs with unacceptable risk that were recommended for risk management in the BERA. The PRG for this chemical was presented at EPA's request).

Notes:
BERA = baseline ecological risk assessment
FS = feasibility study
HH = human health
PCB = polychlorinated biphenyl
PRG = preliminary remediation goal
SWAC = surface weighted average concentration
SVOC = semivolatile organic compound

[a] Background concentrations obtained from Tables 2.2-4 (dry weight) and 2.2-5 (organic carbon normalized) of the Draft Portland Harbor FS Report

Table 7-3. Summary of Estimated Costs for the Arkema Early Action Removal Alternatives

			Alternative 2(i)		Alternative 2 (r)		Alternative 3 (i)		Alternative 3 (r)		Alternative 4 (i)		Alternative 4 (r)		Alternative 5	
			Dredge to Facilitate a Cap and MNR		Dredge to Facilitate Cap		Mass Based Hot Spot Removal, Cap, MNR		Mass Based Hot Spot Removal and Cap		Removal Focused with MNR		Removal Focused		Nearshore CDF	
TASK	**UNIT COST**	**UNIT**	**QTY**	**COST**	**QTY**	**COST**	**QTY**	**COST**	**QTY**	**COST**	**QTY**	**COST**	**QTY**	**COST**	**QTY**	**COST**
DIRECT COSTS																
Site Preparation/Construction Engineering	10%	LS	1	$ 545,679	1	$ 646,758	1	$ 819,845	1	$ 920,924	1	$ 923,333	1	$ 1,206,438	1	$ 1,788,750
Demolition	$ 1,200,000	LS	1	$ 1,200,000	1	$ 1,200,000	1	$ 1,200,000	1	$ 1,200,000	1	$ 1,200,000	1	$ 1,200,000	1	$ 1,200,000
Dredging & Transloading	$ 40	CY	22,311	$ 892,457	28,161	$ 1,126,429	42,545	$ 1,701,819	48,395	$ 1,935,790	51,039	$ 2,041,557	69,968	$ 2,798,729	56,832	$ 2,273,286
Transportation and Disposal	$ 50	TN	30,120	$ 1,516,262	38,017	$ 1,913,775	57,436	$ 2,891,347	65,333	$ 3,288,859	68,903	$ 3,468,554	94,457	$ 4,754,970	-	$ -
Backfill	$ 26	TN	(0)	$ (0)	(0)	$ (0)	51,866	$ 1,348,528	51,866	$ 1,348,528	81,662	$ 2,123,219	111,949	$ 2,910,678	90,931	$ 2,364,217
Capping																
Filter Material	$ 34	TN	14,396	$ 489,460	18,200	$ 618,785	6,593	$ 224,178	10,397	$ 353,503	-	$ -	-	$ -	-	$ -
Armor Material	$ 45	TN	21,302	$ 958,608	26,858	$ 1,208,592	9,613	$ 432,576	15,168	$ 682,560	-	$ -	-	$ -	-	$ -
Water Quality Controls																
Conventional BMPs	$ 400,000	LS	1	$ 400,000	1	$ 400,000	1	$ 400,000	1	$ 400,000	1	$ 400,000	1	$ 400,000	1	$ 400,000
Engineered Barrier Contingency	$ 12,769,000	LS	-	$ -	-	$ -	-	$ -	-	$ -	-	$ -	-	$ -	-	$ -
Riverbank Stabilization	$ 1,156,000	LS	1	$ 1,156,000	1	$ 1,156,000	1	$ 1,156,000	1	$ 1,156,000	1	$ 1,156,000	1	$ 1,156,000	-	$ -
Confined Disposal Facility	$ 11,500,000	LS	-	$ -	-	$ -	-	$ -	-	$ -	-	$ -	-	$ -	1	$ 11,500,000
Habitat Mitigation	$ 150,000	LS	-	$ -	-	$ -	-	$ -	-	$ -	-	$ -	-	$ -	1	$ 150,000
	Subtotal (Direct Costs)			**$ 7,158,466**		**$ 8,270,338**		**$ 10,174,293**		**$ 11,286,165**		**$ 11,312,664**		**$ 14,426,815**		**$ 19,676,254**
INDIRECT COSTS (Percent of Direct Costs)																
Design and Permitting	7%	LS	1	$ 501,093	1	$ 578,924	1	$ 712,200	1	$ 790,032	1	$ 791,886	1	$ 1,009,877	1	$ 1,377,338
Construction QA/Oversight	5%	LS	1	$ 357,923	1	$ 413,517	1	$ 508,715	1	$ 564,308	1	$ 565,633	1	$ 721,341	1	$ 983,813
Project Management (Internal LSS)	2%	LS	1	$ 143,169	1	$ 165,407	1	$ 203,486	1	$ 225,723	1	$ 226,253	1	$ 288,536	1	$ 393,525
Agency oversight	4%	LS	1	$ 286,339	1	$ 330,814	1	$ 406,972	1	$ 451,447	1	$ 452,507	1	$ 577,073	1	$ 787,050
Contingency	30%	LS	1	$ 2,147,540	1	$ 2,481,102	1	$ 3,052,288	1	$ 3,385,850	1	$ 2,353,233	1	$ 2,901,553	1	$ 5,902,876
	Subtotal (Indirect Costs)		-	**$ 3,436,000**	-	**$ 3,970,000**	-	**$ 4,884,000**	-	**$ 5,417,000**	-	**$ 4,390,000**	-	**$ 5,498,000**	-	**$ 9,445,000**
	Total (Direct + Indirect Costs)		-	**$ 10,594,466**	-	**$ 12,240,338**	-	**$ 15,058,293**	-	**$ 16,703,165**	-	**$ 15,702,664**	-	**$ 19,924,815**	-	**$ 29,121,254**
LONG-TERM MONITORING, OPERATION & MAINTENANCE																
Monitoring	$ 214,000	LS	1	$ 214,000	1	$ 214,000	1	$ 214,000	1	$ 214,000	1	$ 214,000	1	$ 214,000	1	$ 214,000
Cap O & M	$ Varies	LS	1	$ 314,000	1	$ 397,000	1	$ 143,000	1	$ 225,000	1	$ 0	1	$ 0	1	$ 31,000
Riverbank O&M	$ 85,000	LS	1	$ 85,000	1	$ 85,000	1	$ 85,000	1	$ 85,000	1	$ 85,000	1	$ 85,000	0	$ -
	Subtotal (O&M, 30-Yr Present Value @ 7%, 30 yrs)		-	**$ 613,000**	-	**$ 696,000**	-	**$ 442,000**	-	**$ 524,000**	-	**$ 299,000**	-	**$ 299,000**	0	**$ 245,000**
	Total Estimated Cost (Direct + Indirect + O&M Costs)		-	**$ 11,207,000**	-	**$ 12,936,000**	-	**$ 15,500,000**	-	**$ 17,227,000**	-	**$ 16,002,000**	-	**$ 20,224,000**	-	**$ 29,366,000**

Notes:

o Estimated costs are for feasibility evaluation purposes only with estimated accuracy of +50/-30%

Table 8-1. Summary of Comparative Analysis of Alternatives

	Alternative 1 No Action	Alternative 2(i) Dredge to Facilitate a Cap and Optimized MNR	Alternative 2(r) Dredge to Facilitate a Cap	Alternative 3(i) Mass-Based Hot Spot Removal, Capping, and Optimized MNR	Alternative 3(r) Mass-Based Hot Spot Removal and Capping
Effectiveness					
Protective of human health and the environment		Protective	Protective	Protective	Protective
Compliance with ARARs		Complies with ARARs	Complies with ARARs	Complies with ARARs	Complies with ARARs
Achievement of RAOs		Achieves RAOs	Achieves RAOs	Achieves RAOs	Achieves RAOs
Reduction of toxicity, mobility, or volume through treatment		Does not include treatment	Does not include treatment	Does not include treatment	Does not include treatment
Long-term effectiveness and permanence		Effective and permanent. Most contaminated material would remain in place but would be reliably and permanently contained under engineered cap, or buried under suitable sediments. Low erosion potential, however consequences of cap erosion are greater than Alternatives 3, 4, and 5.	Effective and permanent. More contaminated material would remain in place, but would be reliably and permanently contained under an engineered cap. This alternative might have somewhat greater long-term permanence than 2(i), though is generally equivalent to other alternatives.	Effective and permanent. A larger volume of contaminated sediment would be removed, potentially greater permanence than Alternatives 2(i) and 2(r). The hot spot removal would eliminate areas where comparatively high DDx and PCCD/F concentrations immediately underlie the cap.	Effective and permanent. Alternative 3(r)may provide greater permanence than Alternative 3(i) due to the greater degree of isolation by capping versus MNR; however, the difference in comparatively small and overall is equivalent to other alternatives.
Short-term effectiveness		Achieves RAOs immediately following construction. Completed in one construction season. Poses the least potential short-term risks to the community since the least amount of material is transported.	Achieves RAOs immediately following construction. Completed in one construction season. More dredging is required than 2(i).	Achieves RAOs immediately following construction. Completed in one to two construction seasons. Poses more potential short-term risks than 2(i) or 2(r) to the community since more material is transported.	Achieves RAOs immediately following construction. No significant risks to workers or community. Completed in one to two construction seasons.
Implementability					
Technical Feasibility		Readily and reliably implemented.	Readily and reliably implemented.	Readily and reliably implemented.	Readily and reliably implemented.
Administrative feasibility		Services, equipment, and materials readily available	Services, equipment, and materials readily available	Services, equipment, and materials readily available	Services, equipment, and materials readily available
Cost					
Direct capital cost (i.e., construction, materials, transportation)		$ 7,158,000	$ 8,270,000	$ 10,174,000	$ 11,286,000
Indirect capital cost (i.e., legal, engineering, administrative)		$ 3,436,000	$ 3,970,000	$ 4,884,000	$ 5,417,000
Post-implementation controls and monitoring		$ 613,000	$ 696,000	$ 442,000	$ 524,000
Total Cost		$ 11,207,000	$ 12,936,000	$ 15,500,000	$ 17,227,000

Table 8-1. Summary of Comparative Analysis of Alternatives

	Alternative 4(i) Removal Focused and Optimized MNR	Alternative 4(r) Removal Focused	Alternative 5 Nearshore CDF
Effectiveness			
Protective of human health and the environment	Protective	Protective	Protective
Compliance with ARARs	Complies with ARARs	Complies with ARARs	Complies with ARARs
Achievement of RAOs	Achieves RAOs	Achieves RAOs	Achieves RAOs
Reduction of toxicity, mobility, or volume through treatment	Does not include treatment	Does not include treatment	Does not include treatment
Long-term effectiveness and permanence	Effective and permanent. Significantly more sediment volume would be removed; however, DDx/contaminant mass removal is comparatively similar to Alternatives 3(i), 3(r), and 5 and, thus, provides little additional permanence and is generally equivalent to other alternatives.	Effective and permanent. Alternative 4(r) may provide greater long-term permanence than Alternative 4(i) due to the greater cap footprint versus MNR; however, the difference in permanence is comparatively small and is generally equivalent to other alternatives.	Effective and permanent. CDF would provide equivalent long-term effectiveness to other alternatives through reliable, permanent containment and removal.
Short-term effectiveness	Achieves RAOs immediately following construction. No significant risks to workers or community. Completed in two to three seasons. Due to additional seasons of in-water work, including significantly more dredging, potential short-term impacts to water quality and environment (e.g. generation of greenhouse gas) greater than 2(i), 2(r), 3(i), and 3(r)	Achieves RAOs immediately following construction. No significant risks to workers or community. Greatest amount of excavation and dredging and related short-term impacts due to duration, including, but not limited to short-term water quality impacts and generation of greenhouse gases.	Achieves RAOs immediately following construction. No significant risks to workers or community. Second greatest amount of excavation and dredging and related short-term impacts due to duration.
Implementability			
Technical Feasibility	Readily and reliably implemented.	Readily and reliably implemented.	Readily and reliably implemented.
Administrative feasibility	Services, equipment, and materials readily available	Services, equipment, and materials readily available	Services, equipment, and materials readily available. Administrative feasibility of CDF is lower than other alternatives.
Cost			
Direct capital cost (i.e., construction, materials, transportation)	$ 11,313,000	$ 14,427,000	$ 19,676,000
Indirect capital cost (i.e., legal, engineering, administrative)	$ 4,390,000	$ 5,498,000	$ 9,445,000
Post-implementation controls and monitoring	$ 299,000	$ 299,000	$ 245,000
Total Cost	$ 16,002,000	$ 20,224,000	$ 29,366,000

APPENDIX A

SEDIMENT DATA SCREENING

- APPENDIX A1. EVALUATION OF MEAN QUOTIENT VALUES AS REMEDIATION GOALS FOR BENTHIC TOXICITY IN AOPC 14 MEMORANDUM
- APPENDIX A2. AOPC 14-SPECIFIC SEDIMENT QUALITY VALUES MEMORANDUM
- APPENDIX A3. DATA SCREENING RESULTS

APPENDIX A1

EVALUATION OF MEAN QUOTIENT VALUES AS REMEDIATION GOALS FOR BENTHIC TOXICITY IN AOPC 14 MEMORANDUM

Integral Consulting Inc.
411 1st Avenue S.
Suite 550
Seattle, WA 98104

telephone: 206.230.9600
facsimile: 206.230.9601
www.integral-corp.com

TECHNICAL MEMORANDUM

To:	Todd Slater, LSS
From:	Les Williams
Date:	July 18, 2012
Subject:	Evaluation of Mean Quotient Values as Remediation Goals for Benthic Toxicity in AOPC 14.
Project No.:	C167.1301.1G

Introduction

To reduce complexity and to facilitate spatial interpretation of potentially affected areas, the mean quotient (MQ) method was adopted in the remedial investigation and feasibility study for Portland Harbor to integrate multiple, chemical-specific hazard quotients[1], which are based on comparisons of sediment quality guidelines (SQGs) to sediment chemistry concentrations. Individual MQs are determined by calculating the hazard quotient for each chemical-SQG pair in a sample, summing the quotients for that sample, and then dividing by the number of quotients. Sample MQs exceeding 0.7 were considered toxic. However, there are numerous limitations to this approach which preclude its meaningful use as an AOPC[2] 14-specific benchmark that could be used to support remedial activities within the removal action area (RAA). The following sections of this memorandum provide an overview of the MQ methodology, a summary of its major limitations, and a recommendation for an alternative approach to establishing chemical- and AOPC 14-specific remediation goals for chemicals of concern to the benthic community within the RAA.

[1] A hazard quotient is calculated by dividing a sample contaminant concentration by its respective SQG.
[2] Area of Potential Concern.

Overview of Mean Quotient Goals

The primary line evidence that was used to judge risk to the benthic community in Portland Harbor was harbor-specific empirical toxicity testing with the amphipod *Hyalella azteca* and the midge *Chironomus dilutus*, where both a survival and a growth (biomass) endpoint were measured in each test. Whether sediments used in each test were considered toxic was based on comparisons of survival and growth in test sediments with that in sediments used in laboratory controls or from reference areas. Sediment chemistry was also measured at each of the sediment toxicity test locations.

The sediment toxicity and sediment chemistry results for Portland Harbor were combined to derive harbor-specific SQGs, which are chemical specific expressions of potential toxicity. Several approaches were used to derive SQGs:

- The logistic regression model (LRM) – A statistical procedure that combines the set of best individual chemical models into a single multi-chemical model that predicts toxicity for a given sample as the maximum probability of toxicity (pMax) across all chemicals.
- The floating percentile model (FPM) – A heuristic method that searches iteratively across all chemicals to optimize false-positive and false-negative error rates to choose individual chemical SQGs that collectively best meet management objectives.

By either method, the resulting SQGs are chemical-specific values that are intended to judge risk at locations where toxicity testing was not conducted, but where sediment chemistry was measured. Consequently, each location can yield multiple hazard quotients—one for each chemical-SQG pair. To reduce this complexity and to facilitate spatial interpretation of potentially affected areas, the MQ method was adopted to integrate the hazard quotients based on FPM SQGs. Individual MQs are determined by calculating the hazard quotient for each chemical-SQG pair in a sample, summing the quotients for that sample, and then dividing by the number of quotients. Sample MQs exceeding 0.7 were considered toxic. The LRM resulted in estimates of the probability of toxicity (pMax values). Because pMax values are already an integration of predictions across chemicals for a given sample, MQs were not calculated for LRM SQGs.

Limitations

The MQ approach was developed to evaluate mixtures of chemicals relative to their SQGs. A number of studies have demonstrated increasing toxicity (both incidence and magnitude) associated with increasing MQs (Long et al. 2006). However, the threshold delineating non-toxic from toxic conditions is often site-specific; the reliability of the MQ

is improved when a relationship between contaminants and effects can be demonstrated and when those SQGs that are most predictive of toxicity are used in the calculation of the MQ (Long et al. 2006). The selected MQ threshold for toxicity (0.7) for Portland Harbor is based on data from other studies that may not be representative of either harbor-specific or AOPC-specific chemical mixtures and is unlikely to be an accurate indicator of which chemicals in the sediments are the cause of toxicity or benthic impairment.

The MQ approach is also subject to the limitation of the FPM predictive model and the SQGs upon which it is based. A major limitation to the FPM SQG values is that they are based on a collective data set that is harbor-specific, but not AOPC-specific. Based on the FPM approach, the SQGs for the entire harbor must be used together to predict the toxicity of a contaminant mixture—they are not independent (Windward 2011). Each SQG explains toxicity along with all the other SQGs that were derived from the model. Consequently, FPM SQGs provided a first approximation of toxicity harbor-wide, but do not account for heterogeneity among the AOPCs, where chemical mixtures vary in their composition and where AOPC-specific SQGs may yield a more accurate prediction of risk and risk-based remediation goals. The LRM approach also included sulfides, which is a sediment chemical stressor that is not typically addressed by CERCLA. However, the SQG for sulfides was not ultimately used to identify benthic community risk areas and, presumably, was not used in MQ calculations. This is a critical limitation for AOPC 14, of which the RAA is a part, because sulfides appear to be one of the few chemicals that explain the results of the empirical toxicity tests.

Recommendations

The MQ approach provides a first approximation for categorization of sediments that are potentially toxic to benthic organisms. However, there are numerous limitations to the method that preclude specific application to the RAA as a remedial goal. An alternative approach is proposed that is based on AOPC-specific SQGs for sum DDD, sum DDE, and sum DDT, additional baseline ecological risk assessment (BERA) sediment contaminants of potential concern (COPCs) (low molecular weight polycyclic aromatic hydrocarbon [PAH], high molecular weight PAH, delta hexachlorocyclohexane, dieldrin) and one conventional chemical (sulfides). These substances were selected based on a principal components analysis that explored potential relationships among the four toxic endpoints and sediment concentrations of select BERA COPCs, conventional chemicals (ammonia and sulfides), and controlling influences of sediment grain size (fines) and sediment total organic carbon.[3] A summary

[3] Four of the chemicals (sulfides, LPAH, HPAH, and delta-HCH) were selected because they have a significant albeit low correlation with one or more of the sediment toxicity endpoints. DDx congeners

of the methods and results of this analysis is provided in a separate memorandum (Appendix A2).

References

Long, E.R., C.G. Ingersoll, and D.D. MacDonald. 2006. Calculation and uses of mean sediment quality guideline quotients: a critical review. *Environ Sci Technol* 40(6):1726–1736.

Windward. 2011. Portland Harbor RI/FS. Appendix G: Baseline Ecological Risk Assessment. Draft Final. WE-09-0001. Windward Environmental, Seattle WA. 709 pp. + appendices.

(sums) were not significantly correlated with toxicity, but were nevertheless selected because the PCA suggests an indirect relationship to the toxicity test results that is likely influenced by sulfides, fines, and TOC. Dieldrin was selected because it had a relatively high degree of correlation with other chlorinated pesticides.

APPENDIX A2

AOPC 14-SPECIFIC SEDIMENT QUALITY VALUES MEMORANDUM

Integral Consulting Inc.
411 1st Avenue S.
Suite 550
Seattle, WA 98104

telephone: 206.230.9600
facsimile: 206.230.9601
www.integral-corp.com

TECHNICAL MEMORANDUM

To:	Todd Slater, LSS
From:	Les Williams, Scott Becker, Damian Preziosi
Date:	July 18, 2012
Subject:	Portland Harbor – AOPC 14-Specific Sediment Quality Values and Benthic Thresholds
Project No.:	C167.1301.1G

Introduction

This technical memorandum summarizes the development of site-specific sediment quality guidelines (SS-SQGs) for benthic toxicity proposed for consideration in establishing injury threshold levels for DDx compounds present in sediment of AOPC 14[1] of Portland Harbor, of which the Arkema Removal Action Area (RAA) is a part.

The harbor-wide SQGs derived in the baseline ecological risk assessment (BERA) for Portland Harbor (Windward 2011) and the probable effects concentrations (PECs) proposed as preliminary remediation goals (PRGs) by EPA (2010) are not reliable for use in establishing benthic injury thresholds for AOPC 14 because they predict benthic toxicity at significantly higher rates than actually observed in toxicity tests performed for AOPC 14, of which the RAA is a part. Consequently, SS-SQGs are needed to establish technically defensible injury threshold values suitable for AOPC 14, including the RAA. The following SS-SQGs were derived for DDx compounds based on a predicted reliability of 75 percent[2] for paired toxicity test and chemistry data obtained for AOPC 14:

- DDD – 1,680 µg/kg dry weight (dw)

[1] Area of Potential Concern 14

[2] The 75 percent reliability level is consistent with the approach described by Long et al. (1995, 1998) and MacDonald et al. (2000).

- DDE – 750 µg/kg dw
- DDT – 5,800 µg/kg dw
- Total DDx – 8,200 µg/kg dw.

The role of other chemicals, such as polycyclic aromatic hydrocarbons (PAHs) and other pesticides, and the potential confounding effect of conventional sediment quality parameters, such as sulfides, ammonia, grain size and organic carbon, were also evaluated relative to the toxicity tests performed in AOPC 14. Toxicity units (TU) for these substances and for DDx compounds were used to distribute potential injury among the various chemicals associated with toxicity. Assuming maximum potential injury, sediment concentrations associated with 10 to 40 percent service loss in the benthic community were then derived for DDD, DDE and DDT.

The remainder of this document presents the results of the technical evaluation used for the derivation of the injury threshold values for DDx compounds.

Overview of Benthic Endpoints and Sediment Quality Guidelines

Numerous SQGs have been proposed to support sediment management decisions for DDx compounds in Portland Harbor:

- Harbor-wide SQGs developed for the Portland Harbor BERA (Windward 2011)
- Probable Effects Concentrations (PECs) – Generic SQGs developed by MacDonald et al. (2000) and proposed as PRGs by EPA (2010)
- Injury Thresholds for the Hylebos Waterway – Derived from Washington State apparent effects threshold and sediment effects concentrations for the Southern California Bight (Wolotira 2002).

The BERA SQGs were developed using the floating percentile method (FPM) and a logistic regression method (LRM) applied to the co-occurring information on sediment toxicity and sediment chemistry that was collected at 271 stations distributed throughout the Portland Harbor Superfund Site. The sediment toxicity tests included the 10-day *Chironomus tentans* and 28-day *Hyalella azteca* tests, with survival and total biomass as endpoints. Within AOPC 14, 132 stations were sampled for sediment chemistry, and 29 of those stations were also evaluated for sediment toxicity. At the 29 sediment toxicity test stations, the prevalence of toxicity for the two test species ranged from 14 to 24 percent for survival and 17to 31 percent for biomass.

When the SQGs derived in the BERA for DDx compounds are applied to AOPC 14, a higher prevalence of toxicity is predicted compared to what was actually observed in the toxicity tests for the 29 locations. For example, the FPM SQG for DDD predicts 37

percent toxicity and the FPM SQG for DDT predicts 73 percent toxicity, which is in contrast to observed toxicity for AOPC 14, ranging from 14 to 24 percent for survival and 17 to 31 percent for biomass. Similar comparisons based on the PEC values selected as PRGs (EPA 2010) predict toxicity at 41 to 64 percent of the stations in AOPC 14.

With respect to spatial extent, harbor-wide SQGs and PECs lead to relatively large areas of predicted benthic risk (Figures 1, 2 and 3). By contrast, the sediment toxicity information collected at 29 of the 132 stations showed that toxicity was found in relatively small areas of the AOPC using either test species.

Site-Specific Sediment Quality Guidelines

Additional analyses were conducted to evaluate whether SS-SQGs could be developed to more accurately predict the presence of toxicity in AOPC 14. As described above, this was done because the empirical sediment toxicity results for AOPC 14 did not show strong agreement with the harbor-wide BERA SQGs and the PECs proposed as PRGs by EPA.

The SS-SQGs were developed for sum DDD, sum DDE, and sum DDT, additional BERA sediment contaminants of potential concern (COPCs) (low molecular weight PAH [LPAH], high molecular weight PAH [HPAH], delta hexachlorocyclohexane [delta HCH], dieldrin) and one conventional chemical (sulfides). These substances were selected based on a principal components analysis that explored potential relationships among the four toxic endpoints and sediment concentrations of the BERA COPCs, conventional chemicals (ammonia and sulfides), and controlling influences of sediment grain size (fines) and sediment total organic carbon.[3]

The SS-SQGs for AOPC 14 were calculated by plotting the predictive ability of each COPC along the concentration gradient observed in AOPC 14. The term "predictive ability" is consistent with the term used by others (e.g., Long et al. 1995, 1998; MacDonald et al. 2000), and was calculated as the percentage of stations predicted to be toxic that are confirmed as toxic using empirical sediment toxicity tests. The minimum predictive ability for identifying a reliable SQG was set at 75 percent, a value that has been used by others (e.g., Long et al. 1995, 1998; MacDonald et al. 2000). The

[3] Four of the chemicals (sulfides, LPAH, HPAH, and delta-HCH) were selected because they have a significant albeit low correlation with one or more of the sediment toxicity endpoints. DDx congeners (sums) were not significantly correlated with toxicity, but were nevertheless selected because the principal components analysis suggests an indirect relationship to the toxicity test results that is likely influenced by sulfides, fines, and total organic carbon. Dieldrin was selected because it had a relatively high degree of correlation with other chlorinated pesticides. Some substances (e.g., PCBs) were not evaluated because the principal component analysis indicated that there is no substantive relationship between their concentration in sediments and observed toxicity within AOPC 14.

concentration at which a predictive ability of 75 percent was achieved was then identified as the SS-SQG for that COPC. Based on this methodology, the recommended SS-SQGs for DDx compounds are:

- DDD – 1,680 µg/kg dw
- DDE – 750 µg/kg dw
- DDT – 5,800 µg/kg dw
- Total DDx – 8,200 µg/kg dw.

The SS-SQGs for DDD, DDE and DDT were then used as "injury thresholds," which in turn were used to assign service loss estimate categories. Total DDx was not used to evaluate injury thresholds. Total DDx was omitted from the final risk management recommendations in the BERA (Windward 2011) because its inclusion would effectively double count potential risk already assigned to the individual congeners.

Injury Thresholds and Service Loss Thresholds

AOPC 14 SS-SQGs for DDD, DDE and DDT were identified as injury thresholds to evaluate potential service loss categories. Although the focus for service loss in AOPC 14 is on the DDx congeners, threshold values were developed for all eight of the chemicals (LPAH, HPAH, delta-HCH, dieldrin, sum DDD, sum DDE, sum DDT, and sulfides) selected for development of SS-SQGs. These substances were selected because service loss (i.e., sediment toxicity) expressed as the difference in survival or biomass between a reference threshold and a site location should be allocated to chemicals that collectively contribute to toxicity rather than to a single substance.

TUs for each chemical-endpoint pair were used to estimate the percent contribution of each of the COPC to service loss within AOPC 14 (Table 1). For each AOPC 14 sample location that was determined to be toxic at either Level 2 or Level 3 in the BERA, the number of TUs attributed to each chemical was estimated as the sediment chemical concentration divided by its SQG.[4] The percent contribution of each chemical was then determined by dividing the chemical-specific TU by the total TU for all the chemicals within that location. By definition the sum of the TU fractions is 100 percent.

Service losses for AOPC 14 stations that were identified as toxic at either Level 2 or Level 3 in the BERA are summarized in Table 1. Service losses at Level 2 or Level 3 toxicity at AOPC 14 stations were distributed among the chemicals of concern for toxicity. For each endpoint-chemical pair, the TU percent was then multiplied by maximum service loss to estimate service loss thresholds associated with the SS-SQG.

[4] The chemical-specific TU is also the hazard quotient.

By this method, service losses for chemicals of concern could be separated from those associated with other substances (e.g., sulfides) contributing to toxicity. The estimated service loss associated with the SS-SQG for each chemical-endpoint pair was then scaled to service loss benchmarks of 10, 20, 30 and 40 percent.[5] The minimum sediment concentrations recommended for each DDx compound and the service loss categories are:

- DDD
  - 10% service loss at 1,246 μg/kg dw
  - 20% service loss at 2,492 μg/kg dw
  - 30% service loss at 3,738 μg/kg dw
  - 40% service loss at 4,984 μg/kg dw
- DDE
  - 10 % service loss at 428 μg/kg dw
  - 20% service loss at 856 μg/kg dw
  - 30% service loss at 1,284 μg/kg dw
  - 40% service loss at 1,712 μg/kg dw
- DDT
  - 10% service loss at 4,297 μg/kg dw
  - 20% service loss at 9,853 μg/kg dw
  - 30% service loss at 14,780 μg/kg dw
  - 40% service loss at 19,706 μg/kg dw.

The above service loss concentrations are spatially depicted in Figures 1 through 3. For comparison purposes the figures include the spatial extent of the BERA SQGs and the PECs identified as PRGs by EPA (2010). As shown, large spatial differences exist which demonstrate that the BERA SQGs and PECs are substantively inconsistent with conditions in the Portland Harbor.

In summary, SS-SQGs are recommended as the starting point for identifying service losses for the DDx compounds because 1) the SS-SQGs were derived specifically for AOPC 14, which includes the RAA, where DDx compounds are predominant and where substantive chemistry and toxicity test data sets are available; 2) the SS-SQGs

[5] These are the service loss thresholds selected by the Natural Resources Trustees to assess damages in the Hylebos Waterway (Wolotira 2002).

incorporate influences of other substances present (including conventional parameters) besides DDx compounds; and 3) the SS-SQGs account for site-specific toxicity observed in areas with elevated concentrations. In addition, a chief advantage of the SS-SQGs is that they may be readily adapted to estimate various levels of potential service loss (e.g., 10, 20, 30 and 40 percent or other percentages).

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Attachments

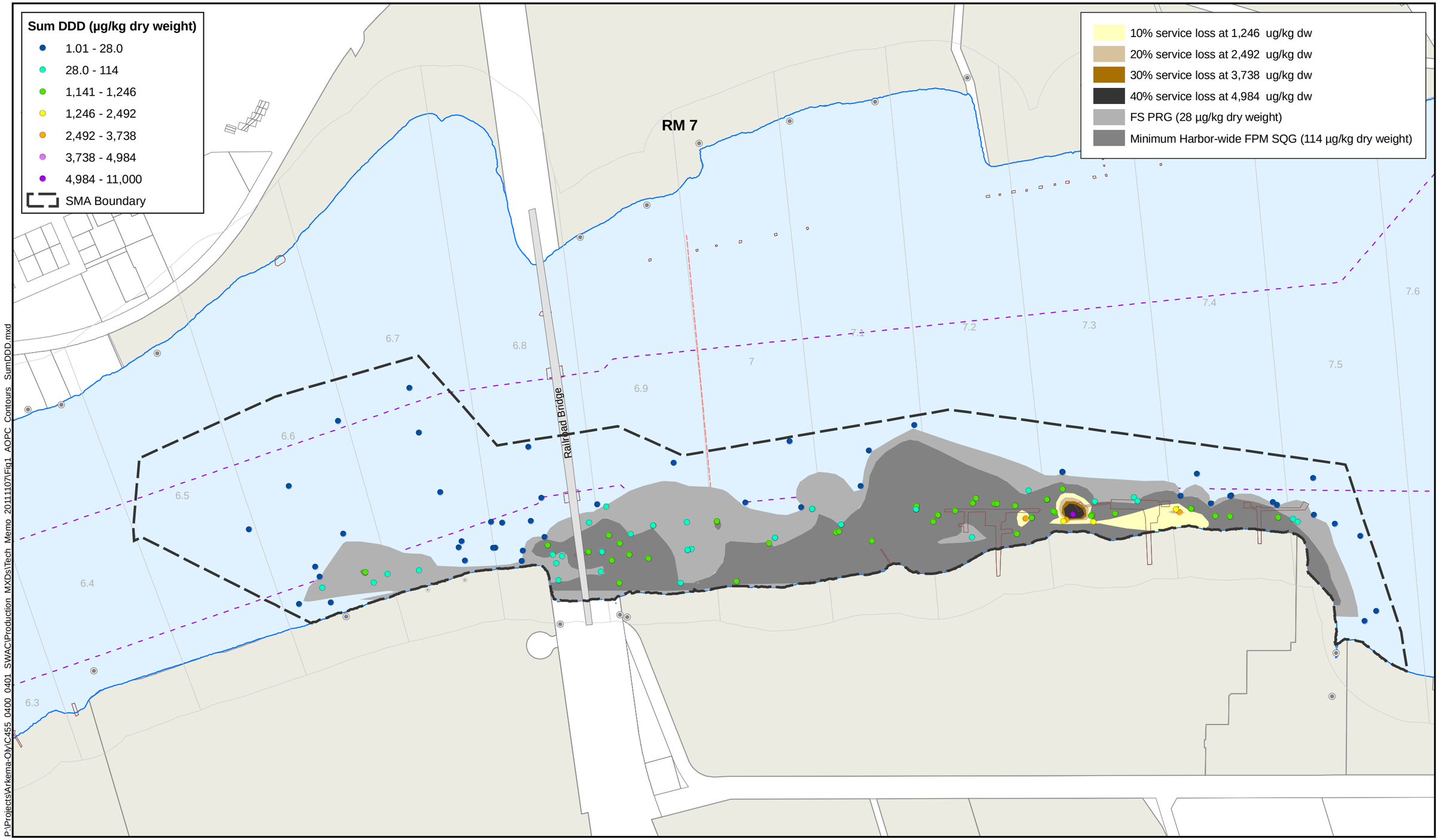
Figure 1. AOPC 14 DDD Service Loss Areas

Figure 2. AOPC 14 DDE Service Loss Areas

Figure 3. AOPC 14 DDT Service Loss Areas

Table 1. Summary of Service Losses in AOPC 14 Associated with Sediment Quality Values Proposed as Injury Thresholds

FIGURES



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integral consulting inc.

FEATURE SOURCES:
Transportation, Property, or Boundaries: Metro RLIS.
Channel & River Miles: US Army Corps of Engineers.
Bathymetric Information: David Evans and Associates, Inc.

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Map Features

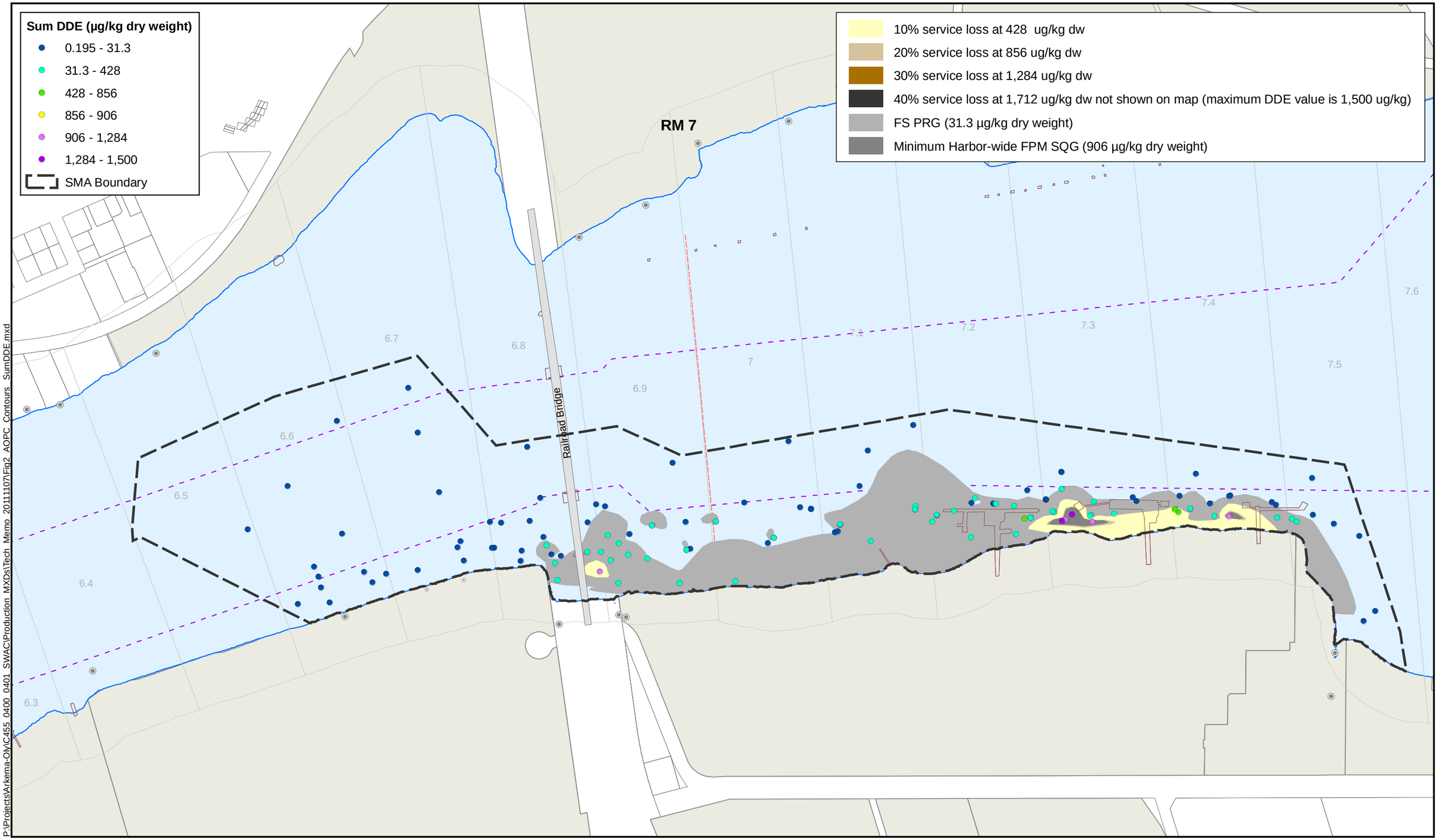
- River Miles
- Navigation Channel
- River Edge +13 ft NAVD

Outfalls

- Outfall
- Dock Drain
- Roof Drain

- Bridges
- Docks and Structures
- Waterfront Taxlots
- Upland ECSI Sites (2008)

Figure 1
AOPC 14 DDD Service Loss Areas



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FEATURE SOURCES:
Transportation, Property, or Boundaries: Metro RLIS.
Channel & River Miles: US Army Corps of Engineers.
Bathymetric Information: David Evans and Associates, Inc.

0 100 200 300 400 500 Feet

Map Features

- River Miles
- Navigation Channel
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Outfalls

- Outfall
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- Roof Drain

- Bridges
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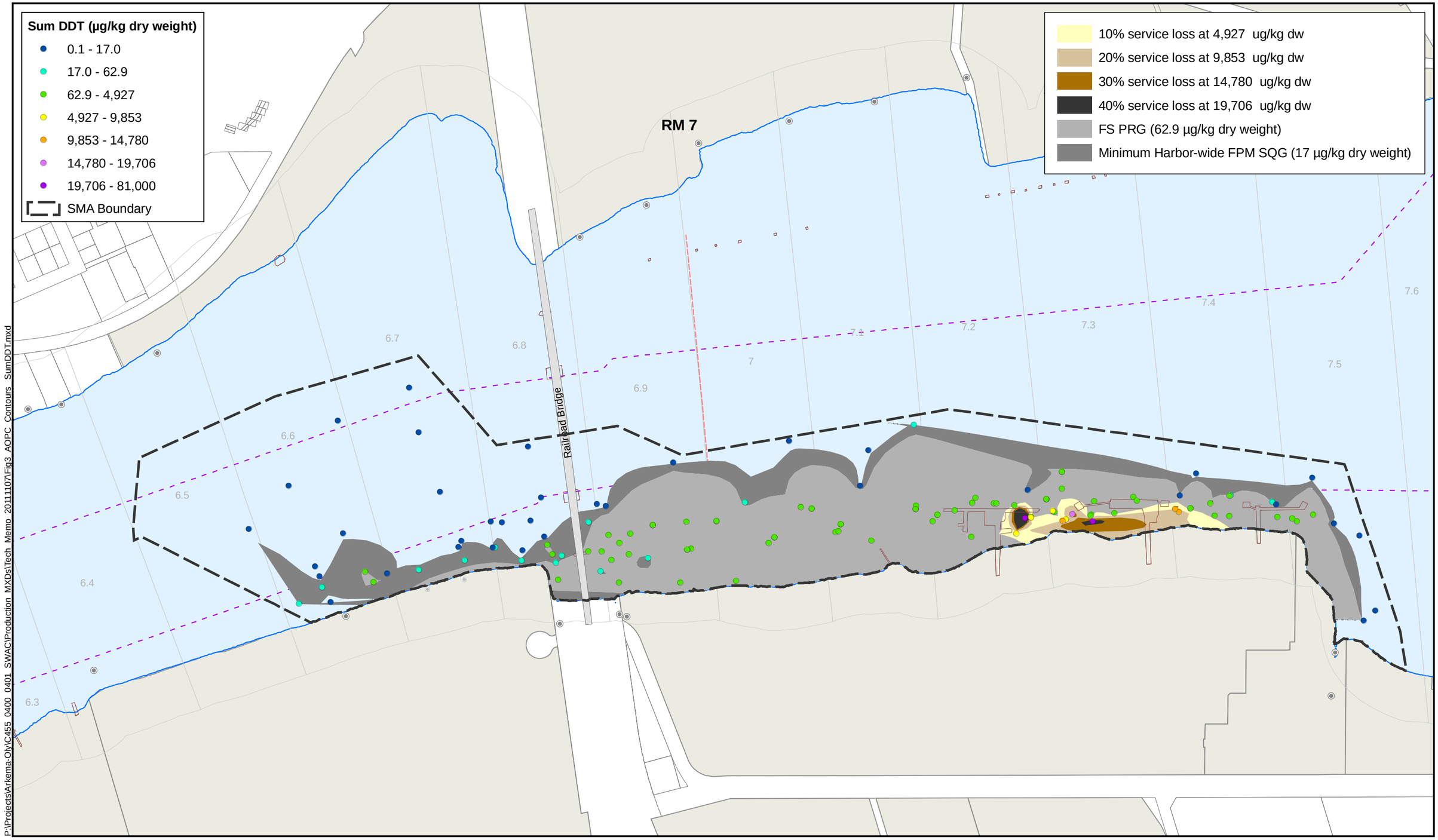
- Waterfront Taxlots
- Upland ECSI Sites (2008)

Figure 2
AOPC 14 DDE Service Loss Areas



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FEATURE SOURCES:
Transportation, Property, or Boundaries: Metro RLIS.
Channel & River Miles: US Army Corps of Engineers.
Bathymetric Information: David Evans and Associates, Inc.

0 100 200 300 400 500 Feet

Map Features
- River Miles
- Navigation Channel
- River Edge +13 ft NAVD

Outfalls
- Outfall
- Dock Drain
- Roof Drain

- Bridges
- Docks and Structures
- Waterfront Taxlots
- Upland ECSI Sites (2008)

Figure 3
AOPC 14 DDT Service Loss Areas

TABLES

Table 1. Summary of Service Losses in AOPC 14 Associated with Sediment Quality Values Proposed as Injury Thresholds

Test Endpoint	Chemical	SS-SQG	Units	AOPC 14 Toxic Units[a]	Maximum Service Loss Injury Thresholds[b]	Sediment Concentrations Assuming Maximum Potential Injury[c]			
						10% Service Loss	20% Service Loss	30% Service Loss	40% Service Loss
Amphipod Biomass	DDD	1680	µg/kg dw	26%	13%	1,344	2,687	4,031	5,374
Amphipod Survival	DDD	1680	µg/kg dw	18%	13%	1,246	2,492	3,738	4,984
Chironomid Biomass	DDD	1680	µg/kg dw	7%	7%	2,381	4,762	7,143	9,524
Chironomid Survival	DDD	1680	µg/kg dw	6%	6%	2,843	5,686	8,529	11,372
Minimum Service Loss Threshold			µg/kg dw			1,246	2,492	3,738	4,984
Amphipod Biomass	DDE	750	µg/kg dw	22%	10%	716	1,432	2,147	2,863
Amphipod Survival	DDE	750	µg/kg dw	23%	18%	428	856	1,284	1,712
Chironomid Biomass	DDE	750	µg/kg dw	5%	5%	1,412	2,824	4,236	5,648
Chironomid Survival	DDE	750	µg/kg dw	8%	8%	895	1,789	2,684	3,578
Minimum Service Loss Threshold			µg/kg dw			428	856	1,284	1,712
Amphipod Biomass	DDT	5800	µg/kg dw	15%	7%	8,060	16,120	24,181	32,241
Amphipod Survival	DDT	5800	µg/kg dw	16%	12%	4,927	9,853	14,780	19,706
Chironomid Biomass	DDT	5800	µg/kg dw	5%	5%	12,271	24,542	36,813	49,084
Chironomid Survival	DDT	5800	µg/kg dw	6%	6%	10,070	20,141	30,211	40,281
Minimum Service Loss Threshold			µg/kg dw			4,927	9,853	14,780	19,706

Notes:

[a] Toxicity units are expressed as the percentage that each chemical contributes to the total toxicity for L2 and L3 stations in AOPC 14.

[b] Maximum service loss for L3 stations in AOPC 14 multiplied by the toxic unit fraction attributed to each chemical.

[c] Calculated by dividing the SS-SQG by the maximum service loss threshold and multiplying by the desired service loss benchmark (e.g., 10%).

APPENDIX A3

DATA SCREENING RESULTS

Table A-3. Comparison of Sediment Data to Portland Harbor PRGs, RALs, and AOPC 14 SQGs

		Portland Harbor PRGs				AOPC 14 Specific	Portland Harbor RALs					RM 7–8 RALs	Borehole Number:	AP-02-A-PG	AP-04-C-PG	AP-04-C-PG-2	LW2-C348	LW2-C348	LW2-C348	LW2-C348
													Matrix:	SE	SE	SE	SE	SE	SE	SE
													Upper Depth, ft:	0	0	0	0	5	7.9	1
													Lower Depth, ft:	0.8	1	1	1	7.9	12.1	5
													Sample Type:	Normal	Normal	Field Replicate	Normal	Normal	Normal	Normal
													Sample Date:	11/30/2005	11/30/2005	11/30/2005	11/9/2004	11/9/2004	11/9/2004	11/9/2004
		PRG-1	PRG-2	PRG-3	PRG-4	SQG	RAL-B	RAL-C	RAL-D	RAL-E	RAL-F	RM 7–8 RALs	Sample ID:	LWG2-PG-AP2A	LWG2-PG-AP4C	LWG2-PG-AP4C-2	LW2-C348-A	LW2-C348-C	LW2-C348-D	LW2-C348-B
Constituent	Units																			
Tributyltin ion	mg/kg-OC	24.1	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	56.0	54.1	20.5	--	--	--	--	--	20.0	10.0	1750		--	--	--	76.8	--	--	521
gamma-Hexachlorocyclohexane	mg/kg	0.00138	--	--	--	--	--	--	--	--	--	--		0.00200 *UJ*	0.00510 *UJ*	0.00430 *UJ*	--	0.0213 *U*	0.000394 *U*	0.000544 *U*
Total Chlordanes (EE/CA)	mg/kg	0.830	0.0830	0.00187	--	--	--	--	--	--	--	--		0.0120 *J*	0.0730 *J*	0.0570 *J*	--	0.900 *NJ*	0.00120 *NJ*	0.0910 *NJ*
Total DDD (EE/CA)	mg/kg	0.900	0.0890	0.0280	--	1.68	--	--	--	0.100	0.0500	--		0.310 *J*	0.350 *J*	0.450 *J*	--	71.0 *NJ*	0.0190 *NJ*	0.280 *NJ*
Total DDE (EE/CA)	mg/kg	0.100	0.00880	0.0313	0.00302	0.750	1.00	1.00	0.200	0.0500	0.0200	0.400		0.130 *J*	0.100 *J*	0.110 *J*	--	1.30 *J*	0.000640 *J*	0.0790 *NJ*
Total DDT (EE/CA)	mg/kg	1.20	0.120	0.0629	--	5.80	--	--	--	0.150	0.0600	6.00		7.80 *J*	2.10 *J*	0.940 *J*	--	23.0 *J*	0.00470 *NJ*	0.340 *NJ*
Total DDx (EE/CA)	mg/kg	0.218	--	--	--	8.20	--	--	--	--	--	--		8.20 *J*	2.60 *J*	1.50 *J*	--	95.0 *NJ*	0.0240 *NJ*	0.700 *NJ*
Hexachlorobenzene	mg/kg-OC	37.0	3.70	--	--	--	--	--	--	--	--	--		1.42	0.896	0.660	--	0.205 *U*	0.0371 *J*	0.840 *J*
Total PCBs (EE/CA)	mg/kg	0.500	0.0295	--	--	--	1.00	0.750	0.500	0.200	0.0750	--		--	--	--	--	0.00352 *U*	0.00259 *U*	0.0717 *U*

Table A-3. Comparison of Sediment Data to Portland Harbor PRGs, RALs, and AOPC 14 SQGs

		Portland Harbor PRGs				AOPC 14 Specific	Portland Harbor RALs					RM 7–8 RALs	Borehole Number:	LW2-C351	LW2-C351	LW2-C351	LW2-C351	LW2-C356	LW2-C356	LW2-C356
													Matrix:	SE	SE	SE	SE	SE	SE	SE
													Upper Depth, ft:	7	1	11	2.6	0	4.5	8.4
													Lower Depth, ft:	11	2.6	13.1	7	1	8.4	10
													Sample Type:	Normal	Normal	Normal	Normal	Normal	Normal	Normal
													Sample Date:	11/9/2004	11/9/2004	11/9/2004	11/9/2004	11/9/2004	11/9/2004	11/9/2004
		PRG-1	PRG-2	PRG-3	PRG-4	SQG	RAL-B	RAL-C	RAL-D	RAL-E	RAL-F	RM 7–8 RALs	Sample ID:	LW2-C351-D	LW2-C351-B	LW2-C351-E	LW2-C351-C	LW2-C356-A	LW2-C356-C	LW2-C356-D
Constituent	Units																			
Tributyltin ion	mg/kg-OC	24.1	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	56.0	54.1	20.5	--	--	--	--	--	20.0	10.0	1750		0.00500 *U*	115	0.00500 *U*	0.120 *J*	--	--	--
gamma-Hexachlorocyclohexane	mg/kg	0.00138	--	--	--	--	--	--	--	--	--	--		0.0000781 *U*	0.00233 *U*	0.0000768 *U*	0.0000778 *U*	--	0.172 *NJ*	--
Total Chlordanes (EE/CA)	mg/kg	0.830	0.0830	0.00187	--	--	--	--	--	--	--	--		0.0000427 *U*	0.180 *NJ*	0.0000419 *U*	0.0000425 *U*	--	1.00 *NJ*	--
Total DDD (EE/CA)	mg/kg	0.900	0.0890	0.0280	--	1.68	--	--	--	0.100	0.0500	--		0.000260 *NJ*	5.10 *NJ*	0.000130 *NJ*	0.00200 *J*	--	44.0 *NJ*	--
Total DDE (EE/CA)	mg/kg	0.100	0.00880	0.0313	0.00302	0.750	1.00	1.00	0.200	0.0500	0.0200	0.400		0.0000462 *U*	0.140 *J*	0.0000454 *U*	0.0000860 *J*	--	1.40 *NJ*	--
Total DDT (EE/CA)	mg/kg	1.20	0.120	0.0629	--	5.80	--	--	--	0.150	0.0600	6.00		0.000410 *NJ*	3.20 *NJ*	0.000150 *J*	0.00130 *J*	--	26.0 *NJ*	--
Total DDx (EE/CA)	mg/kg	0.218	--	--	--	8.20	--	--	--	--	--	--		0.000710 *NJ*	8.40 *NJ*	0.000320 *NJ*	0.00340 *J*	--	72.0 *NJ*	--
Hexachlorobenzene	mg/kg-OC	37.0	3.70	--	--	--	--	--	--	--	--	--		0.243 *J*	0.0505 *J*	7.25 *U*	2.42 *U*	--	2.73 *J*	--
Total PCBs (EE/CA)	mg/kg	0.500	0.0295	--	--	--	1.00	0.750	0.500	0.200	0.0750	--		0.00237 *U*	0.0580 *J*	0.00235 *U*	0.00232 *U*	0.0450 *U*	--	18.0 *U*

Table A-3. Comparison of Sediment Data to Portland Harbor PRGs, RALs, and AOPC 14 SQGs

		Portland Harbor PRGs				AOPC 14 Specific	Portland Harbor RALs					RM 7–8 RALs	Borehole Number:	LW2-C356	LW2-C356	LW2-C359	LW2-C359	LW2-C359	LW2-C360
													Matrix:	SE	SE	SE	SE	SE	SE
													Upper Depth, ft:	1	10	5	8.4	1	1
													Lower Depth, ft:	4.5	11	8.4	12.4	5	3
													Sample Type:	Normal	Normal	Normal	Normal	Normal	Normal
													Sample Date:	11/9/2004	11/9/2004	10/21/2004	10/21/2004	10/21/2004	10/27/2005
		PRG-1	PRG-2	PRG-3	PRG-4	SQG	RAL-B	RAL-C	RAL-D	RAL-E	RAL-F	RM 7–8 RALs	Sample ID:	LW2-C356-B	LW2-C356-E	LW2-C359-C	LW2-C359-D	LW2-C359-B	LW2-C360-B1
Constituent	Units																		
Tributyltin ion	mg/kg-OC	24.1	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	56.0	54.1	20.5	--	--	--	--	--	20.0	10.0	1750		--	--	--	--	--	--
gamma-Hexachlorocyclohexane	mg/kg	0.00138	--	--	--	--	--	--	--	--	--	--		0.000623 *U*	0.000379 *U*	0.000558 *U*	0.00104 *UJ*	0.000563 *U*	0.00270 *UJ*
Total Chlordanes (EE/CA)	mg/kg	0.830	0.0830	0.00187	--	--	--	--	--	--	--	--		0.0110 *NJ*	0.0130 *NJ*	0.000890 *NJ*	0.0560 *NJ*	0.00830 *NJ*	0.00390 *J*
Total DDD (EE/CA)	mg/kg	0.900	0.0890	0.0280	--	1.68	--	--	--	0.100	0.0500	--		0.450 *NJ*	0.280 *NJ*	0.300 *J*	7.40 *J*	0.170 *NJ*	0.000180 *UJ*
Total DDE (EE/CA)	mg/kg	0.100	0.00880	0.0313	0.00302	0.750	1.00	1.00	0.200	0.0500	0.0200	0.400		0.0330 *NJ*	0.00890 *J*	0.0370 *J*	0.240 *J*	0.0470 *J*	0.0120 *NJ*
Total DDT (EE/CA)	mg/kg	1.20	0.120	0.0629	--	5.80	--	--	--	0.150	0.0600	6.00		0.380 *J*	0.0440 *J*	0.700 *J*	12.0 *J*	0.460 *J*	0.380 *J*
Total DDx (EE/CA)	mg/kg	0.218	--	--	--	8.20	--	--	--	--	--	--		0.860 *NJ*	0.330 *NJ*	1.00 *J*	20.0 *J*	0.670 *NJ*	0.400 *NJ*
Hexachlorobenzene	mg/kg-OC	37.0	3.70	--	--	--	--	--	--	--	--	--		0.368 *U*	1.56 *J*	0.148 *J*	0.543	0.0325 *J*	0.0260 *J*
Total PCBs (EE/CA)	mg/kg	0.500	0.0295	--	--	--	1.00	0.750	0.500	0.200	0.0750	--		1.20 *NJ*	--	0.130 *J*	0.110 *J*	0.0360 *J*	0.0780 *U*

Table A-3. Comparison of Sediment Data to Portland Harbor PRGs, RALs, and AOPC 14 SQGs

		Portland Harbor PRGs				AOPC 14 Specific	Portland Harbor RALs					RM 7–8 RALs	Borehole Number:	LW2-C360	LW2-C360-2	LW2-C360-2	LW2-C360-2	LW2-C360-2	LW2-G345	LW2-G345-2
													Matrix:	SE	SE	SE	SE	SE	SE	SE
													Upper Depth, ft:	3	5.9	1	14.7	3	0	0
													Lower Depth, ft:	7	9.8	3	18.8	7	0.9	0.9
													Sample Type:	Normal	Normal	Field Replicate	Field Replicate	Field Replicate	Normal	Field Replicate
													Sample Date:	10/27/2005	10/27/2005	10/27/2005	10/27/2005	10/27/2005	7/22/2004	7/22/2004
		PRG-1	PRG-2	PRG-3	PRG-4	SQG	RAL-B	RAL-C	RAL-D	RAL-E	RAL-F	RM 7–8 RALs	Sample ID:	LW2-C360-C1	LW2-C360-D2	LW2-C360-B2	LW2-C360-F2	LW2-C360-C2	LW2-G345-1	LW2-G345-2
Constituent	Units																			
Tributyltin ion	mg/kg-OC	24.1	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	56.0	54.1	20.5	--	--	--	--	--	20.0	10.0	1750		--	--	--	--	--	--	--
gamma-Hexachlorocyclohexane	mg/kg	0.00138	--	--	--	--	--	--	--	--	--	--		0.00340 *UJ*	0.00500 *U*	0.00400 *UJ*	0.00300	0.00200 *UJ*	0.000115 *UJ*	0.000111 *UJ*
Total Chlordanes (EE/CA)	mg/kg	0.830	0.0830	0.00187	--	--	--	--	--	--	--	--		0.0190 *NJ*	0.250 *U*	0.270 *J*	0.00232 *J*	0.00840 *NJ*	0.00180 *NJ*	0.000330 *NJ*
Total DDD (EE/CA)	mg/kg	0.900	0.0890	0.0280	--	1.68	--	--	--	0.100	0.0500	--		0.170 *J*	1.51	0.460 *J*	0.0113 *J*	0.200 *J*	0.160 *NJ*	0.130 *NJ*
Total DDE (EE/CA)	mg/kg	0.100	0.00880	0.0313	0.00302	0.750	1.00	1.00	0.200	0.0500	0.0200	0.400		0.0200 *J*	0.194 *NJ*	0.160 *J*	0.00360 *NJ*	0.0240 *J*	0.0260 *NJ*	0.0210 *NJ*
Total DDT (EE/CA)	mg/kg	1.20	0.120	0.0629	--	5.80	--	--	--	0.150	0.0600	6.00		0.370 *J*	2.88	1.80 *J*	0.0105	0.400 *J*	0.570 *J*	0.380 *J*
Total DDx (EE/CA)	mg/kg	0.218	--	--	--	8.20	--	--	--	--	--	--		0.560 *J*	4.58 *NJ*	2.50 *J*	0.0254 *NJ*	0.620 *J*	0.760 *NJ*	0.530 *NJ*
Hexachlorobenzene	mg/kg-OC	37.0	3.70	--	--	--	--	--	--	--	--	--		1.54	0.331	0.0972 *U*	0.0196 *J*	0.370	0.124 *J*	0.163 *J*
Total PCBs (EE/CA)	mg/kg	0.500	0.0295	--	--	--	1.00	0.750	0.500	0.200	0.0750	--		0.170 *U*	0.400 *U*	0.0920 *U*	0.165	0.200 *U*	0.0350 *J*	0.0460 *J*

Table A-3. Comparison of Sediment Data to Portland Harbor PRGs, RALs, and AOPC 14 SQGs

		Portland Harbor PRGs				AOPC 14 Specific	Portland Harbor RALs					RM 7–8 RALs	Borehole Number:	LW2-G348	LW2-G353	LW2-G353-2	LW2-G355	LW2-G356	LW2-G359
													Matrix:	SE	SE	SE	SE	SE	SE
													Upper Depth, ft:	0	0	0	0	0	0
													Lower Depth, ft:	0.9	0.9	0.9	0.9	1	0.9
													Sample Type:	Normal	Normal	Field Replicate	Normal	Normal	Normal
													Sample Date:	9/14/2004	8/23/2004	8/23/2004	10/29/2004	8/26/2004	8/25/2004
		PRG-1	PRG-2	PRG-3	PRG-4	SQG	RAL-B	RAL-C	RAL-D	RAL-E	RAL-F	RM 7–8 RALs	Sample ID:	LW2-G348	LW2-G353-1	LW2-G353-2	LW2-G355	LW2-G356	LW2-G359
Constituent	Units																		
Tributyltin ion	mg/kg-OC	24.1	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	0.207
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	56.0	54.1	20.5	--	--	--	--	--	20.0	10.0	1750		--	--	--	--	--	--
gamma-Hexachlorocyclohexane	mg/kg	0.00138	--	--	--	--	--	--	--	--	--	--		0.00122 *J*	0.000604 *U*	0.000570 *UJ*	0.000827 *U*	0.000742 *U*	0.000135 *U*
Total Chlordanes (EE/CA)	mg/kg	0.830	0.0830	0.00187	--	--	--	--	--	--	--	--		0.0120 *NJ*	0.0560 *NJ*	0.0250 *NJ*	0.670 *NJ*	0.00350 *NJ*	0.00590 *J*
Total DDD (EE/CA)	mg/kg	0.900	0.0890	0.0280	--	1.68	--	--	--	0.100	0.0500	--		0.360 *J*	0.860 *NJ*	1.10 *NJ*	2.50 *NJ*	0.0650 *NJ*	0.0260 *J*
Total DDE (EE/CA)	mg/kg	0.100	0.00880	0.0313	0.00302	0.750	1.00	1.00	0.200	0.0500	0.0200	0.400		0.150	0.170 *J*	0.250 *J*	0.910 *NJ*	0.0230 *J*	0.00820 *J*
Total DDT (EE/CA)	mg/kg	1.20	0.120	0.0629	--	5.80	--	--	--	0.150	0.0600	6.00		0.570 *J*	3.50 *J*	5.00 *J*	8.10 *J*	0.180 *J*	0.00390 *J*
Total DDx (EE/CA)	mg/kg	0.218	--	--	--	8.20	--	--	--	--	--	--		1.10 *J*	4.60 *NJ*	6.30 *NJ*	11.0 *NJ*	0.270 *NJ*	0.0380 *J*
Hexachlorobenzene	mg/kg-OC	37.0	3.70	--	--	--	--	--	--	--	--	--		0.411 *J*	0.655 *J*	0.444 *J*	13.4 *J*	0.0688 *J*	0.0977 *J*
Total PCBs (EE/CA)	mg/kg	0.500	0.0295	--	--	--	1.00	0.750	0.500	0.200	0.0750	--		0.120 *J*	0.144	0.0760 *UJ*	0.972	--	0.00438 *UJ*

Table A-3. Comparison of Sediment Data to Portland Harbor PRGs, RALs, and AOPC 14 SQGs

		Portland Harbor PRGs				AOPC 14 Specific	Portland Harbor RALs					RM 7–8 RALs	Borehole Number:	LW2-G360	LW2-G366	LWG0107R006SDS015C00	LWM-C14	LWM-TCLP14B	LWP1-AP03B-1	LWP1-AP03B-2	LWP1-AP04B
													Matrix:	SE	SE	SE	SE	SE	SE	SE	SE
													Upper Depth, ft:	0	0	0	0	0	0	0	0
													Lower Depth, ft:	1	1	0.5	12.3	12.1	1	1	0.7
													Sample Type:	Normal	Normal	Normal	Normal	Normal	Normal	Field Replicate	Normal
													Sample Date:	10/28/2004	10/22/2004	11/12/2002	8/26/2008	8/26/2008	1/19/2005	1/19/2005	1/19/2005
		PRG-1	PRG-2	PRG-3	PRG-4	SQG	RAL-B	RAL-C	RAL-D	RAL-E	RAL-F	RM 7–8 RALs	Sample ID:	LW2-G360	LW2-G366	LWG0107R006SDS015C00	LWM-METCS14	LWM-TCLPC14B	LWP-TZSAP03B-1	LWP-TZSAP03B-2	LWP-TZSAP04B
Constituent	Units																				
Tributyltin ion	mg/kg-OC	24.1	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	56.0	54.1	20.5	--	--	--	--	--	20.0	10.0	1750		--	--	9360	8370 *J*	--	--	--	--
gamma-Hexachlorocyclohexane	mg/kg	0.00138	--	--	--	--	--	--	--	--	--	--		0.00115 *U*	0.000672 *U*	0.430	0.980 *U*	0.0970 *U*	--	--	--
Total Chlordanes (EE/CA)	mg/kg	0.830	0.0830	0.00187	--	--	--	--	--	--	--	--		0.0230 *NJ*	0.00960 *NJ*	0.230 *U*	--	--	--	--	--
Total DDD (EE/CA)	mg/kg	0.900	0.0890	0.0280	--	1.68	--	--	--	0.100	0.0500	--		3.00 *NJ*	0.860 *NJ*	1.64	24.8	--	0.420	0.650	1.30 *J*
Total DDE (EE/CA)	mg/kg	0.100	0.00880	0.0313	0.00302	0.750	1.00	1.00	0.200	0.0500	0.0200	0.400		0.590 *NJ*	1.20 *NJ*	1.33	2.00 *U*	--	0.150	0.300	1.10
Total DDT (EE/CA)	mg/kg	1.20	0.120	0.0629	--	5.80	--	--	--	0.150	0.0600	6.00		13.0 *NJ*	3.40 *NJ*	9.99	33.5	--	1.30	6.00	23.0
Total DDx (EE/CA)	mg/kg	0.218	--	--	--	8.20	--	--	--	--	--	--		16.0 *NJ*	5.40 *NJ*	13.0	60.3	--	1.90	7.00	25.0 *J*
Hexachlorobenzene	mg/kg-OC	37.0	3.70	--	--	--	--	--	--	--	--	--		0.319 *J*	0.153 *J*	4.44 *J*	1.51	0.0447	--	--	--
Total PCBs (EE/CA)	mg/kg	0.500	0.0295	--	--	--	1.00	0.750	0.500	0.200	0.0750	--		0.111	0.0320 *J*	0.496 *J*	1.01 *J*	--	--	--	--

Table A-3. Comparison of Sediment Data to Portland Harbor PRGs, RALs, and AOPC 14 SQGs

		Portland Harbor PRGs				AOPC 14 Specific	Portland Harbor RALs					RM 7–8 RALs	Borehole Number:	OSS-002	OSS-002	OSS-004	OSS-004	OSS-006	OSS-006	R2-AP-02-PG	RB-1
													Matrix:	SE	SE	SE	SE	SE	SE	SE	SO
													Upper Depth, ft:	0	0.3	0	1	0	0.3	0	0
													Lower Depth, ft:	0.3	3	0.3	1.6	0.3	1	1	0.3
													Sample Type:	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
													Sample Date:	1/19/1999	1/19/1999	1/19/1999	1/19/1999	1/19/1999	1/19/1999	11/30/2005	11/23/1998
		PRG-1	PRG-2	PRG-3	PRG-4	SQG	RAL-B	RAL-C	RAL-D	RAL-E	RAL-F	RM 7–8 RALs	Sample ID:	SD0006	SDC001	SD0011	SD0013	SD0016	SD0017	LWG2-PG-R2AP2	SD1001
Constituent	Units																				
Tributyltin ion	mg/kg-OC	24.1	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	56.0	54.1	20.5	--	--	--	--	--	20.0	10.0	1750		--	--	--	--	--	--	--	--
gamma-Hexachlorocyclohexane	mg/kg	0.00138	--	--	--	--	--	--	--	--	--	--		0.0400 *U*	0.0400 *U*	0.0400 *U*	0.400 *U*	0.0400 *U*	0.0400 *U*	0.00400 *UJ*	0.0100 *U*
Total Chlordanes (EE/CA)	mg/kg	0.830	0.0830	0.00187	--	--	--	--	--	--	--	--		0.0400 *U*	0.0400 *U*	0.110 *U*	0.400 *U*	0.0400 *U*	0.0400 *U*	0.0490 *U*	--
Total DDD (EE/CA)	mg/kg	0.900	0.0890	0.0280	--	1.68	--	--	--	0.100	0.0500	--		3.40	5.20	11.0	16.0	2.30	4.10	0.230 *J*	--
Total DDE (EE/CA)	mg/kg	0.100	0.00880	0.0313	0.00302	0.750	1.00	1.00	0.200	0.0500	0.0200	0.400		0.510	0.360	1.50	1.80	0.520	1.20	0.0710 *J*	--
Total DDT (EE/CA)	mg/kg	1.20	0.120	0.0629	--	5.80	--	--	--	0.150	0.0600	6.00		81.0	17.0	18.0	0.400 *U*	10.0	11.0	1.30 *J*	--
Total DDx (EE/CA)	mg/kg	0.218	--	--	--	8.20	--	--	--	--	--	--		85.0	23.0	30.0	18.0	13.0	16.0	1.60 *J*	--
Hexachlorobenzene	mg/kg-OC	37.0	3.70	--	--	--	--	--	--	--	--	--		0.645 *U*	1.51	14.8	639	0.556 *U*	0.787 *U*	0.316	11.1 *U*
Total PCBs (EE/CA)	mg/kg	0.500	0.0295	--	--	--	1.00	0.750	0.500	0.200	0.0750	--		--	--	--	--	--	--	--	--

Table A-3. Comparison of Sediment Data to Portland Harbor PRGs, RALs, and AOPC 14 SQGs

		Portland Harbor PRGs				AOPC 14 Specific	Portland Harbor RALs					RM 7–8 RALs	Borehole Number:	RB-1	RB-2	RB-2	RB-3	RB-3	WB-10	WB-10	WB-10
													Matrix:	SO	SO	SO	SO	SO	SE	SE	SE
													Upper Depth, ft:	0.3	0	0.3	0	0.3	0	7	15
													Lower Depth, ft:	0.7	0.3	0.8	0.3	1	2	9	17
													Sample Type:	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
													Sample Date:	11/23/1998	11/23/1998	11/23/1998	11/24/1998	11/24/1998	3/5/2003	3/5/2003	3/5/2003
		PRG-1	PRG-2	PRG-3	PRG-4	SQG	RAL-B	RAL-C	RAL-D	RAL-E	RAL-F	RM 7–8 RALs	Sample ID:	SD1002	SD1003	SD1004	SD1005	SD1006	SO1947	SO1952	SO1956
Constituent	Units																				
Tributyltin ion	mg/kg-OC	24.1	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	56.0	54.1	20.5	--	--	--	--	--	20.0	10.0	1750		--	--	--	--	--	--	--	--
gamma-Hexachlorocyclohexane	mg/kg	0.00138	--	--	--	--	--	--	--	--	--	--		0.0100 *U*	0.0100 *U*	0.0100 *U*	0.0100 *U*	0.0100 *U*	0.0940 *U*	0.180 *U*	0.170 *U*
Total Chlordanes (EE/CA)	mg/kg	0.830	0.0830	0.00187	--	--	--	--	--	--	--	--		--	--	--	--	--	0.190 *J*	0.180 *U*	0.440 *U*
Total DDD (EE/CA)	mg/kg	0.900	0.0890	0.0280	--	1.68	--	--	--	0.100	0.0500	--		--	--	--	--	--	0.890 *J*	4.60	640
Total DDE (EE/CA)	mg/kg	0.100	0.00880	0.0313	0.00302	0.750	1.00	1.00	0.200	0.0500	0.0200	0.400		--	--	--	--	--	0.180	0.660 *J*	4.30 *U*
Total DDT (EE/CA)	mg/kg	1.20	0.120	0.0629	--	5.80	--	--	--	0.150	0.0600	6.00		--	--	--	--	--	4.00	15.0	19.0
Total DDx (EE/CA)	mg/kg	0.218	--	--	--	8.20	--	--	--	--	--	--		--	--	--	--	--	5.10 *J*	20.0 *J*	660
Hexachlorobenzene	mg/kg-OC	37.0	3.70	--	--	--	--	--	--	--	--	--		20.0 *U*	9.09 *U*	9.09 *U*	12.5 *U*	1.30 *U*	--	--	--
Total PCBs (EE/CA)	mg/kg	0.500	0.0295	--	--	--	1.00	0.750	0.500	0.200	0.0750	--		--	--	--	--	--	--	--	--

Table A-3. Comparison of Sediment Data to Portland Harbor PRGs, RALs, and AOPC 14 SQGs

		Portland Harbor PRGs				AOPC 14 Specific	Portland Harbor RALs					RM 7–8 RALs	Borehole Number:	WB-10	WB-10	WB-11	WB-11	WB-11	WB-11	WB-13	WB-13
													Matrix:	SE	SE	SE	SE	SE	SE	SE	SE
													Upper Depth, ft:	17	25	0	12.5	14.5	20.5	0	14.5
													Lower Depth, ft:	19	27	2	14.5	16.5	22.3	3.5	17
													Sample Type:	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
													Sample Date:	3/5/2003	3/5/2003	3/6/2003	3/6/2003	3/6/2003	3/6/2003	2/26/2003	2/26/2003
		PRG-1	PRG-2	PRG-3	PRG-4	SQG	RAL-B	RAL-C	RAL-D	RAL-E	RAL-F	RM 7–8 RALs	Sample ID:	SO1957	SO1961	SO1963	SO1967	SO1968	SO1971	SO1896	SO1901
Constituent	Units																				
Tributyltin ion	mg/kg-OC	24.1	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	56.0	54.1	20.5	--	--	--	--	--	20.0	10.0	1750		--	--	--	--	--	--	--	--
gamma-Hexachlorocyclohexane	mg/kg	0.00138	--	--	--	--	--	--	--	--	--	--		--	0.00660 *U*	0.0970 *U*	0.190 *U*	--	0.00640 *U*	0.0760 *U*	0.0750 *U*
Total Chlordanes (EE/CA)	mg/kg	0.830	0.0830	0.00187	--	--	--	--	--	--	--	--		--	0.00660 *U*	0.370 *U*	0.440 *U*	--	0.00640 *U*	0.110 *U*	0.0750 *U*
Total DDD (EE/CA)	mg/kg	0.900	0.0890	0.0280	--	1.68	--	--	--	0.100	0.0500	--		3.50	0.0280	1.30 *J*	690	0.0220	0.0360	8.20	0.460
Total DDE (EE/CA)	mg/kg	0.100	0.00880	0.0313	0.00302	0.750	1.00	1.00	0.200	0.0500	0.0200	0.400		0.0380 *U*	0.00660 *U*	0.400 *J*	5.70 *U*	0.000390 *U*	0.00640 *U*	0.780	0.0750 *U*
Total DDT (EE/CA)	mg/kg	1.20	0.120	0.0629	--	5.80	--	--	--	0.150	0.0600	6.00		0.930	0.00660 *U*	3.50 *J*	110	0.00240	0.00640 *U*	26.0	0.610
Total DDx (EE/CA)	mg/kg	0.218	--	--	--	8.20	--	--	--	--	--	--		4.50	0.0350	5.20 *J*	800	0.0240	0.0420	35.0	1.10
Hexachlorobenzene	mg/kg-OC	37.0	3.70	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
Total PCBs (EE/CA)	mg/kg	0.500	0.0295	--	--	--	1.00	0.750	0.500	0.200	0.0750	--		--	--	--	--	--	--	--	--

Table A-3. Comparison of Sediment Data to Portland Harbor PRGs, RALs, and AOPC 14 SQGs

		Portland Harbor PRGs				AOPC 14 Specific	Portland Harbor RALs					RM 7–8 RALs	Borehole Number:	WB-13	WB-14	WB-14	WB-14	WB-14	WB-17	WB-18	WB-18
													Matrix:	SE	SE	SE	SE	SE	SE	SE	SE
													Upper Depth, ft:	17	0	10	16	2	0	0	6
													Lower Depth, ft:	19.5	2	12.5	18	4	2	2	8
													Sample Type:	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
													Sample Date:	2/26/2003	2/27/2003	2/27/2003	2/27/2003	2/27/2003	2/27/2003	2/25/2003	2/25/2003
		PRG-1	PRG-2	PRG-3	PRG-4	SQG	RAL-B	RAL-C	RAL-D	RAL-E	RAL-F	RM 7–8 RALs	Sample ID:	SO1902	SO1906	SO1910	SO1912	SO1907	SO1904	SO1888	SO1890
Constituent	Units																				
Tributyltin ion	mg/kg-OC	24.1	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	56.0	54.1	20.5	--	--	--	--	--	20.0	10.0	1750		--	--	--	--	--	--	--	--
gamma-Hexachlorocyclohexane	mg/kg	0.00138	--	--	--	--	--	--	--	--	--	--		--	0.0970 *U*	--	0.00690 *U*	--	0.0920 *U*	0.0810 *U*	0.150 *U*
Total Chlordanes (EE/CA)	mg/kg	0.830	0.0830	0.00187	--	--	--	--	--	--	--	--		--	0.0970 *U*	--	0.00690 *U*	--	0.0920 *U*	0.450 *J*	0.190 *U*
Total DDD (EE/CA)	mg/kg	0.900	0.0890	0.0280	--	1.68	--	--	--	0.100	0.0500	--		0.0110	0.810	0.0380	0.00690 *U*	3.50	0.320 *J*	1.20	3.60
Total DDE (EE/CA)	mg/kg	0.100	0.00880	0.0313	0.00302	0.750	1.00	1.00	0.200	0.0500	0.0200	0.400		0.000300 *U*	0.150 *J*	0.000360 *U*	0.00690 *U*	0.330	0.0920 *U*	0.350	0.650 *J*
Total DDT (EE/CA)	mg/kg	1.20	0.120	0.0629	--	5.80	--	--	--	0.150	0.0600	6.00		0.00610	1.40	0.120	0.00690 *U*	8.00	6.10	8.00	17.0
Total DDx (EE/CA)	mg/kg	0.218	--	--	--	8.20	--	--	--	--	--	--		0.0170	2.40 *J*	0.160	0.00690 *U*	12.0	6.50 *J*	9.60	21.0 *J*
Hexachlorobenzene	mg/kg-OC	37.0	3.70	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
Total PCBs (EE/CA)	mg/kg	0.500	0.0295	--	--	--	1.00	0.750	0.500	0.200	0.0750	--		--	--	--	--	--	--	--	--

Table A-3. Comparison of Sediment Data to Portland Harbor PRGs, RALs, and AOPC 14 SQGs

		Portland Harbor PRGs				AOPC 14 Specific	Portland Harbor RALs					RM 7–8 RALs	Borehole Number:	WB-18	WB-18	WB-19	WB-19	WB-24	WB-24	WB-24	WB-25	WB-25
													Matrix:	SE	SE	SE	SE	SE	SE	SE	SE	SE
													Upper Depth, ft:	8	16	0	1.4	10.6	16.6	18.6	0	3.7
													Lower Depth, ft:	10	20	1.4	2.9	12.6	18.6	20.6	1.7	5.7
													Sample Type:	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
													Sample Date:	2/25/2003	2/25/2003	2/24/2003	2/24/2003	3/7/2003	3/7/2003	3/7/2003	3/7/2003	3/7/2003
		PRG-1	PRG-2	PRG-3	PRG-4	SQG	RAL-B	RAL-C	RAL-D	RAL-E	RAL-F	RM 7–8 RALs	Sample ID:	SO1891	SO1894	SO1885	SO1886	SO1972	SO1975	SO1976	SO1979	SO1981
Constituent	Units																					
Tributyltin ion	mg/kg-OC	24.1	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--	--
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	56.0	54.1	20.5	--	--	--	--	--	20.0	10.0	1750		--	--	--	--	--	--	--	--	--
gamma-Hexachlorocyclohexane	mg/kg	0.00138	--	--	--	--	--	--	--	--	--	--		--	0.00650 *U*	0.0880 *U*	--	1.80 *U*	0.00690 *U*	--	0.110 *UJ*	--
Total Chlordanes (EE/CA)	mg/kg	0.830	0.0830	0.00187	--	--	--	--	--	--	--	--		--	0.00650 *U*	0.0880 *U*	--	1.80 *U*	0.00690 *U*	--	0.160 *UJ*	--
Total DDD (EE/CA)	mg/kg	0.900	0.0890	0.0280	--	1.68	--	--	--	0.100	0.0500	--		1.90	0.220	0.310	11.0	130	0.0890 *J*	0.00700	0.350 *J*	3.80
Total DDE (EE/CA)	mg/kg	0.100	0.00880	0.0313	0.00302	0.750	1.00	1.00	0.200	0.0500	0.0200	0.400		0.510	0.00650 *U*	0.100	0.340 *U*	13.0	0.00690 *U*	0.00300	0.110 *UJ*	0.240
Total DDT (EE/CA)	mg/kg	1.20	0.120	0.0629	--	5.80	--	--	--	0.150	0.0600	6.00		2.00	0.150	0.620	7.30	3500	27.0	0.400	1.20 *J*	4.70
Total DDx (EE/CA)	mg/kg	0.218	--	--	--	8.20	--	--	--	--	--	--		4.40	0.370	1.00	18.0	3600	27.0 *J*	0.410	1.60 *J*	8.70
Hexachlorobenzene	mg/kg-OC	37.0	3.70	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--	--
Total PCBs (EE/CA)	mg/kg	0.500	0.0295	--	--	--	1.00	0.750	0.500	0.200	0.0750	--		--	--	--	--	--	--	--	--	--

Table A-3. Comparison of Sediment Data to Portland Harbor PRGs, RALs, and AOPC 14 SQGs

		Portland Harbor PRGs				AOPC 14 Specific	Portland Harbor RALs					RM 7–8 RALs	Borehole Number:	WB-25	WB-25	WB-25	WB-25	WB-31	WB-31	WB-31	WB-31	WB-31
													Matrix:	SE	SE	SE	SE	SE	SE	SE	SE	SE
													Upper Depth, ft:	5.7	10.7	14.7	20.2	0	4	6	8	10
													Lower Depth, ft:	10.7	12.7	16.7	21.7	2	6	8	10	12
													Sample Type:	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
													Sample Date:	3/7/2003	3/7/2003	3/7/2003	3/10/2003	9/21/2009	9/21/2009	9/21/2009	9/21/2009	9/21/2009
		PRG-1	PRG-2	PRG-3	PRG-4	SQG	RAL-B	RAL-C	RAL-D	RAL-E	RAL-F	RM 7–8 RALs	Sample ID:	SO1982	SO1983	SO1985	SO1988	ARK-WB-31-0-2	ARK-WB-31-4-6	ARK-WB-31-6-8	ARK-WB-31-8-10	ARK-WB-31-10-12
Constituent	Units																					
Tributyltin ion	mg/kg-OC	24.1	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--	--
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	56.0	54.1	20.5	--	--	--	--	--	20.0	10.0	1750		--	--	--	--	--	--	--	--	--
gamma-Hexachlorocyclohexane	mg/kg	0.00138	--	--	--	--	--	--	--	--	--	--		--	0.00740 *U*	0.00690 *U*	0.00620 *U*	--	--	--	--	--
Total Chlordanes (EE/CA)	mg/kg	0.830	0.0830	0.00187	--	--	--	--	--	--	--	--		--	0.00740 *U*	0.00690 *U*	0.00620 *U*	--	--	--	--	--
Total DDD (EE/CA)	mg/kg	0.900	0.0890	0.0280	--	1.68	--	--	--	0.100	0.0500	--		83.0	0.0100	0.00690 *U*	0.00620 *U*	2.40 *J*	0.220 *J*	0.270 *J*	0.0250	0.0630
Total DDE (EE/CA)	mg/kg	0.100	0.00880	0.0313	0.00302	0.750	1.00	1.00	0.200	0.0500	0.0200	0.400		0.470 *U*	0.00740 *U*	0.00690 *U*	0.00620 *U*	0.410 *J*	0.0450 *J*	0.0540 *J*	0.00830	0.0110 *J*
Total DDT (EE/CA)	mg/kg	1.20	0.120	0.0629	--	5.80	--	--	--	0.150	0.0600	6.00		18.0	0.0240	0.0130	0.00620 *U*	18.0 *J*	0.980 *J*	1.00 *J*	0.0510	0.120
Total DDx (EE/CA)	mg/kg	0.218	--	--	--	8.20	--	--	--	--	--	--		100	0.0380	0.0190	0.00620 *U*	20.0 *J*	1.20 *J*	1.30 *J*	0.0840	0.190 *J*
Hexachlorobenzene	mg/kg-OC	37.0	3.70	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--	--
Total PCBs (EE/CA)	mg/kg	0.500	0.0295	--	--	--	1.00	0.750	0.500	0.200	0.0750	--		--	--	--	--	--	--	--	--	--

Table A-3. Comparison of Sediment Data to Portland Harbor PRGs, RALs, and AOPC 14 SQGs

		Portland Harbor PRGs				AOPC 14 Specific	Portland Harbor RALs					RM 7–8 RALs	Borehole Number:	WB-31	WB-31	WB-31	WB-31	WB-31	WB-31	WB-31
													Matrix:	SE	SE	SE	SE	SE	SE	SE
													Upper Depth, ft:	12	14	0	18	2	20	22
													Lower Depth, ft:	14	16	0	20	4	22	24
													Sample Type:	Normal	Normal	Normal	Normal	Normal	Normal	Normal
													Sample Date:	9/21/2009	9/21/2009	9/21/2009	9/21/2009	9/21/2009	9/21/2009	9/21/2009
		PRG-1	PRG-2	PRG-3	PRG-4	SQG	RAL-B	RAL-C	RAL-D	RAL-E	RAL-F	RM 7–8 RALs	Sample ID:	ARK-WB-31-12-14	ARK-WB-31-14-16	ARK-WB-31-16-18	ARK-WB-31-18-20	ARK-WB-31-2-4	ARK-WB-31-20-22	ARK-WB-31-22-24
Constituent	Units																			
Tributyltin ion	mg/kg-OC	24.1	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	56.0	54.1	20.5	--	--	--	--	--	20.0	10.0	1750		--	--	--	--	--	--	--
gamma-Hexachlorocyclohexane	mg/kg	0.00138	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--
Total Chlordanes (EE/CA)	mg/kg	0.830	0.0830	0.00187	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--
Total DDD (EE/CA)	mg/kg	0.900	0.0890	0.0280	--	1.68	--	--	--	0.100	0.0500	--		0.00120	0.000590 *J*	0.00710	0.000170 *U*	1.70 *J*	0.000170 *U*	0.000170 *U*
Total DDE (EE/CA)	mg/kg	0.100	0.00880	0.0313	0.00302	0.750	1.00	1.00	0.200	0.0500	0.0200	0.400		0.000270 *J*	0.000110 *U*	0.00520 *J*	0.000110 *U*	0.310 *J*	0.000110 *U*	0.000110 *U*
Total DDT (EE/CA)	mg/kg	1.20	0.120	0.0629	--	5.80	--	--	--	0.150	0.0600	6.00		0.00170	0.000780	0.0120	0.000670 *U*	6.10 *J*	0.000590 *U*	0.000520 *U*
Total DDx (EE/CA)	mg/kg	0.218	--	--	--	8.20	--	--	--	--	--	--		0.00320 *J*	0.00150 *J*	0.0250 *J*	0.000670 *U*	8.10 *J*	0.000590 *U*	0.000520 *U*
Hexachlorobenzene	mg/kg-OC	37.0	3.70	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--
Total PCBs (EE/CA)	mg/kg	0.500	0.0295	--	--	--	1.00	0.750	0.500	0.200	0.0750	--		--	--	--	--	--	--	--

Table A-3. Comparison of Sediment Data to Portland Harbor PRGs, RALs, and AOPC 14 SQGs

		Portland Harbor PRGs				AOPC 14 Specific	Portland Harbor RALs					RM 7–8 RALs	Borehole Number:	WB-31	WB-31	WB-31	WB-32	WB-32	WB-32	WB-32
													Matrix:	SE	SE	SE	SE	SE	SE	SE
													Upper Depth, ft:	24	26	28	34	10	12	14
													Lower Depth, ft:	26	28	30	36	12	14	16
													Sample Type:	Normal	Normal	Normal	Normal	Normal	Normal	Normal
													Sample Date:	9/21/2009	9/21/2009	9/21/2009	9/23/2009	9/22/2009	9/22/2009	9/22/2009
		PRG-1	PRG-2	PRG-3	PRG-4	SQG	RAL-B	RAL-C	RAL-D	RAL-E	RAL-F	RM 7–8 RALs	Sample ID:	ARK-WB-31-24-26	ARK-WB-31-26-28	ARK-WB-31-28-30	ARK-WB-32-34-36	ARK-WB-32-10-12	ARK-WB-32-12-14	ARK-WB-32-14-16
Constituent	Units																			
Tributyltin ion	mg/kg-OC	24.1	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	56.0	54.1	20.5	--	--	--	--	--	20.0	10.0	1750		--	--	--	--	--	0.270 *J*	--
gamma-Hexachlorocyclohexane	mg/kg	0.00138	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--
Total Chlordanes (EE/CA)	mg/kg	0.830	0.0830	0.00187	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--
Total DDD (EE/CA)	mg/kg	0.900	0.0890	0.0280	--	1.68	--	--	--	0.100	0.0500	--		0.00160	0.000600 *J*	0.000160 *U*	0.00470	1.50	0.00990	0.00310 *J*
Total DDE (EE/CA)	mg/kg	0.100	0.00880	0.0313	0.00302	0.750	1.00	1.00	0.200	0.0500	0.0200	0.400		0.000570	0.000190 *J*	0.000100 *U*	0.000990 *J*	0.0810 *J*	0.000960 *J*	0.000240 *J*
Total DDT (EE/CA)	mg/kg	1.20	0.120	0.0629	--	5.80	--	--	--	0.150	0.0600	6.00		0.00420	0.000830 *U*	0.000400 *U*	0.00230	4.10	0.0330 *J*	0.00640 *J*
Total DDx (EE/CA)	mg/kg	0.218	--	--	--	8.20	--	--	--	--	--	--		0.00630	0.00130 *J*	0.000400 *U*	0.00800 *J*	5.70 *J*	0.0440 *J*	0.00970 *J*
Hexachlorobenzene	mg/kg-OC	37.0	3.70	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--
Total PCBs (EE/CA)	mg/kg	0.500	0.0295	--	--	--	1.00	0.750	0.500	0.200	0.0750	--		--	--	--	--	--	--	--

Table A-3. Comparison of Sediment Data to Portland Harbor PRGs, RALs, and AOPC 14 SQGs

		Portland Harbor PRGs				AOPC 14 Specific	Portland Harbor RALs					RM 7–8 RALs	Borehole Number:	WB-32	WB-32	WB-32	WB-32	WB-32	WB-32	WB-32
													Matrix:	SE	SE	SE	SE	SE	SE	SE
													Upper Depth, ft:	16	18	20	22	24	26	28
													Lower Depth, ft:	18	20	22	24	26	28	30
													Sample Type:	Normal	Normal	Normal	Normal	Normal	Normal	Normal
													Sample Date:	9/22/2009	9/22/2009	9/23/2009	9/23/2009	9/23/2009	9/23/2009	9/23/2009
		PRG-1	PRG-2	PRG-3	PRG-4	SQG	RAL-B	RAL-C	RAL-D	RAL-E	RAL-F	RM 7–8 RALs	Sample ID:	ARK-WB-32-16-18	ARK-WB-32-18-20	ARK-WB-32-20-22	ARK-WB-32-22-24	ARK-WB-32-24-26	ARK-WB-32-26-28	ARK-WB-32-28-30
Constituent	Units																			
Tributyltin ion	mg/kg-OC	24.1	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	56.0	54.1	20.5	--	--	--	--	--	20.0	10.0	1750		--	0.100 *J*	--	--	--	--	--
gamma-Hexachlorocyclohexane	mg/kg	0.00138	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--
Total Chlordanes (EE/CA)	mg/kg	0.830	0.0830	0.00187	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--
Total DDD (EE/CA)	mg/kg	0.900	0.0890	0.0280	--	1.68	--	--	--	0.100	0.0500	--		0.00930	0.000380 *J*	0.00240	0.000170 *J*	0.000300 *J*	0.00110	0.000170 *U*
Total DDE (EE/CA)	mg/kg	0.100	0.00880	0.0313	0.00302	0.750	1.00	1.00	0.200	0.0500	0.0200	0.400		0.000720	0.000110 *U*	0.000650	0.000110 *U*	0.000170 *J*	0.000200 *J*	0.000100 *U*
Total DDT (EE/CA)	mg/kg	1.20	0.120	0.0629	--	5.80	--	--	--	0.150	0.0600	6.00		0.0180	0.00120	0.00310	0.000390	0.000810	0.00110 *J*	0.000150 *U*
Total DDx (EE/CA)	mg/kg	0.218	--	--	--	8.20	--	--	--	--	--	--		0.0280	0.00170 *J*	0.00620	0.000660 *J*	0.00130 *J*	0.00240 *J*	0.000170 *U*
Hexachlorobenzene	mg/kg-OC	37.0	3.70	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--
Total PCBs (EE/CA)	mg/kg	0.500	0.0295	--	--	--	1.00	0.750	0.500	0.200	0.0750	--		--	--	--	--	--	--	--

Table A-3. Comparison of Sediment Data to Portland Harbor PRGs, RALs, and AOPC 14 SQGs

		Portland Harbor PRGs				AOPC 14 Specific	Portland Harbor RALs					RM 7–8 RALs	Borehole Number:	WB-32	WB-32	WB-35	WB-35	WB-35	WB-35	WB-35	WB-35
													Matrix:	SE	SE	SE	SE	SE	SE	SE	SE
													Upper Depth, ft:	30	32	0	35	10	10	16	18
													Lower Depth, ft:	32	34	10	35.6	20	20	18	20
													Sample Type:	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
													Sample Date:	9/23/2009	9/23/2009	9/30/2009	9/30/2009	9/30/2009	9/30/2009	9/30/2009	9/30/2009
		PRG-1	PRG-2	PRG-3	PRG-4	SQG	RAL-B	RAL-C	RAL-D	RAL-E	RAL-F	RM 7–8 RALs	Sample ID:	ARK-WB-32-30-32	ARK-WB-32-32-34	ARK-WB-35-0-10	ARK-WB-35-35-35.6	ARK-WB-35-10-20	ARK-WB-35-10-20.EPAsplit	ARK-WB-35-16-18	ARK-WB-35-18-20
Constituent	Units																				
Tributyltin ion	mg/kg-OC	24.1	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	0.654 *U*	--	--
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	56.0	54.1	20.5	--	--	--	--	--	20.0	10.0	1750		--	--	1700	--	8800	24100	--	--
gamma-Hexachlorocyclohexane	mg/kg	0.00138	--	--	--	--	--	--	--	--	--	--		--	--	0.240 *U*	--	2.20 *U*	--	--	--
Total Chlordanes (EE/CA)	mg/kg	0.830	0.0830	0.00187	--	--	--	--	--	--	--	--		--	--	1.10	--	2.30 *U*	--	--	--
Total DDD (EE/CA)	mg/kg	0.900	0.0890	0.0280	--	1.68	--	--	--	0.100	0.0500	--		0.000320 *J*	0.00140	7.70	0.270	210	--	4.10 *J*	1.40 *J*
Total DDE (EE/CA)	mg/kg	0.100	0.00880	0.0313	0.00302	0.750	1.00	1.00	0.200	0.0500	0.0200	0.400		0.000110 *U*	0.000200 *J*	2.80	0.0120 *J*	2.60 *U*	--	0.140 *J*	0.0430 *J*
Total DDT (EE/CA)	mg/kg	1.20	0.120	0.0629	--	5.80	--	--	--	0.150	0.0600	6.00		0.000310 *J*	0.00590	18.0	0.120	180	--	1.50 *J*	0.430 *J*
Total DDx (EE/CA)	mg/kg	0.218	--	--	--	8.20	--	--	--	--	--	--		0.000730 *J*	0.00750 *J*	28.0	0.400 *J*	390	--	5.70 *J*	1.90 *J*
Hexachlorobenzene	mg/kg-OC	37.0	3.70	--	--	--	--	--	--	--	--	--		--	--	1.90	--	1.58	10.8 *U*	--	--
Total PCBs (EE/CA)	mg/kg	0.500	0.0295	--	--	--	1.00	0.750	0.500	0.200	0.0750	--		--	--	1.80 *U*	--	1.70 *U*	0.00170 *U*	--	--

Table A-3. Comparison of Sediment Data to Portland Harbor PRGs, RALs, and AOPC 14 SQGs

		Portland Harbor PRGs				AOPC 14 Specific	Portland Harbor RALs					RM 7–8 RALs	Borehole Number:	WB-35	WB-35	WB-35	WB-35	WB-35	WB-35	WB-35	WB-35
													Matrix:	SE	SE	SE	SE	SE	SE	SE	SE
													Upper Depth, ft:	20	20	23	23	26	29	32	32
													Lower Depth, ft:	23	23	26	26	29	32	35	35
													Sample Type:	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
													Sample Date:	9/30/2009	9/30/2009	9/30/2009	9/30/2009	9/30/2009	9/30/2009	9/30/2009	9/30/2009
		PRG-1	PRG-2	PRG-3	PRG-4	SQG	RAL-B	RAL-C	RAL-D	RAL-E	RAL-F	RM 7–8 RALs	Sample ID:	ARK-WB-35-20-23	ARK-WB-35-20-23.EPAsplit	ARK-WB-35-23-26	ARK-WB-35-23-26.EPAsplit	ARK-WB-35-26-29	ARK-WB-35-29-32	ARK-WB-35-32-35	ARK-WB-35-32-35.EPAsplit
Constituent	Units																				
Tributyltin ion	mg/kg-OC	24.1	--	--	--	--	--	--	--	--	--	--		--	20.0 *U*	--	15.6 *U*	--	--	--	21.3 *UJ*
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	56.0	54.1	20.5	--	--	--	--	--	20.0	10.0	1750		--	3.83	--	1.42	--	--	--	0.215 *J*
gamma-Hexachlorocyclohexane	mg/kg	0.00138	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
Total Chlordanes (EE/CA)	mg/kg	0.830	0.0830	0.00187	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
Total DDD (EE/CA)	mg/kg	0.900	0.0890	0.0280	--	1.68	--	--	--	0.100	0.0500	--		0.0880	--	0.0290	--	0.0310	0.200	0.0100	--
Total DDE (EE/CA)	mg/kg	0.100	0.00880	0.0313	0.00302	0.750	1.00	1.00	0.200	0.0500	0.0200	0.400		0.00430	--	0.00120	--	0.00120	0.0100 *J*	0.000260 *J*	--
Total DDT (EE/CA)	mg/kg	1.20	0.120	0.0629	--	5.80	--	--	--	0.150	0.0600	6.00		0.0240 *J*	--	0.0290	--	0.00800 *J*	0.120	0.00230	--
Total DDx (EE/CA)	mg/kg	0.218	--	--	--	8.20	--	--	--	--	--	--		0.120 *J*	--	0.0590	--	0.0400 *J*	0.330 *J*	0.0130 *J*	--
Hexachlorobenzene	mg/kg-OC	37.0	3.70	--	--	--	--	--	--	--	--	--		--	357 *U*	--	267 *U*	--	--	--	361 *U*
Total PCBs (EE/CA)	mg/kg	0.500	0.0295	--	--	--	1.00	0.750	0.500	0.200	0.0750	--		--	0.00150 *U*	--	0.00150 *U*	--	--	--	0.00140 *U*

Table A-3. Comparison of Sediment Data to Portland Harbor PRGs, RALs, and AOPC 14 SQGs

		Portland Harbor PRGs				AOPC 14 Specific	Portland Harbor RALs					RM 7–8 RALs	Borehole Number:	WB-36	WB-36	WB-36	WB-36	WB-36	WB-36	WB-36	WB-36
													Matrix:	SE	SE	SE	SE	SE	SE	SE	SE
													Upper Depth, ft:	0	34	37	10	22	25	28	31
													Lower Depth, ft:	10	37	40	22	25	28	31	34
													Sample Type:	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
													Sample Date:	10/1/2009	10/1/2009	10/1/2009	10/1/2009	10/1/2009	10/1/2009	10/1/2009	10/1/2009
		PRG-1	PRG-2	PRG-3	PRG-4	SQG	RAL-B	RAL-C	RAL-D	RAL-E	RAL-F	RM 7–8 RALs	Sample ID:	ARK-WB-36-0-10	ARK-WB-36-34-37	ARK-WB-36-37-40	ARK-WB-36-10-22	ARK-WB-36-22-25	ARK-WB-36-25-28	ARK-WB-36-28-31	ARK-WB-36-31-34
Constituent	Units																				
Tributyltin ion	mg/kg-OC	24.1	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	56.0	54.1	20.5	--	--	--	--	--	20.0	10.0	1750		28000	--	--	5500	550	--	--	0.340 *J*
gamma-Hexachlorocyclohexane	mg/kg	0.00138	--	--	--	--	--	--	--	--	--	--		0.0470 *U*	--	--	9.90 *U*	--	--	--	--
Total Chlordanes (EE/CA)	mg/kg	0.830	0.0830	0.00187	--	--	--	--	--	--	--	--		0.0480 *U*	--	--	10.0 *U*	--	--	--	--
Total DDD (EE/CA)	mg/kg	0.900	0.0890	0.0280	--	1.68	--	--	--	0.100	0.0500	--		1.70 *J*	0.00220 *J*	0.00290 *J*	290 *J*	39.0	0.0410	0.0220 *J*	0.0110 *J*
Total DDE (EE/CA)	mg/kg	0.100	0.00880	0.0313	0.00302	0.750	1.00	1.00	0.200	0.0500	0.0200	0.400		0.170	0.000360	0.000330	22.0 *J*	3.60 *J*	0.00230 *J*	0.00180 *J*	0.000810 *J*
Total DDT (EE/CA)	mg/kg	1.20	0.120	0.0629	--	5.80	--	--	--	0.150	0.0600	6.00		7.10 *J*	0.00580 *J*	0.00590	1500 *J*	150	0.110	0.0660	0.0240 *J*
Total DDx (EE/CA)	mg/kg	0.218	--	--	--	8.20	--	--	--	--	--	--		8.90 *J*	0.00840 *J*	0.00910 *J*	1800 *J*	190 *J*	0.160 *J*	0.0900 *J*	0.0360 *J*
Hexachlorobenzene	mg/kg-OC	37.0	3.70	--	--	--	--	--	--	--	--	--		5.62	--	--	0.122 *U*	--	--	--	--
Total PCBs (EE/CA)	mg/kg	0.500	0.0295	--	--	--	1.00	0.750	0.500	0.200	0.0750	--		0.260 *U*	--	--	1.40 *U*	--	--	--	--

Table A-3. Comparison of Sediment Data to Portland Harbor PRGs, RALs, and AOPC 14 SQGs

		Portland Harbor PRGs				AOPC 14 Specific	Portland Harbor RALs					RM 7–8 RALs	Borehole Number:	WB-37	WB-37	WB-37	WB-37	WB-37	WB-37	WB-37	WB-39
													Matrix:	SE	SE	SE	SE	SE	SE	SE	SE
													Upper Depth, ft:	0	6	10	12	14	17	20	0
													Lower Depth, ft:	6	14	12	14	17	20	23	8
													Sample Type:	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
													Sample Date:	9/29/2009	9/29/2009	9/29/2009	9/29/2009	9/29/2009	9/29/2009	9/29/2009	9/28/2009
		PRG-1	PRG-2	PRG-3	PRG-4	SQG	RAL-B	RAL-C	RAL-D	RAL-E	RAL-F	RM 7–8 RALs	Sample ID:	ARK-WB-37-0-6	ARK-WB-37-6-14	ARK-WB-37-10-12	ARK-WB-37-12-14	ARK-WB-37-14-17	ARK-WB-37-17-20	ARK-WB-37-20-23	ARK-WB-39-0-8
Constituent	Units																				
Tributyltin ion	mg/kg-OC	24.1	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	56.0	54.1	20.5	--	--	--	--	--	20.0	10.0	1750		2000	1200	--	--	--	0.0690 *U*	--	17000
gamma-Hexachlorocyclohexane	mg/kg	0.00138	--	--	--	--	--	--	--	--	--	--		0.0500 *U*	3.50 *U*	--	--	--	--	--	0.230 *U*
Total Chlordanes (EE/CA)	mg/kg	0.830	0.0830	0.00187	--	--	--	--	--	--	--	--		0.130 *J*	3.60 *U*	--	--	--	--	--	0.240 *U*
Total DDD (EE/CA)	mg/kg	0.900	0.0890	0.0280	--	1.68	--	--	--	0.100	0.0500	--		2.40	430	1200 *J*	0.210 *J*	0.0230 *J*	0.0190	0.00150	3.80
Total DDE (EE/CA)	mg/kg	0.100	0.00880	0.0313	0.00302	0.750	1.00	1.00	0.200	0.0500	0.0200	0.400		0.750 *J*	4.00 *U*	12.0 *J*	0.0100 *J*	0.000480 *J*	0.000480 *U*	0.000100 *U*	0.780 *J*
Total DDT (EE/CA)	mg/kg	1.20	0.120	0.0629	--	5.80	--	--	--	0.150	0.0600	6.00		3.80	63.0	200 *J*	0.0270 *J*	0.00420 *J*	0.00210 *J*	0.00140 *J*	24.0
Total DDx (EE/CA)	mg/kg	0.218	--	--	--	8.20	--	--	--	--	--	--		7.00 *J*	500	1400 *J*	0.250 *J*	0.0280 *J*	0.0210 *J*	0.00300 *J*	29.0 *J*
Hexachlorobenzene	mg/kg-OC	37.0	3.70	--	--	--	--	--	--	--	--	--		0.327 *J*	0.0419 *U*	--	--	--	--	--	2.00
Total PCBs (EE/CA)	mg/kg	0.500	0.0295	--	--	--	1.00	0.750	0.500	0.200	0.0750	--		0.360 *U*	1.70 *U*	--	--	--	--	--	1.70 *U*

Table A-3. Comparison of Sediment Data to Portland Harbor PRGs, RALs, and AOPC 14 SQGs

		Portland Harbor PRGs				AOPC 14 Specific	Portland Harbor RALs					RM 7–8 RALs	Borehole Number:	WB-39	WB-39	WB-39	WB-39	WB-39	WB-39	WB-41
													Matrix:	SE	SE	SE	SE	SE	SE	SE
													Upper Depth, ft:	8	14	16	18	21	24	0
													Lower Depth, ft:	18	16	18	21	24	25.7	6
													Sample Type:	Normal	Normal	Normal	Normal	Normal	Normal	Normal
													Sample Date:	9/29/2009	9/29/2009	9/29/2009	9/29/2009	9/29/2009	9/29/2009	9/28/2009
		PRG-1	PRG-2	PRG-3	PRG-4	SQG	RAL-B	RAL-C	RAL-D	RAL-E	RAL-F	RM 7–8 RALs	Sample ID:	ARK-WB-39-8-18	ARK-WB-39-14-16	ARK-WB-39-16-18	ARK-WB-39-18-21	ARK-WB-39-21-24	ARK-WB-39-24-25.7	ARK-WB-41-0-6
Constituent	Units																			
Tributyltin ion	mg/kg-OC	24.1	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	56.0	54.1	20.5	--	--	--	--	--	20.0	10.0	1750		1400	--	--	0.620 *U*	--	0.0990 *U*	1400
gamma-Hexachlorocyclohexane	mg/kg	0.00138	--	--	--	--	--	--	--	--	--	--		0.470 *U*	--	--	--	--	--	0.0240 *U*
Total Chlordanes (EE/CA)	mg/kg	0.830	0.0830	0.00187	--	--	--	--	--	--	--	--		0.480 *U*	--	--	--	--	--	0.0620 *J*
Total DDD (EE/CA)	mg/kg	0.900	0.0890	0.0280	--	1.68	--	--	--	0.100	0.0500	--		51.0	0.00190 *J*	0.110 *J*	0.0500	0.00410 *J*	0.000750	1.00
Total DDE (EE/CA)	mg/kg	0.100	0.00880	0.0313	0.00302	0.750	1.00	1.00	0.200	0.0500	0.0200	0.400		2.60	0.000180 *J*	0.00420 *J*	0.00570 *J*	0.00150 *J*	0.000100 *U*	0.240
Total DDT (EE/CA)	mg/kg	1.20	0.120	0.0629	--	5.80	--	--	--	0.150	0.0600	6.00		11.0 *J*	0.000430 *J*	0.0290 *J*	0.00820	0.00170	0.00120	1.60
Total DDx (EE/CA)	mg/kg	0.218	--	--	--	8.20	--	--	--	--	--	--		64.0 *J*	0.00250 *J*	0.150 *J*	0.0640 *J*	0.00730 *J*	0.00210	2.80
Hexachlorobenzene	mg/kg-OC	37.0	3.70	--	--	--	--	--	--	--	--	--		0.0500 *U*	--	--	--	--	--	0.329 *J*
Total PCBs (EE/CA)	mg/kg	0.500	0.0295	--	--	--	1.00	0.750	0.500	0.200	0.0750	--		1.50 *U*	--	--	--	--	--	0.340 *UJ*

Table A-3. Comparison of Sediment Data to Portland Harbor PRGs, RALs, and AOPC 14 SQGs

		Portland Harbor PRGs				AOPC 14 Specific	Portland Harbor RALs					RM 7–8 RALs	Borehole Number:	WB-41	WB-41	WB-41	WB-41	WB-42	WB-42	WB-42	WB-42
													Matrix:	SE	SE	SE	SE	SE	SE	SE	SE
													Upper Depth, ft:	6	14	17	20	0	6	6	14
													Lower Depth, ft:	14	17	20	22.8	6	14	14	17
													Sample Type:	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
													Sample Date:	9/28/2009	9/28/2009	9/28/2009	9/28/2009	9/25/2009	9/25/2009	9/25/2009	9/25/2009
		PRG-1	PRG-2	PRG-3	PRG-4	SQG	RAL-B	RAL-C	RAL-D	RAL-E	RAL-F	RM 7–8 RALs	Sample ID:	ARK-WB-41-6-14	ARK-WB-41-14-17	ARK-WB-41-17-20	ARK-WB-41-20-22.8	ARK-WB-42-0-6	ARK-WB-42-6-14	ARK-WB-42-6-14.EPAsplit	ARK-WB-42-14-17
Constituent	Units																				
Tributyltin ion	mg/kg-OC	24.1	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	0.762 *UJ*	--
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	56.0	54.1	20.5	--	--	--	--	--	20.0	10.0	1750		520	--	--	0.0870 *U*	6000	6800	10300	--
gamma-Hexachlorocyclohexane	mg/kg	0.00138	--	--	--	--	--	--	--	--	--	--		0.0550 *U*	--	--	--	0.460 *U*	1.60 *U*	--	--
Total Chlordanes (EE/CA)	mg/kg	0.830	0.0830	0.00187	--	--	--	--	--	--	--	--		0.0570 *U*	--	--	--	0.470 *U*	1.70 *U*	--	--
Total DDD (EE/CA)	mg/kg	0.900	0.0890	0.0280	--	1.68	--	--	--	0.100	0.0500	--		9.60 *J*	0.660	0.0210 *J*	0.00160	17.0	190	--	1.20
Total DDE (EE/CA)	mg/kg	0.100	0.00880	0.0313	0.00302	0.750	1.00	1.00	0.200	0.0500	0.0200	0.400		1.20 *J*	0.0360 *J*	0.00260 *J*	0.000490	1.50 *J*	4.30 *J*	--	0.0350 *J*
Total DDT (EE/CA)	mg/kg	1.20	0.120	0.0629	--	5.80	--	--	--	0.150	0.0600	6.00		3.80 *J*	1.00 *J*	0.0210 *J*	0.000780	47.0	170	--	1.60
Total DDx (EE/CA)	mg/kg	0.218	--	--	--	8.20	--	--	--	--	--	--		15.0 *J*	1.70 *J*	0.0450 *J*	0.00290	66.0 *J*	360 *J*	--	2.90 *J*
Hexachlorobenzene	mg/kg-OC	37.0	3.70	--	--	--	--	--	--	--	--	--		0.0520 *U*	--	--	--	3.91	2.48	11.9 *U*	--
Total PCBs (EE/CA)	mg/kg	0.500	0.0295	--	--	--	1.00	0.750	0.500	0.200	0.0750	--		0.310 *UJ*	--	--	--	1.30 *U*	1.50 *U*	0.00150 *U*	--

Table A-3. Comparison of Sediment Data to Portland Harbor PRGs, RALs, and AOPC 14 SQGs

		Portland Harbor PRGs				AOPC 14 Specific	Portland Harbor RALs					RM 7–8 RALs	Borehole Number:	WB-42	WB-42	WB-42	WB-42	WB-42	WB-43	WB-43	WB-43
													Matrix:	SE	SE	SE	SE	SE	SE	SE	SE
													Upper Depth, ft:	17	20	20	23	23	0	8	14
													Lower Depth, ft:	20	23	23	26	26	8	18	16
													Sample Type:	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
													Sample Date:	9/25/2009	9/25/2009	9/25/2009	9/25/2009	9/25/2009	9/24/2009	9/24/2009	9/24/2009
		PRG-1	PRG-2	PRG-3	PRG-4	SQG	RAL-B	RAL-C	RAL-D	RAL-E	RAL-F	RM 7–8 RALs	Sample ID:	ARK-WB-42-17-20	ARK-WB-42-20-23	ARK-WB-42-20-23.EPAsplit	ARK-WB-42-23-26	ARK-WB-42-23-26.EPAsplit	ARK-WB-43-0-8	ARK-WB-43-8-18	ARK-WB-43-14-16
Constituent	Units																				
Tributyltin ion	mg/kg-OC	24.1	--	--	--	--	--	--	--	--	--	--		--	--	20.0 *U*	--	17.5 *UJ*	--	--	--
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	56.0	54.1	20.5	--	--	--	--	--	20.0	10.0	1750		--	--	0.0325 *U*	--	0.249 *J*	1900	540 *J*	--
gamma-Hexachlorocyclohexane	mg/kg	0.00138	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	0.0560 *U*	0.400 *U*	--
Total Chlordanes (EE/CA)	mg/kg	0.830	0.0830	0.00187	--	--	--	--	--	--	--	--		--	--	--	--	--	0.110 *J*	0.410 *U*	--
Total DDD (EE/CA)	mg/kg	0.900	0.0890	0.0280	--	1.68	--	--	--	0.100	0.0500	--		0.000500 *J*	0.000410 *J*	--	0.00120 *J*	--	3.70	21.0	2.30 *J*
Total DDE (EE/CA)	mg/kg	0.100	0.00880	0.0313	0.00302	0.750	1.00	1.00	0.200	0.0500	0.0200	0.400		0.000110 *U*	0.000110 *U*	--	0.000110 *UJ*	--	0.390 *J*	0.460 *U*	0.220 *J*
Total DDT (EE/CA)	mg/kg	1.20	0.120	0.0629	--	5.80	--	--	--	0.150	0.0600	6.00		0.000270 *J*	0.000360	--	0.00190 *J*	--	6.30	36.0	26.0 *J*
Total DDx (EE/CA)	mg/kg	0.218	--	--	--	8.20	--	--	--	--	--	--		0.000870 *J*	0.000870 *J*	--	0.00320 *J*	--	10.0 *J*	58.0	28.0 *J*
Hexachlorobenzene	mg/kg-OC	37.0	3.70	--	--	--	--	--	--	--	--	--		--	--	329 *U*	--	275 *U*	0.372 *J*	0.0414 *U*	--
Total PCBs (EE/CA)	mg/kg	0.500	0.0295	--	--	--	1.00	0.750	0.500	0.200	0.0750	--		--	--	0.00140 *U*	--	0.00130 *U*	0.350 *U*	0.290 *U*	--

Table A-3. Comparison of Sediment Data to Portland Harbor PRGs, RALs, and AOPC 14 SQGs

		Portland Harbor PRGs				AOPC 14 Specific	Portland Harbor RALs					RM 7–8 RALs	Borehole Number:	WB-43	WB-43	WB-46	WB-46	WB-46	WB-46	WB-46
													Matrix:	SE	SE	SE	SE	SE	SE	SE
													Upper Depth, ft:	16	18	0	4	8	10	12
													Lower Depth, ft:	18	19	2	6	10	12	14
													Sample Type:	Normal	Normal	Normal	Normal	Normal	Normal	Normal
													Sample Date:	9/24/2009	9/24/2009	9/23/2009	9/23/2009	9/23/2009	9/23/2009	9/23/2009
		PRG-1	PRG-2	PRG-3	PRG-4	SQG	RAL-B	RAL-C	RAL-D	RAL-E	RAL-F	RM 7–8 RALs	Sample ID:	ARK-WB-43-16-18	ARK-WB-43-18-19	ARK-WB-46-0-2	ARK-WB-46-4-6	ARK-WB-46-8-10	ARK-WB-46-10-12	ARK-WB-46-12-14
Constituent	Units																			
Tributyltin ion	mg/kg-OC	24.1	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	56.0	54.1	20.5	--	--	--	--	--	20.0	10.0	1750		--	0.0920 *U*	--	--	4.20 *J*	--	0.0800 *U*
gamma-Hexachlorocyclohexane	mg/kg	0.00138	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--
Total Chlordanes (EE/CA)	mg/kg	0.830	0.0830	0.00187	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--
Total DDD (EE/CA)	mg/kg	0.900	0.0890	0.0280	--	1.68	--	--	--	0.100	0.0500	--		0.000650 *J*	0.00120	0.120 *J*	2.90 *J*	0.00450 *J*	0.00810	0.000150 *U*
Total DDE (EE/CA)	mg/kg	0.100	0.00880	0.0313	0.00302	0.750	1.00	1.00	0.200	0.0500	0.0200	0.400		0.000100 *UJ*	0.0000990 *U*	0.0670 *J*	0.390 *J*	0.00200 *J*	0.00730 *J*	0.0000970 *U*
Total DDT (EE/CA)	mg/kg	1.20	0.120	0.0629	--	5.80	--	--	--	0.150	0.0600	6.00		0.000770 *J*	0.000140 *U*	1.60 *J*	5.30 *J*	0.0600	0.0360	0.000550
Total DDx (EE/CA)	mg/kg	0.218	--	--	--	8.20	--	--	--	--	--	--		0.00150 *J*	0.00140	1.70 *J*	8.60 *J*	0.0670 *J*	0.0510 *J*	0.000750
Hexachlorobenzene	mg/kg-OC	37.0	3.70	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--
Total PCBs (EE/CA)	mg/kg	0.500	0.0295	--	--	--	1.00	0.750	0.500	0.200	0.0750	--		--	--	--	--	--	--	--

Table A-3. Comparison of Sediment Data to Portland Harbor PRGs, RALs, and AOPC 14 SQGs

		Portland Harbor PRGs				AOPC 14 Specific	Portland Harbor RALs					RM 7–8 RALs	Borehole Number:	WB-46	WB-46	WB-46	WB-46	WB-46	WB-46	WB-46
													Matrix:	SE	SE	SE	SE	SE	SE	SE
													Upper Depth, ft:	14	16	18	2	20	22	24
													Lower Depth, ft:	16	18	20	4	22	24	25
													Sample Type:	Normal	Normal	Normal	Normal	Normal	Normal	Normal
													Sample Date:	9/23/2009	9/23/2009	9/23/2009	9/23/2009	9/23/2009	9/23/2009	9/23/2009
		PRG-1	PRG-2	PRG-3	PRG-4	SQG	RAL-B	RAL-C	RAL-D	RAL-E	RAL-F	RM 7–8 RALs	Sample ID:	ARK-WB-46-14-16	ARK-WB-46-16-18	ARK-WB-46-18-20	ARK-WB-46-2-4	ARK-WB-46-20-22	ARK-WB-46-22-24	ARK-WB-46-24-25
Constituent	Units																			
Tributyltin ion	mg/kg-OC	24.1	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	56.0	54.1	20.5	--	--	--	--	--	20.0	10.0	1750		--	--	--	--	--	--	--
gamma-Hexachlorocyclohexane	mg/kg	0.00138	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--
Total Chlordanes (EE/CA)	mg/kg	0.830	0.0830	0.00187	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--
Total DDD (EE/CA)	mg/kg	0.900	0.0890	0.0280	--	1.68	--	--	--	0.100	0.0500	--		0.000150 *U*	0.00300	0.000360 *J*	2.50 *J*	0.000160 *U*	0.000160 *U*	0.000150 *U*
Total DDE (EE/CA)	mg/kg	0.100	0.00880	0.0313	0.00302	0.750	1.00	1.00	0.200	0.0500	0.0200	0.400		0.0000950 *U*	0.00350	0.000250 *J*	0.560 *J*	0.000100 *U*	0.000100 *U*	0.0000980 *U*
Total DDT (EE/CA)	mg/kg	1.20	0.120	0.0629	--	5.80	--	--	--	0.150	0.0600	6.00		0.000140 *U*	0.0200	0.00160	13.0 *J*	0.000140 *U*	0.000150 *U*	0.000140 *U*
Total DDx (EE/CA)	mg/kg	0.218	--	--	--	8.20	--	--	--	--	--	--		0.000150 *U*	0.0270	0.00220 *J*	16.0 *J*	0.000160 *U*	0.000160 *U*	0.000150 *U*
Hexachlorobenzene	mg/kg-OC	37.0	3.70	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--
Total PCBs (EE/CA)	mg/kg	0.500	0.0295	--	--	--	1.00	0.750	0.500	0.200	0.0750	--		--	--	--	--	--	--	--

Table A-3. Comparison of Sediment Data to Portland Harbor PRGs, RALs, and AOPC 14 SQGs

		Portland Harbor PRGs				AOPC 14 Specific	Portland Harbor RALs					RM 7–8 RALs	Borehole Number:	WB-48	WB-48	WB-48	WB-48	WB-48	WB-48	WB-48	WB-48
													Matrix:	SE	SE	SE	SE	SE	SE	SE	SE
													Upper Depth, ft:	4	6	8	10	12	14	16	18
													Lower Depth, ft:	6	8	10	12	14	16	18	20
													Sample Type:	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
													Sample Date:	9/10/2009	9/10/2009	9/10/2009	9/10/2009	9/10/2009	9/10/2009	9/10/2009	9/10/2009
		PRG-1	PRG-2	PRG-3	PRG-4	SQG	RAL-B	RAL-C	RAL-D	RAL-E	RAL-F	RM 7–8 RALs	Sample ID:	ARK-WB-48-4-6	ARK-WB-48-6-8	ARK-WB-48-8-10	ARK-WB-48-10-12	ARK-WB-48-12-14	ARK-WB-48-14-16	ARK-WB-48-16-18	ARK-WB-48-18-20
Constituent	Units																				
Tributyltin ion	mg/kg-OC	24.1	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	56.0	54.1	20.5	--	--	--	--	--	20.0	10.0	1750		--	--	--	11.0	--	--	0.870 *J*	--
gamma-Hexachlorocyclohexane	mg/kg	0.00138	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
Total Chlordanes (EE/CA)	mg/kg	0.830	0.0830	0.00187	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
Total DDD (EE/CA)	mg/kg	0.900	0.0890	0.0280	--	1.68	--	--	--	0.100	0.0500	--		0.500	19.0	12.0 *J*	1.70 *J*	1.40 *J*	0.310 *J*	0.00310	0.00970
Total DDE (EE/CA)	mg/kg	0.100	0.00880	0.0313	0.00302	0.750	1.00	1.00	0.200	0.0500	0.0200	0.400		0.220 *J*	1.60 *J*	2.00 *J*	0.120 *J*	0.110 *J*	0.0310 *J*	0.000340	0.000790 *J*
Total DDT (EE/CA)	mg/kg	1.20	0.120	0.0629	--	5.80	--	--	--	0.150	0.0600	6.00		0.420 *J*	6.20	13.0	0.180 *J*	0.480	0.0690	0.000920	0.00340
Total DDx (EE/CA)	mg/kg	0.218	--	--	--	8.20	--	--	--	--	--	--		1.10 *J*	27.0 *J*	27.0 *J*	2.00 *J*	2.00 *J*	0.410 *J*	0.00440	0.0140 *J*
Hexachlorobenzene	mg/kg-OC	37.0	3.70	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
Total PCBs (EE/CA)	mg/kg	0.500	0.0295	--	--	--	1.00	0.750	0.500	0.200	0.0750	--		--	--	--	--	--	--	--	--

Table A-3. Comparison of Sediment Data to Portland Harbor PRGs, RALs, and AOPC 14 SQGs

		Portland Harbor PRGs				AOPC 14 Specific	Portland Harbor RALs					RM 7–8 RALs	Borehole Number:	WB-48	WB-48	WB-49	WB-49	WB-49	WB-49	WB-49	WB-49
													Matrix:	SE	SE	SE	SE	SE	SE	SE	SE
													Upper Depth, ft:	2	20	0	4	6	6	8	10
													Lower Depth, ft:	4	21.9	2	6	8	8	10	12
													Sample Type:	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
													Sample Date:	9/10/2009	9/10/2009	9/9/2009	9/9/2009	9/9/2009	9/9/2009	9/9/2009	9/9/2009
		PRG-1	PRG-2	PRG-3	PRG-4	SQG	RAL-B	RAL-C	RAL-D	RAL-E	RAL-F	RM 7–8 RALs	Sample ID:	ARK-WB-48-2-4	ARK-WB-48-20-21.9	ARK-WB-49-0-2	ARK-WB-49-4-6	ARK-WB-49-6-8	ARK-WB-49-6-8.EPAsplit	ARK-WB-49-8-10	ARK-WB-49-10-12
Constituent	Units																				
Tributyltin ion	mg/kg-OC	24.1	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	5.42 *U*	--	--
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	56.0	54.1	20.5	--	--	--	--	--	20.0	10.0	1750		--	--	--	--	--	60.7	--	--
gamma-Hexachlorocyclohexane	mg/kg	0.00138	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
Total Chlordanes (EE/CA)	mg/kg	0.830	0.0830	0.00187	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
Total DDD (EE/CA)	mg/kg	0.900	0.0890	0.0280	--	1.68	--	--	--	0.100	0.0500	--		0.730 *J*	0.00240 *J*	0.00810 *J*	1.40 *J*	0.300	--	0.110	0.350
Total DDE (EE/CA)	mg/kg	0.100	0.00880	0.0313	0.00302	0.750	1.00	1.00	0.200	0.0500	0.0200	0.400		0.320 *J*	0.000110 *U*	0.000490 *J*	0.190 *J*	0.0260 *J*	--	0.00910 *U*	0.0180 *J*
Total DDT (EE/CA)	mg/kg	1.20	0.120	0.0629	--	5.80	--	--	--	0.150	0.0600	6.00		3.50 *J*	0.00180 *J*	0.00210 *J*	3.90 *J*	0.550	--	0.670	0.530
Total DDx (EE/CA)	mg/kg	0.218	--	--	--	8.20	--	--	--	--	--	--		4.60 *J*	0.00430 *J*	0.0110 *J*	5.50 *J*	0.880 *J*	--	0.790	0.900 *J*
Hexachlorobenzene	mg/kg-OC	37.0	3.70	--	--	--	--	--	--	--	--	--		--	--	--	--	--	87.5 *U*	--	--
Total PCBs (EE/CA)	mg/kg	0.500	0.0295	--	--	--	1.00	0.750	0.500	0.200	0.0750	--		--	--	--	--	--	0.00120 *U*	--	--

Table A-3. Comparison of Sediment Data to Portland Harbor PRGs, RALs, and AOPC 14 SQGs

		Portland Harbor PRGs				AOPC 14 Specific	Portland Harbor RALs					RM 7–8 RALs	Borehole Number:	WB-49	WB-49	WB-49	WB-49	WB-49	WB-49	WB-49	WB-49
													Matrix:	SE	SE	SE	SE	SE	SE	SE	SE
													Upper Depth, ft:	12	14	14	16	18	2	20	20
													Lower Depth, ft:	14	16	16	18	20	4	22	22
													Sample Type:	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
													Sample Date:	9/9/2009	9/9/2009	9/9/2009	9/9/2009	9/9/2009	9/9/2009	9/9/2009	9/9/2009
		PRG-1	PRG-2	PRG-3	PRG-4	SQG	RAL-B	RAL-C	RAL-D	RAL-E	RAL-F	RM 7–8 RALs	Sample ID:	ARK-WB-49-12-14	ARK-WB-49-14-16	ARK-WB-49-14-16.EPAsplit	ARK-WB-49-16-18	ARK-WB-49-18-20	ARK-WB-49-2-4	ARK-WB-49-20-22	ARK-WB-49-20-22.EPAsplit
Constituent	Units																				
Tributyltin ion	mg/kg-OC	24.1	--	--	--	--	--	--	--	--	--	--		--	--	9.29 *U*	--	--	--	--	14.0 *U*
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	56.0	54.1	20.5	--	--	--	--	--	20.0	10.0	1750		--	--	2.60	--	--	--	--	0.167 *J*
gamma-Hexachlorocyclohexane	mg/kg	0.00138	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
Total Chlordanes (EE/CA)	mg/kg	0.830	0.0830	0.00187	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
Total DDD (EE/CA)	mg/kg	0.900	0.0890	0.0280	--	1.68	--	--	--	0.100	0.0500	--		0.0850	0.200 *J*	--	0.00580 *J*	0.00180	0.570 *J*	0.000970 *J*	--
Total DDE (EE/CA)	mg/kg	0.100	0.00880	0.0313	0.00302	0.750	1.00	1.00	0.200	0.0500	0.0200	0.400		0.00790	0.0360 *J*	--	0.00250 *J*	0.000280 *J*	0.140 *J*	0.000160 *J*	--
Total DDT (EE/CA)	mg/kg	1.20	0.120	0.0629	--	5.80	--	--	--	0.150	0.0600	6.00		0.130	0.100	--	0.00630 *J*	0.00270	1.50 *J*	0.00200	--
Total DDx (EE/CA)	mg/kg	0.218	--	--	--	8.20	--	--	--	--	--	--		0.220	0.330 *J*	--	0.0150 *J*	0.00470 *J*	2.20 *J*	0.00310 *J*	--
Hexachlorobenzene	mg/kg-OC	37.0	3.70	--	--	--	--	--	--	--	--	--		--	--	150 *U*	--	--	--	--	200 *UJ*
Total PCBs (EE/CA)	mg/kg	0.500	0.0295	--	--	--	1.00	0.750	0.500	0.200	0.0750	--		--	--	0.00130 *U*	--	--	--	--	0.00120 *UJ*

Table A-3. Comparison of Sediment Data to Portland Harbor PRGs, RALs, and AOPC 14 SQGs

		Portland Harbor PRGs				AOPC 14 Specific	Portland Harbor RALs					RM 7–8 RALs	Borehole Number:	WB-49	WB-50	WB-50	WB-50	WB-50	WB-50	WB-50	WB-50
													Matrix:	SE	SE	SE	SE	SE	SE	SE	SE
													Upper Depth, ft:	22	0	4	6	8	10	12	14
													Lower Depth, ft:	23.5	2	6	8	10	12	14	14.5
													Sample Type:	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
													Sample Date:	9/9/2009	8/27/2009	8/27/2009	##	8/27/2009	8/27/2009	8/27/2009	8/27/2009
		PRG-1	PRG-2	PRG-3	PRG-4	SQG	RAL-B	RAL-C	RAL-D	RAL-E	RAL-F	RM 7–8 RALs	Sample ID:	ARK-WB-49-22-23.5	ARK-WB-50-0-2	ARK-WB-50-4-6	ARK-WB-50-6-8	ARK-WB-50-8-10	ARK-WB-50-10-12	ARK-WB-50-12-14	ARK-WB-50-14-14.5
Constituent	Units																				
Tributyltin ion	mg/kg-OC	24.1	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	56.0	54.1	20.5	--	--	--	--	--	20.0	10.0	1750		--	--	--	--	1.70 *J*	--	0.240 *U*	--
gamma-Hexachlorocyclohexane	mg/kg	0.00138	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
Total Chlordanes (EE/CA)	mg/kg	0.830	0.0830	0.00187	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
Total DDD (EE/CA)	mg/kg	0.900	0.0890	0.0280	--	1.68	--	--	--	0.100	0.0500	--		0.000710	0.280	9.10	12.0	0.0800	0.0430 *J*	0.000910	0.00150
Total DDE (EE/CA)	mg/kg	0.100	0.00880	0.0313	0.00302	0.750	1.00	1.00	0.200	0.0500	0.0200	0.400		0.000140 *J*	0.0970	0.250 *U*	1.40 *J*	0.00950 *J*	0.00550 *U*	0.000100 *U*	0.000180 *J*
Total DDT (EE/CA)	mg/kg	1.20	0.120	0.0629	--	5.80	--	--	--	0.150	0.0600	6.00		0.000670 *U*	0.550	17.0 *J*	3.10 *J*	0.0540 *J*	0.410	0.000260 *J*	0.000850 *J*
Total DDx (EE/CA)	mg/kg	0.218	--	--	--	8.20	--	--	--	--	--	--		0.00130 *J*	0.930	26.0 *J*	17.0 *J*	0.140 *J*	0.460 *J*	0.00130 *J*	0.00250 *J*
Hexachlorobenzene	mg/kg-OC	37.0	3.70	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
Total PCBs (EE/CA)	mg/kg	0.500	0.0295	--	--	--	1.00	0.750	0.500	0.200	0.0750	--		--	--	--	--	--	--	--	--

Table A-3. Comparison of Sediment Data to Portland Harbor PRGs, RALs, and AOPC 14 SQGs

		Portland Harbor PRGs				AOPC 14 Specific	Portland Harbor RALs					RM 7–8 RALs	Borehole Number:	WB-50	WB-51	WB-51	WB-51	WB-51	WB-51	WB-51	WB-51
													Matrix:	SE	SE	SE	SE	SE	SE	SE	SE
													Upper Depth, ft:	2	0	4	6	8	10	10	12
													Lower Depth, ft:	4	2	6	8	10	12	12	14
													Sample Type:	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
													Sample Date:	8/27/2009	8/28/2009	8/28/2009	8/28/2009	8/28/2009	8/28/2009	8/28/2009	8/28/2009
		PRG-1	PRG-2	PRG-3	PRG-4	SQG	RAL-B	RAL-C	RAL-D	RAL-E	RAL-F	RM 7–8 RALs	Sample ID:	ARK-WB-50-2-4	ARK-WB-51-0-2	ARK-WB-51-4-6	ARK-WB-51-6-8	ARK-WB-51-8-10	ARK-WB-51-10-12	ARK-WB-51-10-12.EPAsplit	ARK-WB-51-12-14
Constituent	Units																				
Tributyltin ion	mg/kg-OC	24.1	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	3.18 *U*	--
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	56.0	54.1	20.5	--	--	--	--	--	20.0	10.0	1750		--	--	--	--	--	--	135	--
gamma-Hexachlorocyclohexane	mg/kg	0.00138	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
Total Chlordanes (EE/CA)	mg/kg	0.830	0.0830	0.00187	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
Total DDD (EE/CA)	mg/kg	0.900	0.0890	0.0280	--	1.68	--	--	--	0.100	0.0500	--		6.20	0.510 *J*	23.0 *J*	1.10	110	1.50	--	0.590 *J*
Total DDE (EE/CA)	mg/kg	0.100	0.00880	0.0313	0.00302	0.750	1.00	1.00	0.200	0.0500	0.0200	0.400		0.840 *J*	0.120 *J*	1.40 *J*	0.0400	3.50	0.110 *J*	--	0.0430 *J*
Total DDT (EE/CA)	mg/kg	1.20	0.120	0.0629	--	5.80	--	--	--	0.150	0.0600	6.00		2.90	2.40	9.40 *J*	1.20	170 *J*	1.20	--	0.330
Total DDx (EE/CA)	mg/kg	0.218	--	--	--	8.20	--	--	--	--	--	--		9.90 *J*	3.00 *J*	33.0 *J*	2.40	280 *J*	2.80 *J*	--	0.970 *J*
Hexachlorobenzene	mg/kg-OC	37.0	3.70	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	52.3 *U*	--
Total PCBs (EE/CA)	mg/kg	0.500	0.0295	--	--	--	1.00	0.750	0.500	0.200	0.0750	--		--	--	--	--	--	--	0.00140 *U*	--

Table A-3. Comparison of Sediment Data to Portland Harbor PRGs, RALs, and AOPC 14 SQGs

		Portland Harbor PRGs				AOPC 14 Specific	Portland Harbor RALs					RM 7–8 RALs	Borehole Number:	WB-51	WB-51	WB-51	WB-51	WB-51	WB-52	WB-52	WB-52
													Matrix:	SE	SE	SE	SE	SE	SE	SE	SE
													Upper Depth, ft:	14	16	18	2	20	0	4	6
													Lower Depth, ft:	16	18	20	4	21.5	2	6	8
													Sample Type:	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
													Sample Date:	8/28/2009	8/28/2009	8/28/2009	8/28/2009	8/28/2009	9/9/2009	9/9/2009	9/9/2009
		PRG-1	PRG-2	PRG-3	PRG-4	SQG	RAL-B	RAL-C	RAL-D	RAL-E	RAL-F	RM 7–8 RALs	Sample ID:	ARK-WB-51-14-16	ARK-WB-51-16-18	ARK-WB-51-18-20	ARK-WB-51-2-4	ARK-WB-51-20-21.5	ARK-WB-52-0-2	ARK-WB-52-4-6	ARK-WB-52-6-8
Constituent	Units																				
Tributyltin ion	mg/kg-OC	24.1	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	56.0	54.1	20.5	--	--	--	--	--	20.0	10.0	1750		--	--	0.500 *J*	--	--	--	--	--
gamma-Hexachlorocyclohexane	mg/kg	0.00138	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
Total Chlordanes (EE/CA)	mg/kg	0.830	0.0830	0.00187	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
Total DDD (EE/CA)	mg/kg	0.900	0.0890	0.0280	--	1.68	--	--	--	0.100	0.0500	--		0.0160	0.0370	0.00650 *J*	4.50 *J*	0.00460	0.260 *J*	0.0340 *J*	0.00320
Total DDE (EE/CA)	mg/kg	0.100	0.00880	0.0313	0.00302	0.750	1.00	1.00	0.200	0.0500	0.0200	0.400		0.000850	0.00240 *J*	0.000490 *J*	1.60 *J*	0.000190 *J*	0.210 *J*	0.00340 *J*	0.00210 *J*
Total DDT (EE/CA)	mg/kg	1.20	0.120	0.0629	--	5.80	--	--	--	0.150	0.0600	6.00		0.0260	0.0760	0.00450	4.00 *J*	0.00320	1.10 *J*	0.440 *J*	0.00660
Total DDx (EE/CA)	mg/kg	0.218	--	--	--	8.20	--	--	--	--	--	--		0.0430	0.120 *J*	0.0110 *J*	10.0 *J*	0.00800 *J*	1.50 *J*	0.480 *J*	0.0120 *J*
Hexachlorobenzene	mg/kg-OC	37.0	3.70	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
Total PCBs (EE/CA)	mg/kg	0.500	0.0295	--	--	--	1.00	0.750	0.500	0.200	0.0750	--		--	--	--	--	--	--	--	--

Table A-3. Comparison of Sediment Data to Portland Harbor PRGs, RALs, and AOPC 14 SQGs

		Portland Harbor PRGs				AOPC 14 Specific	Portland Harbor RALs					RM 7–8 RALs	Borehole Number:	WB-52	WB-52	WB-52	WB-52	WB-52	WB-52	WB-53	WB-53
													Matrix:	SE	SE	SE	SE	SE	SE	SE	SE
													Upper Depth, ft:	8	10	12	14	16	2	0	4
													Lower Depth, ft:	10	12	14	16	18	4	2	6
													Sample Type:	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
													Sample Date:	9/9/2009	9/9/2009	9/9/2009	9/9/2009	9/9/2009	9/9/2009	8/24/2009	8/24/2009
		PRG-1	PRG-2	PRG-3	PRG-4	SQG	RAL-B	RAL-C	RAL-D	RAL-E	RAL-F	RM 7–8 RALs	Sample ID:	ARK-WB-52-8-10	ARK-WB-52-10-12	ARK-WB-52-12-14	ARK-WB-52-14-16	ARK-WB-52-16-18	ARK-WB-52-2-4	ARK-WB-53-0-2	ARK-WB-53-4-6
Constituent	Units																				
Tributyltin ion	mg/kg-OC	24.1	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	56.0	54.1	20.5	--	--	--	--	--	20.0	10.0	1750		--	--	--	--	--	--	--	--
gamma-Hexachlorocyclohexane	mg/kg	0.00138	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
Total Chlordanes (EE/CA)	mg/kg	0.830	0.0830	0.00187	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
Total DDD (EE/CA)	mg/kg	0.900	0.0890	0.0280	--	1.68	--	--	--	0.100	0.0500	--		0.000400 *J*	0.00250 *J*	0.000320 *J*	0.000170 *U*	0.000160 *U*	2.80 *J*	0.370	11.0
Total DDE (EE/CA)	mg/kg	0.100	0.00880	0.0313	0.00302	0.750	1.00	1.00	0.200	0.0500	0.0200	0.400		0.000110 *UJ*	0.00160 *J*	0.000100 *U*	0.000110 *U*	0.000100 *U*	0.380	0.140	0.240 *U*
Total DDT (EE/CA)	mg/kg	1.20	0.120	0.0629	--	5.80	--	--	--	0.150	0.0600	6.00		0.000170 *UJ*	0.00130	0.000140 *U*	0.000220 *J*	0.000140 *U*	4.80 *J*	0.790	19.0
Total DDx (EE/CA)	mg/kg	0.218	--	--	--	8.20	--	--	--	--	--	--		0.000660 *J*	0.00540 *J*	0.000540 *J*	0.000440 *J*	0.000160 *U*	8.00 *J*	1.30	30.0
Hexachlorobenzene	mg/kg-OC	37.0	3.70	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
Total PCBs (EE/CA)	mg/kg	0.500	0.0295	--	--	--	1.00	0.750	0.500	0.200	0.0750	--		--	--	--	--	--	--	--	--

Table A-3. Comparison of Sediment Data to Portland Harbor PRGs, RALs, and AOPC 14 SQGs

		Portland Harbor PRGs				AOPC 14 Specific	Portland Harbor RALs					RM 7–8 RALs	Borehole Number:	WB-53	WB-53	WB-53	WB-53	WB-53	WB-53	WB-54	WB-54
													Matrix:	SE	SE	SE	SE	SE	SE	SE	SE
													Upper Depth, ft:	6	8	10	12	14	2	0	4
													Lower Depth, ft:	8	10	12	14	15.3	4	2	6
													Sample Type:	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
													Sample Date:	8/24/2009	8/24/2009	8/24/2009	8/24/2009	8/24/2009	8/24/2009	8/21/2009	8/21/2009
		PRG-1	PRG-2	PRG-3	PRG-4	SQG	RAL-B	RAL-C	RAL-D	RAL-E	RAL-F	RM 7–8 RALs	Sample ID:	ARK-WB-53-6-8	ARK-WB-53-8-10	ARK-WB-53-10-12	ARK-WB-53-12-14	ARK-WB-53-14-15.3	ARK-WB-53-2-4	ARK-WB-54-0-2	ARK-WB-54-4-6
Constituent	Units																				
Tributyltin ion	mg/kg-OC	24.1	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	56.0	54.1	20.5	--	--	--	--	--	20.0	10.0	1750		--	0.0720 *U*	--	--	0.200 *U*	--	--	--
gamma-Hexachlorocyclohexane	mg/kg	0.00138	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
Total Chlordanes (EE/CA)	mg/kg	0.830	0.0830	0.00187	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
Total DDD (EE/CA)	mg/kg	0.900	0.0890	0.0280	--	1.68	--	--	--	0.100	0.0500	--		0.660	0.000820	0.00170	0.000190 *J*	0.000150 *U*	2.30	0.400 *J*	20.0 *J*
Total DDE (EE/CA)	mg/kg	0.100	0.00880	0.0313	0.00302	0.750	1.00	1.00	0.200	0.0500	0.0200	0.400		0.0530 *J*	0.0000990 *U*	0.000400	0.0000940 *U*	0.0000950 *U*	0.220 *J*	0.170 *J*	1.50 *J*
Total DDT (EE/CA)	mg/kg	1.20	0.120	0.0629	--	5.80	--	--	--	0.150	0.0600	6.00		1.40 *J*	0.000650	0.00110 *J*	0.000140 *U*	0.000140 *U*	0.240	1.20	7.70 *J*
Total DDx (EE/CA)	mg/kg	0.218	--	--	--	8.20	--	--	--	--	--	--		2.10 *J*	0.00160	0.00320 *J*	0.000400 *J*	0.000150 *U*	2.70 *J*	1.80 *J*	29.0 *J*
Hexachlorobenzene	mg/kg-OC	37.0	3.70	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
Total PCBs (EE/CA)	mg/kg	0.500	0.0295	--	--	--	1.00	0.750	0.500	0.200	0.0750	--		--	--	--	--	--	--	--	--

Table A-3. Comparison of Sediment Data to Portland Harbor PRGs, RALs, and AOPC 14 SQGs

		Portland Harbor PRGs				AOPC 14 Specific	Portland Harbor RALs					RM 7–8 RALs	Borehole Number:	WB-54	WB-54	WB-54	WB-54	WB-54	WB-54	WB-54	WB-63
													Matrix:	SE	SE	SE	SE	SE	SE	SE	SE
													Upper Depth, ft:	6	8	10	12.3	14	16	2	0
													Lower Depth, ft:	8	10	12.3	14	16	18	4	2
													Sample Type:	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
													Sample Date:	8/21/2009	8/24/2009	8/24/2009	8/24/2009	8/24/2009	8/24/2009	8/21/2009	8/20/2009
		PRG-1	PRG-2	PRG-3	PRG-4	SQG	RAL-B	RAL-C	RAL-D	RAL-E	RAL-F	RM 7–8 RALs	Sample ID:	ARK-WB-54-6-8	ARK-WB-54-8-10	ARK-WB-54-10-12.3	ARK-WB-54-12.3-14	ARK-WB-54-14-16	ARK-WB-54-16-18	ARK-WB-54-2-4	ARK-WB-63-0-2
Constituent	Units																				
Tributyltin ion	mg/kg-OC	24.1	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	56.0	54.1	20.5	--	--	--	--	--	20.0	10.0	1750		7.10	--	--	--	0.140 *J*	--	--	--
gamma-Hexachlorocyclohexane	mg/kg	0.00138	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
Total Chlordanes (EE/CA)	mg/kg	0.830	0.0830	0.00187	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
Total DDD (EE/CA)	mg/kg	0.900	0.0890	0.0280	--	1.68	--	--	--	0.100	0.0500	--		0.0310	0.420	0.00490	0.120	0.00110	0.000260 *J*	5.80 *J*	0.380
Total DDE (EE/CA)	mg/kg	0.100	0.00880	0.0313	0.00302	0.750	1.00	1.00	0.200	0.0500	0.0200	0.400		0.00450	0.0200	0.00180 *J*	0.00670	0.000100 *U*	0.0000960 *U*	2.30 *J*	0.130
Total DDT (EE/CA)	mg/kg	1.20	0.120	0.0629	--	5.80	--	--	--	0.150	0.0600	6.00		0.0140	0.520	0.00240	0.0730	0.00200 *J*	0.000140 *U*	2.90 *J*	0.450
Total DDx (EE/CA)	mg/kg	0.218	--	--	--	8.20	--	--	--	--	--	--		0.0490	0.960	0.00910 *J*	0.200	0.00310 *J*	0.000470 *J*	11.0 *J*	0.960
Hexachlorobenzene	mg/kg-OC	37.0	3.70	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
Total PCBs (EE/CA)	mg/kg	0.500	0.0295	--	--	--	1.00	0.750	0.500	0.200	0.0750	--		--	--	--	--	--	--	--	--

Table A-3. Comparison of Sediment Data to Portland Harbor PRGs, RALs, and AOPC 14 SQGs

		Portland Harbor PRGs				AOPC 14 Specific	Portland Harbor RALs					RM 7–8 RALs	Borehole Number:	WB-63	WB-63	WB-63	WB-63	WB-63	WB-63	WB-63	WB-63
													Matrix:	SE	SE	SE	SE	SE	SE	SE	SE
													Upper Depth, ft:	4	6	8	10	10	12	14	16
													Lower Depth, ft:	6	8	10	12	12	14	16	16.7
													Sample Type:	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
													Sample Date:	8/20/2009	8/20/2009	8/20/2009	8/20/2009	8/20/2009	8/20/2009	8/20/2009	8/20/2009
		PRG-1	PRG-2	PRG-3	PRG-4	SQG	RAL-B	RAL-C	RAL-D	RAL-E	RAL-F	RM 7–8 RALs	Sample ID:	ARK-WB-63-4-6	ARK-WB-63-6-8	ARK-WB-63-8-10	ARK-WB-63-10-12	ARK-WB-63-10-12.EPAsplit	ARK-WB-63-12-14	ARK-WB-63-14-16	ARK-WB-63-16-16.7
Constituent	Units																				
Tributyltin ion	mg/kg-OC	24.1	--	--	--	--	--	--	--	--	--	--		--	--	--	--	2.55 *U*	--	--	--
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	56.0	54.1	20.5	--	--	--	--	--	20.0	10.0	1750		--	--	--	--	18.3	0.430 *J*	--	--
gamma-Hexachlorocyclohexane	mg/kg	0.00138	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
Total Chlordanes (EE/CA)	mg/kg	0.830	0.0830	0.00187	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
Total DDD (EE/CA)	mg/kg	0.900	0.0890	0.0280	--	1.68	--	--	--	0.100	0.0500	--		0.610 *J*	31.0	11.0	1.50	--	0.0130	0.00270 *J*	0.00210
Total DDE (EE/CA)	mg/kg	0.100	0.00880	0.0313	0.00302	0.750	1.00	1.00	0.200	0.0500	0.0200	0.400		0.270 *J*	1.50 *J*	0.330 *J*	0.0590 *J*	--	0.000490 *J*	0.0000990 *U*	0.000100 *U*
Total DDT (EE/CA)	mg/kg	1.20	0.120	0.0629	--	5.80	--	--	--	0.150	0.0600	6.00		0.530 *J*	6.30 *J*	26.0	3.20	--	0.0150	0.00110 *J*	0.00110 *J*
Total DDx (EE/CA)	mg/kg	0.218	--	--	--	8.20	--	--	--	--	--	--		1.40 *J*	39.0 *J*	37.0 *J*	4.80 *J*	--	0.0280 *J*	0.00390 *J*	0.00340 *J*
Hexachlorobenzene	mg/kg-OC	37.0	3.70	--	--	--	--	--	--	--	--	--		--	--	--	--	43.1 *U*	--	--	--
Total PCBs (EE/CA)	mg/kg	0.500	0.0295	--	--	--	1.00	0.750	0.500	0.200	0.0750	--		--	--	--	--	0.00130 *UJ*	--	--	--

Table A-3. Comparison of Sediment Data to Portland Harbor PRGs, RALs, and AOPC 14 SQGs

		Portland Harbor PRGs				AOPC 14 Specific	Portland Harbor RALs					RM 7–8 RALs										
													Borehole Number:	WB-63	WB-64	WB-64	WB-64	WB-64	WB-64	WB-64	WB-64	WB-64
													Matrix:	SE	SE	SE	SE	SE	SE	SE	SE	SE
													Upper Depth, ft:	2	0	4	6	8	10	12	14	16
													Lower Depth, ft:	4	2	6	8	10	12	14	16	18
													Sample Type:	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
													Sample Date:	8/20/2009	8/25/2009	8/25/2009	8/25/2009	8/25/2009	8/25/2009	8/25/2009	8/25/2009	8/25/2009
		PRG-1	PRG-2	PRG-3	PRG-4	SQG	RAL-B	RAL-C	RAL-D	RAL-E	RAL-F	RM 7–8 RALs	Sample ID:	ARK-WB-63-2-4	ARK-WB-64-0-2	ARK-WB-64-4-6	ARK-WB-64-6-8	ARK-WB-64-8-10	ARK-WB-64-10-12	ARK-WB-64-12-14	ARK-WB-64-14-16	ARK-WB-64-16-18
Constituent	Units																					
Tributyltin ion	mg/kg-OC	24.1	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--	--
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	56.0	54.1	20.5	--	--	--	--	--	20.0	10.0	1750		--	--	--	50.0	--	--	0.180 *J*	--	--
gamma-Hexachlorocyclohexane	mg/kg	0.00138	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--	--
Total Chlordanes (EE/CA)	mg/kg	0.830	0.0830	0.00187	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--	--
Total DDD (EE/CA)	mg/kg	0.900	0.0890	0.0280	--	1.68	--	--	--	0.100	0.0500	--		1.60	0.0860	1.70	0.0930	0.0560	0.0130	0.000920	0.0120	0.00280
Total DDE (EE/CA)	mg/kg	0.100	0.00880	0.0313	0.00302	0.750	1.00	1.00	0.200	0.0500	0.0200	0.400		0.960	0.220	1.50 *J*	0.0640 *J*	0.0270 *J*	0.0170 *J*	0.00120 *J*	0.0130 *J*	0.00380 *J*
Total DDT (EE/CA)	mg/kg	1.20	0.120	0.0629	--	5.80	--	--	--	0.150	0.0600	6.00		1.60	0.210	2.20 *J*	0.170	0.140	0.0110	0.000560	0.00780	0.00200
Total DDx (EE/CA)	mg/kg	0.218	--	--	--	8.20	--	--	--	--	--	--		4.10	0.520	5.40 *J*	0.330 *J*	0.220 *J*	0.0410 *J*	0.00260 *J*	0.0330 *J*	0.00860 *J*
Hexachlorobenzene	mg/kg-OC	37.0	3.70	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--	--
Total PCBs (EE/CA)	mg/kg	0.500	0.0295	--	--	--	1.00	0.750	0.500	0.200	0.0750	--		--	--	--	--	--	--	--	--	--

Table A-3. Comparison of Sediment Data to Portland Harbor PRGs, RALs, and AOPC 14 SQGs

		Portland Harbor PRGs				AOPC 14 Specific	Portland Harbor RALs					RM 7–8 RALs	Borehole Number:	WB-64	WB-64	WB-64	WB-64	WB-64	WB-64	WB-65	WB-65
													Matrix:	SE	SE	SE	SE	SE	SE	SE	SE
													Upper Depth, ft:	18	2	20	22	24	26	0	6.5
													Lower Depth, ft:	20	4	22	24	26	26.5	1.5	8
													Sample Type:	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
													Sample Date:	8/25/2009	8/25/2009	8/25/2009	8/25/2009	8/25/2009	8/25/2009	8/18/2009	8/18/2009
		PRG-1	PRG-2	PRG-3	PRG-4	SQG	RAL-B	RAL-C	RAL-D	RAL-E	RAL-F	RM 7–8 RALs	Sample ID:	ARK-WB-64-18-20	ARK-WB-64-2-4	ARK-WB-64-20-22	ARK-WB-64-22-24	ARK-WB-64-24-26	ARK-WB-64-26-26.5	ARK-WB-65-0-1.5	ARK-WB-65-6.5-8
Constituent	Units																				
Tributyltin ion	mg/kg-OC	24.1	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	56.0	54.1	20.5	--	--	--	--	--	20.0	10.0	1750		--	--	--	--	--	--	--	--
gamma-Hexachlorocyclohexane	mg/kg	0.00138	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
Total Chlordanes (EE/CA)	mg/kg	0.830	0.0830	0.00187	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
Total DDD (EE/CA)	mg/kg	0.900	0.0890	0.0280	--	1.68	--	--	--	0.100	0.0500	--		0.00450	0.0760	0.000290 *J*	0.000170 *U*	0.000280 *J*	0.0480	9.30	6.70 *J*
Total DDE (EE/CA)	mg/kg	0.100	0.00880	0.0313	0.00302	0.750	1.00	1.00	0.200	0.0500	0.0200	0.400		0.00400 *J*	0.190 *J*	0.000150 *J*	0.000110 *U*	0.000570 *J*	0.0510 *J*	0.590	1.30 *U*
Total DDT (EE/CA)	mg/kg	1.20	0.120	0.0629	--	5.80	--	--	--	0.150	0.0600	6.00		0.00320	0.0840 *J*	0.000210 *J*	0.000280 *J*	0.000850	0.0610	2.40 *J*	110
Total DDx (EE/CA)	mg/kg	0.218	--	--	--	8.20	--	--	--	--	--	--		0.0120 *J*	0.350 *J*	0.000650 *J*	0.000500 *J*	0.00170 *J*	0.160 *J*	12.0 *J*	120 *J*
Hexachlorobenzene	mg/kg-OC	37.0	3.70	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
Total PCBs (EE/CA)	mg/kg	0.500	0.0295	--	--	--	1.00	0.750	0.500	0.200	0.0750	--		--	--	--	--	--	--	--	--

Table A-3. Comparison of Sediment Data to Portland Harbor PRGs, RALs, and AOPC 14 SQGs

		Portland Harbor PRGs				AOPC 14 Specific	Portland Harbor RALs					RM 7–8 RALs	Borehole Number:	WB-65	WB-65	WB-65	WB-65	WB-65	WB-66	WB-66	WB-66
													Matrix:	SE	SE	SE	SE	SE	SE	SE	SE
													Upper Depth, ft:	8	8	10	15	16	0	4	6
													Lower Depth, ft:	10	10	15	16	18	2	6	8
													Sample Type:	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
													Sample Date:	8/18/2009	8/18/2009	8/18/2009	8/18/2009	8/18/2009	8/19/2009	8/19/2009	8/19/2009
		PRG-1	PRG-2	PRG-3	PRG-4	SQG	RAL-B	RAL-C	RAL-D	RAL-E	RAL-F	RM 7–8 RALs	Sample ID:	ARK-WB-65-8-10	ARK-WB-65-8-10.EPAsplit	ARK-WB-65-10-15	ARK-WB-65-15-16	ARK-WB-65-16-18	ARK-WB-66-0-2	ARK-WB-66-4-6	ARK-WB-66-6-8
Constituent	Units																				
Tributyltin ion	mg/kg-OC	24.1	--	--	--	--	--	--	--	--	--	--		--	1.40 *U*	--	--	--	--	--	--
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	56.0	54.1	20.5	--	--	--	--	--	20.0	10.0	1750		--	157	2.30 *J*	0.0500 *U*	--	--	--	--
gamma-Hexachlorocyclohexane	mg/kg	0.00138	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
Total Chlordanes (EE/CA)	mg/kg	0.830	0.0830	0.00187	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--
Total DDD (EE/CA)	mg/kg	0.900	0.0890	0.0280	--	1.68	--	--	--	0.100	0.0500	--		0.440	--	0.00910 *J*	0.00260	0.00130 *J*	0.120	0.770 *J*	25.0
Total DDE (EE/CA)	mg/kg	0.100	0.00880	0.0313	0.00302	0.750	1.00	1.00	0.200	0.0500	0.0200	0.400		0.0490	--	0.000700 *J*	0.000100 *U*	0.000100 *UJ*	0.0260	0.470 *J*	1.40 *J*
Total DDT (EE/CA)	mg/kg	1.20	0.120	0.0629	--	5.80	--	--	--	0.150	0.0600	6.00		0.110	--	0.00160 *J*	0.000730	0.00100 *J*	0.580 *J*	0.690	48.0
Total DDx (EE/CA)	mg/kg	0.218	--	--	--	8.20	--	--	--	--	--	--		0.600	--	0.0110 *J*	0.00340	0.00240 *J*	0.720 *J*	1.90 *J*	75.0 *J*
Hexachlorobenzene	mg/kg-OC	37.0	3.70	--	--	--	--	--	--	--	--	--		--	24.0 *U*	--	--	--	--	--	--
Total PCBs (EE/CA)	mg/kg	0.500	0.0295	--	--	--	1.00	0.750	0.500	0.200	0.0750	--		--	0.00140 *U*	--	--	--	--	--	--

Table A-3. Comparison of Sediment Data to Portland Harbor PRGs, RALs, and AOPC 14 SQGs

		Portland Harbor PRGs				AOPC 14 Specific	Portland Harbor RALs					RM 7–8 RALs	Borehole Number:	WB-66	WB-66	WB-66	WB-66	WB-66	WB-66	WB-66	WB-8
													Matrix:	SE	SE	SE	SE	SE	SE	SE	SE
													Upper Depth, ft:	8	8	10	12	14	16	2	0
													Lower Depth, ft:	10	10	12	14	16	17.5	4	4.3
													Sample Type:	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
													Sample Date:	8/19/2009	8/19/2009	8/19/2009	8/19/2009	8/19/2009	8/19/2009	8/19/2009	2/28/2003
		PRG-1	PRG-2	PRG-3	PRG-4	SQG	RAL-B	RAL-C	RAL-D	RAL-E	RAL-F	RM 7–8 RALs	Sample ID:	ARK-WB-66-8-10	ARK-WB-66-8-10.EPAsplit	ARK-WB-66-10-12	ARK-WB-66-12-14	ARK-WB-66-14-16	ARK-WB-66-16-17.5	ARK-WB-66-2-4	SO1915
Constituent	Units																				
Tributyltin ion	mg/kg-OC	24.1	--	--	--	--	--	--	--	--	--	--		--	0.586 *U*	--	--	--	--	--	--
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	56.0	54.1	20.5	--	--	--	--	--	20.0	10.0	1750		--	1470	58.0	--	--	0.550 *J*	--	--
gamma-Hexachlorocyclohexane	mg/kg	0.00138	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	0.0760 *U*
Total Chlordanes (EE/CA)	mg/kg	0.830	0.0830	0.00187	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	0.120 *U*
Total DDD (EE/CA)	mg/kg	0.900	0.0890	0.0280	--	1.68	--	--	--	0.100	0.0500	--		53.0	--	1.50	1.50	0.900	0.0910	0.180 *J*	3.80
Total DDE (EE/CA)	mg/kg	0.100	0.00880	0.0313	0.00302	0.750	1.00	1.00	0.200	0.0500	0.0200	0.400		3.70	--	0.0980 *J*	0.130 *J*	0.0430 *U*	0.00350 *J*	0.0720 *J*	0.570 *J*
Total DDT (EE/CA)	mg/kg	1.20	0.120	0.0629	--	5.80	--	--	--	0.150	0.0600	6.00		29.0	--	1.40	1.20 *J*	3.50 *J*	0.0290	0.170 *J*	34.0
Total DDx (EE/CA)	mg/kg	0.218	--	--	--	8.20	--	--	--	--	--	--		86.0	--	3.00 *J*	2.80 *J*	4.40 *J*	0.120 *J*	0.430 *J*	38.0 *J*
Hexachlorobenzene	mg/kg-OC	37.0	3.70	--	--	--	--	--	--	--	--	--		--	10.0 *U*	--	--	--	--	--	--
Total PCBs (EE/CA)	mg/kg	0.500	0.0295	--	--	--	1.00	0.750	0.500	0.200	0.0750	--		--	0.00170 *U*	--	--	--	--	--	--

Table A-3. Comparison of Sediment Data to Portland Harbor PRGs, RALs, and AOPC 14 SQGs

		Portland Harbor PRGs				AOPC 14 Specific	Portland Harbor RALs					RM 7–8 RALs	Borehole Number:	WB-8	WB-8	WB-8	WB-8	WB-8	WB-9	WB-9	WB-9	WB-9
													Matrix:	SE	SE	SE	SE	SE	SE	SE	SE	SE
													Upper Depth, ft:	34.3	6.8	14.3	18.3	20.3	0	8	18	20
													Lower Depth, ft:	36.3	9.3	16.3	20.3	22.3	4	10	20	22
													Sample Type:	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
													Sample Date:	2/28/2003	2/28/2003	2/28/2003	2/28/2003	2/28/2003	3/4/2003	3/4/2003	3/4/2003	3/4/2003
		PRG-1	PRG-2	PRG-3	PRG-4	SQG	RAL-B	RAL-C	RAL-D	RAL-E	RAL-F	RM 7–8 RALs	Sample ID:	SO1929	SO1917	SO1919	SO1921	SO1922	SO1931	SO1934	SO1938	SO1939
Constituent	Units																					
Tributyltin ion	mg/kg-OC	24.1	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--	--
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	56.0	54.1	20.5	--	--	--	--	--	20.0	10.0	1750		--	--	--	--	--	--	--	--	--
gamma-Hexachlorocyclohexane	mg/kg	0.00138	--	--	--	--	--	--	--	--	--	--		0.00700 *U*	0.0800 *U*	0.00710 *U*	--	--	0.110 *U*	1.40 *U*	0.130 *U*	--
Total Chlordanes (EE/CA)	mg/kg	0.830	0.0830	0.00187	--	--	--	--	--	--	--	--		0.00700 *U*	0.0930 *U*	0.00710 *U*	--	--	0.200 *J*	1.40 *U*	0.130 *U*	--
Total DDD (EE/CA)	mg/kg	0.900	0.0890	0.0280	--	1.68	--	--	--	0.100	0.0500	--		0.0260	470	0.0950	1.30	0.0190	1.90	240	0.130 *U*	3.60
Total DDE (EE/CA)	mg/kg	0.100	0.00880	0.0313	0.00302	0.750	1.00	1.00	0.200	0.0500	0.0200	0.400		0.00700 *U*	9.00	0.00710 *U*	0.0330 *U*	0.000330 *U*	0.730	24.0	0.130 *U*	0.620
Total DDT (EE/CA)	mg/kg	1.20	0.120	0.0629	--	5.80	--	--	--	0.150	0.0600	6.00		0.0170	920	0.330	4.90	0.0500	12.0	4500	1.90	53.0
Total DDx (EE/CA)	mg/kg	0.218	--	--	--	8.20	--	--	--	--	--	--		0.0470	1400	0.430	6.20	0.0690	15.0	4800	2.00	57.0
Hexachlorobenzene	mg/kg-OC	37.0	3.70	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--	--
Total PCBs (EE/CA)	mg/kg	0.500	0.0295	--	--	--	1.00	0.750	0.500	0.200	0.0750	--		--	--	--	--	--	--	--	--	--

Table A-3. Comparison of Sediment Data to Portland Harbor PRGs, RALs, and AOPC 14 SQGs

		Portland Harbor PRGs				AOPC 14 Specific	Portland Harbor RALs					RM 7–8 RALs									
													Borehole Number:	WB-9	WB-9	WLCDRD05PG072	WLCEAF02WB13	WLCRPB95WR-1	WR-WSI98SD087	WR-WSI98SD092	WR-WSI98SD092
													Matrix:	SE	SE	SE	SE	SE	SE	SE	SE
													Upper Depth, ft:	24	32	0	14	0	0	0	0
													Lower Depth, ft:	26	34	0.9	17	0.5	0.3	0.3	3
													Sample Type:	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
													Sample Date:	3/4/2003	3/4/2003	5/25/2005	2/26/2003	2/1/1995	9/22/1997	9/22/1997	10/16/1997
		PRG-1	PRG-2	PRG-3	PRG-4	SQG	RAL-B	RAL-C	RAL-D	RAL-E	RAL-F	RM 7–8 RALs	Sample ID:	SO1941	SO1945	WLCDRD05PG07272	WLCEAF02WB13SO1901	WLCRPB95WR-1WR-1SE	WR-WSI98SD0870	WR-WSI98SD0920000CC	WR-WSI98SD0920000A
Constituent	Units																				
Tributyltin ion	mg/kg-OC	24.1	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	0.583 *U*
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	56.0	54.1	20.5	--	--	--	--	--	20.0	10.0	1750		--	--	9.57	--	0.650 *U*	--	--	11000
gamma-Hexachlorocyclohexane	mg/kg	0.00138	--	--	--	--	--	--	--	--	--	--		--	0.00660 *U*	0.000580 *U*	0.0750 *U*	0.00800 *U*	0.0500 *U*	0.0190 *U*	3.80 *U*
Total Chlordanes (EE/CA)	mg/kg	0.830	0.0830	0.00187	--	--	--	--	--	--	--	--		--	0.00660 *U*	0.0110 *U*	0.0750 *U*	--	0.0500 *U*	--	3.80 *U*
Total DDD (EE/CA)	mg/kg	0.900	0.0890	0.0280	--	1.68	--	--	--	0.100	0.0500	--		0.150	0.0200	0.0880	0.460	0.0160 *U*	0.110	0.375	29.0
Total DDE (EE/CA)	mg/kg	0.100	0.00880	0.0313	0.00302	0.750	1.00	1.00	0.200	0.0500	0.0200	0.400		0.00720	0.00660 *U*	0.0290	0.0750 *U*	0.0160 *U*	0.100 *U*	0.0200 *J*	7.50 *U*
Total DDT (EE/CA)	mg/kg	1.20	0.120	0.0629	--	5.80	--	--	--	0.150	0.0600	6.00		0.920	0.240	0.830	0.610	0.0160 *U*	0.810	0.280	22.0
Total DDx (EE/CA)	mg/kg	0.218	--	--	--	8.20	--	--	--	--	--	--		1.10	0.260	0.950	1.11	0.0160 *U*	0.970	0.675 *J*	54.8
Hexachlorobenzene	mg/kg-OC	37.0	3.70	--	--	--	--	--	--	--	--	--		--	--	0.0542	--	--	1.43 *U*	1.03 *U*	62.5
Total PCBs (EE/CA)	mg/kg	0.500	0.0295	--	--	--	1.00	0.750	0.500	0.200	0.0750	--		--	--	0.0960 *U*	--	--	2.00 *U*	0.750 *U*	150 *U*

Notes:

-- = not analyzed
PRG = preliminary remediation goal
RAL = removal action level
SLV = screening level value
SMA = sediment management area
SQG = sediment quality guideline
SVOC = semivolatile organic compound

[a] This sample was normalized for organic carbon number using the 95th percent LCL calculated for 134 surface sediment samples collected in AOPC 14.

Data Qualifiers:

J = The associated numerical value is an estimated quantity.
N = The result is presumptive. The analyte was tentatively identified, but a confirmation analysis was not performed.
U = The material was analyzed for, but was not detected. The associated numerical value is the sample detection limit.
UJ = The laboratory reporting and/or method detection limits for this analyte have been elevated during validation. Undetected results are flagged *UJ* to indicate that the sample reporting lmits have been adjusted.

= Detection limit for non-detect exceeded one PRG, RAL, or SQG

= Detection limit for non-detect exceeded more than one PRG, RAL, or SQG

= Detected concentration exceeded one PRG, RAL, or SQG

= Detected concentration exceeded more than one PRG, RAL, or SQG

APPENDIX B

BIOLOGICAL ASSESSMENT

DRAFT BIOLOGICAL ASSESSMENT AND ESSENTIAL FISH HABITAT ASSESSMENT

Draft Engineering Evaluation and Cost Analysis
Arkema Early Action

Prepared for
Legacy Site Services LLC
468 Thomas Jones Way
Suite 150
Exton, PA 19341

Prepared by

integral consulting inc.

319 SW Washington Street
Suite 1150
Portland, OR 97204

July 26, 2012

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ACRONYMS AND ABBREVIATIONS

AOC	Administrative Order on Consent
BA	biological assessment
BMP	best management practice
CDF	confined disposal facility
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CWA	Clean Water Act
DEQ	Oregon Department of Environmental Quality
DPS	distinct population segment
EE/CA	engineering evaluation/cost analysis
EFH	essential fish habitat
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
ESU	evolutionarily significant unit
FNU	formazin nephelometric unit
FS	feasibility study
HUC	Hydrologic Unit Boundary
LCR	lower Columbia River
LSS	Legacy Site Services LLC
LWR	lower Willamette River
MSA	Magnuson-Stevens Fishery Conservation and Management Act
NMFS	National Marine Fisheries Service
NTCRA	non-time-critical removal action
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCE	primary constituent element
PFMC	Pacific Fishery Management Council
RAA	removal action area

RI	remedial investigation
RM	river mile
SOW	Statement of Work
TMDL	total maximum daily load
UCR	upper Columbia River
USC	United States Code
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UWR	upper Willamette River

1 INTRODUCTION

This document presents a preliminary draft Biological Assessment (BA) for the engineering evaluation and cost analysis (EE/CA) prepared in support of a non-time-critical removal action (NTCRA) for the Arkema Inc. facility in Portland, Oregon (hereafter Arkema BA). The EE/CA is required by the Administrative Order on Consent (AOC) Statement of Work (SOW) between the U.S. Environmental Protection Agency (EPA) and Arkema, effective June 27, 2005 (Docket No. CERCLA 10-2005-0191). The purpose of the EE/CA is to design an early action for the EPA-directed Removal Action Area (RAA) at the Arkema site (Figure 1).

The EE/CA, to which this document is an appendix, has been prepared by Integral Consulting Inc. (Integral) on behalf of Legacy Site Services LLC (LSS), agent for Arkema, for the implementation of remedial activities at the proposed RAA. The RAA, described in Section 2, is located on the Willamette River between river mile (RM) 7.0 and 7.5. The RAA and areas outside of the RAA may be used for compensatory mitigation, if necessary, consistent with the Proposed Action Area described in the Portland Harbor draft preliminary site-wide BA (the site-wide BA [Anchor QEA 2012b]). The EE/CA fulfills the requirements of Section 4 of the SOW, which includes preparation of a BA to document compliance with Section 7(c) of the Endangered Species Act (ESA) of 1973, as amended.[1] The Magnuson-Stevens Fishery Conservation and Management Act (MSA), which was reauthorized and amended in 1996, requires the National Marine Fisheries Service (NMFS) to recommend conservation and enhancement measures for any federal or state activity that may adversely affect essential fish habitat (EFH). The Proposed Action Area provides EFH for Pacific salmon, so an EFH assessment is also provided herein.

This document has been prepared to meet three objectives:

- To review the proposed project in sufficient detail to determine to what extent the proposed action may affect species that are listed as threatened or endangered and designated or proposed critical habitats
- To determine whether any potential removal activities at the site may adversely affect designated EFH for relevant commercially, federally managed fisheries species within the Proposed Action Area
- To describe conservation measures proposed to avoid, minimize, or otherwise offset any potential adverse effects to designated EFH resulting from the proposed action.

This preliminary draft BA follows the framework of the Portland Harbor site-wide BA and refers to that BA as appropriate to provide a consistent and comparable approach that will

[1] 50 Code of Federal Regulations (CFR) 402; 16 United States Code (U.S.C.) 1536 [c]

support an efficient remediation and construction process for the Proposed Action Area pursuant to the site-wide Record of Decision. This document is intended for review by EPA, inclusive of its references to the site-wide BA, to support the selection of the sediment remedy for the Proposed Action Area that will be incorporated into the Portland Harbor Site-wide Proposed Plan and Record of Decision. During the design phase, the Arkema BA can be updated with more project-specific information and compared to the site-wide BA to determine if the resulting Portland Harbor Site-wide Biological Opinion is applicable to the Arkema BA. If the Portland Harbor Site-wide Biological Opinion is found to be appropriate and applicable to the proposed actions described in the Arkema EE/CA and BA, a separate formal consultation may not be necessary for the Arkema BA.

1.1 PROJECT AND FEDERAL ACTION HISTORY

In 2000, EPA added the Portland Harbor Superfund site to the National Priorities List pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980.[2] The Portland Harbor Superfund site currently encompasses approximately 10 miles (RM 1.9 to 11.8) of the lower Willamette River (LWR) in Portland, Oregon, and includes the areas adjacent to the Arkema site (Figure 1). In fall 2001, EPA and ten parties, including Arkema, entered into an Administrative Settlement AOC for Remedial Investigation/Feasibility Study (RI/FS; CERCLA-10-2001-0240) for the Portland Harbor site. The RI/FS characterizes the nature and extent of contamination, assesses the ecological and human health risks at the Portland Harbor site, and evaluates feasibility alternatives for cleanup. The revised draft final RI was submitted to EPA in 2011 (Integral et al. 2011) and the draft FS was submitted to EPA in 2012 (Anchor QEA et al. 2012).

The NTCRA for the Arkema site will be conducted under CERCLA. CERCLA Section 121(d) requires that a cleanup 1) be protective and 2) if any hazardous substance will remain on the site, attain a level of cleanup that complies with legally applicable or relevant and appropriate requirements.

1.2 REPORT ORGANIZATION

Section 2 of this biological assessment contains a description of the RAA and Proposed Action Area. Section 3 summarizes the status, ecology, potential site use, and designated critical habitat of listed fish and wildlife species that may potentially be present in the vicinity of the Proposed Action Area. Section 4 describes the EFH relevant to the Proposed Action Area and provides an overview of the descriptions for federally managed species associated with this EFH that are relevant to the proposed project area. Section 5 describes the baseline

[2] as amended, 42 U.S.C. § 9601, et seq.

environmental conditions and expected effects on baseline conditions associated with project activities. Section 6 discusses potential direct and indirect adverse effects on listed species and EFH that may result from proposed project activities. References are provided in Section 7.

2 DESCRIPTION OF THE PROPOSED ACTION AREA

The Arkema site is located in Portland, Oregon, on the southwest bank of the LWR between approximate RM 6.9 and 7.6 (Figure 1). The upland portion of the site encompasses approximately 54 acres of land. The in-water portion of the site is defined as the land below mean high water (+13.3 ft NAVD88). The EE/CA NTCRA is primarily focused on the in-water portion of the site. However, elements of the EE/CA removal action may integrate portions of the riverbank above mean high water to the top of bank to facilitate engineering and planning for construction of potential riverbank source control measures in those areas. The remainder of the riverbank will be addressed, as needed, with the Oregon Department of Environmental Quality (DEQ) in accordance with the AOC dated October 31, 2008. Ultimately, the timing of and coordination between the upland source control measure and NTCRA projects will dictate under which regulatory program selected portions of the riverbank will be addressed.

The horizontal RAA boundary, as directed by EPA, is based on the 5 mg/kg total DDx contour in the EVS model (EE/CA report, Figure 2-1). The EE/CA alternatives will be evaluated within the horizontal RAA boundary and may integrate portions of the riverbank above mean high water to the top of bank. Constituents of interest outside of this horizontal RAA boundary will be addressed as part of the Portland Harbor site-wide remedy.

The Proposed Action Area is the same as that identified in the site-wide BA, which includes the Portland Harbor site and portions of the lower Columbia River (LCR) within the 4th level Hydrologic Unit Boundary (HUC). This designation accounts for where the remedial activities of the proposed action will occur, and the area where compensatory mitigation could occur, if necessary. Therefore, potential, indirect, interrelated and cumulative effects of the proposed actions would occur within this Proposed Action Area. A project-specific Action Area may be refined during the design phase if the selected remedies are found to describe an action area that differs from that described in the site-wide BA.

2.1 PROJECT ACTIVITIES AND OPERATIONAL CHARACTERISTICS

The proposed actions consist of the remedial activities or technologies that could occur as part of the alternatives described in the EE/CA for the Proposed Action Area. Specifically, the elements of the proposed actions may include some or all of the following:

- Monitored natural recovery/enhanced monitored natural recovery
- *In situ* capping
- *In situ* treatment
- Dredging

- Transport and disposal of dredged material
- Removal and installation of pilings and other structures
- Confined disposal facility (CDF) construction
- Activities to support compensatory mitigation.

Compensatory mitigation would be performed under Section 404 of the Clean Water Act (CWA) if necessary, but would also provide benefits under ESA to address potential adverse effects associated with remediation activities.

Under the preferred alternative outlined in the EE/CA (Alternative 2i), the goal is to complete project activities within a single work window, if possible. Some alternatives that involve more intensive construction activities such as extensive dredging or CDF construction may extend into an additional one or two seasons to accomplish the work. Alternatives with the potential for multiple year time frames (e.g., Alternative 5) would be expected to have greater impacts to aquatic resources and listed species because of the longer work period; however, in all cases the proposed alternatives are not expect to extend past a few seasons of in-water work.

The proposed alternatives evaluated in the EE/CA are summarized in Table 1 and shown on Figures 2 through 8. These alternatives include remedial activities that have already been summarized in the site-wide BA as well as additional activities that are specific to the Arkema site. If the selected alternative for the RAA includes any departures from technologies covered in the site-wide BA, potential methods and impacts of those technologies to listed species will be addressed in a future update of the Arkema BA. Elevations above the EPA site boundary of +13.3 ft North American Vertical Datum of 1988 (NAVD88) and below the DEQ upland source control action (top of bank) were not addressed in the site-wide BA. Therefore, Section 3 of this document describes riparian and upland species that might be affected by proposed remedial actions within the Proposed Action Area, focusing on the Arkema site where remedial activities will occur, and Section 6 discusses the determination of effects relevant to riparian species.

2.2 PROPOSED CONSERVATION MEASURES

Consistent with the U.S. Army Corps of Engineers mitigation policy (USACE and USEPA 2008), the proposed project should strive to avoid adverse impacts, minimize any potential impacts that may occur, and offset unavoidable adverse impacts to existing aquatic resources. Conservation measures are proposed for this project to avoid or minimize potential impacts to listed species and habitats, including adherence to state-identified in-water work windows and water quality requirements, and implementation of best management practices (BMPs) for dredging and disposal methods. Work in the LWR will occur within the in-water work window of July 1 – October 31, when most species of anadromous fish are expected to be present in very low numbers (ODFW 2008). If compensatory mitigation is necessary and occurs in the LCR

portion of the Proposed Action Area, project activities will be planned to occur within the in-water work window of October 1 – December 31, consistent with recent guidance from Oregon Department of Fish and Wildlife on when anadromous fish, particularly Pacific eulachon, are expected to be present in low numbers (West 2012, pers. comm.) in the LCR. In addition, the project will adhere to water quality protection conditions outlined in the CWA Section 404(b)(1) evaluation. It is anticipated that the impact avoidance and minimization methods proposed in the Portland Harbor preliminary draft site-wide BA for remediation activities, including dredging, capping, piling and structure removal and installation, would be considered for the proposed action at the Proposed Action Area. The final selection of conservation measures will be determined during the remedial design after selection of the preferred alternative for the Proposed Action Area.

The proposed actions are intended to provide long-term benefits for listed species by remediating contaminated sediments in the Proposed Action Area and, thereby, improving conditions for benthic prey, as well as reducing potential exposure to contaminants by listed species. In addition, the proposed actions may include construction of compensatory mitigation as required under CWA Section 404(b)(1) to replace aquatic functions that are adversely affected or lost due to a placement of fill into the aquatic environment. Compensatory mitigation is only invoked if adverse effects to aquatic functions cannot be fully addressed through avoiding, minimizing or rectifying potential impacts. A compensatory mitigation framework for the Portland Harbor site alternatives was presented as part of the Portland Harbor FS (Anchor QEA et al. 2012, Appendix M and attachments). Results of the mitigation analysis for sediment management area 14, which includes the RAA, indicates a wide range of mitigation possibilities depending on the alternative and relative habitat value framework applied, from a mitigation debit of 5.04 acres to a mitigation credit of 1.41 acres (Table 2). Therefore, the specific mitigation requirements or the necessity of any mitigation at all will depend on the specific alternatives chosen and implemented in the Proposed Action Area. It is anticipated that if there are unavoidable impacts resulting from activities at the Proposed Action Area, specific remediation requirements will be identified in the design phase, and construction of these requirements will be consistent with the methods outlined in the site-wide BA.

3 STATUS OF LISTED SPECIES AND CRITICAL HABITAT

Implementation of the proposed Removal Action within the Proposed Action Area will potentially impact the species found within the main stem LWR. If compensatory mitigation is required, the proposed area of compensatory mitigation within the 4th-level HUC may be considered as described in the preliminary draft site-wide BA.

3.1 LISTED SPECIES STATUS

The status, life history, habitat requirements, and critical habitat information for each ESA-listed species found within the Portland Harbor Site-wide Proposed Action Area is presented in Section 4 of the site-wide BA (Anchor QEA 2012b). Additional information on listed species was reviewed from Federal Register documents and published reports from U.S. Fish and Wildlife Service (USFWS) and National Oceanic and Atmospheric Administration. In addition, BAs from nearby properties were reviewed and relevant information was considered from these documents (Anchor QEA 2006; Anchor QEA 2012a). Species' ESA status, critical habitat status, and presence in one or both areas (LWR and LCR) of the proposed action area are described in Table 3. Tables 4 and 5 delineate the timing of expected presence of juvenile and adult listed species in the LWR, and Tables 6 and 7 review the timing of juvenile and adult migrations in the LCR.

Table 3 also reviews the status of upland listed species. These include listed plants and animals that are not reviewed in the Portland Harbor preliminary draft site-wide BA, because that document focused primarily on listed aquatic species. Therefore, Section 3.1 provides additional discussion of the status and ecological requirements of these species so that they may be evaluated with respect to any proposed project actions that may affect riparian components of the Proposed Action Area, particularly in relation to remedial activities proposed for the Arkema RAA.

3.2 UPLAND WILDLIFE SPECIES

Additional listed species of wildlife and plants that may occur in the vicinity of the Proposed Action Area include the following:

- Northern spotted owl (*Strix occidentalis caurina*) — The northern spotted owl was listed under the ESA in 1990 (50 CFR Part 17). This species relies on structurally complex, mature and old growth forests for nesting, roosting, and foraging, and is found in this type of habitat from southwest British Columbia through the Cascade Mountains and coastal ranges in Washington, Oregon, and California (USFWS 2010a). Critical habitat was designated in 1992 and revised in 2008, and includes areas of mature forest in the

coastal Pacific Northwest; critical habitat does not occur in the vicinity of the Proposed Action Area (USFWS 2008).

- Columbian white-tailed deer (*Odocoileus virginianus leucurus*) — The Columbia River population of Columbia white-tailed deer is found in multiple counties of Oregon and Washington surrounding the LCR and is federally listed as endangered (USFWS 2010c). Areas with forested cover adjacent to preferred vegetation for browsing, including a variety of herbaceous species, are thought to be preferred habitats for this species (USFWS 1983). Historically, this species was found throughout a large area of southwestern Washington and western Oregon, but the current distribution is far more limited. Changes in land use and hunting are thought to have played important roles in their decline over the past century or longer (USFWS 1983). There is no critical habitat designated for Columbia white-tailed deer.
- Nelson's checker-mallow *(Sidalcea nelsoniana*) — Nelson's checker-mallow is listed as a threatened species by USFWS. This species is an herbaceous plant in the Mallow family that is found in swales, wet meadows, in wetlands within remnant prairie grasslands, and is sometimes found alongside road crossings at streams. Nelson's checker-mallow primarily occurs in open areas with little or no shade and will not tolerate encroachment of woody species (USFWS 2010b). These habitat requirements are not consistent with the dry riverbank soils and, where vegetation is present, with shading by woody and invasive species present in the riverbank portion of the Proposed Action Area. The species' range extends from southern Benton County, Oregon, north to Cowlitz County, Washington, and from central Linn County, Oregon, west to the crest of the Coast Range; records of distribution from 1990 to present do not include the Arkema site vicinity (USFWS 2010b). There is no critical habitat designated for this plant.
- Willamette daisy (*Erigeron decumbens var. decumbens*) – Willamette daisy is listed as an endangered species by USFWS. This species in the Asteraceae family occurs on heavy alluvial soils in seasonally wet native or dry upland prairie grasslands. Willamette daisy is vulnerable to the invasion of woody species. Critical habitat was designated in 2006. Historically, this plant was likely widespread throughout the Willamette Valley. Currently, 18 sites are known, between Grand Ronde and Goshen, Oregon; all sites are south of Multnomah county (USFWS 2012).
- Water howellia (*Howellia aquatilis*) – Water howellia is listed as a threatened species by USFWS. Though Water howellia is distributed over a large geographic area spanning five states, it exists in small pockets of a very particular and sensitive ecological habitat. This aquatic plant occurs among small, vernal, freshwater wetlands, glacial pothole ponds, or former river oxbows that have an annual cycle of filling with water over the fall, winter and early spring, followed by drying during the summer months. These habitats are generally less than one hectare in size and contain water less than 3 ft deep. Associated species include duckweed (*Lemna* spp.), water starworts (*Callitriche* spp.), water buttercup (*Ranunculus aquaticus*), yellow water-lily (*Nuphar polysepalum*),

bladderwort (*Utricularia vulgaris*), and pondweeds (*Potamogeton* spp.). The habitat requirements and species associations of this plant are not consistent with Arkema site conditions. There is no critical habitat designated for this plant.

- Bradshaw's desert parsley (*Lomatium bradshawii*) – Bradshaw's desert parsley is listed as an endangered species by USFWS. The majority of populations occur within 10 miles of Eugene, Oregon. This perennial herb is typically found at low elevations near water, on seasonally saturated or flooded prairies, and alluvial soils adjacent to creeks and small rivers. Bradshaw's desert parsley typically occurs on heavy clays, with a slowly permeable clay layer located 6–12 in. below the surface. Bradshaw's desert parsley currently extends from Clark County, Washington, to the southern end of the Willamette Valley, Oregon, and does not include the northern Willamette Valley. There is no critical habitat designated for this plant.
- Kincaid's lupine (*Lupinus sulphureus spp. kincaidii*) – Kincaid's lupine is listed as a threatened species by USFWS. It is found mainly in the Willamette Valley, where it occupies native grassland habitats, a few sites in the Umpqua River Basin, and one site in southern Washington. Kincaid's lupine is typically found in native upland prairie, and is vulnerable to herbicides and invasion by alien plant species such as Himalayan blackberry, Scotch broom, and aggressive pasture grasses. Critical habitat was designated in 2006. The northern limit of Kincaid's lupine is Lewis County, Washington, and it ranges south to Douglas County, Oregon. USFWS data indicates that this species distribution is south and west of Multnomah County.

A review of priority habitats and species for the Proposed Action Area and its associated uplands did not identify occurrences of the above listed species, nor is appropriate habitat for these species present in the Arkema site vicinity. This is consistent with the conclusions of the site-wide BA, which states that it is not expected that listed terrestrial species are present within the highly industrialized areas of the Portland Harbor site (Anchor QEA 2012b).

4 ESSENTIAL FISH HABITAT

The MSA, as amended, requires proposed projects requiring a federal action, such as a permit, to evaluate their impacts on the habitat of commercially managed fish populations. For the purposes of the MSA, EFH has been defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity".[3] NMFS has further added the following interpretations to clarify this definition:

- "Waters" include aquatic areas and associated physical, chemical, and biological properties that are used by fish
- "Substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities
- "Necessary" means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem
- "Spawning, breeding, feeding, or growth to maturity" includes all habitat types utilized by a species throughout its life cycle (PFMC 2012).

The EFH mandate applies to all species managed under a federal fisheries management plan. There is one fisheries management plan relevant to the action area, covering Pacific salmon. Potential impacts of a proposed action must be considered for the Pacific salmon EFH. As the proposed project area is consistent with the action considered in the site-wide BA, the EFH analysis contained in Section 8 of the site-wide BA (Anchor QEA 2012b) is applicable to the Proposed Action Area of this BA.

EFH for the Pacific coast salmon fishery includes those waters and substrate necessary for salmon, which are needed to support long-term sustainable salmon fisheries and contribution to a healthy ecosystem (PFMC 2012). The geographic extent of the freshwater Pacific salmon EFH is defined as all currently viable waters and most of the habitat historically accessible to salmon, excluding areas upstream of longstanding naturally impassible barriers such as waterfalls. This description is applicable to the freshwater habitat in the Proposed Action Area (PFMC 1999).

EFH has been designated by the Pacific Fishery Management Council (PFMC) for federally managed Chinook (*Oncorhynchus nerka*) and coho (*O. kisutch*) salmon in the waters of the LCR and LWR (PFMC 1999). Chinook and coho salmon are expected to be present in the vicinity of the Proposed Action Area. Both hatchery and wild populations are considered by the PFMC in targeting conservation measures that will support persistence of these species.

[3] 16 U.S.C. 1802[10]

4.1 FALL-RUN CHINOOK SALMON

The life history, current status, and potential use of the Proposed Action Area by Chinook salmon are addressed in the site-wide BA. The proposed action area does not contain suitable spawning habitat for Chinook salmon and, therefore, eggs, larvae, and spawning adult Chinook salmon are not expected to be present in the vicinity of the Proposed Action Area. The action area may provide suitable habitat for juvenile salmon during rearing and migration (Tables 4 and 6), and for pre-spawning adult Chinook migrating to freshwater spawning grounds further upstream and in tributaries to the Columbia River (Tables 5 and 7).

4.2 COHO SALMON

The life history, current status, and potential use of the Proposed Action Area by coho salmon are addressed in the site-wide BA. The proposed action area does not contain suitable spawning habitat for coho salmon and, therefore, eggs, larvae, and spawning adults are not expected to be present in the vicinity of the action area. The Proposed Action Area may provide suitable habitat for juvenile salmon during rearing and migration and, as juvenile coho overwinter in freshwater habitat, there is the potential for them to be found in the Proposed Action Area any time of the year (Tables 4 and 6). Pre-spawning adults migrating through the LCR and LWR to freshwater spawning grounds further upstream and to tributaries to these systems may occur in the Proposed Action Area (Tables 5 and 7).

5 EXISTING ENVIRONMENTAL CONDITIONS

The existing, or baseline, conditions in the proposed action area are described in this section in order to define the geographical area for which the baseline is established, describe the habitats and physical and chemical conditions present in this area, and discuss habitat features that may be affected by project activities, particularly with respect to critical habitat designated for listed species.

5.1 DESCRIPTION OF THE PROPOSED ACTION AREA

The Proposed Action Area is described in Section 2. The RAA consists of the in-water areas that are proposed to be addressed through remedial action. The Proposed Action Area encompasses:

- The RAA boundary within the LWR, with the additional consideration that moderately elevated turbidity could extend downstream of the immediate footprint of the proposed action area during any dredging activities
- The potential transport corridor from the LWR action area to an offloading facility within the LWR for accepting dredged materials.
- If compensatory mitigation is required, the area within the 4th HUC, including a portion of the LCR as described in the site-wide BA.

Most of the potential effects of the proposed action are expected to occur within the RAA, and any additional remediation or containment activities are expected to occur in the adjacent riverbank area. As such, the remainder of this section provides detailed environmental baseline information for the LWR in the vicinity of the RAA, and more generalized information for the LCR portion of the Proposed Action Area.

5.2 LOWER WILLAMETTE RIVER ENVIRONMENTAL BASELINE

5.2.1 Shoreline and In-Water Habitats

The Proposed Project Area's physical and biological conditions are consistent with the conditions described in the Portland Harbor preliminary site-wide BA. The Arkema site where the RAA is located is an industrial property located in the heavily industrialized area of Portland Harbor. The Arkema property encompasses approximately 54 acres of land on four upland lots and one tract along the Willamette River. Lots 1 and 2 are located on the north end of the site and are covered by a mixture of grasses, bare soil, and disturbed scrub/shrub vegetation (Figure 9). Lots 3 and 4 encompass the developed portion of the site where the

majority of chemical manufacturing and processing historically occurred. Tract A along the river is steeply sloping and in some areas is covered with rubble used for bank stabilization; a limited amount of ruderal vegetation (colonizing grasses and invasive forbs such as blackberry) grows among the bank-armoring material.

The physical features of the site are defined by its industrial history during former plant operations. The shoreline adjacent to the RAA has been substantively developed for industrial activities. Large portions of the shoreline have been rip-rapped (Integral 2010). In unarmored portions of the shoreline, the substrate is sandy and in areas where vegetation is present, it is primarily ruderal. Banks are moderately steep in many areas and largely devoid of overhanging vegetation or complex features that would support nearshore habitat that is valuable to foraging fish and wildlife, particularly in the vicinity of the docks, with an increase in some shallow water habitat and overhanging vegetation downstream of the docks on Lot 1 (Integral 2010).

Three docks are present at the Arkema site (Dock 1, Dock 2, and the Salt Dock; see Figure 9). Dock 1 was originally constructed in the 1940s and consists of a pier section that runs perpendicular to the river and the dock section that runs parallel to the river, both with a timber walkway hung from the bottom of the dock. Independent timber walkways that provide access from the dock to two concrete dolphins supported on steel H-piles are located adjacent to the dock. Dock 2 was originally constructed in the late 1950s and early 1960s and has the same configuration and walkways as Dock 1, with the exception that the adjacent dolphins are timber piles and stairs lead under the dock to a small platform, which provides access to barges at low-river stage elevations. The Salt Dock was built in the 1960s to support a conveyor belt system used to offload salt products from ships to the facility. The structure consists mainly of a pier section that runs perpendicular to the river to support the conveyor belt system and a short section of dock that runs parallel to the river, with walkways to two adjacent concrete dolphins.

A surface debris survey was conducted in 2009 as part of the Removal Action Area Characterization (Integral and ARCADIS 2011). The river bank and in-water portions of the site in the area downstream of Dock 2 (Figure 9) include a piling field from a historical dock, miscellaneous concrete debris, metal debris, and logs. Between Docks 1 and 2, surface debris includes concrete, historical pilings and dolphins, metal debris, logs, and a cover of thick invasive vegetation. Debris between Dock 1 and the Salt Dock consists primarily of concrete debris, with smaller amounts of scrap metal, logs, pilings, and a few dolphins. The riverbank along the Arkema property includes four active outfalls, three of which will soon be abandoned in accordance with a stormwater Mutual Agreement and Order between LSS and DEQ.

Known and potential dredge and fill activities at Arkema are summarized in the EE/CA Work Plan (Parametrix 2007). Periods of maintenance dredging were historically necessary off the Salt Dock and Dock 1 to maintain sufficient depth for docking ships.

Industrial development has altered the nearshore areas as well; some shallow water areas persist, but historical dredging to accommodate vessel access has likely increased the water depth and steepened the nearshore profile in many areas of the LWR. Depths in the proposed RAA range from mean high water 13.3 ft NAVD 88 to deeper than 20 ft below river level (-10 ft NAVD 88). Aquatic vegetation has not been documented in the RAA. The surface sediments in the Arkema RAA are primarily silts with varying amounts of sand and clay. A mixture of sands and silts characterize the shallow areas, transitioning to primarily silty materials in the deepwater channel. Areas near the shoreline consist primarily of sand with varying amounts of gravel and coarse anthropogenic debris.

5.2.2 Prey Resources

Juvenile salmonids and other foraging fish rely heavily on macroinvertebrates as a food source, and amphipods and invertebrates in the water column can be particularly important prey items for many fish species (McCabe et al. 1997; Quinn 2005). Studies of benthic macroinvertebrates in the LWR have shown a fairly consistent suite of numerically dominant macroinvertebrates, including oligochaetes, chironomids, cladocerans, copepods, *Corbicula* and *Corophium* spp. (Integral et al. 2011; Anchor QEA 2012b). Planktonic crustaceans including *Daphnia* and *Corophium* are abundant in the LWR and are a common component of juvenile Chinook and coho diets (Anchor QEA 2012b).

Substantial spatial and temporal variation in benthic macroinvertebrates is the norm for lotic systems, and it can be difficult to understand effects of discrete disturbances given such high spatial and temporal variability (Allan 1995; Weber 2009). However, because many benthic macroinvertebrates have short life spans and fast generation rates, invertebrate communities tend to rebound quickly from acute disturbances such as dredging. For example, a study of benthic community recovery following dredging in the LCR found no significant changes in total benthic invertebrate densities or in community composition; most metrics of abundance and diversity were as high or higher than pre-dredging conditions within a year of the dredging activities (McCabe et al. 1998).

5.2.3 Sediment Quality

The sediment quality in the LWR is provided in Section 5.1.3.2 of the preliminary draft of the Portland Harbor draft site-wide BA (Anchor QEA 2012b). Potentially unacceptable risks have been demonstrated in the draft final site-wide RI including the bounding indicator chemicals, polychlorinated biphenyls (PCBs), DDx compounds, dioxins and furans, and polycyclic aromatic hydrocarbons (PAHs). The bounding indicator chemicals generally encompass the spatial extent of other contaminants that pose potentially unacceptable risk (Integral et al. 2011). Arkema site constituents of interest as directed by EPA for the EE/CA are

DDx, polychlorinated dibenzo-*p*- /furans, hexachlorobenzene, PCBs, total chlordanes, tributyltin, and lindane (gamma-hexachlorocyclohexane).

5.2.4 Water Quality and Quantity

The water quality and quantity in the LWR is provided in Sections 5.1.2.1.1 and 5.1.2.1.2, respectively, of the site-wide BA (Anchor QEA 2012b). As described in that document, the entire LWR is water quality limited. DEQ's 2006 CWA section 303(d) list identified water quality that was limited for temperature, fecal coliform, biological criteria (fish skeletal deformities), and toxics (mercury in fish tissue, dieldrin, aldrin, PCBs, DDT/DDE, dioxin [2,3,7,8-TCDD], PAHs, manganese, iron, and pentachlorophenol) (Anchor QEA et al. 2012). EPA-approved total maximum daily loads (TMDLs) are also in place for mercury, bacteria, and temperature. No TMDLs have been established for DDT/DDE.

5.2.5 Anthropogenic Activities

The RAA lies within an industrial waterway with substantial upland industrial, commercial, municipal, and urban activities. The upland adjacent to the action area has been modified for commercial and industrial activities and includes roads, buildings, and overwater structures to support industrial activities. Movements of ships through the LWR are ongoing, and noise and movement are regularly generated as part of these activities. Noise or movement generated during proposed activities in the action area is not expected under the preferred alternative to exceed these baseline conditions for noise or movement as they relate to potential disturbance of fish and wildlife in the area. If project activities are revised to include activities such as extensive pile-driving or other activities that may be expected to generate substantive noise above background levels, the potential impacts of such activities may be revisited and refined during the design phase, and the Arkema BA can be updated with more project-specific information.

5.2.6 Summary of Baseline Conditions and Expected Project Effects on Baseline

Baseline environmental conditions and expected effects of the proposed actions are summarized in Table 8. Sediment and substrate conditions in the Proposed Action Area are representative of the general substrate conditions in the LWR in terms of depth and grain size, although nearshore bathymetric profiles have been altered over time by dredging to maintain access to the port facilities by vessels. Many of the alterations to water quantity and quality in the vicinity of the action area are a function of upstream, large-scale actions related to power generation and commercial, municipal, urban, and agricultural land use. Shoreline conditions are a function of the long-term presence of commercial activities. The proposed project activities are expected to maintain and in some cases improve baseline environmental conditions in the action area for all the constituents discussed above (Table 8).

5.2.7 Current Conditions of Primary Constituent Elements of Critical Habitat in the LWR

Primary constituent elements (PCEs) are those physical and biological features of a landscape that a species needs to survive and reproduce (NOAA 2005). PCEs are established for listed species for which critical habitat has been established (Table 9). The following listed species have designated critical habitat that includes the LWR component of the proposed action area:

- Chinook salmon: LCR evolutionary significant unit (ESU); upper Willamette River (UWR) ESU
- Steelhead (*O. mykiss*): LCR DPS; UWR DPS.

For salmon and steelhead, there are five PCEs that govern 1) freshwater spawning sites, 2) freshwater rearing sites, 3) freshwater migration corridors, 4) estuarine habitats, and 5) marine habitats. As there are no estuarine or marine habitats present in the proposed action area, PCEs 4 and 5 are not applicable. As salmon and steelhead do not spawn in the LWR, PCE 1 is not applicable. The characterization of PCEs 2 and 3 in the vicinity of the project area includes the following:

PCE 2. Freshwater rearing sites with sufficient water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks.

The Willamette River in the vicinity of the Proposed Action Area is wide and relatively deep, with a substrate dominated by sandy and finer materials. There are some nearshore shallow areas that may be used as foraging areas for juvenile salmonids, though shoreline modification for navigational access has likely altered and reduced shallow nearshore habitat in the LWR relative to historic conditions, particularly at and upstream of Dock 2 (see Section 5.2.1). Benthic invertebrate surveys in the LWR support that the benthic and planktonic community is composed of macroinvertebrates that can serve as prey for juvenile salmonids, such as oligochaetes, chironomids, amphipods and *Daphnia*. Side channels, log jams, undercut banks, and similar features that provide the type of complex habitat that supports refugia and resources for juvenile salmon are not present in the vicinity of the action area. There is little overhanging vegetation in the vicinity of the RAA that could serve as a source of inputs of organic material or invertebrate prey. Extensive armoring and several overwater structures are present along the shoreline of the project area. It is unknown if overwater structures might serve as a physical habitat for freshwater rearing, growth, or mobility

PCE 3. Freshwater migration corridors that are free of obstruction, that have natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and

boulders, side channels, and undercut banks, and have water quality and quantity conditions that support juvenile and adult mobility and survival.

There are no impediments within the proposed action area that would preclude the movement of juvenile or adult salmon through the LWR migratory corridor. The types of complex habitat described for this PCE are generally not present in the action area, as shorelines are generally armored or have overwater structures, and there is little, if any, natural shading from overhanging vegetation present along the shoreline. As described in Section 5.2.4, the water quality of the LWR is currently impaired and is 303(d) listed for multiple contaminants.

5.3 LOWER COLUMBIA RIVER ENVIRONMENTAL BASELINE

5.3.1 Shoreline and In-Water Habitats

The project area's physical and biological conditions are consistent with the conditions described in the draft biological assessment (Anchor QEA 2012b). Industrial development has altered the near-shore areas in portions of the LCR; some shallow water areas persist, but historical dredging to accommodate vessel access has likely increased the water depth and steepened the nearshore profile in portions of the LCR. Depths in the LCR portion of the Proposed Action Area range from ordinary high water to deeper than 40 ft.

5.3.2 Prey Resources

Juvenile salmonids and other foraging fish rely heavily on macroinvertebrates as a food source, and amphipods and invertebrates in the water column can be particularly important prey items for many fish species (McCabe et al. 1997; Quinn 2005). Numerically dominant invertebrate taxa that have been identified in the main channel of the LCR include turbellaria, oligochaetes, chironomids, ceratopogonids, the invasive bivalve *Corbicula fluminea*, and the amphipod *Corophium salmonis*, with *Corbicula* and ceratopogonid larvae among the most abundant taxa (McCabe et al. 1997).

5.3.3 Sediment Quality

The sediment quality in the LCR is described in Section 5.2 of the site-wide BA (Anchor QEA 2012b), which reviews the substantive historic and ongoing large-scale hydrologic alterations to the LCR and its watersheds, including dams, levees, and loss of floodplain connectivity, and how these changes have led to substantive changes in sediment supply to the LCR.

5.3.4 Water Quality and Quantity

The water quality and quantity in the LCR is described in Section 5.2 of the preliminary draft of the site-wide BA (Anchor QEA 2012b). The U.S. Geological Survey (USGS) monitoring station

gage 14245900, at the Columbia River near Quincy, Oregon, RM 53.8, reported the following ranges of water quality parameters in the river for water year 2009: dissolved oxygen ranging between 8.8 and 13.3 mg/L; temperatures from a low of 3.8°C in February to 20.8°C in August, and turbidity ranging between 3.7 and 50 FNU[4] (USGS 2010). Suspended sediments are seasonally variable in the LCR, with lower loads in winter and early spring, and increasing loads in spring through early summer, which closely corresponds to the hydrograph and inputs of sediments with increasing water quantities (Fuhrer et al. 2006). The Cowlitz River and Willamette Rivers, in particular, have been noted as contributing high sediment load, up to 5 to 10 times higher than other tributaries to the LCR (Fuhrer et al. 2006).

The Columbia River has been subject to substantive modifications in water quantity and quality in association with long-term anthropogenic activities including hydroelectric projects, withdrawals for irrigation, and major land use changes including commercial and agricultural development. Dams have reduced peak flows, increased base flows, and trap much of the sediment that moves in from upper watershed tributaries. A TMDL, which establishes limitations for pollutants that are of concern for a specific water body, has been established for the LCR from the mouth to the Snake River, for total dissolved gas in association with four hydroelectric projects on the river (WDFW and DEQ 2002). A TMDL for dioxin in the Columbia River basin was approved by EPA in 1991. The LCR in Cowlitz County is also on the CWA 303(d) list for fecal coliform and temperature (WDOE 2010). Proposed project activities are not expected to substantively affect any of these water quality parameters.

5.3.5 Anthropogenic Activities

The LCR is characterized by a robust level of commercial and industrial activity relevant to the transport of materials both upriver and downriver to ports within and external to the Columbia River basin. Upland landscapes adjacent to the LCR have been extensively modified for commercial, industrial, and agricultural activities and include roads, buildings, and overwater structures to support industrial activities. Movements of ships through the action area to upstream and downstream ports are ongoing activities, and noise and movement are regularly generated as part of these activities. Noise and visual disturbance generated during mitigation activities, if necessary, would not be expected to exceed these baseline conditions for noise or movement as they relate to potential disturbance of fish and wildlife in the area.

[4] FNU = formazin nephelometric unit, and is similar to the NTU but for its use of infrared instead of white light to measure particle abundance. The FNU is USGS's standard unit of measurement for turbidity.

5.3.6 Current Conditions of Primary Constituent Elements of Critical Habitat in the LCR

The following listed species have designated critical habitat within the LCR portion of the Proposed Action Area (Table 9):

- Chinook salmon: UCR spring run ESU; Snake River spring/summer run ESU; Snake River fall run ESU; LCR ESU; UWR ESU
- Sockeye Salmon (*O. nerka*): Snake River ESU
- Chum salmon (*O. keta*): Columbia River ESU
- Steelhead: UCR DPS; Snake River Basin DPS; middle Columbia River DPS; LCR DPS; UWR DPS
- Bull trout (*Salvelinus confluentus*): Columbia River DPS
- Eulachon (*Thaleichthys pacificus*): Southern DPS.

The following sections discuss PCEs for the species listed above and evaluate the ability of current conditions in the action area to provide for these elements.

5.3.6.1 PCEs for Salmon and Steelhead

For salmon and steelhead, there are five PCEs that govern 1) freshwater spawning sites, 2) freshwater rearing sites, 3) freshwater migration corridors, 4) estuarine habitats, and 5) marine habitats. PCE 1 is not applicable because salmon and steelhead do not spawn in the LCR component of the Proposed Action Area. PCEs 4 and 5 are not applicable because there are no estuarine or marine habitats present in the Proposed Action Area. The characterization of PCEs 2 and 3 in the Proposed Action Area include:

PCE 2. Freshwater rearing sites with sufficient water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks.

The Columbia River in the vicinity of the Proposed Action Area is wide and deep, with a substrate dominated by sandy and fine-grained sediments. Benthic invertebrate surveys in the LCR suggest the benthic community is composed primarily of oligochaetes, amphipods, chironomids, and ceratopogonids, and these types of macroinvertebrates can serve as prey resources for juvenile salmonids. The shoreline of the main stem LCR is primarily shallow gradient or steep vertical banks that are relatively uncomplex, with intermittent areas highly developed for ports and other commercial activities.

PCE 3. Freshwater migration corridors free of obstruction and with sufficient water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks to support juvenile and adult mobility and survival.

The main stem LCR is an extremely broad, deep, and swift lotic system that does not generally have obstructions that would impede the movement of juvenile or adult salmon through the LCR migratory corridor. As described in Section 5.3.4, water quantity and quality conditions have been substantively altered by anthropogenic activities and the LCR is 303(d) listed for chemical and physicochemical contaminants of concern.

5.3.6.2 PCEs for Bull Trout

For bull trout, there are nine PCEs:

PCE 1. Springs, seeps, groundwater sources, and subsurface water connectivity (hyporehic flows) to contribute to water quality and quantity and provide thermal refugia.

PCE 2. Migratory corridors with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and freshwater and marine foraging habitats.

PCE 3. An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.

PCE 4. Complex river, stream, lake, reservoir, and marine shoreline aquatic environments and processes with features such as large wood, side channels, pools, undercut banks and substrates, to provide a variety of depths, gradients, velocities, and structure.

PCE 5. Water temperatures ranging from 2 to 15°C (36 to 59°F), with adequate thermal refugia available for temperatures at the upper end of this range. Specific temperatures within this range will vary depending on bull trout life-history stage and form; geography; elevation; diurnal and seasonal variation; shade, such as that provided by riparian habitat; and local groundwater influence.

PCE 6. Substrates of sufficient amount, size, and composition to ensure survival of eggs and embryos overwinter, fry emergence, and survival of young-of-the-year and juveniles. A minimal amount (e.g., less than 12 percent) of fine substrate less than 0.85 mm (0.03 in.) in diameter and minimal embeddedness of these fines in larger substrates characterize these conditions.

PCE 7. A natural hydrograph, including peak, high, low, and base flows within historic and seasonal ranges or, minimal departures from a natural hydrograph if flows are controlled.

PCE 8. Sufficient water quality and quantity to support normal reproduction, growth, and survival.

PCE 9. Few or no nonnative predatory (e.g., lake trout, walleye, northern pike, smallmouth bass); inbreeding (e.g., brook trout); or competitive (e.g., brown trout) species present.

Bull trout may be expected to use the main stem of the Columbia River in low numbers as a migration corridor between tributaries, during outmigration of juveniles, or during upstream migration of adults to spawning areas. The proposed action area fulfills the definition of PCE 2, in being free of barriers to passage for migration of these life stages. For the other PCEs, the action area does not contain appropriate conditions: substrates are too fine to support successful spawning; summer temperatures are above the thermal requirements for this species; the action area is lacking the types of complex habitats preferred for rearing and foraging conditions, including suitable physical and thermal refugia; and a diversity of fish species have been introduced to the LCR ecosystem, several of them predatory or potential competitors with native trout, including smallmouth bass, striped bass, and walleye (Sytsma et al. 2004).

5.3.6.3 PCEs for Eulachon

The PCEs relevant to eulachon critical habitat in the LCR include:

PCE 1. Freshwater spawning and incubation sites with water flow, quality and temperature conditions and substrate supporting spawning and incubation, and with migratory access for adults and juveniles.

PCE 2. Freshwater and estuarine migration corridors associated with spawning and incubation sites that are free of obstruction and with water quality and temperature conditions supporting larval and adult mobility, and with abundant prey items supporting larval feeding after the yolk sac is depleted.

PCE 3. Marine foraging habitat.

Elements 1 and 2 are present within the proposed action area: spawning and incubation sites are known to occur along the main stem LCR, though much is still not known about the timing, frequency of use, and distribution of these spawning and incubation sites. There are no migratory impediments within the proposed action area that would preclude the movement of juvenile or adult eulachon through the LCR. As larval eulachon are expected to move quickly downstream into estuarine areas following emergence from the gravel, the primary forage base for eulachon is expected to occur primarily outside of the proposed action area. Marine foraging habitat is not present within the proposed action area of the LCR.

6 EFFECTS DETERMINATIONS

6.1 EFFECTS ON LISTED SPECIES

The proposed action considered in this preliminary draft BA consists of remedial technologies and construction methods that are substantively consistent with the technologies and construction methods described by the site-wide BA. The proposed action for the Arkema RAA may include riverbank work that is not considered in the site-wide BA; however, the proposed technologies and methods are still expected to be substantively consistent with those described in the site-wide BA. Therefore, for the listed in-water species outlined in Section 3 and Table 3, the effects of the proposed action within the Proposed Action Area, as outlined in Section 2 and described in the EE/CA, is expected to result in species and critical habitat effects determinations consistent with the findings of the site-wide BA. Potential adverse effects on PCEs, upland species, and EFH are additionally summarized below in Section 6.2 (Adverse Effects on Critical Habitat), Section 6.3 (Adverse Effects on Listed Upland Species), and Section 6.4 (Adverse Effects on Salmon EFH).

6.2 ADVERSE EFFECTS ON CRITICAL HABITAT

PCEs identified as potentially occurring in the Proposed Action Area include two PCEs for salmon and steelhead, rearing habitat and migration corridors; one PCE for bull trout, migration corridors; and two PCEs associated with proposed critical habitat for eulachon, freshwater spawning and migration corridors. The potential for adverse effects on these PCEs are evaluated in this section. As discussed in Section 5.2 and 5.3 other PCEs of critical habitat, including spawning areas for all listed species other than eulachon, are not expected to occur in the Proposed Action Area and, therefore, will not be affected by proposed activities.

6.2.1 Freshwater Rearing PCE for Salmon and Steelhead

The Proposed Action Area provides potential freshwater rearing habitat for listed salmon and steelhead species. Effects to habitat within the RAA portion of the area may include the removal and burial of sediments that support benthic communities that may be used as forage for listed species, and temporary and localized areas of suspended sediments in areas that juvenile salmon and steelhead use for foraging. These effects are expected to be limited in extent and duration, and will be minimized by limiting work to the in-water work window during which the lowest numbers of listed species are expected to be present. Habitat conditions are expected to be maintained or improved relative to baseline (Table 8). Activities downstream in the LWR and in the LCR, which could include compensatory mitigation if necessary, are not expected to adversely affect freshwater rearing PCEs for salmon or steelhead.

6.2.2 Migration PCE for Salmon, Steelhead and Bull Trout

Proposed activities are not expected to create a meaningful barrier to movement or migration of juvenile or adult salmonids. Work will occur during the in-water work window to minimize the likelihood that fish will be migrating through or using the area during project activities; as described in Section 2 and in Tables 4 and 5, the in-water work window represents the period during which the fewest species and numbers of individuals are expected to be migrating through the site vicinity. Dredging equipment will be limited to a subsection of the river, with much of the channel remaining unaffected by project activities so that migration of listed species is not impeded.

6.2.3 Freshwater Spawning and Migration PCEs for Eulachon

Proposed critical habitat designation for the southern DPS of eulachon includes two PCEs that may potentially be present at the LCR portion of the site: freshwater spawning/incubation and a migration corridor for returning adults and for dispersing larvae.

Proposed activities are not expected to create meaningful barriers to movement or migration of larval or returning adult eulachon in the LCR. Activities along the LCR portion of the action area are expected to primarily consist of compensatory mitigation activities, if necessary. Work will occur during the in-water work window to minimize any overlap with the period during which eulachon might use sediments in the vicinity of the Proposed Action Area for spawning, and adherence to the in-water work window will also reduce the likelihood that eulachon will be migrating through or using the area during project activities.

6.3 ADVERSE EFFECTS ON LISTED UPLAND SPECIES

Given that none of the upland species discussed in Section 3.1 have ecological requirements that are consistent with habitats in the action area, the proposed action area is not expected to have any potential for direct effects on these species. Potential indirect effects would be limited to noise disturbance to animals that might be migrating near the action area en route to foraging or home range areas.

6.4 ADVERSE EFFECTS ON SALMON EFH

The potential effects to salmon are limited to those life stages expected to be present in the action area which, as discussed in Section 4, are in-migrating adult salmon and out-migrating juvenile Chinook and coho salmon that may use the action area for rearing and/or migration. Therefore, potential effects on EFH are expected to be the same as those discussed in the Portland Harbor preliminary draft site-wide BA, including:

- Entrainment
- Turbidity
- Disruption of the benthic community which may serve as a food resource
- Noise and movement associated with dredging operations.

These potential effects have been discussed in Section 5 above, and expected effects on baseline habitat conditions are reviewed in Table 8. As listed species include the salmon species that are addressed in the Pacific salmon EFH, the effects discussed in these sections fully describe potential effects on salmon EFH.

6.5 EFFECTS DETERMINATION

Potential adverse effects on listed species and designated critical habitat, as discussed above, are expected to be localized and relatively short-term in nature. The effects of the proposed action for the Proposed Action Area are consistent with the effects described and analyzed for ESA-listed species and EFH in the Portland Harbor preliminary draft site-wide BA. While the proposed action is likely to include riverbank work not considered in the Portland Harbor preliminary draft site-wide BA, this work is expected to be conducted using methodologies substantively similar to those described in the site-wide BA and, in addition, as discussed in Section 6.2., upland listed species are unlikely to be present in the vicinity of the action area. Therefore, no effects are expected on ESA-listed upland plant or wildlife species.

The potential effects described will further be avoided and minimized by adherence to established in-water work windows, so that activities are occurring during the periods when the lowest diversity and abundance of listed species are expected to be present in the area. The project will also adhere to all water quality requirements and will adhere to BMPs and conservation measures outlined in Section 2.2 of this document and in the CWA Section 404 evaluation (Appendix C). Therefore, for the species identified in Section 3, the potential effects of the proposed action within the proposed project area are expected to result in species and critical habitat effects and determinations consistent with the findings of the site-wide BA.

If the preferred alternative for the Arkema Proposed Action Area consists of technologies and/or activities not considered in the Portland Harbor preliminary draft site-wide BA, or if the mitigation sequence implemented in the design phase does not allow adverse effects to be avoided, minimized, or compensated to the extent to which adverse effects to listed species are *de minimis*, re-evaluation of the effects determination will be conducted for appropriate species in a future revision of this document.

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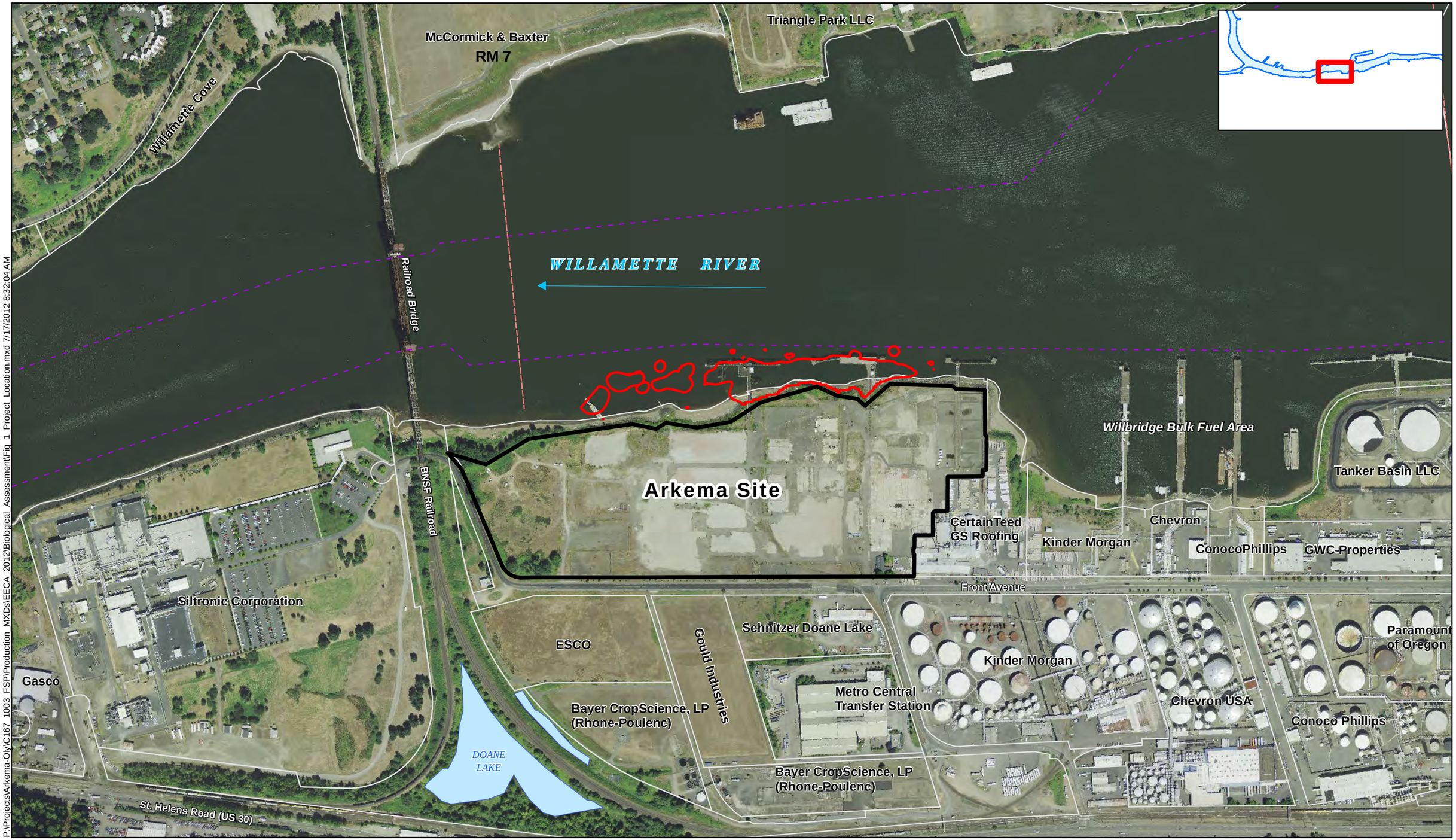
FIGURES



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FEATURE SOURCES:
Aerial: Metro, 2007
Property Boundaries: Metro RLIS

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Map Features

- EPA-Directed Horizontal RAA Boundary
- River Miles
- Navigation Channel
- Waterfront Taxlots
- Doane Lake (Current)

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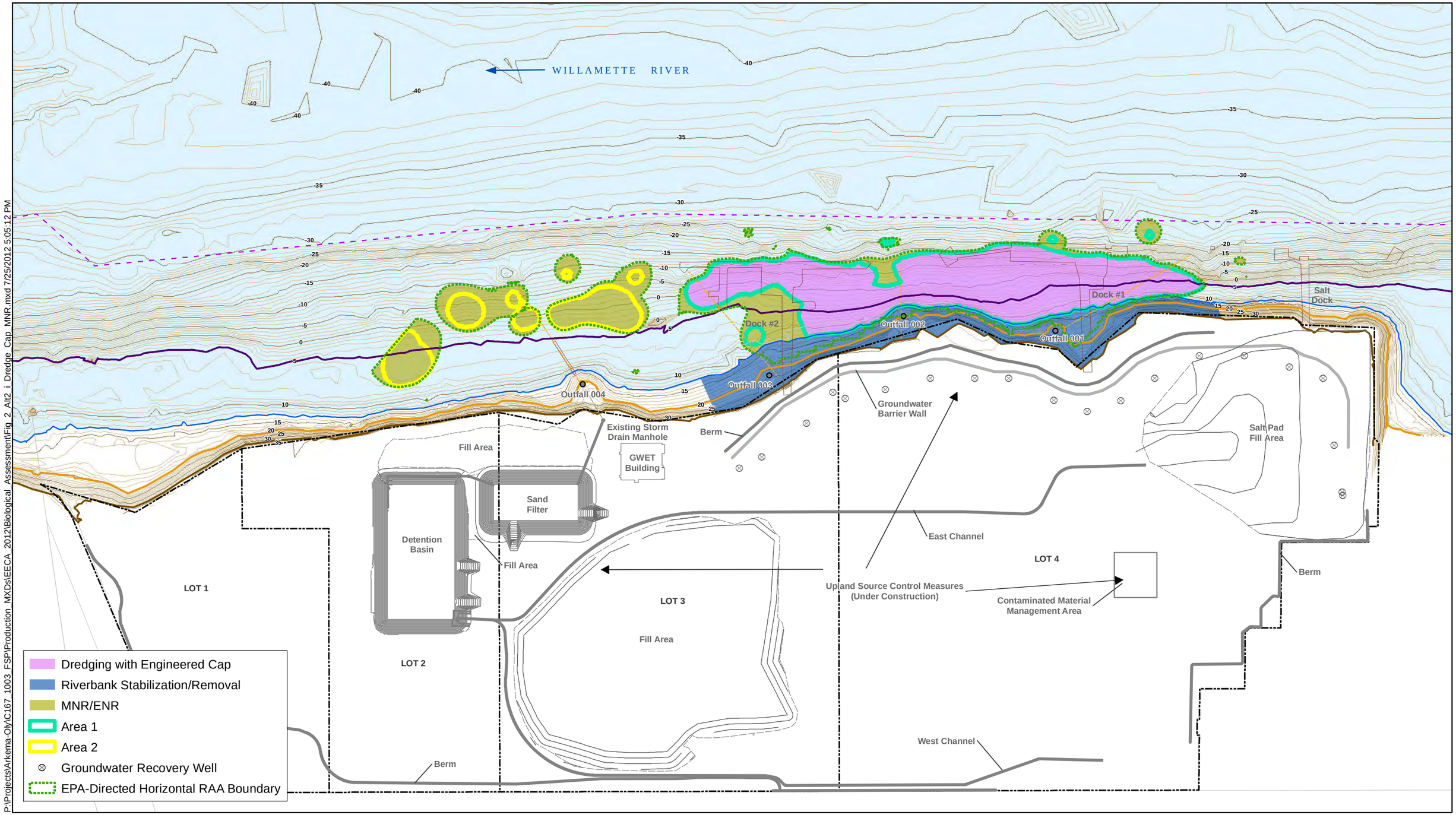
Figure 1
Project Location
Arkema Early Action
Biological Assessment and Essential Fish Habitat Assessment



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FEATURE SOURCES:
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Navigation Channel: US Army Corps of Engineers
Elevation Contours: Areas Below +16 ft: 2004 Bathymetry and 2001 LiDAR;
Area above +16ft: 2007 DEA Topographic Survey

0 100 200 Feet

Map Features

- Property and Lot Boundary
- Storm Drain
- Navigation Channel
- Top of Bank
- +13 ft NAVD88
- Ordinary High Water (20.5 ft NAVD88)
- Ordinary Low Water (5 ft NAVD88)
- 5 ft Contour (NAVD88)
- 1 ft Contour (NAVD88)
- Docks and Structures
- River Edge

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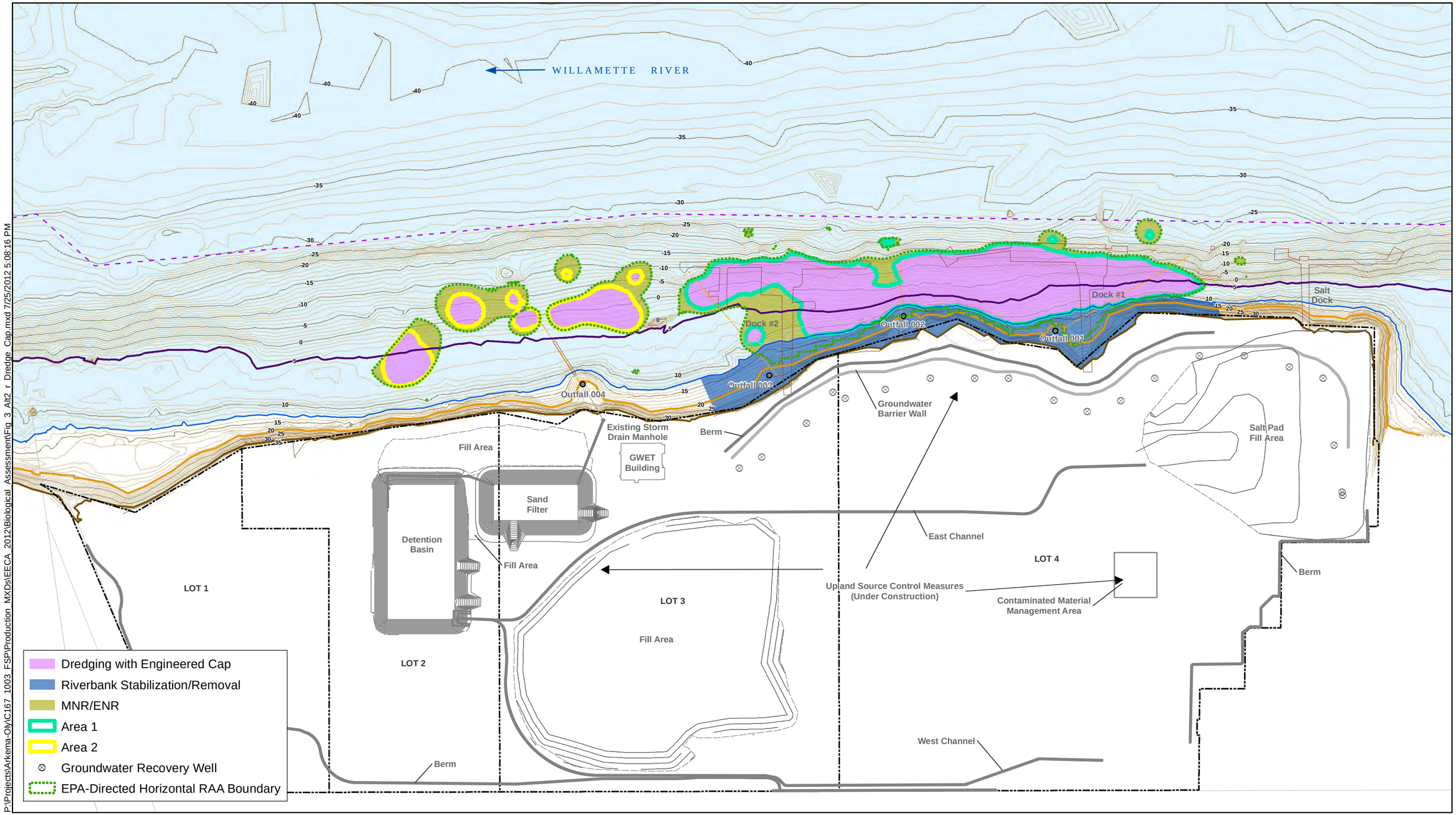
Figure 2
Alternative 2(i): Dredge to Facilitate a Cap and Optimized MNR
Arkema Early Action
Biological Assessment and Essential Fish Habitat Assessment



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Elevation Contours: Areas Below +16 ft: 2004 Bathymetry and 2001 LiDAR;
Area above +16ft: 2007 DEA Topographic Survey

0 100 200 Feet

Map Features

- Property and Lot Boundary
- Storm Drain
- Navigation Channel
- Top of Bank
- +13 ft NAVD88
- Ordinary High Water (20.5 ft NAVD88)
- Ordinary Low Water (5 ft NAVD88)
- 5 ft Contour (NAVD88)
- 1 ft Contour (NAVD88)
- Docks and Structures
- River Edge

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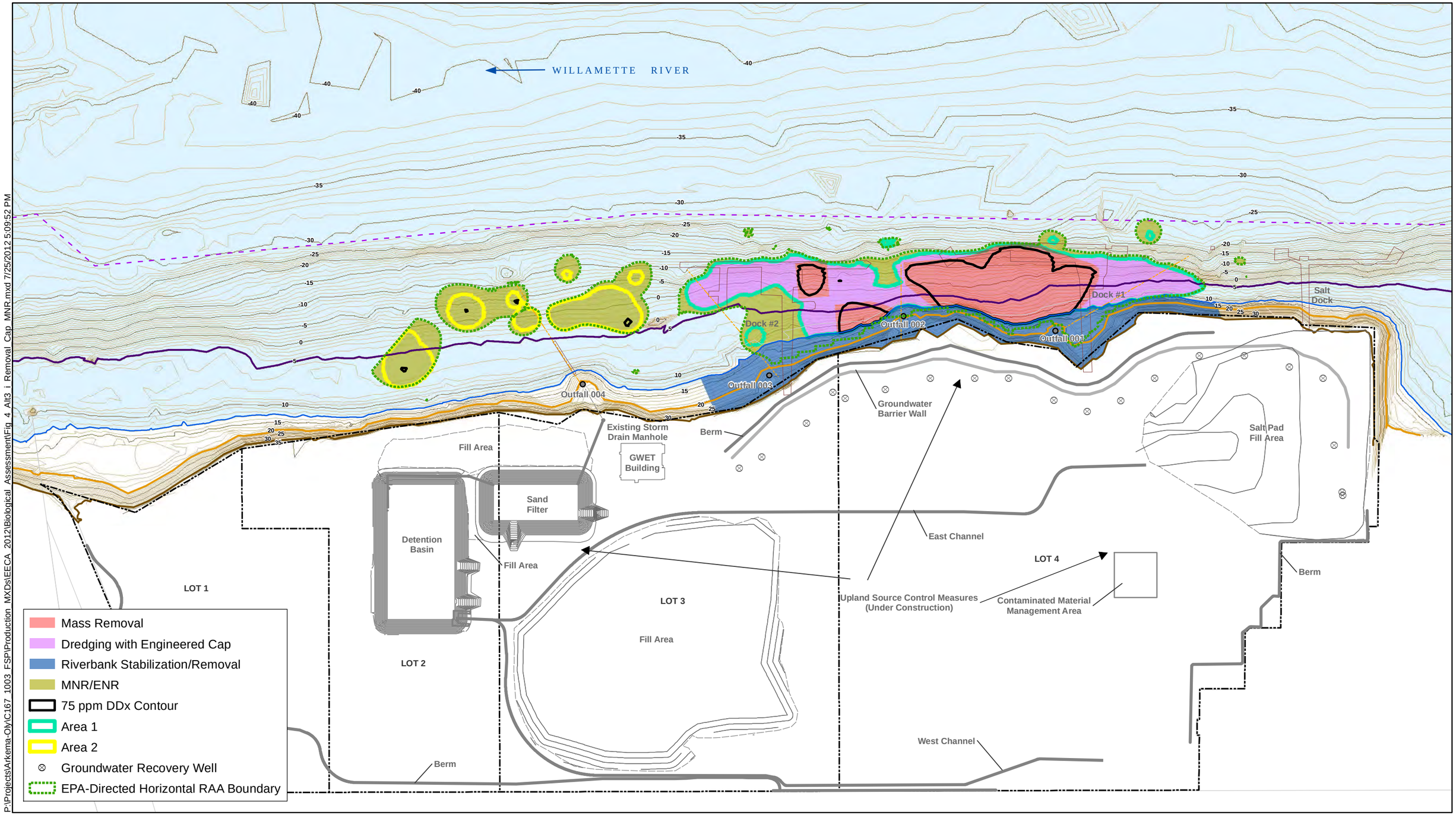
Figure 3
Alternative 2(r): Dredge to Facilitate a Cap
Arkema Early Action
Biological Assessment and Essential Fish Habitat Assessment



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Area above +16ft: 2007 DEA Topographic Survey

0 100 200 Feet

Map Features

- Property and Lot Boundary
- Storm Drain
- Navigation Channel
- Top of Bank
- +13 ft NAVD88
- Ordinary High Water (20.5 ft NAVD88)
- Ordinary Low Water (5 ft NAVD88)
- 5 ft Contour (NAVD88)
- 1 ft Contour (NAVD88)
- Docks and Structures
- River Edge

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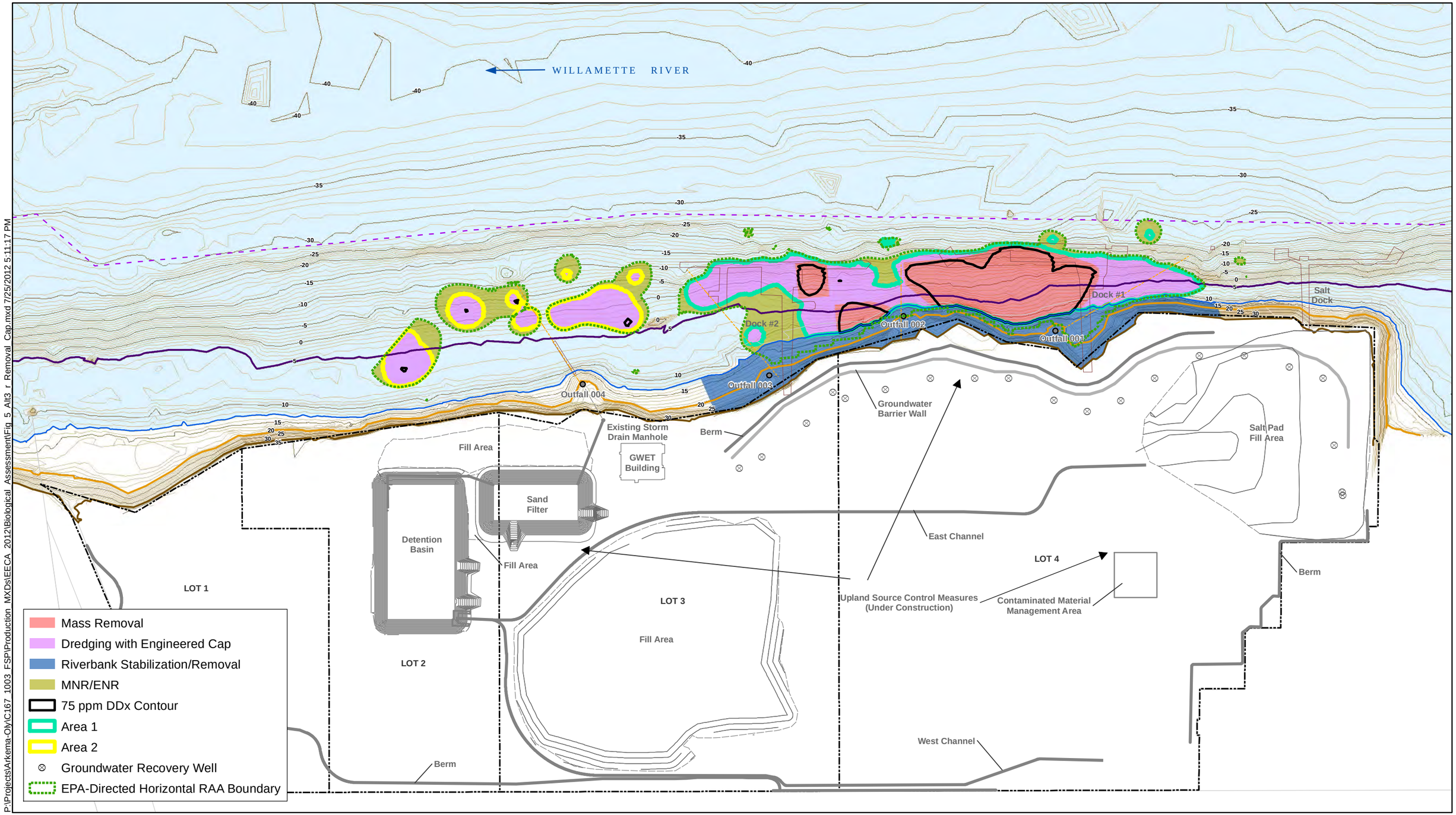
Figure 4
Alternative 3(i): Mass-Based Removal, Capping, and Optimized MNR
Arkema Early Action
Biological Assessment and Essential Fish Habitat Assessment



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FEATURE SOURCES:
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Navigation Channel: US Army Corps of Engineers
Elevation Contours: Areas Below +16 ft: 2004 Bathymetry and 2001 LiDAR;
Area above +16ft: 2007 DEA Topographic Survey

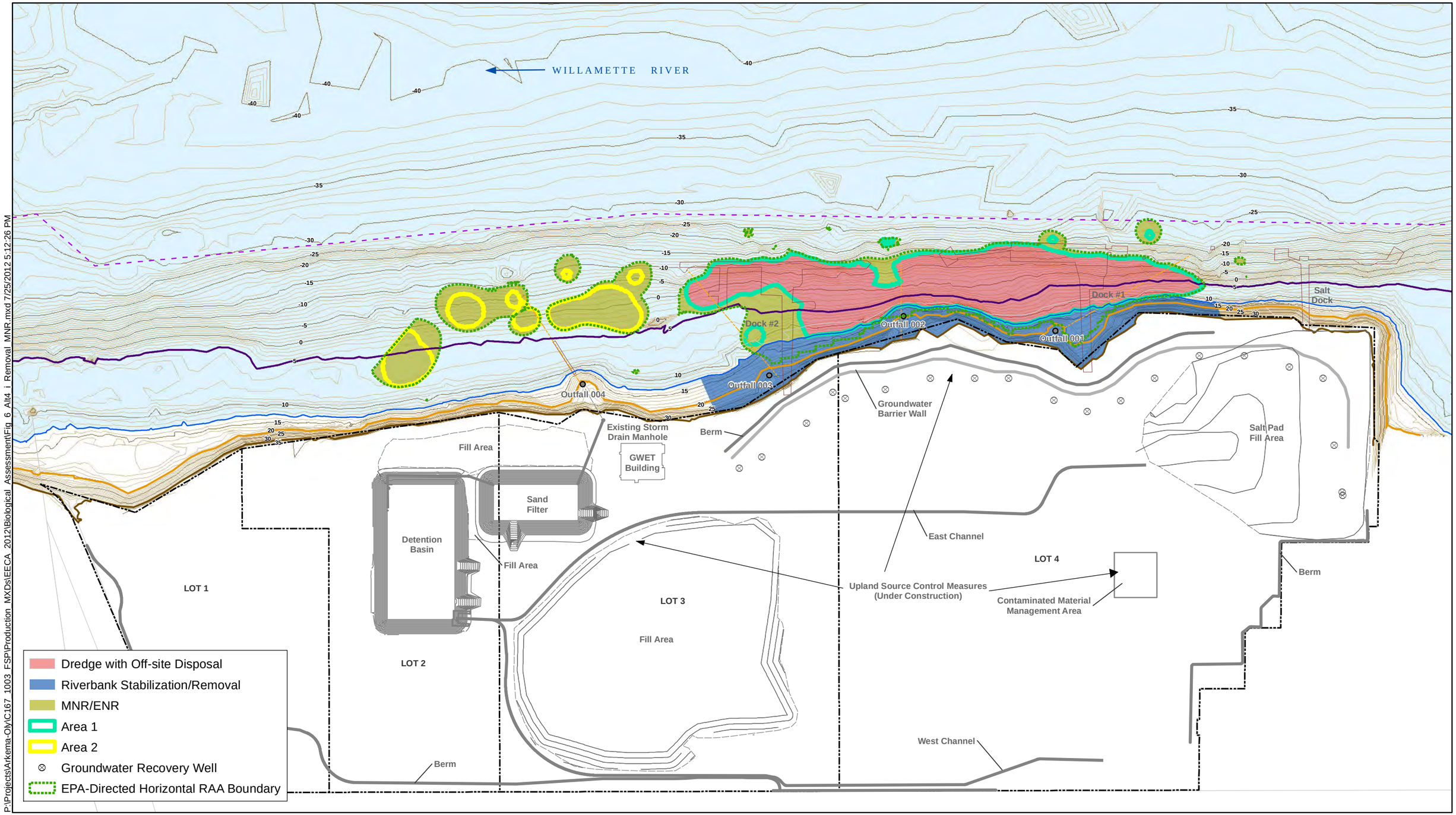
0 100 200 Feet

Map Features

- Property and Lot Boundary
- Storm Drain
- Navigation Channel
- Top of Bank
- +13 ft NAVD88
- Ordinary High Water (20.5 ft NAVD88)
- Ordinary Low Water (5 ft NAVD88)
- 5 ft Contour (NAVD88)
- 1 ft Contour (NAVD88)
- Docks and Structures
- River Edge

DRAFT

Figure 5
Alternative 3(r): Mass-Based Removal and Capping
Arkema Early Action
Biological Assessment and Essential Fish Habitat Assessment



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integral consulting inc

FEATURE SOURCES:
Property Boundaries, OHW, TOB: 2007 DEA Topographic Survey
Navigation Channel: US Army Corps of Engineers
Elevation Contours: Areas Below +16 ft: 2004 Bathymetry and 2001 LiDAR;
Area above +16ft: 2007 DEA Topographic Survey

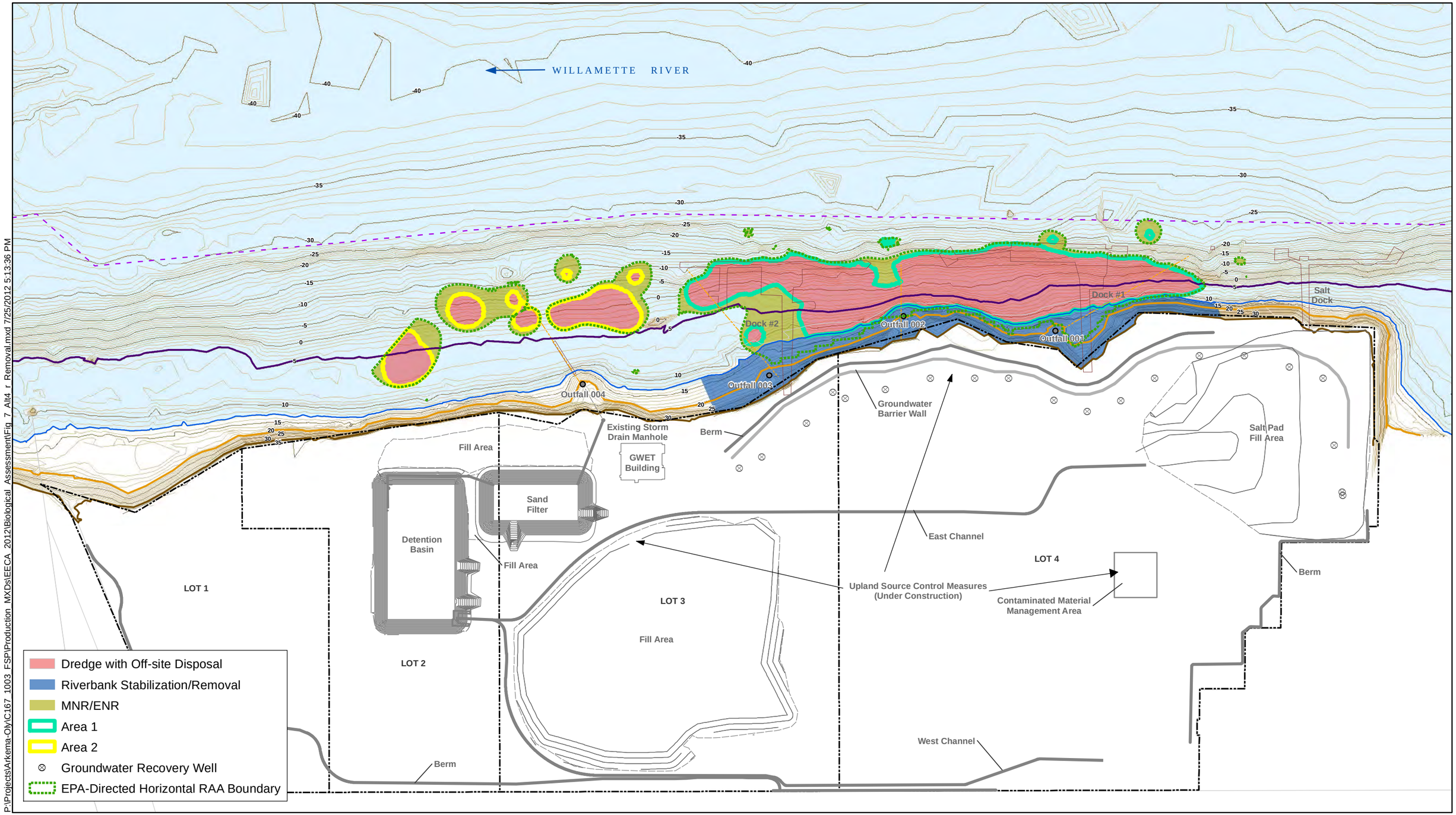
0 100 200 Feet

Map Features

- Property and Lot Boundary
- Storm Drain
- Navigation Channel
- Top of Bank
- +13 ft NAVD88
- Ordinary High Water (20.5 ft NAVD88)
- Ordinary Low Water (5 ft NAVD88)
- 5 ft Contour (NAVD88)
- 1 ft Contour (NAVD88)
- Docks and Structures
- River Edge

DRAFT

Figure 6
Alternative 4(i): Removal Focused and Optimized MNR
Arkema Early Action
Biological Assessment and Essential Fish Habitat Assessment



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integral consulting inc

FEATURE SOURCES:
Property Boundaries, OHW, TOB: 2007 DEA Topographic Survey
Navigation Channel: US Army Corps of Engineers
Elevation Contours: Areas Below +16 ft: 2004 Bathymetry and 2001 LiDAR;
Area above +16ft: 2007 DEA Topographic Survey

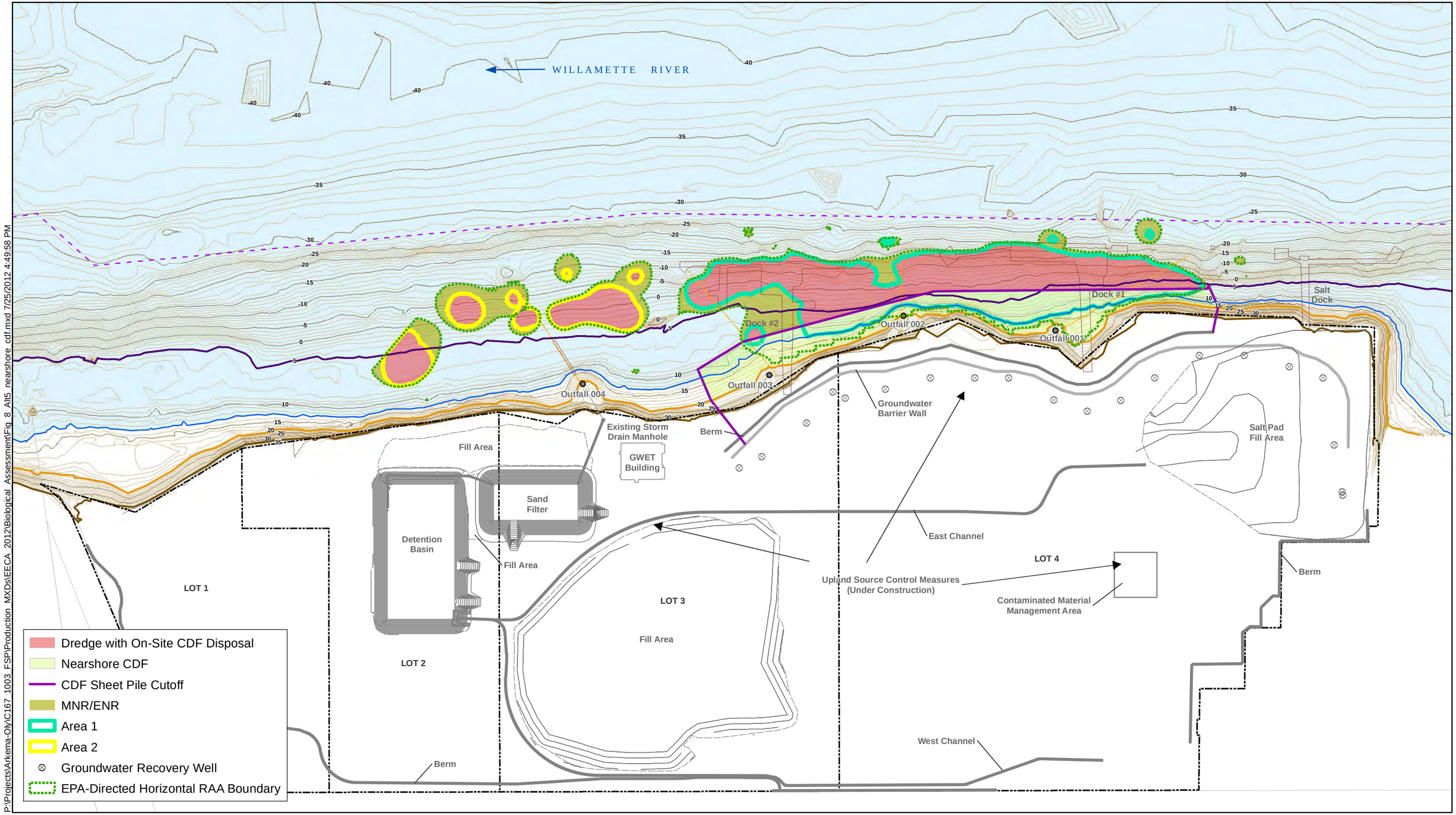
0 100 200 Feet

Map Features

- Property and Lot Boundary
- Storm Drain
- Navigation Channel
- Top of Bank
- +13 ft NAVD88
- Ordinary High Water (20.5 ft NAVD88)
- Ordinary Low Water (5 ft NAVD88)
- 5 ft Contour (NAVD88)
- 1 ft Contour (NAVD88)
- Docks and Structures
- River Edge

DRAFT

Figure 7
Alternative 4(r): Removal Focused
Arkema Early Action
Biological Assessment and Essential Fish Habitat Assessment



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integral consulting inc

FEATURE SOURCES:
Property Boundaries, OHW, TOB: 2007 DEA Topographic Survey
Navigation Channel: US Army Corps of Engineers
Elevation Contours: Areas Below +16 ft: 2004 Bathymetry and 2001 LiDAR;
Area above +16ft: 2007 DEA Topographic Survey

0 100 200 Feet

Map Features

- Property and Lot Boundary
- Storm Drain
- Navigation Channel
- Top of Bank
- +13 ft NAVD88
- Ordinary High Water (20.5 ft NAVD88)
- Ordinary Low Water (5 ft NAVD88)
- 5 ft Contour (NAVD88)
- 1 ft Contour (NAVD88)
- Docks and Structures
- River Edge

DRAFT

Figure 8
Alternative 5: Nearshore CDF
Arkema Early Action
Biological Assessment and Essential Fish Habitat Assessment

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integral consulting inc.

N

FEATURE SOURCES:
Property Boundaries, OHW, TOB: 2007 DEA Topographic Survey
Navigation Channel: US Army Corps of Engineers
Aerial: Metro, June-July 2009

0 100 200 400 Feet

Map Features

- Property and Lot Boundary
- Navigation Channel
- River Edge +13 ft NAVD
- Docks and Structures

DRAFT

Figure 9
Site Map
Arkema Early Action
Biological Assessment and Essential Fish Habitat Assessment

TABLES

Table 1. Summary of Arkema EE/CA Alternatives

No.	Description	Summary
1	No Further Action	No Further Action
2(i)	Dredge to Facilitate a Cap and Optimized MNR	Partial dredge and cap placement within Area 1. Use MNR/EMR to address remainder of RAA footprint. A maintenance and monitoring program will be developed and implemented to monitor the cap and MNR performance. The riverbank area will be regraded and capped. Disposal to Subtitle D Landfill.
2(r)	Dredge to Facilitate a Cap	Partial dredge and cap placement within Areas 1 and 2. Use MNR/ENR to address remainder of RAA boundary as described for Alternative 2(i). The riverbank area will be regraded and capped. Disposal to Subtitle D Landfill.
3(i)	Mass-Based Removal, Capping and Optimized MNR	Targeted removal of sediment containing the most highly contaminated sediments to a maximum depth of 15 feet. Partial dredge and cap of rest of sediments within Area 1. Use MNR/ENR to address remainder of RAA boundary as described for Alternative 2(i). The riverbank area will be regraded and capped. Disposal to Subtitle D Landfill.
3(r)	Mass-Based Removal and Capping	Targeted removal of sediment containing the most highly contaminated sediments to a maximum depth of 15 feet. Partial dredge and cap sediments within remainder of Area 1 and all of Area 2. Use MNR/ENR to address remainder of RAA boundary as described for Alternative 2(i). The riverbank area will be regraded and capped. Disposal to Subtitle D Landfill.
4(i)	Removal Focused and Optimized MNR	Dredge majority of horizontal footprint within Area 1 to a maximum depth of 15 feet. Use MNR/ENR to address remainder of RAA boundary as described for Alternative 2(i). The riverbank area will be regraded and capped. Disposal to Subtitle D Landfill.
4(r)	Removal Focused	Dredge approximate horizontal footprint within Areas 1 and 2 to a maximum depth of 15 feet. Use MNR/ENR to address remainder of RAA boundary as described for Alternative 2(i). The riverbank area will be regraded and capped. Disposal to Subtitle D Landfill.
5	Nearshore CDF	Construct nearshore CDF. Outside CDF footprint, dredge approximate horizontal footprint of Areas 1 and 2 to a maximum depth of 15 feet. Use MNR/ENR to address remainder of RAA boundary as described for Alternative 2(i). The riverbank area will be regraded and capped. Disposal onsite in CDF.

Notes:
CDF = confined disposal facility
ENR = enhanced natural recovery
MNR = monitored natural recovery
RAA = removal action area

Table 2. Summary of Compensatory Mitigation for SMA 14 by Portland Harbor Draft FS Alternative

Integrated (i) Alternatives					Removal (r) Focused Alternatives				
		LWG RHV Determination					LWG RHV Determination		
SMA	NMFS RHV Determination	Rearing Function Total	Migration Function Total	Total	SMA 14	NMFS RHV Determination	Rearing Function Total	Migration Function Total	Total
Alternative Bi					**Alternative Br**				
SMA 14	-0.53	-0.15	-0.04	-0.19	SMA 14	-0.04	-0.07	-0.06	-0.14
Alternative Ci					**Alternative Cr**				
SMA 14	-2.95	-0.87	-0.24	-1.12	SMA 14	1.29	0.09	-0.07	0.02
Alternative Di					**Alternative Dr**				
SMA 14	-3.27	-1.00	-0.27	-1.28	SMA 14	1.41	0.07	-0.09	-0.02
Alternative Ei					**Alternative Er**				
SMA 14	-5.04	-1.01	-0.42	-1.43	SMA 14	-0.69	-0.27	-0.16	-0.43
Alternative Fi					**Alternative Fr**				
SMA 14	-4.08	-1.23	-0.32	-1.55	SMA 14	-0.97	-0.4	-0.22	-0.62

Source:
Anchor QEA (2012a)

Notes:
FS = feasibility study
LWG = Lower Willamette Group
NMFS = National Marine Fisheries Services
RHV = relative habitat value
SMA = sediment management area

Table 3. Endangered Species Act Status of Species That May Be Present in the Proposed Action Area

Species[a]	Potentially Present in Proposed Action Area (LCR/LWR)[b]	Endangered Species Act Listing Status	Federal Agency Jurisdiction	Essential fish habitat designated?	Critical Habitat Designated?	Critical Habitat Designation for Proposed Action Area (LCR/LWR), if any
Sockeye Salmon (*Oncorhynchus nerka*)						
Snake River ESU	LCR	Endangered	NOAA	No	Yes	LCR
Chinook Salmon (*O. tshawytscha*)						
Upper Columbia River spring-run ESU	LCR	Endangered	NOAA	Yes	Yes	LCR
Snake River spring/summer-run ESU	LCR	Threatened	NOAA	Yes	Yes	LCR
Snake River fall-run ESU	LCR	Threatened	NOAA	Yes	Yes	LCR
Lower Columbia River ESU	LCR & LWR	Threatened	NOAA	Yes	Yes	LCR & LWR
Upper Willamette River ESU	LCR & LWR	Threatened	NOAA	Yes	Yes	LCR & LWR
Coho Salmon (*O. kisutch*)						
Lower Columbia River ESU	LCR & LWR	Threatened	NOAA	Yes	No	N/A
Chum Salmon (*O. keta*)						
Columbia River ESU	LCR & LWR[c]	Threatened	NOAA	No	Yes	LCR
Steelhead (*O. mykiss*)						
Upper Columbia River DPS	LCR	Threatened	NOAA	No	Yes	LCR
Snake River Basin DPS	LCR	Threatened	NOAA	No	Yes	LCR
Lower Columbia River DPS	LCR	Threatened	NOAA	No	Yes	LCR
Lower Columbia River DPS	LCR & LWR	Threatened	NOAA	No	Yes	LCR & LWR
Upper Willamette River DPS	LCR & LWR	Threatened	NOAA	No	Yes	LCR & LWR
Bull Trout (*Salvelinus confluentus*)	LCR	Threatened	USFWS	N/A	Yes	LCR
Pacific Eulachon (*Thaleichthys pacificus*)						
Southern DPS	LCR	Threatened	NOAA	No	Yes	LCR
Green Sturgeon (*Acipenser medirostris*)						
Southern DPS	LCR	Threatened	NOAA	No	Yes	No
Steller Sea Lion (*Eumetopias jubatus*)						
Eastern DPS	LCR	Threatened	NOAA	No	Yes	No

Table 3. Endangered Species Act Status of Species That May Be Present in the Proposed Action Area

Species[a]	Potentially Present in Proposed Action Area (LCR/LWR)[b]	Endangered Species Act Listing Status	Federal Agency Jurisdiction	Essential fish habitat designated?	Critical Habitat Designated?	Critical Habitat Designation for Proposed Action Area (LCR/LWR), if any
Northern Spotted Owl (*Strix occidentalis caurina*)	LCR & LWR	Threatened	USFWS	N/A	Yes	No
Columbia White-Tailed Deer (*Odocoileus virginianus leucurus*)	LCR & LWR	Endangered	USFWS	N/A	No	N/A
Nelson's Checker-Mallow (*Sidalcea nelsoniana*)	LWR	Threatened	USFWS	N/A	No	N/A
Bradshaw's Desert-Parsley (*Lomatium bradshawii*)	LWR	Endangered	USFWS	N/A	No	N/A
Water Howellia (*Howellia aquatilis*)	LWR	Threatened	USFWS	N/A	No	N/A
Willamette Daisy (*Erigeron decumbens var. decumbens*)	LWR	Endangered	USFWS	N/A	Yes	No
Kincaid's Lupine (*Lupinus sulphureus* (=*oreganus*) *ssp. kincaidii* (=*var. kincaidii*))	LWR	Threatened	USFWS	N/A	Yes	No

Sources:
NOAA (2005, 2012)
USFWS (2012)

Notes:
DPS = distinct population segment
ESA = Endangered Species Act
ESU = evolutionarily significant unit
LCR = lower Columbia River
LWR = lower Willamette River
N/A = not applicable
NOAA = National Oceanic and Atmospheric Administration
USFWS = U.S. Fish and Wildlife Service

[a] The ESA defines a "species" to include any distinct population segment of any species of vertebrate fish or wildlife. For Pacific salmon, NOAA Fisheries Service considers an evolutionarily significant unit, or "ESU," a "species" under the ESA. For Pacific steelhead, NOAA Fisheries Service has delineated distinct population segments (DPSs) for consideration as "species" under the ESA.

[b] Indicates whether the species is potential present in the LCR portion of the Proposed Action Area, LWR portion of the Proposed Action Area, or both.

[c] Limited use of the LWR by juvenile chum salmon; adults are not expected. Critical habitat does not include the LWR.

Table 4. Timing of Downstream Juvenile Fish Migrations[a] in the Lower Willamette River

Fish Species / ESU or DPS	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Chinook Salmon[b]												
Upper Willamette River ESU												
Lower Columbia River ESU												
Coho Salmon[b]												
Lower Columbia River ESU												
Chum Salmon[c]												
Columbia River ESU												
Steelhead Trout												
Lower Columbia River DPS												
Upper Willamette River DPS												

Sources:
ODFW (2008)
Murtagh (2012)

Notes:
Black bars represent the peak migration periods.
Gray bars represent the estimated total period of occurrence with the action area.
DPS = distinct population segment
ESU = evolutionarily significant unit
LWR = lower Willamette River

[a] For species that may use the lower Willamette River for rearing as well as migration (lower Columbia and upper Columbia Chinook \ lower Columbia coho), the time period shown is inclusive of both rearing and outmigration.

[b] Juvenile coho and chinook salmon overwinter in freshwater streams, so may be expected in freshwater habitats year round, but the primary period of outmigration is in spring, and the lowest abundances in the Site vicinity may be expected in summer.

[c] Chum salmon are believed to have been extirpated from the LWR and its tributaries; juveniles may occasionally move into the LWR with tidal cycles to forage, but are generally expected to be rare in this system.

Table 5. Timing of Upstream Adult Aquatic Species Migrations in the Lower Willamette River

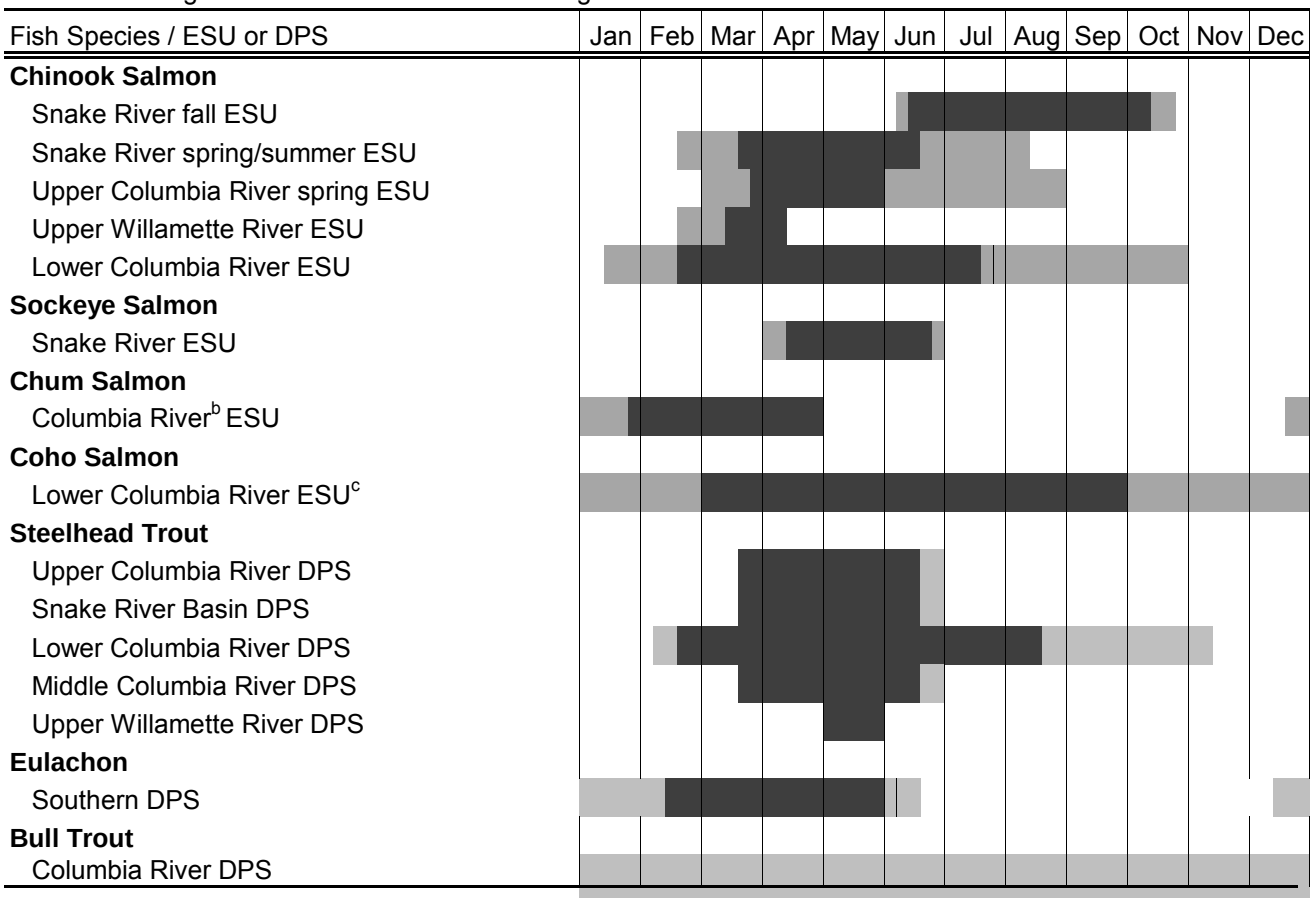
Fish Species / ESU	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Chinook Salmon												
Upper Willamette River ESU												
Lower Columbia River ESU[a]												
Coho Salmon												
Lower Columbia River ESU												
Steelhead Trout												
Lower Columbia River DPS												
Upper Willamette River DPS												

Sources:
ODFW (2008)
Murtagh (2012)

Notes:
Black bars represent the peak migration periods.
Gray bars represent the estimated total period of occurrence with the action area.
DPS = distinct population segment
ESU = evolutionarily significant unit
LCR = lower Columbia River

[a] Spring-run lower Columbia River Chinook that move into the Clackamas River via the lower Willamette River are excluded from the ESU listing; fall run Chinook are expected to be a very small component of the LCR ESU (see text for discussion).

Table 6. Timing of Downstream Juvenile Fish Migrations[a] in the Lower Columbia River



Sources:
NRC (2005)
Parametrix (2010)

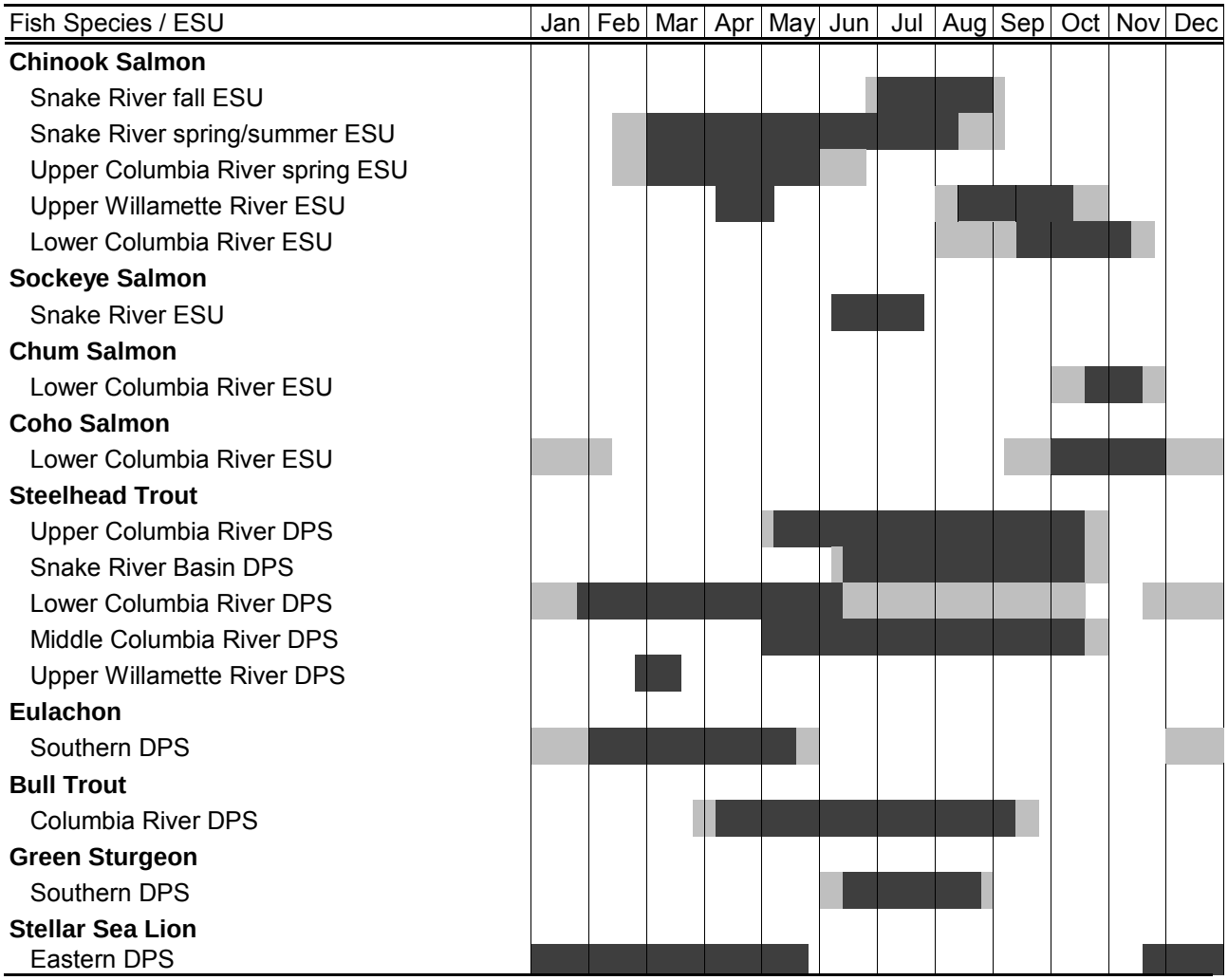
Notes:
Black bars represent the peak migration periods.
Gray bars represent the estimated total period of occurrence with the action area.
DPS = distinct population segment
ESU = evolutionarily significant unit

[a] For species that may use the lower Columbia River for rearing as well as migration (lower Columbia and upper Columbia Chinook \ lower Columbia coho), the time period shown is inclusive of both rearing and outmigration.

[b] Although the Columbia River crossing project identifies both rearing and outmigration for chum, chum are not expected to have a substantive rearing period and this period more accurately reflects outmigration.

[c] Juvenile coho salmon overwinter in freshwater streams, so may be expected in freshwater habitats year round, but the primary period of outmigration is in spring and summer.

Table 7. Timing of Upstream Adult Aquatic Species Migrations in the Lower Columbia River



Sources:
NRC (2005)
Parametrix (2010)

Notes:
Black bars represent the peak migration periods.
Gray bars represent the estimated total period of occurrence with the action area.
DPS = distinct population segment
ESU = evolutionarily significant unit

Table 8. Checklist for Documenting Environmental Baseline and Effects of Proposed Action(s) on Relevant Indicators

Pathways	Environmental Baseline			Effects of the Action(s)		
Indicators	Properly Functioning	At Risk	Not Properly Functioning	Restore[a]	Maintain[b]	Degrade[c]
Water Quality						
Temperature		x			x	
Sediment	x				x	
Chemical contaminants			x	x		
Nutrients		x			x	
Habitat Access						
Physical barriers	x				x	
Habitat Elements						
Substrate and sediment	x				x	
Large woody debris		N/A			x	
Off-channel habitat		N/A			x	
Refugia		N/A			x	
Channel Condition and Dynamics						
Width/depth ratio		x			x	
Streambank condition		x			x	
Floodplain connectivity		x			x	
Flow/Hydrology						
Peak/base flows		x			x	
Drainage network increase		x			x	
Watershed Conditions						
Road density and location		x			x	
Disturbance history		x			x	
Riparian reserves		N/A			x	

Source:
NOAA (1996)

Notes:

[a] For the purposes of this checklist, "restore" means to change the function of an "at risk" indicator to "properly functioning," or to change the function of a "not properly functioning" indicator to "at risk" or "properly functioning" (i.e., it does not apply to "properly functioning" indicators).

[b] For the purposes of this checklist, "maintain" means that the function of an indicator does not change (i.e., it applies to all indicators regardless of functional level.

[c] For the purposes of this checklist, "degrade" means to change the function of an indicator for the worse (i.e., it applies to all indicators regardless of functional level). In some cases, a "not properly functioning" indicator may be further worsened, and this should be noted.

Table 9. Primary Constituent Elements of Critical Habitat for ESA of Salmon and Steelhead Relevant to the Proposed Action Area

	PCEs That May Be Present in the Proposed Action Area				
Species	1. Freshwater spawning sites	2. Freshwater rearing sites to provide for juvenile growth and development	3. Freshwater migration corridors	4. Estuarine areas	5. Nearshore marine areas
Sockeye Salmon (*Oncorhynchus nerka*)					
Snake River	No	Yes[a,c]	Yes[c]	No	No
Chinook Salmon (*O. tshawytscha*)					
Upper Columbia River spring-run	No	Yes[c]	Yes[c]	No	No
Snake River spring/summer-run	No	Yes[c]	Yes[c]	No	No
Snake River fall-run	No	Yes[c]	Yes[c]	No	No
Lower Columbia River	No	Yes	Yes	No	No
Upper Willamette River	No	Yes	Yes	No	No
Chum Salmon (*O. keta*)					
Columbia River	No	Yes[b]	Yes[c]	No	No
Bull Trout (*Salvelinus confluentus*)					
Columbia River	No	Yes[c,d]	Yes[c,d]	No	No
Steelhead (*O. mykiss*)					
Upper Columbia River	No	Yes[a,c]	Yes[c]	No	No
Snake River Basin	No	Yes[a,c]	Yes[c]	No	No
Lower Columbia River	No	Yes	Yes	No	No
Upper Willamette River	No	Yes[a]	Yes	No	No
Middle Columbia River	No	Yes[a,c]	Yes[c]	No	No

Sources:
NOAA (2009, 2012)
USFWS (2012)

Notes:
ESA = Endangered Species Act

[a] These populations are spawning and rearing primarily upstream of the Proposed Action Area; the use by juveniles of the action area for rearing in these cases is considered to be limited. Critical habitat designation in these cases is primarily as a migration corridor.

[b] Chum salmon spend very little time in freshwater, heading quickly out to estuarine and marine areas after emergence from gravel, so freshwater rearing is not considered an appreciable component of their life cycle.

[c] Lower Columbia River portion of the Proposed Action Area only

[d] Bull trout primarily use cold-water tributaries to the LCR for spawning and rearing; their use of the mainstem LCR for feeding or holding is unknown but likely to be limited; use of the mainstem for migration between tributaries may occur in low numbers.

APPENDIX C

CLEAN WATER ACT 404(b)(1) EVALUATION

PRELIMINARY DRAFT CLEAN WATER ACT SECTION 404(b)(1) EVALUATION

Draft Engineering Evaluation and Cost Analysis
Arkema Early Action

Prepared for
Legacy Site Services LLC
468 Thomas Jones Way
Suite 150
Exton, PA 19341

Prepared by

integral consulting inc
319 SW Washington Street
Suite 1150
Portland, OR 97204

July 26, 2012

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LIST OF ACRONYMS AND ABBREVIATIONS

AOC	Administrative Settlement Agreement and Order on Consent
ARAR	applicable and relevant or appropriate requirements
BA	biological assessment
BMP	best management practice
CDF	confined disposal facility
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
COI	constituent of interest
CWA	Clean Water Act
DEQ	Oregon Department of Environmental Quality
EE/CA	engineering evaluation and cost analysis
ENR	enhanced natural recovery
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FS	feasibility study
LWG	Lower Willamette Group
MNR	monitored natural recovery
NAVD88	North American Vertical Datum 1988
NPL	National Priorities List
NRHP	National Register of Historic Places
Portland Harbor Site	Portland Harbor Superfund Site
RAA	removal action area
RAL	removal action levels
RAO	remedial action objective
RI	remedial investigation
RM	river mile

ROD	Record of Decision
SCM	source control measure
SMA	Sediment Management Area
SOW	Statement of Work

1 INTRODUCTION

On behalf of Legacy Site Services LLC, agent for Arkema Inc., this document presents a preliminary draft Clean Water Act (CWA) Section 404(b)(1) evaluation for the Arkema Inc. facility in Portland, Oregon, in support of the draft engineering evaluation and cost analysis (EE/CA). This EE/CA was prepared in support of a non-time-critical removal action (NTCRA) for the Arkema facility. The EE/CA is required by the Administrative Order on Consent (AOC) Statement of Work (SOW) between the U.S. Environmental Protection Agency (EPA) and Arkema, effective June 27, 2005 (Docket No. CERCLA 10-2005-0191). The purpose of the EE/CA is to design a removal action for the EPA-directed removal action area (RAA) at the Arkema site, which is located within a portion of sediment management area (SMA) 14 of the Portland Harbor Superfund Site (also referred to as Portland Harbor Site).

In 2000, the EPA added the Portland Harbor Site to the National Priorities List (NPL) pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended, 42 United States Code Section 9601, et seq. The Portland Harbor Site Study Area currently encompasses approximately 10 miles (river mile [RM] 1.9 to 11.8) of the lower Willamette River in Portland, Oregon, and the riverbank of the Arkema site (Figure 1). In fall 2001, EPA and 10 parties, including Arkema Inc., entered into an AOC for Remedial Investigation/Feasibility Study (RI/FS; CERCLA-10-2001-0240) for the Portland Harbor Superfund Site. The RI/FS characterizes the nature and extent of contamination, assesses the ecological and human health risks at the Portland Harbor Superfund Site, and evaluates feasibility alternative for cleanup. The revised draft final RI was submitted to EPA in August 2011 (Integral et al. 2011), and the Portland Harbor draft FS was submitted to EPA in March 2012 (Anchor QEA et al. 2012).

The EE/CA, to which this document is an appendix, is for the implementation of remedial activities for the Arkema site, located on the Willamette River within the Portland Harbor Superfund Site between RM 6.9 and 7.6 (Figure 2). The EE/CA report partially fulfills the requirements of Sections 3 and 4 of the SOW, which also requires preparation of a biological assessment (BA) and CWA Section 404(b)(1) evaluation to document compliance with these regulations, which were identified by EPA as potentially applicable and relevant or appropriate requirements (ARARs) for the Portland Harbor Superfund Site and specifically the Arkema site.

The sediment remedy for the Arkema site is anticipated to be incorporated as part of the overall remedy selected by EPA for the Portland Harbor Superfund Site, as part of the Proposed Plan or Record of Decision (ROD). The Arkema AOC SOW states that construction of the remedy would occur under the existing AOC with EPA for completion of a NTCRA under CERCLA. Therefore, the Arkema remedy is to be conducted under CERCLA and, under EPA's request, will be coordinated with the Portland Harbor Superfund Site remedy. CERCLA exempts cleanup actions from the process of obtaining permits but requires that cleanup actions comply with ARARs established by EPA. For CERCLA actions where CWA Section 404 is an ARAR,

Section 404 establishes protocols for evaluating alternatives and demonstrating substantive compliance (USEPA 1994). These protocols are referred to as "equivalency analyses."

As part of the Portland Harbor draft FS (Anchor QEA et al. 2012), the Lower Willamette Group (LWG) prepared a preliminary draft CWA Section 404(b)(1) evaluation (Appendix M of the draft Portland Harbor FS report; Anchor QEA et al. 2012) as part of the equivalency analysis. This site-wide draft 404(b)(1) evaluation provide an FS-level estimate of potential compensatory mitigation required to be completed in order to substantially comply with CWA Section 404. The LWG evaluation determined that all of the proposed alternatives evaluated in the Portland Harbor draft FS would comply with CWA Section 404(b)(1). In addition, some of the Portland Harbor draft FS alternatives may require compensatory mitigation to achieve substantive compliance with CWA Section 404(b)(1).

Because the Arkema site remedy is anticipated to be integrated with the overall remedy for the Portland Harbor Superfund site, this preliminary draft CWA Section 404(b)(1) evaluation considers the eight alternatives evaluated in the draft EE/CA as they relate to the alternatives evaluated for the Portland Harbor Site to determine whether the findings of the site-wide 404(b)(1) evaluation are applicable to the EE/CA alternatives.

The Arkema project ideally has a goal of no net loss of aquatic habitat and thus compensatory mitigation may not be necessary. The design approach and site-specific avoidance and minimization measures that can be identified and applied to the selected remedy that would avoid the aquatic habitat impacts are described in Appendix M of the draft Portland Harbor FS report (Anchor QEA et al. 2012). Based on the habitat area occupied by the Arkema RAA and SMA 14 (of which the RAA is a part), compensatory mitigation may or may not be necessary. Based on information presented in the EE/CA, EPA will select one of the alternatives as the proposed action for the Arkema site. LSS anticipates that a revised CWA Section 404(b)(1) evaluation would be conducted on the selected alternative to determine if site-specific compensatory mitigation is necessary and confirm that the selected alternative remains consistent with the Portland Harbor site-wide draft 404(b)(1) evaluation findings.

2 PURPOSE AND NEED FOR THE PROPOSED ACTION

Detailed information on the NTCRA is presented in the AOC between EPA and Arkema, effective June 27, 2005 (Docket No. CERCLA 10-2005-0191).

The purpose of the proposed action is to remediate contaminated sediments to reduce potential risks to acceptable levels consistent with the remedial action objectives (RAOs) for the Arkema site and Portland Harbor Superfund Site. The exact proposed action for the Arkema site will be identified through selection by EPA from the various alternatives developed and assessed in the draft EE/CA, to which this document is an appendix. The remedial alternatives evaluated in the draft EE/CA address nearshore and offshore sediment contamination that is located within potentially jurisdictional waters and, therefore, the sediment remediation is a water-dependent activity (40 Code of Federal Regulations [CFR] § 230.10).

The Arkema site is located within a working harbor with ongoing industrial activities and contains a federally maintained navigation channel. Three docks are present at the Arkema site (Dock 1, Dock 2, and the Salt Dock; see Figure 3). Thus, the proposed action must achieve the project purpose (i.e., sediment remediation) in a manner that is consistent with the current and future maritime uses of the river and the Arkema site and minimize temporary disruptions of these activities. All of the site buildings have been demolished except for the office building, and the only activity at the site is related to the construction of stormwater and groundwater source control measures (SCMs).

3 DESCRIPTION OF THE PROPOSED ACTION

3.1 LOCATION

The Arkema site is located in Portland, Oregon, on the southwest bank of the lower Willamette River between approximate RM 6.9 and 7.6 (Figure 2). The upland portion of the site encompasses approximately 54 acres of land. All of the site buildings have been demolished except for the office building. The EE/CA NTCRA is primarily focused on the in-water portion of the site.[1] However, elements of the EE/CA removal action will integrate portions of the riverbank above mean high water (+13.3 ft National Geodetic Vertical Datum of 1988 [NAVD88]) to the top of bank to facilitate engineering and planning for construction of potential riverbank SCMs in those areas. The remainder of the riverbank will be addressed, as needed, directly with the Oregon Department of Environmental Quality (DEQ) in accordance with the AOC between LSS and DEQ dated October 31, 2008.

The site is bounded to the south (upstream) by the Bird Inc./CertainTeed roofing products facility and the Willbridge petroleum storage terminal (consisting of Kinder Morgan, Chevron, and ConocoPhillips). To the north (downstream), the site is bounded by a City of Portland sewer right-of-way that includes a discharge pipe from the groundwater remediation system located on the former Rhône Poulenc site. The City of Portland right-of-way is located immediately south of the BNSF Railroad Bridge (Figure 2).

3.2 SITE HISTORY AND PHYSICAL SITE CHARACTERISTICS

The following sections briefly describe site history, physical site characteristics, and Willamette River Hydrogeology.

3.2.1 Site History

Inorganic chemicals were manufactured at the Arkema site from 1941 until 2001, when the facility was closed and chemical manufacturing was discontinued. For most of the site's history, the chemical activities involved electrolytic decomposition of brine solutions to manufacture inorganic chemicals, including sodium chlorate, chlorine, sodium hydroxide, hydrogen, and hydrochloric acid. Other chemical manufacturing processes during the site's operational history included the production of dichloro-diphenyl-trichloroethane (DDT) from 1947 to 1954, and ammonium perchlorate from 1958 to 1962 (ERM 2005). A more detailed description of the operational history is presented in the EE/CA Work Plan (Parametrix 2007) and the Upland RI Report (ERM 2005).

[1] The in-water portion of the site below mean low water is leased from the Oregon Division of State Lands.

3.2.2 Physical Site Characteristics

The Arkema property encompasses approximately 54 acres of land comprised of four upland lots and one tract along the Willamette River. Lots 1 and 2 are located on the north end of the site and are covered by a mixture of grasses, bare soil, and disturbed scrub/shrub vegetation (Figure 3). Lots 3 and 4 encompass the developed portion of the site where the majority of chemical manufacturing and processing historically occurred. Tract A along the river is steeply sloping and in some areas is covered with rubble used for bank stabilization; a limited amount of ruderal vegetation (colonizing grasses and invasive forbs such as blackberry) grows among the bank-armoring material. All of the site buildings have been demolished except for the office building and the only activity at the site is related to the construction of stormwater and groundwater SCMs.

The physical features of the site are defined by its industrial history during former plant operations. The shoreline adjacent to the RAA has been substantively developed for industrial activities. Large portions of the shoreline have been rip-rapped (Integral 2010). In unarmored portions of the shoreline, the substrate is sandy and in areas where vegetation is present, it is primarily ruderal. Banks are moderately steep in many areas and largely devoid of overhanging vegetation or complex features that would support nearshore habitat that is valuable to foraging fish and wildlife, particularly in the vicinity of the docks, with an increase in some shallow water habitat and overhanging vegetation downstream of the docks (Integral 2010).

Three docks are present at the Arkema site (Dock 1, Dock 2, and the Salt Dock; see Figure 3). Dock 1 was originally constructed in the 1940s and consists of a pier section that runs perpendicular to the river and the dock section that runs parallel to the river, both with a timber walkway hung from the bottom of the dock. Independent timber walkways that provide access from the dock to two concrete dolphins supported on steel H-piles are located adjacent to the dock. Dock 2 was originally constructed in the late 1950s and early 1960s and has the same configuration and walkways as Dock 1, with the exception that the adjacent dolphins are timber piles and stairs lead under the dock to a small platform, which provides access to barges at low-river stage. The Salt Dock was built in the 1960s to support a conveyor belt system used to offload salt products from ships to the facility. The structure consists mainly of a pier section that runs perpendicular to the river to support the conveyor belt system and a short section of dock that runs parallel to the river, with walkways to two adjacent concrete dolphins.

A surface debris survey was conducted in 2009 as part of the Removal Action Area Characterization (Integral and ARCADIS 2011). The river bank and in-water portions of the site in the area downstream of Dock 2 (Figure 3) include a piling field from a historical dock, miscellaneous concrete debris, metal debris, and logs. Between Docks 1 and 2, surface debris includes concrete, historical pilings and dolphins, metal debris, logs, and a cover of thick invasive vegetation. Debris between Dock 1 and the Salt Dock consists primarily of concrete debris, with smaller amounts of scrap metal, logs, pilings, and a few dolphins. The riverbank

along the Arkema property includes four active outfalls, three of which will soon be abandoned in accordance with a stormwater Mutual Agreement and Order between LSS and DEQ.

Known and potential dredge and fill activities at Arkema are summarized in the EE/CA Work Plan (Parametrix 2007). Periods of maintenance dredging were historically necessary off the Salt Dock and Dock 1 to maintain sufficient depth for docking ships.

3.2.3 Willamette River Hydrology

River stage and currents at the Portland Harbor site are influenced by hydrologic conditions in both the Willamette and Columbia rivers, and are further affected by the operations of federal and non-federal dams along these two rivers. Tidal fluctuations of up to approximately 3 ft per day were observed at the Arkema site during the 2009 EE/CA sediment investigation. A period of relatively high Willamette River stage occurs from late May through June when the Willamette River discharge to the Columbia River is restricted by high flows in the Columbia River that are associated with the spring freshet, as a result of snowmelt in the much larger Columbia River watershed (Anchor QEA et al. 2012). Under certain river stages, flows, and flood tidal conditions, typically in the late summer and fall, the influence of the Columbia River causes periodic slack water and flow reversals in the lower portion of the Willamette River (Anchor QEA et al. 2012).

Average annual mean discharge in the Willamette River during the water years[2] 1973 through 2007 was approximately 33,000 cubic ft per second (cfs) measured at the Morrison Bridge (near RM 12.8) in Portland (Anchor QEA et al. 2012). Late summer discharge levels were typically less than 10,000 cfs and December/January averages approached 100,000 cfs. Most of the Willamette River discharge is from upstream flow sources. A detailed review and discussion of flows on the lower Willamette River are provided in the draft final Portland Harbor RI (Integral et al. 2011) and Portland Harbor FS (Appendix La, Sediment Transport Modeling, Anchor QEA et al. 2012). It is interesting to note that the Portland Harbor RI report documented that DDx compounds are the only constituents of interest (COIs) from upstream sources that increase in concentration during higher Willamette River flows.

The mudline elevation in the vicinity of the EPA-directed horizontal RAA boundary ranges from approximately +15 to +20 ft NAVD88 near the shoreline to -15 to -25 ft NAVD88 on the eastern side of the RAA boundary (Figure 3). The bathymetry presented in Figure 3 shows the riverbed sloping steeply toward the navigation channel upstream of Dock 1 and sloping more gently toward the navigation channel downstream of Dock 2. The distance from the shoreline to the navigation channel ranges from approximately 200 ft between Docks 1 and 2 to 400 ft in the area downstream of Dock 2 (Figure 3).

[2] A water year is defined as the 12-month period beginning October 1 and continuing through September 30 of the following year.

The surface sediment in the Arkema RAA is primarily silt with varying amounts of sand and clay. A mixture of sand and silt characterizes the shallow areas, transitioning to primarily silty materials in the deepwater channel. Areas near the shoreline consist primarily of sand with varying amounts of gravel and coarse anthropogenic debris. Habitat within the EPA-directed horizontal RAA boundary includes Nearshore Shallow Water (+5.1 to -4.9 ft NAVD88), Shallow Water Main Channel (-4.9 to -14.9 ft NAVD88) and Deep Water (deeper than -14.9 ft NAVD88).

3.3 SUMMARY OF ALTERNATIVES AND TECHNOLOGIES

The draft EE/CA considers eight alternatives, including the no action alternative (Alternative 1) and seven active removal alternatives (Alternatives 2(i), 2(r), 3(i), 3(r), 4(i), 4(r), and 5). The proposed alternatives evaluated in the EE/CA are summarized in Table 1 and shown on Figures 4 through 10.

The contaminant distribution was sorted into two general areas within the EPA-directed horizontal RAA boundary (see Figure 3-1 of the draft EE/CA) to support the removal alternative development:

- **Area 1.** The first area is generally between Docks 1 and 2, and is defined by a relatively contiguous area of sediment impacts that exceed the DDT and DDE RALs at any depth, and a few isolated "islands" where COIs were detected predominantly at depth. In general, the highest concentrations of DDx, furans, and selected other EPA-directed COIs occur within the footprint of contiguous sediment impacts of Area 1, and this area encompasses the estimated extent of sediments that exceed the RAL for 2,3,4,7,8-PCDF. Area 1 corresponds to the area where the majority of COI mass resides both in surface and subsurface sediment.

- **Area 2.** The second area consists of relatively isolated islands of sediment downstream of Dock 2 characterized by sporadic and low DDx concentrations at depth. DDx concentrations are not above RALs in surface sediments in this area, and the other EPA-directed COIs are generally not elevated in this portion of the RAA.

Alternative 2(i) integrates a containment approach by capping and also utilizing monitored natural recovery (MNR). Under this alternative, sediments within the majority of Area 1 would be dredged to accommodate an engineered cap of suitable materials, placed to return the sediment bed to grade. The banks would be regraded and capped. Removed materials would be disposed of in an offsite upland facility. MNR would be used to address the remainder of the RAA footprint, including portions of Area 1 where RAL exceedances are largely absent in surface sediments and all of Area 2. A maintenance and monitoring program would be developed and implemented to monitor the cap and MNR performance, and provide protocols for response actions (e.g., incorporation of enhanced natural recovery [ENR] or additional capping) should monitoring indicate a failure to meet the performance standards. However, since surface sediments in areas identified for MNR already meets RALs, changes or response actions are considered to be highly unlikely.

Alternative 2(r) is the same as Alternative 2(i) with the exception that the dredge and cap footprint would include the footprint where any sediments are present above the DDT RAL, regardless of depth (i.e., both Areas 1 and 2). The remainder of the RAA would be addressed by MNR/ENR under a maintenance and monitoring program as described in Alternative 2(i) above.

Alternative 3(i) integrates removal of the most highly contaminated sediments, capping, regrading of riverbanks, and MNR. Removed materials would be disposed of in an offsite upland facility. Engineered sediment caps would be constructed over most of the remainder of Area 1, including placement of engineered slope caps on the affected banks. MNR/ENR would be applied to address the remainder of the RAA footprint (including portions of Area 1 where RAL exceedances are largely absent in surface sediments and all of Area 2) under a maintenance and monitoring program, as described for Alternative 2(i).

Alternative 3(r) is the same as Alternative 3(i) except that sediments in the remainder of Area 1 (i.e., outside the mass removal area) and in all of Area 2, would be dredged to facilitate the placement of an engineered cap. Engineered slope caps would be placed on the affected banks. MNR/ENR would be applied to address the remainder of RAA footprint under a maintenance and monitoring program, as described for Alternative 2(r).

Alternative 4(i) includes dredging to a maximum depth of 15 ft throughout the majority of Area 1, based on practicality considerations and to minimize impacts to adjacent banks, and backfilled to original grades. The riverbanks would be excavated and regraded. In areas where dredging could not remove all contaminated materials, the backfill would be designed to function as a cap. Engineered slope caps would be constructed on the affected banks. Removed materials would be disposed in an offsite upland facility. MNR/ENR would be applied to the remaining RAA footprint (including portions of Area 1 where RAL exceedances are largely absent in surface sediments and all of Area 2) under a maintenance and monitoring program, as described for Alternative 2(i).

Alternative 4(r) includes the greatest amount of dredging within the EPA-directed RAA among the alternatives. The alternative is the same as Alternative 4(i), except all material exceeding the DDE and DDT RALs would be dredged wherever reasonably feasible (combined footprint of Areas 1 and 2). MNR/ENR would be applied to the portion of the RAA footprint that is below the DDE and DDT RALs under a maintenance and monitoring program, as described for Alternative 2(r).

Alternative 5 includes dredging and in-place containment using a nearshore CDF. A nearshore CDF would be constructed to contain a portion of the EPA-directed RAA boundary in-place (i.e., constructed around a portion of the most highly contaminated material). The remaining RAA footprint exceeding the DDE and DDT RALs (combined footprint of Areas 1 and 2 outside of the CDF footprint) would be dredged to a maximum depth of 15 ft (as discussed for Alternative 4(r)) and suitable backfill placed to return the site to original grades. Docks, piling,

and debris would be removed. Outfall 4 would be protected, and outfalls which fall within the footprint of the CDF would be removed. In areas where dredging could not remove all contaminated materials, the backfill would be designed to function as a cap. Engineered slope caps would also be constructed in bank areas. MNR/ENR would be applied to the portion of the RAA footprint that is below the DDE and DDT RALs under a maintenance and monitoring program, as described for Alternative 2(r).

3.4 TIMING OF DISCHARGE AND FILL

The construction schedule for implementation of the removal action will be developed during the remedial design and will take into account considerations of site operations as well as the implementation timing for the overall Portland Harbor site-wide remedy. It is anticipated that the construction of the remedial action would occur during the approved in-water work window for the Willamette River. Timing for completion of any compensatory mitigation that may be required to offset potential adverse impacts of the sediment remedy will be determined during remedial design.

Under the preferred alternative outlined in the EE/CA (Alternative 2(i)), the goal is to complete project activities within a single work window. Some alternatives that involve more intensive construction activities such as extensive dredging or CDF construction may extend into an additional one or two seasons to accomplish the work. Alternatives with the potential for multiple year time frames (e.g., Alternatives 4(i), 4(r), and 5) would be expected to have greater impacts to aquatic resources and listed species because of the longer period of time; however, in all cases the proposed alternatives are not expect to extend past a few seasons of in-water work.

3.5 SOURCES AND GENERAL CHARACTERISTICS OF DREDGED AND FILL MATERIAL

Characteristics of dredged and fill material will be determined during remedial design and will be consistent with the details provided in Section 3.6 of Appendix M of the draft Portland Harbor FS report (Anchor QEA et al. 2012).

3.6 QUANTITY OF MATERIAL

Table 2 presents the proposed quantity of material to be discharged and removed under each proposed alternative.

3.7 PROJECTED LIFE

The remedial alternatives represent actions that would reduce or isolate potential risks posed by contaminated sediments. The minimum estimated life of the cap material proposed for use in the action alternatives is at least 100 years. General long-term monitoring requirements are included in the Portland Harbor draft FS (Anchor QEA et al. 2012) and include measures to ensure caps are stable and satisfy performance standards. Specific monitoring requirements and response measures will be included in a long-term monitoring and reporting plan to be

developed as part of the Arkema NTCRA design. Following implementation, long-term monitoring will commence to monitor effectiveness of the remedial actions.

4 EVALUATION CRITERIA

The regulations under 40 CFR 230 "Section 404(b)(1) Guidelines for Specification of Disposal Sites for Dredged and Fill Material" (or CWA Section 404(b)(1) regulations) were used to support the development of the site-wide draft 404(b)(1) evaluation and also to apply to the evaluation of alternatives for the Arkema project.

The CWA Section 404(b)(1) regulations require evaluation of the aquatic impacts associated with the discharge of dredged or fill material. The purpose of CWA Section 404(b)(1) as described in 40 CFR § 230.1(a) "is to restore and maintain the chemical, physical, and biological integrity of waters of the United States through the control of discharges of dredged or fill material." Specifically, 40 CFR § 230.1(c) states that "dredged or fill material should not be discharged into the aquatic ecosystem, unless it can be demonstrated that such a discharge will not have an unacceptable adverse impact…" Section 230.10 of Subpart B of the CWA Section 404(b)(1) regulations provides four conditions that must be satisfied in order to make a finding that a proposed discharge complies with the requirements described in 40 CFR Part 230. These four conditions include:

1. No discharge of dredged or fill material shall be permitted if there is a practicable alternative to the proposed discharge that would have less adverse impact on the aquatic ecosystem, so long as the alternative does not have other significant adverse environmental impacts (see Section 5.0 and 6.0). An alternative is considered practicable if it is "available and capable of being done after taking into consideration cost, existing technology, and logistics in light of overall project purposes." 40 CFR § 230.10(a).
2. No discharge of dredged or fill material shall be permitted if it violates any water quality standards, jeopardizes any endangered or threatened species, destroys or adversely modifies critical habitat, or disturbs any marine sanctuaries (see Sections 5.0, 6.0, and 7.0). 40 CFR § 230.10(b).
3. No discharge of dredged or fill material shall be permitted that will result in significant degradation of any waters of the United States, including adverse effects on human health or welfare, effects on municipal water supplies, aquatic organisms, wildlife, or special aquatic sites (see Section 8.0). 40 CFR § 230.10(c).
4. No discharge of dredged or fill material shall be permitted unless appropriate and practicable steps have been taken that will minimize potential adverse impacts (see Sections 10.0 and 13.0). 40 CFR § 230.10(d).

Due to the EE/CA process, specific detailed design information is not available for the remedial actions considered in this evaluation. The potential impacts to aquatic and other resources discussed in this evaluation are, therefore, estimated extents of effects based upon the EE/CA information and determination of effects in the Portland Harbor site-wide draft 404(b)(1) evaluation (Appendix M of the draft Portland Harbor FS report; Anchor QEA et al. 2012).

Specific conservation measures to avoid and minimize construction impacts will be developed as a component of the remedial design prior to determining if compensatory mitigation consistent with CWA Section 404(b)(1) is necessary. Potentially relevant impact avoidance and minimization measures and compensatory mitigation measures are discussed in Section 13 of Appendix M of the draft Portland Harbor FS report (Anchor QEA et al. 2012). During remedial design for the Arkema project, it is anticipated that this preliminary draft CWA Section 404(b)(1) will be refined to determine whether the design generates conditions that exceed the adverse impacts of the EPA-selected site-wide remedy in the ROD and determine an adequate amount of compensatory mitigation. Should the final remedial design for the Arkema project include these measures where appropriate, or include actions that are otherwise compliant with these measures, it should be considered consistent with the findings of the Portland Harbor site-wide draft 404(b)(1).

The potential impacts of the eight EE/CA alternatives are evaluated based on conditions and factors set forth in 40 CFR § 230.11, and the factual determination and discussion of conditions for compliance are provided in Section 12 and discussed in more detail in Appendix M of the draft Portland Harbor FS report (Anchor QEA et al. 2012).

In Appendix M of the draft Portland Harbor FS report (Anchor QEA et al. 2012), potential impacts resulting from implementation of the various alternatives and technologies are characterized by their relative magnitude. For the purposes of the Portland Harbor site-wide draft 404(b)(1) evaluation, the following definitions are used:

- Short-term impacts are localized and temporal in nature and occur for less than several weeks. Short-term impacts are characterized as having a lesser magnitude than that of long-term impacts, which can have more substantial effects to the surrounding environment. Short-term impacts will often be avoided or minimized (mitigated) through use of certain construction methods and/or best management practices (BMPs) selected during the design phase.
- Long-term impacts include actions that result in a permanent change in the condition or use of the surrounding environment, or impacts that are measurable years after completion of the action. Six terms were used to describe the magnitude of impact, compared to the existing baseline. These terms, in order from least to highest impact are: 1) No Impact; 2) Beneficial Impact; 3) Negligible Impact; 4) Minor Adverse Impact; 5) Moderate Adverse Impact; and 6) Significant Adverse Impact. Table 3 describes the hierarchy of impacts and terminology that will be used throughout the document.

The Portland Harbor site–wide draft 404(b)(1) evaluation identified the potential impacts to the components of the aquatic environment based on the distinction between removal focused alternatives (those distinguished with -r) and integrated alternatives (those distinguished with -i). The eight action alternatives considered in the EE/CA include combinations of removal and

in-place technology applied to the Arkema site, so some mix of potential impacts will be present in each EE/CA alternative.

5 POTENTIAL IMPACTS ON PHYSICAL AND CHEMICAL CHARACTERISTICS OF THE AQUATIC ECOSYSTEM

The Portland Harbor site-wide draft 404(b)(1) evaluation indicated that each of the proposed alternatives evaluated in the Portland Harbor draft FS (Anchor QEA et al. 2012) could be designed to be substantially compliant with the regulations. However, the evaluation also indicated that potential impacts on physical and chemical characteristics of the aquatic ecosystem were likely to become increasingly adverse on a site-wide basis for the larger footprint alternatives that required 10 or more years to implement due to the cumulative effect of the disturbances on the aquatic ecosystem.

It is anticipated that the potential impacts resulting from implementation of the draft EE/CA proposed alternatives would be consistent with the determinations sets forth in Section 5 of Appendix M of the draft Portland Harbor FS report (Anchor QEA et al. 2012).

5.1 SUBSTRATE

Existing physical and chemical substrate conditions in the Arkema site are described in detail in the EE/CA.

For the purposes of the assessment of the physical condition of substrate in the Portland Harbor site-wide-draft 404(b)(1) evaluation, several classes of substrate were identified based on their importance to aquatic species in Arkema project area (see Anchor QEA et al. 2012, Appendix M for additional detail on habitat indicators):

- Sand
- Silt/sand (less than 40 percent silty material)
- Silt (greater than 40 percent)
- Cobble (e.g., 3 to 6-in. rounded rock)
- Angular rock (e.g., 3 to 6-in. quarry spall or mechanically processed rock)
- Large rock (greater than 6 in. in diameter)
- Anthropogenic debris.

The chemical conditions of the substrate within the Arkema RAA are presented in Section 2.2 of this EE/CA report. The removal action at the Arkema site is intended to reduce any potentially unacceptable risks associated with the chemical conditions of the substrate. Findings for the EE/CA-level analysis with respect to the conditions of the substrate are deferred to the findings of the Portland Harbor evaluation, because the potential impacts to physical and chemical conditions of the substrate in the Arkema project area are expected to be consistent with the

potential impact findings of the Portland Harbor site-wide draft 404(b)(1) evaluation (presented in Section 5.1.2 in Appendix M of the draft Portland Harbor FS report; Anchor QEA et al. 2012) Additional Arkema site information will be provided in an updated version of this document during remedial design.

The potential impacts to physical and chemical conditions of the substrate in the Arkema project area are expected to be consistent with the potential impact findings of the Portland Harbor site-wide draft 404(b)(1) evaluation presented in Section 5.1.2 in Appendix M of the draft Portland Harbor FS report (Anchor QEA et al. 2012). Alternative 1 (No Action) would have no impact on the physical or chemical condition of the substrate. As the alternative active areas increase from Alternative 2(i) to 5, there would be increased potential for adverse impacts to the physical conditions of the substrate. Alternatives 2(i) through 5 may involve placement of armor rock (e.g., in the shoreline area), which would have a moderate adverse effect on the physical condition of the substrate that may require implementation of avoidance and minimization measures and/or possibly compensatory mitigation. Alternatives 2(i), 2(r), 3(i), 3(r), 4(i), 4(r) and 5 would involve significant removal of sediment from within the nearshore area and the slope of the shoreline may be reconfigured. In addition, Alternatives 4(i), 4(r), and 5 may take 2 or more years to construct and represent the longest duration of short-term impacts. It is anticipated that proposed Alternatives 2(i) through 5 would have a beneficial long-term impact on the chemical conditions of the substrate.

5.2 SUSPENDED PARTICULATES/TURBIDITY

Existing turbidity conditions for surface water within the Arkema project area are based on processes that occur at or within the larger watershed. Additional Arkema site–specific information regarding existing conditions will be provided in an updated version of this document during remedial design.

For the EE/CA analysis, conditions and impacts related to turbidity are assumed to be similar to the findings of the Portland Harbor site-wide draft 404(b)(1) evaluation (Appendix M of the draft Portland Harbor FS report; Anchor QEA et al. 2012). The remedial technologies and methods for implementing Alternatives 2(i) through 5 are similar to the methods evaluated in Appendix M of the draft Portland Harbor FS report (Anchor QEA et al. 2012), and the surface water within the Arkema site was included in the site-wide evaluation conducted for the Portland Harbor draft FS (Anchor QEA et al. 2012). Therefore, consistent with the findings in Section 5.2 of Appendix M of the draft Portland Harbor FS report (Anchor QEA et al. 2012), large footprint alternatives, which involve more removal of sediments, are more likely to lead to adverse impacts on turbidity. The potential impacts of implementation of remedial alternatives on turbidity with the Arkema site are expected to be negligible to minor adverse, depending on the extent of the dredging involved. As discussed in the EE/CA, there is likely little benefit from deploying barrier controls for the purpose of controlling turbidity, relative to their disproportionate impacts on implementability, schedule, and cost.

5.3 WATER QUALITY

Existing water quality within the Arkema project area is generally based on processes that occur at or within the larger watershed although some localized areas are impacted by transition zone water. Additional LSS site–specific information regarding existing conditions will be provided in an updated version of this document during remedial design.

For the EE/CA analysis, conditions and impacts related to water quality are assumed to be similar to the findings of the Portland Harbor site-wide draft 404(b)(1) evaluation (Appendix M of the draft Portland Harbor FS report; Anchor QEA et al. 2012). The removal technologies and methods for implementing Alternatives 2(i) through 5 are similar to the methods evaluated in Appendix M of the draft Portland Harbor FS report (Anchor QEA et al. 2012) and the surface water within the Arkema site is included in the site-wide evaluation conducted for the Portland Harbor draft FS (Anchor QEA et al. 2012). Therefore, consistent with the findings in Section 5.3 of Appendix M of the draft Portland Harbor FS report (Anchor QEA et al. 2012), large footprint alternatives, which involve more removal of sediments, are more likely to lead to minor adverse impacts on water quality. The Portland Harbor draft FS indicates that all of the alternatives are predicted to result in similar long-term surface water COI concentrations, which included remediation of the sediments within the Arkema site.

Alternative 1 (No Action) would not result in any active remediation, and therefore no impact on surface water quality. For Alternatives 2(i) through 5, the potential impacts of implementation of active remedial alternatives on water quality are expected to be negligible (Alternatives 2(i) and 2(r)) to minor adverse (Alternatives 3(i), 3(r), 4(i), 4(r), and 5) based on the extent of dredging involved and duration of construction. Per Section 6.3.4.2 of the EE/CA, the use of sheetpile barriers considered during removal is not expected to appreciably decrease the surface water impacts due to releases that will occur during sheetpile placement and removal, losses through sheetpile interlocks and equalization ports, and loss of retained water once the sheetpile system is removed.

5.4 CURRENT PATTERNS AND WATER CIRCULATION AND NORMAL WATER FLUCTUATIONS

Existing conditions for water flow and circulation within the Arkema site are a function of processes in the lower Willamette River watershed. Section 5.4 of Appendix M of the draft Portland Harbor FS report (Anchor QEA et al. 2012), indicates that implementation of the Portland Harbor draft FS alternatives would have negligible impact on current patterns, water circulation and water fluctuations. Similarly, it is anticipated that implementation of EE/CA Alternatives 2(i) through 5 would also have negligible impacts on these characteristics of the aquatic environment through discharge of dredged or fill material.

5.5 SALINITY GRADIENTS

The Willamette River is a freshwater system with no significant salinity factors; therefore, this criterion does not apply.

6 POTENTIAL IMPACTS ON BIOLOGICAL CHARACTERISTICS OF THE AQUATIC ECOSYSTEM

The Portland Harbor site-wide draft 404(b)(1) evaluation indicated that each of the proposed alternatives evaluated in the Portland Harbor draft FS (Anchor QEA et al. 2012) could be designed to be substantively compliant with the regulations. However, the Portland Harbor site-wide evaluation also indicated the potential impacts on the biological characteristics of the aquatic ecosystem were likely to become increasingly adverse on site-wide basis for the larger footprint alternative that required 10 or more years to implement due to the cumulative effect of the disturbances on the aquatic ecosystem.

Under the preferred alternative outlined in the EE/CA, Alternative 2(i), the goal is to complete project activities within a single work window. Some alternatives that involve more intensive construction activities such as extensive dredging or CDF construction may extend into an additional one or two seasons to accomplish the work. Alternatives with the potential for multiple year time frames (i.e., Alternatives 4(i), 4(r), and 5) would be expected to have greater impacts to aquatic resources and listed species because of the longer period of time; however, in all cases the proposed alternatives are not expected to extend past a few seasons of in-water work.

It is anticipated that the potential impacts from implementation of Alternatives 1 through 5 would be consistent with the determinations set forth in Section 6 of Appendix M of the draft Portland Harbor FS report (Anchor QEA et al. 2012).

6.1 THREATENED AND ENDANGERED SPECIES

To demonstrate compliance with Section 7(a) of the Endangered Species Act (ESA; Section 7), which was identified by EPA as an ARAR for the Portland Harbor Superfund Site and the Arkema site, the LWG has prepared a preliminary draft site-wide BA (Anchor QEA 2012) that considers the potential impacts of the proposed removal action, including potential remedial technologies and construction of compensatory mitigation that may be conducted, if necessary. The Portland Harbor preliminary draft site–wide BA covers the entire Portland Harbor but does not evaluate the potential impact of the various alternatives; rather it considers the likely construction methods to be used and considers the potential impacts to listed species from an action using those methods. The Portland Harbor preliminary draft site–wide BA includes an overall action area for the project that is significantly larger than the Portland Harbor Site to accommodate a range of areas where compensatory mitigation might occur. The Arkema Preliminary Draft BA, which was prepared in support of the EE/CA (see Appendix B to the EE/CA), relies upon the findings of the Portland Harbor preliminary draft site–wide BA.

The species that may be present within the Arkema project area and vicinity are discussed in more detail in Section 6.1 of Appendix M of the draft Portland Harbor FS report (Anchor QEA et al. 2012) and presented in Table 4.

Because the implementation of the remediation within the Arkema project site was considered as part of the proposed action evaluated in the preliminary draft site-wide BA (Anchor QEA 2012), the conclusions of that document apply to the implementation of the proposed alternatives evaluated in the draft EE/CA.

Based on the guidance and definitions provided in the preliminary draft site-wide BA (Anchor QEA 2012), and previously discussed project effects relative to baseline conditions, it was determined that the remedial actions may affect and are likely to adversely affect Lower Columbia River Chinook, and Upper Willamette River Chinook salmon. Additionally, it is concluded that the proposed action may affect and is not likely to adversely affect Lower Columbia River steelhead, Upper Willamette River steelhead, and Lower Columbia coho. Justification for these determinations is provided in the preliminary draft site-wide BA, as well as determinations for the species that are found in the broader action area considered in the preliminary draft site-wide BA, but are not common within the Willamette River or the Arkema site.

Although there may be some short-term adverse effects, overall, the proposed removal action will provide long-term benefits for listed species by removing contaminated sediments. BMPs, avoidance, and minimization measures, and possible compensatory mitigation, are anticipated to be components of the selected remedy to meet mitigation requirements under the CWA. The CWA mitigation may be applicable conservation measures for ESA species. Therefore, the overall impact of the site-wide project, which includes completion of remediation with the Arkema project, on ESA-listed species is anticipated to result in a net benefit in the long term to threatened and endangered species.

For the purposes of assessing potential impact for this evaluation of the proposed Alternatives 2(i) through 5, alternatives with larger active remediation footprint and/or remediation requiring two or more in-water work seasons to complete (Alternatives 4(i), 4(r), and 5) are more likely to have an adverse effect on listed fish than alternatives which have a smaller active remediation footprint and require fewer in-water work seasons to complete (Alternatives 2(i) and 2(r)). Specific potential adverse impacts are consistent with those described in Section 6.2 of Appendix M of the draft Portland Harbor FS report (Anchor QEA et al. 2012). Alternative 1 (No Action) would have no impact on listed species. In the long term, the removal of contaminated sediments would be anticipated to have a beneficial impact on listed species for all alternatives.

6.2 FISH, CRUSTACEANS, MOLLUSKS, AND OTHER AQUATIC ORGANISMS IN THE FOOD WEB

Contaminant concentrations within the Arkema site may affect aquatic organisms in the food web. Further, the highly modified nature of the Arkema site and adjacent uplands (as described previously in Section 2) limits the availability of suitable habitat for many species.

Physical impacts to fish and invertebrates in the food web may occur as a result of potential short-term water quality impacts related to turbidity or other water quality issues identified in the draft EE/CA Section 7, discussed in Section 5 of Appendix M of the draft Portland Harbor FS report (Anchor QEA et al. 2012), and summarized in Section 5 of this document. Initially, the dredging and placement of material for in-place treatment or the dredge residuals cover layer will remove the existing non-mobile benthic species in the area of active remediation. Food web impacts may also occur due to changes in substrate and water depth of habitats.

The removal activities are conducted in order to remove or isolate contaminants and may also provide some beneficial long-term impacts to benthic habitat from some of the substrate changes. In the long term, removal or isolation of the contamination may improve benthic forage conditions nearby and aid in the recovery of the ecosystem. Specific assessment of existing habitat conditions will occur as part of the remedial design process based on the footprint of the preferred alternative.

Alternative 1 (No Action) would have no impact on the food web. Implementation of the remaining alternatives would be anticipated to have some short-term adverse impacts on the food web, with Alternatives 4(i), 4(r), and 5 resulting in short-term impacts over a few years. It is anticipated that the implementation of the remedial action along with possible compensatory mitigation would result in a net benefit to chemical conditions of the substrate and overall aquatic environment by removing contaminated material and replacing potentially lost habitat functions. The local food web would be negligibly impacted in the short-term through implementation of Alternatives 2(i), 2(r), 3(i), and 3(r), increasing to minor adverse impacts for Alternatives 4(i), 4(r), and 5, due to the longer duration of construction required for completing these alternatives.

6.3 IMPACTS ON OTHER WILDLIFE

As indicated in Section 6.3 of Appendix M of the draft Portland Harbor FS report (Anchor QEA et al. 2012), a diverse group of birds and a small number of aquatic or aquatic-dependent mammals are known to occupy habitat areas in the lower Willamette River. As indicated in Section 2, there is limited suitable habitat within the Arkema project area. Table 5 lists the Oregon Department of Fish and Wildlife state-listed sensitive species that my occur within the Action Area defined in the Portland Harbor preliminary draft site-wide BA (Anchor QEA 2012) and the Arkema RAA draft BA.

Consistent with the findings of the Portland Harbor site-wide 404(b)(1) evaluation (Appendix M, Anchor QEA et al. 2012), the in-water work for either in-place treatment or removal proposed for Alternatives 2(i) through 5 may disrupt other wildlife through noise and additional construction activity in the Arkema project. Although the active remediation area affected increases by each alternative for Alternatives 2(i) through 5, it is anticipated that the remedial action alternatives will result in a net benefit to fish and wildlife and the overall aquatic environment by removing the contaminated material. The project-related activities are anticipated to be conducted only within the approved in-water work window; therefore construction activities will not occur year round. Alternatives 4(i), 4(r), and 5 would require approximately two or three in-water work seasons to complete construction and, therefore, would have additional short-term disruptions to wildlife over a longer timeframe than the alternatives that can be completed in fewer work seasons. The No Action alternative (Alternative 1) would have no impact on other wildlife.

7 POTENTIAL IMPACTS ON SPECIAL AQUATIC SITES

The Portland Harbor site-wide draft 404(b)(1) evaluation indicated that each of the proposed alternatives evaluated in the Portland Harbor draft FS (Anchor QEA et al. 2012) could be designed to be substantively compliant with the regulations. However, the Portland Harbor site-wide evaluation also indicated that potential impacts on special aquatic sites were likely to become increasingly adverse on a site-wide basis for the larger footprint alternatives that required 10 or more years to implement due to the cumulative effect of the disturbances on the aquatic ecosystem.

It is anticipated that the impacts resulting from implementation of Alternatives 1 through 5 would be consistent with the determinations set forth in Section 7 of Appendix M of the draft Portland Harbor FS report (Anchor QEA et al. 2012).

7.1 SANCTUARIES AND REFUGES

No sanctuaries and refuges exist within the Arkema project area; therefore, Alternatives 1 through 5 would have no impact on sanctuaries and refuges.

7.2 WETLANDS

Based on the wetlands identification process conducted for the Portland Harbor Site, as detailed in Section 7.2 of Appendix M of the draft Portland Harbor FS report (Anchor QEA et al. 2012), no wetlands occur within the Arkema project area. Therefore, Alternatives 1 through 5 would have no impact on wetlands.

7.3 MUDFLATS

Based on the mudflat identification process conducted for the Portland Harbor Site, as detailed in Section 7.3 of Appendix M of the draft Portland Harbor FS report (Anchor QEA et al. 2012), no mudflats occur within the Arkema project area. Therefore, Alternatives 1 through 5 would have no impact on mudflats.

7.4 VEGETATED SHALLOWS

Based on the vegetated shallows identification process conducted for the Portland Harbor Site, as detailed in Section 7.4 of Appendix M of the draft Portland Harbor FS report (Anchor QEA et al. 2012), no vegetated shallows occur within the Arkema project area. Therefore, Alternatives 1 through 5 would have no impact on vegetated shallows.

7.5 CORAL REEFS

Because the Willamette River is a temperate inland freshwater system, no coral reefs occur within the Arkema project area. Therefore, Alternatives 1 through 5 would have no impact on coral reefs.

7.6 RIFFLE AND POOL COMPLEXES

Based on the riffle and pool identification process conducted for the Portland Harbor Site, as detailed in Section 7.3 of Appendix M of the draft Portland Harbor FS report (Anchor QEA et al. 2012), no riffle and pool complexes occur in the Arkema project area. Therefore, Alternatives 1 through 5 would have no impact on riffle and pool complexes.

8 POTENTIAL EFFECTS ON HUMAN USE CHARACTERISTICS

The Portland Harbor site-wide draft 404(b)(1) evaluation indicated that each of the proposed alternatives evaluated in the Portland Harbor draft FS (Anchor QEA et al. 2012) could be designed to be substantively compliant with the regulations. However, the site-wide evaluation also indicated that potential impacts on human use characteristics were likely to become increasingly adverse on a site-wide basis for the larger footprint alternatives that required 10 or more years to implement due to the cumulative effect of the disturbances on the aquatic ecosystem.

It is anticipated that the potential impacts resulting from implementation of Alternatives 1 through 5 would be consistent with the determinations set forth in Section 8 of Appendix M of the draft Portland Harbor FS report (Anchor QEA et al. 2012).

8.1 MUNICIPAL AND PRIVATE WATER SUPPLIES

Based on the municipal and private water supplies identification process conducted for the Portland Harbor Site, as detailed in Section 8.1 of Appendix M of the draft Portland Harbor FS report (Anchor QEA et al. 2012), no points of diversion occur in the Arkema project area, and there are no plans for use of Willamette River water for drinking water. Consistent with the findings of the Portland Harbor site-wide draft 404(b)(1) evaluation, implementation of remedial alternatives are not anticipated to impact industrial/manufacturing water uses, and the implementation of Alternatives 1 through 5 would have no impact on water rights within the vicinity of the Arkema project area.

8.2 RECREATIONAL AND COMMERCIAL FISHERIES

It was determined that implementation of the Portland Harbor draft FS alternatives would have negligible impacts on recreational and commercial fisheries (see Section 8.2 of Appendix M of the draft Portland Harbor FS report; Anchor QEA et al. 2012). During construction of EE/CA Alternatives 2(i) through 5, recreational fishing activities would be excluded from the Arkema project area. Assessment of the impact to recreational fishing in the Arkema project area will be revised during remedial design for the preferred alternative, when the specific details of institutional controls are identified. Alternative 1 would have no impact on recreational and commercial fisheries.

8.3 WATER-RELATED RECREATION

Water-related recreation is common throughout the Willamette River and includes recreational boating, personal motorized recreational watercraft use (e.g., jet skis), and wakeboarding, primarily during the summer months. Due to the extensive commercial and industrial use of

the Arkema project area and site-specific security controls, water-related recreational activities previously listed, as well as activities such as swimming, SCUBA diving, and windsurfing, are not common in the Arkema project area, and in fact these would be trespasser scenarios in the RAA. Assessment of the impact to water-related recreation in the Arkema project area will be revised during remedial design for the preferred alternative, when the specific details of construction sequencing and institutional controls are identified. Alternative 1 would have no impact on water-related recreational activities.

8.4 AESTHETICS

The Arkema project area is located within the Portland metropolitan area, and the properties within the Arkema project area and adjacent properties are primarily zoned as heavy industrial and river industrial and are located within the River Industrial Greenway Overlay Zone (COP 2011). According to Portland City Code 33.440.030(A)(4), the River Industrial Greenway Overlay Zone "encourages and promotes the development of river-dependent and river-related industries which strengthen the economic viability of Portland as a marine shipping and industrial harbor, while preserving and enhancing the riparian habitat and providing public access where practical." The aesthetic nature of the Arkema project area is characterized by its urban setting and includes a variety of commercial and industrial uses.

Any impacts from the action alternatives to the aesthetic character of Portland Harbor would be temporary (primarily during the in-water work window) and localized to the area where remedial activities are being conducted. Assessment of the impact to aesthetics in the Arkema project area will be revised during remedial design for the preferred alternative, when the specific details of the remedy, construction sequencing, and institutional controls are identified. Alternative 1 would have no impact on aesthetics.

8.5 PARKS, NATURAL AND HISTORIC MONUMENTS, NATIONAL SEASHORES, WILDERNESS AREAS, RESEARCH SITES, AND SIMILAR PRESERVES

No parks, natural and historic monuments, national seashores, wilderness areas research sites, or similar preserves exist within the Arkema project area; therefore, Alternatives 1 through 5 would have no impact on these areas.

8.6 OTHER FACTORS IN THE PUBLIC INTEREST

8.6.1 Cultural Resources

The cultural resources analysis for the Portland Harbor site-wide draft 404(b)(1) evaluation indicates that the potential of any alternative, including any proposed alternative to be

conducted for the Arkema project area, to affect historic or cultural properties depends on the amount of associated upland ground disturbance.

As required by the AOC, a site-specific cultural resources evaluation was conducted for the Arkema NCTRA site. A summary of the evaluation results is provided in Section 5 of the EE/CA report and the complete report (Ogle and Ellis 2012) can be found in Appendix E of the EE/CA report. Willamette Cultural Resource Associates (Ogle and Ellis 2012) indicated that it is unlikely that the Arkema NCTRA site contains intact archaeological deposits, and because of the degree of industrial development at the site, if cultural resources are present, they are unlikely to retain enough integrity to be eligible for listing on the National Register of Historic Places (NRHP).

Alternative 1 involves no action, and would have no impact on cultural resources. Given the results of the archaeological assessment as presented in Section 5 and Appendix E of the EE/CA, it is unlikely that any archaeological materials would be encountered within the Arkema project area proposed for Alternatives 2(i) through 5. Three dock structures may be removed under Alternatives 2(i) through 5. These docks have been recommended as not eligible for listing in the NRHP. Therefore, the potential to affect an NRHP-eligible historic property is low under any of the alternatives.

8.6.2 Activities Affecting Coastal Zones

The Oregon Coastal Zone extends inland along the Columbia River to the downstream end of Puget Island at approximately RM 39 (OAR 660-035-0010(7)(c)). Therefore, the Arkema project area is not within a Coastal Zone as defined by the State of Oregon and this section is not applicable.

8.6.3 Navigation

Much of the work involved in remedial activities proposed for Alternatives 2(i) through 5 involves large vessels and machinery that would be relatively consistent with the types of vessels and equipment typically in the Arkema project area. However, since the RAA is outside the navigation channel, potential navigation impacts resulting from the implementation of Alternatives 2(i) through 5 are unlikely, but may arise to protect the integrity of capping areas. The EE/CA evaluated the site use requirements within the Arkema project area to determine the application of remedial technologies such that future maintenance dredge depths in and near the federal navigation channel would not be adversely affected through implementation of the remedy in those areas. Short-term impacts to navigation would occur primarily during the in-water work window and would be localized to the area where remedial activities are being conducted. Assessment of the impact to navigation in the Arkema project area will be revised during remedial design for the preferred alternative, when the specific details of the remedy, construction sequencing, and institutional controls are identified. Alternative 1 would have no impact on navigation.

9 EVALUATION AND TESTING OF DISCHARGE OR FILL MATERIAL

The evaluation procedures and testing sequences outlined in 40 CFR Subpart G are intended to support the determinations concerning the suitability of the material proposed for discharge into waters of the United States.

It is anticipated that all in-place remediation materials discharged as fill, including the residuals cover layer, will be obtained from a source that meets the standards for suitability of material according to specifications established at the time of the removal action design. Therefore, any materials imported to the Arkema project area will have low or non-detectable levels of contaminants that are not expected to have significant adverse impacts on water quality or biota in the short or long term.

Depending on the selected alternative, additional testing may be necessary at the design level to determine characteristics of sediments to be removed within the Arkema project area to inform the proposed plans for disposal of those sediments in other facilities as discussed in Section 6 of the Portland Harbor draft FS (Anchor QEA et al. 2012).

10 ACTIONS TO MINIMIZE POTENTIAL ADVERSE EFFECTS AND PRACTICABLE STEPS TO MINIMIZE POTENTIAL ADVERSE IMPACTS (SUBPART H)

10.1 ACTIONS CONCERNING THE LOCATION OF THE DISCHARGE (230.70)

Under each alternative, the specific remedial action location was determined through an assessment of the COIs in the sediment. More information is provided in Section 3 of the EE/CA. The locations of active remediation under all the alternatives are therefore based on the project purpose and need to reduce potential risk.

The development of the remedial alternatives also considered the following criteria:

- Vertical extent of sediment contamination within the Arkema project area, considering the depth of sediment exceeding RALs
- Physical features (e.g., outfalls, existing bathymetry, and docks) and slope stability considerations
- Substantive requirements of CWA Section 404, including a goal of no net loss of aquatic habitat.

10.2 ACTIONS CONCERNING THE MATERIAL TO BE DISCHARGED, THE MATERIAL AFTER DISCHARGE, THE METHOD OF DISPERSION AND TECHNOLOGY

Section 13 of Appendix M of the draft Portland Harbor FS report (Anchor QEA et al. 2012) provides a detailed overview of the potential avoidance and minimization measures, BMPs, and compensatory mitigation estimates related to the implementation of the proposed alternatives evaluated in the EE/CA. It is anticipated that EPA, consistent with CWA Section 404(b)(1) regulations to first avoid and then minimize impacts to the aquatic environment, will select specific avoidance and minimization measures appropriate to the remedy during development of the remedial design. Because Alternative 1 involves no action, no minimization actions will be required. The following sections focus on Alternatives 2(i) through 5.

10.3 ACTIONS AFFECTING PLANT AND ANIMAL POPULATIONS

The implementation of Alternatives 2(i) through 5 would be conducted in such a way as to minimize potential impact to plant and animal populations through avoidance and minimization measures and possible implementation of compensatory mitigation.

10.4 ACTIONS AFFECTING HUMAN USE

The remedial alternatives are proposed for implementation in order to improve human health and the environment through remediation of contaminated sediments that potentially impacts biota; therefore, the overall effect on human use as a result of implementation of Alternatives 2(i) through 5 is assumed to be beneficial in the long term for recreational fishing and other recreation. Some short-term impacts that occur may be avoided or minimized through application of the avoidance and minimization measures discussed in Section 13. However, water-based recreation and recreational fishing do not commonly occur within the Arkema project area, especially in the RAA due to security-based access restrictions, although some recreational use occurs within and near the federal navigation channel.

11 ANALYSIS OF PRACTICAL ALTERNATIVES PURSUANT TO SITE CRITERIA

Section 6.6 of the EE/CA provides the analysis of practical alternatives pursuant to CERCLA criteria. As previously stated, the purpose of the proposed action is to remediate the contaminated sediments at the Arkema project area to reduce potentially unacceptable risks to acceptable levels consistent with the RAOs for the Arkema project area and Portland Harbor Site. The EE/CA evaluates the available alternatives, including discharge locations, capable of achieving the project purpose consistent with 40 CFR 230.10(a). It is anticipated that the remedial alternative selected by EPA in the proposed plan and ROD will be the alternative (consistent with CERCLA criteria) most available and capable of achieving the project purpose in a manner that is designed to avoid unacceptable adverse impacts to the aquatic ecosystem.

The subsections below summarize the findings of the EE/CA relative to the CWA Section 404(b)(1) alternatives analysis criteria.

11.1 SITE AVAILABILITY

Pursuant to the CWA Section 404(b)(1) regulations, an alternative is practicable if it is available to meet and is capable of meeting the project purpose, among other considerations. The regulations at 40 CFR 230.1(a)(2) state "an area not presently owned by the applicant, which could be reasonably obtained, utilized, expanded, or managed in order to fulfill the basic purpose of the proposed activity may be considered." For the Portland Harbor draft FS (Anchor QEA et al. 2012), which includes the Arkema project area, EPA has determined that an alternative would be available if it is owned or could be reasonably obtained, used, expanded, or managed by the individual responsible parties. For the purposes of the draft EE/CA, it is assumed that neither site ownership nor access to the remedial action area at the Arkema project area will be an impediment to the implementation of the proposed alternatives.

Within the Portland Harbor draft FS (Anchor QEA et al. 2012), it is assumed that proposed confined aquatic disposal and CDF sites are examples of the types of sites that may be used in combination to address disposal requirements. This does not preclude the consideration of other sites owned by others for use in removal action design as necessary. Therefore, availability of a specific disposal site is not assessed in the EE/CA or this document.

11.2 COST EFFECTIVENESS

Pursuant to the CWA Section 404(b)(1) regulations, a determination of practicability must consider if fill or disposal can be accomplished at a reasonable cost (40 CFR 230.10[a][2]). To determine cost effectiveness, the costs of the alternatives and their protectiveness were compared to other alternatives and considered in light of the project purpose. Costs for each

alternative are evaluated in Section 7 of the EE/CA and compared among the alternatives in Section 8.3. It is anticipated that the removal action alternative for the Arkema project area selected by EPA in the action memorandum, as further developed during remedial design, will be the alternative (consistent with CERCLA's cost-effectiveness criteria) most available and capable of achieving the project purpose in a manner that is designed to avoid unacceptable adverse impacts to the aquatic ecosystem.

11.3 FEASIBILITY

It is anticipated that the remedial alternative for the Arkema project area selected by EPA in the action memorandum, as further developed during removal action design, will be the alternative (considering technical and administrative feasibility) most available and capable of achieving the project purpose in a manner that is designed to avoid unacceptable adverse impacts to the aquatic ecosystem.

11.4 AQUATIC IMPACTS FROM DISPOSAL

Potential aquatic impacts from the removal action are discussed in Sections 5 and 6.

11.5 CONSERVATION AND RECOVERY

Section 13 of Appendix M of the draft Portland Harbor FS report (Anchor QEA et al. 2012) provides a detailed set of potential avoidance and minimization measures that may be applied in the development of the removal action design. Implementation of specific avoidance and minimization measures, such as the decision to backfill a dredged area up to the pre-existing grade, are decisions requiring more information than is available at the EE/CA level of detail. Section 13 also describes the process for determining compensatory mitigation to account for the unavoidable losses to aquatic functions. Finally, conservation measures that may account for impacts to any ESA-listed species and their critical habitat are described in the Portland Harbor preliminary draft site-wide BA (Anchor QEA 2012).

11.6 LIMIT NUMBER OF SITES

The sizes and locations of the removal action areas were determined through application of a mass-removal breakpoint analysis and risk-based screening. This process is described in detail in Section 2 and 3 of the EE/CA. The process for identification of the disposal sites considered in the EE/CA is described in Section 6.6 of this EE/CA.

12 FACTUAL DETERMINATIONS ON SIGNIFICANT DEGRADATION, EITHER INDIVIDUALLY OR CUMULATIVELY, OF THE AQUATIC ECOSYSTEM

Because Alternatives 2(i), 2(r), 3(i), 3(r), 4(i), 4(r), and 5 are substantively similar in type and application of technology to the remedial alternatives considered in the Portland Harbor draft FS (Anchor QEA et al. 2012), the factual determinations set forth in Section 12 of Appendix M of the draft Portland Harbor FS report (Anchor QEA et al. 2012) apply to the EE/CA alternatives, and it is determined that based on available information, each of the alternatives could be designed to be in compliance with CWA Section 404(b)(1) (Table 6).

13 DETERMINATION ON INCLUSION OF ALL APPROPRIATE AND PRACTICABLE MEASURES TO MINIMIZE POTENTIAL HARM ON THE AQUATIC ECOSYSTEM

In evaluating a specific discharge, EPA is required to examine other practicable alternatives to the proposed discharge, which may include not discharging or discharging at a different aquatic site (40 CFR 230.5[c]). The guidelines state that discharge of dredged or fill material is not permitted "if there is a practicable alternative to the proposed discharge which would have less adverse impact on the aquatic ecosystem, so long as the alternative does not have other significant adverse environmental consequences" (40 CFR 230.10[a]). An alternative is considered practicable "if it is available and capable of being done after taking into consideration cost, existing technology, and logistics in light of overall project purposes." That is, if there are locations or suitable methods that meet the overall project purpose and do not have other significant adverse environmental consequences, then the least environmentally damaging option will be the highest priority for selection of these alternatives. Thus, EPA may find under its regulatory criteria that alternatives that emphasize capping and MNR (e.g., Alternatives 2(i) or 2(r)) are preferred to the alternatives that emphasize removal and thus have involve greater discharge from dredging (e.g., Alternatives 3(i), 3(r), 4(i), 4(r), or 5), as alternatives emphasizing capping and MNR would have less adverse impact on the aquatic ecosystem and "do not have other significant adverse environmental consequences" (40 CFR § 230.10[a]).

Because detailed design work is not yet available for areas considered under this evaluation, the short-term and long-term aquatic impacts expected for the EE/CA are representative examples using the preliminary engineering design information. These expected impacts are also consistent with the impacts expected for the alternatives described in the Portland Harbor draft FS (Anchor QEA et al. 2012) and Portland Harbor site-wide draft 404(b)(1) evaluation. Specific conservation measures to avoid and minimize short-term construction impacts will be developed during the removal action design phase.

Preliminary conservation measures that should be considered in developing the final plan to minimize construction impacts are presented in Section 13 of Appendix M of the draft Portland Harbor FS report (Anchor QEA et al. 2012). To the extent that the removal action ultimately selected results in an unavoidable net loss in terms of the relative function and value of habitat, the loss will be evaluated and mitigated, as appropriate, in accordance with applicable federal and state ARARs, as described in Section 13.4 of Appendix M of the draft Portland Harbor FS report (Anchor QEA et al. 2012). The Portland Harbor draft FS (Anchor QEA et al. 2012) provided preliminary evaluations of potential compensatory mitigation estimates for each SMA under each proposed Portland Harbor draft FS alternative. The results for SMA 14, which includes the Arkema RAA, depending on the Portland Harbor draft FS alternative evaluated, ranged from a mitigation debit of 5.04 acres to a mitigation credit of 1.41 acres, which

corresponds to the area in acres of high-quality, off-channel, shallow-water habitat with gently sloped shorelines and natural substrates that need to be created or restored to offset potential adverse impacts. For the purpose of the EE/CA, it is assumed that a potential range of compensatory mitigation may be necessary based on the implementation of Alternatives 2(i) through 5; Alternative 1 (No Action) would have no impact on the aquatic environment and would not require any compensatory mitigation.

14 OTHER FACTORS IN THE PUBLIC INTEREST

14.1 NEED

The remedial alternatives assessed in the EE/CA represent the set of alternatives that passed through an initial screening for feasibility and cost effectiveness. The cleanup or remediation should address the contaminated sediments in a way that is consistent with the maritime uses of the Arkema project area and Portland Harbor Site.

Potential impacts from the sediment remedy will be avoided and minimized to the extent practicable, and any unavoidable losses of aquatic functions resulting from the sediment remedy will be addressed through possible compensatory mitigation.

The project purpose is to achieve remediation in a manner that is consistent with other maritime uses of the Arkema project area and minimization of disruptions of these activities. The longer time frames and construction requirements (up to two or three in-water work seasons) for Alternatives 4(i), 4(r), and 5 would involve more disruption of existing maritime uses and have a potential economic impact at the Arkema site and, therefore, such an alternative is less able to demonstrate consistency with the stated purpose and need for the removal action. EPA may determine that the other alternatives are more practicable with less adverse impact on the aquatic ecosystem and do not have "other significant adverse environmental consequences" (40 CFR 230.10[a]).

Other factors include:

- Fish and wildlife impacts (see Section 6)
- Water quality (see Section 5)
- Historic and cultural resources (see Section 8)
- Activities affecting coastal zones (not applicable)
- Environmental benefits (see Portland Harbor draft FS [Anchor QEA et al. 2012] for discussion of overall green remediation and potential impacts on habitat in Section 14.6)
- Navigation (see Section 8).

15 REVIEW OF CONDITIONS FOR COMPLIANCE

The potential for significant adverse impacts on the aquatic ecosystems resulting from implementation of the removal action alternatives are mitigated to the extent possible through the application of avoidance and minimization measures and possibly by compensatory mitigation described in Section 13 of Appendix M of the draft Portland Harbor FS report (Anchor QEA 2012). According to the guidance, "…no discharge of dredged or fill material shall be permitted if there is a practicable alternative to the proposed discharge which would have less adverse impact on the aquatic ecosystem, so long as the alternative does not have other significant adverse environmental consequences" (40 CFR 230.10 [a]).

The alternatives with the most potential for adverse impacts on the aquatic environment are Alternatives 4(i), 4(r), and 5 because of their larger active remediation footprint and greater amount of material discharged as fill, as well as the extended timeframe required for implementation. However, proposed Alternatives 2(i) through 5 are all anticipated to result in a net benefit in the long-term due to removal of contamination.

15.1 AVAILABILITY OF PRACTICABLE ALTERNATIVES

CFR 230.10 of Subpart B of the CWA Section 404(b)(1) regulations further specifies four general conditions which must be met for compliance (see Section 4). These include consideration of practicability, compliance with the ESA, protections for water quality and human uses, and compliance with the avoidance, minimization, and possibly compensatory mitigation requirements. Activities that do not involve a discharge of material into waters of the United States (e.g., the Willamette River) include Alternative 1 (No Action). However, even though the Portland Harbor site already meets a risk goal of 10^{-4} for DDT, DDD, and DDE, this alternative is not considered to be acceptable. Alternatives that result in fewer impacts to the aquatic environment due to the duration of implementation (i.e., Alternatives 2(i) and 2(r)) and that meet the purpose and need of the remedial action may be considered available. The results of the analyses for the alternatives evaluated in the Portland Harbor draft FS (Anchor QEA et al. 2012) are applicable to the EE/CA alternatives and are summarized in Section 15.1 of Appendix M of the draft Portland Harbor FS report (Anchor QEA et al. 2012).

15.2 COMPLIANCE WITH PERTINENT LEGISLATION

All alternatives are expected to comply with the Oregon Environmental Cleanup Law, ESA, CWA Section 404(b)(1), and Federal Emergency Management Agency requirements. As noted in Section 8.2.3 of the Portland Harbor draft FS (Anchor QEA et al. 2012), although all alternatives result in reductions in levels of contamination in the Arkema site surface water, remediation of the Arkema site alone is not sufficient for the site surface water to achieve

certain chemical-specific water quality standards or National Recommended Water Quality Criteria due to background concentrations in upstream surface water.

16 FINDINGS

Based on the results of the evaluation of the Portland Harbor draft FS alternatives and the demonstrated consistency between those Portland Harbor draft FS alternatives and the proposed remedial alternatives for the Arkema project area evaluated in the EE/CA, it is determined that each of the proposed action Alternatives 2(i) through 5 evaluated in the draft EE/CA would comply with the CWA Section 404(b)(1) regulations; however, the implementation of Alternatives 4(i), 4(r), and 5 would result in short-term minor adverse impacts over more years than Alternatives 2(i), 2(r), 3(i) and 3(r).

Specific findings are reserved for a future draft of this document.

17 REFERENCES

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FIGURES

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FEATURE SOURCES:
Property Boundaries and Transportation Features: Metro RLIS, 2010

0 0.75 1.5 3 Miles

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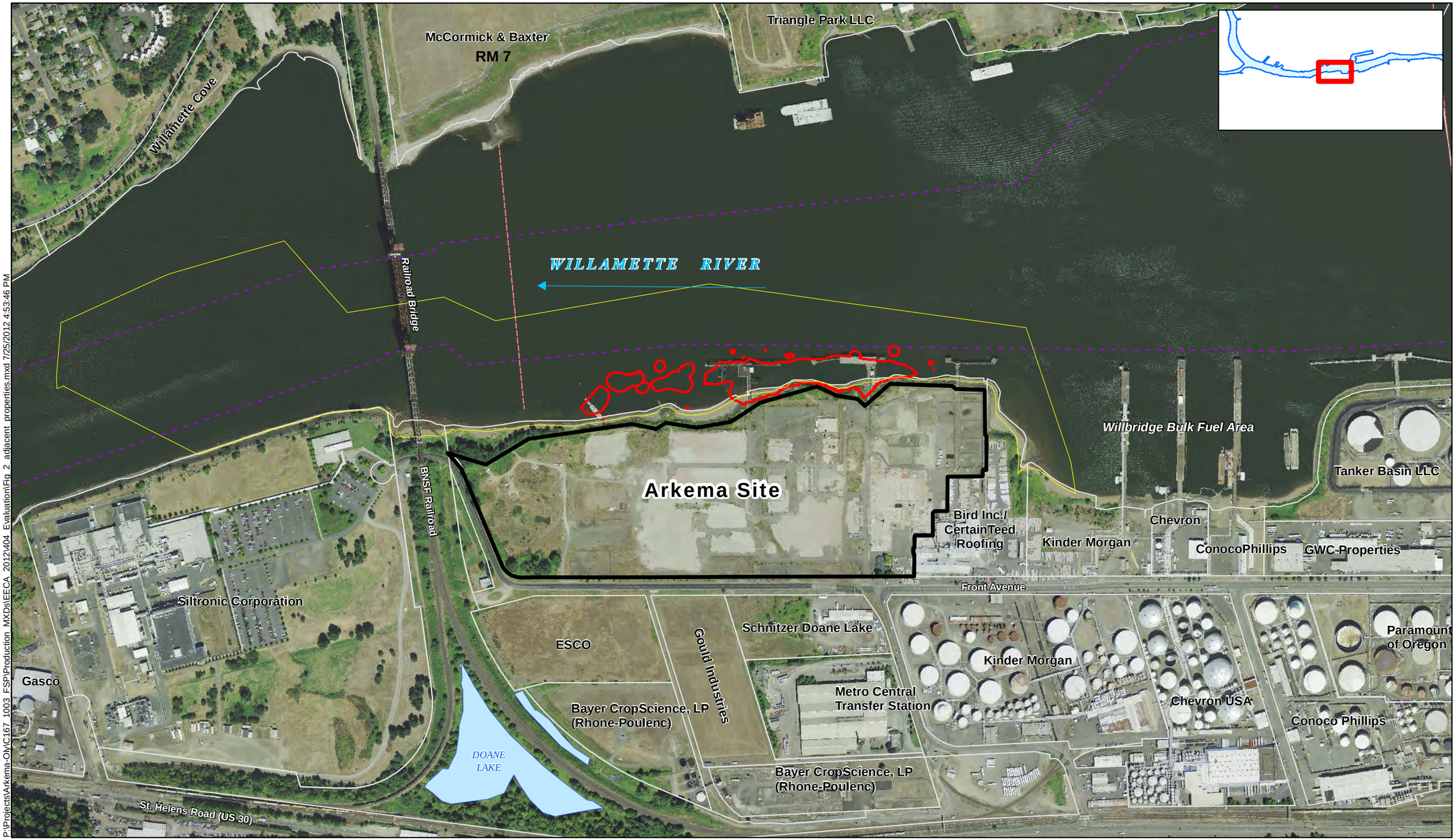
Figure 1
Site Location
Arkema Early Action
Clean Water Act Section 404(b)(1) Evaluation



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FEATURE SOURCES:
Aerial: Metro, 2007
Property Boundaries: Metro RLIS

0 250 500 Feet

N

Map Features

- EPA-Directed Horizontal RAA Boundary
- Sediment Management Area 14
- River Miles
- Navigation Channel
- Waterfront Taxlots
- Doane Lake (Current)

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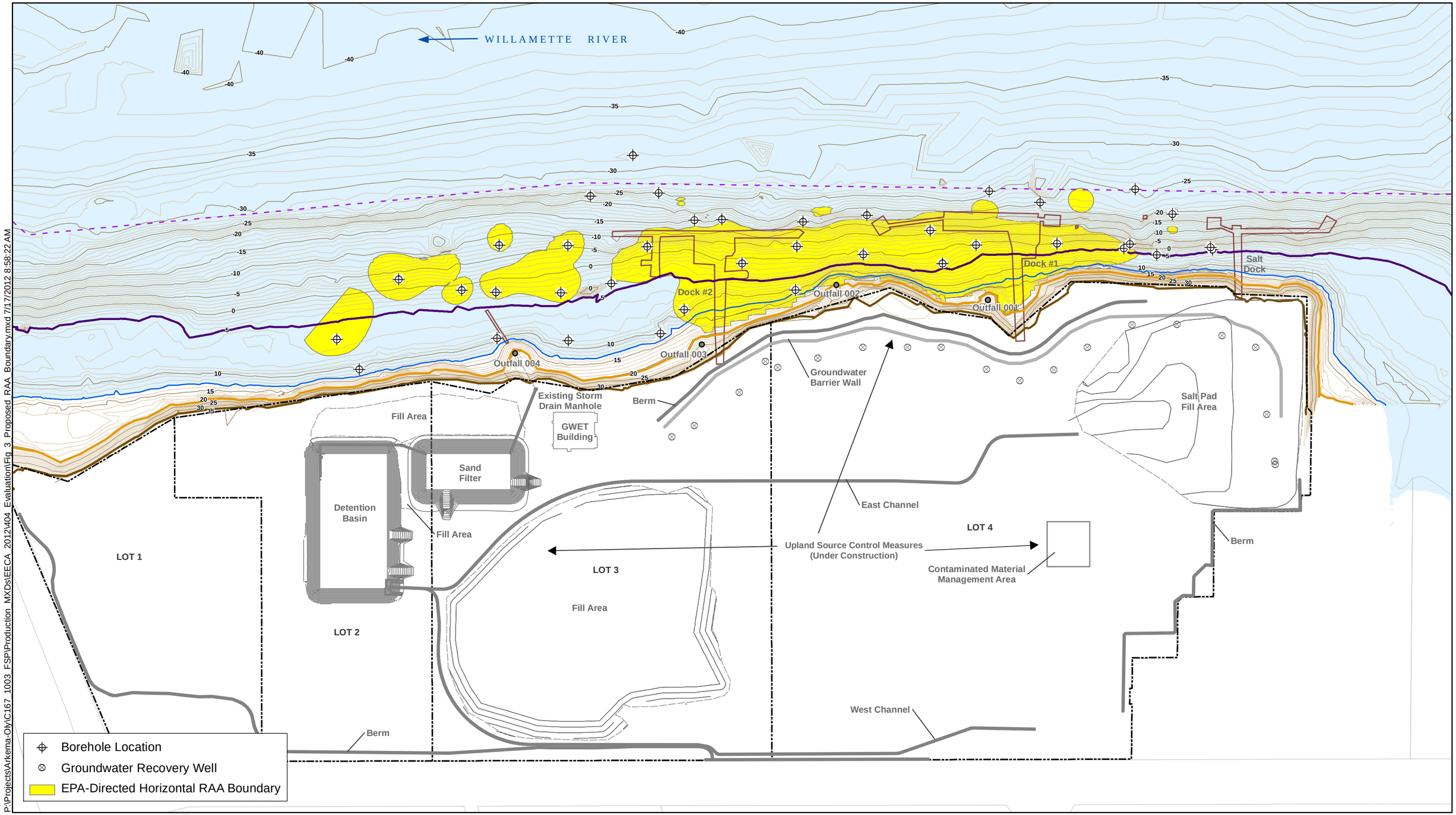
Figure 2
Aerial Photograph and Adjacent Properties
Arkema Early Action
Clean Water Act Section 404(b)(1) Evaluation



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FEATURE SOURCES:
Property Boundaries, OHW, TOB: 2007 DEA Topographic Survey
Navigation Channel: US Army Corps of Engineers
Elevation Contours: Areas Below +16 ft: 2004 Bathymetry and 2001 LiDAR;
Area above +16ft: 2007 DEA Topographic Survey

0 100 200 Feet

N

Map Features

- Property and Lot Boundary
- Navigation Channel
- Top of Bank
- +13 ft NAVD88
- Ordinary High Water (20.5 ft NAVD88)
- Ordinary Low Water (5 ft NAVD88)
- 5 ft Contour (NAVD88)
- 1 ft Contour (NAVD88)
- Docks and Structures
- River Edge

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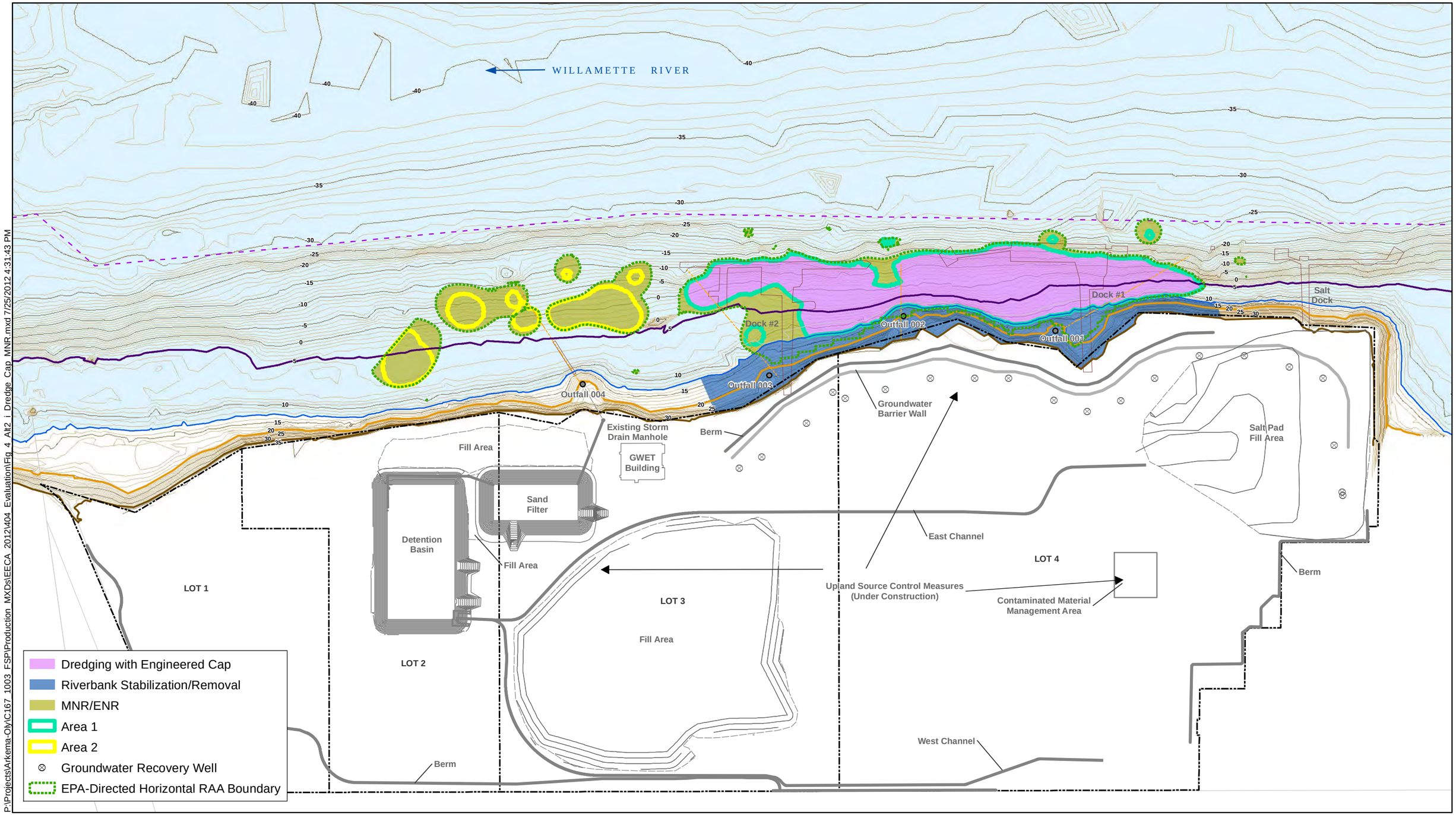
Figure 3
Horizontal RAA Boundary
Arkema Early Action
Clean Water Act Section 404(b)(1) Evaluation



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FEATURE SOURCES:
Property Boundaries, OHW, TOB: 2007 DEA Topographic Survey
Navigation Channel: US Army Corps of Engineers
Elevation Contours: Areas Below +16 ft: 2004 Bathymetry and 2001 LiDAR;
Area above +16ft: 2007 DEA Topographic Survey

0 100 200 Feet

Map Features

- Property and Lot Boundary
- Storm Drain
- Navigation Channel
- Top of Bank
- +13 ft NAVD88
- Ordinary High Water (20.5 ft NAVD88)
- Ordinary Low Water (5 ft NAVD88)
- 5 ft Contour (NAVD88)
- 1 ft Contour (NAVD88)
- Docks and Structures
- River Edge

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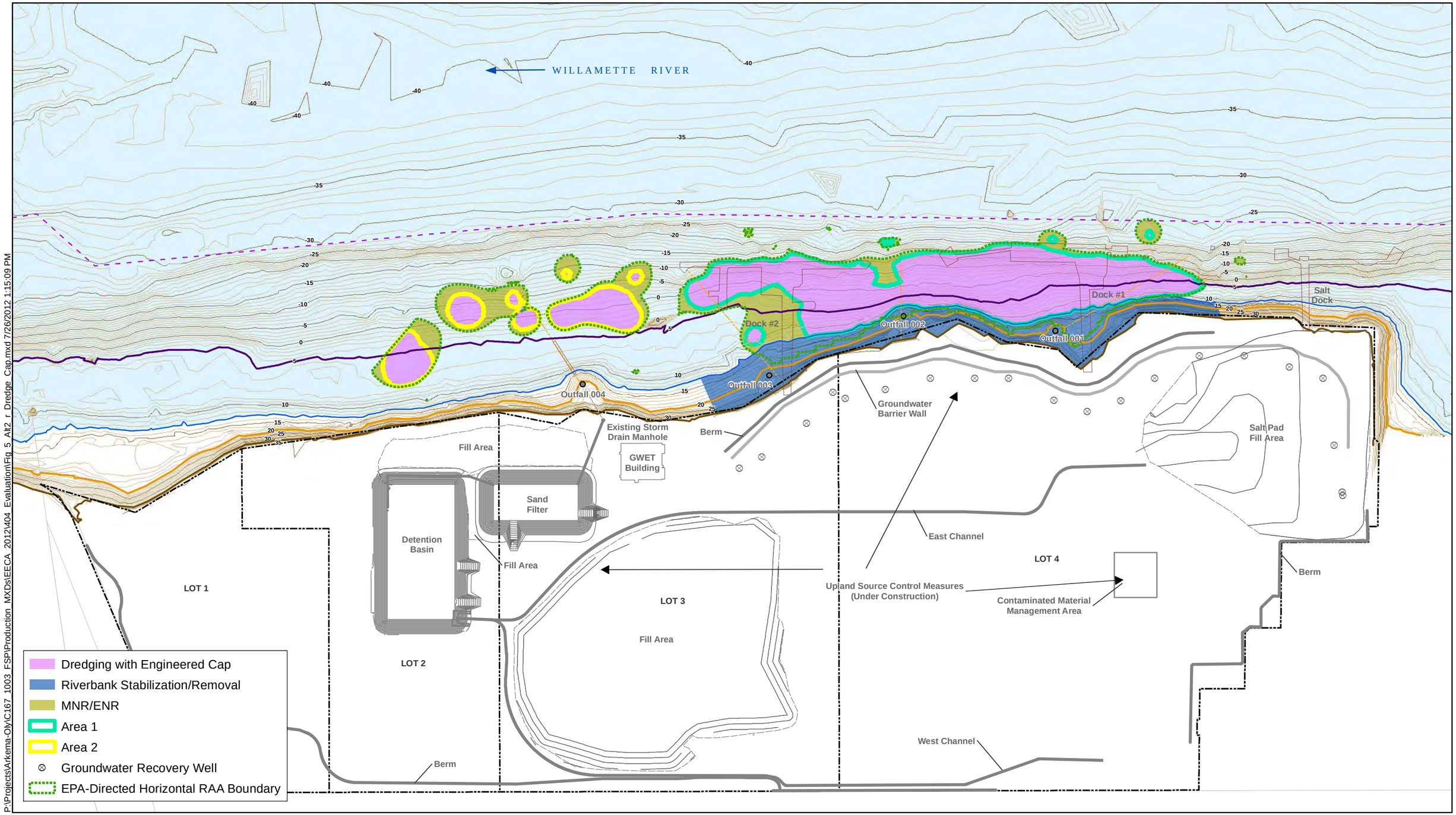
Figure 4
Alternative 2(i): Dredge to Facilitate
a Cap and Optimized MNR
Arkema Early Action
Clean Water Act Section 404(b)(1) Evaluation



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FEATURE SOURCES:
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Navigation Channel: US Army Corps of Engineers
Elevation Contours: Areas Below +16 ft: 2004 Bathymetry and 2001 LiDAR;
Area above +16ft: 2007 DEA Topographic Survey

0 100 200 Feet

Map Features

- Property and Lot Boundary
- Storm Drain
- Navigation Channel
- Top of Bank
- +13 ft NAVD88
- Ordinary High Water (20.5 ft NAVD88)
- Ordinary Low Water (5 ft NAVD88)
- 5 ft Contour (NAVD88)
- 1 ft Contour (NAVD88)
- Docks and Structures
- River Edge

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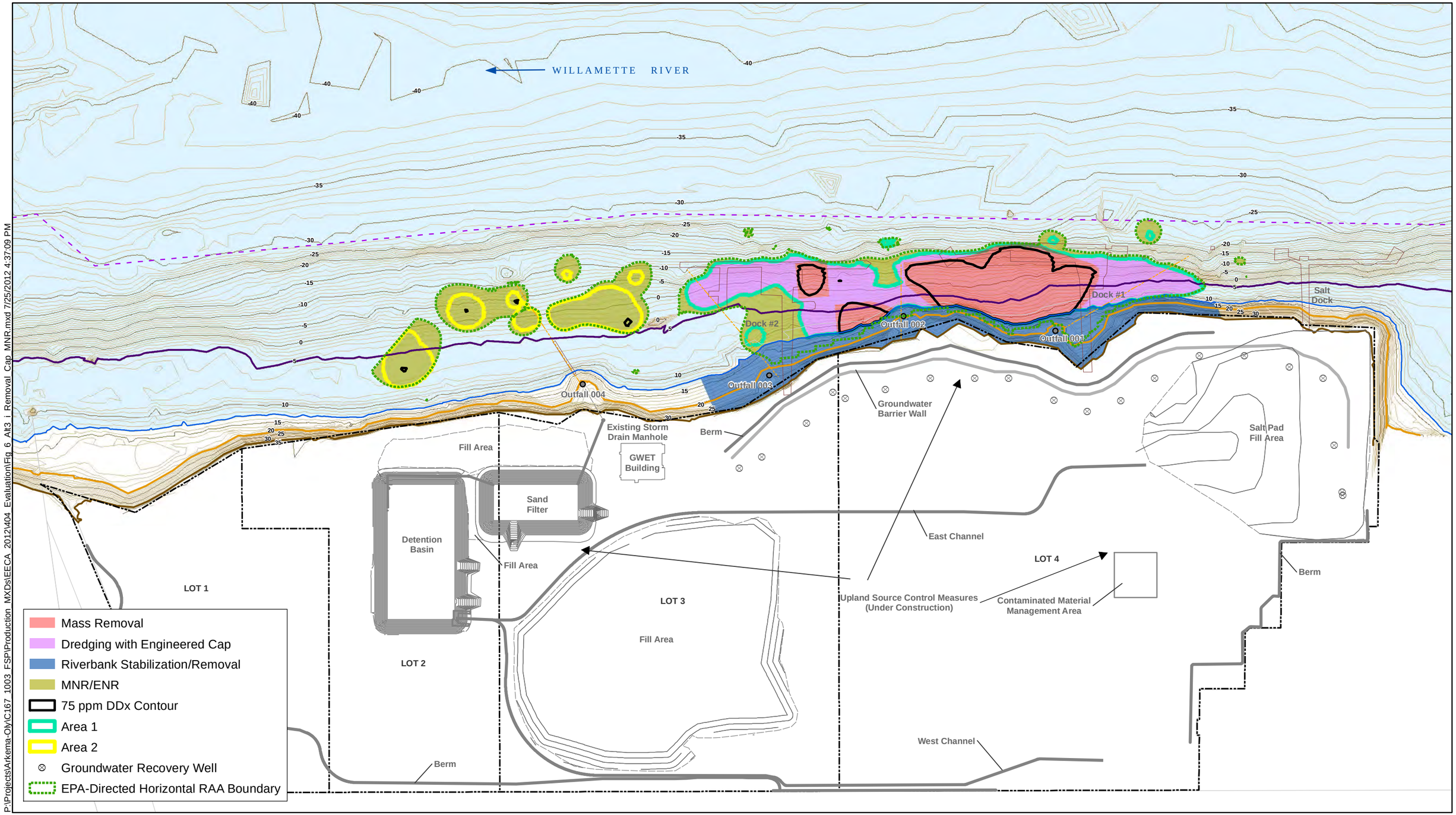
Figure 5
Alternative 2(r): Dredge to Facilitate a Cap
Arkema Early Action
Clean Water Act Section 404(b)(1) Evaluation



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FEATURE SOURCES:
Property Boundaries, OHW, TOB: 2007 DEA Topographic Survey
Navigation Channel: US Army Corps of Engineers
Elevation Contours: Areas Below +16 ft: 2004 Bathymetry and 2001 LiDAR;
Area above +16ft: 2007 DEA Topographic Survey

0 100 200 Feet

Map Features

- Property and Lot Boundary
- Storm Drain
- Navigation Channel
- Top of Bank
- +13 ft NAVD88
- Ordinary High Water (20.5 ft NAVD88)
- Ordinary Low Water (5 ft NAVD88)
- 5 ft Contour (NAVD88)
- 1 ft Contour (NAVD88)
- Docks and Structures
- River Edge

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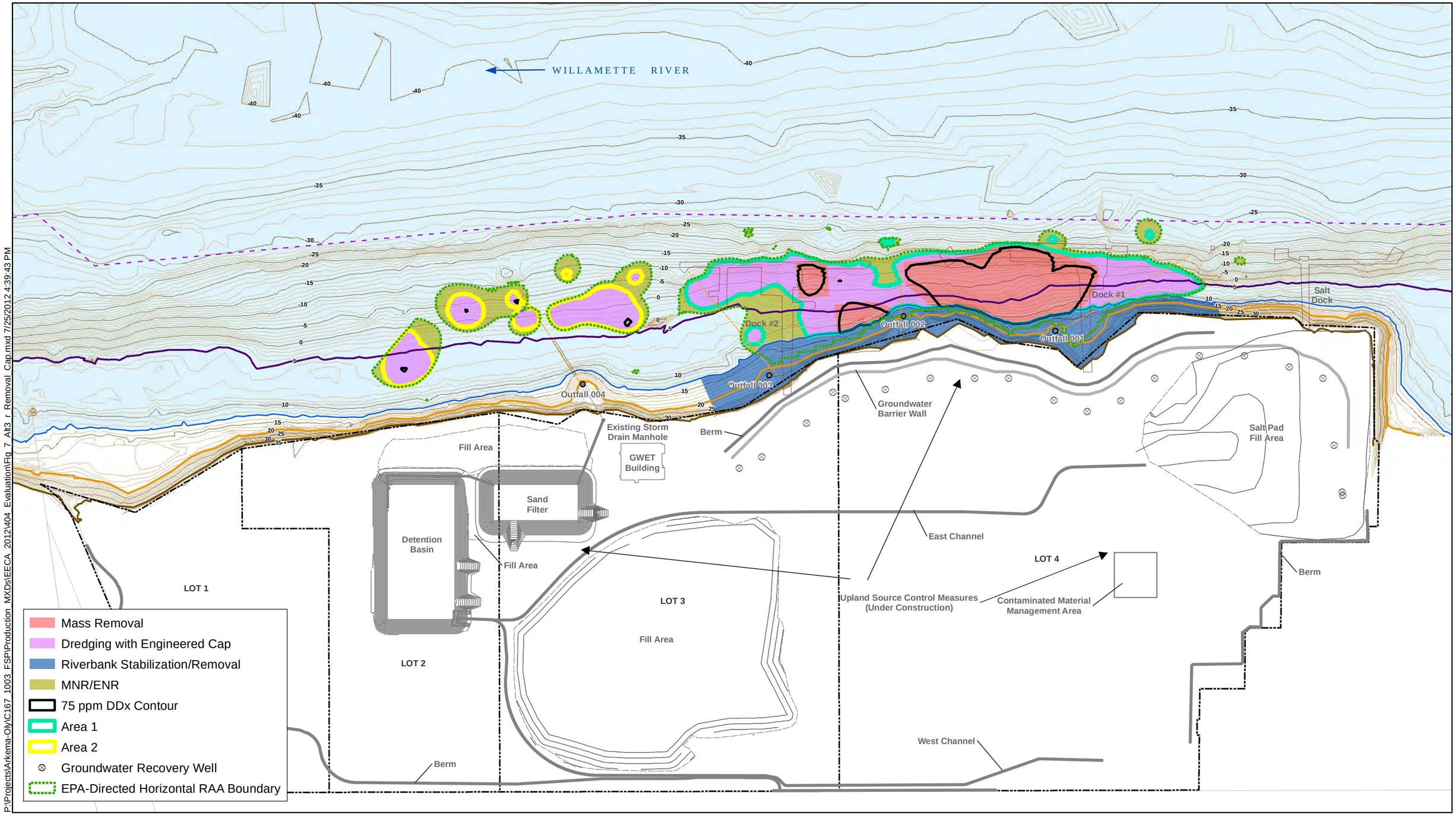
Figure 6
Alternative 3(i): Mass-Based Removal, Capping, and Optimized MNR
Arkema Early Action
Clean Water Act Section 404(b)(1) Evaluation



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FEATURE SOURCES:
Property Boundaries, OHW, TOB: 2007 DEA Topographic Survey
Navigation Channel: US Army Corps of Engineers
Elevation Contours: Areas Below +16 ft: 2004 Bathymetry and 2001 LiDAR;
Area above +16ft: 2007 DEA Topographic Survey

0 100 200 Feet

Map Features

- Property and Lot Boundary
- Storm Drain
- Navigation Channel
- Top of Bank
- +13 ft NAVD88
- Ordinary High Water (20.5 ft NAVD88)
- Ordinary Low Water (5 ft NAVD88)
- 5 ft Contour (NAVD88)
- 1 ft Contour (NAVD88)
- Docks and Structures
- River Edge

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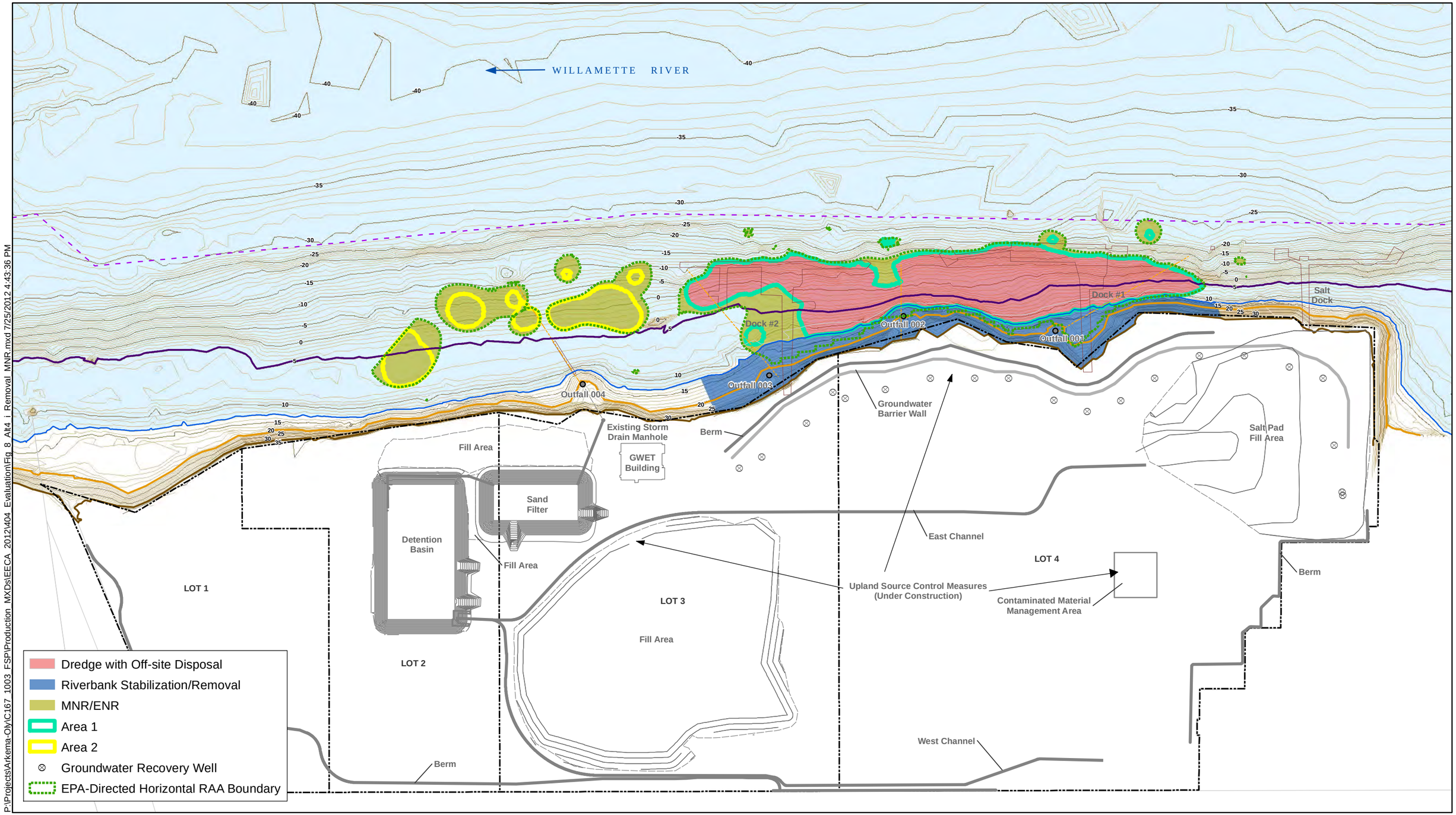
Figure 7
Alternative 3(r): Mass-Based Removal and Capping
Arkema Early Action
Clean Water Act Section 404(b)(1) Evaluation



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FEATURE SOURCES:
Property Boundaries, OHW, TOB: 2007 DEA Topographic Survey
Navigation Channel: US Army Corps of Engineers
Elevation Contours: Areas Below +16 ft: 2004 Bathymetry and 2001 LiDAR;
Area above +16ft: 2007 DEA Topographic Survey

0 100 200 Feet

Map Features

- Property and Lot Boundary
- Storm Drain
- Navigation Channel
- Top of Bank
- +13 ft NAVD88
- Ordinary High Water (20.5 ft NAVD88)
- Ordinary Low Water (5 ft NAVD88)
- 5 ft Contour (NAVD88)
- 1 ft Contour (NAVD88)
- Docks and Structures
- River Edge

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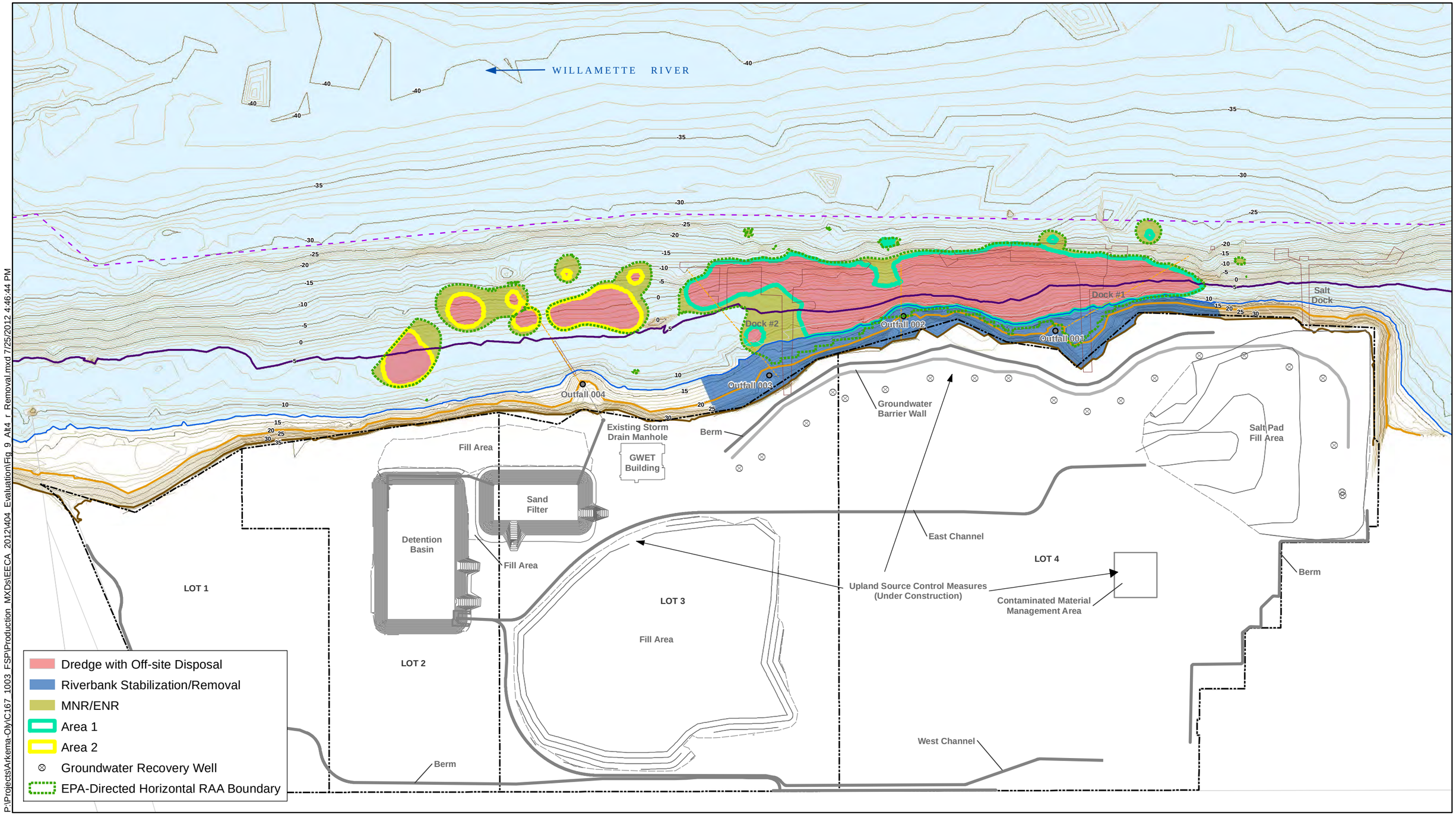
Figure 8
Alternative 4(i): Removal Focused and Optimized MNR
Arkema Early Action
Clean Water Act Section 404(b)(1) Evaluation



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FEATURE SOURCES:
Property Boundaries, OHW, TOB: 2007 DEA Topographic Survey
Navigation Channel: US Army Corps of Engineers
Elevation Contours: Areas Below +16 ft: 2004 Bathymetry and 2001 LiDAR;
Area above +16ft: 2007 DEA Topographic Survey

0 100 200 Feet

Map Features

- Property and Lot Boundary
- Storm Drain
- Navigation Channel
- Top of Bank
- +13 ft NAVD88
- Ordinary High Water (20.5 ft NAVD88)
- Ordinary Low Water (5 ft NAVD88)
- 5 ft Contour (NAVD88)
- 1 ft Contour (NAVD88)
- Docks and Structures
- River Edge

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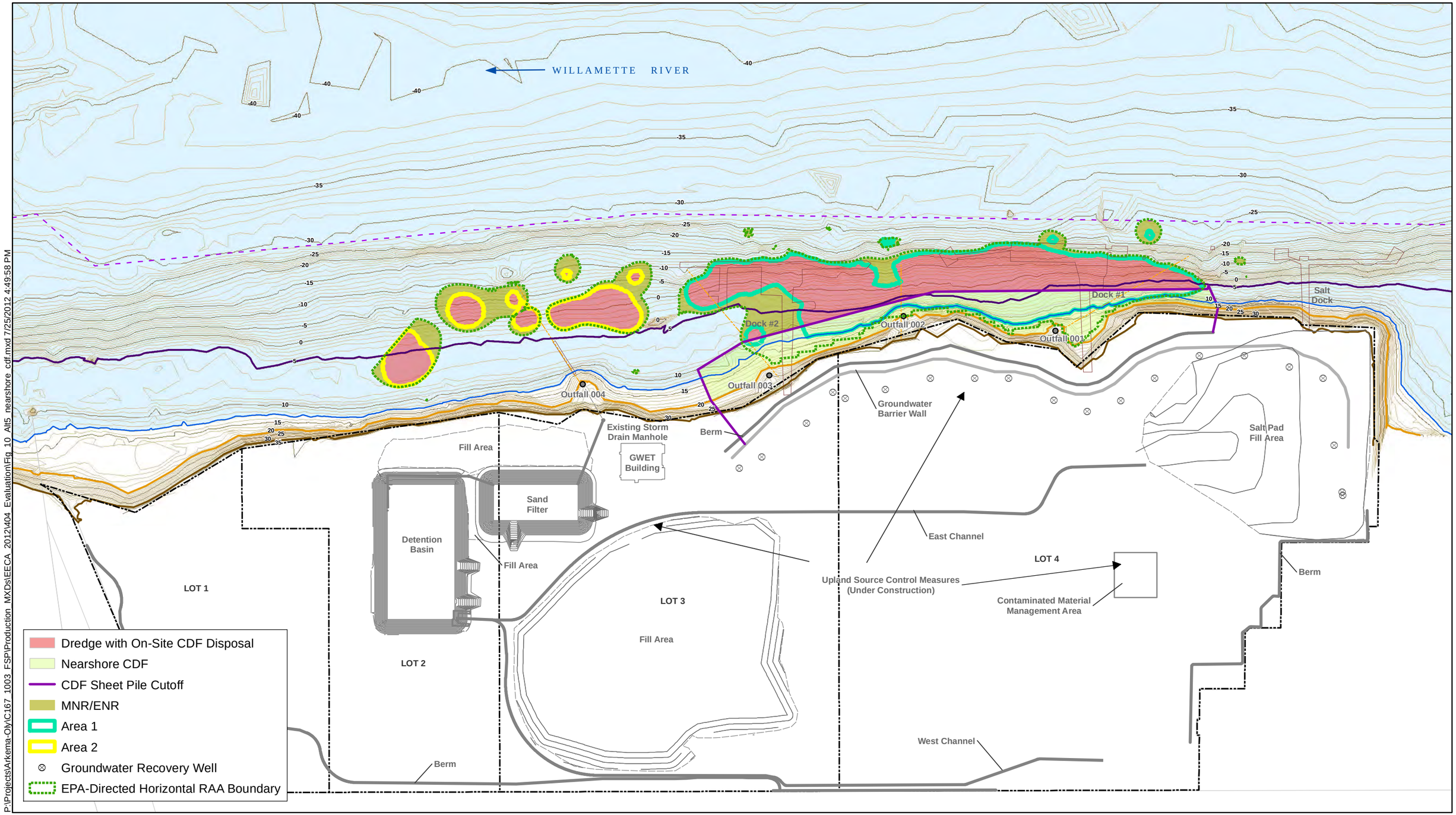
Figure 9
Alternative 4(r): Removal Focused
Arkema Early Action
Clean Water Act Section 404(b)(1) Evaluation



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FEATURE SOURCES:
Property Boundaries, OHW, TOB: 2007 DEA Topographic Survey
Navigation Channel: US Army Corps of Engineers
Elevation Contours: Areas Below +16 ft: 2004 Bathymetry and 2001 LiDAR;
Area above +16ft: 2007 DEA Topographic Survey

0 100 200 Feet

Map Features

- Property and Lot Boundary
- Storm Drain
- Navigation Channel
- Top of Bank
- +13 ft NAVD88
- Ordinary High Water (20.5 ft NAVD88)
- Ordinary Low Water (5 ft NAVD88)
- 5 ft Contour (NAVD88)
- 1 ft Contour (NAVD88)
- Docks and Structures
- River Edge

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Figure 10
Alternative 5: Nearshore CDF
Arkema Early Action
Clean Water Act Section 404(b)(1) Evaluation

TABLES

Table 1. Summary of Arkema EE/CA Alternatives

No.	Description	Summary
1	No Further Action	No Further Action
2(i)	Dredge to Facilitate a Cap and Optimized MNR	Partial dredge and cap placement within Area 1. Use MNR/EMR to address remainder of RAA footprint. A maintenance and monitoring program will be developed and implemented to monitor the cap and MNR performance. The riverbank area will be regraded and capped. Disposal to Subtitle D Landfill.
2(r)	Dredge to Facilitate a Cap	Partial dredge and cap placement within Areas 1 and 2. Use MNR/ENR to address remainder of RAA boundary as described for Alternative 2(i). The riverbank area will be regraded and capped. Disposal to Subtitle D Landfill.
3(i)	Mass-Based Hot Spot Removal, Capping and Optimized MNR	Targeted removal of sediment containing the most highly contaminated sediments to a maximum depth of 15 feet. Partial dredge and cap of rest of sediments within Area 1. Use MNR/ENR to address remainder of RAA boundary as described for Alternative 2(i). The riverbank area will be regraded and capped. Disposal to Subtitle D Landfill.
3(r)	Mass-Based Hot Spot Removal and Capping	Targeted removal of sediment containing the most highly contaminated sediments to a maximum depth of 15 feet. Partial dredge and cap sediments within remainder of Area 1 and all of Area 2. Use MNR/ENR to address remainder of RAA boundary as described for Alternative 2(i). The riverbank area will be regraded and capped. Disposal to Subtitle D Landfill.
4(i)	Removal Focused and Optimized MNR	Dredge majority of horizontal footprint within Area 1 to a maximum depth of 15 feet. Use MNR/ENR to address remainder of RAA boundary as described for Alternative 2(i). The riverbank area will be regraded and capped. Disposal to Subtitle D Landfill.
4(r)	Removal Focused	Dredge approximate horizontal footprint within Areas 1 and 2 to a maximum depth of 15 feet. Use MNR/ENR to address remainder of RAA boundary as described for Alternative 2(i). The riverbank area will be regraded and capped. Disposal to Subtitle D Landfill.
5	Nearshore CDF	Construct nearshore CDF. Outside CDF footprint, dredge approximate horizontal footprint of Areas 1 and 2 to a maximum depth of 15 feet. Use MNR/ENR to address remainder of RAA boundary as described for Alternative 2(i). The riverbank area will be regraded and capped. Disposal onsite in CDF.

Notes:
CDF = confined disposal facility
ENR = enhanced natural recovery
MNR = monitored natural recovery
RAA = removal action area

Table 2. Summary of Quantities - Arkema NTCRA Removal Action Alternatives

Quantity	Alternative						
	2(i)	2(r)	3(i)	3(r)	4(i)	4(r)	5
Removal/ Disposal Volumes (cy) [a]							
Bank Excavation	11,000	11,000	11,000	11,000	11,000	11,000	-
Dredging	22,000	28,000	43,000	48,000	51,000	70,000	57,000
Total Volume Removed	33,000	39,000	54,000	59,000	62,000	81,000	57,000
Fill Volumes (cy)							
Sediment Caps	22,000	28,000	10,000	16,000	-	-	-
Riverbank Slope Cap[b]	11,000	11,000	11,000	11,000	11,000	11,000	-
Targeted Removal Backfill	-	-	32,000	32,000	51,000	70,000	57,000
Total Fill Volume	33,000	39,000	53,000	59,000	62,000	81,000	57,000
Areas (acres)							
Cap Area	2.9	3.7	1.4	2.2	0	0	0
MNR Area	2.1	1.3	2.1	1.3	2.1	1.3	1.2

Notes:

cy = cubic yard

MNA = monitored natural recovery

NCTRA = non-time-critical removal action

[a] All quantities are rounded to two significant figures. All removal volume estimates include a 6-inch overdepth allowance. 50% contingency applied to neatline volume estimates to accommodate dredge cut side slopes and refinements to dredge prism during design. For Alternatives 3 and 4, assumed maximum dredge depth of 15 ft and 3:1 cut slope from toe of riverbank (elev. +13 ft NAVD88) to bottom of dredge cut.

[b] Riverbank Slope Cap volume estimate includes re-use of bank soils, clean soil cover, riprap, and sand fill.

Table 3. LWG Section 404(b)(1) Impact Terminology and Scale

	Terminology	Description
	No Impact	Impact of the remedial action has no measurable impact.
	Beneficial Impact	Impact of the remedial action is an overall benefit with no adverse impacts.
Impact Increasing ↓	Negligible Impact	Impact of the remedial action is insignificant and discountable but more adverse than beneficial. Short-term impacts can be mostly avoided or minimized through BMPs or other measures.
	Minor Adverse Impact	Impact of the remedial action is not discountable but is relatively minor and can generally be mitigated through BMPs or compensatory mitigation. Some impacts may be short term (e.g., acute water quality impacts), while others may be short-term impacts experienced over a long-term time frame.
	Moderate Adverse Impact	Impact of the action is more substantial but may be reduced by BMPs or other avoidance and minimization measures and may require compensatory mitigation to address. Impacts are typically experienced over long term rather than short term.
	Significant Adverse Impact	Impact is substantial, long term, and cannot be avoided or minimized and would require compensatory mitigation to replace lost function.

Notes: BMP = best management practice

Table 4. Listed Species That May Be Present in the Vicinity of the Removal Action Area and Their Critical Habitat

Species	Status/Agency	Critical Habitat Status in the Project Area	Notes
Lower Columbia River ESU Chinook (*Oncorhynchus tshawytscha)*	Threatened; NMFS	Designated	
Upper Willamette River ESU Chinook (*O. tshawytscha)*	Threatened; NMFS	Designated	
Columbia River ESU Chum (*O. keta)*	Threatened; NMFS	Designated, but not in the project area	Limited use of the LWR by juveniles; adults are not expected to use the LWR
Lower Columbia River ESU Coho (*O. kisutch)*	Threatened; NMFS	None	Critical habitat proposal under development.
Lower Columbia River DPS Steelhead (*O. mykiss)*	Threatened; NMFS	Designated	
Upper Willamette River DPS Steelhead (*O. mykiss)*	Threatened; NMFS	Designated	

Source: NOAA (2005, 2012)

Notes: DPS = distinct population segment
ESA = Endangered Species Act
ESU = evolutionarily significant unit
LWR = lower Willamette River
NMFS = National Marine Fisheries Service
USFWS = U.S. Fish and Wildlife Service

Table 5. ODFW State-Listed Sensitive Species That May Occur in the Vicinity of the Proposed Action Area

Common Name	Scientific Name
Critical	
Burrowing owl	*Athene cunicularia*
Common nighthawk	*Chordeiles minor*
Foothill yellow-legged frog	*Rana boylii*
Gray wolf	*Canis lupus*
Lewis's woodpecker	*Melanerpes lewis*
Oregon spotted frog	*Rana pretiosa*
Oregon vesper sparrow	*Pooecetes gramineus affinis*
Pacific pond turtle	*Actinemys marmorata*
Painted turtle (only C. p. bellii SC)	*Chrysemys picta*
Purple martin	*Progne subis*
Streaked horned lark	*Eremophila alpestris strigata*
Townsend's big-eared bat	*Corynorhinus townsendii*
Western meadowlark	*Sturnella neglecta*
Western rattlesnake	*Crotalus oreganus*
Yellow-billed cuckoo	*Coccyzus americanus*
Yellow-breasted chat	*Icteria virens*
Vulnerable	
Acorn woodpecker	*Melanerpes formicivorus*
American peregrine falcon	*Falco peregrinus anatum*
Bald eagle	*Haliaeetus leucocephalus*
Black-tailed jack rabbit	*Lepus californicus*
Clouded salamander	*Aneides ferreus*
Hoary bat	*Lasiurus cinereus*
Little willow flycatcher	*Empidonax traillii brewsteri*
Long-legged myotis	*Myotis volans*
Lower Columbia River/Columbia River coastal cutthroat	*Oncorhynchus clarkia clarkii*
Northern goshawk	*Accipiter gentilis*
Northern red-legged frog	*Rana aurora*
Northern spotted owl	*Strix occidentalis caurina*
Olive-sided flycatcher	*Contopus cooperi*
Oregon slender salamander	*Batrachoseps wrighti*
Pacific lamprey	*Lampetra tridentata*
Pallid bat	*Antrozous pallidus*
Silver-haired bat	*Lasionycteris noctivagans*
Western bluebird	*Sialia Mexicana*
Western brook lamprey	*Lampetra richardsoni*
Western gray squirrel	*Sciurus griseus*
Western toad	*Anaxyrus boreas*
White-breasted nuthatch	*Sitta carolinensis aculeate*

Source: ODFW (2008)

Notes: DPS = Distinct Population Segment
ESA = Endangered Species Act
ESU = Evolutionarily Significant Unit
NMFS = National Marine Fisheries Service
ODFW = Oregon Department of Fish and Wildlife
USFWS = U.S. Fish and Wildlife Service

Table 6. Substantive Compliance with CWA Section 404(b)(1)

Alternative	Substantive Compliance with Section 404(b)(1)	Compensatory Mitigation Estimated to be Required?[a]
1 (No Action)	N/A	N/A
2	Yes	Yes
3	Yes	Yes
4	Yes	Yes
5	Yes	Yes

Notes: NA = not applicable

[a] Based on net result for each alternative (i.e., sum of all credits and debits generated for each SMA) as in Section 13.

APPENDIX D

CULTURAL RESOURCES EVALUATION

Cultural Resources Analysis of the Former Arkema, Inc. Facility, Portland, Oregon

Final Report

By
Todd Ogle, M.A., R.P.A.
and
David V. Ellis, M.P.A.

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Prepared for
Integral Consulting, Inc.
Portland, Oregon

Willamette Cultural Resource Associates, Ltd.

Portland, Oregon

WillametteCRA Report Number 12-12

Introduction

Integral Consulting, Inc. (Integral) contracted with Willamette Cultural Resources Associates, Ltd. (WillametteCRA) to perform a cultural resources evaluation of the Arkema Inc. facility in Portland, Oregon. The project area is along the Willamette River shoreline between River Mile 6.9 and 7.6 immediately southeast of the Burlington Northern Railroad Bridge (also known as the Willamette River or St. Johns Railroad Bridge) in Section 13, Township 1 North, Range 1 West and Section 18, Township 1 North, Range 1 East of the Willamette Meridian (Figure 1).

This cultural resources evaluation was conducted for the engineering evaluation/cost analysis (EE/CA) in support of a non-time critical removal action (NTCRA) for the Arkema facility. The EE/CA is required by the Administrative Order on Consent (AOC) Statement of Work (SOW) between U.S. Environmental Protection Agency (EPA) and Arkema, effective June 27, 2005 (Docket No. CERCLA 10-2005-0191).

A comprehensive cultural resource analysis was conducted for the Lower Willamette Group as part of the Remedial Investigations/Feasibility Study for the Portland Harbor site (Ellis et al. 2005). The Arkema property and the rest of the lower Willamette River are designated in the *Cultural Resource Analysis Report for the Portland Harbor Superfund Site* as a low-probability area. This cultural resources evaluation is a site-specific follow-up study to the comprehensive analysis conducted for the Portland Harbor site. A records review and a site reconnaissance survey of the Arkema removal action area (RAA) was conducted to determine if there are any native soil exposures or physical evidence of archaeological or historical resources. This technical memorandum presents the results of the survey.

The Arkema facility is located at 6400 N.W. Front Avenue in Portland, Oregon, on the southwest bank of the lower Willamette River. The Arkema property encompasses approximately 54 acres of land and is often discussed in terms of four lots and one tract along the Willamette River. Lots 1 and 2 are an undeveloped portion on the north end of the site that is covered by a mixture of grasses, bare soil, and disturbed scrub/shrub vegetation. Lots 3 and 4 are the developed portion of the site where the majority of chemical manufacturing and processing occurred. Tract A along the river is steeply sloping and in some areas is covered with rubble used for bank stabilization; a limited amount of vegetation grows among the bank-armoring material (Figure 2).

The in-water portion of the site is defined as the land below mean high water (18.1 feet [ft] City of Portland Datum). The EE/CA NTCRA is primarily focused on the in-water portion of the site. However, elements of the EE/CA removal action will integrate portions of the

riverbank above mean high water to the top of bank to facilitate engineering and planning for construction of potential riverbank source control measures in those areas. The remainder of the riverbank will be addressed, as needed, with the Oregon Department of Environmental Quality (DEQ) in accordance with the Agreed Order on Consent dated October 31, 2008. Ultimately, the timing of and coordination between the upland source control measure and NTCRA projects will dictate under which regulatory program selected portions of the riverbank will be addressed.

The Arkema site operated as a chlor-alkali plant throughout most of its history from 1941 until 2001, when the entire facility was shut down due to escalating electricity costs. The facility used electrolytic cells to reduce concentrated sodium chloride brine to produce chlorine, caustic soda, hydrogen, hydrochloric acid, and sodium chlorate (CH2M Hill 1997). Other chemicals that have been produced historically at the facility include potassium chlorate, DDT, sodium hydroxide, sodium orthosilicate, magnesium chloride hexahydrate, ammonia, ammonium perchlorate, and sodium perchlorate.

WillametteCRA reviewed documents on file with the Oregon State Historic Preservation Office (SHPO) to determine if archaeological resources have been recorded in the project area, and to identify any previous archaeological studies in the vicinity. WillametteCRA staff also examined copies of historical maps and records to assess the potential for historic-period archaeological resources in the project vicinity and to identify areas likely to contain intact native shoreline. WillametteCRA archaeologist Todd Ogle, M.A., performed a pedestrian survey of all portions of the project shoreline on May 30, 2012. Mr. Ogle did not identify any evidence of cultural resources during this pedestrian survey. As the following report explains in detail with results based on our studies and the current proposed activities, WillametteCRA recommends no additional archaeological studies for the Arkema, Inc. Facility.

Environmental Setting

The current project area is on the left bank of the Willamette River just above the Burlington Northern Railroad Bridge at River Mile 6.9-7.6. The entire project area is within the Willamette River floodplain where elevations typically range from about 9.1 to 15.2 meters (m) (30 to 50 ft) above mean sea level. This floodplain has been substantially altered by historic development as described in more detail below, greatly altering the topography, hydrology, and vegetation. The site was covered by a former industrial plant which has since been demolished except for an office building and concrete pads, and there is very little of the natural land or vegetation visible today. Most of the property is relatively flat with the concrete pads that once supported plant structures. The shoreline largely consists of a steep slope from this flat upper landform to the river's edge, with three docks remaining.

The project is in the northwestern portion of the Willamette Valley Physiographic Province, a broad depression bounded by the Coast and Cascade mountain ranges and characterized by gently sloping alluvial flats and low hills (Franklin and Dyrness 1988). Near-surface sediments in the valley are dominated by a series of late-Pleistocene floods that scoured eastern Washington and the Columbia Gorge, and formed large temporary lakes including Lake Allison that covered the entire Willamette Valley, reaching over 107 m (350 ft) above mean sea level. These flood waters deposited large amounts of fine sediment throughout the valley and rafted large glacial erratics as far south as Eugene (Orr and Orr 2000). After this late-Pleistocene deposition, the local streams incised their (eventually) modern channels and deposited more recent alluvium across the landscape. In the Portland Basin, these late-Pleistocene floods deeply scoured the Columbia River channel to a level much deeper and wider than its present configuration. All of the near-river sediments along the Columbia and lower Willamette rivers in the Portland Basin were deposited during the Holocene as global sea levels rose when the ice sheets melted and sedimentation gradually filled the scoured river valley. Currently, the entire project area has been mapped as urban land for the soil survey of Multnomah County (NRCS 2012).

The project is within the Willamette Valley vegetation zone or *Quercus* Woodland that is characterized by a mosaic of deciduous oaks and open prairies or grasslands, coniferous forests, and riparian forests (Franklin and Dyrness 1988). Maps and survey notes that describe the local vegetation from the 1850s and 1860s General Land Office (GLO) surveys indicate that the project area was located on a narrow strip of land between the Willamette River to the northeast and Doanes Lake to the southwest. This lake was a typical floodplain lake, being quite shallow and fluctuating in size depending on the season. The GLO surveyor's notes indicate that there was a line of trees (cottonwood and ash) along the top of the riverbank, probably located on a natural levee. Inland from this natural levee were grasslands or prairie with willow and ash trees bordering Doanes Lake. Similar to the fluctuating lake leve, the grasslands or prairie were likely seasonally inundated by spring meltwater-fed floods. While surveying the Doane Donation Land Claim (DLC) (Ford 1854), the surveyor noted that the bottomlands were flooded.

Native People

From historical accounts and ethnographic data, anthropologists have reconstructed that the lower Willamette River from its mouth to Willamette Falls lies within the traditional homeland of the Chinookan peoples. At the time of Euroamerican contact various Chinookan-speaking groups occupied the Columbia River valley from the Dalles area to the Pacific Ocean. Ethnographers today differentiate the Chinookans primarily on linguistic variation. Speakers of the Lower Chinookan language included the Clatsop and Chinook proper, who lived around the mouth of the Columbia River. Upper Chinookan speakers occupied the upriver areas. Upper Chinookans in the Portland area consisted of two groups, the Multnomah and the Clackamas.

Multnomah villages were concentrated on Sauvie Island, along the Multnomah Channel, and along the northern bank of the Columbia River downstream of the mouth of the Willamette. The Clackamas were found primarily on the river of that name, at Willamette Falls, and along the lower Willamette River. There is some evidence that the area around the mouth of the Willamette River and the southern shore of the Columbia River between the Willamette and Sandy rivers was occupied by both Clackamas and Multnomah groups (French and French 1998:360-363; Silverstein 1990:533-535).

As noted above, the first known Euroamerican exploration of the area was by Lt. William Broughton of the *H.M.S. Chatham* in October 1792. Broughton's exploration was brief, however, and he did not proceed up the Willamette River. Other than referencing a few villages along the Columbia River, Broughton provided little information on the Indians of the area (Vancouver 1984:II:754-760).

Much better information is provided in the journals of the Lewis and Clark Expedition, which passed through the research area in the fall of 1805 and the spring of 1806. The accounts of the fall journey through the area are brief as the expedition was anxious to reach the Pacific before winter set in. A cluster of islands around the mouth of the Willamette River prevented the expedition from recognizing the river on their westward journey. A group of Indians they encountered just below Hayden Island informed them that there was a village "Situated back of those Islands on the Lard. [larboard] side" (Moulton 1990:18).

Clark's brief exploration up the Willamette River the following spring included an overnight camp near a large Indian house on the east side of the river. The house was vacant at the time and Clark was told by his Indian guide that its residents were fishing at Willamette Falls (Moulton 1991:59). Lewis and Clark later prepared lists of the Native settlements and groups they had visited or been told of. One of these lists (Moulton 1990:478) contains the only reference to the name of the lower Willamette village visited by Clark, the "Ne-mal-quin-ner Tribe." (Silverstein [1990:Figure 1] suggests that "Ne-mal-quin-ner" was in anglicized version of the Chinookan *nimáłoewinix*). The location of the Ne-mal-quin-ner village is uncertain as Clark references it as either 8 or 10 miles from the confluence with the Columbia River (Moulton 1991:59-60). Based on current river miles on the Willamette River, this would place the village in the vicinity of Swan Island. The accuracy of Clark's mileage estimate is questionable and it is likely that he estimated mileage from where he passed between the islands that then clustered at the mouth of the Willamette River. Clark, for example, reported it was five river miles to the confluence of the Willamette River and the Multnomah Channel. This confluence is at RM 3.5 in modern river mileage.

The Lewis and Clark map of this area shows the Ne-mal-quin-ner village at the first eastward bend of the river upstream of the confluence with the Multnomah Channel. The map also suggests that the village was at the foot of a range of hills that extend to the southeast. Historic and modern maps indicate the bend (if the Lewis and Clark map is reliable) is downriver of St. Johns and opposite Linnton. This location would place Ne-mal-quin-ner in the vicinity of the historic Gatton's Slough and modern Terminal 4. This location also fits the relationship with the line of hills (i.e., Alameda Ridge, with St. Johns located at the northwestern tip of the ridge). As noted above, an important archaeological site was known historically at the mouth of Gatton's Slough, and Strong (1959:31) identified this site as the location of Ne-mal-quin-ner.

There are no written references to the Ne-mal-quin-ner village or any specific settlement at that location after the Lewis and Clark Expedition. John Wacheno, a Clackamas Indian, told ethnographer Philip Drucker of a village at modern St. Johns known as *woxsûn* (Drucker 1934:18). It is unclear with which Native group this village was associated. Curtis (1911:181) gives the name of this village as Wákshĭn, which he translates as "dam", and states that it was occupied by the Gahláwákshĭn, a Chinookan group (this name simply means "the people of Wákshĭn"). Silverstein (1990:534) terms this village *wáksin* and places it on Sauvie Island at the mouth of the Willamette River. These are the only written references to Indian settlements on the Willamette River in the general area of the Arkema location.

By the 1840s the character of the Native settlements throughout the lower Columbia River drainage had been radically altered by the epidemics of introduced European diseases. A smallpox epidemic is known to have struck the lower Columbia region in the 1770s and is estimated to have killed about a third of the Native population. Native peoples experienced periodic outbreaks of smallpox and possibly other introduced diseases such as measles through the 1860s. For the people of the lower Columbia, the most catastrophic epidemic was an outbreak of malaria in the 1830s. This epidemic devastated the Indian people of the lower Columbia region (Boyd 1990:146-147, 1999:233-238). The malaria epidemic of the early 1830s destroyed entire villages in a matter of days or weeks. The Indian population of the Willamette Valley and the lower Columbia River valley was reduced by 75 to 90 percent or higher. Boyd (1999:Table 3) has estimated that Cathlamet, Multnomah, Clackamas, and Cascades populations declined from about 12,000 in about 1,800 to 300 by the 1850s (a population loss of almost 98%).

The first major expansion of Euroamerican settlements began in the 1840s, as thousands of American settlers flooded into western Oregon and Washington. They met with minimal resistance from the Native groups that had been devastated by the epidemics described above. There was a brief period through the 1840s when the new settlers and the Native populations

lived uneasily side by side. By 1850, however, the need to clear Indian title to the land to provide a legal basis for the land claims of American settlers led to a series of treaty negotiations beginning in 1851.

The first treaties signed with the surviving tribes of western Oregon would have established several Indian reserves in the Willamette Valley. These treaties were never ratified by Congress due to opposition by American settlers to the reservations. Treaties signed during a second round of negotiations in 1854 and 1855 were ratified. One of these treaties included the Kalapuyan peoples of the Willamette Valley and Chinookan groups of the Clackamas and lower Willamette river drainages (Beckham 1990; Kappler 1904:II:665). No reservations were formally defined in the treaties with the tribes of western Oregon, but two reservations (Coast and Grand Ronde) were established by executive order shortly after the treaties were ratified. With creation of the reservations, federal troops began the process of relocating the Willamette Valley groups to the reservations. Some of the Chinookans of the Clackamas and lower Willamette river areas moved to the Warm Springs and Yakama reservations where they could be with their upriver relatives. Recent research for the Willamette Falls area (Hajda et al. 2004) indicates that there was regular movement of Indian people with ties to the Willamette Falls area between the Grand Ronde, Siletz, Warm Springs, and Yakama reservations.

Euroamerican History

The first Euroamerican visitor to the project vicinity was Lt. William Brougton of the Royal Navy during the Vancouver expedition in 1792. Broughton passed the mouth of the Willamette River (he called it the "River Munnings") while exploring the lower Columbia River but did not explore the Willamette itself (Vancouver 1984:II:754-760 [1798]). As mentioned above, William Clark of the Lewis and Clark Expedition explored up the Willamette some distance (the exact distance is disputed) and possibly reached Swan Island just upstream from the current project area.

Additional Euroamerican exploration of the area occurred during the fur trade period beginning with the establishment of Fort Astoria (later Fort George) in 1811. Alexander Henry provided one of the first written descriptions of the lower Willamette based on his January 1814 travels, noting that the river is low-lying and flooded during the summer (Gough 1992:656). Aside from occasional exploratory forays, the Hudson's Bay Company presence in the region largely avoided the lower Willamette, with the focus of activities being on the north bank of the Columbia River where the Company operated a fort and associated farms and dairy operations.

Permanent Euroamerican settlement in the region began in earnest in the 1840s but was primarily focused on the Willamette and Tualatin valleys to the south and west. As these

agricultural settlements grew, they spurred an increased demand for river landings to transport their produce and for importing their needed goods and supplies. The lower Willamette River below the falls in Oregon City became an important area for this commerce. M. M. McCarver and Peter Burnett platted the community of Linnton in 1844 with the hope of being the primary shipping point for Tualatin Valley farmers via a road between Linton and Bethany. Linnton did not thrive, however; within a few years of its founding it was reported to consist of a single family, and the road to Bethany was later abandoned (Corning 1973:10-11; Schafer 1909:46). Linnton has since revived to a certain degree as a lumber town and suburb of Portland. A second community of Springville was initially more successful but has since disappeared. Springville was founded on the William W. Baker DLC near the modern approach to the St. Johns Bridge to the northwest of the project, area along with a road to Hillsboro and a ferry across the Willamette to the community of St. Johns. Springville thrived until the late 1860s with a large warehouse for storing grain, but improvements to transportation routes in Portland proper led to Springville's eventual decline. The warehouse burned in 1872 and was not rebuilt, with the rest of the community quickly disappearing. (Corning 1973:166-170)

The project area itself was selttled by Milton Doane, whose DLC (Claim 39) includes all of the project area. Doane immigrated to the Oregon Territory before 1846 from Kentucky, initially settling a claim in what is now Washington before moving to the lower Willamette River in 1847 (Genealogical Forum of Portland 1957-1975:I:56; Gurley 1982:62, 172). The 1855 General Land Office (GLO) map of Township 1 North, Range 1 West shows a road paralleling the Willamette River north of Doane Lake and presumably passing through the Arkema property (Figure 3). This was the river road between Portland and Sauvie Island built in 1852. This GLO map shows an agricultural field near the southern edge of the Doane DLC but no other developments in the project area. While the 1855 map and associated survey notes do not indicate a residence, the 1850 census data suggest he was living on his claim with his wife and seven children (U.S. Bureau of the Census 1850) and he was described as living along the Willamette River not far from Baker's Landing (Springville) in 1852 (Corning 1973:167).

By 1888 (U.S. Coast and Geodetic Survey Map), the road along the river was gone, having been replaced by a road and the Northern Pacific Railroad on higher ground along the current US 30/Burlington Northern railroad corridor (Figure 4). The railroad was built in 1883 from Portland to Goble on the lower Columbia River (Culp 1972). This 1888 map also shows a small farm at Doanes Point (just north of the railroad bridge) to the northwest of the project area. Most of the remaining floodplain was undeveloped, likely due to seasonal flooding that made permanent habitation or use of the land for anything but pasture and hay production impractical.

Use of the low-lying floodplain increased during the 1905 Lewis and Clark Exposition that was centered on Guild Lake about 3.2 kilometers (km) (2 miles [mi]) southeast. After the

exposition, Guild Lake and much of the floodplain to the south of the project area was filled and developed for industry; Doanes Lake initially remained untouched. The construction of the railroad bridge across the Willamette River in 1906-1908 and railroad across the floodplain lake marked the beginning of major modifications to the Doanes Lake hydrology. Around the same time, a railroad spur was constructed across the lake to a dock or wharf on the river, presumably within the current project area south of the railroad bridge (Staehli 1985:12-13).

Industrial development spread to the southern edge of Doanes Lake in the 1940s, by which point the lake had shrunk to three ponds, probably due to changes in the drainage system rather than fill. The spur line to the river across the lake abandoned prior 1945 and the remaining agricultural land had been abandoned and reverted to woodland and brush. A general land use history map based on 1936 data shows the entire project area as undeveloped at that time (Integral et al. 2007:Map 4.1-6).

Based on information provided in a comprehensive review of Portland Harbor (Ellis et al. 2005) based on historic aerial photography, the southern portion of the project area was developed prior to 1948 while the northern half was developed between 1961 and 1974 (Integral et al. 2007:Maps 4.1-5a-c, 4.1-6-9). As stated in the introduction, the Arkema site operated as a chlor-alkali plant beginning in 1941 in the southern portion of the current project area. Additionally, the project shoreline appears to have undergone extensive modification as a 2000 aerial photograph showing the 1936 and 1948 shorelines indicate that the existing shoreline has been moved well into the previous river channel (Integral et al. 2007:Map 4.1-11a). Another map provided in the Portland Harbor study indicates that the southern half of the project area had fill added between 1948 and 1957 while the northern half had fill added in 1957 (Integral et al. 2007:Map 4.1-12d). Geologic cross sections based on geotechnical boring performed for the current project show that artificial fill is found in all but the very bottom few feet of the river bank in the far northern portion of the project area, with this fill covering native alluvium by approximately 6 m (20 ft) on the upper portion of the project area. The central and southern portions of the project area contain artificial fill to below the ordinary high water level of the Willamette River with a similar depth of fill on the upper portion of the parcel. Following its closure in 2001, the Arkema plant has since been demolished and, with the exception of concrete pads and an office building, removed from the site.

Three docks are currently located within the project area (see Figure 2), while earlier docks closer to the railroad bridge were removed in 1957 (Integral et al. 2007:Map 4.1-12d). Of the existing docks, Dock 1 was built between 1936 and 1941 based on aerial photography (Integral et al. 2007:Map 4.1-5a; Brubaker Aerial Surveys, 1941, Portland, Oregon, OHS Photo Number 41159), and was expanded between 1941 and 1948 and again between 1961 and 1963 (AMEC Earth and Environmental, 2003, Historical Aerials 1961, 1963, 1967, 1971, on file, Integral

Consulting, Inc., Portland, Oregon). Dock 2 was built between 1957 and 1959 (Integral et al. 2007:Map 4.1-5b; Ackroyd Photography Inc., 1959, Untitled Aerial Photograph, on file, Integral Consulting, Inc., Portland, Oregon), with expansion occurring between 1963 and 1967 (AMEC Earth and Environmental, 2003, Historical Aerials 1961, 1963, 1967, 1971, on file, Integral Consulting, Inc., Portland, Oregon). The last of the three docks to be built, the Salt Dock, was installed between 1961 and 1963 (AMEC Earth and Environmental, 2003, Historical Aerials 1961, 1963, 1967, 1971, on file, Integral Consulting, Inc., Portland, Oregon), with no apparent subsequent modifications.

Previous Archaeological Investigations

To determine if previous archaeological studies or archaeological sites occur in the project vicinity WillametteCRA staff reviewed records on file with the Oregon SHPO. While not found in the SHPO GIS database, the closest previous archaeological study was for a then-proposed correctional facility site adjacent to the current project area to the southwest (Ellis and Chapman 1997). Aside from this previous study, SHPO records indicate that the closest previous archaeological studies are located along the U.S. Highway 30 and Burlington Northern Railroad corridor approximately 430 m (1,400 ft) southwest of the Arkema parcels (Ellis et al. 1999; Iverson et al. 2000) or further to the northwest of the current project (Ellis 1981; Ellis and Baker 2004; Ogle and Ellis 2005). No previously recorded archaeological sites are in the immediate project vicinity but one prehistoric site is reported to be located approximately 1.6 km (1 mi) to the northwest (Strong 1959).

As mentioned above, the closest previous archaeological study was performed for a proposed correctional facility location immediately southwest of the Arkema, Inc. property (Ellis and Chapman 1997). This 1997 project area was located in the now mostly filled and developed Doane (or Doanes) Lake area. This study provided a review of background information but did not include a systematic archaeological survey due to the presence of fill, industrial development, and contamination by hazardous wastes from previous industrial activities.

Two proposed fiber-optic line surveys are located along the U.S. Highway 30 and Burlington Northern Railroad corridor southwest of the current project area. While these studies did include an on-ground archaeological survey, neither identified evidence of archaeological or historical resources in the project vicinity (Ellis et al. 1999; Iverson et al. 2000).

The other projects in the vicinity are located between the railroad and St. Johns bridges approximately 1.6 km (1 mi) to the northwest. An assessment of the potential for archaeological and historical resources, monitoring of geotechnical borings (Ellis and Baker 2004), and subsequent monitoring of contaminated sediment removal at the GASCO location (Ogle and

Ellis 2005) failed to identify any archaeological deposits. While modern field investigations did not identify archaeological resources, Strong (1959) notes the presence of a prehistoric site from which artifacts were collected prior to it being "covered by the plant of the Portland Gas and Coke Company" at this location in 1912-1913. Unfortunately, Strong provides no details regarding the artifacts found at this location. The remaining study in the project vicinity was an assessment of proposed modifications of buildings at the U.S. Government Moorings immediately northwest of the GASCO location (Ellis 1981) that did not identify any archaeological resources.

Results of the Field Investigations

WillametteCRA conducted a cultural resources survey of the Willamette River shoreline across the entire project area (Tract A) on May 30, 2012. Todd Ogle, M.A., performed this pedestrian survey by walking all of the accessible shoreline and by examining areas of steep fill material extending to the river from the adjacent bank. Mr. Ogle examined all areas of exposed ground surface (i.e., those areas not covered by modern fill debris or extremely dense vegetation) for evidence of archaeological deposits. With the exception of modern debris placed in the project area as fill or deposited by the Willamette River, Mr. Ogle observed no cultural material within the project area. Due to the presence of structural remains, ongoing construction activities, and a lack of currently proposed activities, the current investigations did not address the remainder of the Arkema, Inc. parcels farther from the shoreline.

The project area shoreline can be characterized as three distinct sections based on the amount of modern disturbance and fill: the southeasternmost portion around the Salt Dock; the central portion around Docks 1 and 2 and approximately 250 m (820 ft) downstream from Dock 2; and the northwesternmost portion north of Lot 1. In general terms, the level of modern disturbance decreases as one moves downstream (northwest) along the shoreline.

The southeasternmost portion of the shoreline surrounding the Salt Dock consists of a very steep slope from the upper bank to the Willamette River composed entirely of fill (Figure 5). This area contained large pieces of concrete and metal and is partially overgrown by grasses and blackberry. The 90-degree angle of the bank in the far southeastern corner of the project area (see Figure 2) indicates that this entire landform is artificial and has little to no likelihood of containing archaeological deposits.

The central portion of the shoreline within the project area is more varied, with areas of modern fill extending from the upper bank to the shoreline, interspersed with small sandy beaches exposed at the bottom of the bank slope (Figure 6). All of this central portion contains a steep fill slope from the upper bank to the shoreline or these small sandy beaches with a

composition similar to that seen in the area surrounding the Salt Dock. While this area has a greater potential of containing archaeological resources than the fill slope to the southeast, it is still considered unlikely. The sandy beaches undoubtedly represent very recent alluvium with older shorelines and higher ground likely to contain habitation sites covered by the modern fill.

The northwesternmost portion of the shoreline is a wide sandy beach that supports deciduous trees and grasses (Figure 7). The upper bank is much lower in this area, and while modern debris is visible in the bank itself, this fill is not a thick as seen to the southeast (Figure 8). Of all the areas observed in the project area, this is the most likely to contain archaeological deposits. However, as is the case in the smaller sandy beaches to the southeast, this shoreline is likely the result of recent alluvium, while older shorelines and habitable areas are buried beneath the modern fill and recent alluvium.

Conclusions and Recommendations

WillametteCRA completed a records review for the entire Arkema Inc. property and performed a cultural resources survey of the Willamette River shoreline (Tract A) in Multnomah County, Oregon. While the records review identified multiple previous archaeological studies in the immediate project vicinity, none included the current project area itself. Reported archaeological sites in the vicinity have been largely destroyed or buried by modern development, indicating that while prehistoric occupation of this area was widespread, the modern evidence of such activity is rare. Documented historic developments in the project area indicate that this location has been extensively altered from its original state. Evidence of prehistoric or historic activities is therefore considered unlikely to be present.

Our review of historic photographs indicates that the three docks within the current project area that are potentially slated for removal are each 50 years old or older. However, given the abundance of similar docks on the lower Willamette River, modifications to the oldest two docks, and the lack of any significant historic association, we recommend that the docks are not eligible for listing in the National Register of Historic Places.

Our survey of the Arkema facility shoreline supports the conclusions of this background research that the landscape has been extensively modified. Virtually all of the southeastern portion of Tract A (northeast of Lot 4) is covered by a very steep slope composed entirely of fill to the current river shoreline. The central portion of the shoreline (northeast of Lot 3) contains small sections of sandy beach and the northwestern portion is almost entirely sandy beach, but these areas are bounded by a steep bank composed largely or entirely of fill material. Given that the sandy beaches represent very recent alluvium and that historic documents show that the

current shoreline occupies a portion of the historic river channel, it is very unlikely that Tract A contains intact archaeological deposits.

If cultural resources are present within the project area, they are likely to be buried beneath modern fill inland from the current shoreline (within Lots 1-4). Given the degree of industrial development on this parcel, if cultural resources are present, they are very unlikely to retain enough integrity to be eligible for listing on the National Register of Historic Places. As a result, we recommend no additional cultural resources investigations for the Arkema RAA.

Should unanticipated archaeological or historical resources be encountered during future activities at this location, all ground-disturbing activity in the vicinity of the find should be halted and SHPO notified immediately. In the event that evidence of human skeletal remains is encountered during future work, all ground-disturbing activity in the vicinity of the discovery should be halted immediately, efforts taken to protect such evidence in place, and the Oregon SHPO, Oregon State Police, Legislative Commission on Indian Services, appropriate Tribes, and Multnomah County Medical Examiner promptly notified to ensure compliance with state and federal laws.

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Figure 1. Project area location.

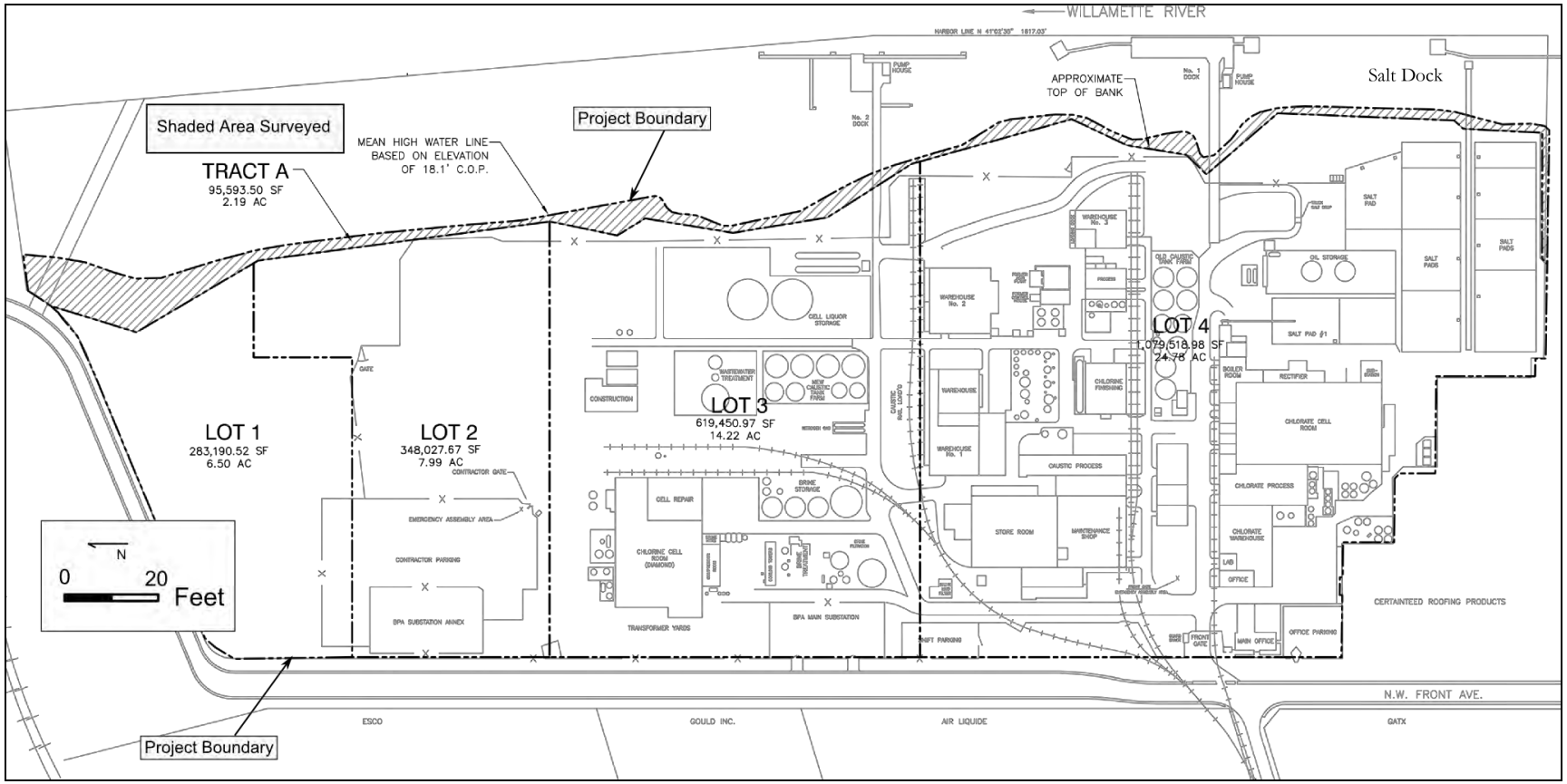

Figure 2. Configuration of the project area. Note pedestrian survey occurred in the shaded areas.

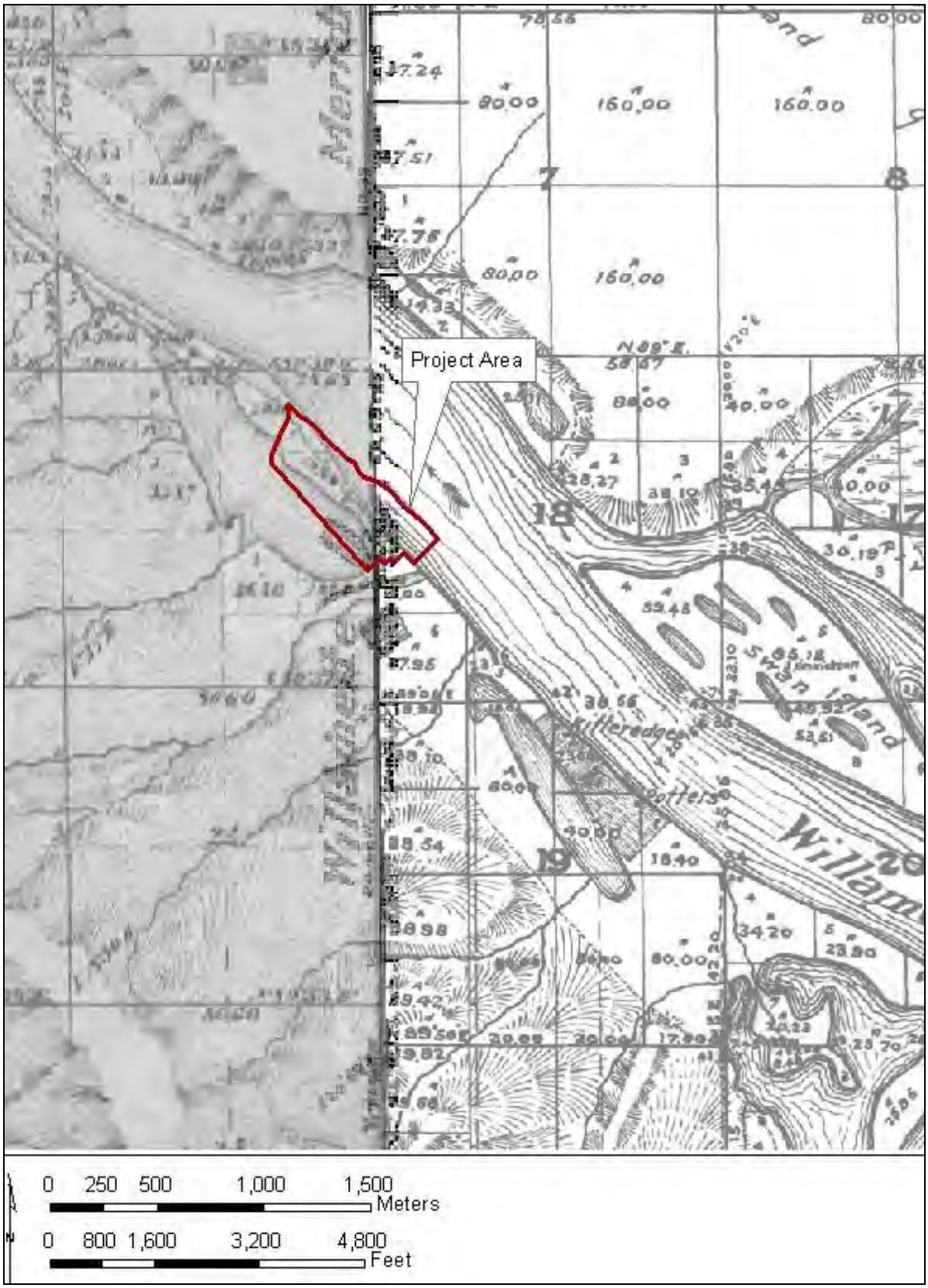

Figure 3. Project area depicted on the ca. 1850s General Land Office maps.

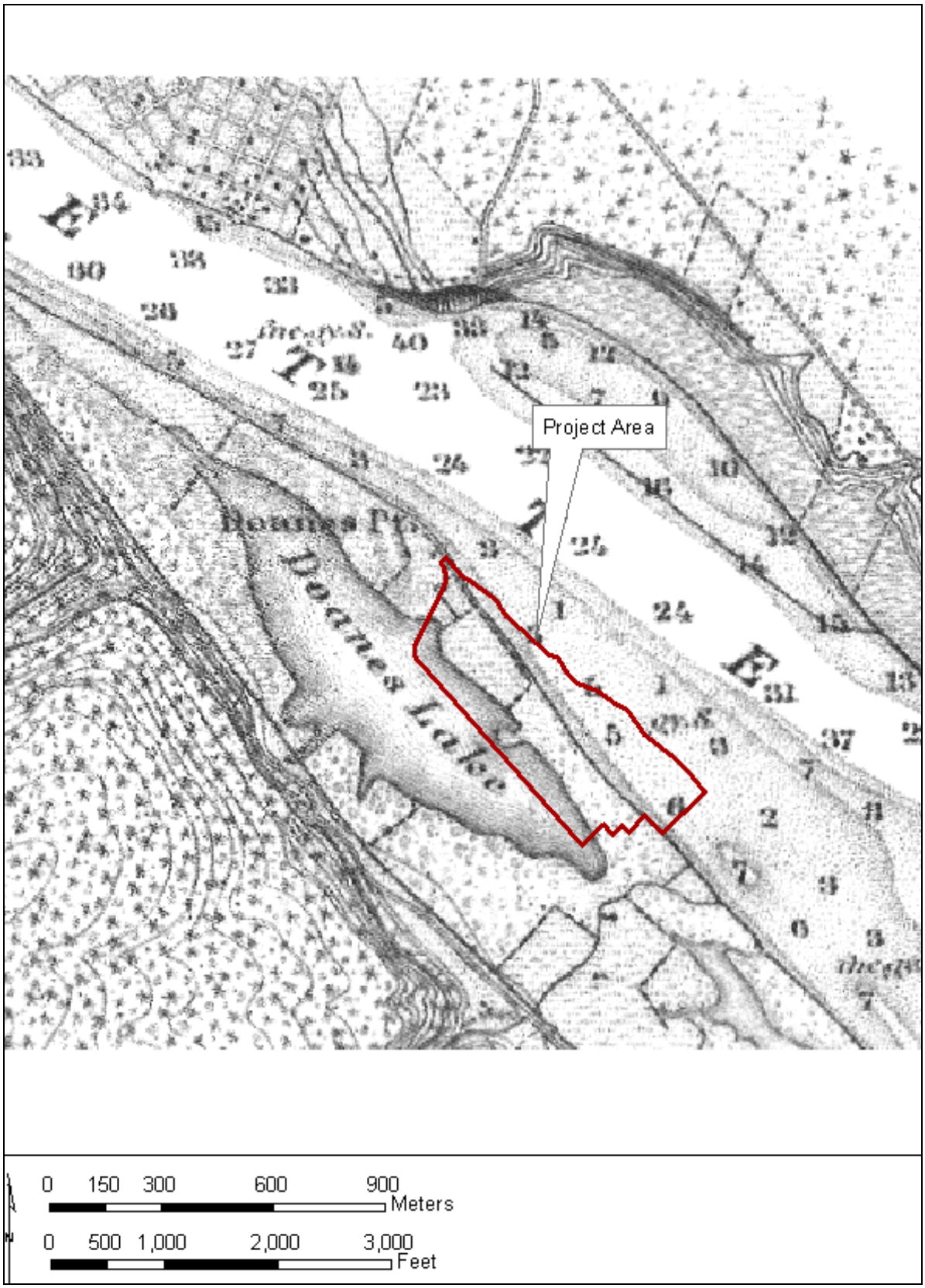

Figure 4. Project area depicted on the 1888 U.S. Coast and Geodetic Survey map.

Figure 5. View to the southeast of the steep fill shoreline in the southeast portion of the project area.

Figure 6. View to the northwest of the central portion of the project area showing a small sandy beach bounded by steep fill slopes.

Figure 7. View to the southeast of the northwest portion of the project area showing a wide, sandy beach and emerging riparian vegetation.

Figure 8. View to the southwest of the lower bank containing some modern fill debris in the northwestern portion of the project area.

APPENDIX E

COST ESTIMATE DETAILS

Table E1. Cost Estimate Sources and Key Assumptions

TASK	UNIT COST	UNIT	Assumptions/Basis
DIRECT COSTS			
Site Preparation/Construction Engineering	10%	LS	Includes mob/demob, temporary facilities, erosion controls, contractor engineering & surveying, PM, bonding. Source: LSS based on past project experience; Other regional projects.
Dock Removal	$ 1,200,000	LS	Assumes removal of Docks 1 and 2, non-hazardous waste disposal. Source: Engineer's estimate; LSS based on past project experience.
Dredging & Transloading	$ 40	CY	Assumes mechanical dredging, gravity dewatering, nearby transloading facility (possibly on-site). Quantity includes provisions for 6" allowable overdredge and 50% design contingency. Source: LSS based on past project experience.
Transportation and Disposal	$ 50	TN	Assumes truck, rail, barge to regional Subtitle D landfill. No moisture restrictions. Source: Vendor quotes; LSS based on past project experience.
Backfill	$ 26	TN	Assumes sand and gravel backfill to original grades. Armor as required. Source: LSS based on past project experience; Other regional projects.
Capping			
Filter Material	$ 34	TN	Assumes 12" sand filter layer amended with GAC (2.5% by weight). (Other cap types will be evaluated during design.) Source: LSS based on past project experience; Other regional projects.
Armor Material	$ 45	TN	Assumes 24" rock armor layer over filter material. Source: LSS based on past project experience; Other regional projects.
Water Quality Controls			
Conventional BMPs	$ 400,000	LS	Includes provisions for barge decant water filtration, absorbent booms and conventional silt curtains (as needed). Source: LSS based on past project experience; Other regional projects.
Engineered Barrier Contingency	$ 12,769,000	LS	Assumes ~2,300 LF steel sheetpile enclosure around RAA. Includes mob/demob, installation and removal, 20% contingency. Source: Based on extrapolation of engineer's estimate for sheet pile deflection wall barrier concept.
Riverbank Stabilization	$ 1,156,000	LS	Includes excavation and regrading of designated bank slope, offsite disposal of contaminated soil & debris, bank capping, mob/demob. Source: Engineer's Estimate (ERM).
Confined Disposal Facility	$ 11,500,000	LS	Assumes king-pile and tie-back supported sheetpile containment with low permeable cap and groundwater monitoring/extraction wells. Source: LSS based on past project experience.
Habitat Mitigation	$ 150,000	LS	Assumes CDF encroachment into waterway will require habitat mitigation. Source: Assumed value (TBD during design).
INDIRECT COSTS (Percent of Direct Costs)			
Design and Permitting	7%	LS	Includes preparation of design documents and work plans, permitting support. Source: Recent Projects.
Construction QA/Oversight	5%	LS	Includes independent QA oversight, WQ monitoring, post-dredge/cap sediment sampling and analysis, reporting . Source: Recent projects.
Project Management (Internal LSS)	2%	LS	Internal management costs. Source: LSS experience on recent projects.
Agency oversight	4%	LS	Includes assumed EPA oversight costs. Source BPJ.
Contingency	30%	LS	Design/Construction Contingency. Source: BPJ & EPA cost guidance.
LONG-TERM MONITORING, OPERATION & MAINTENANCE			
Monitoring	$ 214,000	LS	Assumes bathymetric survey, sediment chemistry (10 samples) at years 1, 3, 5, 10, 15, 20, and 30. NPV with 7% discount. Source: Recent projects.
Cap O & M	$ Varies	LS	Assumes O&M costs = 10% of cap construction costs + 15% mob for yrs 5, 10, 15, 20, 30. NPV with 7% discount. Source: Recent similar projects.
Riverbank O&M	$ 85,000	LS	Riverbank cap maintenance. Source: Engineer's estimate (ERM)

APPENDIX F

RIVERBANK ALTERNATIVES EVALUATION

Draft Memorandum

Environmental Resources Management

1001 SW 5th Avenue,
Suite 1010
Portland, Oregon 97204
(503) 488-5282
(503) 488-5142 (fax)

To: Todd Slater, Legacy Site Services LLC, agent for Arkema Inc.

From: Erik Ipsen P.E., Brendan Robinson, P.E., ERM

Cc: David Livermore, Integral Consulting, Inc.

Date: July 26, 2012

Subject: RAA Riverbank Alternatives Evaluation, Arkema Inc., Portland, Oregon

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On behalf of Legacy Site Services LLC (LSS), agent for Arkema Inc. (Arkema), ERM-West, Inc. (ERM) has prepared this Technical Memorandum in support of the Riverbank Alternatives Evaluation (RAE) for the former Arkema facility in Portland, Oregon (the "Site").

The purpose of this memorandum is to evaluate riverbank source control measure (SCM) alternatives for a focused portion of the riverbank as it relates to the non-time critical removal action being conducted at the site under the direction of U.S Environmental Protection Agency (EPA). The portion of the riverbank considered in this memorandum is the area of riverbank that is co-located with the sediment Removal Action Area (RAA) defined in the Removal Action Area Characterization Report (Integral 2011).

The recommended focused Riverbank SCM alternative developed herein will be used during the evaluation of in-water Removal Action alternatives in the Engineering Evaluation /Cost Analysis (EE/CA) that is currently being prepared by Integral Consulting, Inc. (Integral) on behalf of LSS. A full Riverbank SCM Alternatives Evaluation will evaluate source control alternatives for the entire riverbank pending Oregon Department of Environmental Quality (ODEQ) approval of the Hot Spot Evaluation Update. This current memorandum, which considers only a specific portion of riverbank, is intended to enable preparation of the Arkema EE/CA and comply with EPA directives.

The source control measure alternatives presented in this memorandum comprise the range of alternatives that will be considered for the remaining areas in the full Riverbank SCM Alternatives Evaluation.

SITE INFORMATION

This section presents a description of the Site, the results of the riverbank source control screening evaluation, and the riverbank source control measure objectives.

SITE BACKGROUND

The Site is located at 6400 N.W. Front Avenue in the Northwest Industrial Area of Portland, Oregon. The facility is bounded by Front Avenue on the north and west, the Willamette River on the east, and an asphalt roofing manufacturer on the south. The Arkema site is located on the southwest bank of the lower Willamette River (LWR) between River Mile (RM) 6.9 and RM 7.6, immediately upstream of the Burlington Northern Santa Fe (BNSF) Railroad Bridge in the northwest industrial area of Portland, Oregon (Figure 1). The property is located within Portland Harbor, part of which was designated as a federal Superfund site in 2000 by the United States Environmental Protection Agency (EPA).

The property lies within the Guild's Lake Industrial Sanctuary Plan (formerly the Northwest Portland Industrial Sanctuary) (Integral 2006). The Site is zoned and designated "IH" for heavy industrial use, which precludes it from most nonindustrial uses (Portland Development Commission 2004). The purpose of the Guild's Lake Industrial Sanctuary Plan is to maintain and protect this land as a dedicated area for heavy and general industrial uses. Therefore, while future use of the facility is unknown, it will likely be heavy industrial.

RAA Riverbank Conditions

This riverbank alternatives evaluation focuses on the region of the riverbank which is co-located and adjacent to the in-water RA (Figure 2). The riverbank is defined as the area between the top of bank and the edge of the Willamette River. For the purpose of this evaluation, the river's edge, or the toe of the slope, is defined at an elevation of 13.3 feet using the 1988 North American Vertical Datum (NAVD 88) as shown in the conceptual riverbank cross section (Figure 3).

The portion of river bank under consideration (the RAA Riverbank) is characterized by steep slopes and is covered with large pieces of concrete and asphalt for much of its 1100-foot length. The slope of the RAA Riverbank varies between 1.5H:1V and 2H:1V for approximately 850 feet. In limited portions of the riverbank (approximately 250 feet length) that are adjacent to the dock structures, the riverbank slope decreases to between 4H:1V and 5H:1V.

Baseline Habitat Condition Survey

The RAA Riverbank is covered with concrete debris and asphalt rubble that serve as riprap, providing erosion control and slope stability.

In accordance with an ODEQ request, LSS performed a baseline analysis of the riverbank salmonid habitat conditions along the entire riverbank in early 2010. The results of the condition survey were presented in the Baseline Salmonid Habitat Survey (Integral 2010). A baseline habitat survey was performed that consisted of taken systematic observations of the plant community; soil; debris; fill material present; covered structures; pilings; and coarse woody material. Observations were made every 50 feet along the riverbank.

The riverbank is heavily industrial in nature and is dominated by structures associated with the former site use. What nominal plant community exists on the sloped riverbank has few native species, and is predominantly comprised of weedy or ruderal invasive species.

The results of the baseline habitat survey within the RAA indicated that the riverbank in the vicinity of Docks 1 and 2 (Figure 2) is characterized by steep slopes, predominance of riprap, and covered structures. These characteristics result in a low salmonid habitat quality value for this area of riverbank. One of the major conclusions of the baseline habitat survey was that any remedial alternative that added vegetated grass/shrub land would improve existing conditions. In particular, alternatives that include unarmored or bioengineered slopes would result in improved salmonid habitat value of the riverbank area.

The active channel, or in-water, portion of the Dock 1 and 2 area was found to have a moderate salmonid habitat value. This moderate value was due to the presence of high habitat value gravel and finer substrates, but was diminished by the presence of covered structures (i.e., the docks).

The Baseline Salmonid Habitat Survey also included a relative habitat evaluation of the existing conditions. Specific salmonid habitat ranking values potentially applicable in Portland Harbor (National Marine Fisheries Service [NMFS] 2010) were assigned to each habitat. These habitat ranking values were multiplied by the percentage of each condition within each area, then summed to derive a habitat value for the portion of riverbank under consideration.

Area habitat value rankings as described above can be used to evaluate the relative values of existing conditions and the potential benefits/cost of subsequent remedial alternatives. However, due to the uncertainty of habitat ranking values applicable to Portland Harbor, no specific habitat value comparison was developed for this RAA Riverbank alternatives evaluation memorandum.

Further evaluation of the existing habitat ranking value and the comparison of potential future riverbank modifications that change this value (i.e., that either improve habitat or require habitat mitigation), will be assessed further once a preferred remedy is selected and removal action design is conducted.

SUMMARY OF RIVERBANK SOURCE CONTROL SCREENING EVALUATION

The *Riverbank Erodible Soil Source Control Screening Evaluation* (SCSE), dated December 2008 (ERM 2008) was prepared in order to evaluate historical site characterization data in accordance with the ODEQ and United States Environmental Protection Agency (EPA) Portland Harbor Joint Source Control Strategy (JSCS) (ODEQ 2005) guidance document. The SCSE considered the analytical results for 37 riverbank and beach samples collected from the riverbank along the Willamette River between 1998 and 2007. The analytical results were screened against JSCS screening level values (SLVs) and other appropriate screening levels. The results of the screening evaluation related to the RAA riverbank are summarized below.

Conclusions from Source Control Screening and Weight-of-Evidence Evaluation

The following conclusions regarding the RAA Riverbank were reached in the source control screening and weight-of-evidence evaluation:

- DDT, DDD, and DDE (collectively DDx) in the area of No. 2 Dock (samples RB-9 and RB-10) are considered a high priority. This location is co-located with the in-water RAA;

- Furan congeners are considered a high priority in the RAA Riverbank. However, the furans and DDx appear to be co-located in the river bank soil in the area of Dock 2. Therefore, the area of furan concentrations will be addressed in tandem with the DDx area.

Based on these conclusions, an alternatives evaluation for the high-priority DDx area identified above was recommended.

Agency Review of the Riverbank Source Control Screening Evaluation

ODEQ and EPA provided comments on the SCSE dated 21 July 2009 (ODEQ 2009). ODEQ requested that proposed remedial alternatives be provided for review and approval prior to preparing the riverbank alternatives evaluation. The *Summary of Remedial Alternatives, Riverbank Source Control Measure* (SRA) memorandum, dated 16 October 2009 (ERM 2009) was prepared in response to this request. The SRA is the basis for the alternatives included in this focused alternatives evaluation.

The ODEQ and EPA provided comments on the SRA in April 2010. The agency comments included directives to consider specific alternatives (i.e., cut slope angles and clean cover requirements). This memorandum addresses these agency requirements where applicable to the area under consideration.

REMEDIAL ACTION OBJECTIVES

In accordance with the *Administrative Order on Consent for Removal Action* between Arkema and EPA, dated 27 June 2005, the objectives of the RA, including sediment and riverbank actions, are to include:

- Reduce human health risks to acceptable levels from direct contact with and incidental ingestion of chemicals of concern (COCs) in sediments and riverbank within the RAA;

- Reduce COC concentrations in sediment and riverbank within the RAA to levels that will result in acceptable risks to humans that eat fish and shellfish from the Willamette River;

- Reduce human health risks to acceptable levels from direct contact with and incidental ingestion of water with COCs within the RAA;

- Reduce ecological risks from contact with and ingestion of COCs in sediments or riverbank material or prey within the RAA to acceptable levels;

- Reduce ecological risks to acceptable levels from direct contact with and incidental ingestion of water with COCs within the RAA;

- Eliminate the potential for migration of contaminants at unacceptable levels from RAA to the Willamette River; and

- Reduce contaminant flux from uplands, riverbank, and sediment so that recontamination of any sediment or riverbank caps put in place does not occur.

Additional remedial action objectives for the Riverbank SCM that have been identified include:

- Ensure compatibility with the Groundwater and Stormwater SCMs;

- Ensure compatibility with other potential remedial actions (e.g., in-water Removal Action, Groundwater SCM, and Stormwater SCM), including a phased design and implementation schedule; and

- Ensure compatibility with the upland feasibility study and final site remedy selection.

Consideration of Hot Spots

Per agreement between ODEQ and LSS, riverbank soils were specifically excluded from a hot spot evaluation (HSE) update submitted to the ODEQ in January 2012 (ERM 2012). Agency comments on the HSE update were received on 28 June 2012. Negotiation and finalization of the HSE is ongoing. Thus, any potential hot spots associated with riverbank soils have not yet been fully identified. For the purposes of this evaluation, and because the primary COC associated with the RA, DDT, is present in riverbank soil in the Dock No. 2 area, the RAA Riverbank was assumed to require remedial measures per ODEQ rules. Remedial measures that prevent contact, either through source removal or providing a barrier to contact, can address these areas of DDT in soil.

In general, the remedial technologies under consideration for the RAA Riverbank SCM involve removal of some portion of riverbank material, including debris and soil. The removal of this material is anticipated to include removal of any potential hot spot material. Complete removal of any potential hot material is technically impracticable due to multiple site constraints as discussed below.

The Groundwater SCM that is currently being implemented at the site is intended to prevent flux of COCs in groundwater from the site to the Willamette River. This will be achieved by maintaining an inward hydraulic gradient from the Willamette River. Any COCs potentially leaching from soil to groundwater on the riverward side of the GWBW, including the RAA Riverbank, will tend to flow towards the barrier wall (i.e., away from the river), thus containing any potentially highly mobile hot spots.

Compatibility with In-Water Removal Action

One of the requirements of the RAA and Riverbank SCM is compatibility with other remedial actions and source control measures at the site. The proposed in-water sediment RA will likely require some armoring to be placed over sediment removal and/or cap areas. For the purpose of this memorandum, ERM has assumed that armoring material (e.g., rip rap, habitat gravel, etc.) used for riverbank stabilization will be consistent with the armoring material used for the in-water RA and other recently implemented riverbank source control measures implemented in the Lower Willamette River (e.g., Zidell Waterfront Property).

The extent of removal of sediment as part of the in-water RA is likely to intersect with the toe of the riverbank slope. The depth of sediment removed will be determined by the depth required to achieve the RAOs, while also maintaining riverbank stability. The depth of sediment removal is anticipated to be between 3 and 5 feet from existing mudline within the area under consideration in this memorandum. In order to maintain slope stability, the depth of riverbank soil removal will also be limited to a maximum of approximately 3 feet. A slope stability analysis to determine the safe depth of removal will be conducted as part of the detailed design of the selected in-water RA and Riverbank SCM.

SOURCE CONTROL ALTERNATIVES EVALUATION

This section presents a focused feasibility evaluation of four alternatives for riverbank source control in the RAA Riverbank.

IDENTIFICATION AND DESCRIPTION OF REMEDIAL ALTERNATIVES

Four remedial alternatives were identified in the Summary of Remedial Alternatives Memorandum dated 16 October 2009, including:

- No action;
- Limited action;
- Riverbank regrading and stabilization; and
- Riverbank soil removal and stabilization.

For the purpose of this alternatives evaluation, the sheet pile wall stabilization technology identified in the Summary of Remedial Alternatives Memorandum (ERM 2009) is considered a standalone alternative as it involves a different technological approach than the riverbank regrading and soil removal alternatives.

ODEQ and USEPA comments, dated 20 April 2010 and 16 October 2009, respectively, on the Summary of Remedial Alternatives Memorandum requested that several variations of these four alternative technologies be considered, including increased soil removal and establishing lower angle slopes (e.g., a 5H:1V slope). The requested variations have been incorporated into this alternatives evaluation in the form of sub-alternatives to the broader alternative technologies identified above. The sub-alternatives were developed by combining the different stabilization technologies with the range of slope angles (1.5H:1V, 2H:1V, and 5H:1V) considered in this evaluation. The major components of the resulting seven sub-alternatives are summarized below and presented in Table 1.

No Action

The no action alternative consists of leaving the riverbank in its current state. It is included as an alternative in the evaluation process in order to provide a baseline comparison to the other alternatives. This alternative does not include active remedial measures and, therefore, represents the findings in the Human Health Risk Assessment (Integral 2008) and Baseline Ecological Risk Assessment (Integral 2008) and addenda.

Limited Action

The limited action alternative consists of the following components:

- Institutional controls to prevent activities from disturbing the riverbank; and
- Periodic inspection and maintenance of the riverbank to ensure that existing vegetation and armoring is maintained.

Implementation of institutional controls and a periodic inspection and maintenance program will minimize the potential for riverbank erodible soils to become mobilized in the future.

Riverbank Regrading and Stabilization

The riverbank regrading and stabilization alternative consists of the following components:

- Removal of debris and potential localized hot spot material;
- Cutting and filling soil along the riverbank in order to create a uniform slope from the top of the bank to the toe that is more stable and resistant to erosion;
- Placement of suitable cover soil; and
- Stabilization of the riverbank with vegetation, riprap, or suitable soil-filled geocell.

For the purpose of this evaluation and for the EE/CA, it was assumed that all excavated material will be disposed of off-site at a Subtitle D landfill

facility. Additional disposal options, including on site management may be developed and be evaluated as part of the comprehensive Riverbank SCM Alternatives Evaluation to be prepared subsequent to this memorandum.

Various options exist for stabilizing the regraded riverbank. As noted above, stabilizing the regraded slope with vegetation, riprap, or geocell has been considered for this alternatives evaluation. Given the varying effectiveness, reliability, and acceptability of these stabilization technologies, three riverbank regrading sub-alternatives have been created to facilitate this evaluation. For each sub-alternative, one of the three stabilization techniques is paired with the other components of the overall alternative, as identified above. The resulting sub-alternatives are:

- 3A - Regrading, Soil Cover, and Riprap;
- 3B - Regrading, Soil Cover, and Geocell; and
- 3C - Regrading, Soil Cover, and Vegetation.

A conceptual schematic for each of these sub-alternatives is presented in Figures 4 through 6.

Riverbank Soil Removal and Stabilization

The riverbank soil removal and stabilization alternative consists of the following components:

- Removal of debris, potential localized hot spot material, and soil, in order to decrease the slope of the riverbank;
- Placement of suitable cover soil; and
- Stabilization of the riverbank with vegetation, riprap, or suitable soil-filled geocell.

As discussed above, for the purpose of this evaluation, it was assumed that all excavated material will be disposed of off-site at a Subtitle D landfill facility.

Similar to the riverbank regrading and stabilization alternative, three sub-alternatives have been created to facilitate evaluation of the vegetation,

riprap, and geocell stabilization technologies. Additionally, each sub-alternative includes laying back the riverbank to a different slope angle. Three slope angles have been considered in this alternatives evaluation, including slopes of one and one-half horizontal to one vertical (1.5H:1V), 2H:1V, and 5H:1V. For the purpose of this focused alternatives evaluation, each stabilization technology has been paired with a slope angle that is complementary to the characteristics and limitations of that technology. In general, the stabilization technology is paired with the maximum slope angle achievable with that technology. The resulting sub-alternatives are:

- 4A - Removal, Soil Cover, and Riprap, (2H:1V slope). Riprap cover, can typically achieve the steepest un-reinforced slopes.

- 4B - Removal, Soil Cover, and Geocell (1.5H:1V slope). Reinforced stabilization technology such as Geocell allows for the steepest vegetated slopes to be achieved; and

- 4C - Removal, Soil Cover, and Vegetation, (5H:1V slope). This slope angle is typically used to achieve the maximum habitat value for riverbank stabilization activities and can be achieved without reinforcement.

A conceptual schematic for each of these sub-alternatives is presented in Figures 7 through 9.

Other slope angle – stabilization technology combinations are possible and may be considered as part of the comprehensive Riverbank SCM Alternatives Evaluation.

Sheet Pile Wall

The sheet pile wall alternative consists of the following components:

- Sheet pile retaining wall at the toe of the riverbank; and

- Placement of backfill, possibly including suitable dredge material, within the void behind the wall to create a flat slope.

A conceptual schematic for this alternative is presented in Figure 10. The sheet pile wall will function as a retaining wall. One of the alternatives under evaluation in the EE/CA is a nearshore confined disposal facility

(CDF) for sediment. The footprint of the conceptual nearshore steel sheet pile CDF extends further in water than any potential riverbank sheet pile wall alignment. If a nearshore CDF is implemented, a second interior sheet pile wall, and indeed any potential RAA Riverbank SCM, will not be required, as this portion of riverbank will be physically separated from the Willamette River and become encapsulated in the CDF structure.

ALTERNATIVES EVALUATION

The above alternatives for riverbank source control were evaluated on the basis of the following factors:

- Effectiveness;
- Long-Term Reliability;
- Implementability;
- Implementation Risk; and
- Reasonableness of Cost.

The evaluation of the alternatives with respect to each factor is summarized in Table 2.

Comparative Analysis of Alternatives

Characteristics common to, and distinguishing, multiple alternatives were evaluated for each of the alternatives.

Effectiveness

Although the existing rip rap and large concrete debris protect against erosion and scour, the no action and limited action alternatives may not necessarily prevent potential transport of impacted riverbank materials.

The riverbank regrading and stabilization alternatives are effective at preventing erosion and transport of potentially impacted riverbank materials. The cover soil component of these alternatives prevents contact with underlying riverbank soil and is protective of burrowing animals, if any. The riprap and geocell technologies are expected to be more effective than vegetation at resisting erosion and scour.

The riverbank soil removal and stabilization alternatives are also effective at preventing potential erosion and transport of riverbank soil. Greater quantities of riverbank material will be removed under the removal alternatives rather than the regraded riverbank alternative. Similar to the riverbank regrading and stabilization alternatives, the riprap and geocell materials will be more effective than vegetation alone at resisting erosion and scour. Both the vegetation and geocell sub-alternatives are expected to improve the quality of the riverbank habitat for fish and other in-water and upland biota.

The sheet pile wall alternative is very effective at preventing erosion and transport of potentially impacted riverbank materials as a result of the rigid barrier between riverbank soils and river water.

Long-Term Reliability

The no action and limited action alternatives are considered somewhat less reliable in the long-term due to limited ability to prevent transport of potentially impacted riverbank materials to the river under certain conditions.

The riprap and geocell sub-alternatives of the riverbank regrading and stabilization alternative are considered reliable in the long-term as they are widely available and proven techniques for preventing shoreline erosion and scour. The vegetation sub-alternative has slightly reduced long-term reliability due to susceptibility to erosion during severe flood events.

Similarly, the riprap and geocell sub-alternatives of the riverbank soil removal and stabilization alternative are considered reliable in the long-term. The 5:1 slope sub-alternative, which was paired with vegetative stabilization for the purpose of this alternatives evaluation, is considered less reliable due to susceptibility to erosion during severe flood events.

The sheet pile wall alternative is considered reliable in the long-term.

Implementability

The no action and limited action alternatives are considered highly implementable.

The riverbank regrading and stabilization alternatives are considered readily implementable. These alternatives involve regrading the riverbank and, depending on the existing riverbank configuration, may involve a net fill situation in the floodplain. There are additional permitting requirements for actions that involve filling within the floodplain.

The riverbank soil removal and stabilization alternatives are considered implementable. However, the 5:1 slope sub-alternative of soil removal and stabilization technology would, in many locations, result in the top of bank being approximately 70 feet landward of the current top of bank (see Figure 11 for the approximate location of the proposed top of bank for the three slope angles considered). This offset is likely to affect the stability of existing and proposed site structures. There is a potential for interference with implementation of the Stormwater and Groundwater SCMs.

The Stormwater SCM consists of regrading the site to direct stormwater through a large detention basin and then through a sand filter basin. The treated stormwater is then discharged to the Willamette River through an existing outfall.

The Groundwater SCM consists of a bentonite slurry groundwater barrier wall (GWBW) and a Groundwater Extraction and Treatment (GWET) System. The GWBW will be installed from ground surface to basalt bedrock (approximately 50 and 85 feet below ground surface). Groundwater recovery wells will be installed on the upland side of the GWBW and be used to maintain an inward hydraulic gradient across the GWBW. Extracted groundwater will be collected and treated in the GWET System, then discharged to the Willamette River through an existing outfall.

The GWBW alignment was selected to maximize capture of groundwater, while maintaining an offset from the top bank that provided an acceptable factor of safety for slope stability.

Laying back the riverbank to low slopes (i.e., 5H:1V) will require removal of significant portions of the riverbank. As presented in Figure 11, the resulting top of bank will intersect and compromise the stability of the slurry wall, the groundwater recovery system, and the treatment system building, particularly during seismic events. This constraint limits the implementability of a 5H:1V, slope particularly within the RAA Riverbank.

The sheet pile wall alternative is considered to have low implementability as it is unlikely that sufficient embedment depth can be attained in sediment to maintain stability, particularly in the northern region of the RAA riverbank. Significant permitting challenges are associated with this alternative due to the elimination of the riverbank, and the subsequent decrease in salmonid habitat ranking value.

As noted above, one of the alternatives under evaluation in the EE/CA is a nearshore CDF for sediment. If a nearshore CDF is implemented any potential RAA Riverbank SCM will not be required, as this portion of riverbank will be become encapsulated in the CDF structure.

Implementation Risk

The no action and limited action alternatives are considered to have low implementation risk.

The limited grading associated with the riverbank regrading and stabilization alternative presents little implementation risk to the community and site workers.

The riverbank soil removal and stabilization alternatives involve more extensive soil excavation, grading, and on site transport, and thus present a moderate implementation risk to the community and environment.

The sheet pile wall alternative is considered to have a moderate to high implementation risk due to in water pile driving activities and significant backfilling operations required.

Reasonableness of Cost

The no action and limited action alternatives are projected to have the lowest capital and operation and maintenance (O&M) costs.

The riverbank regrading and stabilization alternatives are projected to have low to moderate capital costs and low O&M costs.

The riverbank soil removal and stabilization alternatives are projected to have moderate to high capital costs and low O&M costs due to the need to manage large quantities of materials removed from the riverbank.

The sheet pile wall alternative is projected to have the highest capital cost due to high equipment mobilization/demobilization costs and material expenses. This alternative will likely have a relatively low O&M cost.

Recommended Alternative

Based on the alternatives evaluation, the riverbank regrading and stabilization with riprap alternative is the recommended measure for the RAA Riverbank. The selection of this alternative is based primarily on the following factors:

- Effectiveness – Debris and some potential hot spot soil will be removed, and riverbank regraded to a uniform, more stable configuration that is more resistant to erosion. Contact with underlying riverbank soil and potential erosion and transport of impacted materials is minimized as a result of the soil cover and riprap cover.

- Long-Term Reliability – The alternative consists of a proven riverbank stabilization technique. Additionally, the quality of habitat will be improved from the current riverbank conditions.

- Implementability – The alternative involves widely available materials and conventional construction techniques.

- Implementation Risk – There is little potential for adverse impacts to the community and site workers from implementation of this alternative.

- Reasonableness of Cost – Limited excavation and grading and common, proven construction materials result in projected moderate capital costs and low O&M costs.

As noted above, the intent of the riverbank regrading alternative is to create a more stable slope from the top of the bank to the toe by cutting and filling soil along the riverbank. The slope of the regraded riverbank will, therefore, largely be similar to the existing slope.

The capital cost for implementation of the recommended alternative is approximately $1,200,000. This EE/CA-level cost is estimated to be within +50 percent / - 30 percent of actual costs. An itemized breakdown of the estimated capital costs is included as Attachment 1. This estimate will be

incorporated into the cost analysis of the EE/CA and used for selection of a preferred RAA alternative.

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United States Environmental Protection Agency. 2009. Memorandum Correspondence: *Review Comments on Summary of Remedial Alternatives, Riverbank Source Control Measure*. 1 December 2009.

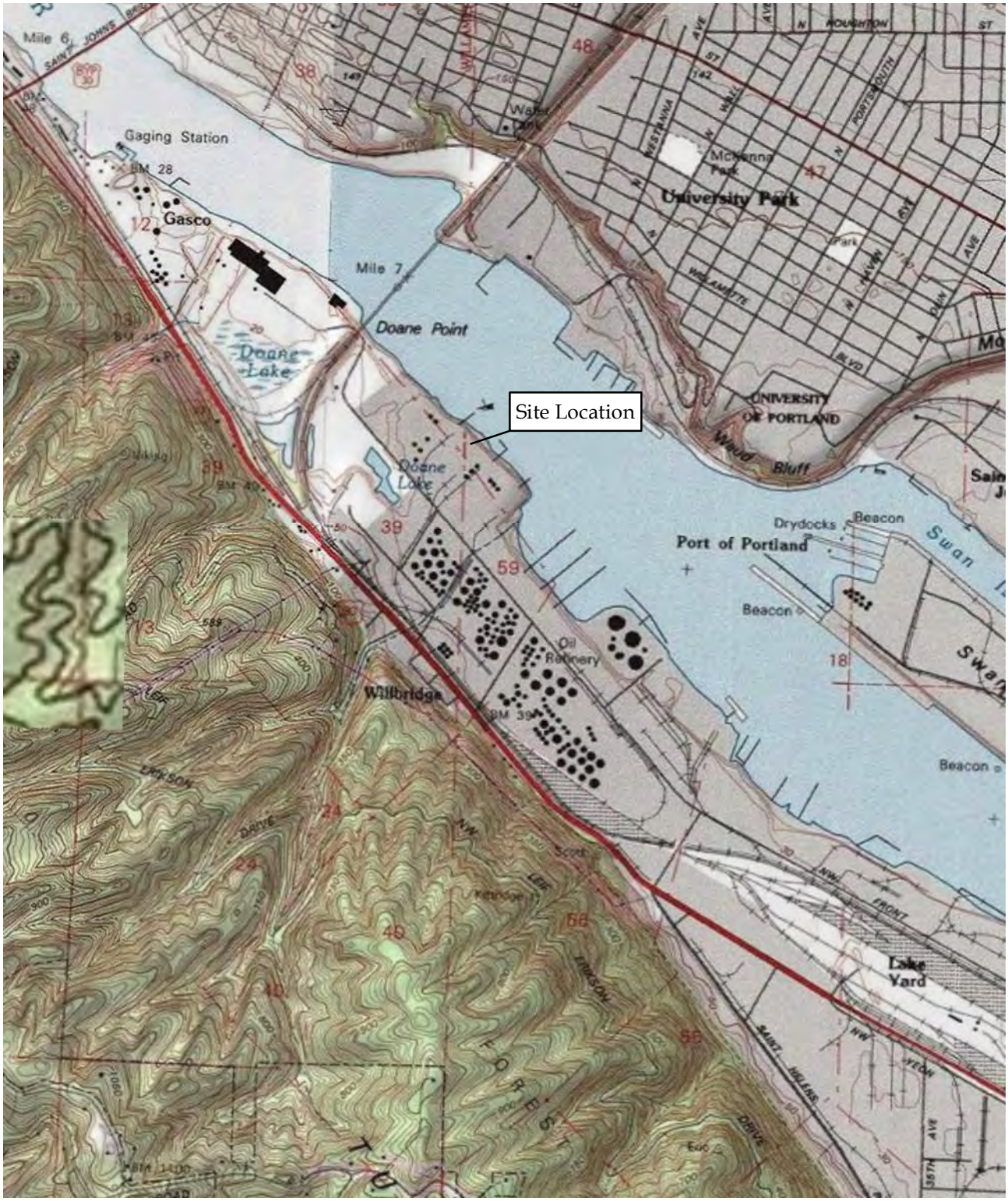
Figures

Project: 0093634

Date: 7/24/2012

Drawn By: MJA/SHD

File: F:\Projects\Arkema Portland\GIS Figures\0093634 GW SCM and Upland FS\GIS\RAAFigures\Figure 1 - RAASiteLocation.mxd



Arkema Parcel and Property Boundaries

ESRI USA Topo Maps Web Service
U.S.G.S 7.5 Minute Topograhic Quadrangles:
Linnton, OR 1990
Portland, OR 1990

0 2,000 4,000 Feet

1:24,000

N

Figure 1

Site Location Map

EE/CA RAA Riverbank Alternatives Evaluation

Arkema Inc.

Portland, Oregon

Environmental Resources Management
1001 SW 5th Ave, Suite 1010
Portland, Oregon 97204

Project: 0093634.07

Date: 7/24/2012

Drawn By: mike.appel

File: F:\Projects\Arkema Portland\GIS Figures\0093634 GW SCM and Upland FS\GIS\RAAFigures\Figure 2- RAASCMArea.mxd

- Top of Bank (appoximate)
- Ordinary High Water (20.5 ft NAVD88)
- Ordinary Low Water (5 ft NAVD88)
- Approximate River Edge (13 ft NAVD88)
- Index Contour (10 ft)
- Surface Contour (2 ft)
- Parcel and Property Boundaries
- EPA Directed Horizontal RAA Boundary
- Lot 3 riverbank Area
- Lots 1 and 2 Riverbank Area
- Salt Pad Riverbank Area
- RAA-Riverbank Area

N

0 200 400 Feet

Figure 2

Riverbank Areas

EE/CA RAA Riverbank Alternatives Evaluation

Arkema Inc.

Portland, Oregon

Environmental Resources Management
1001 SW 5th Ave, Suite 1010
Portland, Oregon 97204
ERM

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Date: 7/25/2012

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File: F:\Projects\Arkema Portland\GIS Figures\0093634 GW SCM and Upland FS\GIS\RAAFigures\Figure 3 - RAASCMRiverCrossSection.mxd

RAA Riverbank Cross-Section

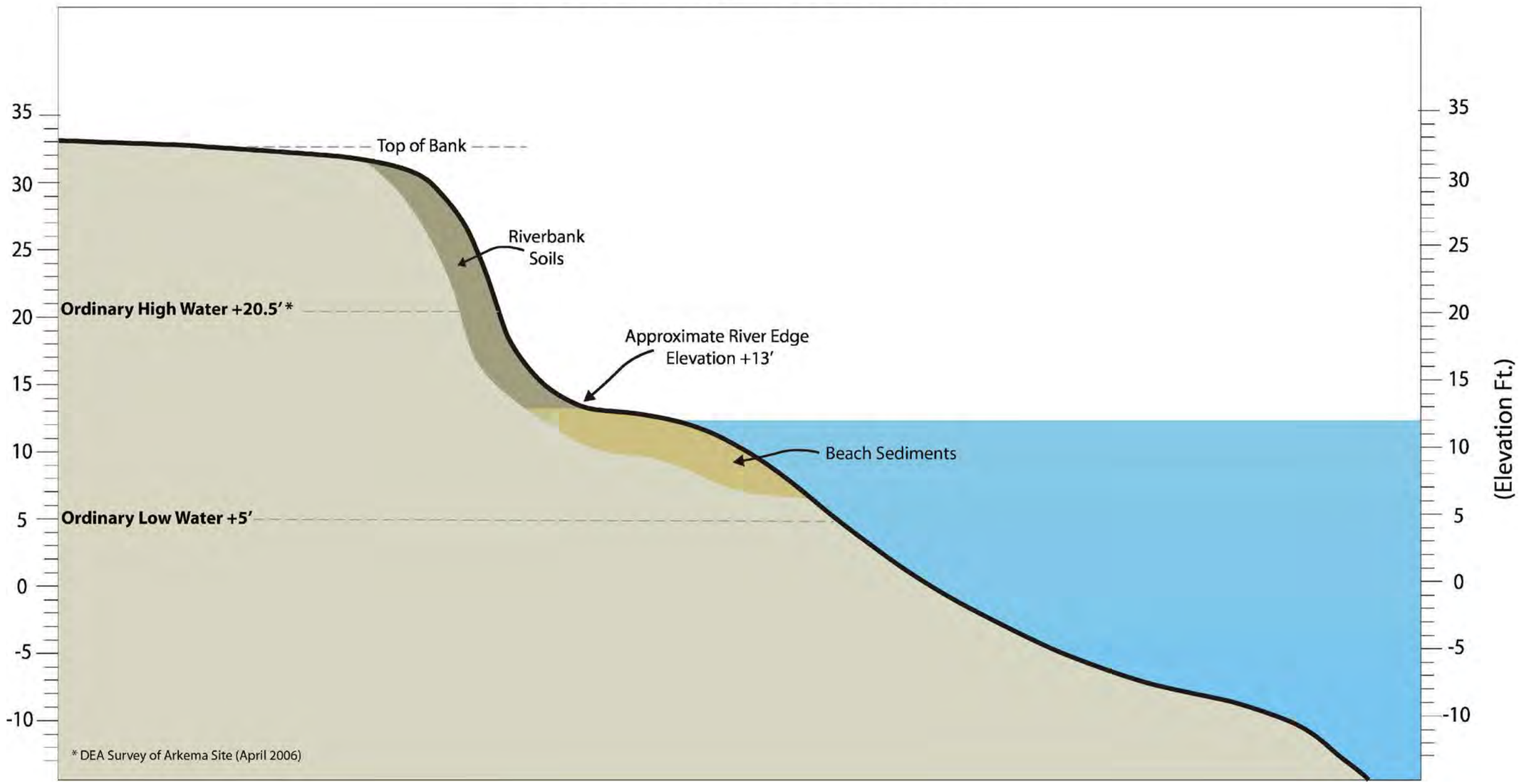

Figure 3

Schematic Willamette River Bank Cross-Section
EE/CA RAA Riverbank Alternatives Evaluation
Arkema Inc.
Portland, Oregon

Vertical Datum: NAVD88 (For River Mile 7 to 8 Subtract 5.2 feet for elevation in CRD.)

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Portland, Oregon 97204
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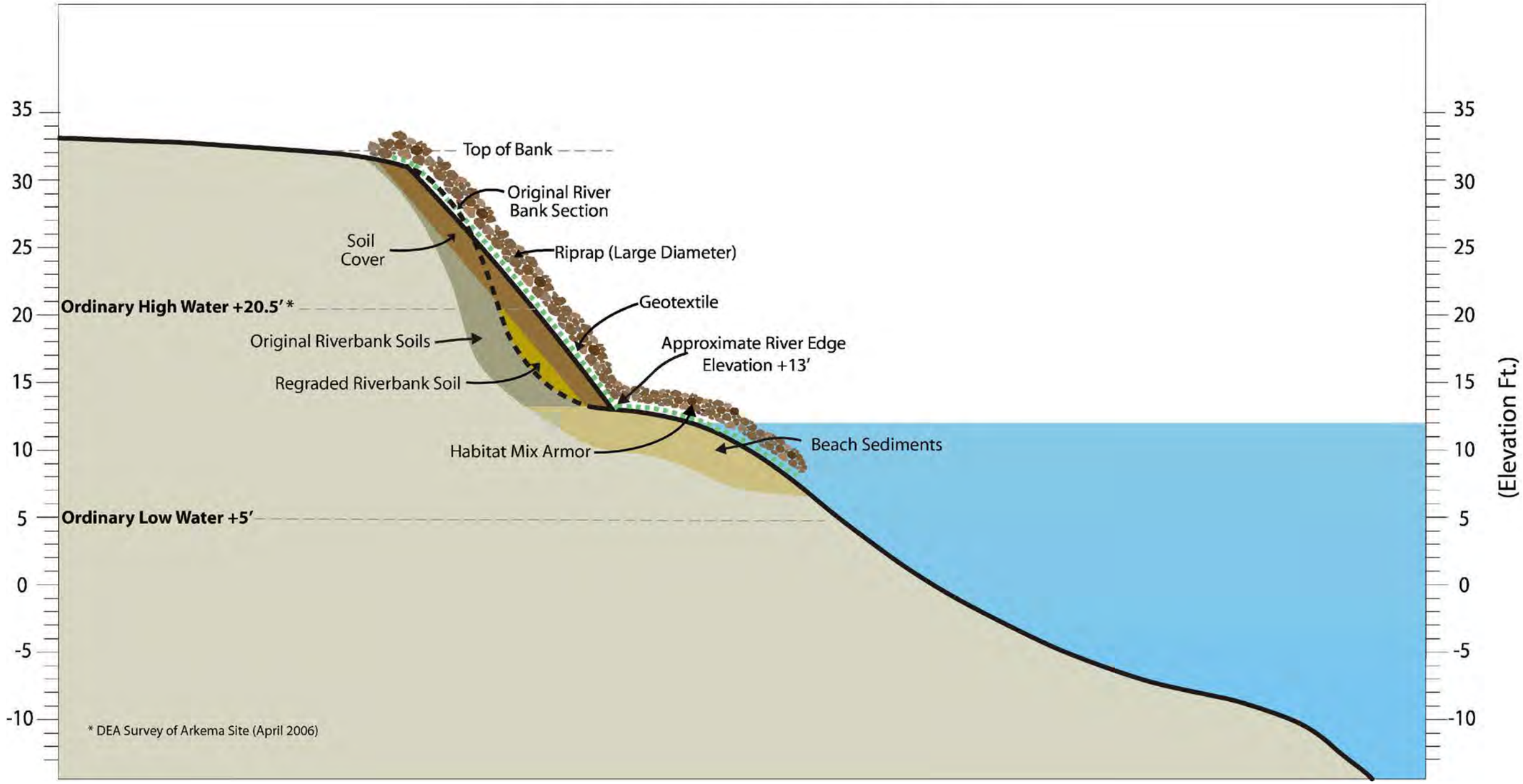
RAA Riverbank Cross-Section



Vertical Datum: NAVD88 (For River Mile 7 to 8 Subtract 5.2 feet for elevation in CRD.)

Figure 4

Alternative 3a - Regrading, Soil Cover, and Riprap
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Portland, Oregon

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Portland, Oregon 97204
ERM

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File: F:\Projects\Arkema Portland\GIS Figures\0093634 GW SCM and Upland FS\GIS\RAAFigures\Figure 4 - RAASCMRegradeRiprap.mxd

RAA Riverbank Cross-Section

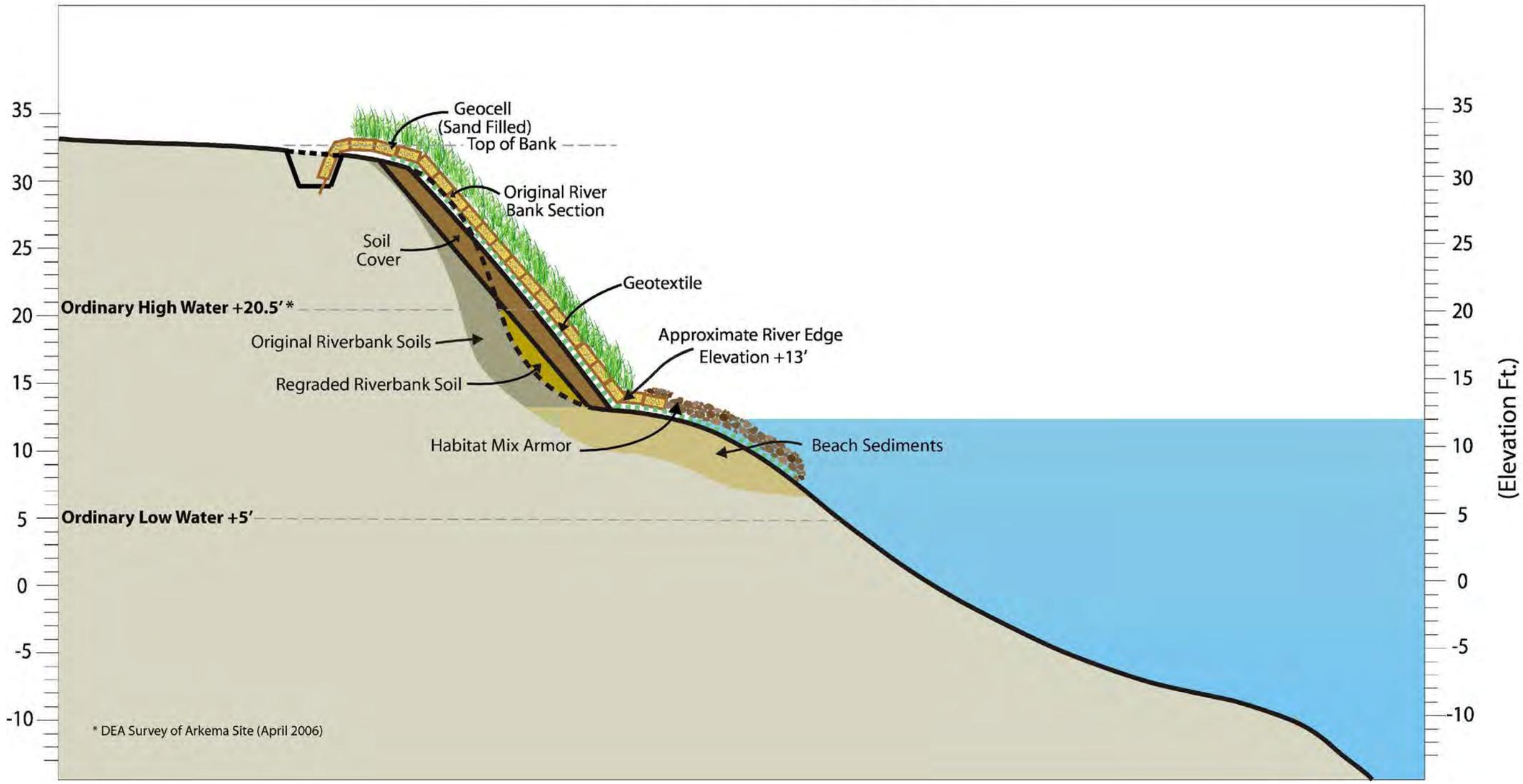

Figure 5

Alternative 3b - Regrading, Soil Cover, and Geocell
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Arkema Inc.
Portland, Oregon

Vertical Datum: NAVD88 (For River Mile 7 to 8 Subtract 5.2 feet for elevation in CRD.)

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Project: 0093634

Date: 7/25/2012

Drawn By: MJA/SHD

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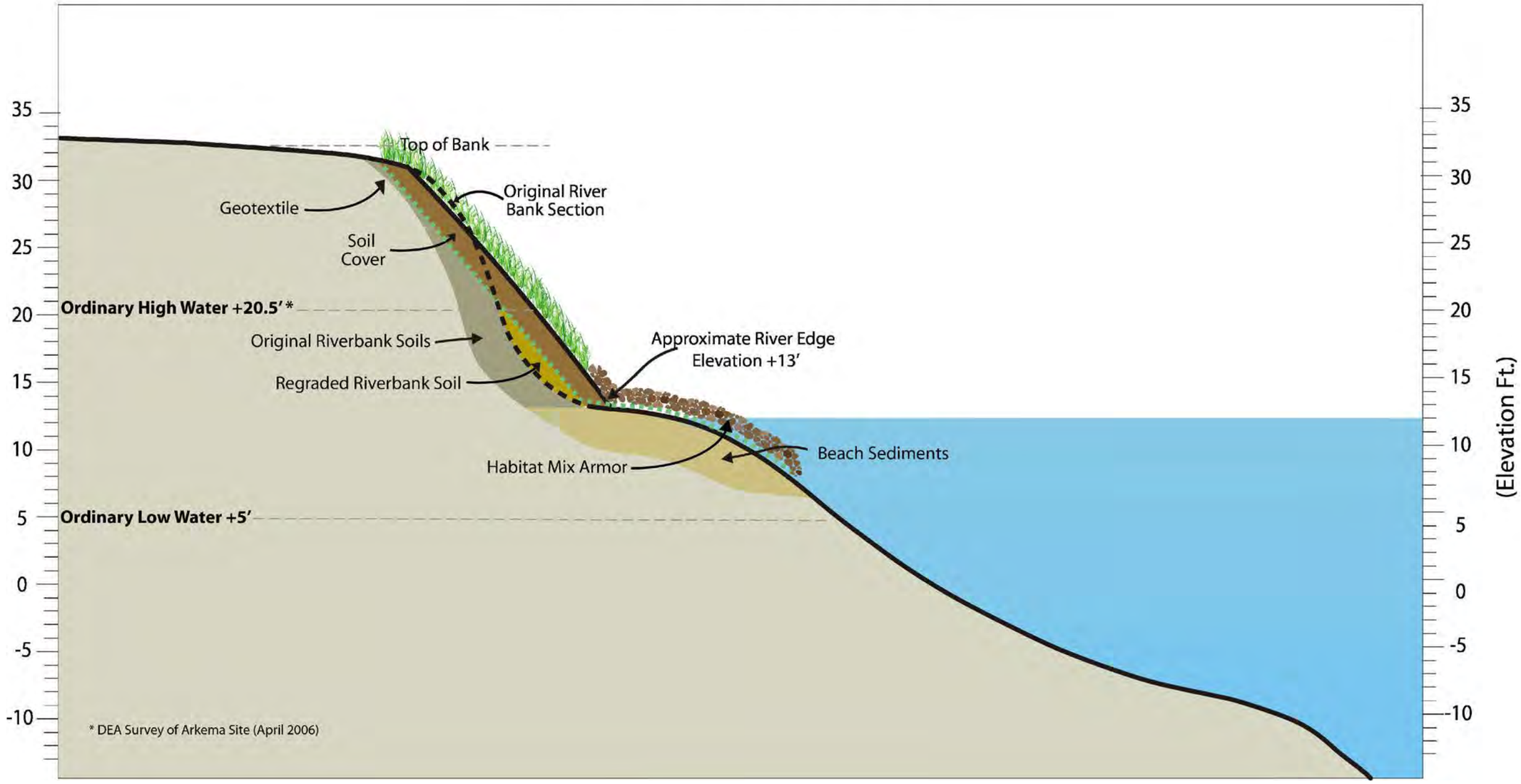
RAA Riverbank Cross-Section



Vertical Datum: NAVD88 (For River Mile 7 to 8 Subtract 5.2 feet for elevation in CRD.)

Figure 6

Alternative 3c - Regrading, Soil Cover, and Vegetation
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Arkema Inc.
Portland, Oregon

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RAA Riverbank Cross-Section

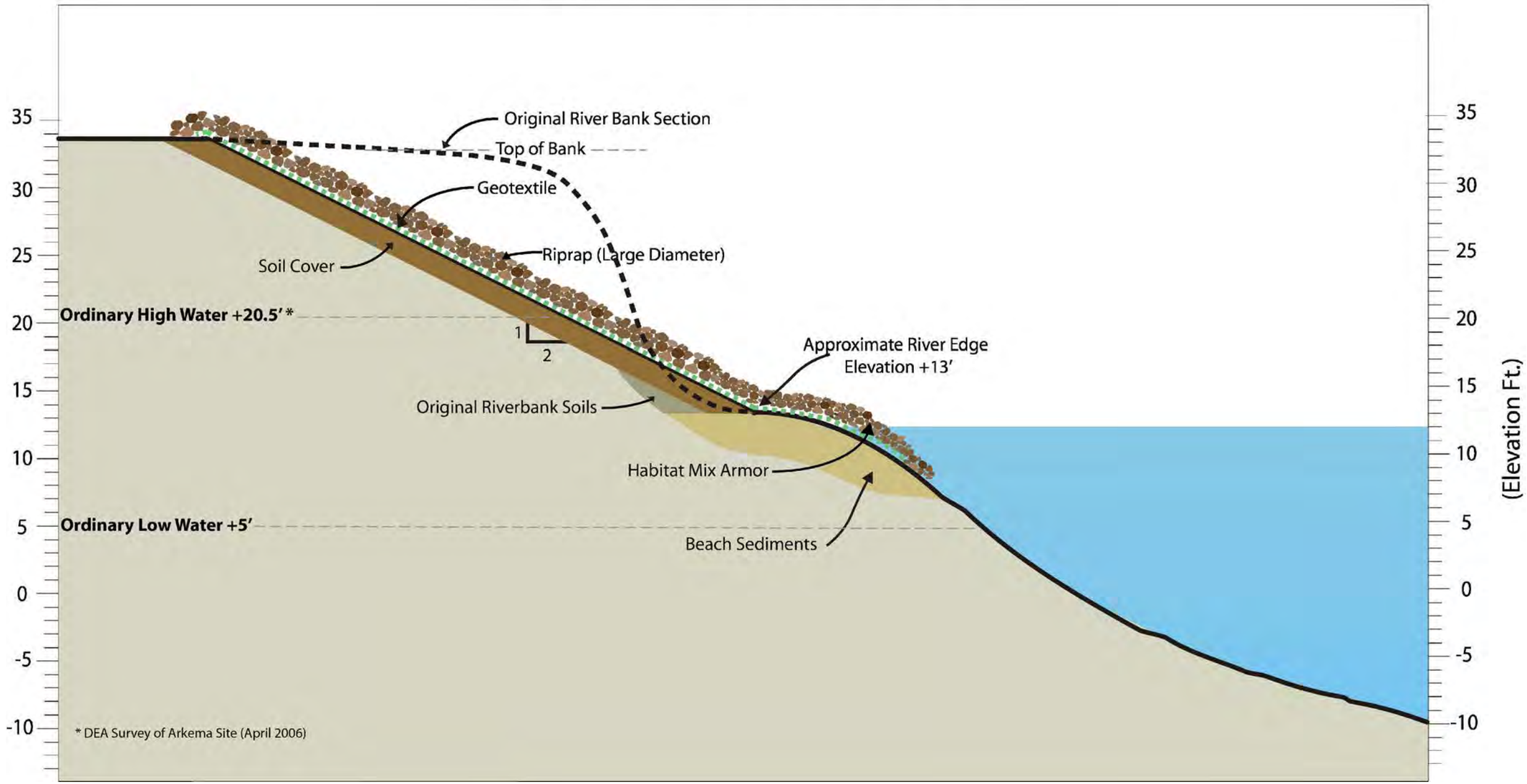

Figure 7
Alternative 4a - Removal, Soil Cover, and Riprap
EE/CA RAA Riverbank Alternatives Evaluation
Arkema Inc.
Portland, Oregon

Vertical Datum: NAVD88 (For River Mile 7 to 8 Subtract 5.2 feet for elevation in CRD.)

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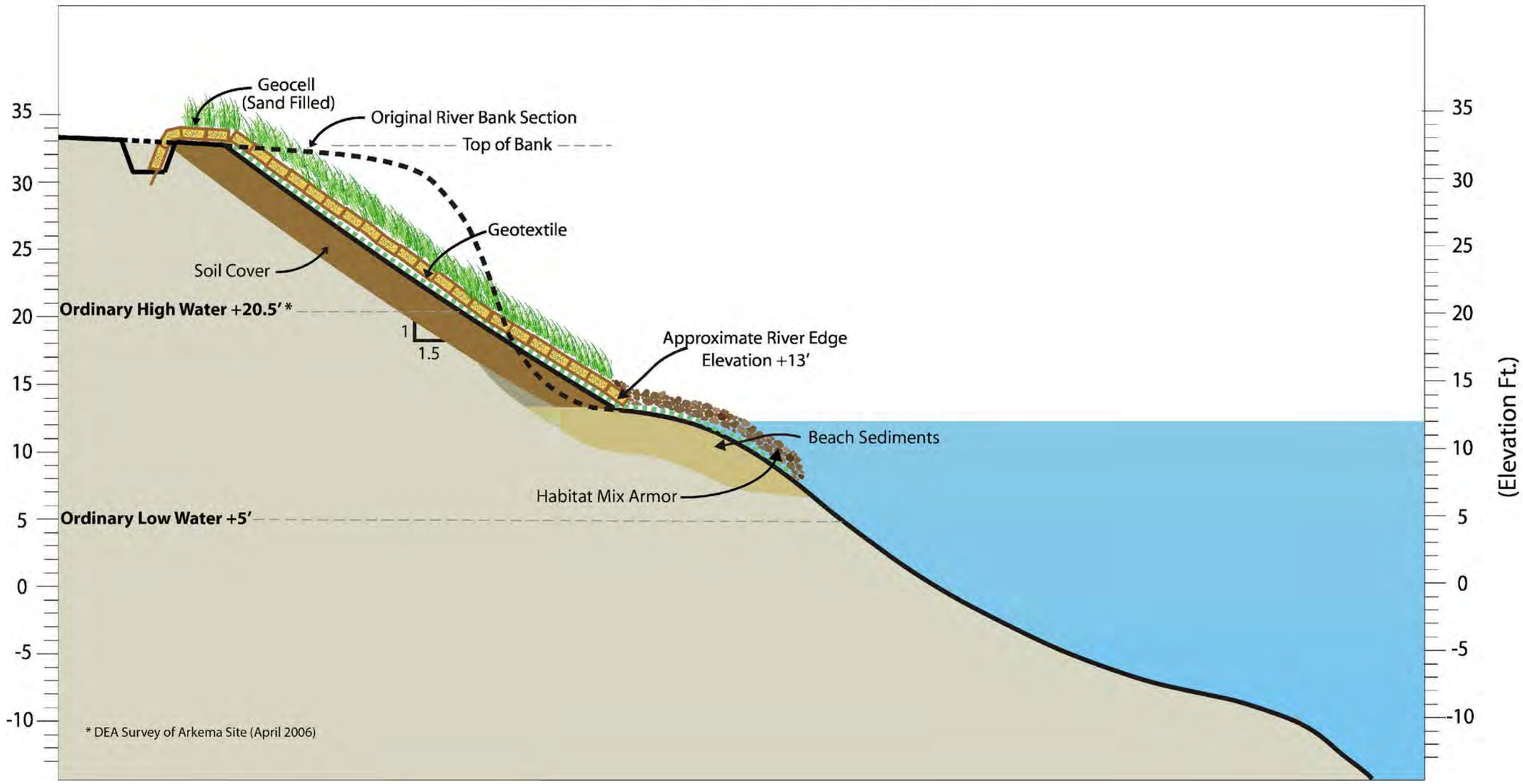
RAA Riverbank Cross-Section



Vertical Datum: NAVD88 (For River Mile 7 to 8 Subtract 5.2 feet for elevation in CRD.)

Figure 8

Alternative 4b - Removal, Soil Cover, and Geocell
EE/CA RAA Riverbank Alternatives Evaluation
Arkema Inc.
Portland, Oregon

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File: F:\Projects\Arkema Portland\GIS Figures\0093634 GW SCM and Upland FS\GIS\RAAFigures\Figure 8 - RAASCMRemoval15-1.mxd

RAA Riverbank Cross-Section

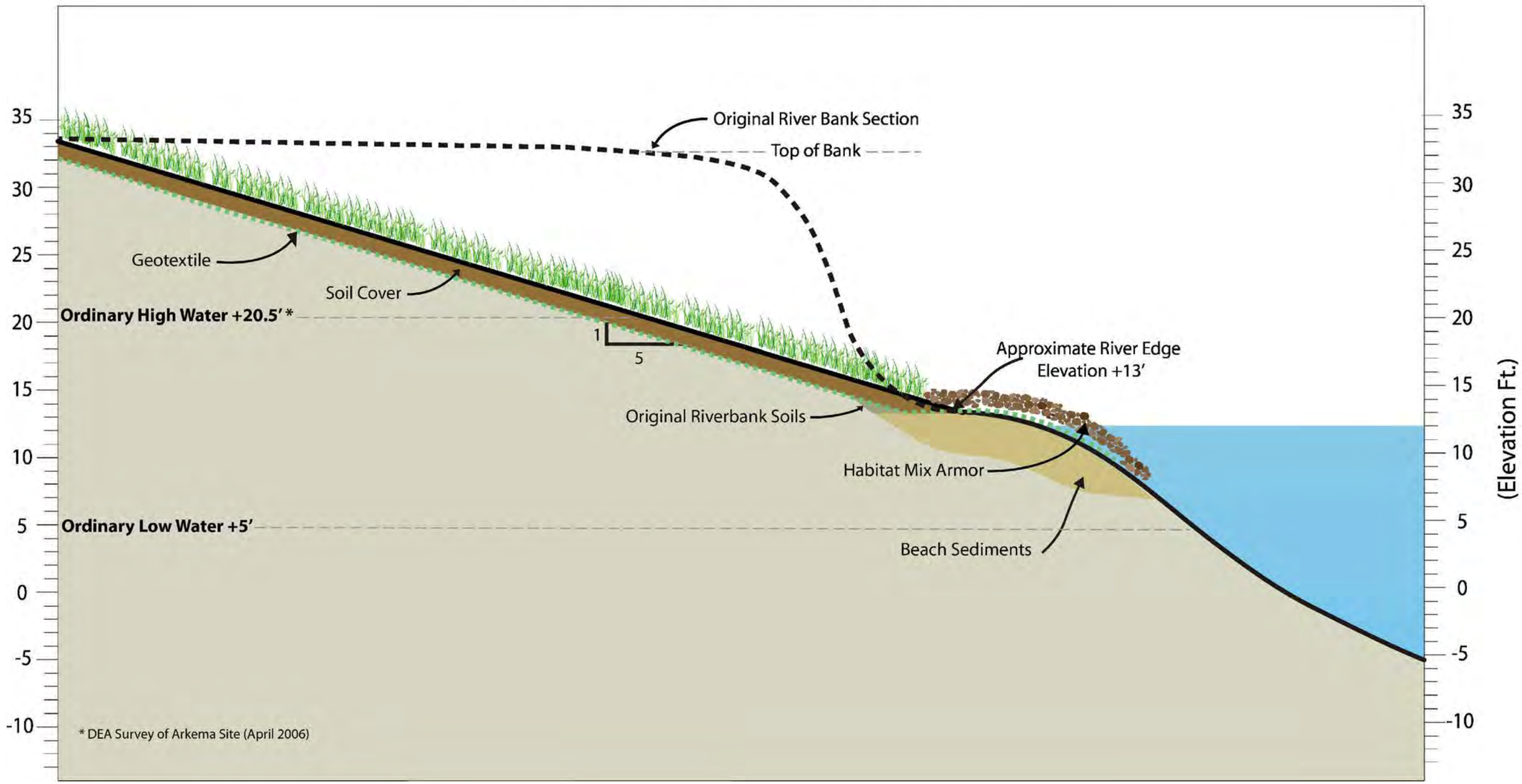

Figure 9

Alternative 4c - Removal, Soil Cover, and Vegetation
EE/CA RAA Riverbank Alternatives Evaluation
Arkema Inc.
Portland, Oregon

Vertical Datum: NAVD88 (For River Mile 7 to 8 Subtract 5.2 feet for elevation in CRD.)

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RAA Riverbank Cross-Section

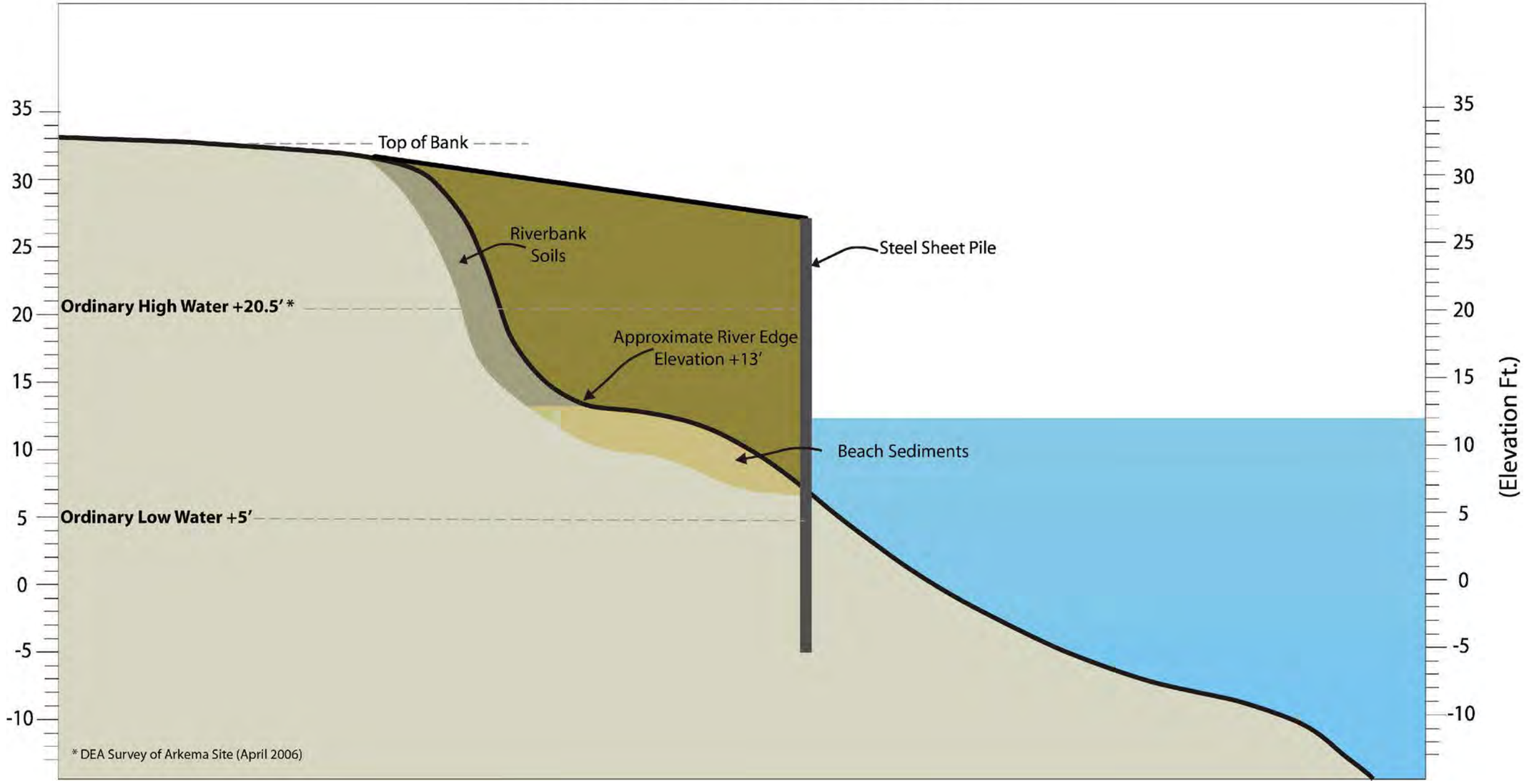

Figure 10
Alternative 5 - Steel Sheet Pile Wall
EE/CA RAA Riverbank Alternatives Evaluation
Arkema Inc.
Portland, Oregon

Vertical Datum: NAVD88 (For River Mile 7 to 8 Subtract 5.2 feet for elevation in CRD.)

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Portland, Oregon 97204 ERM

Project: 0093634
Date: 7/25/2012
Drawn By: MJA/SHD
File: F:\Projects\Arkema Portland\GIS Figures\0093634 GW SCM and Upland FS\GIS\RAAFigures\Figure 10 - RAASCMSheetpile.mxd

Project: 0093634.07

Date: 7/24/2012

Drawn By: mike.appel

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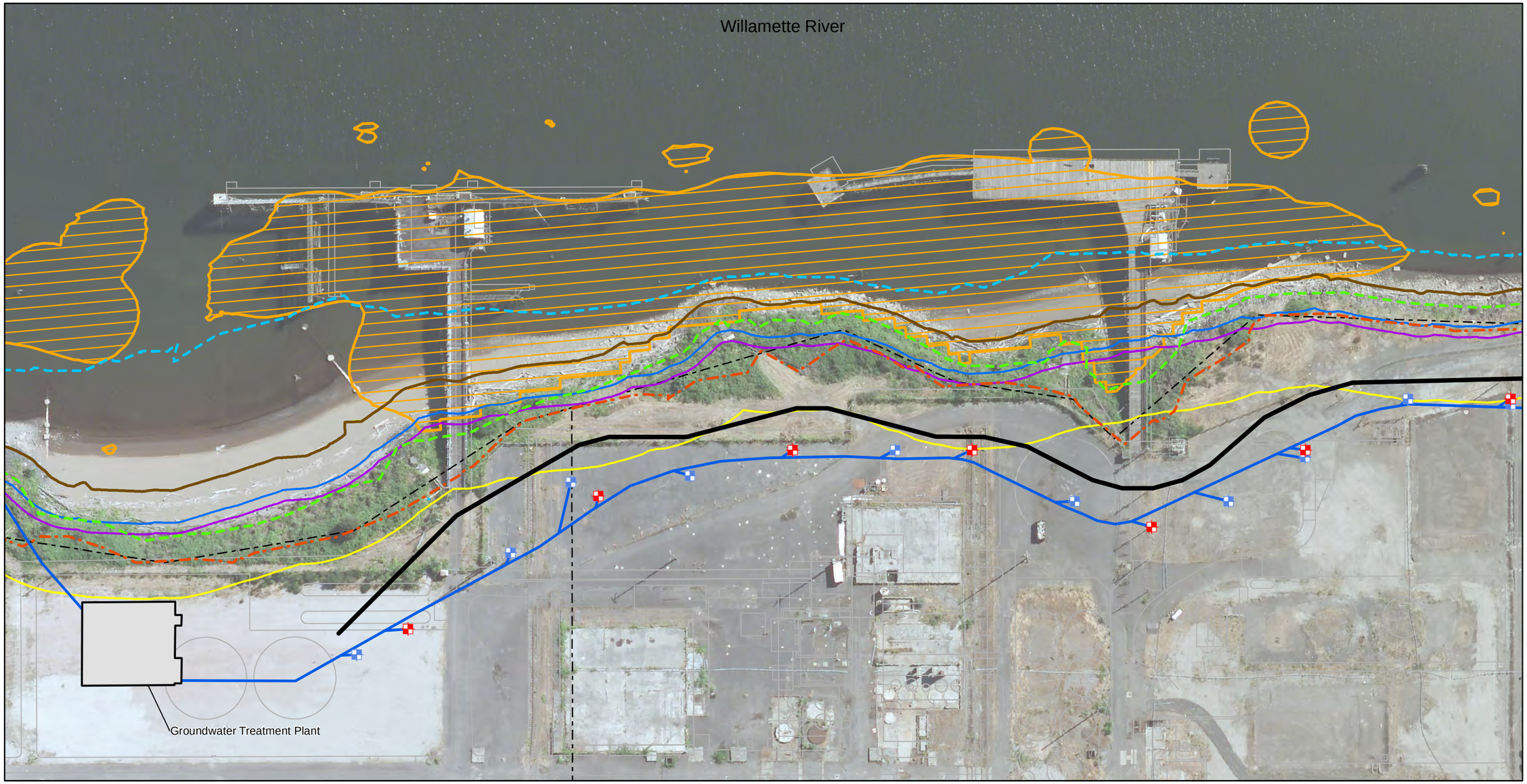


Top of Bank (appoximate)
Ordinary High Water (20.5 ft NAVD88)
Ordinary Low Water (5 ft NAVD88)
Approximate River Edge (13 ft NAVD88)
EPA Directed Horizontal RAA Boundary
Parcel and Property Boundaries

Proposed Top of Bank for 1.5:1 Cut
Proposed Top of Bank for 2:1 Cut
Proposed Top of Bank for 5:1 Cut
Proposed Barrier Wall Alignment
Underground Groundwater Conveyance Piping
Shallow Zone RW
Intermediate Zone RW

N

0 100 200 Feet

Figure 11
Proposed Top of Bank for Soil Removal Options
EE/CA RAA Riverbank Alternatives Evaluation
Arkema Inc.
Portland, Oregon

Environmental Resources Management
1001 SW 5th Ave, Suite 1010
Portland, Oregon 97204
ERM

Tables

DRAFT

Table 1

Summary of Riverbank Alternatives

EE/CA RAA Riverbank Alternatives Evaluation

Arkema Inc. - Portland, Oregon

Remedial Alternative	Remedial Components
Alternative 1 No Action	- No further action
Alternative 2 Limited Action	- Institutional controls - Periodic riverbank inspection and maintenance
Alternative 3a Regrading, Soil Cover, and Riprap	- Debris removal - Regrading riverbank - Placement of suitable fill - Riprap
Alternative 3b Regrading, Soil Cover, and Geocell	- Debris removal - Regrading riverbank - Placement of suitable fill - Geocell
Alternative 3c Regrading, Soil Cover, and Vegetation	- Debris removal - Regrading riverbank - Placement of suitable fill - Vegetation and TRMs
Alternative 4a Removal, Soil Cover, and Riprap	- Layback slope to 2:1 - Placement of suitable fill - Riprap
Alternative 4b Removal, Soil Cover, and Geocell	- Layback slope to 1.5:1 - Placement of suitable fill - Geocell
Alternative 4c Removal, Soil Cover, and Vegetation	- Layback slope to 5:1 - Placement of suitable fill - Vegetation and TRMs
Alternative 5 Steel Sheet Pile Wall	- Sheet pile retaining wall at toe of riverbank - Soil backfill from on and/or off site

TRMs = Turf Reinforcement Mats

Table 2

Evaluation Summary for Riverbank Alternatives

EE/CA RAA Riverbank Alternatives Evaluation

Arkema Inc. - Portland, Oregon

Remedial Alternative	Remedial Components	Effectiveness	Score	Long-Term Reliability	Score	Implementability	Score	Implementation Risk	Score	Reasonableness of Cost	Score	Summary of Evaluation	Average Score
Alternative 1 No Action	- No further action	– Existing riprap, concrete and asphalt debris protects against erosion and scour; however, may contribute COPCs - The future risk may remain and not all RAOs will be achieved	1	- Potential risk may remain in the future	2.5	- No constraints to implementation	5	- No adverse impact on community - No adverse impact on environment, such as release of residuals to the river	5	- No capital cost - No O&M cost	5	- Alternative does not meet all RAOs	3.7
Alternative 2 Limited Action	- Institutional controls - Periodic riverbank inspection and maintenance	– Existing riprap, concrete and asphalt debris protects against erosion and scour; however, may contribute COPCs - The future risk may remain and not all RAOs will be achieved - Land use controls will prevent future disturbance	2	- Potential risk may remain in future - Periodic inspections will facilitate maintenance of riprap, existing debris and vegetative cover	3	- Requires coordination with multiple agencies	4.5	- No adverse impact on community - No adverse impact on environment, such as release of residuals to the river	5	- Low capital cost - Low O&M cost	4.5	- Alternative does not meet RAOs	3.8
Alternative 3a Regrading, Soil Cover, and Riprap	- Debris removal - Regrading riverbank - Placement of suitable fill - Riprap	- Impacted soil regraded but largely left in place - Cover soil/cap prevents contact with impacted material - Large diameter riprap will limit erosion and scour potential - Effective immediately upon completion of construction - Combination of large diameter riprap and fine gravel can be used to increase salmonid habitat ranking value	5	- Compatible with upland SCMs and reasonable range of in water actions (e.g., dredging, sediment capping) - Riprap is a proven riverbank armoring method	5	- Conventional construction methods and materials - Proven riverbank stabilization methodology - - Common controls likely needed to minimize risk of releasing impacted materials to river during construction	4.5	- Limited grading presents moderate risk of releasing impacted materials to river during implementation - No significant adverse impacts on community - Little potential for adverse impact on workers; PPE and work procedures address worker risks	4.5	- Moderate capital cost - Low O&M cost	4.5	- Good effectiveness - Good long-term reliability - Good implementability - Good implementation risk - Good reasonableness of cost	4.7
Alternative 3b Regrading, Soil Cover, and Geocell	- Debris removal - Regrading riverbank - Placement of suitable fill - Geocell	- Impacted soil regraded but largely left in place - Cover soil/cap prevents contact with impacted material - Cells can be in-filled with soil and vegetated, creating a natural appearance and habitat, while enhancing erosion and scour protection - Effective immediately upon completion of construction - Vegetated condition has high salmonid habitat ranking value	4	- Compatible with upland SCMs and reasonable range of in water actions (e.g., dredging, sediment capping) - Proven erosion countermeasure and shallow soil stabilization technique	4.5	- Conventional construction methods and materials - Proven riverbank stabilization methodology - Common controls likely needed to minimize risk of releasing impacted materials to river during construction	4.5	- Limited grading presents moderate risk of releasing impacted materials to river during implementation - No significant adverse impacts on community - Little potential for adverse impact on workers; PPE and work procedures address worker risks	4.5	- Moderate capital cost - Moderate O&M cost	3.5	- Good effectiveness - Excellent long-term reliability - Good implementability - Good implementation risk - Good reasonableness of cost	4.2

Remedial Alternative	Remedial Components	Effectiveness	Score	Long-Term Reliability	Score	Implementability	Score	Implementation Risk	Score	Reasonableness of Cost	Score	Summary of Evaluation	Average Score
Alternative 3c Regrading, Soil Cover, and Vegetation	- Debris removal - Regrading riverbank - Placement of suitable fill - Vegetation and TRMs	- Impacted soil regraded but largely left in place - Cover soil/cap prevents contact with impacted material - Vegetated slope will be less resistant to erosion and scour than other bank stabilization measures - Effective immediately upon completion of construction - Vegetated condition has high salmonid habitat ranking value	3	- Compatible with upland SCMs and reasonable range of in water actions (e.g., dredging, sediment capping) - TRMs and erosion control blankets are a proven erosion countermeasure	3.5	- Conventional construction methods and materials - Proven riverbank stabilization methodology - - Common controls likely needed to minimize risk of releasing impacted materials to river during construction	4	- Limited grading presents moderate risk of releasing impacted materials to river during implementation - No significant adverse impacts on community - Little potential for adverse impact on workers; PPE and work procedures address worker risks	4	- Low to moderate capital cost - Moderate O&M cost	4	- Moderate effectiveness - Good long-term reliability - Good implementability - Good implementation risk - Good reasonableness of cost	3.7
Alternative 4a Removal, Soil Cover, and Riprap	- Layback slope to 2:1 - Placement of suitable fill - Riprap	- Material excavated during slope layback is taken off site or managed on site - Cover soil/cap prevents contact with impacted material - Combination of large diameter riprap and fine gravel can be used to increase suitability for fish habitat. - Effective immediately upon completion of construction - Riverbank is generally flatter than existing conditions and less susceptible to erosion and instability - Combination of large diameter riprap and fine gravel can be used to increase salmonid habitat ranking value	5	- Compatible with upland SCMs and reasonable range of in water actions (e.g., dredging, sediment capping) - Riprap is a proven riverbank armoring method	5	- Conventional construction methods and materials - Proven riverbank stabilization methodology - - Common controls likely needed to minimize risk of releasing impacted materials to river during construction	4.5	- Intensive grading and removal presents elevated risk of releasing impacted materials to river during implementation - No significant adverse impacts on community - Little potential for adverse impact on workers; PPE and work procedures address worker risks	3	- Moderate to high capital cost - Low O&M cost	3	- Excellent effectiveness - Good long-term reliability - Good implementability - Moderate implementation risk - Moderate reasonableness of cost	4.1
Alternative 4b Removal, Soil Cover, and Geocell	- Layback slope to 1.5:1 - Placement of suitable fill - Geocell	- Material excavated during slope layback is taken off site or managed on site - Cover soil/cap prevents contact with remaining impacted material - Cells can be infilled with soil and vegetated, creating a natural appearance while enhancing erosion and scour protection - Effective immediately upon completion of construction - Riverbank is generally flatter than existing conditions and less susceptible to erosion and instability - Vegetated condition has high salmonid habitat ranking value	4.5	- Compatible with upland SCMs and reasonable range of in water actions (e.g., dredging, sediment capping) - Proven erosion countermeasure and shallow soil stabilization technique	4.5	- Conventional construction methods and materials - Proven riverbank stabilization methodology - Steep slope angles can be achieved - Common controls likely needed to minimize risk of releasing impacted materials to river during construction	4	- Intensive grading and removal presents elevated risk of releasing impacted materials to river during implementation - No significant adverse impacts on community - Little potential for adverse impact on workers; PPE and work procedures address worker risks	3	- Moderate to high capital cost - Moderate O&M cost	2.5	- Good effectiveness - Very good long-term reliability - Good implementability - Moderate implementation risk - Moderate reasonableness of cost	3.7

Remedial Alternative	Remedial Components	Effectiveness	Score	Long-Term Reliability	Score	Implementability	Score	Implementation Risk	Score	Reasonableness of Cost	Score	Summary of Evaluation	Average Score
Alternative 4c Removal, Soil Cover, and Vegetation	- Layback slope to 5:1 - Placement of suitable fill - Vegetation and TRMs	- Material excavated during slope layback is taken off site or managed on site - Cover soil/cap prevents contact with impacted material - Vegetated slope will be less resistant to erosion and scour than other bank stabilization measures - Effective immediately upon completion of construction - Riverbank is flatter than existing conditions and less susceptible to erosion and instability - Vegetated condition has high salmonid habitat ranking value	3.5	- Not compatible with Groundwater SCM (i.e., GWBW) - TRMs and erosion control blankets are a proven erosion countermeasure	1	- Not compatible with Groundwater SCM (i.e., GWBW) Conventional construction methods and materials - Proven riverbank stabilization methodology - Common controls likely needed to minimize risk of releasing impacted materials to river during construction	1.5	Intensive grading and large volume of soil handling presents elevated risk of releasing impacted materials to river during implementation - No significant adverse impacts on community - Little potential for adverse impact on workers; PPE and work procedures address worker risks	2.5	- High capital cost - Moderate O&M cost	1	- Not compatible with Upland Remedies - Moderate effectiveness - Low long-term reliability - Low implementability - Moderate implementation risk - Poor reasonableness of cost	1.9
Alternative 5 Steel Sheet Pile Wall	- Sheet pile retaining wall at toe of riverbank - Soil backfill from on and/or off site	- Sheet pile wall will limit erosion and scour potential - Sheet pile wall prevents contact with impacted material - Effective immediately upon completion of construction - Sheet pile wall has very low salmonid habitat ranking value	4	- Compatible with upland SCMs and reasonable range of in water actions (e.g., dredging, sediment capping) - Sheet pile is a proven riverbank stabilization method	3.5	- Conventional construction methods and materials - Proven riverbank stabilization methodology - Common controls likely needed to minimize risk of releasing impacted materials to river during construction - May involve challenging permit conditions due to likely net fill in floodplain - May involve challenging permit conditions due to low habitat value - Existing dock structures present an obstruction	2	- Limited grading presents low risk of releasing impacted materials to river during implementation - No significant adverse impacts on community - Little potential for adverse impact on workers; PPE and work procedures address worker risks	3	- High capital cost - Low O&M cost	1	- Good effectiveness - Good long-term reliability - Fair implementability - Excellent implementation risk - Poor reasonableness of cost	2.7

Notes:

1. Each alternative was scored against each criterion on a scale of 1 to 5 (1 = poor, 2 = fair, 3 = moderate, 4 = good, and 5 = excellent)

COPCs = Constituents of Potential Concern
GWBW = Groundwater Barrier Wall
O&M = Operation and Maintenance
RAOs = Remedial Action Objectives
TRMs = Turf Reinforcement Mats

Attachment 1

Opinion of Probable Construction Cost - Capital Costs
RAA Riverbank Alternatives Evaluation
Arkema, Inc.
Portland, Oregon

Item	Unit	Quantity	Unit Price	Total Cost
Site Preparation				
Mobilization/Demobilization (incl. H&S, site mgmt)	LS	1	$ 50,000	$ 50,000
Erosion and Sediment Control (incl. controls and sequencing)	LS	1	$ 60,000	$ 60,000
Decontamination Pad	LS	1	$ 10,000	$ 10,000
Construction Survey	AC	3	$ 5,500	$ 13,750
Subtotal				**$ 133,750**
Earthwork				
Excavation	CY	10,910	$ 3	$ 32,730
Furnish and Place Clean Soil Cover	CY	6,530	$ 18	$ 117,540
Furnish and Place Riprap	CY	4,355	$ 50	$ 217,750
Sand/Gravel Infill	CY	1,745	$ 25	$ 43,625
Subtotal				**$ 411,645**
Transportation and Disposal				
Transportation and Disposal of Excess Excavated Soil and Debris	TON	15,262	$ 40	$ 610,480
Subtotal				**$ 610,480**
			CONSTRUCTION SUBTOTAL:	$ 1,155,875
Post Closure				
Operation and Maintenance (30 Years NPV)	LS	1	$ 84,548	$ 84,548
Subtotal				**$ 84,548**
			POST-CLOSURE SUBTOTAL:	$ 84,548
			TOTAL PRESENT WORTH COST (INCLUDING CAPITAL AND POST CLOSURE COSTS):	**$ 1,240,423**

Notes:
1. All costs include material and labor.
2. Unit prices obtained from Building Construction RS Means, Environmental Remediation RS Means, and engineering experience.
3. The Engineering and Administration and Construction Management line item calculations do not include cost for transportation and disposal.
4. Disposal of impacted soil is assumed non-hazardous.
5. LS = Lump Sum, AC = Acre, CY = Cubic Yard, SF = Square Foot, SY = Square Yard, TON = Short Ton, NPV = Net Present Value
6. The cost provided is for stabilization of the portion of the riverbank directly upgradient of the in-water removal action area (assumed to be approximately 1,100 feet in length along the river).
7. The remedy includes regrading the riverbank adjacent to the in-water removal action area. Slopes steeper than 2 horizontal to 1 vertical (2:1) will be regraded to 2:1, while flatter slopes will remain at their current slope. The excavated soil will be managed with a combination of off-site disposal and on-site regrading. A clean soil cover will be placed over the riverbank.
8. Sand/Gravel infill is used to fill the voids of the riprap layer and does not add to the total volume of fill with respect to the cut/fill balance.

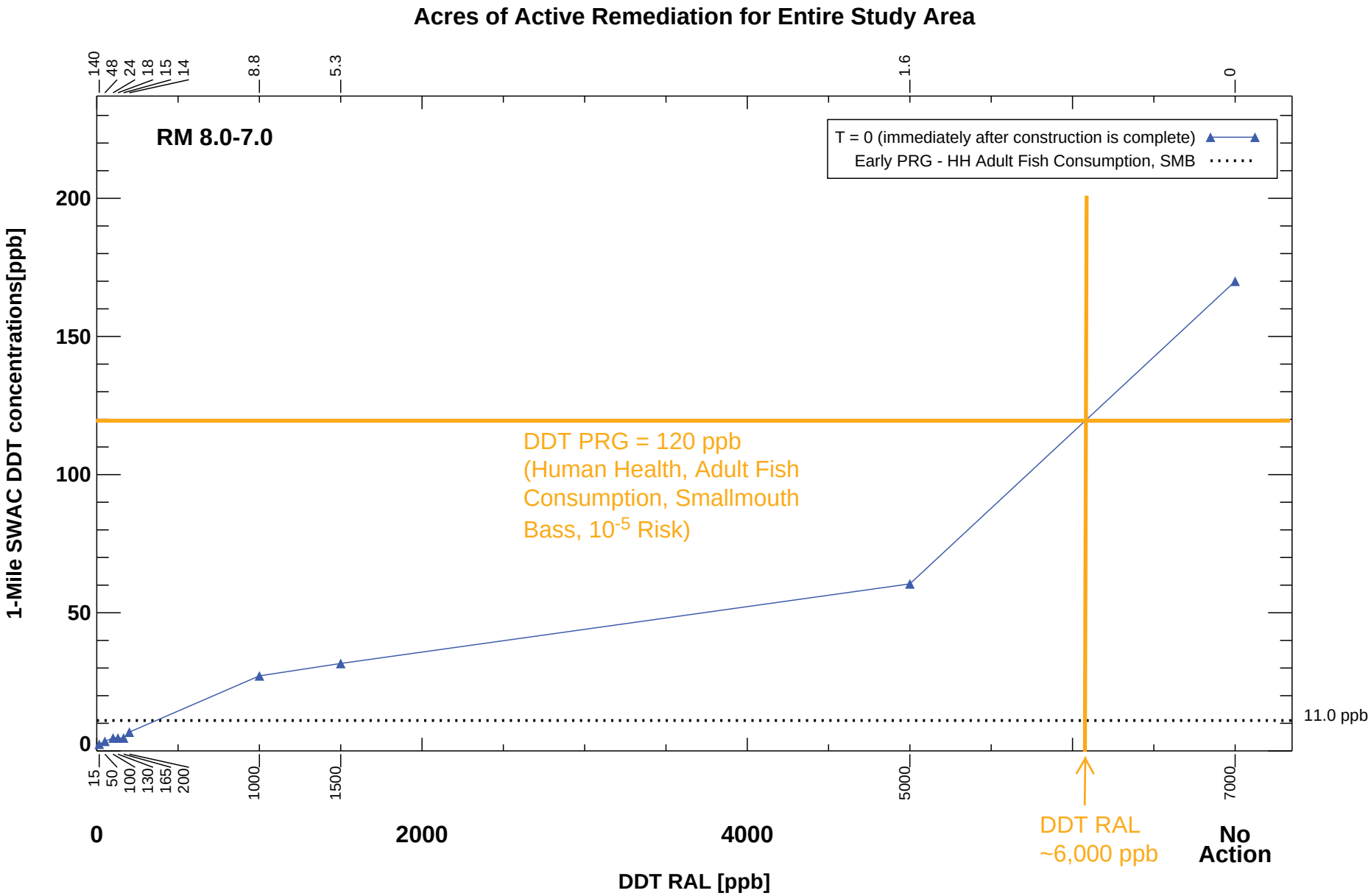
APPENDIX G

SUPPORTING DOCUMENTS

- APPENDIX G1. DRAFT FEASIBILITY STUDY FIGURES
- APPENDIX G2. ERM DATA GAPS ASSESSMENT WORK PLAN
- APPENDIX G3. DOANE LAKE MEMORANDUM

APPENDIX G1

DRAFT FEASIBILITY STUDY FIGURES



Appendix Db

Portland Harbor RI/FS

Draft Feasibility Study

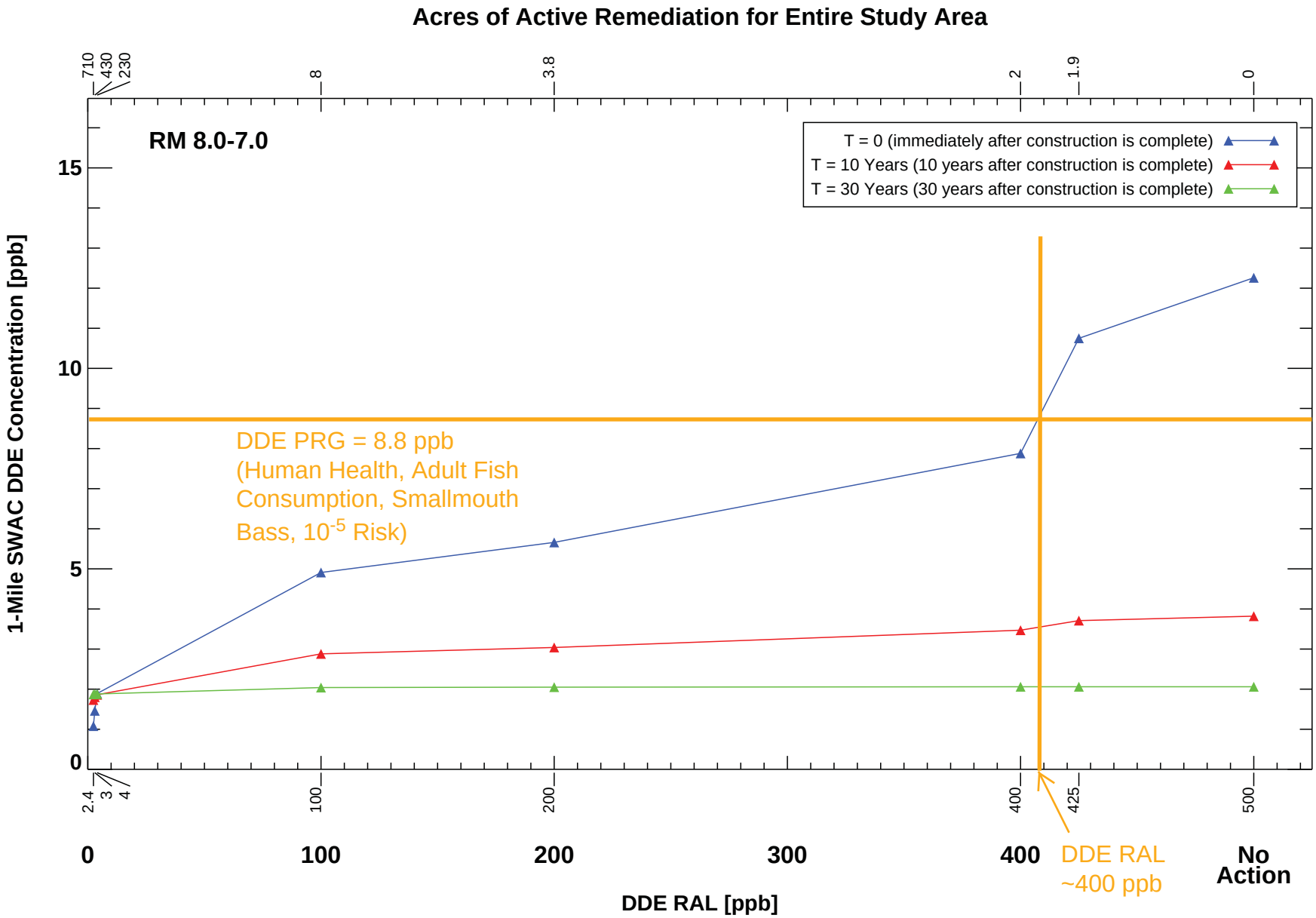
DO NOT QUOTE OR CITE
This document is currently under review by US EPA and its federal, state, and tribal partners, and is subject to change in whole or in part.

Comparison of DDT River Mile SWAC to Potential RALs/Acres Remediated Following Construction Completion.

Note: "No Action RAL" set to 7000 ppb for plotting

Adapted from Anchor QEA et al. (2012), additions are shown in orange.

RRM/KAB - B:\Projects\Lower_Willamette_Group\Lower_Willamette_Group_(010142-01)\Model\Analysis\RAL_Curves\IDL\RAL_plots_DDXs_1panel_axisflip.pro Tue Mar 13 16:24:35 2012



ANCHOR QEA

LWG LOWER WILLAMETTE GROUP

DO NOT QUOTE OR CITE
This document is currently under review by US EPA and its federal, state, and tribal partners, and is subject to change in whole or in part.

Appendix Db

Portland Harbor RI/FS

Draft Feasibility Study

Comparison of DDE River Mile SWAC to Potential RALs/Acres Remediated at Three Points in Time Following Construction Completion.

Adapted from Anchor QEA et al. (2012), additions are shown in orange.

Note: "No Action RAL" set to 500 ppb for plotting

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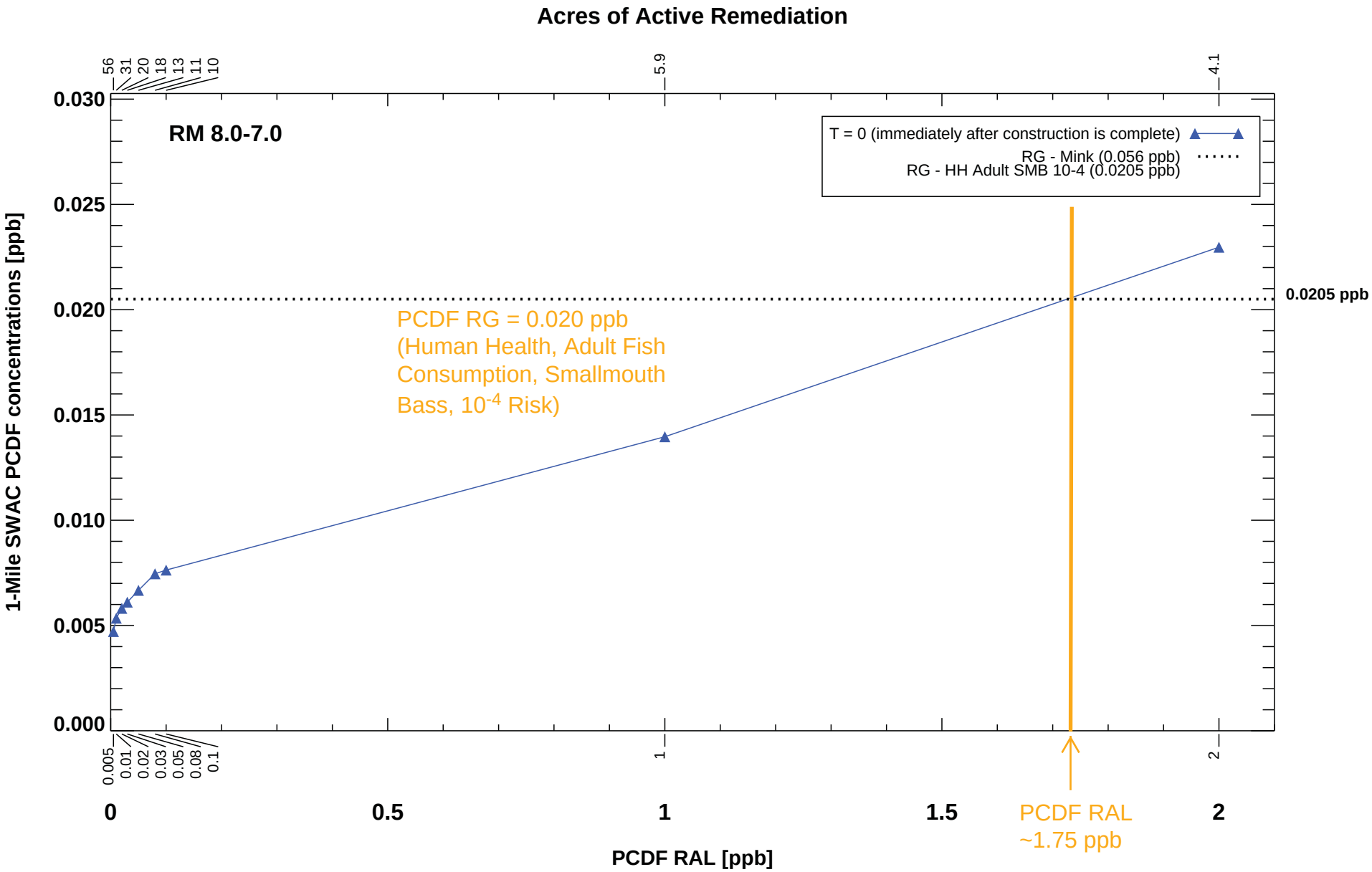


DO NOT QUOTE OR CITE
This document is currently under review by US EPA and its federal, state, and tribal partners, and is subject to change in whole or in part.

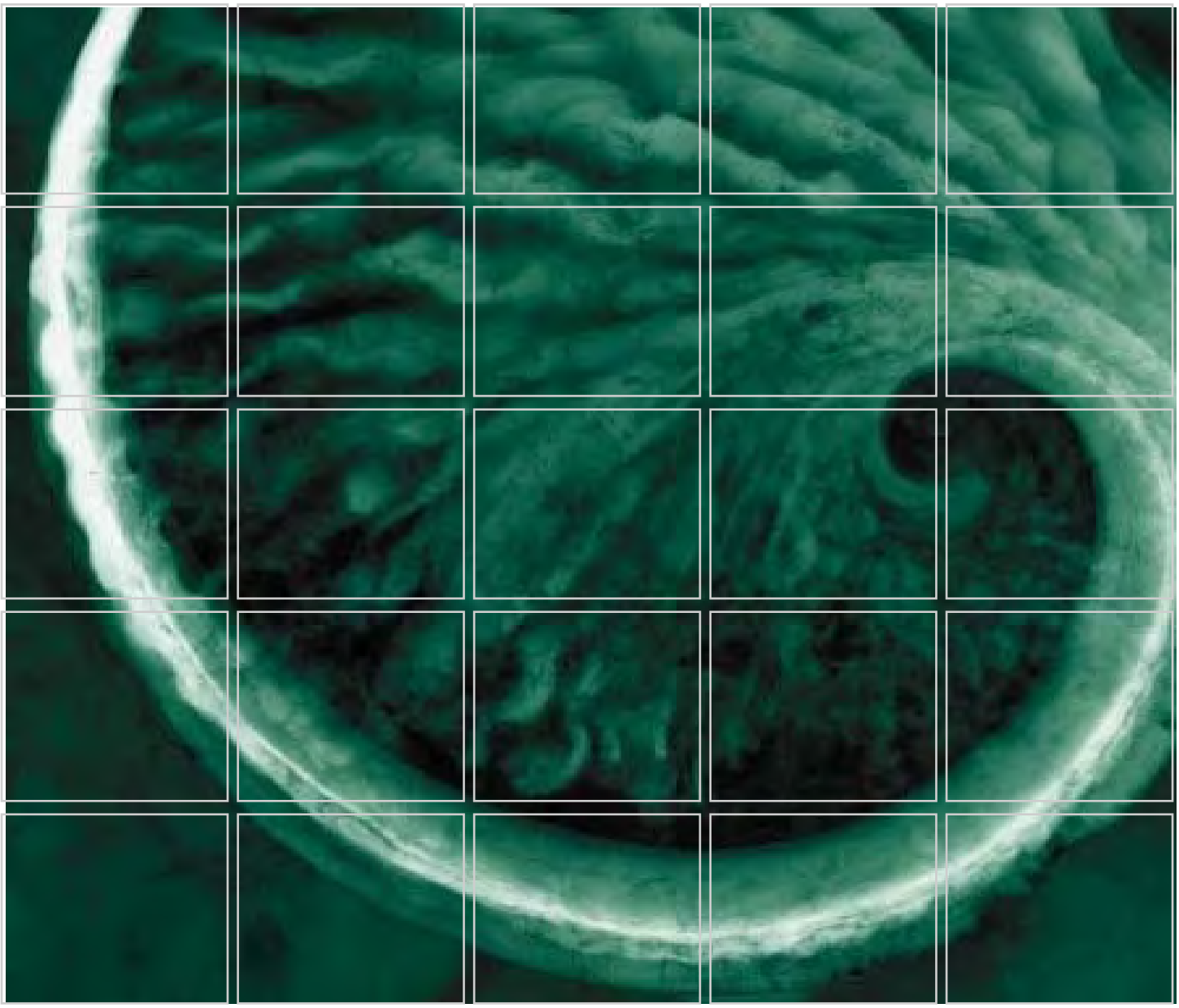
Adapted from Anchor QEA et al. (2012), additions are shown in orange.

Appendix Db
Portland Harbor RI/FS
Draft Feasibility Study
Comparison of PCDF 1-Mile SWAC to Potential RALs/Acres Remediated Following Construction Completion

KAB - B:\Projects\Lower_Willamette_Group\Lower_Willamette_Group_(010142-01)\Model\Analysis\RAL_Curves\IDL\RAL_plots_PCDF__20111101_axisflip.pro Tue Mar 13 16:31:01 2012

APPENDIX G2

ERM DATA GAPS ASSESSMENT WORK PLAN



DRAFT - Data Gaps Assessment Work Plan

Arkema Inc. Facility
Portland, Oregon

March 2009

Prepared for:
Legacy Site Services LLC

www.erm.com

Delivering sustainable solutions in a more competitive world

ERM

Legacy Site Services LLC

Draft - Data Gaps Assessment Work Plan

Arkema Inc. Facility
Portland, Oregon

March 2009

Project No. 93634.06

DRAFT

Brendan Robinson, P.E.
Project Manager

DRAFT

Erik Ipsen, P.E.
Partner-in-Charge

Environmental Resources Management
101 SW Main Street, Suite 804
Portland, Oregon 97204
T: 503-488-5282
F: 503-488-5142

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LIST OF ACRONYMS

BES	Bureau of Environmental Services
bgs	Below Ground Surface
CDD	Chlorodibenzo-p-dioxins
CDF	Chlorodibenzo-p-furans
COI	Constituents of interest
DDT	Dichloro-diphenyl-trichloroethane
EPA	Environmental Protection Agency
ERM	ERM-West, Inc.
FS	Feasibility Study
gpm	gallons per minute
ID	Internal Diameter
ITRC	Interstate Technology and Regulatory Council
LSS	Legacy Site Services LLC
LWG	Lower Willamette Group
NTU	Nephelometric Turbidity Units
ODEQ	Oregon Department of Environmental Quality
PCP	Pentachlorophenol
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
R	Coefficient of Correlation
RP	Rhone-Poulenc
SCM	Source Control Measure
TEQ	Toxicity Equivalency Quotient
µg/L	Microgram per liter
USEPA	United States Environmental Protection Agency

1.0 INTRODUCTION

On behalf of Legacy Site Services LLC (LSS), agent for Arkema Inc., ERM-West Inc. (ERM) has prepared this *Data Gaps Investigation Work Plan* (Work Plan) for the former Arkema Portland Plant (the Site) located at 6400 NW Front Avenue, Portland, Oregon (Figure 1-1). This work plan provides the rationale and proposed scope of work to fill identified data gaps in support of the upland feasibility study (FS) and groundwater source control measure (SCM) to be performed at the Site.

On 28 January 2009, and again on 24 February, representatives from LSS, Oregon Department of Environmental Quality (ODEQ), ERM, and Integral met to discuss and agree upon data gaps to be investigated at the Site as part of this investigation. This work plan has been prepared in accordance with the agreements reached in those meetings.

This work plan includes the following three scope of work elements:

- Collection of one round of groundwater samples from all site monitoring wells and analysis for a wide range of constituents of interest (COIs);
- Collection of soil samples from two areas of the site and analysis of the samples for dioxins/furans. The samples will be collected from 1) the vicinity of the historical chlorate cell room (now identified as the former maintenance shop) and, 2) the area of the former brine residue and asbestos ponds; and
- Performance of four aquifer hydraulic conductivity tests (i.e., pump tests): two in the shallow groundwater aquifer and two in the intermediate groundwater aquifer.

This work will be conducted in general accordance with the procedures described in *Elf Atochem Acid Plant Area Remedial Investigation and Feasibility Study Work Plan* (Exponent 1998) (RI/FS Work Plan).

The following subsections provide the objectives of this Work Plan and the data gaps investigation, a Site description and history, and the organization for the remainder of the work plan.

1.1 OBJECTIVES

The objectives of this Data Gaps Work Plan and the data gaps investigation are to:

- Provide an updated Conceptual Site Model (CSM) for dioxins/furans at the Site;
- Identify and fill data gaps sufficient to evaluate remedial technology alternatives in the uplands FS; and
- Collect data to support the design of the groundwater SCM.
- Provide additional information regarding the migration of contaminants from the upgradient Rhone-Poulenc facility (across NW Front Ave) onto the Site

1.2 SITE DESCRIPTION

The Site is located at 6400 N.W. Front Avenue in the Northwest Industrial Area of Portland, Oregon. The facility is bounded by Front Avenue on the north and west, the Willamette River on the east, and an asphalt roofing manufacturer on the south. The Site is located on the southwest bank of the lower Willamette River between River Mile 6.9 and River Mile 7.6, immediately upstream of the Burlington Northern Santa Fe Railroad Bridge in the northwest industrial area of Portland, Oregon (Figure 1-1). The property is located adjacent to the Portland Harbor Superfund site.

The property lies within the Guild's Lake Industrial Sanctuary Plan (formerly the Northwest Portland Industrial Sanctuary). The Site is zoned and designated "IH" for heavy industrial use, which precludes it from non-industrial uses. The purpose of the Guild's Lake Industrial Sanctuary Plan is to maintain and protect this land as a dedicated area for heavy and general industrial uses. Therefore, while future use of the facility is unknown, it will likely be heavy industrial.

1.3 SITE HISTORY

Inorganic chemicals were manufactured at the Site from 1941 until 2001, when the facility was closed and chemical manufacturing was discontinued. For most of the Site's history, the chemical activities involved electrolytic decomposition of brine solutions to manufacture inorganic chemicals, including sodium chlorate, chlorine, sodium

hydroxide, hydrogen, and hydrochloric acid. Other chemical manufacturing processes during the Site's operational history included the production of dichloro diphenyl trichloroethane (DDT) from 1947 to 1954 and ammonium perchlorate from 1958 to 1962 (ERM 2005).

Decommissioning and removal of the manufacturing infrastructure were completed in early 2005. The only structure remaining is the office building at the Site entrance on Front Street and some concrete floor slabs left in place as environmental caps. Arkema maintains leases from the Oregon Department of State Lands for the docks in the Willamette River, but the docks are not currently in use. Current and historical upland contaminant sources are shown in Figure 1-2.

Arkema (formerly known as ATOFINA Chemicals, Inc., Elf Atochem North America, Inc., and the Pennwalt Corporation) has conducted investigations and performed a number of Interim Remedial Measures (also referred to as SCMs) in the upland portion of the Site since 1994. In 1995, Arkema (then known as Elf Atochem) submitted an intent to participate in the ODEQ Voluntary Cleanup Program, an agreement that was later signed with ODEQ in 1996. In 1998, Arkema signed a voluntary agreement with ODEQ to complete a remedial investigation and feasibility study (RI/FS) of the former DDT manufacturing area. The RI/FS was later expanded to include other areas and chemicals at the Site (e.g., hexavalent chromium and perchlorate). The *Upland Remedial Investigation Report Lots 3 & 4 and Tract A – Revision 1* (RI Report) was submitted to ODEQ in December 2005 (ERM 2005). For the RI, Arkema completed two phases of in-river investigations to assess the extent of chemicals from the former DDT manufacturing process in near shore Willamette River sediments and groundwater. In addition to the RI work, the Lower Willamette Group (LWG) has conducted a number of investigations that included sample stations adjacent to the Site as part of the Portland Harbor RI/FS. Brief descriptions of these investigations are provided in the draft EE/CA work plan (Section 3.1, Integral 2006a). In addition, following the submittal of the final RI Report, ODEQ and Environmental Protection Agency (EPA) issued the Portland Harbor Joint Source Control Strategy guidance document (ODEQ 2005).

Arkema and EPA entered into an Administrative Order on Consent on 27 June 2005 for the in water portion of the Site. The draft EE/CA work plan was submitted to EPA and stakeholders (the government team) on 26 September 2005, for review and comment. A revised work plan that incorporated responses to comments received from the government team was submitted to the government team on 14 July 2006 (Integral 2006a).

The revised work plan included screening results for sediments, river bank soils and groundwater, transition zone water, and surface water at the Site. In 2007, EPA prepared the *Arkema Early Action EE/CA Work Plan* (EPA 2007). An EE/CA work plan addendum was subsequently prepared by Integral and dated 22 July 2008 (Integral 2008b).

In May 2008, LSS submitted a focused feasibility study for a groundwater SCM at the Site (ERM 2008). On 23 February 2009, ODEQ approved the general approach for the groundwater SCM. This approach includes installation of a slurry groundwater barrier wall and a groundwater extraction and treatment system, with treated water discharge to the Willamette River.

Arkema and ODEQ entered into an Administrative Order on Consent on 31 October 2008 (Consent Order) for the upland portion of the Site. The upland Order requires submittal of various documents in support of upland source control (groundwater, storm water, and erodible soil) and the upland Feasibility Study. This Data Gaps Work Plan is one of the documents specified in the Consent Order.

1.4 REPORT ORGANIZATION

The remainder of this report is organized as follows:

- Section 2 provides an updated conceptual site model, focusing on dioxin and furans on site.
- Section 3 presents an analysis of data gaps to be investigated.
- Section 4 details the scope of activities to be performed as part of this investigation.
- Section 5 contains the schedule for activities proposed in this work plan.
- Section 6 lists the references cited in the work plan.

Appendix A provides standard operating procedures for the proposed aquifer pump test.

2.0 DIOXINS AND FURANS CONCEPTUAL SITE MODEL

The CSM for the Site has been presented in several previous documents, including the RI report (ERM 2005) and, most recently, the *Revised Draft Arkema Work Plan: Engineering Evaluation/Cost Analysis* (Integral 2006a). To date, the Site CSM has not included discussion of the presence of chlorodibenzo-p-dioxins (CDDs) and chlorodibenzo-p-furans (CDFs) (collectively referred to as dioxins/furans). This section presents the revised CSM for dioxins/furans at the Site.

2.1 BACKGROUND

When used in an environmental context, the term "dioxins" refers to CDDs and CDFs, of which there are 210 individual compounds, or congeners. Concentrations of dioxins are typically given as toxic equivalency quotients (TEQs), or equivalent amounts of 2,3,7,8-tetrachlorodibenzo-p-dioxin, the most toxic congener. Chromographic patterns associated with different congeners and their relative amounts, referred to as the "dioxin fingerprint," are also reflective of the sources of the dioxins.

The 75 individual CDDs and 135 CDFs form a set of CDD and CDF congeners. When CDDs and CDFs are subdivided by the degree of chlorination, the term homolog is used, e.g., the Tetrachlorodibenzo-p-dioxin homolog, in which there are 14 different CDD congeners each containing four chlorine atoms. CDDs and CDFs of a given homolog with different chlorine substitution positions are isomers. Individual CDDs and CDFs are referred to as congeners.

To evaluate dioxin/furan sources at the Site, in the immediate vicinity, and in the region, congener profiles were prepared from groundwater, soil, and sediment CDD and CDF analyses. Congener profiles present the fractional distribution of CDDs and CDFs contained in a sample (i.e., dioxin fingerprint). Congener profiles can be used to compare or distinguish differences in the types and amounts of congeners present and provide insights on formation of CDDs and CDFs from different sources. In the analysis of the CDDs and CDFs, congener profiles were prepared by summing the concentration of CDDs and CDFs in a sample and dividing the homologous groups by the total CDD/CDF concentration.

The histogram charts for solids (soil, river sediment, and catch basin sediment) and groundwater are shown on Figures 2-1 and 2-2, respectively. The pie charts for solids (soil, river sediment, and catch basin sediment) and groundwater are shown on Figure 2-3 and 2-4, respectively.

2.2 *CDD/CDF FORMATION AND SOURCES*

CDDs and CDFs are formed as a by-product or contaminant in manufacturing and combustion processes. Sources of CDDs/CDFs vary widely, but are typically a combination of chlorine, organics, and oxygen coupled with heat. The EPA has grouped the major sources of environmental releases of CDDs and CDFs into five broad categories (EPA 2006):

1) Combustion Sources: CDDs /CDFs are formed in most combustion systems, including waste incineration, burning of fuels such as coal and petroleum products, and uncontrolled combustion such as forest or building fires.

2) Metal Smelting, Refining, and Processing Sources: CDDs/CDFs can be formed during primary and secondary metals operations including sintering, steel production, and scrap metal recovery.

3) Chemical Manufacturing: CDDs/CDFs can be formed as by-products from the manufacture of chorine bleached wood pulp, chlorinated phenols, polychlorinated biphenyls, phenoxy herbicides, and chlorinated aliphatic compounds.

4) Biological and Photochemical Processes: Studies suggest that CDDs/CDFs can be formed under certain environmental conditions (e.g., composting) and from photolysis of highly chlorinated phenols.

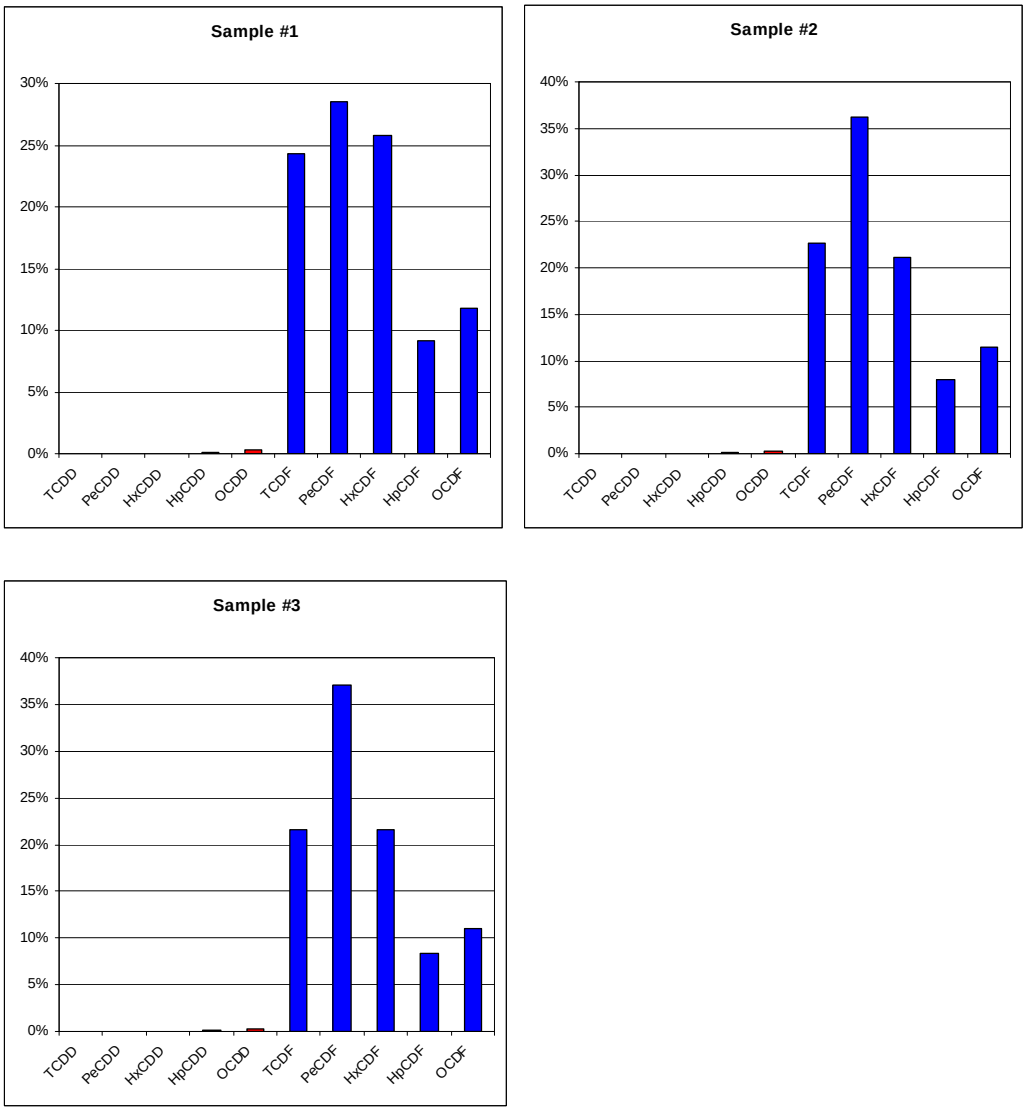
5) Reservoir Sources: Reservoirs are material or sources that contain previously formed CDDs/CDFs that have the potential for redistribution into the environment. Potential reservoir sources include soils sediments, biota, and water.

2.3 *CDDS/CDFS AND THE CHLOR-ALKALI PROCESS*

Rappe, et al (Rappe 1991) and EPA (EPA 2006) have reported that CDDs and CDFs are produced during chlorine production using the chlor-alkali process. Chlorine gas is produced by electrolysis of brine electrolytic cells. Until the late 1970s, the primary type of electrolytic process used in the chlor-alkali industry to produce chlorine consisted of the use of cells containing graphite electrodes (EPA 2006). Elevated concentrations of CDFs have been detected in the sludge formed on graphite electrodes. Although the origin of the CDFs in graphite electrode sludge is uncertain, chlorination of the cyclic aromatic hydrocarbons (such as dibenzofuran) present in the coal tar used as a binding agent in the graphite electrodes has been proposed as the primary source (Strandell 1994).

Both Rappe and EPA observed that, predominately, CDFs were produced in the process and that the concentrations of CDDs were below detection limits. Rappe has called this pattern the "chlor-alkali pattern." Various studies have observed this distribution of CDFs in sludge and soil at chlor-alkali plants (EPA 2006, Shields 2006). Examples of the chlor-alkali pattern, based on profiles presented in *An Inventory of Sources and Environmental Releases of Dioxin-Like Compounds in the United States for the Years 1987, 1995, and 2000* (EPA 2006), are provided in Figure 2-5 below.

Figure 2-5 *Examples of chlor-alkali CDF/CDD homolog patterns in three samples of graphite electrode sludge from chlorine production. Source:* **An Inventory of Sources and Environmental Releases of Dioxin-Like Compounds in the United States for the Years 1987, 1995, and 2000** *(EPA 2006)*



Based on the distinctions between CDD/CDF congener profiles observed in different sources, and the CDF-dominated congener profile observed by Rappe and others at chlor-alkali plants, comparison of congener profiles can be used to evaluate sources of groundwater, soil, and sediment CDD/CDF contamination at the Site.

2.4 *SOURCES OF CDDS/CDFS AT THE ARKEMA SITE*

Chlorine was manufactured in two areas of the facility: the old chlorine cell room (more recently used as a maintenance shop), and the new chlorine cell room (also referred to as "Diamond") (Figure 1-2). The old chlorine cell room used asbestos diaphragm chlorine cells with graphite anodes. As discussed in Section 2.3 above, chlorine production using graphite anodes is a potential source of predominately CDFs. Production in this area ceased in 1971.

Chlorine manufacturing was then moved to the new chlorine cell room. Graphite anodes were not employed in the new cell room; rather, titanium metal anodes were used. Sludge produced using titanium anodes are not expected to contain CDFs (EPA 2006). Waste asbestos from the new chlorine cell room was stored in the former asbestos pond located on Lot 2 of the Site (Figure 1-2).

2.5 *VICINITY SOURCES OF CDDS/CDFS*

The presence of CDDs/CDFs has been documented in "practically all media including air, soil, meat, milk, fish, vegetation, and human biological samples" (Travis 1991). The widespread occurrence of CDDs/CDFs is likely the result of "atmospheric dispersion and deposition of particles resulting from combustion processes, from forest fires to waste incineration to auto exhaust" (Shields 2006).

Table 1-1 provides a summary of known or suspected sources of CDDs/CDFs in the vicinity of the Site. This information has been obtained from the ODEQ Environmental Cleanup Site Information database. Many of the sites in Table 1-1 have undergone, or are currently undergoing, cleanup for CDD/CDF contamination. Possible transport pathways from these sites to surrounding sites include groundwater migration, air deposition, and surface run-off.

In addition to the vicinity sources identified in Table 1-1, other point and non-point sources of CDDs/ CDFs exist in the region, which fall within the five broad EPA categories identified above. These sources present a source of airborne CDDs/CDFs, and include coal fired utilities, metal smelting, incinerators, diesel trucks, land application of sewage sludge, burning treated wood, and trash burn barrels (EPA 2006).

2.6 *SOURCES OF DATA AT THE ARKEMA SITE*

Groundwater, soil, and sediment samples have been collected and analyzed for dioxins/furans during several rounds of sampling at the Site. The primary sources of dioxin/furan and other analytical data to prepare this revised CSM include:

- August 2006 groundwater sampling results from the Site;
- April 2007 groundwater sampling results from the Site;
- Storm water catch basin sampling results from the Site;
- Riverbank soil sampling from the Site;
- LWG river sediment sampling results; and
- Historical soil and groundwater sampling results from the former Rhone-Poulenc (RP) property (currently owned by Starlink Logistics, Inc.) and surrounding properties. Detailed references for RP data are provided in the last section of this report.

The analytical results from these sampling events, including CDD/CDF fingerprints, are presented on Figures 2-1 through 2-4.

2.7 *ANALYSIS OF CDD/CDF DISTRIBUTION*

The following sections present an analysis of the observed dioxin/furan fingerprint patterns for the various media for which data were obtained.

2.7.1 *Solids*

Solid samples include soil (shallow and deep), river sediment, and storm water catch basin sediment. The dioxin fingerprints for these media are shown on Figures 2-1 and 2-3. Figure 2-6 presents a "scatter diagram" of CDD and CDF detections in upland solid samples (soil and catch basin sediment) from the study area. Figure 2-7 presents a "scatter diagram" of CDD and CDF detections in river sediment samples from the study area.

Figure 2-6 Scatter diagram of CDD and CDF detections in upland solid samples (soil and catch basin sediment) from the study area (µg/kg)

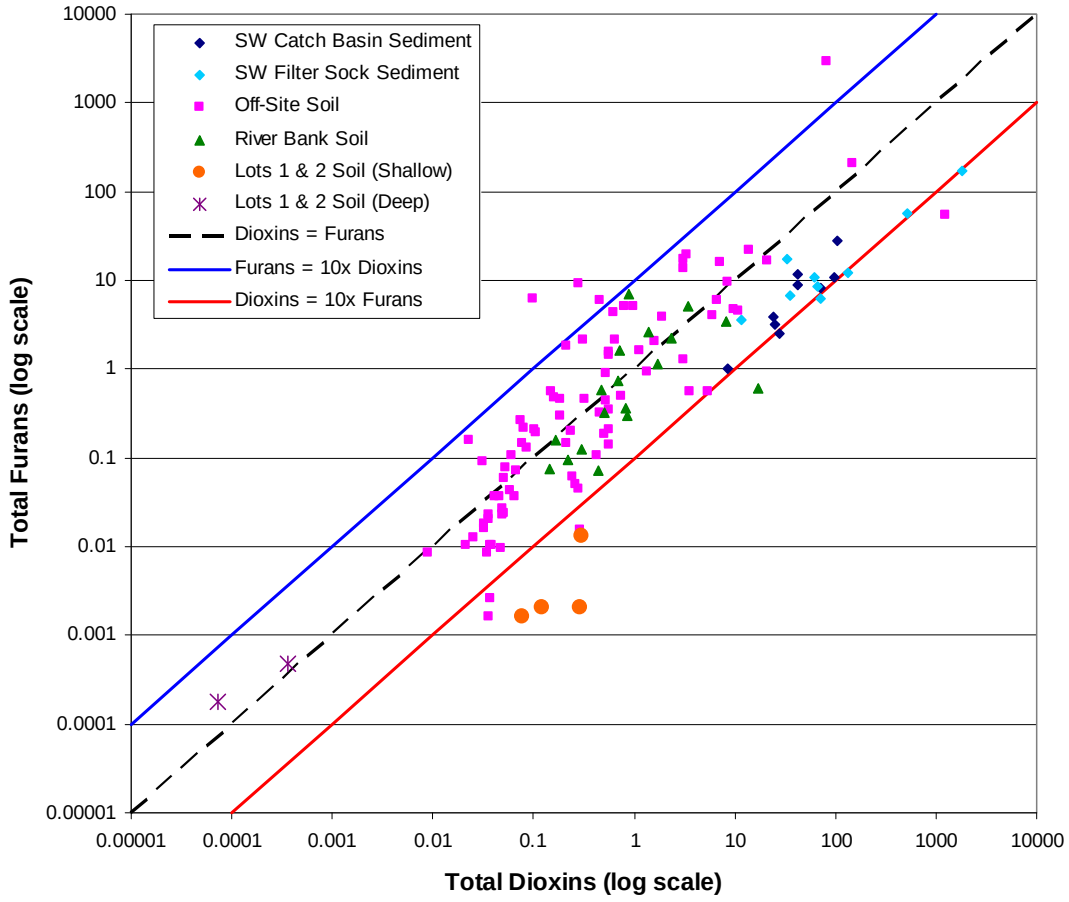
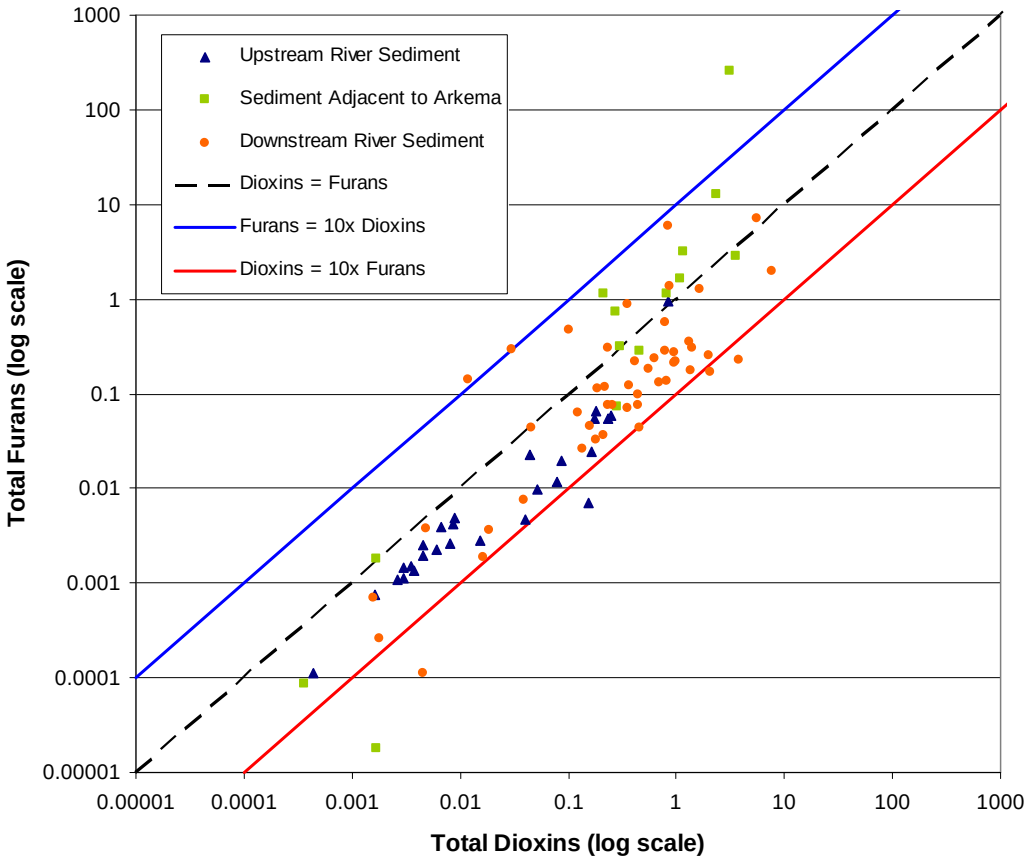


Figure 2-7 Scatter diagram of CDD and CDF detections in river sediment samples from the study area (µg/kg)



2.7.1.1 *Storm Water Catch Basin Samples*

Samples of storm water catch basin sediment (which include samples collected from the catch basins themselves and from filter socks placed above the catch basin) indicate a fairly uniform signature that is predominately composed of CDDs (average of 86 percent relative CDDs compared to total CDDs/CDFs). A typical fingerprint from the catch basin samples is shown on Figure 2-1 (Sample CB-001-05-FS). The high relative CDD content indicates the source of CDDs/CDFs in the catch basins is not likely associated with historical chlor-alkali operations at the Site. Figure 2-3 shows the close grouping with respect to percent composition of these samples – evidence of the consistent nature of these results. All of the catch basin sediment samples share remarkably similar dioxin fingerprints and concentrations. These fingerprints are similar to

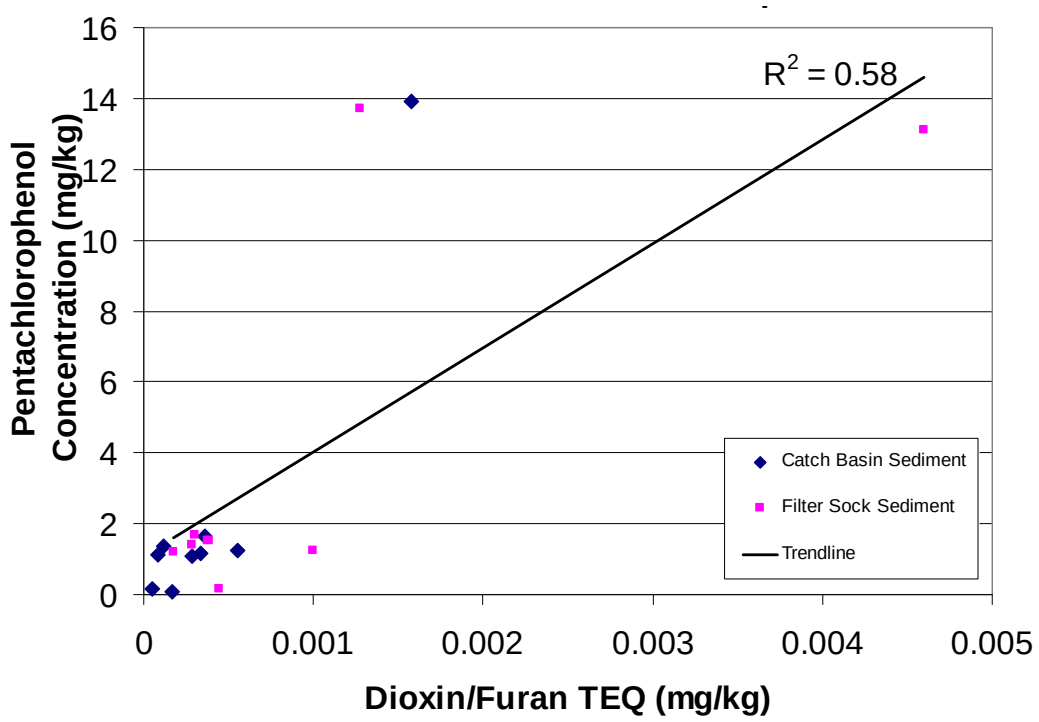
documented background dioxin fingerprints (Shields 2006, EPA 2006), providing evidence these detections are likely the result, at least in part, of ubiquitous atmospheric sources of CDDs/CDFs discussed above.

Sediment samples from the catch basins themselves are representative of material that could have been deposited years ago, up through the time of sampling. Since the filter socks were only recently placed (after site demolition), sediment samples from the filter socks are representative of material generated post-demolition. Figure 2-6 reveals that the samples with the highest CDD/CDF concentrations were collected from the filter socks, indicating that at least the majority of CDDs/CDFs were transported post-demolition. There is strong evidence that pentachlorophenol (PCP) from treated wood poles may be this post-demolition source, and is the major source of the CDD/CDF detections in the storm water catch basins and filter socks, especially the three samples with the highest detections.

PCP has historically been used for a variety of commercial applications, most commonly for wood treatment or use as a biocide. Utility poles, and other wood products, are still currently treated using PCP. CDDs and CDFs are common contaminants in PCP. During a walk of the Arkema property, it was observed that several cut power poles were located immediately adjacent to storm water catch basins that contained elevated CDD/CDF and PCP concentrations. It was noted that these power poles were removed immediately prior to the catch basin sampling, and thus CDDs/CDFs could have resulted from the cutting and removal of the power poles. Analytical results for samples from the power pole stumps confirmed the presence of elevated concentrations of CDDs and CDFs. The observed fingerprint was consistent with PCP.

Figure 2-8 presents a "scatter diagram" of the CDD/CDF TEQ and PCP concentrations in the Arkema storm water catch basins and filter socks. The diagram shows that the three samples with the highest CDD/CDF concentrations also possessed the three highest PCP concentrations. The coefficient of correlation (R) for the TEQ and PCP variables is 0.76 (coefficient of determination [R^2] is 0.58). This indicates good correlation between CDD/CDF concentrations and PCP concentrations (R = 1 indicates perfect correlation, R = 0 indicates no correlation), and offers evidence that the CDDs/CDFs detected in the catch basins is likely related to contaminated PCP from the nearby power poles. A comparison of PCP concentrations to the total Hx-CDF and Pe-CDF homologs, two homologs which have been associated with PCP contamination (Shields 2006), reveal an identical R value (0.76).

Figure 2-8 ***Scatter diagram of CDD/CDF TEQ and PCP concentrations in Arkema storm water catch basin sediment samples. R = 0.76***



While three of the sediment catch basin samples contained relatively high concentrations of CDFs, as well as CDDs, the total concentration of all CDFs was less than or on the same order of magnitude as soil samples from the upgradient RP site, and sediment samples from the vicinity of storm sewer Outfall 22B. The consistency in dioxin/furan fingerprint between all of the catch basin samples, regardless of magnitude of the concentrations detected, indicates that it is unlikely the elevated CDF detections in some of the catch basins are "masking" a chlor-alkali CDF signature. If chlor-alkali activities were responsible for the CDDs/CDFs detected in catch basin samples, a chlor-alkali signature would be evident in the samples with low concentration detections. This is not the case, and therefore other sources (e.g., treated wood poles or atmospheric sources) appear to be the more likely source of CDDs/CDFs in all of these catch basin samples.

2.7.1.2 *Soil*

Figures 2-1, 2-3, and 2-6 reveal that there is a diversity of relative CDD/CDF composition and fingerprints for soil results across the study

area (i.e., Arkema and upgradient sites). While soil samples from the former RP site display some localized patterns, the fingerprints from the RP site cover a spectrum of profiles. This is consistent with the variety of potential CDD/CDF sources which exist at the RP site and in the immediate vicinity, including herbicide production, lead smelting, and waste handling.

River bank soil samples from the Arkema site show similar variability with little consistency in dioxin fingerprints. While some samples show high relative concentrations of CDFs, only one river bank sample (out of 18 samples) indicated greater than 70 percent relative CDFs (compared to total CDD/CDF concentration). This appears to indicate that the source of CDDs/CDFs in the river bank soil is not predominately historical chlor-alkali operations.

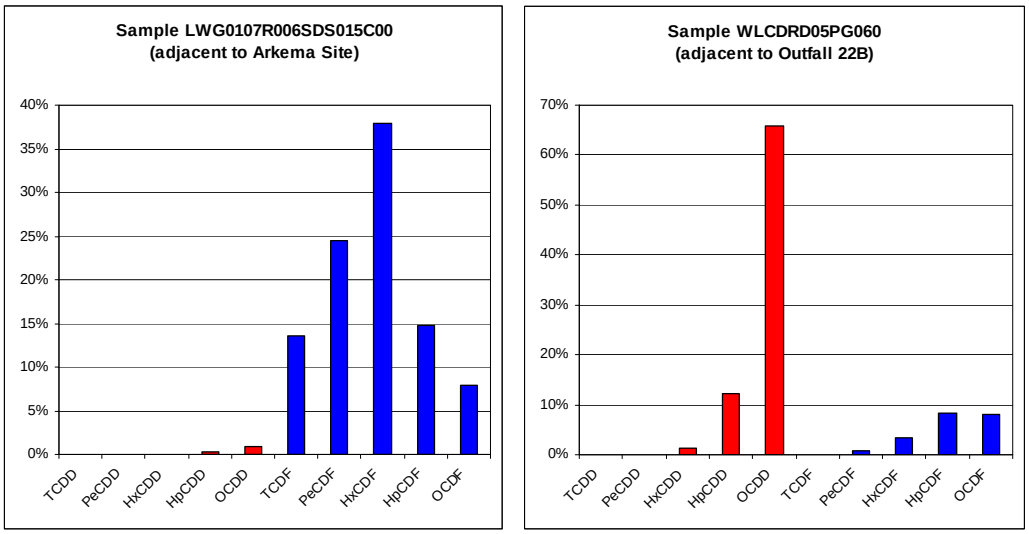
Soil samples that showed consistency were the shallow soil samples from Lots 1 and 2, which are clustered closely on Figure 2-6. These four samples, which were collected between 2- and 13-feet below ground surface (bgs) during Starlink Logistics, Inc.'s soil investigation of Lots 1 and 2, indicate relative CDD concentrations between ten and 100 times the respective CDF concentrations (96 to 99 percent CDDs). By comparison, the two deep soil samples from Lots 1 and 2 (86- to 93-feet bgs) indicated more evenly-distributed relative CDD and CDF concentrations. Although the number of samples in this data subset is small, these data indicate that the CDDs in these shallow soil samples are *not* attributable to historical chlor-alkali operations at the Site. The concentrations of CDDs detected in these samples are very low compared to other on- and off-site soil samples and may be attributable to dredge sediment historically placed on Lots 1 and 2.

2.7.1.3 *River Sediment*

Figure 2-7 provides relative CDD and CDF compositions for sediment samples from the Willamette River upstream, downstream (near the railroad bridge), and immediately adjacent to the Site. A few patterns are apparent from this figure. First, total CDD/CDF concentrations (but not TEQs) are generally higher immediately adjacent to the Site, although concentrations do span the entire spectrum for river sediments. This is driven primarily by the CDF concentrations in several samples in the vicinity of docks No. 1 and No. 2 (e.g., Sample LWG0107R006SDS015C00). Concentrations upstream of the Site are generally lower than adjacent and downstream samples.

Second, while upstream and downstream samples indicated CDD concentrations greater than the respective CDF concentrations (in-between the red and black bars on Figure 2-7), sediment samples from adjacent to the Site showed the opposite (in-between the blue and black bars on Figure 2-7). For example, the sediment sample collected from between docks No. 1 and No. 2 (LWG0107R006SDS015C00) contained 99 percent relative CDFs, whereas samples from the vicinity of Outfall 22B show a more CDD-dominated profile (see comparative fingerprints in Figure 2-9). This indicates a separate signature (and likely source) for the CDFs in these sediments samples. The high relative CDF concentrations in sample LWG0107R006SDS015C00 appear to suggest that the source of the CDDs/CDFs could be historical chlor-alkali operations at the Site.

Figure 2-9 Dioxin/furan fingerprints for sediment samples collected between No. 1 and No. 2 docks (left) and adjacent to Outfall 22B (right)



The dioxin fingerprints for the sediment samples collected downstream of the Arkema property, immediately adjacent to the railroad bridge and the RP storm water outfall 22B, are very similar in profile, relative percent CDD, and concentrations (see Figures 2-1, 2-3, and 2-7). This consistency appears to be indicative of a common source of the CDDs/CDFs in these samples. The location of the samples, and the associated consistent fingerprints which differ from those adjacent to the Arkema site, appear to indicate the nearby RP storm water outfall is the likely source of these CDDs/CDFs.

2.7.2 *Groundwater*

Detections of CDDs/CDFs in groundwater on the Site have been characterized by relatively low concentrations and predominately CDF compositions. Less than 30 percent of the wells sampled during the 2006 and 2007 monitoring events and analyzed for CDDs/CDFs indicated detectable levels of CDDs/CDFs (eight detections total). Six of the eight detections were 100 percent CDFs. Of the remaining two samples with CDD detections, the concentrations were very low ("J" or estimated values). Historical groundwater data (year 2000) from the properties immediately upgradient of the Site (e.g., Esco, Gould, and Metro) also reveal low concentration, all-CDF detections.

The CDD/CDF TEQs for the monitoring wells in the former Acid Plant area of the Site are higher than those observed on Lots 1 and 2, and in upgradient wells (Figure 2-4). Two possible explanations for CDF detections in the former Acid Plant area are: 1) CDFs are related to historical chlor-alkali operations at the Site, or 2) the elevated CDFs represent a "slug" of higher concentration groundwater moving from an upgradient source.

CDD/CDF impacts on Lots 1 and 2 appear to be minimal. Groundwater detections at the former RP site are relatively high and cover a spectrum of fingerprints (see Figure 2-2). Thus, it is possible that the CDDs/CDFs on Lots 1 and 2 result from an upgradient source (e.g., the former RP site).

3.0 IDENTIFICATION OF DATA GAPS

The following section present the rationale for identification of the data gaps addressed in this work plan.

3.1 DIOXINS/FURANS

As presented in the CSM for dioxins/furans in Section 2.0 above, sufficient data exists for groundwater, river bank soil, and sediment at the Site to allow risk assessment and evaluation of remedial alternatives in the upland FS. However, to date, upland soil samples have only been collected from Lots 1 and 2. As a result, several soil samples will be collected and analyzed for dioxins/furans as part of this data gap investigation.

Samples will be collected from two areas of the Site: the old chlorine cell room (Lot 4) and the former asbestos and brine residue ponds (Lot 2). As discussed in Section 2.4, chlorine was manufactured in the old chlorine cell room using diaphragm cells with graphite anodes. These graphite anodes are a possible source of predominately CDFs, and therefore several soil samples will be collected from this area.

The former asbestos pond received asbestos waste from the new chlorine cell room. While it is highly unlikely that the newer asbestos diaphragm chlorine cells that used titanium anodes would generate quantities of furans above industrial background levels (EPA 2006), soil samples will be collected from this area to confirm the absence of furans at concentrations indicative of a source area.

3.2 GROUNDWATER CHEMICAL DATA

The last complete round of groundwater sampling was performed at the Site in April 2007 (ERM 2007). Since that time, seven new monitoring wells have been installed that have not yet been sampled. In order to provide current groundwater data for the upland FS and the groundwater SCM, a complete round of groundwater samples will be collected and analyzed for a wide spectrum of COIs.

3.3 GROUNDWATER SOURCE CONTROL MEASURE

An important design component of the groundwater SCM is the groundwater extraction well design. Extraction wells must be properly designed and spaced to provide hydraulic capture. Hydraulic conductivities for both the shallow and intermediate groundwater aquifers (the two aquifers from which groundwater will be captured) are key parameters in the design of these extraction wells.

To date, hydraulic conductivity has been estimated based on several short pump tests performed at the Site. In order to provide a reliable estimate of hydraulic conductivity in both the shallow and intermediate groundwater aquifers, several long-term pump tests are required.

4.0 SCOPE OF WORK AND SAMPLING METHODOLOGY

4.1 GROUNDWATER MONITORING

One groundwater monitoring event will be conducted to support the design of the proposed groundwater SCM. A monitoring well location map is included in Figure 3-1. Groundwater sampling activities will be conducted in accordance with the Remedial Investigation/FS Work Plan.

Groundwater monitoring field work will include the collection of groundwater elevation data, general water quality data, and groundwater samples for laboratory analysis.

4.1.1 Groundwater Elevation Monitoring

Groundwater elevation data will be collected from monitoring wells to be sampled prior to sampling activities. The measurements will be recorded to the nearest 0.01 inch with an electronic water level indicator relative to a surveyed reference point. The water level indicator will be rinsed with isopropyl alcohol, followed by deionized water between each measurement.

4.1.2 Low Flow Groundwater Sample Collection Procedure

Groundwater samples will be collected using low flow sampling techniques from a total of 97 monitoring wells. One sample will be collected from each well, except for well MWA-75i. Samples will be collected from two depths in well MWA-75i, where a 15-foot screen interval was installed across two potential water-bearing zones. Monitoring well locations are shown on Figure 3-1. The proposed analytical schedule for each well is outlined in Table 3-1.

Groundwater samples will be collected using low-flow sampling techniques employing a submersible, air-actuated bladder pump. Low-flow purging and sampling methods will be used to obtain representative groundwater samples while minimizing the amount of purge water generated. Low-flow well purging procedures are as follows:

- New, disposable polyethylene (or equivalent) tubing will be attached to the outlet of the decontaminated pump prior to purging

each well. The pump will be slowly lowered into the well to minimize the mixing of casing water and the suspension of silt at the bottom of the well. The pump will be placed near the middle or slightly above the middle of the screened interval and as close as possible to the same depth used in past sampling events. The pumping rate will be adjusted to approximately 100 to 500 milliliters per minute, and as close to the same rate used during past sampling events based on field notes. The depth of the pump intake will be recorded in the field notes.

  - At well MWA-75i, the well will be purged and then sampled at two separate depths. The pump will first be set between 27 and 30 feet bgs. The pump will then be set between 34 to 40 feet bgs.

- Purge water temperature, pH, specific conductance, dissolved oxygen, redox potential, and turbidity will be monitored using an in-line flow cell. At a minimum, readings will be taken and recorded every three to five minutes.
- Purging will be suspended when the following parameters have stabilized for three successive readings or when at least one well casing volume has been purged:
  - Temperature: ± 1 degree Celsius;
  - pH: ± 0.1 units;
  - Specific conductance: ± 10 percent; and
  - Dissolved oxygen or turbidity: ± 10 percent.
- Purging will be continued with a goal of turbidity readings less than 10 nephelometric turbidity units (NTUs).
- After well-purging criteria are satisfied, the in-line flow cell will be disconnected and groundwater samples will be collected in the appropriate containers. Samples to be analyzed for dissolved phase constituents shown on Table 3-1 will be field filtered using a 0.45 micron filter.
- The pump will be removed from the well, disposable tubing will be discarded, and the pump will be decontaminated as described in Section 4.1.5.

When purging and sampling wells with relatively low-yield rates where continuous flow is not sustainable during well purging, the pump will be turned off and the well will be allowed to recover for a period not longer than 24 hours. After the water level in the well has recovered, the

required samples will be collected with the pump placed near the middle of the screened interval.

4.1.3 *Regenerative Cellulose Dialysis Membrane Sampling*

Several monitoring wells (MWA-15r and MWA-69) have historically elevated, but variable, concentrations of DDT. These samples are thought to be influenced by the inclusion of soil/sediment entrained in sample during collection. Previous efforts to investigate the interference of DDT absorbed to entrained soil have included decanting or filtering (0.45 micron) the samples. The results of these investigations have been inconclusive (ERM 2007).

Recent advancements in passive sampling technology include the development of regenerated-cellulose dialysis membrane (RCDM) samplers (Interstate Technology and Regulatory Council (ITRC) 2006). RCDM samplers are passive samplers consisting of a tube of high-grade regenerated-cellulose dialysis membrane filled with deionized water. The RCDM tube is held inside an outer protective layer of low density polyethylene (LDPE) mesh. The semi-permeable membrane allows diffusion of dissolved ionic species into the sampler.

The sampler is lowered into the well to the required sampling depth and secured. The sampler is left in place for approximately 2 weeks, and then retrieved. The sample bag is opened and the contents transferred into the appropriate laboratory container. The sample is then packaged and submitted for analysis as per the low flow sampling procedures (Section 4.1.2).

Currently, RCDM samplers are not commercially available, in part because they will tend to biodegrade over time. The proposed samplers will require custom construction for use at the Site following ITRC guidance on RCDM construction, modified for use in smaller (2-inch) diameter wells.

4.1.4 *Analytical Requirements*

Groundwater samples from monitoring wells will be selectively analyzed for one or more of the following:

- Volatile organic compounds by United States Environmental Protection Agency (USEPA) Method 8260B;

- Total Petroleum Hydrocarbons (Diesel range) by method NWTPH-Dx;
- Polycyclic Aromatic Hydrocarbons by USEPA Method 8270;
- Organochlorine pesticides by USEPA Method 8081A;
- Herbicides (silvex, 2,4-D) by USEPA 8151A;
- Dioxin and Furans by USEPA Method 8290;
- Chloride by USEPA Method 300.0;
- Perchlorate by USEPA Method 314.0;
- Hexavalent Chromium by USEPA Method 7195;
- Dissolved metals (arsenic, aluminum, cadmium, copper, lead, nickel, zinc, iron, and manganese) by USEPA Method 6010B; and
- Dissolved Methane by Method RSK 175.

The analytical requirements for individual monitoring wells are detailed in Table 3-1. These analyses are in accordance with the Quality Assurance Project Plan (QAPP) for the RI/FS Work Plan and addenda.

Based on the results of the April 2007 site-wide groundwater monitoring, the dissolved metals analytical schedule has been reduced in order to focus on areas that are potentially impacted by COIs, and provide information for the design of the proposed groundwater SCM. The proposed changes in analytical scope are as follows:

- Arsenic sampling to be focused on those areas that have historical arsenic concentrations greater than the Portland Harbor Joint Source Control Strategy screening level value of 50 micrograms per liter (µg/L), and have low or high pH.
- Removing total chromium from the list of dissolved metals analyses due to the low solubility and low toxicity of chromium and the historically low concentrations following implementation of the Hexavalent Chromium IRM. Hexavalent chromium will continue to be monitored.
- Manganese sampling to be focused on providing information for the planning and design of the aquifer pumping test and groundwater extraction and treatment system.

The samples collected for hexavalent chromium analysis will be delivered to Columbia Analytical Services in Kelso, Washington. All other samples

will be delivered either by hand or shipped to TestAmerica Laboratories in Beaverton, Oregon for analysis.

4.1.5 *Equipment Decontamination*

All non-disposable sampling equipment will be decontaminated prior to use and between sample locations. Sampling equipment will be scrubbed with an aqueous solution of laboratory-grade detergent (e.g., Alconox), followed by a rinse with tap water, followed by an iso-propyl alcohol rinse, followed by a rinse with deionized water. To avoid cross contamination between samples, the disposable bladder on the pump and the polyethylene tubing will be changed between each well.

4.1.6 *Investigation-Derived Waste Management*

Decontamination fluids and purge water will be contained in segregated 55-gallon drums. ERM will be responsible for collecting, sampling, characterizing, and labeling containers, as necessary. ERM will be responsible for coordinating disposal of investigation-derived wastes.

4.1.7 *Quality Assurance/Quality Control*

Field quality assurance/quality control (QA/QC) samples will be collected in accordance with the QAPP. Trip blanks will be included in each cooler that contains volatile organic compound samples. One field duplicate sample will be collected for every 20 samples with a minimum of one for each analyte. In order to verify efficacy of decontamination of equipment, one rinsate sample will be collected for every 20 samples with a minimum of one per sampling event. QA/QC samples will preferentially be collected at wells known to have significant concentrations of the selected analytes. A summary of all groundwater analyses, including the QA/QC samples, is provided in Table 3-2.

Field notes taken during sampling activities will be recorded in the field log book using indelible ink. Samples will be immediately labeled following collection, with the required data. Sample data will be entered into the Chain-of-Custody record to ensure proper tracking and control. Samples will be shipped or delivered to the laboratory in sealed containers and accompanied by the Chain-of-Custody record. QA/QC samples, including trip blanks, field duplicates, and rinsate samples will be collected, controlled, and shipped in the same manner as normal field samples.

4.2 *SOIL SAMPLING*

Soil samples will be collected from three locations (B-122 to B-124) near the historical chlorate cell room (now identified as the former maintenance shop) to assess for the presence of dioxins and furans. Dioxin and furan samples will also be collected from the former brine residue pond (B-125) and the former asbestos pond (B-126). Proposed soil sampling locations are shown on Figure 3-2.

4.2.1 *Utility Clearance*

Prior to drilling, the boring locations will be marked in the field for inspection and approval by a facility representative familiar with utilities at the Site. The boring locations will be cleared for underground utilities by facility personnel. In addition, the Oregon Utility Notification Center will be notified prior to any drilling activities. In the event that one of the planned locations interferes with subsurface utilities, the boring will be relocated as close to the original location as possible. Relocated drilling locations will be approved by ERM's project/site manager and an LSS representative.

Additionally, attempts will be made to hand-clear all selected drilling locations to a depth of 4 feet bgs.

4.2.2 *Soil Sampling Approach*

Soil samples will be collected from locations B-122, B-123, and B-124 using a hand auger (or equivalent) to 4 feet bgs and by direct-push drilling rig from 4 feet bgs to the top of the water table (approximately 10 feet bgs). One soil sample will be collected from each of B-125 and B-126 at approximately 10 feet bgs by direct-push drilling rig.

Soil samples will be collected in 2-foot intervals (i.e. 0 to 2 feet bgs, 2 to 4 feet bgs, etc.). Each interval will be composited by mixing in a stainless steel bowl and then transferred to laboratory-provided sample collection jars.

Composite samples collected from the 0 to 2-foot interval will be analyzed within standard turn-around-time. Deeper sample intervals will be held by the laboratory at 4 degrees Celsius. Samples from deeper sample intervals will be released for analysis if data indicates a need for further vertical delineation.

4.2.3 *Sample Identification*

Samples will be identified by the sample location (B-122 through B-126) and the sample depth interval. For instance, the soil sample collected from 4 to 6 feet bgs at location B-122 will be identified as B-122-4-6.

4.2.4 *Analytical Method*

All soil samples will be analyzed for dioxins and furans by USEPA Method 8290.

4.2.5 *Equipment Decontamination*

All reusable drilling and sampling equipment will be decontaminated prior to use and between borings or sample collection. Sample equipment may include the drill sample rod and shoe, hand auger, soil mixing bowl, and mixing trowel. Sampling equipment will be scrubbed with an aqueous solution of laboratory-grade detergent (e.g., Alconox), followed by a rinse with tap water, followed by a rinse with isopropyl alcohol, followed by a rinse with deionized water. All equipment will be positioned after the decontamination to preclude inadvertent contamination prior to reuse.

4.2.6 *Investigation-Derived Waste Management*

Decontamination fluids and soil cuttings will be contained in segregated 55-gallon drums. ERM will be responsible for collecting, sampling, characterizing, and labeling containers, as necessary. ERM will be responsible for coordinating disposal of investigation-derived wastes.

4.2.7 *Quality Assurance/Quality Control*

Field QA/QC samples will be collected in accordance with the QAPP, included in the Remedial Investigation/FS Work Plan, and will include the following samples:

- One field duplicate sample will be collected from a shallow soil sample within the study area. The field duplicate will be identified with the sample location name and depth followed by a "-D".
- One rinsate sample will be collected in order to verify efficacy of decontamination of equipment. The rinsate blank will be collected by collecting deionized water poured over the shoe of the sample collection rod and the hand auger collection bucket. Sample

identifiers for equipment rinsate blanks will be the same as the primary sample collected immediately prior to the rinsate blank, followed by an "R."

Field notes taken during sampling activities will be recorded in the field log book using indelible ink. Samples will be immediately labeled following collection, with the required data. Sample data will be entered into the Chain-of-Custody record to ensure proper tracking and control. Samples will be shipped or delivered to the laboratory in sealed containers and accompanied by the Chain-of-Custody record. QA/QC samples, including trip blanks, field duplicates, and rinsate samples will be collected, controlled, and shipped in the same manner as normal field samples.

4.3 AQUIFER TESTING PROGRAM

4.3.1 Objectives

Pumping tests will be performed on four new recovery wells installed near the proposed alignment of the barrier wall (Figure 4-1 and 4-2). These tests will be performed to obtain better estimates of the hydraulic properties of the Shallow and Intermediate Zones, and the radius of influence of pumping wells in this area. The drawdown data from the aquifer tests will also used to re-calibrate the groundwater flow model developed for the Groundwater SCM Focused Feasibility Study (ERM 2008).

4.3.2 Background

Currently, limited pumping test data are available from the Arkema facility to support the design of the barrier wall system. Short-term (4-hour), constant-rate pumping tests of three wells screened in the Shallow Zone were performed in April 2006. Two of the wells tested, PT-1 and PT-2, are located near the former Chlorate Cell Room and the third well, PT-3, is located downgradient of the former Chlorate Cell Room near the Willamette River (Figure 4-3). Only one of the wells tested, PT-2, had a significant yield (27.6 gallons per minute [gpm]) during testing. The other two wells had yields of less than 1.0 gpm and irregular drawdown responses indicating possible damage to the well borings during drilling. A more detailed discussion of the pumping tests performed on these three wells is provided in *Arkema Active Pilot Test Workplan, Appendix B, Hydraulic Testing Summary* (GeoSyntec 2006).

The following sections describe components of the aquifer testing program.

4.3.3 *Observation and Recovery Well Design and Installation*

4.3.3.1 *Observation Well Design and Installation*

Four shallow zone (i.e., approximately 30 feet bgs) and four intermediate zone (i.e., approximately 50 feet bgs) observation wells will be used during aquifer testing to monitor the effects of pumping in the shallow and intermediate aquifers. A pair of observation wells will serve to monitor the effects of pumping in each aquifer, at each recovery well location. The observation wells will be spaced approximately 15 feet and 50 feet from each recovery well (see Figures 4-1 and 4-2 for recovery well locations). Existing monitoring wells MWA-2, MWA-8i, MWA-41, and MWA-60 will be assessed (location and screened interval) for feasibility of use as observation wells.

The observation wells will be constructed such that the screen intervals are approximately the same as the screened interval of the recovery wells (see Section 4.3.3.2 for recovery well design). The observation wells will be installed using sonic drilling techniques, and continuous soil cores will be collected and described geologically by ERM personnel.

Representative soil samples will be collected from screen zone intervals from two shallow observation wells and two intermediate observation wells. Soil samples will be collected, described, and submitted to a geotechnical laboratory for grain size (sieve) analysis. The results of the sieve analyses will be used to properly size the recovery well filter packs and well screen slot size, in order to optimize the operational efficiency of each recovery well.

Construction specifications for the observation wells were based on previous boring logs and existing monitoring wells in the proposed installation areas, therefore, the following construction information is assumed. Modifications will be made based on actual observations and data. Observation wells will be constructed using 2-inch diameter, Schedule 40 PVC, flush-jointed well screen and riser pipe. The well screens will have 0.010-inch slots and have a sand pack consisting of No. 2/12 Morie sand (or equivalent) installed to a minimum height of 2 feet above the top of the well screen. Upon completion of the placement of the sand pack, bentonite chips will be installed to approximately 2 feet bgs. Observation wells will be completed with lockable well caps and flush-

mounted steel traffic-rated well boxes concreted to depth of approximately 2 feet bgs.

4.3.3.2 *Recovery Well Installation and Design*

Two shallow and two intermediate zone recovery wells will be installed for aquifer testing to determine hydraulic properties of the aquifers for the design of the barrier wall. A pair of recovery wells (one shallow and one intermediate) will be installed at the north and south ends of the proposed barrier wall alignment, as presented on Figures 4-1 and 4-2. The recovery well locations were selected such that:

- The recovery wells can be used as part of the proposed groundwater extraction system; and
- Impacted groundwater removed during the pump tests can be managed efficiently and cost effectively.

The screen intervals for the recovery wells were identified based on previous borings and monitoring wells completed in the vicinity of the north and south barrier wall end points. The actual screen intervals will be based on lithologic observations during well installation. The recovery well screen intervals are presented in Table 4-1.

The recovery wells will be installed using hollow stem auger drilling techniques. Sonic drilling techniques will not be used so as to not damage the aquifer during well installation. For the shallow zone recovery well installations, a borehole will be advanced to the top of the shallow-intermediate silt horizon using 6-1/4-inch internal diameter (ID) augers. Split spoon soil samples will be collected every five feet to a depth of 25 feet bgs and continuously thereafter, until the silt horizon is identified. All soil samples will be described geologically by ERM personnel.

For the intermediate zone recovery well installations, a borehole will be advanced to the top of the underlying shallow-intermediate silt horizon using 12-1/4-inch ID augers. Split spoon soil samples will be collected every five feet to a depth of 25 feet bgs and continuously thereafter, until the silt horizon is identified. Once the silt horizon is identified, a permanent conductor casing will be installed within the augers in the borehole and will be backfilled with cement grout. After the grout has cured, a borehole will be advanced through the conductor casing to the top of the deep zone (approximately 50 ft bgs) using 8-1/4-inch ID augers. Split spoon sampling will resume at a frequency of every five feet below the shallow-intermediate silt.

Recovery wells will be constructed using 4-inch diameter, stainless steel well screens (length as indicated above) and stainless steel casings. Recovery well sand pack and screen slot size will be determined based on the results of the sieve analyses completed by the geotechnical laboratory during the installation of the observation wells. Upon completion of the placement of the sand pack, bentonite chips will be installed to approximately 2 feet bgs. Recovery wells will be completed with lockable well caps and flush-mounted steel traffic-rated well boxes concreted to depth of approximately 2 feet bgs.

4.3.3.3 *Monitoring and Recovery Well Development*

The objectives of the observation and recovery well development will be to remove fines (silts and fine sands) from the filter pack and the natural formation in the vicinity of the well screen. Removal of the aforementioned materials will result in maximizing the well efficiency, porosity, permeability, and the hydraulic communication between the well and the adjacent formation. Proper well development increases both the reliability of data from aquifer tests and the operating efficiency of the well.

Following completion, the monitoring well and recovery well installations each will be developed by purging via a submersible pump and surge-block methods (Driscoll 1986). Each recovery well will be developed for a maximum duration of approximately 10 hours, or until sand-free/silt free water is obtained (i.e., less then 50 NTUs). Each observation well will be developed for a maximum of 4 hours or until sand free/silt free water is obtained (i.e., less than 50 NTUs).

Water generated during well development activities will be managed in accordance with the steps outlined in Section 4.3.5.10.

4.3.4 *Recovery Well Stepped-Discharge Testing*

Following well development, stepped-discharge tests will be performed on each of the four newly installed recovery wells to determine a sustainable discharge rate for the constant rate pumping test. Ground water will be pumped with a 3-inch submersible pump which is temporarily installed in the well. A total of three successive higher rate pumping steps will be conducted at flow rates to be determined (i.e., 5, 10 and 15 gpm). Each step rate will be maintained until drawdown appears

to stabilize and/or a maximum duration of four (4) hours per pumping rate (i.e., no longer than 12 hours per recovery well). Detailed procedures and guidelines for conducting the stepped-discharge tests are presented in Appendix A.

Step test data will be used to determine, specific capacities and specific drawdowns for each step rate and will be utilized in selecting the most appropriate pumping rate for the 24-hour constant rate aquifer test.

4.3.5 Groundwater Elevation Monitoring

4.3.5.1 Objectives

The objectives of the constant rate pumping tests will be to estimate the hydraulic properties of the shallow and intermediate zones and the radius of influence of pumping wells in this area for the design the barrier wall system. It has been assumed that each pump testing at each recovery well will be conducted independently. Detailed procedures and guidelines for conducting the constant rate discharge tests are presented in Appendix A.

4.3.5.2 Background Ground Water Level Monitoring

In order to facilitate the analysis of background water level fluctuations, hourly background water level data will be obtained from an on-site monitoring well (to be determined) that is located outside the expected area of influence of the tests. Hourly background water level data will be collected a minimum of 24 hours before the pumping tests begin, during the 24-hour test, and for a minimum of 24 hours after pumping is stopped. The water level data will be obtained using remote data loggers equipped with a pressure-sensitive transducer (one background well).

4.3.5.3 Synoptic Water Level Measurements

Static water level measurements prior to pumping tests will be collected from all on-site monitoring and observation wells. The depth-to-water in each well will be measured from the previously surveyed permanent elevation marks at the top of each inner well casing, and the measurements will be recorded in a field notebook. Water level measurements will be taken to the nearest 0.01 foot and double-checked to ensure that the readings are accurate.

The depth-to-water level measurements will be used to calculate ground water elevations in the shallow and intermediate zones, and to construct ground water contour maps.

4.3.5.4 *Weather Data*

Prior to initiating the pumping tests, barometric pressure will be monitored and recorded. The barometric monitoring will continue throughout the tests and for 24 hours following completion of the tests. The barometric pressure transducer (i.e., BaroTroll) will be placed in one well (to be determined) during the pumping tests.

4.3.5.5 *Equipment*

In order to perform the pumping tests of the four recovery wells, a 3-inch diameter submersible pump will be temporarily installed in the wells by a drilling subcontractor. The submersible pump will be suspended in the well and will be equipped with check valves, a pressure gauge, an instantaneous and totalizing flow meter, y-fitting and valve after flow meter to connect an inline flow through cell for measurement of field parameters and a gate valve for discharge rate control. The groundwater discharge will be directed to the on-site holding tanks and additional storage as described in Section 4.3.5.10

4.3.5.6 *Pumping Test Period*

A constant-discharge pumping test will be performed at each of the newly installed recovery wells. The duration of each pumping test will be 24 hours, and the discharge rate of the pump will be held at a constant rate as determined by the step test at each well. During the first hour of the pumping test, the discharge rate in each pumping well will be monitored and recorded from the instantaneous and totalizing flow meter as frequently as practical. At a minimum, the discharge rate will be checked four times after the first hour, throughout the pumping test period.

4.3.5.7 *Groundwater Sample Collection*

Groundwater samples will be collected from each of the four recovery wells during pump testing. Groundwater samples will be collected at the startup, during the mid-point, and at the completion of the constant rate pumping tests and will be analyzed for VOCs, pesticides, dissolved metals, perchlorate, and chloride using the methods described in Section

4.1 of this Work Plan. Samples will be delivered to Test America Inc., of Portland, Oregon and will be analyzed at a standard turnaround time.

4.3.5.8 Drawdown Measurements

During the pumping tests, water level measurements will be collected from the pumping well and the two new observation wells associated with each of the recovery wells using pressure transducer/data logging systems. Vented pressure transducer cables will be used, which will compensate for any changes in barometric pressure that might affect the water level measurements.

At the start of pumping, water level measurements for the aforementioned observation points and pumping well will be collected. The data loggers will be programmed to record logarithmically for 30 minutes followed by linear measurements every 5-10 minutes for the remainder of the tests.

As previously described, hourly water level data will be collected from a background monitoring well during the background monitoring period, the 24-hour pump test and the recovery period.

4.3.5.9 Recovery Measurements

At the 24 hour point of the pumping test, the pump in the recovery well will be shut off and the recovery water level data will be collected for approximately 24 hours. The recovery water level data will be collected in each of the observation wells associated with the recovery well that was pumped using data loggers equipped with pressure-sensitive transducers.

At the end of pumping, water level measurements for the aforementioned observation points and for the pumping well will be collected. The data loggers will continue to collect measurements every 5-10 minutes until the 24-hour recovery period is complete.

As previously described, hourly water level data will be collected from the background monitoring period, the 24-hour pump test and the recovery period.

4.3.5.10 Pump Test Water Conveyance and Disposal

Development and pump test water will be discharged to the Publicly Owned Treatment Works sewer network with permission from the City of Portland – Bureau of Environmental Services (BES). ERM will coordinate

with the City of Portland and will complete permitting requirements and the BES Batch Discharge Authorization Application prior to discharge of any development or pumping test water generated at the Site (see Appendix B).

Water generated during the well development and testing will be conveyed to the existing on-site tank for temporary storage and additional tank storage (i.e., 20,000 gallon steel tank) as necessary, through the existing on-site piping network. Prior to well development and testing activities, the on-site piping conveyance network will be checked by ERM personnel, and damaged or aged sections will be replaced as necessary.

Water collected in the tanks after well development and testing activities will be batch sampled for the presence of VOCs, pesticides, metals, perchlorate, and chloride. Batch samples will be submitted to Test America, Inc. of Portland, Oregon on an expedited 24-hour turnaround time. The analytical results from each batch test will be used to determine if concentrations meet the applicable discharge values. If the values exceed the approved discharge criteria, the accumulated water will need to be treated prior to discharge. As such, accumulated development and pump test water will be pumped through liquid phase granular activated carbon to remove the dissolved organic contamination ensuring that discharge limitations are achieved. Therefore, mobilization of the granular activated carbon treatment vessel prior to receipt of the analytical results of the first batch test will be necessary in order to meet the project schedule.

If discharge to the Publicly Owned Treatment Works is approved, water will be directed to a pre-designated sanitary sewer manhole. Water discharged to the sanitary sewer will not exceed the discharge rate limit established in the permit.

4.3.6 Calculation of Aquifer Parameters

4.3.6.1 Analytical Methods

The water level data from the constant-discharge and recovery tests will be analyzed to obtain estimates of the hydraulic conductivity and storage coefficient of the shallow and intermediate zones. The water level data will be analyzed using drawdown and recovery models that are appropriate for both the type of tests that are performed and the groundwater flow conditions at the Site. The flow test data will analyzed

with AQTESOLVE for Windows™, a software package for estimated aquifer properties from slug and pumping tests (HydroSOLVE, 2003).

The effective radius of influence of the pumping wells will also be estimated from the measured drawdown in the observation wells by projecting a linear regression of the maximum drawdown versus the log of the radial distance between the observation wells and the pumping well to zero drawdown according to the method described by Dawson and Istok (1991).

5.0 PROJECT SCHEDULE

The project is expected to start upon approval of this work plan. The following preliminary schedule is anticipated:

- Fieldwork completion: July 2009;
- Draft Report: January 2010; and
- Review Meeting: upon ODEQ review.

This schedule may be adjusted as needed.

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Figures

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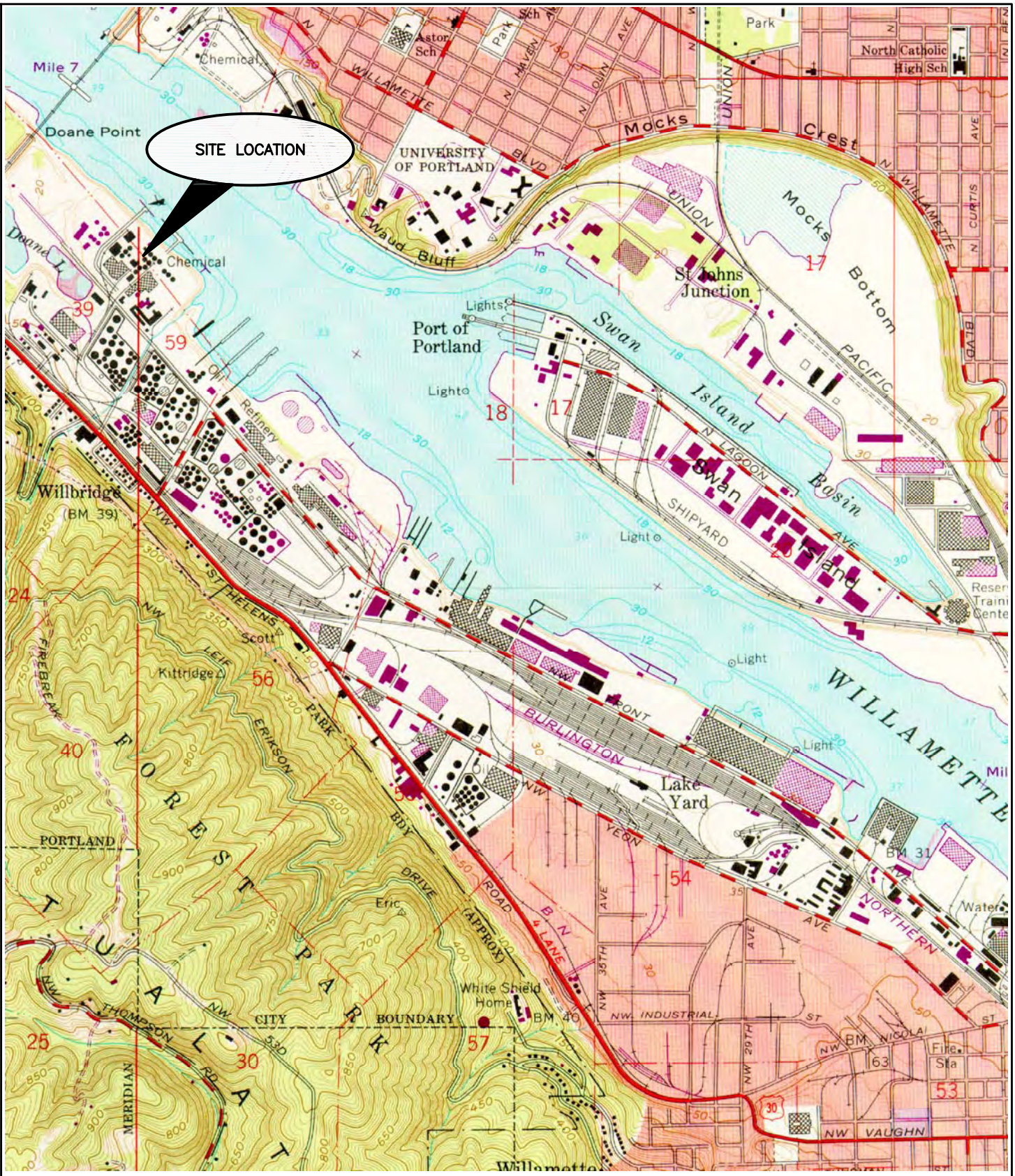

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1 1/2 0 1 MILE

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1 .5 0 1 KILOMETER

N

References:
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Dated: 1961; Photorevised 1970 and 1977

Figure 1-1
Site Location Map
Arkema Inc.
Portland, Oregon

ERM 03/09

Project No. 0093634.06
Date: 03/24/09
Drawn By: R. Olson
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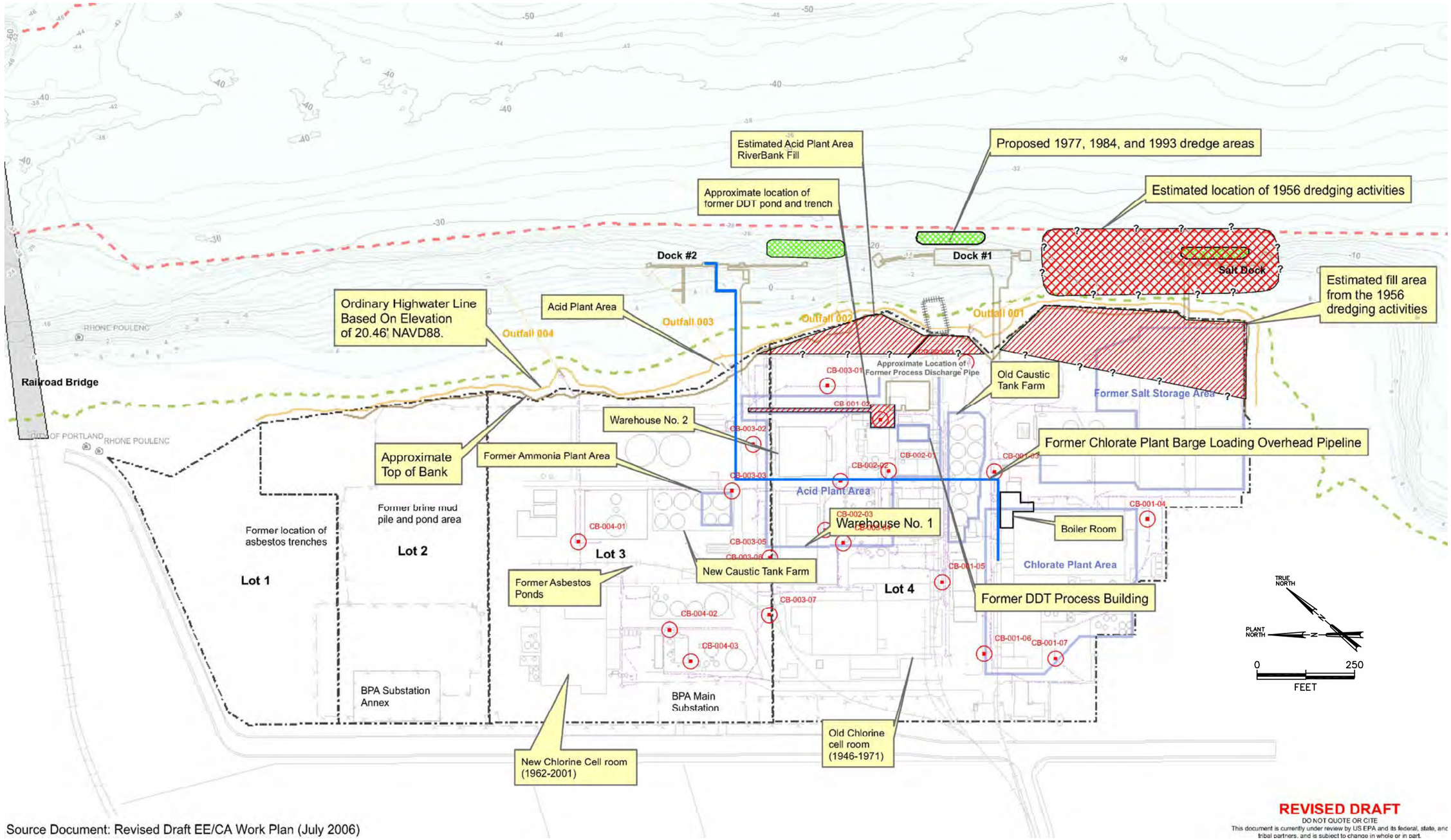


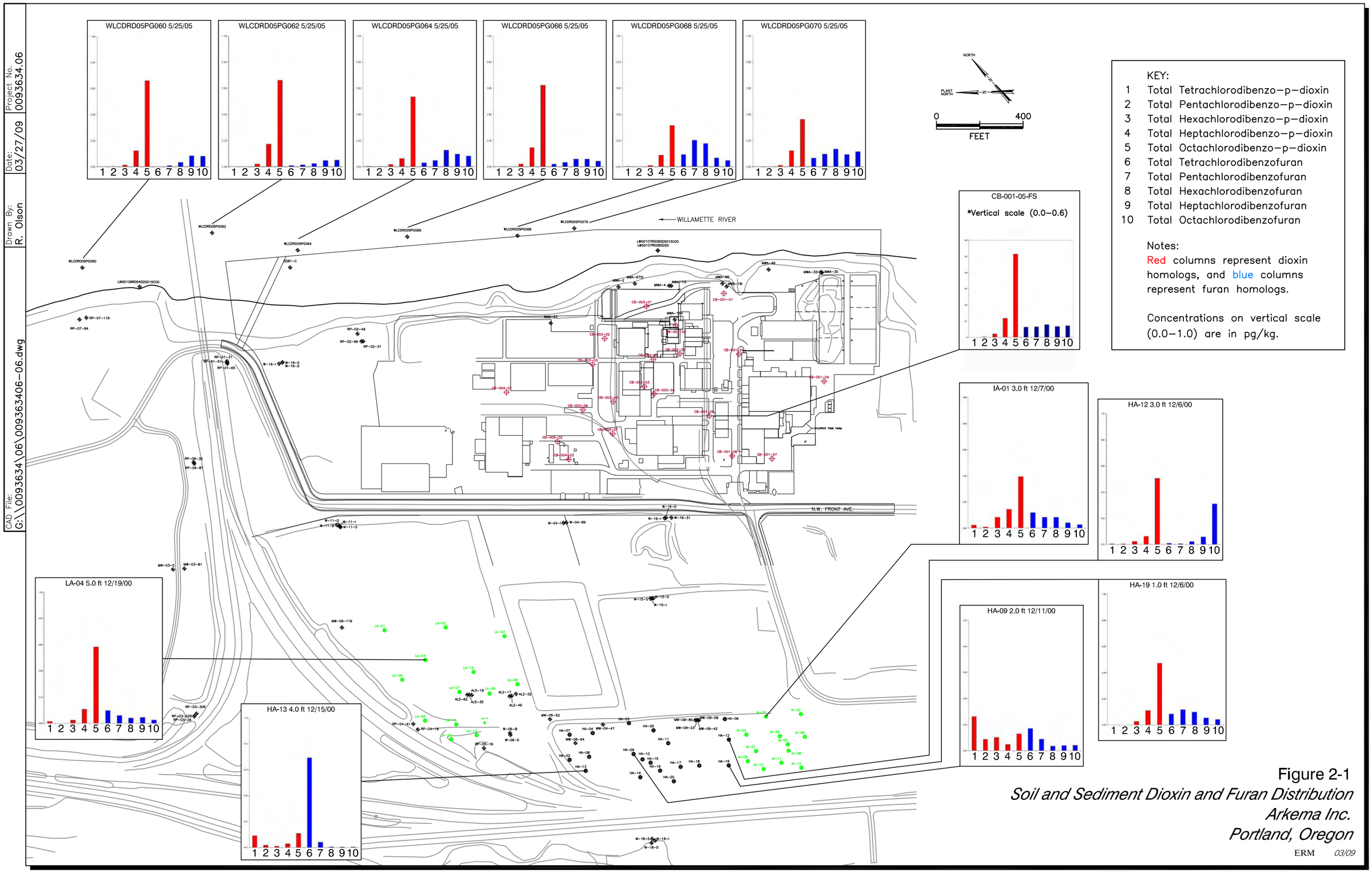
Source Document: Revised Draft EE/CA Work Plan (July 2006)

REVISED DRAFT
DO NOT QUOTE OR CITE
This document is currently under review by US EPA and its federal, state, and tribal partners, and is subject to change in whole or in part.

NOTE
Most buildings and structures noted on this diagram have been demolished and/or removed.

- Ordinary High Water
- Top of Bank
- E-Sewer-L
- Storm Drain
- 12ft_Contour
- Navigation Channel
- Bridges
- Property Lines
- Outfalls
- Catch Basins
- Overhead Pipeline
- Estimated Fill Area
- Proposed 1977, 1984, and 1993 dredge areas
- Estimated Dredged Area

Figure 1-2
Current and Historic Upland Contaminant Sources
Arkema Inc.
Portland, Oregon
ERM 03/09



KEY:

1 Total Tetrachlorodibenzo–p–dioxin
2 Total Pentachlorodibenzo–p–dioxin
3 Total Hexachlorodibenzo–p–dioxin
4 Total Heptachlorodibenzo–p–dioxin
5 Total Octachlorodibenzo–p–dioxin
6 Total Tetrachlorodibenzofuran
7 Total Pentachlorodibenzofuran
8 Total Hexachlorodibenzofuran
9 Total Heptachlorodibenzofuran
10 Total Octachlorodibenzofuran

Notes:
Red columns represent dioxin homologs, and blue columns represent furan homologs.

Concentrations on vertical scale (0.0–1.0) are in pg/kg.

Figure 2-1
Soil and Sediment Dioxin and Furan Distribution
Arkema Inc.
Portland, Oregon

ERM 03/09

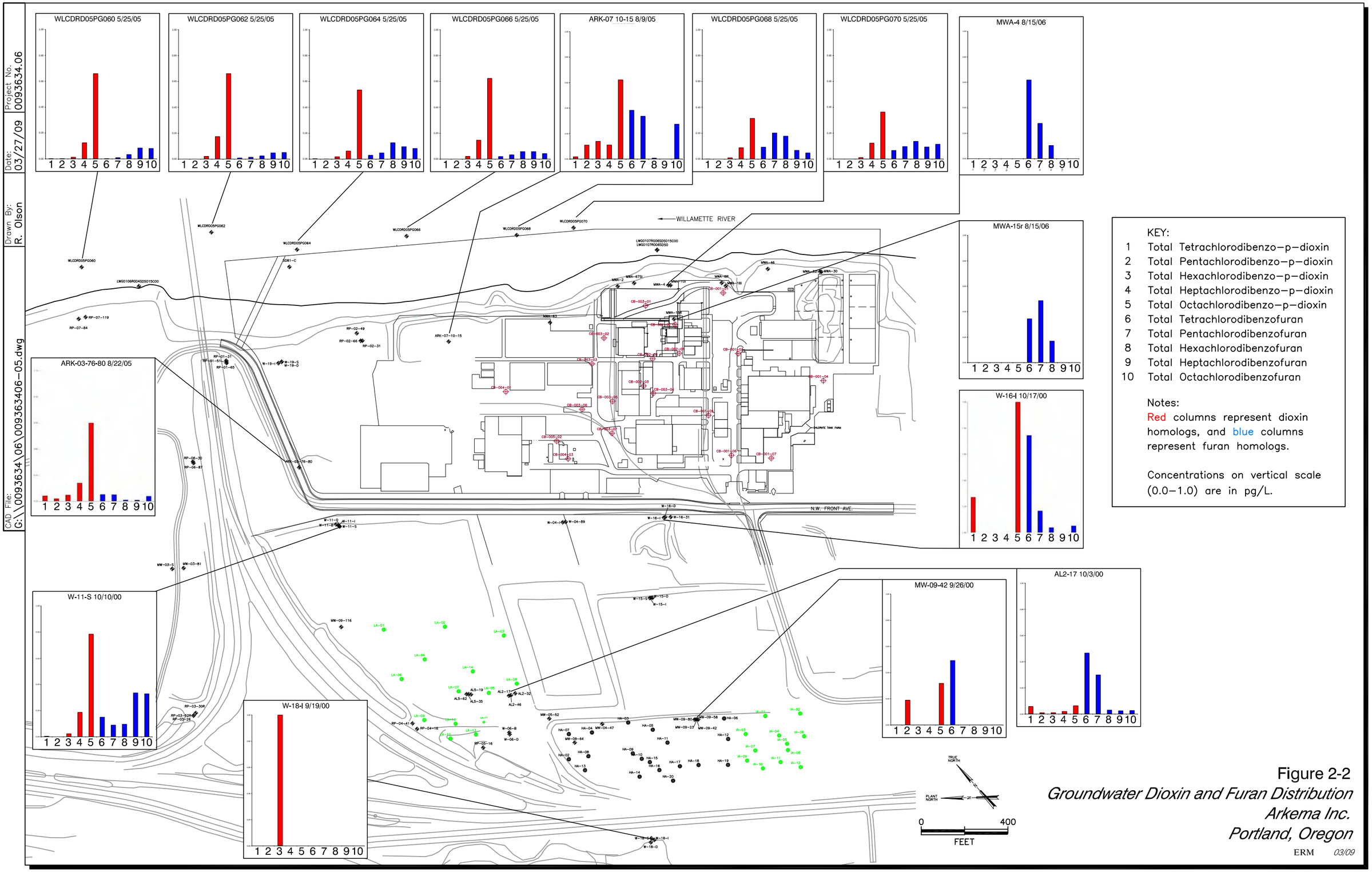
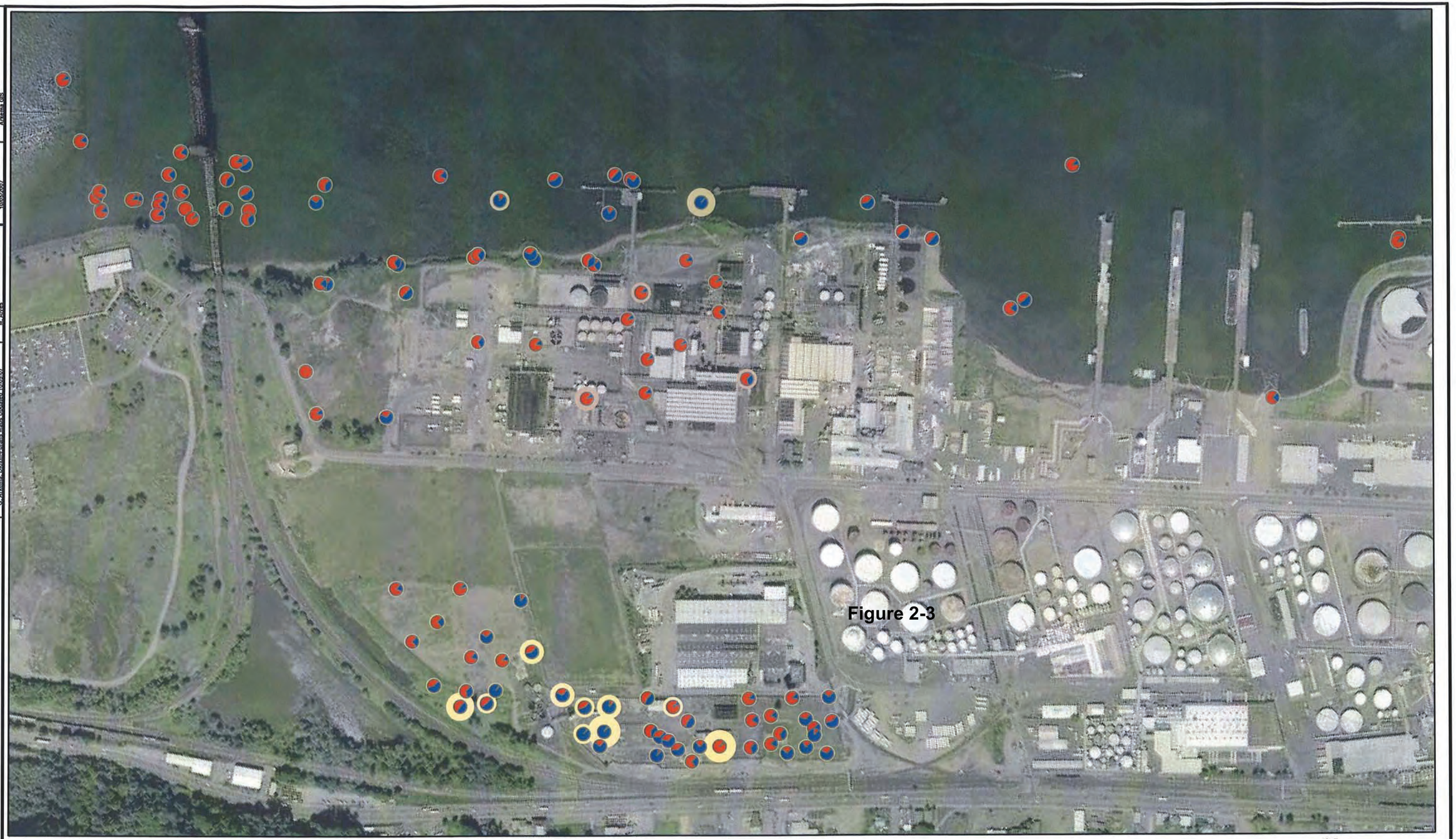


Figure 2-2
Groundwater Dioxin and Furan Distribution
Arkema Inc.
Portland, Oregon



LEGEND

Graduated TEQ Values Upland Soil (ug/kg)	Graduated TEQ Values River Sediment (ug/kg)	Graduated TEQ Values Sediment Catch Basins (ug/kg)
0.000000 - 0.437170	0.000000 - 0.437170	0.000000 - 0.437170
0.437171 - 2.076413	0.437171 - 2.076413	0.437171 - 2.076413
2.076414 - 4.858000	2.076414 - 4.858000	2.076414 - 4.858000
4.858001 - 16.600000	4.858001 - 16.600000	4.858001 - 16.600000
16.600001 - 66.622843	16.600001 - 66.622843	16.600001 - 66.622843

Pie Charts
Dioxins
Furans

Scale 1:5,000

N

Figure 2-3

Soil/River Sediment/Catch Basin Sediment Dioxin-Furan Data Arkema Portland, OR

ERM 10/07

Project Number Arkema GIS

Date 10/05/2007

Drawn By: M. Alves

GIS File G:\Arkema-Dioxin-Furans Maps Updated 10-05-07

Figure 2-3

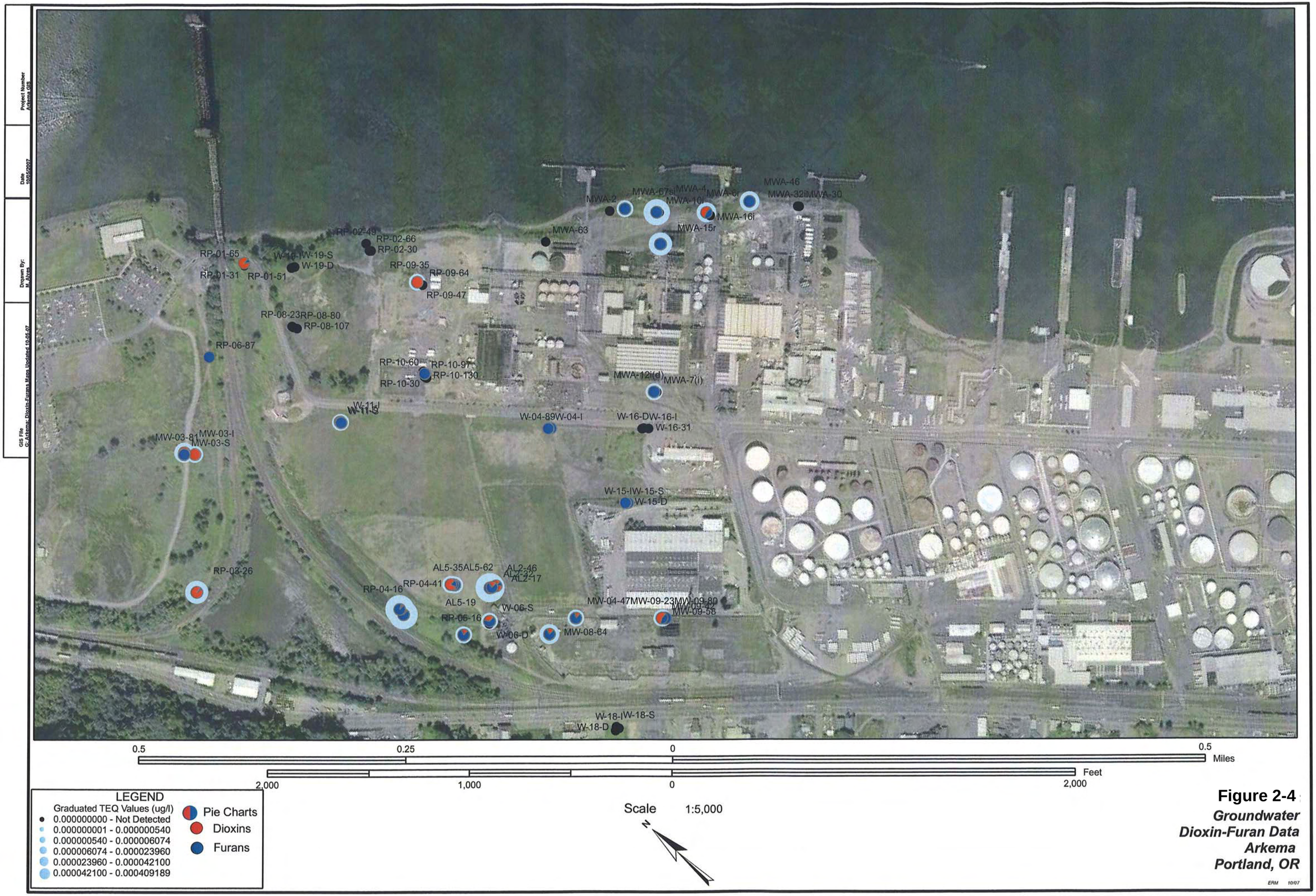


Figure 2-4

Groundwater Dioxin-Furan Data Arkema Portland, OR

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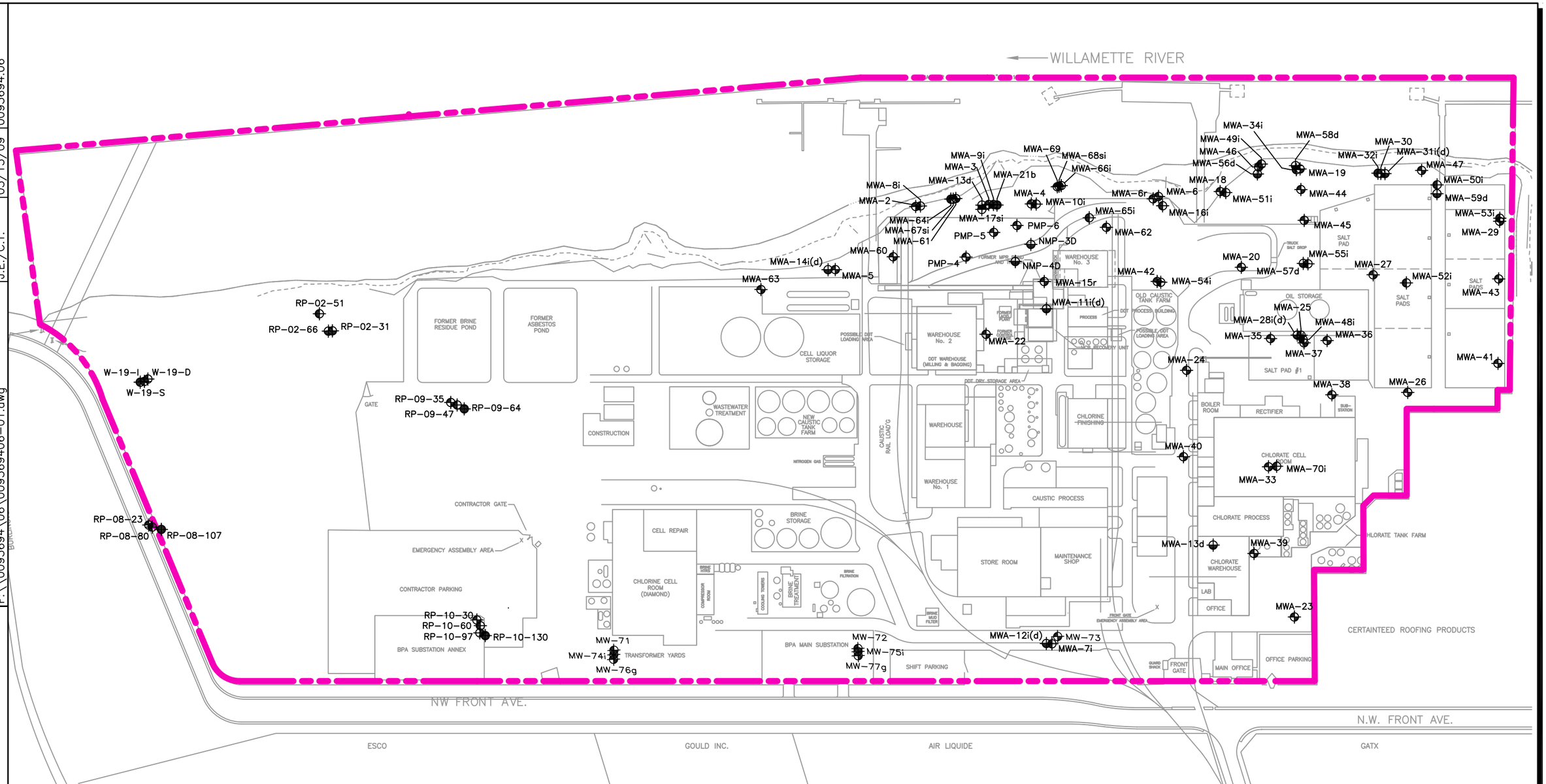


LEGEND

- Monitoring Well, Shallow Zone
- Monitoring Well, Shallow–Intermediate Zone
- Monitoring Well, Intermediate Zone
- Monitoring Well, Deep Zone
- Monitoring Well, Gravel Zone
- Monitoring Well, Basalt

NOTE
Most buildings and structures noted on this diagram have been demolished and/or removed.

TRUE NORTH
PLANT NORTH
0 200
FEET

Figure 3-1
Monitoring Well Locations
Arkema Inc.
Portland, Oregon

ERM 03/09

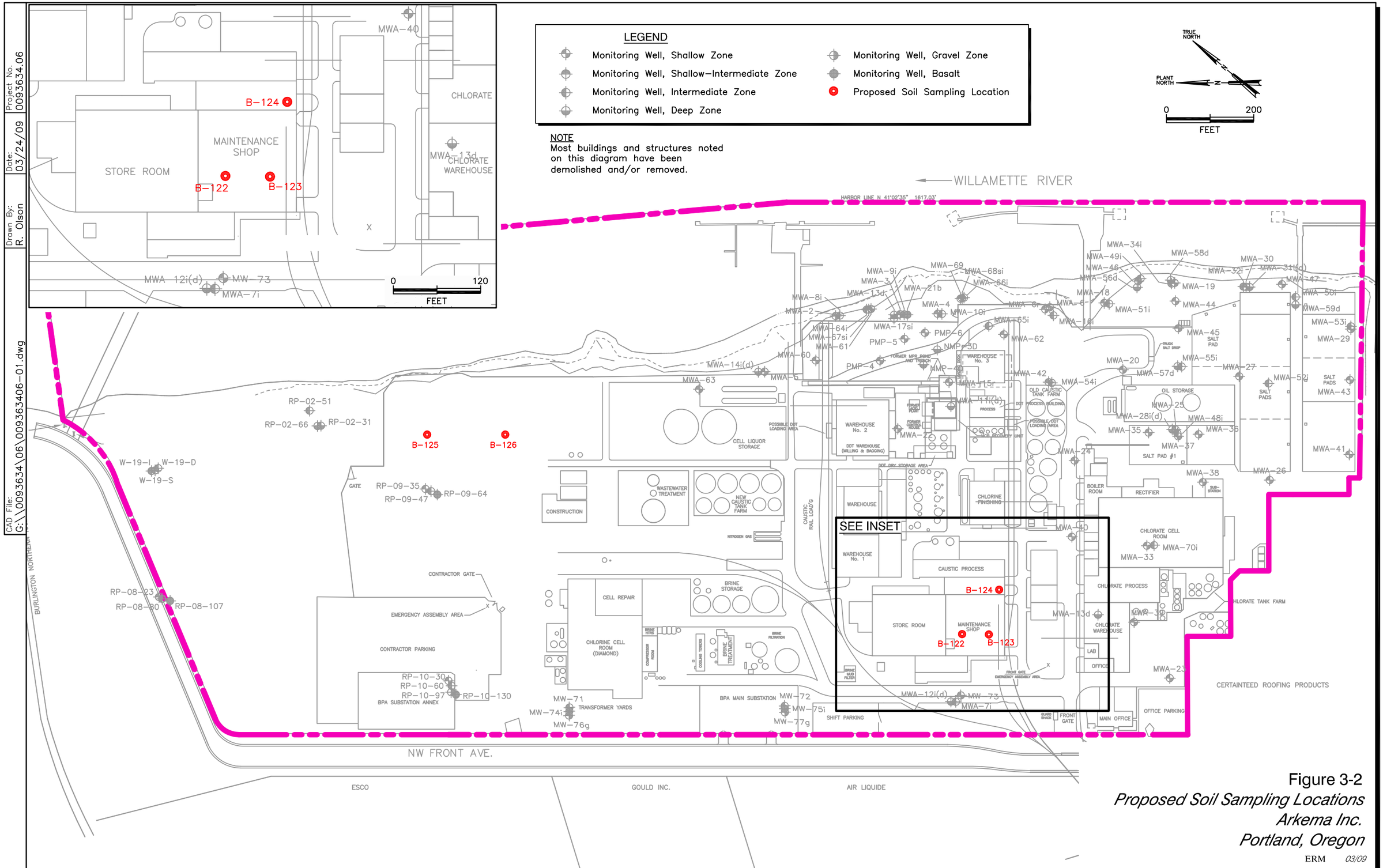


Figure 3-2
Proposed Soil Sampling Locations
Arkema Inc.
Portland, Oregon

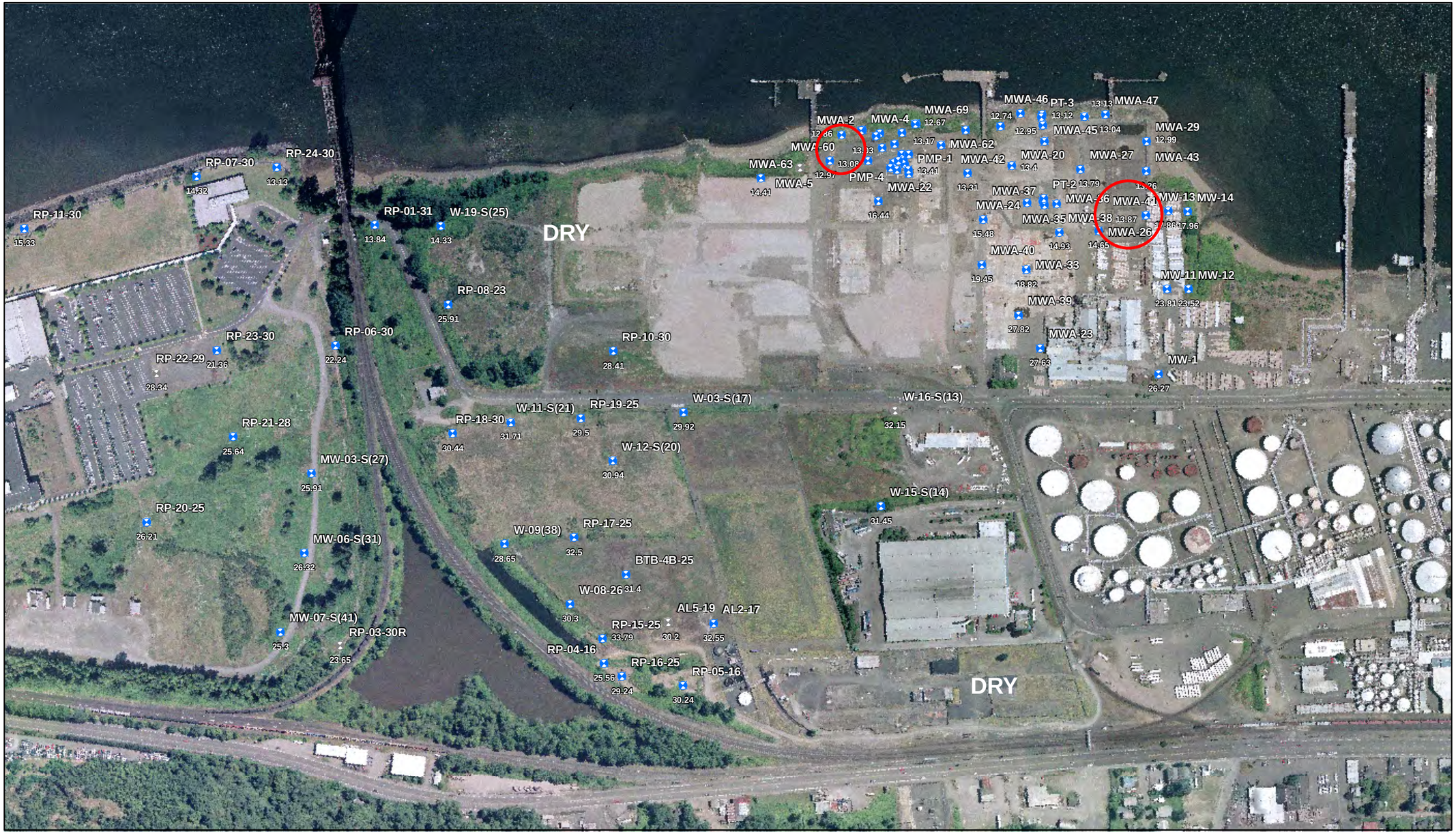
ERM 03/09

Project No. 0057055

Date: 10/03/07

Drawn By: T. Cota

GIS File:



Aerial Photography - July, 2005

LEGEND

Shallow Zone Monitoring Well

Monitoring Well Not Used for Contouring

True North

Plant North

0 400 800

Feet

General Area of Proposed Pumping and Observation Wells

Figure 4-1

Location of Shallow Zone Pumping Wells

March 2009

Arkema, Inc.

Portland, Oregon

ERM 03/09

Project No. 0057055

Date: 10/03/07

Drawn By: T. Cota

GIS File:

Aerial Photography - July, 2005

LEGEND

Intermediate Zone Monitoring Well

Monitoring Well Not Used for Contouring

True North

Plant North

0 400 800

Feet

General Area of Proposed Pumping and Observation Wells

Figure 4-2

Location of Intermediate Zone Pumping Wells

March 2009

Arkema, Inc.

Portland, Oregon

ERM 03/09

Project No. 0093634.06
Date: 03/24/09
Drawn By: R. Olson
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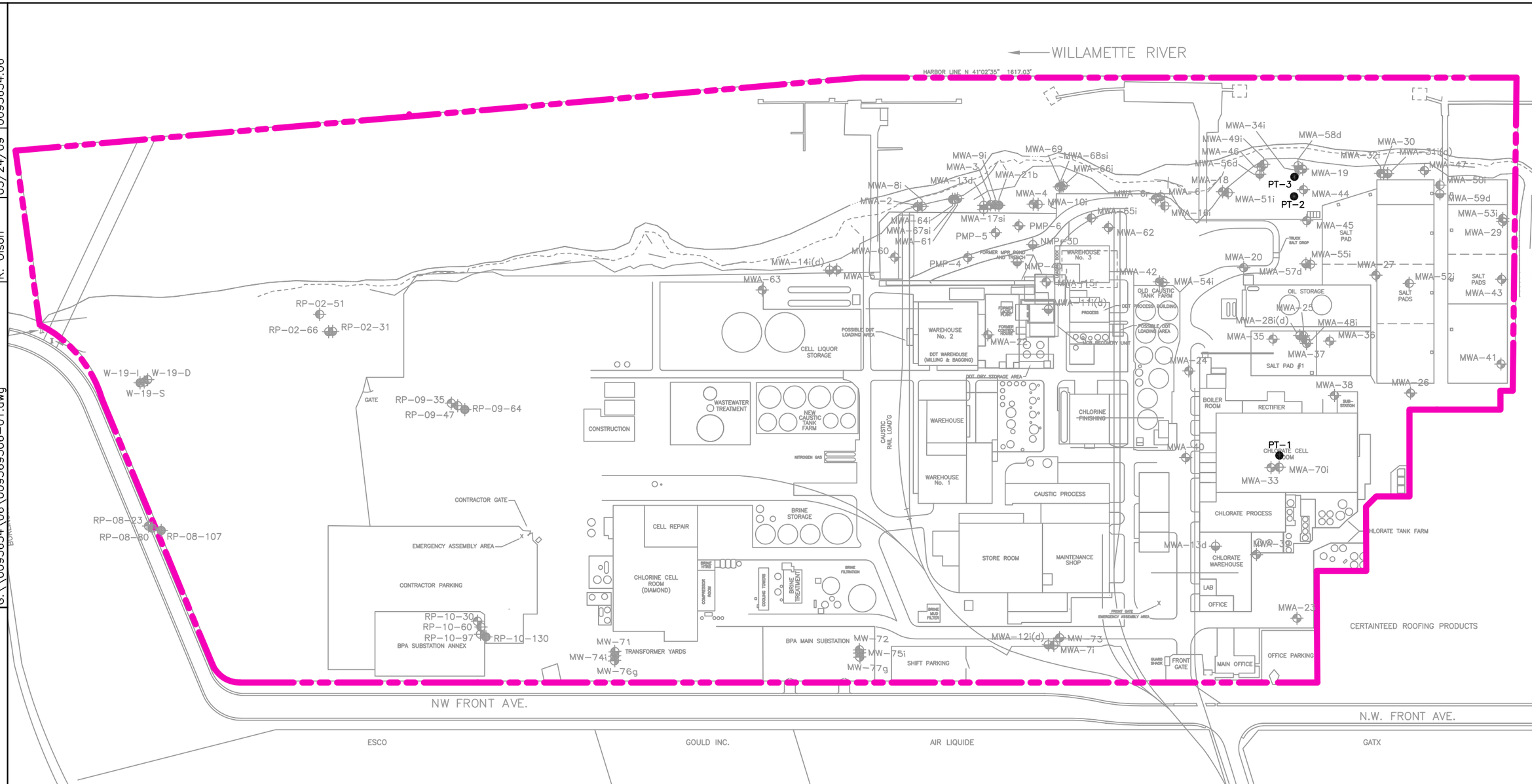

LEGEND

- Monitoring Well, Shallow Zone
- Monitoring Well, Shallow–Intermediate Zone
- Monitoring Well, Intermediate Zone
- Monitoring Well, Deep Zone
- Monitoring Well, Gravel Zone
- Monitoring Well, Basalt
- Pumping Well

NOTE
Most buildings and structures noted on this diagram have been demolished and/or removed.

TRUE NORTH
PLANT NORTH
0 200
FEET

Figure 4-3
Existing Pumping Well Locations
Arkema Inc.
Portland, Oregon

ERM 03/09

Tables

ODEQ ID	Site	Address	Activities	Data Source	Products	Precursors/Products used on site	Additional COCs/Indicator Compounds
183	Wacker Siltronic Corp.	7200 NW Front Ave	Former Oil-gas manufacturer (NW Natural), on site disposal of coal-tar (30,000 cyds). Subsequent releases of solvents (TCE) by current occupant (microchip wafer manufacturer).	ECSI	LPG	TCE, PAHs, Vinyl Chloride, BTEX, phenols	Coal-Tar. PAHs, TCE, VC, BTEX, phenols and metals detected in subsurface soils and groundwater
49	Gould Inc./NL Industries	5909 NW 61st Ave	Secondary lead smelter, lead-acid battery recycling, lead oxide production. Battery acid drained to Doan Lake. Smelter wastes and battery casings used as fill.	ECSI, EPA Website	Lead, lead oxide	Plastic battery casings, battery acid	pH, As, Cd, Cr, Zn
395	Schnitzer Investment - Doane Lake	6529 NW Front Ave	Acetylene manufacturer, on-site disposal of calcium hydroxide, releases of oil, acetone and MEK. Subsurface soils have detections of PCB1254, PCE, TCA, and 1,2-DCA. Dioxin contamination in subsurface soils, part of Rhone-Poulenc cleanup.	ECSI	Acetylene, calcium hydroxide	Acetone, MEK, heavy oils	Lead, arsenic, PCBs, pH, tetrachloroethane, PCE, 1,1-DCA
155	Rhone-Poulenc	6200 NW St Helens Rd, Portland, OR	Insecticide and herbicide manufacturer	ECSI, Consent Order, SOW and RI	Bromoxnil Octanoate, 2,4-D (2-(2,4-dichlorophenoxy)acetic acid), MCPA (2-(4-chloro-2-methyl-phenoxy)acetic acid), 2,4,5-TP (Silvex), 2,4-DB (butyl 2-(2,4-dichlorophenoxy)acetate), 2-(2,4-dichlorophenoxy)propanoic acid, DDT, Aldrin, Endrin, Heptachlor, Malathion, Arsenic based herbicides	2,4,6-Trichlorophenol, 2-Chlorophenol, Pentachlorophenol, Phenol, 1,4-Dichlorobenzene, benzene, chlorobenzene, TCE, diesel	Pb, Hg, Vn, 1,2,4-Trimethylbenzene, TCE, Vinyl Chloride, 2-Methylnaphthalene, Benzo(a)pyrene, Chrysene, Naphthalene, dioxins
74	McCormick and Baxter	6900 N Edgewater St	Wood Treatment Facility, directly across river from Arkema site. Undergoing remedial action (almost complete). Sheet-pile / slurry wall installed to contain upland plume, sediment cap. Known source of dioxins to sediment.	ECSI, RI/FS	Treated Wood Products	Creosote, pentachlorophenol, diesel, heavy oils, arsenic, chromium, copper, zinc.	Dioxins, metals, PAHs,
117	GenStar Roofing Products/Certainteed Roofing	6350 NW Front Ave	Asphalt roofing manufacturer. Historic releases of fuel oil and gasoline to soil and groundwater. NFA issued for site.	ECSI	Asphalt roof tiles	Fuel oil, asphalt	Gasoline, benzene
1549	Kinder Morgan Willbridge Terminal	5924 NW Front Avenue	Bulk Fuel Terminal. Petroleum releases to soil, groundwater, surface water. DDT and chlorinated solvents detected in soil and groundwater	ECSI	Petroleum products (gasoline, diesel, fuel oil, heavy oils)	Fuel oils, oil sludge	DDT, chlorinated solvents, VOCs, lead

Notes
ECSI = Oregon DEQ Environmental Cleanup Site Information database
RI/FS = Remedial Investigation / Feasibility Study
SOW = Scope of Work

Well ID	Screened Interval ft-bgs	VOCs USEPA 8260B	TPH- Diesel Range TPH-Dx	PAHs USEPA 8270	Organo-chlorine Pesticides USEPA 8081A	Dissolved[3] Organo-chlorine Pesticides USEPA 8081A	Silvex / 2,4-D USEPA 8151A	Dioxin-Furans USEPA 8290	Chloride USEPA 300.0	Perchlorate USEPA 314.0	Metals										Dissolved Methane RSK 175
											Hexavalent Chromium USEPA 7195	Dissolved Arsenic USEPA 6010B	Dissolved Aluminum USEPA 6010B	Dissolved Cadmium USEPA 6010B	Dissolved Copper USEPA 6010B	Dissolved Lead USEPA 6010B	Dissolved Nickel USEPA 6010B	Dissolved Zinc USEPA 6010B	Dissolved Iron USEPA 6010B	Dissolved Manganese USEPA 6010B	
Volume (L)		0.04	1	1	1		1	2	0.25	0.25	0.25	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.04
Containers		3	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	3
NMP-3D	25.0-30.0	X			X				X										X		X
NMP-4D	25.0-30.0	X			X				X										X		X
MWA-2	21.5-31.5	X			X				X	X									X	X	X
MWA-3	20.7-30.7	X			X				X	X									X		X
MWA-4	19.5-29.5	X			X				X	X	X										
MWA-5	36-38	X			X				X	X											
MWA-6r	30.5-33.5	X			X				X	X	X								X		X
MWA-7	28.2-33.2	X			X			X	X	X									X		X
MWA-8i	42-47	X			X				X	X		X								X	
MWA-9i	40.5-45	X			X				X	X											
MWA-10i	40.2-45.2	X			X				X	X	X	X									
MWA-11i	46.2-50.8	X			X				X	X	X	X									
MWA-12i	42-51.75	X			X			X	X	X		X									
MWA-13d	51-53	X			X				X										X		X
MWA-14i	44-49	X			X				X	X		X									
MWA-15r	22.5-32.5	X			X	X			X		X	X							X		X
MWA16i	39.2-44.2	X			X				X	X	X										
MWA-17si	33.5-35	X			X				X	X									X		X
MWA-18	19.2-29.2	X			X				X	X	X										
MWA-19	19.2-29.2	X			X				X	X	X										
MWA-20	24.7-34.7	X			X				X	X	X	X									
MWA-21b	61-68.2	X			X				X										X		X
MWA-22	24.7-34.7	X			X				X		X	X									
MWA-23	15.2-25.2								X		X	X							X		X
MWA-24	24-34	X							X	X	X	X									
MWA-25	23.7-33.7								X	X	X	X							X		X
MWA-26	21.2-31.2								X	X	X									X	
MWA-27	24-34								X	X	X								X		X
MWA-28i(d)	53.9-58.9								X	X	X	X									
MWA-29	24.9-34.9				X				X	X	X										
MWA-30	19.1-29.1	X			X				X	X	X	X							X	X	X
MWA-31i(d)	54.8-59.8	X			X				X	X	X								X		
MWA-32i	37-42	X			X				X	X	X	X							X		
MWA-33	20-30				X				X	X	X	X							X		
MWA-34i	32-37	X			X				X	X	X	X							X		
MWA-35	23-33								X	X	X	X							X		
MWA-36	23-33								X	X	X	X							X		
MWA-37	23-33								X	X	X	X							X		
MWA-38	22-32								X	X	X	X							X		
MWA-39	15.05-24.3								X	X	X								X		
MWA-40	20.25-29.5								X	X	X	X							X		
MWA-41	25.05-34.3								X	X	X								X	X	
MWA-42	21.55-30.8	X			X				X	X	X	X							X		
MWA-43	25.05-34.3								X	X	X								X	X	
MWA-44	25.05-34.3	X			X				X	X	X	X							X	X	
MWA-45	24.55-33.8	X			X				X	X	X	X							X		
MWA-46	19.75-29	X			X				X	X	X								X		
MWA-47	25.05-34.3	X			X				X	X	X								X		
MWA-48i	42.05-46.5								X	X	X	X							X	X	
MWA-49i	38.85-43.3	X			X				X	X	X	X							X		
MWA-50i	40.85-45.3	X			X				X	X	X								X		
MWA-51i	37.35-41.8	X			X				X	X	X	X							X		
MWA-52i	38.15-42.6								X	X	X								X	X	
MWA-53i	39.25-43.7								X	X	X								X		
MWA-54i	35.95-40.4	X			X				X	X	X								X		
MWA-55i	38.55-43	X			X				X	X	X	X							X		
MWA-56d	55.5-60.25	X			X				X	X	X								X		
MWA-57d	54.7-59.45	X			X				X	X	X								X		
MWA-58d	55.2-59.95	X			X				X	X	X								X		

Well ID	Screened Interval ft-bgs	VOCs USEPA 8260B	TPH- Diesel Range TPH-Dx	PAHs USEPA 8270	Organo-chlorine Pesticides USEPA 8081A	Dissolved[3] Organo-chlorine Pesticides USEPA 8081A	Silvex / 2,4-D USEPA 8151A	Dioxin-Furans USEPA 8290	Chloride USEPA 300.0	Perchlorate USEPA 314.0	Metals										Dissolved Methane RSK 175
											Hexavalent Chromium USEPA 7195	Dissolved Arsenic USEPA 6010B	Dissolved Aluminum USEPA 6010B	Dissolved Cadmium USEPA 6010B	Dissolved Copper USEPA 6010B	Dissolved Lead USEPA 6010B	Dissolved Nickel USEPA 6010B	Dissolved Zinc USEPA 6010B	Dissolved Iron USEPA 6010B	Dissolved Manganese USEPA 6010B	
MWA-59d	54.7-59.45	X			X				X	X	X								X		
MWA-60	27-36.8	X			X				X	X									X	X	
MWA-61	22.3-32.1	X			X				X	X									X		
MWA-62	20.5-30.3	X			X				X	X	X	X							X		
MWA-63	19.8-29.6	X			X				X	X		X	X	X	X	X	X	X	X	X	
MWA-64i	42-46.5	X			X				X	X		X							X		
MWA-65i	42-46.5	X			X				X		X								X		
MWA-66i	37.6-42.4	X			X				X	X	X								X		
MWA-67si	36.3-37.8	X			X				X	X		X							X	X	
MWA-68si	32.3-33.8	X			X				X	X	X	X							X		
MWA-69	19.5-29.3	X			X	X			X	X		X							X		
MWA-70i	42.5-32.7								X	X	X								X		
MWA-71	12.5-22.5	X	X	X	X		X	X	X			X									
MWA-72	12.0-22.0	X	X	X	X		X	X	X			X									
MWA-73	11.0-21.0	X	X	X	X		X	X	X			X									
MWA-74i	38.0-43.0	X	X	X	X		X	X	X			X									
MWA-75i[(1)]	25.0-40.0	X	X	X	X		X	X	X			X									
MWA-75i[(2)]	25.0-40.0	X	X	X	X		X	X	X			X									
MWA-76g	89.0-94.0	X	X	X	X		X	X	X			X									
MWA-77g	86.0-91.0	X	X	X	X		X	X	X			X									
PMP-4	21.6-31	X			X				X										X		
PMP-5	22.2-31.6	X			X				X										X		
PMP-6	25.9-34.9	X			X				X										X		
RP-02-31	25-30	X	X	X	X		X	X	X	X		X	X	X	X	X	X	X	X	X	
RP-02-51	43-48	X	X	X	X		X	X	X			X	X	X	X	X	X	X	X	X	
RP-02-66	60-65	X	X	X	X		X	X	X			X	X	X	X	X	X	X	X	X	
RP-08-23	13-22.5	X	X	X	X		X	X	X			X									
RP-08-80	73-79.5	X	X	X	X		X	X	X			X									
RP-08-107	102-107	X	X	X	X		X	X	X			X									
RP-09-35	24.5-35	X	X	X	X		X	X	X	X		X									
RP-09-47	42-46.5	X	X	X	X		X	X	X			X									
RP-09-64	59-64	X	X	X	X		X	X	X			X									
RP-10-30	20-29.5	X	X	X	X		X	X	X			X									
RP-10-60	55-59.5	X	X	X	X		X	X	X			X									
RP-10-97	92-97	X	X	X	X		X	X	X			X									
RP-10-130	125-130	X	X	X	X		X	X	X			X									
W-19-S	20-25	X	X	X	X		X	X	X	X		X	X	X	X	X	X	X	X	X	
W-19-I	44-49	X	X	X	X		X	X	X			X	X	X	X	X	X	X	X	X	
W-19-D	63-68	X	X	X	X		X	X	X			X	X	X	X	X	X	X	X	X	
	Totals	79	24	24	80	2	24	26	98	66	52	58	7	7	7	7	7	7	63	18	14

ft-bgs = Feet below ground surface
VOC = Volatile organic compound
TPH = Total Petroleum Hydrocarbons
PAH = Polycyclic Aromatic Hydrocaorbons
1 = Collect sample from middle of 27- to 30-foot range, within upper water-bearing zone
2 = Collect sample from middle of 34- to 40-foot range, within lower water-bearing zone
3 = Collected using regenerated cellulose dialysis membrane (0.0018 micron) diffusion samples

Table 3-2

Groundwater Quality Assurance/Quality Control Samples
Data Gaps Work Plan
March 2009

Parameters	Method	Standard Samples	Trip Blank[a]	Duplicate[b]	Rinsate[c]	Total
Volatile Organic Compounds	USEPA 8260B	79	7	4	4	94
TPH Diesel Range	NWTPH-Dx	24	-	1	1	26
PAHs	USEPA 8270	24	-	1	1	26
Organochlorine Pesticides	USEPA 8081A	82	-	4	4	90
Silvex / 2,4-D	USEPA 8151A	24	-	1	1	26
Dioxin-Furans	USEPA 8290	26	-	1	1	28
Chloride	USEPA 300.0	98	-	5	5	108
Perchlorate	USEPA 314.0	66	-	4	4	74
Hexavalent Chromium	USEPA 7195	52	-	3	3	58
Dissolved Arsenic	USEPA 6010B	58	-	5	5	68
Dissolved Aluminum	USEPA 6010B	7	-	1	1	9
Dissolved Cadmium	USEPA 6010B	7	-	1	1	9
Dissolved Copper	USEPA 6010B	7	-	1	1	9
Dissolved Lead	USEPA 6010B	7	-	1	1	9
Dissolved Nickel	USEPA 6010B	7	-	1	1	9
Dissolved Zinc	USEPA 6010B	7	-	1	1	9
Dissolved Iron	USEPA 6010B	63	-	4	4	71
Dissolved Manganese	USEPA 6010B	18	-	4	4	26
Dissolved Methane	RSK 175	14	-	1	1	16

a = To be included in each cooler containing volatile organic compound samples.
b = To be collected at the frequency of 1 per 20 standard samples with a minimum of 1 per sampling event.
c = To be collected at the frequency of 1 per 20 standard samples with a minimum of 1 per sampling event, and a minimum of one per each plant area in which the analyte is collected.
USEPA = United States Environmental Protection Agency

Table 4-1
Recovery Well Screen Intervals
Data Gaps Work Plan
March 2009

Location Along Proposed Barrier Wall	Aquifer Zone	Nearby Well	Approximate Screen Zone Setting (feet bgs)	Screen Length (feet)
North	Shallow	MWA-60	22 to 37	15
	Intermediate	None	37 to 47	10
South	Shallow	MWA-41	18 to 33	15
	Intermediate	MWA-41	39 to 54	15

Appendix A
Standard Operating Procedures: Stepped-Discharge and Constant Rate Discharge Testing

APPENDIX A - STANDARD OPERATING PROCEDURES: STEPPED-DISCHARGE AND CONSTANT RATE DISCHARGE TESTING

DEFINITIONS

Aquifer Testing - Refers to flow testing methods used to estimate the hydraulic properties of confined or unconfined aquifers. Slug tests, and specific capacity, stepped-discharge and constant-discharge pumping tests are commonly used testing methods.

Stepped-Discharge Pumping Tests - Used to estimate well performance, determine a sustainable optimum pumping rate for the well, and estimate aquifer properties. The test is conducted by pumping the well at several successively higher rates and measuring the corresponding water level drawdown.

The Constant-Discharge Pumping Test - Involves discharging water at a constant rate from a well by pumping and monitoring the corresponding water level drawdown. The recovery of water levels in the well may also be monitored after pumping is terminated (recovery test). Water level monitoring during a pumping and recovery test commonly includes the pumping well and one or more nearby observation wells. In certain instances, observation wells are not available and water level monitoring is limited to only the pumping well.

Cone of Depression - A depression in the groundwater table or potentiometric surface that has the shape of an inverted cone around a well from which water is being withdrawn.

Confined or Artesian Aquifer - An aquifer that is overlain and underlain by confining layers of lower hydraulic conductivity and, at a given point, the total head of the aquifer is higher than the base of the upper confining layer.

Drawdown - The difference between the height of the static water level and that of the water level in a well during pumping or water withdrawal. Or, in a confined aquifer, the reduction of the pressure head as a result of the withdrawal of free water.

Discharge (Q) - Volume of water removed per unit of time (l^3/t).

Electronic Water Level Indicator - A water level measuring device that uses a light, or sounds a buzzer, to show that the end of the tape has entered the water. The water in the well completes an electric circuit that turns on the light or sounds a buzzer. The tape is graduated to show the depth.

Flow Regulator - Flow regulators (flow controllers) are used to control the discharge rate (in volume/time) of water from the well while pumping. The discharge from the mechanical pump is normally set at a constant rate.

Hydraulic Conductivity (k) - A quantitative measure of the ability of a porous material to transmit a fluid. Also defined as the volume of water that will flow through a unit cross-sectional area of porous material per unit time under a unit hydraulic gradient (l/t). Hydraulic conductivity is dependent upon properties of the material and fluid.

Measuring Point - A fixed and clearly identified point of reference from which water levels in a monitoring well may be measured. It is generally established on the upper rim of the outer protective well casing and has a surveyed location and elevation.

Mechanical Pump - An electric-powered water pump used to withdraw water from the well during a pumping test.

Observation Well - A non-pumping well used to observe the groundwater levels during a pumping test.

Potentiometric Surface - The surface defined by water levels from multiple tightly cased wells that penetrate an aquifer or hydrogeologic unit. Also, a map of the hydraulic head of an aquifer.

Pressure Transducer and Data Logger - An electronic sensor that can accurately measure hydrostatic pressure. By relating hydrostatic pressure to depth below the water level, the water level can be electronically measured as the transducer is held in the water. Periodic water level measurements can be stored by the data logger for later recall and data evaluation.

Recovery - The time rate of return to the static water level during a slug test or after cessation of a pumping test. This is related to the aquifer's response to the change in water level during the flow test. After the water level has been raised or lowered by raising or lowering the slugging rod, or after the pump is turned off during a pumping test, the water will return to static conditions (static water level).

Saturated Thickness (b) - For unconfined aquifers, the interval between the water table and base of the unconfined water bearing unit. For confined aquifers, the interval between the base of the upper confining unit and the top of the lower confining unit.

Specific Capacity (C) - Discharge per unit of drawdown in a pumping well (Q/s).

Specific Yield (Sy) - The ratio of the volume of water that saturated soil or rock will yield under the influence of gravity, per unit volume of the saturated soil or rock. Specific yield is dimensionless.

Storage Coefficient or Storativity (S) - The volume of water that an aquifer releases from, or takes into storage per unit area of aquifer, per unit change in head. Storage coefficient is dimensionless.

Transmissivity (T) - A quantitative measure of the ability of an aquifer to transmit water. It is the product of the hydraulic conductivity and saturated thickness ($k \bullet b$) (l^2/t).

Unconfined Aquifer - An aquifer in which the water table forms the upper boundary.

Water Level - The position of the air-water interface in a well. The water level is usually measured as the depth to the water from a measuring point (such as the top of the outer protective well casing) by the use of a weighted measuring tape or electronic water level indicator. Changes in the water level over time may also be monitored by a pressure transducer installed at a known depth within the water column inside the well. The water level is called the static water level when it is not influenced by well drilling activities, aquifer testing, well development, or groundwater sampling.

Water Table - The saturated zone surface at which the pore water pressure is equal to atmospheric pressure. The water table is the potentiometric surface for an unconfined aquifer.

Wellhead Flow Meter - A meter installed in the water discharge line near the well head to measure the discharge (in volume/time) of water by the mechanical pump and controlled by the flow regulator.

FIELD METHODS

This section describes the field procedures, data collection methods, and documentation requirements for aquifer testing.

Stepped-Discharge and Constant-Discharge Testing

The pumping tests covered in this section include stepped-discharge and constant-discharge pumping tests. A stepped-discharge test is conducted for the pumping well and is recommended prior to initiation of any constant-discharge pumping test. The data provided by the stepped-discharge test is used to evaluate well performance and determine the optimum discharge rate for the subsequent constant-discharge test.

The stepped-discharge test entails conducting three or more steps of increased discharge while monitoring water level drawdown. This effectively produces successive stepped drawdown curves. Flow testing may potentially be discontinued at a well after the stepped-discharge pumping test if: 1) only a single well pumping test is planned; and 2) the stepped-discharge test provides all the necessary data of a single well pumping test.

The constant-discharge test involves the pumping of water from a well at a constant rate and monitoring the water level drawdown in response to the pumping. Water level recovery may also be monitored after the pumping is discontinued.

Water level monitoring may be limited to the pumping well (single well pumping test) or include one or more nearby observation wells (multiple well pumping test). The single well pumping test utilizes a single well (the pumped well) and a mechanical pump to remove water at a constant rate from the water bearing unit. The same well is used to measure water level drawdown and recovery in the formation. The multiple well test utilizes one or more observation wells at selected distances and locations relative to the pumping well. Water levels are monitored in the pumping and observation wells throughout the duration of the test.

The remaining discussion provides the general guidelines and procedures for stepped-discharge tests, and single and multiple well constant-discharge tests. These represent minimum requirements as site- and project-specific information and criteria must be incorporated in planning and conducting pumping tests.

The procedures below describe the use of pressure transducers/data loggers to monitor water levels during the pumping tests.

Stepped-Discharge Tests

Stepped-discharge testing should be conducted before other pumping tests. All newly installed wells should be developed before conducting stepped-discharge tests.

- Inspect the equipment to be used to ensure that it is in good working order. Equipment used for the stepped-discharge testing will vary widely based upon site-specific conditions. The project work plans will outline the type of equipment to be used.
- Measuring and test equipment (M&TE) used for field activities will be calibrated by the equipment manufacturer or an approved calibration laboratory using appropriate standards. Certificates of calibration for M&TE will be obtained from the M&TE supplier and kept in the project files. No M&TE will be utilized without verification of calibration certification.
- Decontaminate all downhole equipment.
- Visually inspect and access the well.
- Obtain a depth to water level measurement and sound the bottom of the well with the electronic water level indicator. Compare the measured total depth to the bottom of the well to the well construction diagram to determine if sediment is in the bottom of the well.
- Install the mechanical pump in the well using the manufacturer's instructions. The position of the pump intake inside the well should be based upon well construction and site specific factors stipulated in the project work plans. The criteria for placement of the pump in the well should also be contained on the project work plans. Note the height of the water column from the static water level to the pump intake. Record all information on the appropriate form as specified by the project work plans. During testing, the drawdown should not be so great as to cause the pump to cavitate.
- Connect the pressure transducer to the data logger. Lower the pressure transducer inside the pumping well to a depth below the bottom of the anticipated drawdown. The transducer should be installed at a level that: 1) eliminates effects from the pump intake; 2) is below the anticipated water level during maximum drawdown; and 3) does not exceed the maximum transducer head limitation. In addition, the transducer must be secured inside the pumping well in such a manner that the transducer will not be affected by turbulence from the pump. Record the depth of the transducer.
- Turn on the pressure transducer/data logger, set the recording frequency for pre-test monitoring to that specified by the project work plans. (Data loggers should be placed in a secure location to prevent tampering.)

- Physically measure the water level with the electronic water level indicator and record along with the time. Commence pre-test monitoring with the pressure transducer/data logger. The total length of time over which the pre-test measurements are made will be provided in the project work plans. Generally water levels are recorded for a period before the stepped-discharge test that is at least twice as long as the time expected for the stepped-discharge test and the recovery period. Record the information, including times of measurements, on the appropriate form as specified by the project work plans.
- Once the pre-test monitoring period is ended, re-measure the water level using the electronic water level indicator and record along with the time.
- Change the recording frequency on the data logger to the appropriate frequency of stepped-discharge data entry as required by the project work plans. Begin recording water level measurements with pressure transducer/data logger as required by the project work plans for the initial pumping phase of the stepped-discharge test. Start the mechanical pump and adjust the valve or flow regulator to maintain the constant rate of discharge specified by the project-specific work plan. This rate will be the first step in the stepped-discharge test. Record the time of the start of the stepped-discharge test as specified in the project work plans.
- Continue to monitor water level decline during the first step with the pressure transducer/data logger, taking periodic water level measurements with the electronic water level indicator. Data logger and electronic water level indicator readings should be conducted in accordance with the schedule outlined in the project work plans. As the first step continues, review the water level data and, if necessary, adjust the recording frequency of the data logger. Observe and record the wellhead flow meter readings as required by the project work plans.
- Continue pumping and recording water levels and flow meter readings in the first step as long as required by the project work plans.
- Once the first step is ended, measure the water level with the electronic water level indicatory and record depth and time. Adjust the data logger as necessary (based upon review of data from the first step) or specified in the project work plans for commencement of the second step of the test.
- Without turning the mechanical pump off, initiate the second step of the test by changing the pumping rate with the valve or flow regulator to the rate specified by the project work plans.
- Monitor the water levels and flow meter readings continue pumping and recording water levels and flow meter readings in the first step as long as required by the project work plan. Once the first step is ended, measure the water level with the electronic water level indicatory and record depth and time.

Adjust the data logger as necessary (based upon review of data from the first step) or specified in the project work plans for commencement of the second step of the test.

- Repeat the cycles of changing pumping rate and recording depth of water as often as is required (for each step of the stepped-discharge test) by the project work plan.
- Once the last step is completed, re-set the data logger for the recovery period measurement duration and frequency as specified in the project work plans. Obtain a water level measurement with the electronic water level indicatory and record the measurement and time. Shut down the mechanical pump. Record the time (to the nearest 10 sec) that the pump was shut down on the appropriate form.
- Continue to measure and record the water level recovery with the pressure transducer/data logger as long as is required by the project work plans or until the water level has recovered to within 90 percent of the level expected from the pretest trends. Also, continue to take physical water level measurements periodically during recovery. Once the recovery period is ended, take a physical water level measurement at the end of the test. Record the measurement and time on the appropriate form.
- The data should be reviewed in the field to help ensure the validity of the test. The field data review may also be used to determine the discharge rate to be used during the subsequent single or multiple well pumping test. Complete all documentation on the appropriate form as outlined in the project work plans.
- Once the stepped-discharge test is satisfactorily completed for the well, the equipment may be left in the well for subsequent single or multiple well pump testing. If the subsequent testing will not be conducted then the downhole equipment may be removed and the wellhead secured.

Single and Multiple Well Constant-Discharge Tests

The procedures in this section are written for a multiple well constant-discharge test; however, these procedures are directly applicable to a single well constant-discharge test. The only difference is that testing and measuring equipment are installed only in the pumping well, and water level measurements are only collected from this well.

- Inspect the equipment to be used to ensure that it is in good working order. Equipment used for the pump testing will vary widely based upon site-specific

conditions. The project work plans will outline the type of equipment to be used.

- M&TE used for field activities will be calibrated by the equipment manufacturer or an approved calibration laboratory using appropriate standards. Certificates of calibration for M&TE will be obtained from the M&TE supplier and kept in the project files. No M&TE will be utilized without verification of calibration certification.
- Decontaminate all downhole equipment. Equipment maintained inside the pumping well from the stepped-discharge test and to be used directly for the subsequent pumping test does not need to be re-decontaminated.
- Visually inspect and access the wells to be used during the pumping test.
- Obtain a depth to water level measurement and sound the bottom of each well to be used with the electronic water level indicator. Compare the measured total depths to the bottom of the wells to their respective construction diagrams to determine if sediment is in the bottom of the wells.
- If necessary, install the mechanical pump in the well using the manufacturer's instructions. The position of the pump intake inside the well should be based upon well construction and site specific factors stipulated in the project work plans. The criteria for placement of the pump in the well should also be contained on the project work plans. Note the height of the water column from the static water level to the pump intake. Record all information on the appropriate form as specified by the project work plans. During testing, the drawdown should not be so great as to cause the pump to cavitate.
- If a multiple well test is being conducted, connect the pressure transducers to their respective data loggers. Install the transducers inside the observation wells at this time. The transducers should be installed at a position inside each well that is below the anticipated water level during maximum drawdown, and does not exceed the maximum head limitation. Set up another pressure transducer in an outlying well (outside of the suspected influence of the pumping well) to record station barometric effects. Connect the pressure transducer to the data logger. Lower the pressure transducer inside the pumping well to a depth below the bottom of the anticipated drawdown. The transducer should be installed at a level that: 1) eliminates effects from the pump intake; 2) is below the anticipated water level during maximum drawdown; and 3) does not exceed the maximum transducer head limitation. In addition, the transducer must be secured inside the pumping well in such a manner that the transducer will not be affected by turbulence from the pump. Record the depth of the transducer.

- If any transducer cables are run across traffic areas, they must be appropriately protected. Data loggers should also be placed in a secure location to prevent tampering.
- Turn on the pressure transducers/data loggers, set the recording frequencies for pre-test monitoring to that specified by the project work plans. It is also important before initiating pre-test monitoring for the pumping test to ensure that water levels from any previous stepped-discharge testing have completely recovered.
- Physically measure the water levels in the pumping and observation wells with the electric tape and record along with the time. Separate data sheets should be used for each well.
- Commence pre-test monitoring with the pressure transducers/data loggers. The total length of time over which the pre-test measurements are made will be provided in the project work plans. Generally water levels are recorded for a period before the pumping test that is at least as long as the time expected for the pumping and recovery period. Record the information, including times of measurements, on the appropriate form as specified by the project work plans.
- Once the pre-test monitoring period is ended, re-measure the water levels in the wells using the electronic water level indicator and record along with time.
- Change the recording frequencies in the data loggers for the pumping test as required by the project work plans. Just before starting the pump, begin recording the pressure transducer measurements.
- Start the mechanical pump and adjust the valve or flow regulator to maintain a constant rate of discharge as determined from the stepped-discharge test and/or specified by the project work plans. Record pump start time on the appropriate form.
- Continue to monitor water levels during pumping with the pressure transducers/data loggers, taking periodic water level measurements in each of the wells with the electronic water level indicator. Data logger and electronic water level indicator readings should be conducted in accordance with the schedule outlined in the project work plans. However, the water level data should be evaluated during the test and, if necessary, the recording frequencies of the data loggers adjusted.
- Observe and record the wellhead flow meter readings as required by the project work plans.
- The project hydrogeologist or designee will determine the time that the mechanical pump should be shut down as specified in the project work plans

and/or based on review of field generated drawdown versus time plots from the pumping and observation wells.

- Once the pumping phase is completed, re-set the data loggers for the recovery period recording duration and frequencies as specified in the project work plans. Obtain a water level measurement in each of the wells with the electronic water level indicator and record the measurements and times. Shut down the mechanical pump. Record the time (to the nearest 10 sec) that the pump was shut down on the appropriate form.
- Continue to record the water level recovery in the wells with the pressure transducers/data loggers as long as is required by the project work plans or until the water levels have recovered to within 90 percent of the level expected from the pretest trends. Also, continue to take physical water level measurements periodically during recovery. Once the recovery period is ended, take a physical water level measurement in each well at the end of the test. Enter the measurements and times on the appropriate form.
- The project work plans may require additional depth to water measurements to be physically taken following complete well recovery in order to monitor post test trends in water level. The project work plans will specify the frequency of measurements, and the length of time that the measurements must be taken.
- The data should be reviewed in the field to help ensure the validity of the test. Complete all documentation on the appropriate form as outlined in the project work plans.
- Once the pump test is satisfactorily completed for the wells, the downhole equipment may be removed and the wellheads secured.

FIELD DOCUMENTATION

At minimum, flow testing information will be documented on a Flow Test Field Data form and in the field logbook. Both documents will be completed in the field at the time of flow testing. All entries will be legible and recorded in indelible black ink.

Changes or corrections on any project documentation will be made by lining through the erroneous entry and dating and initialing (by the person performing the correction) the correction. The original entry, although erroneous, must remain legible. The new information will be written above the crossed-out entry. Corrections must be written clearly and legibly with indelible ink.

Flow Test Field Data

The following items will be recorded on the Flow Test Field Data form:

- Project Name
- Project Location
- Project Number (OHM)
- Date
- Observers
- Pumping Well
- Observation Well
- Type of Test
- Measuring Point
- Measuring Point Elevation
- Radial Distance to Pumping Well
- Static Water Level
- Discharge Rate
- Water Level Measurement Method
- Discharge Measurement Method
- Start Time of Test
- End Time of Test
- Duration of Test
- Elapsed Time Since Pumping Started
- Elapsed Time Since Pumping Stopped
- Depth to the Water Level
- Drawdown or Recovery of the Water Level
- Comments.

Field Logbook

A permanently bound field logbook with consecutively pre-numbered pages will be assigned to this project. All entries will be recorded in indelible black ink. Corrections will be made by lining through erroneous data with a single line,

dating, and initialing the correction. At the end of each workday, the logbook pages will be signed by the responsible sampler and any unused portions of logbook pages will be crossed out, signed, and dated.

If it is necessary to transfer the logbook to another person, the person relinquishing the logbook will sign and date the last page used, and the person receiving the logbook will sign and date the next page to be used.

At minimum, the logbook will contain the following information:

- Project name and location;
- Date and time;
- Personnel in attendance;
- General weather information;
- Work performed;
- Field observations;
- Flow testing performed, including well tested, type of test performed, start time of test, end time of test, test duration;
- Instruments used during flow testing and instrument checks, including problems, and calibration records;
- Descriptions of deviations from Flow Testing Procedures;
- Problems encountered and corrective action taken;
- QC activities;
- Verbal or written instructions; and
- Any other events that could affect the flow tests.

Appendix B
BES Batch Discharge
Authorization Application

ENVIRONMENTAL SERVICES
CITY OF PORTLAND

BATCH DISCHARGE AUTHORIZATION APPLICATION

Batch Discharge Number:

_____ -- _____
(For City use only)

Date of Request: _____

Requested by:

Contact Name: _____

Company Name: _____

Company Address: _____

City: _____ State: _____ Zip: _____

Telephone: _____ Cellular: _____

Facsimile: _____ Pager: _____

Email Address: _____

Waste Generator:

Facility Name: _____

Facility Address: _____

City: _____ State: _____ Zip: _____

Facility Contact: _____ Telephone: _____

Description of Discharge (attach analytical data report if applicable): _____

_____

Proposed Date(s) of Discharge: _____

Discharge Volume: _____ gallons Requested Rate of Discharge: _____ gallons per minute

Building Permit/City Project Number: _____

City of Portland Project Manager (if applicable): _____

Proposed point of disposal (attach diagram): _____

_____

_____ _____
Signature Date

APPENDIX G3

DOANE LAKE MEMORANDUM

February 25, 2010

Mr. David Lacey
Oregon Department of Environmental Quality
Northwest Region
2020 Southwest 4th Avenue, Suite 400
Portland, Oregon 97201-4987

Subject: Review and Evaluation of Historical Source Information and Assessment of Historical Connections to Doane Lake, Doane Creek, and Saltzman Creek
Former Rhône Poulenc Portland Site
ECSI Nos. 36 and 155

Dear David,

This letter provides a summary of Legacy Site Services' (LSS) review of historical documents, maps, and photos that relate to historical manufacturing operations and disposal practices at the Rhône Poulenc site. LSS, agent for Arkema Inc., is submitting this information for several reasons:

- After review of the additional information provided herein, LSS is concerned that Rhône Poulenc has not adequately investigated all of their source areas and related transport pathways, including former surface water pathways to the river (other than HDD and LADD). There are many other transport pathways (e.g., Doane Creek and Saltzman Creek) and groundwater beneath the METRO and Air Liquide facilities through which Rhône Poulenc chemicals have migrated.

- LSS is also concerned that not all chemicals of interest (COIs) generated by the many herbicide, pesticide, and other chemical manufacturing processes that were conducted at the site for approximately 50 years have been adequately investigated. The absence of a full and complete investigation of the chemicals generated by Rhône Poulenc leaves substantial uncertainty in any conclusions drawn from the remedial investigations and source control measures being considered for the Rhône Poulenc site.

- Finally, LSS is concerned that many of the areas where waste disposal occurred (as documented in DEQ file and other historical document sources) have not been adequately located or investigated. Some disposal practices, both on and off the Rhône Poulenc site, are documented; however, many of the disposal practices especially in the first 20-30 years of manufacturing, including the southern portions of the Rhône Poulenc facility appear to have been left largely unexplored. These uninvestigated source areas may pose a serious threat to

Legacy Site Services LLC
468 Thomas Jones Way
Exton, PA 19341-2528
Tel: 610 594-4421

human health and the environment and could be a continuing long term source of contamination to the Willamette River and/or downgradient properties.

LSS hopes that that the information provided in this letter will provide summaries of source areas, COIs, and disposal practices and likely COI pathways that will aid DEQ in the resolution of issues as summarized above. This information will also aid the Department of Environmental Quality (DEQ) in the review and assessment of the groundwater source control evaluation being conducted by Starlink Logistics for the Rhône Poulenc site. A final reason for LSS' review is recent assertions by Oregon DEQ and the U.S. Environmental Protection Agency (USEPA) that certain chemicals that are presently detected in buried sediments in the Willamette River adjacent to and immediately downstream of the Arkema Portland site, a depositional area, are related to historical practices and sources on the Arkema facility. LSS has investigated the likely sources of some of these chemicals (e.g., insecticides and herbicides such as aldrin and lindane [gamma-hexachlorocyclohexane], and dioxins) and have concluded that the likely sources of some of these and other chemicals are from historical discharges from Rhône Poulenc via Saltzman Creek, Doane Lake, Doane Creek and/or Rhône Poulenc's former outfalls.

Some of the information provided in this letter is critical to the understanding of the Rhône Poulenc site conceptual model and, in particular, its relevance to the historical and/or ongoing transport and disposition of Rhône Poulenc chemicals in soil, groundwater, stormwater, and Willamette River surface water and sediments. This review focuses on historical information that illuminates the historical processes and pathways that have allowed for the transport of Rhône Poulenc chemicals to the Willamette River, via various connections including Doane Lake, Doane Creek, historic Rhône Poulenc outfalls, Outfall 22B, and Saltzman Creek. Based on this review, there is extensive documentation on known direct discharge of Rhône Poulenc wastes to Doane Lake and to the Willamette River north of the Rhône Poulenc facility, as well as other evidence that Rhône Poulenc wastes may have been either discharged directly or spilled and transported to the Willamette River via Saltzman Creek south of the Rhône Poulenc facility, where the earliest records indicate production of pesticides and herbicides were initiated on the Rhône Poulenc Site.

This comprehensive review draws upon an extensive amount of historical information that was available from the following sources:

- DEQ cleanup and water quality files for the Rhone-Poulenc site (ECSI No. 155), including archived DEQ files and some files originally designated as "lost" by DEQ but later recovered by DEQ from their archives.

- DEQ cleanup files for the Doane Lake site (ECSI No. 36).

- DEQ fact sheet for the Alkali Lake Chemical Waste Disposal site (ESCI No. 291).

- Historical aerial photos, including both plan view and oblique photos, of the area in the vicinity of the Rhône Poulenc site, Doane Lake, and Saltzman Creek dating

from 1923 through 1983. Aerial photos were obtained from both private and public sources.

- Willamette river sediment data that were summarized in the Arkema revised draft EE/CA work plan (Integral 2006).

- Historical City of Portland as-built storm-sewer maps obtained from Portlandmaps.com.

- Historical United States Geologic Survey (USGS) topographic maps obtained from Environmental Data Resources Inc. (EDR) and the U.S. Geological Survey.

- Sanborn maps obtained from EDR.

- Reports on sediment and stormwater sampling of the Front Avenue sewer (AMEC 2005 and 2009b; City of Portland 2009a).

- An article from the Oregon Historical Quarterly regarding the early days of regulating pollution in Oregon, published by the Oregon Historical Society (Carter 2006).

Documents cited in this letter are listed in Attachment A. Complete copies of selected cited references, as identified in the letter, are provided in Attachment B. Selected historical aerial photos, topographic maps, sewer maps, and Sanborn maps are provided in Attachment C.

The remainder of this letter summarizes:

- Historical Rhône Poulenc chemical handling and waste generation and disposal practices, including a description of the historical site layout, and waste disposal practices from 1943 through the mid 1990s.

- A description of the historical connections between Rhône Poulenc and the Willamette River via Doane Lake and Doane Creek, including information from aerial photos.

- A summary of recent sampling completed by the City of Portland in the Front Avenue stormwater conveyance system (Outfall 22B) from locations upgradient of Arkema and downgradient of the Rhône Poulenc site.

- A description of the historical connections between Rhône Poulenc and the Willamette River via Saltzman Creek, including information from aerial photos, historic topographic maps, and current and historical City of Portland sewer maps.

Historical Rhône Poulenc Processes and Waste Generation and Historical Disposal Practices

DEQ files do not provide a comprehensive description of the Rhône Poulenc waste generation and handling activities. However, based on the limited historical information from DEQ files a brief summary of selected historical waste generation and handling activities that are documented for the Rhône Poulenc Portland site is provided below.

Rhône Poulenc (historically known as Chipman Chemical and Rhodia Inc.) manufactured and formulated herbicides and insecticides (pesticides) from 1943 to 1990 (Integral et al. 2009). A 1957 Chipman Chemical Catalogue obtained from DEQ's files (Chipman Chemical Company 1957; Attachment B) identifies chemicals that were manufactured by Chipman at that time. Manufactured chemicals identified in the catalogue included insecticides (e.g., Aldrin, Chlordane, Dieldrin, DDT, and lead arsenate), herbicides (e.g., 2,4-D, 2,4,5-T, and a mixture of 2,4-D and 2,4,5-T [also known as Agent Orange]), as well as many others.

The production of Agent Orange and its two active ingredients, 2,4-D and 2,4,5-T, are known to contain high levels of dioxins (particularly highly toxic 2,3,7,8-TCDD) and furans, not only in the commercial product, but also in their associated wastes. The manufacture of 2,4,5-T was suspected to have exposed Rhône Poulenc workers to dioxins (particularly 2,3,7,8-TCDD) and was the subject of an investigation by the National Institute of Occupational Safety and Health (NIOSH) in 1982 (Fingerhut and Blade 1982; Attachment B). Approximately 608,000 lbs of 2,4,5-T was manufactured from 1960 to 1963 in the 2,4-D Plant. The employees working in the 2,4-D Plant during the time period February 1961 and December 1962 were recommended to be added to the NIOSH dioxin registry (Fingerhut and Blade 1982; Attachment B).
An article written by Oregon State Sanitary Authority (OSSA) pioneer Glen D. Carter states that "The company [Chipman Chemical] – located on the west bank of the Willamette near the old Spokane, Portland, and Seattle Railroad bridge – had greatly increased its production [of herbicides] to accommodate the U.S. military, which was then applying millions of gallons of herbicides in Vietnam to defoliate the jungle. The increase in production resulted in a corresponding increase in the company's waste discharges" (Carter 2006; Attachment B). Carter also stated in the article that "the continued production of herbicides for the Vietnam War was a matter of national security, OSSA allowed Chipman Chemical Company to continue operations, but ordered them to work toward ameliorating the water pollution". A 1969 Sanborn map indicates that the Chipman facility operated 24 hours per day in the late 1960s, apparently to keep up with demand from the U.S. military for the Vietnam War effort (see Sanborn map in Attachment C). Wastes at this time were either discharged to Doane Lake or directly to the Willamette River via a 6-inch outfall (DEQ No date; Attachment B). It was also during these high 24 hr per day production periods that the frequent reporting of tainted fish in the Willamette River was occurring (see further discussion about tainted fish in the *Rhône Poulenc wastes in the 1960s* section below). Unfortunately, at that time dioxin and furan testing was not completed.

According to Rhône Poulenc, the 2,4-D Plant was built and operations were started without pollution control equipment (Rhône Poulenc 1987, Attachment B). During the time period from 1966 to 1971, approximately 25,000 drums of pesticide wastes generated by Rhône Poulenc were disposed of at the Alkali Lake Chemical Waste Disposal Site (ESCI No. 291; DEQ 2007,

Attachment B). The waste products were mostly distillation residues from the production of 2,4-D, 2,4-dichlorophenol, and 2-methyl-4-chlorophenoxyacetic acid (MCPA). The DEQ fact sheet for the Alkali Lake site states that all of these chemicals contain dioxins (DEQ 2007; Attachment B).

In general, little information is available that provides the volume of product or waste generated. However, in a 1990 DEQ memorandum, a former Rhône Poulenc employee stated that "In the '50s until '65, 16-18 tons of DDT per day was made in the dust plant. Volume-wise, DDT was the biggest product" (DEQ 1990; Attachment B). A 1983 report submitted by Rhone Poulenc to NIOSH as part of the NIOSH Dioxin Registry indicates that from 1963-1982 approximately 221,794,000 lbs of 2,4-D acid was produced for use in the various 2,4-D products. From 1966-1976, 22,886,000 lbs of MCPA was also produced for use in the production of the Chiptox brand herbicide (Fingerhut and Blade 1982; Attachment B). According to Rhône Poulenc, insecticide manufacturing ceased at the site in 1969, whereas herbicide manufacturing continued until the plant closed in 1990 (Integral et al. 2009).

Site Layout

A 1979 site map from DEQ files[1] shows the Rhône Poulenc site layout including the location of buildings, process and storage areas, mixing tanks, and rail access (1979 Rhône Poulenc plant layout map; Attachment C). The site map shows that the manufacturing processes were primarily located in the northern two-thirds of the site, during this period, and that there were more than four dozen storage and mixing tanks located throughout the site. Site access for vehicles was by either a driveway directly to NW St. Helens Road on the west, or to Front Avenue at the southern end of the site. Three main rail spurs are also shown entering the site from the south. The site access shown on the 1979 map is essentially unchanged from 1957 as shown on an oblique aerial photo from that period (1957 aerial photo; Attachment C). A 1965 site map shows the location of the insecticide plant and drainage to a dry well near the southern property boundary (1965 Rhône Poulenc plant layout map; Attachment C). In 1965, the insecticide plant was located in the building labeled "warehouse" on the 1979 plant layout map.

Sanborn maps show the historical site layout in 1950 and 1969 (Attachment C). The 1950 Sanborn map shows four buildings located on the facility, a warehouse south of the entry driveway off of NW St. Helens Road, a combination office/lab/warehouse facility building in the same location as the office (1979 Rhône Poulenc plant layout map), a small chemical mixing building located east of the office building and where the laboratory building is shown in the 1979 map, and a combination warehouse and mixing room building located where the storage building is north of the office (1979 Rhône Poulenc plant layout map). An elevated liquid spray tank is also shown on the 1950 map immediately north of the combination office/lab/warehouse building.

The Sanborn maps show a much more expanded facility in 1969 in a layout that is very similar to the 1979 Rhône Poulenc plant layout map. Many more production facilities and tanks are identified in the 1969 map. Facility descriptions on the Sanborn map include: shop, lab, pipe

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[1] Received by DEQ Water Quality Control on November 12, 1982

rack, equipment warehouse and service building, offices, lunch room, steel grating, chemical manufacturing, chemical storage, chemical mixing, an esterfying plant, multiple chemical tanks and boilers, tanks, and drum storage. The 1969 Sanborn map also noted that the plant operated 24 hours, presumably to keep up with the demands for Agent Orange production at that time.

United States Geologic Survey (USGS) topographic quadrangle maps also show the facility expansion in the northern portion of the site between 1961 and 1970 (see the new buildings depicted in red on the 1970 topographic map; Attachment C).

Chemical Waste Streams

Waste streams are documented in various DEQ records that date back to the early 1960s. LSS did not find records prior to 1963 in DEQ files; therefore the first 20 years of waste generation and disposal activities are not documented in this letter. One of the earliest DEQ file documents on Rhône Poulenc wastes is an August 19, 1963 Oregon Sate Board of Health (OSBH) memorandum authored by EJW, that describes a request from Chipman chemical to inject "their liquid waste effluents by deep well injection into the salt water aquifer" (OSBH 1963; Attachment B). There is no indication that Chipman Chemical ever followed through with this request or assessment of its feasibility; however, the memorandum indicates that Chipman Chemical was exploring ways to handle liquid waste disposal at that time. The memo also indicates that Rhône Poulenc was operating an MCP process and was obtaining data on the effluent from the process for OSBH.

Rhône Poulenc Wastes from 1943 to 1963

No documentation of Rhône Poulenc wastes streams or discharges prior to 1963 were provided in DEQ files. Aerial photographs, however, show the Rhône Poulenc operations through this time period. Based on DEQ file information, it is assumed that Rhône Poulenc waste discharges were directed to West Doane Lake and that West Doane Lake discharges to the Willamette River, via various pathways, occurred during this time frame, just as it did in subsequent periods (i.e., the 1960s, 1970s, 1980s, etc.).

Rhône Poulenc Wastes in the 1960s

Throughout the mid to late 1960s, during the peak of their Agent Orange production, Rhône Poulenc attempted to address discharges of phenolic wastes that were causing "bad chemical tastes" in salmon and other fish caught in the lower Willamette River and Multnomah Channel. The earliest memorandum from DEQ's file that addresses this issue is dated March 16, 1965 (OSBH 1965; Attachment B). The OSBH memo simply documents a "complaint on the taste of two spring Chinooks caught in the vicinity of Gray's Moorage near the head of Sauvies Island." The taste of the fish was described as "medicinal" and the memo notes that it is "probably the first complaint we have received on tainted fish this year." This last statement indicates that complaints about tainted fish in the Willamette River had evidently occurred prior to 1965. LSS requested from DEQ, but did not obtain, any earlier records on the Willamette River fish taste issue from DEQ's file.

Two Oregonian articles from spring 1965 also mention the contaminated Willamette River fish (The Oregonian 1965a and 1965b; Attachment B). The April 6, 1965 article states that "more than 100 complaints of a medicinal taste and smell from these fish have been received by the

sanitary authority, state fish and game commissions and US Public Health Service." The article also mentions that some of the fish samples were tested at the US Public Health Service laboratory in Cincinnati. At that time, the source of the chemical was not known.

By August 1965, the source of the tainted fish had been established as the Chipman Chemical plant along the Willamette River. In an October 26, 1965 letter from Ely J. Weathersbee, Deputy State Sanitary Engineer, to R. F. Gitschlag of Chipman Chemical, Chipman Chemical is given notice that it must comply with an August 26 action of the OSSA which established a March 1, 1966 deadline by which "the liquid effluents from your Portland, Oregon, plant and Doane Lake must be adequately treated or disposed of in a manner so as not to cause objectionable tastes and odors in fish" (Weathersbee 1965; Attachment B). The letter indicates that OSSA was expecting a letter from Chipman Chemical that among other things identifies: "Facilities and procedure for pumping out Doane Lake," and "Proposed changes in 2-4-D plant to further reduce waste concentrations." According to the OSSA letter, improvements to the fish taste problem were to be gained by changes in the MCPA plant and process and "by pumping out or neutralizing the fish tainting effects of the large inventory of waste waters in Doane Lake."

A July 14, 1966 letter from Kenneth H. Spies, State Sanitary Engineer, to Mr. Gitschlag conditionally approves the plan for a new MCPA/MCPP plant submitted by Chipman Chemical in June 1966 (Spies 1966; Attachment B). Among the conditions for approval are that,

- "Discharge of liquid effluents from your plant to the Willamette River is considered by our office to be temporary until a municipal sewer is available in the area."

- "A considerable quantity of water containing DCP [dichlorophenol] is still contained in Doane Lake. Not only does this present a potential source material that may, under low flow conditions, produce off-flavors in fish; but it also contributes to the odor problem in the local area."

- "Monitoring for O-cresol and DCM [dichloromethane] in the plant area shall be done on a continual basis. In addition, monitoring of the proposed incinerator facility and all odor and abatement equipment shall be continually accomplished in order to maintain them in an effective and efficient operating condition."

An August 31, 1967 OSBH memorandum documents discharges of Chipman Chemical water from Morgan Creek (currently referred to as Doane Creek) to the Willamette River (OSHB 1967; Attachment B). Based on the description in the OSBH memorandum, Doane Creek is the drainage from the north side of the railroad embankment to the Willamette River. The memorandum states that "I started at the mouth of the creek and followed it upstream to the point where it becomes a pond or lake of sorts. Up to this point the creek exhibited some foaming at points where it was getting aeration (small falls, etc.) and was rusty brown in appearance…. It appears the only source of water is seepage from Doane Lake across the railroad fill. There was very definite signs of this occurring all along the railroad side of the pond. Apparently because of the long dry spell any runoff, etc., has been drained away and the drainage to the river is

straight seepage from Doane Lake. This evidently accounts for the foaming and the strong odors."

In August 5, 1968, an OSBH memorandum documented additional complaints about tainted fish (OSBH 1968a; Attachment B). In addition, an August 23 memorandum documented that Dick Gitschlag of Rhodia Inc. Chipman Division stated to the OSBH that their effluent tests indicated that total phenol (which included DCP, TCDP, and cresol [dioxin/furan analysis was not conducted at this time]) was in the range of 20-25 mg/L (OSBH 1968b; Attachment B). By the end of December 1968, Mr. Gitschlag provided a plan for treating MCPA waste discharges which were identified as the primary contributors to the tainted fish taste issue in the river (Gitschlag 1968). In the letter, Mr. Gitschlag documented that concentrations of phenolic compounds had been reduced from 100-500 ppm, prior to the installation of a treatment system in February 1966, to 5-15 ppm. According to Mr. Gitschlag, this had reduced the complaints about tainted fish in the Willamette River to one complaint in 1968. In the December 1968 letter, Mr. Gitschlag's proposed a charcoal absorption system to absorb phenolics and other organic carbon. According to the letter the treatment system was going to be applied to the MCPA system wastes only because these wastes were found to be the biggest contributor to the fish taste problem. The plant was supposed to be completed by May 1969.

A May 6, 1969 Oregonian article (Holm 1969; Attachment B) documented another tainted fish caught in the river in April 1969 and DEQ memos from September 15 and 19 1969 (DEQ 1969a, 1969b; Attachment B) indicate that tainted fish were still being caught in the Willamette River at that time. The September 19, 1969 memo indicated that Rhodia's MCPA treatment system was still not online.

A document titled "Recollections of the 1966 Doane Lake (Chipman Chemical) Brouhaha" by Robert A. McHugh[2] (McHugh 1976) provides a synopsis of the tainted fish issues within the Willamette River. The memorandum is stamped as received by Oregon DEQ on March 24, 1976. A few key observations from the McHugh memo include:

- "DEQ installed live-boxes containing hatchery steelhead and rainbow trout of about two pounds each at sites from the Sellwood Bridge upstream to St. Helens downstream. Fish were removed for tasting every 24 hour period of exposure to the river water."

- "No tainted fish were ever found at the Sellwood Bridge (most upstream live-box) or at St. Helens. All fish in the three live-boxes in the Multnomah Channel were tainted, as were fishes exposed at the Corps of Engineers dock and at a fire-boat dock in lower Portland Harbor."

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[2] Robert McHugh is identified by Glen Carter in an article titled "Pioneering Water Pollution Control in Oregon" (Carter 2006) as an OSAA biologist. The OSAA was the forerunner to the DEQ, which was established in 1969.

- "Doane Lake received a variety of materials from Chipman Chemical, mostly 2,4-D and materials used in its manufacture. The company had a large order from the U.S. government for defoliants to be used in the Viet Nam War, then in progress. The lake itself was a black, stinking mass of chemical wastes, some of which had doubtless interacted within the lake. DEQ analysis of river water were (sic) for phenol, a probable constituent of many if not all of these wastes."

- "The Northern end of Doane Lake was blocked by a rock railway embankment. It was through this rock fill that material from the lake leaked into a small creek, which emptied into the Willamette River. As the river is tidal at this point, the tainting materials spread for some distance upstream as well as downstream."

It is clear from this partially documented history that Rhône Poulenc waste chemicals were discharging continuously to Doane Lake, which, at that time, either drained directly to the Willamette River through the Historical Drainage Ditch or via seepage through the railroad track embankment to Doane Creek throughout the 1960s. According to the file records, the direct discharges occurred at a minimum from 1963 through the 1960s and continued into the 1970s even after water treatment was added as discussed below. Despite the fact that these wastes were in part from their Agent Orange component processes, no dioxin and furan analysis was performed at that time.

Rhône Poulenc Wastes in the 1970s to 1995

An undated Public Notice and Fact Sheet (Application No. 071-OYA-2-000314) from DEQ files presents information on the status of Rhône Poulenc discharges to the Willamette River in the late 1960s and early to mid-1970s (DEQ no date; Attachment B). In the Description of Facility and Discharge section the notice states that "In November 1969 Rhodia completed installation of two carbon absorption/filtration units with lime neutralization for removal of phenols, cresols and product related molecules from waste waters. The company has two waste streams. The total combined flow averages 0.129 MGD (0.193 cfs). The existing outfall line has become inoperative so that both streams flow to what remains of Doane Lake and overflows to the Willamette River." This notice indicates that at that time, Rhône Poulenc was discharging approximately 85-90 gallons per minute, of waste to Doane Lake, which then discharged to the Willamette River.

The public notice indicated the plant had the following effluent concentrations at the time of the public notice:

- phenols (including chlorophenols) of 2.15 lbs/day

- cholorophenols (including chlorocresols) of 1.07 lbs/day

- Total chlorinated hydrocarbons of 22.0 lbs/day

- Chemical oxygen demand (COD) of 1,800 lbs/day

- Total suspended solids (TSS) of 260 lbs/day, and

- Total dissolved solids (TDS) of 46,000 lbs/day.

The proposed permit required the "installation of a treated waste outfall line and diffuser in the Willamette River by September 1, 1974" and to "upgrade waste treatment and take other measures to achieve effluent limits required after April 1, 1976". The permit notice also specifies that the mixing zone for the Willamette River discharge will be allowed and will be 25 ft upstream, 50 ft on either side, and 100 ft downstream of the diffuser. Despite the fact that these wastes were in part from their Agent Orange process and the link between Agent Orange and dioxin/furans had been established, no dioxin/furan analysis was performed at that time.

Other DEQ files, and submissions to the EPA document various spills or waste handling activities at the Rhône Poulenc site. A synopsis of selected documented activities of note is provided below. Some of the drum disposal practices described below have recently been confirmed by a magnetic survey and test pit investigation and drum removal activities conducted in 2007 and 2008 (AMEC 2009a).

- An interoffice memo documented interviews of Dick Forney and Don Beckle, who were former Rhône Poulenc employees (DEQ 1990; Attachment B). Dick Forney was a truck driver at the Rhône Poulenc plant and Don Beckle was the foreman at the dust (insecticide) plant from 1951 until the early 1970s. Don Beckle worked in the shipping department from the early 1970s until he retired in November 1982. The memo documented a number of disposal practices that are summarized below.

    - A pit in the yard behind the dust plant was open for a couple of weeks and received 2-3 tons of bad batches of Parathion, Heptachlor, empty Parathion drums, Ag Rocks (a mercury product), and Mergamma, also a mercury product, and talc used to clean out the containers.

    - Most of the waste water from the dust (insecticide plant) drained into a ditch which drained into the "lake" behind the dust plant on the Rhône Poulenc property. The memo also states that "the ditch frequently "ran red" from the dye used to mark mercury products".

    - Drums are buried beneath the waste water treatment plant and all over the undeveloped portion of the plant [see AMEC 2009a for recent drum removal activities in this portion of the plant]. Chlordane and parathion are buried in what is now the northwest corner of the wastewater treatment plant.

    - During the early 70s, an attempt was made to pump Doane Lake dry. An 8" pipe was run from the lake to the river and the lake was pumped and discharged to the river. The memo states that normally a ditch ran from the lake to the river [likely the Historical Drainage Ditch].

- A pit was dug behind the office to mix DCP bleed with water so it could be re-barreled and shipped to Alkali Lake. The pit was 18-20 ft deep and lined with metal [Sandra Anderson, the DEQ project manager for the Rhône Poulenc site, speculated that this may have been the "underground storage tank" that is labeled on some of the plant diagrams]. The DCP bleed, which was eventually sent to Alkali Lake (one of Rhône Poulenc's largest Agent Orange component and dioxin/furan hazardous waste site in Oregon), was stored in 33 tank cars on the Linton Spur toward Scappoose. Some of the tank cars leaked.

- A submission to the EPA documenting spill information for a variety of chemicals from 1958 to 1985 (Ferguson 1983; Attachment B). The document details the material spilled, the location of the spill, and comments about the spill. Examples include:

  - A 1969 spill of 50,000 lbs of 2,4-D ester mixture containing approximately 10,000 lbs of 2,4-D.

  - A 1958 spill of 4,000 lbs of 2,4-D.

  - Two spills in March 1976 of phenolics and O-cresol.
  - A 1975 spill of 2,000 gallons of 2,4-D ester which overflowed from the storage tank. Only 320 gallons of this material was recovered.

- A memo documented interviews of three long-time employees with Rhône Poulenc by Sandra Anderson of DEQ (Anderson 1990; Attachment B). The names of the employees interviewed were not included in the memo. The memo documented a number of spills and disposal practices that are summarized below.

  - Aldrin, Malathion, DDT, Parathion, Toxaphene, mercury products, Chlordane, Heptachlor, and Dieldrin were formulated in the insecticide plant (also referred to as the dust plant).These insecticides were manufactured in a 400 gallon tank, which needed to be cleaned between batches to avoid contamination. The water used to wash the tank drained to the soil beneath the building. The tank was considered clean when the water ran clean. The memo states that "Enough water collected at times to give the appearance of a waist-high lake." Mineral spirits were also run through the tank and then discharged to the ground beneath the building. The water discharged from the insecticide plant followed a natural drainage along the railroad spur to the yard behind the plant where it ran into a pit dug to receive the excess water.

  - Open barrels containing DCP caustic were buried in the insecticide plant yard, likely west of the railroad spur. The memo also noted that

insecticides and the contents from four condensation tanks from the 2,4-D plant were also buried in the insecticide plant yard.

- There were spills and overfills associated with unloading tank cars containing bleed DCP. The drums that were filled with the bleed DCP were stacked on pallets without containment while filling.

- Drains in the floor of the 2,4-D building discharged directly to Doane Lake through an open ditch off the north end of the building [presently referred to as the Lake Area Drainage Ditch]. The interviewees mentioned a number of spills that went to the lake including 2,500 gallons of 2,4-D slurry and DCP.

- Spills from the 2,4,5-T in the ester room also drained to the lake through the same ditch as the 2,4-D building.

- In the formulation area north of the maintenance building, Tank 15 released a mixture of 2,4-D and 2,4,5-T [likely Agent Orange] that flowed to a low-lying area along the fence with Kirk Battery and then toward the lake. All spills in the formulation area drained along this path. Near Tank 15, a railcar full of 2,4,5-T ester tech spilled when the railroad inadvertently dragged the car down the tracks as it was being emptied. The ester drained along the same path mentioned above.

- The 2,4-DB and the early experimental MCPA plant buildings were built on a gravel base. In the 1950s, very cold temperatures resulted in frozen pipes and many spills.

- On the railroad tracks near the office, 2,4-D isobutyl ester tech boiled over and spilled from a tank car.

- In the late 1960s, 3,000 to 4,000 gallons of MCPA (fall-out batches) were discharged to Doane Lake at irregular intervals. A gate allowed the lake to discharge to the Willamette River.

- The 2,4-DB plant and the MCPA plant were combined and spills and wash/rinse water drained into a sump in the floor about 7-8 ft deep. The sump was to be pumped to the 2,4-D plant, but the sump leaked so much for many months in the late 1960s or early 1970s that there was insufficient water in the sump to pump it out. The sump would have contained 2,4-DB, MCPA, tars, creosol, and other materials used in the two plants.

- Thousands of drums containing bleeds and insecticides were stacked along the north and east boundaries of the property in the late 1960s or early 1970s. The drums were in bad shape and rusty before they were removed.

Some of the drums were buried in Doane Lake and in the vicinity of the waste water treatment plant [see AMEC 2009a for recent drum removal activities in this portion of the plant].

- Crushed barrels and insecticides were dumped intermittently to Doane Lake in the 1960s and prior to 1974. In some instances the lake was filled in and then holes were dug and the wastes buried. Other times the metal barrels were dumped into the lake and the lake was filled over the barrels [see AMEC 2009 for recent drum removal activities in this portion of the plant]. Thousands of drums may have been disposed of in this fashion.

- Rhône Poulenc used City water to flush lines and tanks. The water lines were connected directly to the process lines. One time in approximately 1970, chemicals in the process lines back-flushed into the city water lines in the buildings that supplied drinking water.

- A number of other spills are mentioned in the memorandum, but are not summarized in this list (see Attachment B).

- An interoffice memo documented a spill of 2,4-D butyl ester on January 27, 1982 (DEQ 1982). Approximately 139 gallons were spilled when a rail car tank was overfilled. Some of the material went into a storm drain and solidified. The memo stated that "Rhône Poulenc thinks they cleaned up the majority of the spill."

- A DEQ memo documented the release of approximately 20-50 gallons 2,4-D iso-octyl ester on June 17, 1982 (Clinton 1982). The release occurred when the tank of a truck cracked when loading the 2,4-D. The 2,4-D was spilled on concrete, but some spilled on the railroad tracks. Bob Briggs from Rhône Poulenc reported the release and indicated that the soil would be removed from the railroad track area.

- A letter from DEQ dated January 27, 1995 documented a total of six hazardous waste violations at the Rhône Poulenc facility (Christiansen 1995; Attachment B).

Drainages and Connections from Rhône Poulenc to the Willamette River via Doane Lake and Doane Creek

DEQ's Rhône Poulenc file has extensive information on the connection from the Rhône Poulenc site to Doane Lake and the Willamette River. Because of the topography at the site, drainage from operations on the northern end of the facility naturally drained to Doane Lake. In addition Rhône Poulenc had documented discharges to Doane Lake as identified in DEQ files (see previous section of this letter for selected summary).

The most direct documentation of the Rhône Poulenc to Willamette River connection via Doane Lake is from the review of the extensive documentation from the 1960s that indicated Chipman

Chemical's wastes were tainting migratory fish that were passing through the Willamette River during this period. Based on this documentation alone, Rhône Poulenc waste streams were discharging to the River near the Burlington Northern RR bridge and impacting fish downstream, past the Corps of Engineers Dock, and in Multnomah Channel adjacent to Sauvie Island at least 4 miles downstream of Rhône Poulenc. The connection from Doane Lake was described by Robert McHugh as seepage through the railroad embankment and discharge from the outlet stream to the river. This is likely the same drainage that was described as discharging Rhône Poulenc wastes to the river in an August 31, 1967 OSBH memo (OSBH 1967; Attachment B). In an April 1, 1971 memorandum Roger Sherwood from DEQ stated that "Their plant [Chipman Chemical] drainage is still going into Doane Lake with seepage to Morgan [Doane] Creek[3] and the River. We need to evaluate this seepage problem" (DEQ 1971; Attachment B).

Discharges to the Willamette River prior to 1963 are not documented; however a map accompanying the DEQ Public Notice for the NPDES permit shows an "Exist. 6 Outfall Line (inoperative)" that extends directly from the Chipman Chemical Company site to the Willamette River (DEQ no date; Attachment B). The figure is dated October 7, 1965, so it is likely that this outfall line was used to discharge wastes to the Willamette River sometime prior to the 1960s, during the first two decades of operation of the Rhône Poulenc (then Chipman Chemical) plant. In addition, untreated waste streams were discharged from the Rhône Poulenc site through the Lake Area Drainage Ditch[4] to West Doane Lake. During storm events, water with untreated waste streams from West Doane Lake was discharged directly to the Willamette River through the Historic Drainage Ditch[5] (Figure 1a). The discharge of chemical waste streams would have been consistent with the historical use of the Willamette River as an industrial sewer as documented in the article by Glen Carter, an early OSAA employee (Carter 2006, Attachment B).

Based on the NPDES permit application, discharge from Rhône Poulenc operations was still allowed at least through the mid- to late 1970s, and even though the water was being "treated", based on the discharge limits provided in the permit, a substantial flux of Rhône Poulenc waste material was still directly entering the Willamette river through this period. It is not known if Rhône Poulenc ever discharged effluent waters to the Guilds Lake Interceptor sewer line, but a report indicates they were looking into the possibility of connecting to this sewer line in 1975 (Bryan M. Johnson and Associates 1975). The Guilds Lake Interceptor sewer line was

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[3] Doane Creek was referred to as Morgan Creek in memos from DEQ and OSBH (DEQ 1971 and OSBH 1967; Attachment B). The current nomenclature for this drainage is Doane Creek (see 2009 City of Portland Doane Lake map, Attachment C).

[4] The term "Lake Area Drainage Ditch" has been used in a number of recent documents produced by AMEC for the Rhône Poulenc site (e.g., AMEC 2009c).

[5] The term "Historic Drainage Ditch" has been used in a number of recent documents produced by AMEC for the Rhône Poulenc site (e.g., AMEC 2009c).

completed in about 1969 and pumps sewage through pipes beneath the Willamette River to the Columbia Boulevard Treatment Plant (Bryan M. Johnson and Associates 1975).

Aerial Photographs

Aerial and oblique aerial photographs were reviewed from 1923 to 1983. The information from these photographs was used to prepare figures that present the historical drainage/effluent water pathways from the Rhône Poulenc facility to the Willamette River through West Doane Lake, North Doane Lake, and Doane Creek from 1943 to present (Figures 1a through 1f).

Figure 1a presents the historical drainage pattern from 1943 through 1947. Beginning in approximately 1943, untreated waste streams from the Rhône Poulenc site were discharged to West Doane Lake through the Lake Area Drainage Ditch and seeped through the BNRR track ballast into North Doane Lake. North Doane Lake drained through a small tributary into Doane Creek, which discharged to the Willamette River near the boundary between the Gasco and Siltronic sites (Figure 1a). During storm events, water with untreated waste streams from West Doane Lake was discharged directly to the Willamette River through the Historic Drainage Ditch, located just south of and parallel to the BNRR tracks (Figure 1a).

The general interpretation of flow paths observed from the aerial photos described above is confirmed by a 1964 map from the DEQ file for the Rhône Poulenc site (1964 Doane Lake drainage map; Attachment C) and by historical topographic maps (Appendix C). Seepage through the BNRR ballast is documented in the 1964 map and by observations from DEQ and OSBH personnel in two separate memoranda (DEQ 1971 and OSBH 1967; Attachment B).

Figure 1b presents the historical drainage patterns from 1948 to 1956. During this time interval the path of the main channel of Doane Creek had been straightened just downstream of St. Helens Road. The rest of the features are similar to those shown on Figure 1a. Figure 1C presents the historical drainage patterns from 1957 to 1964. The main channel of Doane Creek has been moved to the south, apparently a result of filling activities on the Siltronic site. During this time interval, West Doane Lake increased in size, likely due to filling near the present alignment of Front Avenue that raised the water level of the lake. The other drainage patterns are similar to the previous time periods.

Figure 1d presents the historical drainage patterns from 1965 to 1971. Doane Creek has been rerouted around the Siltronic site and through North Doane Lake. Active excavation of the new channel between North Doane Lake and the Willamette River (parallel to the BNRR tracks) is shown on the 1964 aerial photo presented in Attachment C. The footprint of North Doane Lake is significantly smaller than it is in Figure 1c as a result of being drained by the rerouted Doane Creek channel. The rerouting of Doane Creek through North Doane Lake also likely increased the flushing of contaminants in North Doane Lake to the Willamette River. According to Rhône Poulenc, the tainted Willamette River migratory fish issue in the mid to late 1960s was caused by the excavation of the ditch, which drained water from North Doane Lake and West Doane Lake (via seepage through railroad ballast) to the Willamette River (Rhône Poulenc 1987).

Between 1968 and 1969, the railroad spur that bends to the north from the Burlington Northern Railroad (BNRR) Bridge was constructed (see aerial photos from 1968 and 1969 in Attachment

C). This enclosed North Doane Lake as a triangle between the three railroad spurs. In the 1971 aerial photo, the Siltronic site was actively being filled with spoils from dredging activities adjacent to the site (Attachment C). Some water from the dredge spoils appears to be draining into Doane Creek. At the same time, rock mining activities were occurring near the channel of Doane Creek immediately west (upstream) of St. Helens Road.

Figure 1e presents the drainage patterns from 1972 to present. North Doane Lake has been confined to the area between the railroad spurs and the section of Doane Creek between North Doane Lake and the Willamette River has been routed through a culvert. The path of the culvert parallels the railroad tracks. Seepage from North Doane Lake through the railroad ballast is still likely discharging to the Willamette River through the open channel of Doane Creek, cracks/joints in the Doane Creek culvert, and through the fill material surrounding the culvert. Periodic discharge of West Doane Lake through the Historical Drainage Ditch reportedly ended in 1980 when an earthen berm was raised on the northwestern end of the lake (AMEC 2009c).

A composite of the drainage patterns from 1936 to present is shown on a recent (2007) aerial photograph in Figure 1f. The present configuration of Doane Creek is also presented in a map produced by the City of Portland (Attachment C), which was part of a National Resource Inventory Report (City of Portland 2009b).

Recent Rhône Poulenc Chemical Discharges through Outfall 22B

The City of Portland's Outfall 22B discharges to the Willamette River at the north end of Lot 1/Tract A at the Arkema site (Figure 2). Outfall 22B was installed in 1980. Stormwater along NW Front Avenue and 61st Street has discharged to the Willamette River through Outfall 22B from 1980 to present. Prior to 1980, stormwater from Front Avenue and 61st Street discharged to the Willamette River via Saltzman Creek (see the Saltzman Creek discussion below).

Groundwater plumes from the Rhône Poulenc site continue to infiltrate into the Outfall 22B stormwater system. A number of Rhône Poulenc's preliminary chemicals of potential concern (COPC) have historically been detected in Outfall 22B effluent samples, including 2,4-D, 2,4,5-T, 1,2-dichlorobenzene, 1,4-dichlorobenzene, and dioxins/furans (AMEC 2005, 2009b). This indicates that Rhône Poulenc chemicals continue to be discharged to the Willamette River through City of Portland's Outfall 22B.

City of Portland Front Avenue Sewer Sampling

In 2007-8, the City of Portland (City) collected stormwater solids (sediment) from inline samplers located in the sewer pipeline along Front Avenue (City of Portland 2009a). Sediment was collected from two locations at the upstream end of the Outfall 22B catchment, which represents sediment sources from the Air Liquide and Metro Waste Transfer facilities. Sample results detected various chemicals above Joint Source Control Strategy screening values including, PCBs, DDx, chlordane, dieldrin, and selected metals (i.e., cadmium, lead, and mercury). The sediment samples were not analyzed for chlorinated herbicides or dioxins/furans.

Based on these results, the City concluded that the detected chemicals were derived from the Metro and Air Liquide sites, which are both located immediately downgradient from the Rhône Poulenc site. According to the City's analysis, at least some of these chemicals are entering the

storm water drainage system as a result of migration of Rhône Poulenc chemicals in groundwater onto neighboring properties. This area of chemical migration is in the same general vicinity as the Saltzman Creek drainage along NW 61st Avenue on the southern end of the Rhône Poulenc, Metro, and Air Liquide sites. The presence of Rhône Poulenc chemicals in this Front Avenue storm drain location indicates that current and/or historical migration of Rhône Poulenc wastes into the storm drain system immediately adjacent to Saltzman Creek is also very likely. To LSS' knowledge, no direct sampling of any of the NW 61st Avenue vicinity storm drains has yet been conducted and, therefore, the actual impact of Rhône Poulenc chemicals on the Saltzman Creek drainage basin in this area has not been directly measured.

Doane Lake/Doane Creek Drainage Summary

The following is a summary of the documentation of discharges of Rhone Poulenc wastes to the Willamette River via direct discharge through outfalls, Doane Lake, and/or Doane Creek.

- Discharges to the Willamette River prior to 1963 are not well documented, but may have been through a 6-inch outfall line that is identified as extending directly from the Chipman Chemical Company site to the Willamette River.
- During the mid to late 1960s, extensive documentation describes the connection from Rhône Poulenc to Willamette River via Doane Lake and Doane Creek as evidenced by the Chipman Chemical wastes that were found to be tainting migratory fish that were passing through the lower Willamette River during this period.
    - From at least 1936 through 1980, West Doane Lake drained either directly to the Willamette River through the Historic Drainage Ditch or by seepage through railroad ballast and into North Doane Lake located on the north side of the BNRR tracks (Figures 1a through 1f). North Doane Lake drained into Doane Creek, which discharged to the Willamette River near the present Siltronic/Gasco site boundary (1936 to 1964) or the area immediately north of the BNSF railroad bridge (1964 to present; Figure 1f).
    - In 1964, a ditch was excavated to drain North Doane Lake on the north side of the BNSF railroad tracks and re-route Doane Creek (Figure 1d). This drainage ditch was approximately 8 ft wide and 6 ft deep and conveyed water from North Doane Lake to the Willamette River (Rhône Poulenc 1987). According to Rhône Poulenc, the tainted migratory fish issue in the mid to late 1960s was caused by the excavation of this ditch, which drained water from North Doane Lake to the Willamette River (Rhône Poulenc 1987).
    - Between 1968 and 1969, the railroad spur that bends to the north from the BNRR Bridge was constructed enclosing a triangular North Doane Lake. After this period, North Doane Lake continued to drain to Doane Creek and ultimately to the Willamette River by seepage through railroad ballast

into the open channel of Doane Creek, through cracks/joints in the Doane Creek culvert, and through fill material surrounding the culvert.

- Historical sampling of City of Portland Outfall 22B, which was installed in 1980, has shown detections of Rhône Poulenc chemicals in effluent discharging to the Willamette River (including 2-4-D, 2,4,5-T, 1,2-dichlorobenzene, 1,4-dichlorobenzene, and dioxins/furans; AMEC 2005, 2009b). Some of these Rhône Poulenc chemicals have been detected in sediment samples collected from the Willamette River in the vicinity of Outfall 22B.
- Recent sampling of sediment from two locations at the upstream end of the Outfall 22B catchment, representing Air Liquide and Metro Waste Transfer facilities detected various chemicals including, PCBs, DDx, chlordane, dieldrin, and selected metals (i.e., cadmium, lead, and mercury) above JSCS values. Sediment samples were not analyzed for chlorinated herbicides or dioxins/furans.

Drainages and Connections from Rhône Poulenc to the Willamette River via Saltzman Creek

There area number of lines of evidence that strongly suggest that Rhône Poulenc wastes also historically entered the Willamette River via Saltzman Creek. These lines of evidence include aerial photographs, historical topographic maps, City of Portland storm-sewer plans and as-built maps, City of Portland Outfall 22B chemical data, and chemical data and observations from drilling of sediments near and immediately downstream of the mouth of Saltzman Creek. Each of these lines of evidence is described further below. Figure 2 presents the drainages and sewer lines connecting Rhône Poulenc effluent wastes to the Willamette River through Saltzman Creek.

Aerial Photographs

A number of aerial photographs clearly show black water discharging into the Willamette River from Saltzman Creek from approximately 1951 to 1967 (see photos from 1951, 1955, 1959, 1961, and 1967 in Attachment C). The black water discharging from Saltzman Creek was observed from the lower reaches of Saltzman Creek to the Willamette River. The black water discharging from the creek is very distinct and has a color similar to that of Doane Lake in these same years. The water in Doane Lake was black from Rhône Poulenc's treated effluent waters that were discharged to the lake in the 1960s.

A portion of the Saltzman Creek channel just downstream of Front Avenue was filled between 1959 and 1961 (compare the 1959 and 1961 aerial photos in Attachment C). It is unknown where the fill materials were obtained or if the fill contained any chemicals of concern.

Topographic Maps

Historical USGS and United States Army Corps of Engineer (USACE) topographic maps from 1897, 1940, 1954, 1961, and 1970 were reviewed to determine how the drainage pattern of Saltzman Creek has changed through time (Attachment C). All of the topographic maps show a relatively straight creek channel that originates in Forest Park and discharges to the Willamette

River. In addition to the main creek channel, the 1940 USACE topographic map shows two small intermittent tributaries on the north side of the creek. One of these small tributaries originates in the general vicinity of the southern end of the Rhône Poulenc site. In 1940 the Rhône Poulenc site was beginning operations at the southern portion of the site. Based on site topography, chemical spills that occurred near one of the tributaries would have ultimately drained to Saltzman Creek and discharged directly to the Willamette River.

Historical Storm Sewer Maps

Historical storm sewer maps along NW Front Avenue from 1951, 1969, and 1980 were obtained from the City of Portland Bureau of Environmental Services (BES) through the website Portlandmaps.com. Maps showing the current configuration of the storm sewer system along NW Front Avenue were also obtained from the website Portlandmaps.com. These sewer maps are presented in Attachment C.

The 1951 sewer map shows a 10-in diameter sewer pipe along the west side of Front Avenue from 61st Avenue north of Saltzman Creek and discharging directly to the 8-ft square concrete culvert at Balboa Avenue that conveys Saltzman Creek to the Willamette River. The 10-in diameter sewer pipe had a slope of 0.80%. The cross section shows a 30 ft long section of 8-in sewer pipe that is connected to the 10-in sewer pipe near 61st Avenue. The 1969 as-built sewer map shows the same sewer pipe along the west side of Front Avenue from NW 61st Avenue and discharging to the 8-ft square concrete culvert that conveys Saltzman Creek (Figure 2). The 1980 as built storm sewer system map shows the current configuration of the storm sewer line along Front Avenue toward the Saltzman Creek box culvert (Figure 2). The 1980 as built map calls for the abandonment of selected manholes that were shown on the 1951 and 1969 sewer maps.

The historical sewer maps show the storm sewer line along NW Front Avenue from NW 61st Avenue to Balboa Avenue discharged to the 8-ft square concrete culvert that conveys Saltzman Creek to the Willamette River from 1951 to present. From 1980 to present, storm water north of the intersection of 61st Avenue and Front Avenue has flowed to the north along Front Avenue and discharged through City of Portland Outfall 22B. The new storm sewer lines shown on the 1980 “as-built” maps were installed when NW Front Avenue was extended north to the Siltronic facility. Although historical sewer maps that show the drainage from the Rhône Poulenc facility entrance at NW 61st Avenue and NW Culebra Avenue toward NW 61st Avenue were not available, the current configuration of the storm sewer lines show that stormwater flow from this area would flow toward Front Avenue and drain to the Saltzman Creek box culvert at Front Avenue (2009 sewer map, Attachment C). Based on surface topography and the location of the Willamette River, historical and current surface water flow in the southern portion of the Rhône Poulenc property drained overland or by storm sewer pipes from the Rhône Poulenc facility entrance toward Front Avenue and ultimately to the Willamette River via Saltzman Creek from at least 1951 to present (Figure 2). The Rhône Poulenc site operated from 1943 to 1990; therefore, any liquid spills or process effluents discharged to the storm sewer line along Front Avenue and 61st Avenue between 1951 and present would have discharged to the Willamette River through Saltzman Creek.

Rhône Poulenc Chemicals in Buried Sediments

Rhône Poulenc chemicals have been detected in buried sediments in the Willamette River just downstream of Saltzman Creek. Aldrin and lindane, insecticides manufactured at the Rhône Poulenc facility, were both detected in buried sediment samples collected in the Willamette River off the Arkema property, just downstream of Saltzman Creek. Both of these Rhône Poulenc chemicals were detected in sediments from 4-8 ft and greater than 8 ft below mudline (Maps 214, 215, 249, and 250; Integral 2006; Attachment C). Mercury, another Rhône Poulenc chemical, was also detected in sediments at a depth of 4-8 ft and greater than 8 ft below mudline just downstream of Saltzman Creek (Map D1.1-50h; Integral et al 2009; Attachment C). The area around the docks at the Arkema site where these chemicals were detected is known to be a depositional area (Integral 2006). The relatively deep sediment where these chemicals were detected indicates they were likely deposited historically during the time interval that the Rhône Poulenc plant was operating and could have discharged to the Saltzman Creek drainage.

Saltzman Creek Drainage Summary

The following is a summary of the evidence for connection from the Rhône Poulenc site to the Willamette River via Saltzman Creek.

- A number of aerial photographs clearly show black water discharging from Saltzman Creek from approximately 1951 to 1967. The black water discharging from the creek was very distinct with a color similar to that of Doane Lake. The black water discharging from Saltzman Creek was observed in the lower half of Saltzman Creek (i.e., halfway between Front Avenue and the Willamette River). This suggests there could have been a conveyance system or conduit that terminated in the lower portion of the creek. In addition, a portion of the Saltzman Creek channel just downstream Front Avenue was filled between 1959 and 1961 with materials from an unknown source that could also contain chemicals of concern.
- A number of historical spills and discharges have been documented at the Rhône Poulenc site. One small tributary to Saltzman Creek that was shown on the 1940 USACE topographic map originates in the general vicinity of the southern end of the Rhône Poulenc site. In the early 1940s, Rhône Poulenc was operating on the southern portion of the site and spills or discharges that would have occurred in this area would have flowed naturally to the tributary or directly to Saltzman Creek.
- Historical sewer maps obtained from the City of Portland showed the sewer line along Front Avenue from NW 61st Avenue to Balboa Avenue discharged to the 8-ft square concrete culvert that conveys Saltzman Creek to the Willamette River from 1951 to present. From 1980 to present, storm water north of the NW 61st Avenue to Front Avenue intersection has flowed to the north along Front Avenue and discharged through City of Portland Outfall 22B. The Rhone-Poulenc site operated from 1943 to 1990, therefore any water discharged to the sewer line south of Front Avenue and along NW 61st Avenue from 1951 to present would have discharged to the Willamette River through Saltzman Creek.

- Rhône Poulenc chemicals, including aldrin, lindane, and mercury, have been detected in buried sediments immediately downstream of Saltzman Creek.

Summary and Conclusions

Based on the review of DEQ file documents, current and historical maps, and aerial photos, it has been conclusively shown that Rhône Poulenc generated waste liquids that were discharged directly and continuously to West Doane Lake for at least a 30-35 year period (from 1943 to at least 1975). Even though the approximately 20 year period of plant operation prior to 1963 are not well documented in the DEQ file information obtained by LSS, waste handling procedures during these years are assumed to be no better than they were in the 1960s when direct discharge to the river was occurring. This practice is well documented by Glen Carter in his summary of historic pollution discharges to the Willamette River (Carter 2006). In addition, interviews of long-term employees conducted in 1990 showed very poor waste handling practices, some of which were confirmed by a recent geophysical survey and test pit investigation.

Rhône Poulenc waste chemicals discharging to West Doane Lake at various times either drained directly to the Willamette River through an old outfall pipe or the Historical Drainage Ditch, or drained to the river via seepage through the railroad track embankment to North Doane Lake and then to Doane Creek. Doane Creek discharged to the river near the current boundary of the NW Natural and Siltronic sites prior to 1965 and immediately downstream of the BNRR railroad embankment after the Doane Creek drainage was modified and diverted immediately north along the railroad embankment in about 1965. According to Rhône Poulenc, the tainted migratory fish issue in the mid to late 1960s was caused by the excavation of this ditch, which drained water from North Doane Lake to the Willamette River (Rhône Poulenc 1987).

The evidence also indicates that discharges occurred to the Willamette River via Saltzman Creek. Waste handling and disposal practices occurred in the southern portion of the site (including leakage from railcars that were often located in this portion of the property). The natural topographic drainage and connections of City storm water conduits to Saltzman Creek were well established prior to the construction of the Chipman Chemical plant and would naturally carry any waste spills or discharges in these parts of the site to the Saltzman Creek drainage and discharge to the Willamette River. From 1980 to present, storm water north of the intersection of NW 61st Avenue and Front Avenue have discharged through City of Portland Outfall 22B. Water discharged from Outfall 22B continues to convey groundwater plumes with Rhône Poulenc chemicals to the Willamette River.

As a result of this file review, LSS has determined that:

- Rhône Poulenc has not adequately investigated all of their source areas and related transport pathways, especially former surface water pathways to the river.

- Not all COIs generated by the many herbicide, pesticide, and other chemical manufacturing processes that were conducted at the site for approximately 50

years have been adequately identified leaving data gaps in the understanding of COIs that may need to be remediated or controlled.

- Many of the areas where waste disposal occurred have not been adequately located or investigated, especially those identified in the first 20-30 years of manufacturing, including the southern portions of the Rhône Poulenc facility. Uninvestigated source areas may pose a serious threat to human health and the environment and could be a continuing long term source of contamination to the Willamette River and/or downgradient properties.

LSS appreciates the opportunity to provide this historical information and review to DEQ. Please do not hesitate to contact me (610-594-4430) or David Livermore at Integral Consulting (503-284-5545) if you have any questions about the information summarized in this letter.

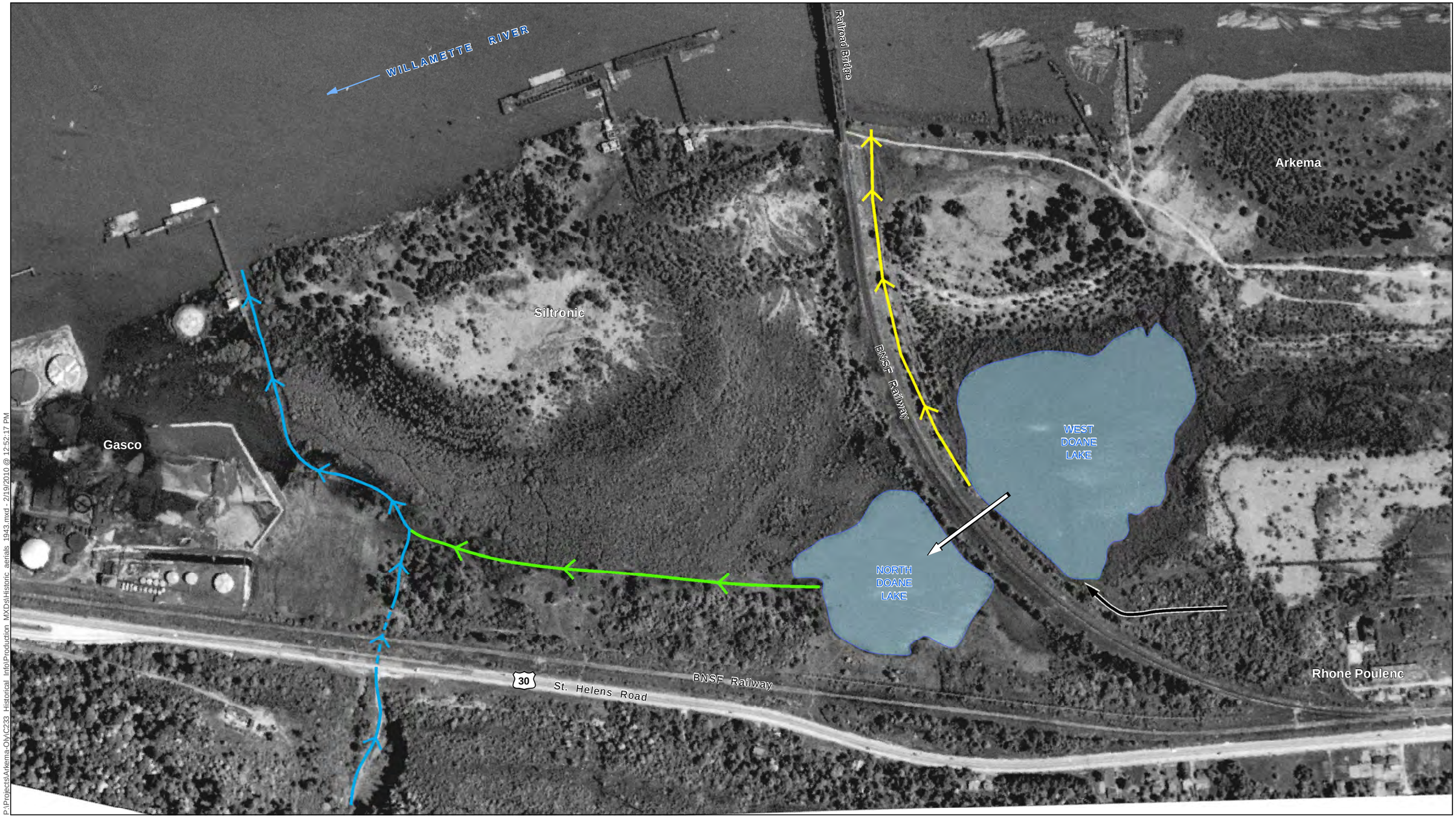
Sincerely,

Legacy Site Services LLC

J. Todd Slater
Manager, Environmental Technologies
And Remedial Procurement

Attachments

cc: Sean Sheldrake, EPA
Matt McClincy, DEQ
Tom Gainer, DEQ
Henning Larsen, DEQ
Karen Traeger, LSS
Steve Parkinson, Groff Murphy
David Livermore, Integral
Erik Ipsen, ERM
Larry Patterson, ERM



P:\Projects\Arkema-Oly\C233 Historical Info\Production MXDs\Historic aerials 1943.mxd - 2/19/2010 @ 12:52:17 PM

integral consulting inc

FEATURE SOURCES:
Historic Aerial Imagery: 1936, Provided by AMEC 2006

0 100 200 400
Feet

- Doane Creek
- North Doane Lake Drainage Channel
- Doane Creek Culvert
- Periodic Overland Flow Path of West Doane Lake During Storm Events (Historic Drainage Ditch)
- Doane Lake
- Drainage Through Railroad Ballast
- Rhone Poulenc Effluent Discharge (Lake Area Drainage Ditch)

DRAFT
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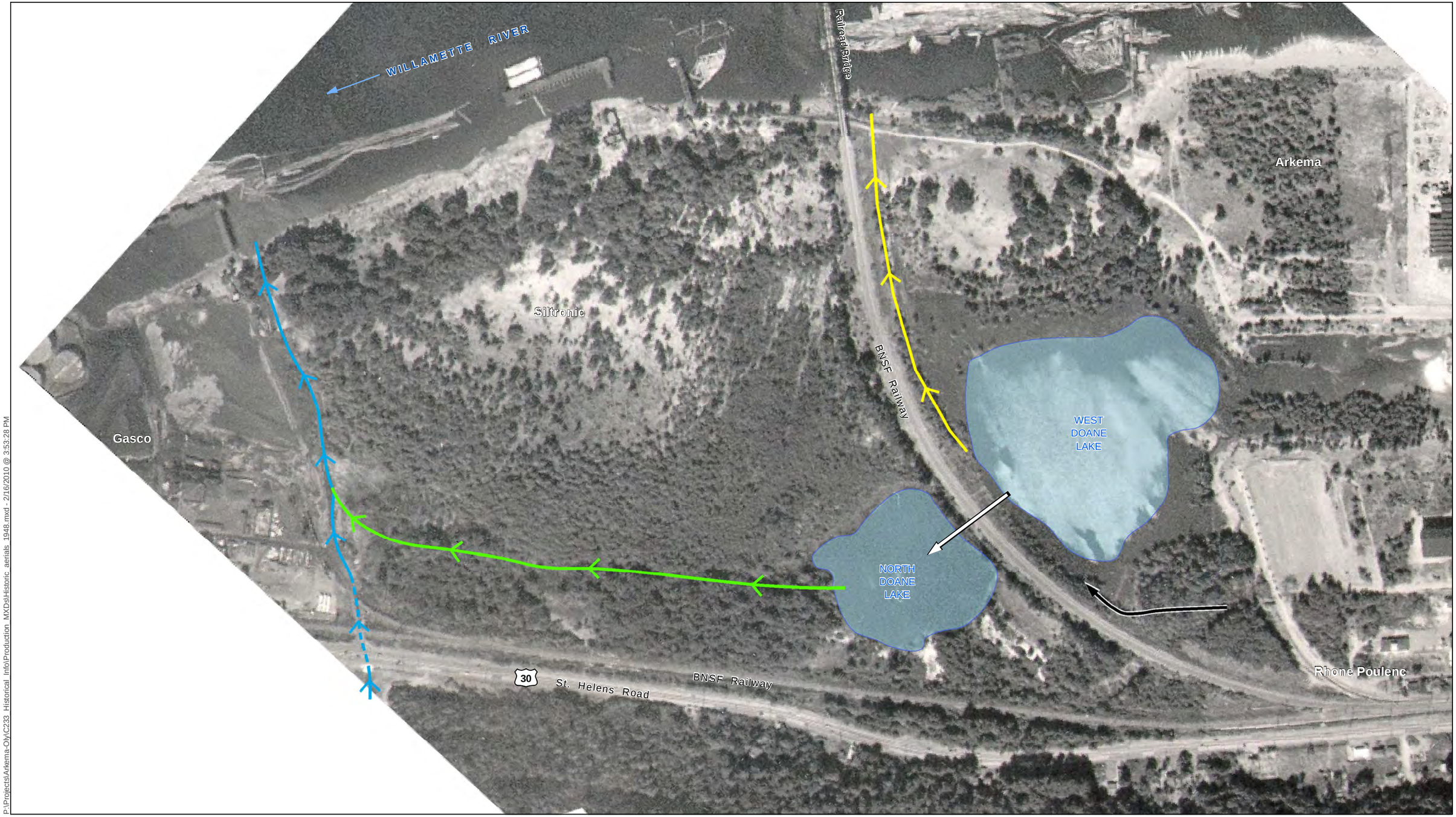
Figure 1a.
Historical Drainage Pattern of Doane Creek 1943-1947



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FEATURE SOURCES:
Historic Aerial Imagery: 1948, Provided by AMEC 2006

0 100 200 400
Feet

Doane Creek
North Doane Lake Drainage Channel
Doane Creek Culvert
Periodic Overland Flow Path of West Doane Lake During Storm Events (Historic Drainage Ditch)
Doane Lake
Drainage Through Railroad Ballast
Rhone Poulenc Effluent Discharge (Lake Area Drainage Ditch)

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Figure 1b.
Historical Drainage Pattern of Doane Creek 1948-1956

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FEATURE SOURCES:
Historic Aerial Imagery: 1957, Provided by AMEC 2006

0 100 200 400
Feet

- Doane Creek
- North Doane Lake Drainage Channel
- Doane Creek Culvert
- Periodic Overland Flow Path of West Doane Lake During Storm Events (Historic Drainage Ditch)
- Doane Lake
- Drainage Through Railroad Ballast
- Rhone Poulenc Effluent Discharge (Lake Area Drainage Ditch)

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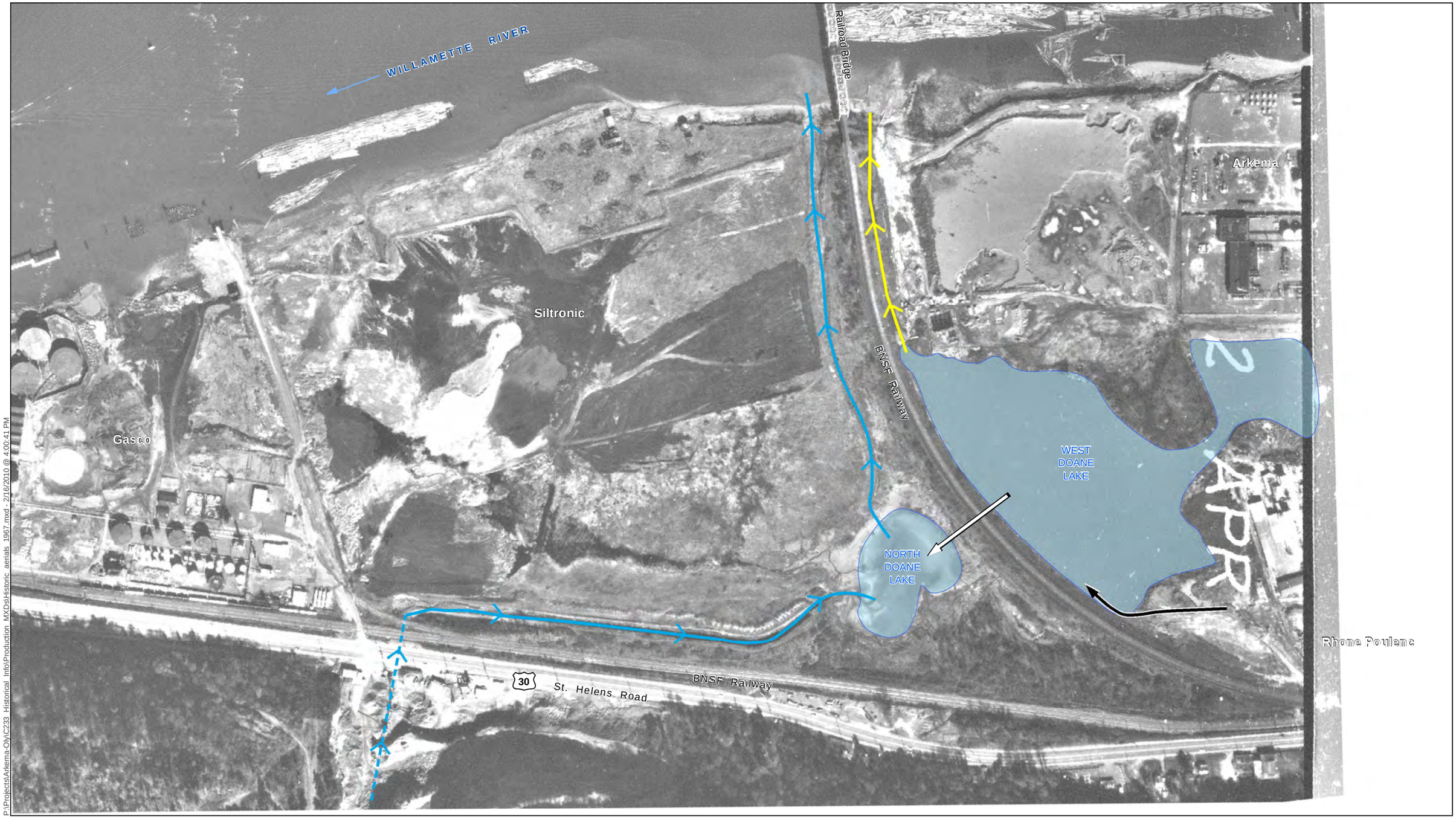
Figure 1c.
Historical Drainage Pattern of Doane Creek 1957-1964



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FEATURE SOURCES:
Historic Aerial Imagery: 1967, Provided by AMEC 2006

0 100 200 400
Feet

Doane Creek
Doane Creek Culvert
Periodic Overland Flow Path of West Doane Lake During Storm Events (Historic Drainage Ditch)
Doane Lake
Drainage Through Railroad Ballast
Rhone Poulenc Effluent Discharge (Lake Area Drainage Ditch)

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Figure 1d.
Historical Drainage Pattern of Doane Creek 1965-1971

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FEATURE SOURCES:
Historic Aerial Imagery: 1972, Provided by AMEC 2006

0 100 200 400
Feet

Doane Creek
Doane Creek Culvert
Periodic Overland Flow Path of West Doane Lake During Storm Events, Reportedly until 1980 (Historic Drainage Ditch)
Doane Lake
Drainage Through Railroad Ballast
Rhone Poulenc Effluent Discharge (Lake Area Drainage Ditch)

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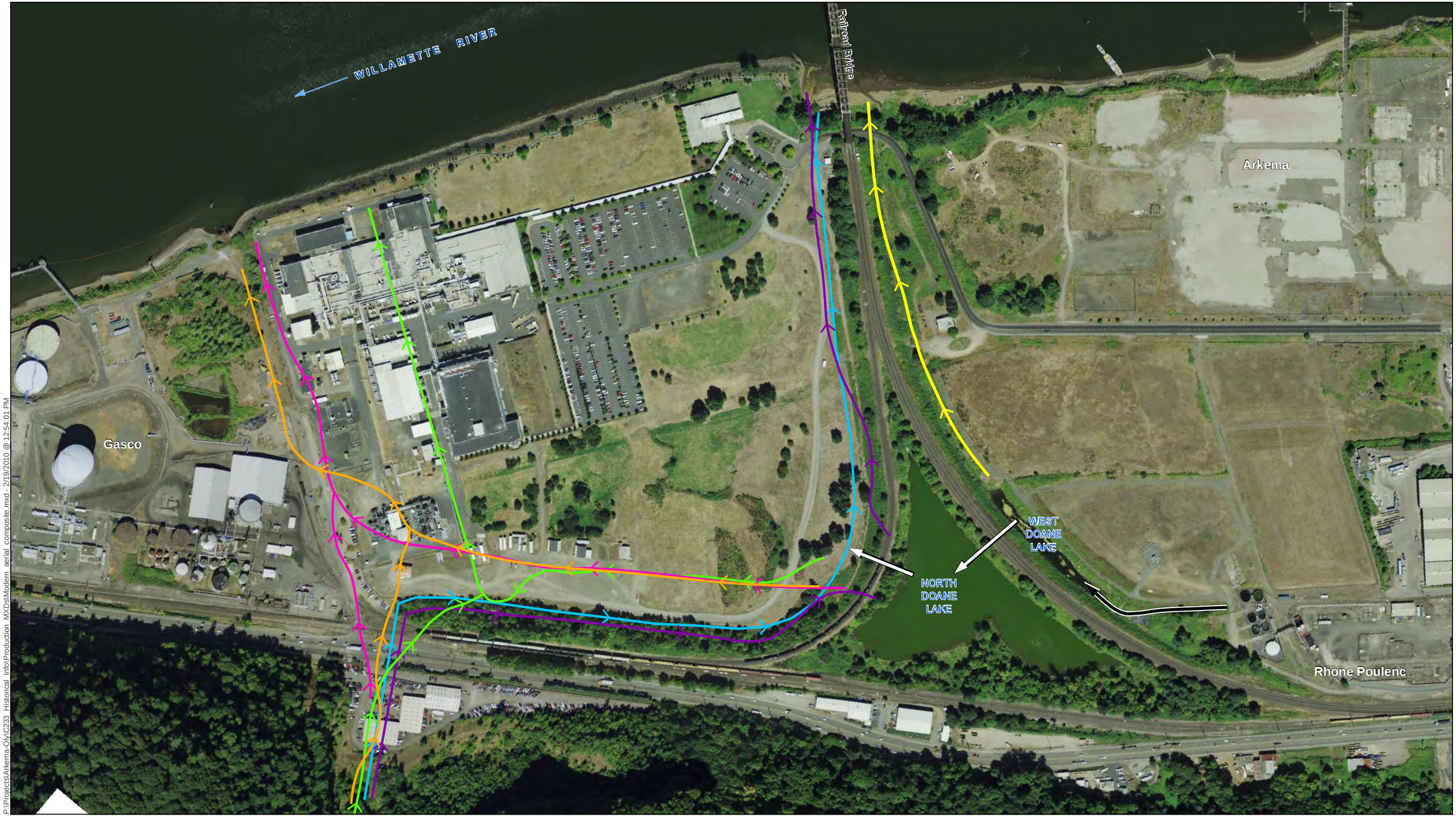
Figure 1e.
Historical Drainage Pattern of Doane Creek 1972-Present



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FEATURE SOURCES:
Current Aerial Imagery: RLIS 2007

0 100 200 400
Feet

Doane Creek 1936-1947
Doane Creek 1948-1956
Doane Creek 1957-1964
Doane Creek 1965-1971
Doane Creek 1972 to Present
Periodic Overland Flow Path of West Doane Lake During Storm Events, Reportedly Until 1980 (Historical Drainage Ditch)
Drainage Through Railroad Ballast
Rhone Poulenc Effluent Discharge (Lake Area Drainage Ditch)

Figure 1f.
Composite of Historical Drainage Patterns of Doane Creek, 1943-Present

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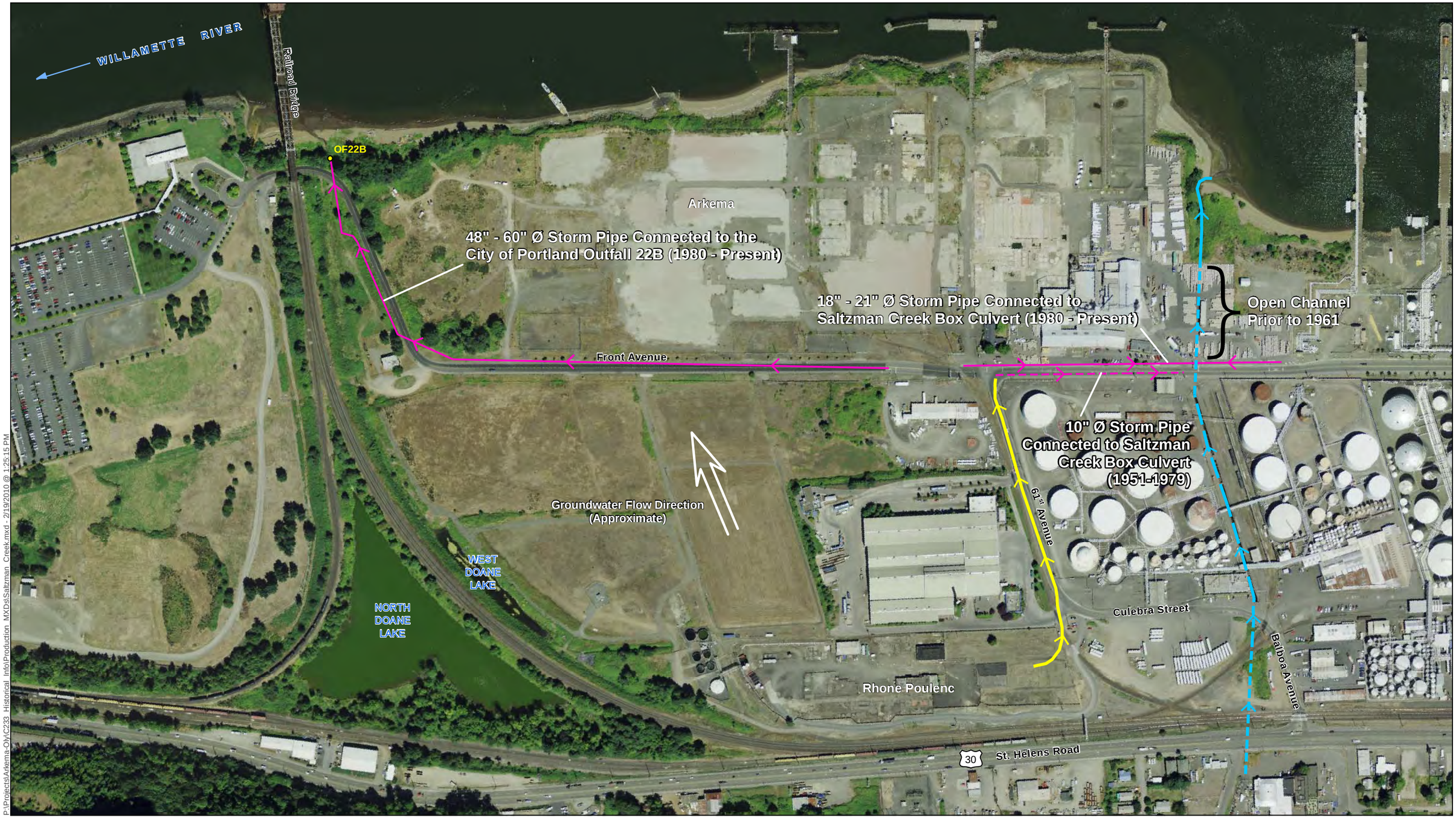

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FEATURE SOURCES:
Current Aerial Imagery: RLIS 2007

0 100 200 400
Feet

Storm Pipe (1951-1979)
Storm Pipe (1980-Present)
Saltzman Creek
Saltzman Creek Culvert
Saltzman Creek Culvert (Open)
Periodic Overland Flow Path During Storm Events
Outfall

Figure 2
Discharges to the Willamette River
Through Saltzman Creek and City Outfall 22B

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STATE OF OREGON

DEPARTMENT OF ENVIRONMENTAL QUALITY **INTEROFFICE MEMORANDUM**

DATE: December 28, 1990

TO: The Files, Rhône Poulenc

FROM: Sandra Anderson, Project Manager
Site Response Section

SUBJECT: Employee Interview

I interviewed Dick Forney and Don Beckle, formerly of Rhône-Poulenc, on July 16, 1990 in Gresham where Don now lives. Other employees at Rhône-Poulenc had recommended that I speak with Don because he was the foreman at the dust plant (insecticide plant).

Dick stated that he was a truck driver at the plant. Don said he was the foreman at the dust plant from 1951 until the early '70s. He went to the shipping department in the early 70s until November of 1982 when he retired.

The insecticide building is built on cement pillars. There is no drainage in the building. To drain the liquid wastes, holes were drilled through the floor with a jackhammer. The floor is raised and about 8 inches thick. There is a dirt floor underneath the building. The holes allowed them to wash down the equipment in the plant with water.

A pit in the yard behind the dust plant was open for a couple of weeks and received a conservative estimate (says Don) of 2-3 tons of bad batches of Parathion, Heptachlor, empty Parathion drums, Ag Rocks (a mercury product), and Mergamma, also a mercury product, and talc used to clean out the containers.

Over the life of the dust plant, some waste went to St. Johns, but nothing from the dust plant went to Alkali Lake, or anywhere else off-site. Most of the waste water drained into a ditch which drained to the "lake" behind the dust plant on Rhône-Poulenc property. This drainage continued out of the "lake" and along the border between Gilmore Steel, Kirk Battery (Gould), and RP, and then into Doane Lake. In the late '60s, the ditch was filled in, and after that, the waste was dumped behind the dust plant and/or taken to St. Johns. The material dumped in the yard was mostly talc used to clean the containers in which the insecticides were made. There were no fences between properties at that time, and Don believes that the ditch would be on the other side of RP's property line as now defined by the ditch. In other words, the ditch ran on Gilmore

Steel and Kirk Battery. The ditch frequently "ran red" from the dye used to mark mercury products.

In the '50s until '65, 16-18 tons of DDT per day were made in the dust plant. Volume-wise, DDT was the biggest product. Aldrin was probably the next most abundant product, but also made Malathion, Toxaphene, Heptachlor, Chlordane, Lindane, Dieldrin, and Rotenone. The plant was used mostly for manufacturing, but towards the end, did some repackaging and added DDT to other packages to resell.

As far as Don knows, nothing was buried in Doane Lake north of the railroad tracks. Drums are buried beneath the waste water treatment plant and all over the undeveloped portion of the plant. Chlordane and parathion are buried in what is now the northwest corner of the wastewater treatment plant.

During the early '70s, an attempt was made to pump Doane Lake dry. He's not sure why. An 8" pipe was laid from the Lake to the river and the lake was pumped and discharged to the river, but it didn't go dry. Normally a ditch ran from the lake to the river.

In other parts of the site, a pit was dug behind the office to mix DCP bleed with water so it could be rebarrelled and shipped to Alkali Lake. The pit was 18-20 feet deep and lined with metal. [This is probably the "underground storage tank" on some of the diagrams for which I have little mention of history of use in work plan.] Don is not familiar with the MCPA plant.

The DCP bleed which was eventually sent to Alkali Lake was stored in 33 tank cars on the Linton Spur towards Scappose. Some of the tank cars leaked.

The dust plant closed when most of the products made there were banned by EPA.

interview by Sandra Anderson April 24, 1990

Ray Ritchie stated that in the 1960s he was ordered by his supervisor in writing to pipe bad batches of MCPA directly to Doane Lake while he was working the night shift. A batch is about 3,000 to 4,000 gallons. His supervisor was Lazlo Santo. Ritchie still has the written notes with his instructions. Santo was later fired, but not for environmental reasons. According to Ritchie, Santo is still in Portland, and operates a detail shop.

Ritchie also stated that in a separate incident, John Hubbert, the maintenance supervisor, came in at 3:00 am to cover the drums dumped in Doane Lake.

Sandra Anderson
4/30/90

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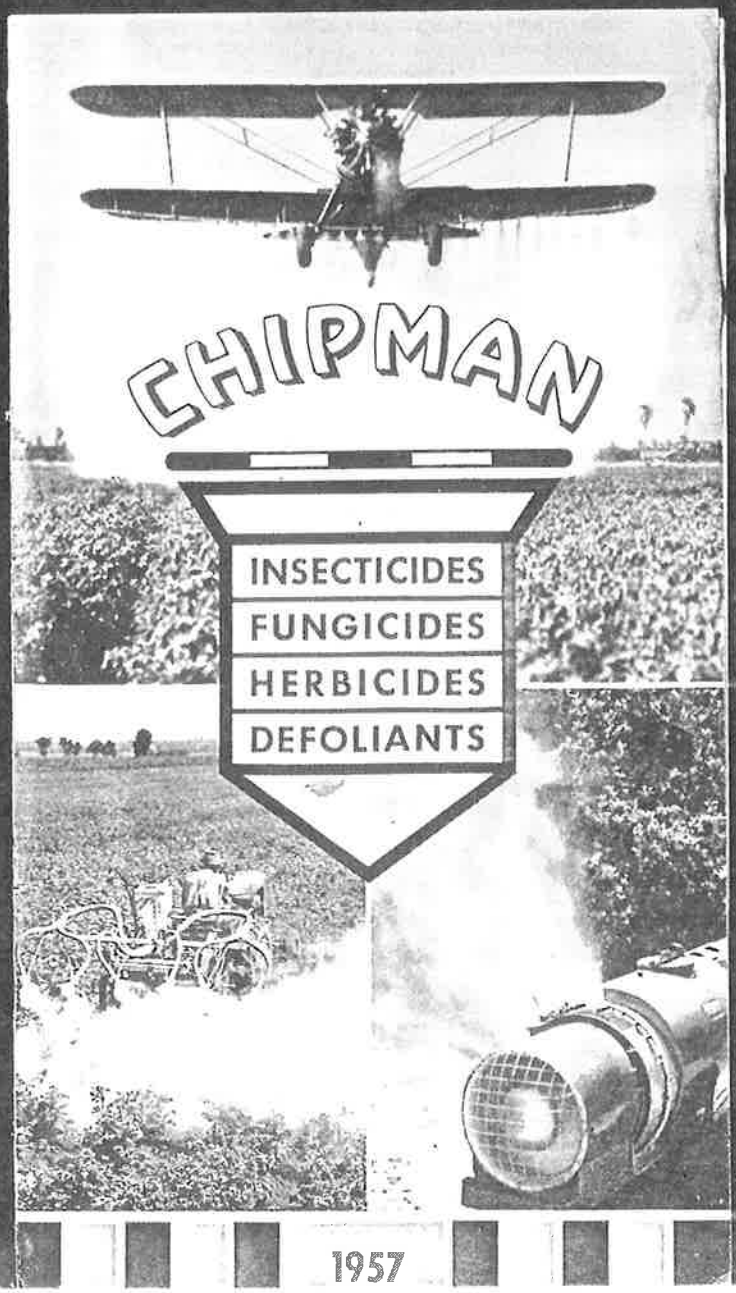
CHIPMAN
INSECTICIDES
FUNGICIDES
HERBICIDES
DEFOLIANTS
1957

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CHIPMAN

INSECTICIDES
FUNGICIDES
HERBICIDES
DEFOLIANTS

Since 1912

CHIPMAN CHEMICAL COMPANY, INC.

CHICAGO, ILL.
BESSEMER, ALA.
N. KANSAS CITY, MO.

BOUND BROOK, N. J.
PALO ALTO, CALIF.

PASADENA, TEX.
PORTLAND, ORE.
ST. PAUL, MINN.

Insecticides

[illegible] PRODUCTS

Kill by Contact and Stomach Poisoning

[illegible] An emulsifiable liquid containing 2 pounds of Aldrin equivalent per gallon. For corn rootworm in corn, cotton insects and grasshoppers.

55 gal. drums—30 gal. drums—5 gal. drums
1 gal. jugs (4 in case)

[illegible] Contains 4 pounds of Aldrin equivalent per gallon. For same purposes as Aldrin 2L.

55 gal. drums—30 gal. drums—5 gal. drums
1 gal. jugs (4 in case)

[illegible]

50 lb. bags

Portland, Ore.

[illegible]

50 lb. bags

Portland, Ore.

[illegible] (Granular Aldrin) Contains 25% granular Aldrin. For control of certain soil and turf insects. Used in insecticide-fertilizer combinations.

50 lb. bags

[illegible]

For Control of Mites

[illegible] Contains 2 pounds of Aramite per gallon. Applied as a water-emulsion spray on cotton, apples and ornamentals.

55 gal. drums—5 gal. drums—1 gal. jugs (4 in case)

[illegible] Use on apples, peaches, citrus and ornamentals.

50 lb. bags—4 lb. bags (12 in case)

Sodium Arsenite Solution

See Page 16 for Detailed Description.

ATLAS CATTLE DIP

A standard arsenical dip, approved by the U. S. Department of Agriculture for control of Texas fever tick.

5 gal. drums

Pasadena, Tex., Bessemer, Ala.

BENZAHEX DUSTS & SPRAYS

Contain Benzene Hexachloride

BENZAHEX DUSTS: Combinations of 2% or 3% gamma isomer and 5% or 10% DDT — with or without 3% Malathion or 40% sulfur. Also available as "straight dusts" containing 1%, 2% or 3%, gamma isomer. For control of boll weevil, bollworm, aphids, fleahoppers and certain other insects on cotton.

50 lb. bags

BENZAHEX LIQUID: Contains 1 pound gamma isomer per gallon. Used as an emulsion spray. For control of corn rootworm and certain cotton insects.

55 gal. drums—30 gal. drums—5 gal. drums
1 gal. jugs (4 in case)

BENZAHEX-DDT COMBINATION LIQUID: Contains 0.9 pounds gamma isomer and 1.5 pounds of DDT per gallon. For control of certain cotton insects.

55 gal. drums—30 gal. drums—5 gal. drums

BENZAHEX W-12: Wettable powder containing 12% gamma isomer. Used as water-miscible spray or dip. For control of lice and mange on cattle and hogs; sheep tick and scabies on sheep and goats.

50 lb. bags—4 lb. bags (12 in case)

CHIPMAN CALCIUM ARSENATE

Contains over 47% arsenic pentoxide (killing ingredient), and not more than 0.49% water soluble arsenic. Used for control of boll weevil, bollworm, cotton leafworm, tomato hornworm, tomato fruitworm, cabbage worms, potato bugs and other chewing insects. Applied as a dust or spray; may be mixed with copper fungicides. Also used in poison baits.

50 lb. bags—25 lb. bags—4 lb. bags (12 in case)

LOW-CAL

For Cotton Insect Control

A low-lime calcium arsenate, particularly intended for control of boll weevil and cotton leafworm.

50 lb. bags

Available in combination with sulfur, DDT, or Parathion and DDT. For control of certain cotton insects.

50 lb. bags

Pasadena, Tex.

Quick-killing organic insecticides; kill by contact and stomach poisoning. Used for a wide variety of insects including alfalfa weevil, ants, cabbage maggot, chiggers, chinch bug, grasshoppers, Japanese beetle larvae, mole cricket, onion maggot, sod webworm, wireworms, termites and certain other species of insects.

50 lb. bags

50 lb. bags—4 lb. bags (8 in case)

50 lb. bags—4 lb. bags (8 in case)

Contains 8 pounds of chlordane per gallon; applied as a water emulsion spray.

55 gal. drums—30 gal. drums
5 gal. cans—1 gal. jugs (4 in case)

**Pasadena, Tex., Palo Alto, Calif., Portland, Ore.*

Granular Chlordane

Free-flowing granular insecticides for control of certain soil-inhabiting insects such as wireworms in potatoes and field crops, corn rootworms in corn fields, Japanese beetle grubs, also other related species.

Contains 5% Chlordane; applied as is or mixed with fertilizer.

50 lb. bags—5 lb. bags (10 in case)

Contains 10% Chlordane; applied as is or mixed with fertilizer.

50 lb. bags

Contains 25% Chlordane. Used in insecticide-fertilizer combinations.

50 lb. bags

[illegible] DUSTS

High Quality Rotenone Dusts

[illegible]: Contains not less than 0.75% *pure rotenone.* Effective against a wide variety of insects including pea weevil, Mexican bean beetles, cabbage and cauliflower worms, asparagus beetles and cherry fruit fly.

50 lb. bags—4 lb. bags (12 in case)

[illegible]: Contains not less than 1.00% *pure rotenone.* Also available with sulfur.* Recommended for more resistant species of soft-bodied worms, aphids, pea weevil, beetles and other similar species.

50 lb. bags—4 lb. bags (12 in case)

**Pasadena, Tex.*

[illegible] DDT PRODUCTS

For Use on Crops and Livestock

[illegible]: Contain 5%* and 10% DDT finely ground in inert carrier. Control Colorado potato beetle, potato leafhopper, cabbage caterpillars, tomato fruitworms and other insects on vegetables; also for certain insects on forage crops. DDT 10% Dust controls lice on animals, chinch bugs and Japanese beetle grubs.

50 lb. bags—*4 lb. bags (12 in case)

Note: Chipman DDT-Parathion Dusts are also available.

[illegible]: Contain 5% or 10% DDT plus sulfur. For use on cotton, certain truck crops and fruits.

50 lb. bags

[illegible]

50 lb. bags

[illegible]: Contains 2 pounds of DDT per gallon. For use as an emulsion spray on potatoes and wherever DDT emulsion sprays are recommended.

55 gal. drums—30 gal. drums—5 gal. drums
1 gal. jugs (4 in case)

CHIPMAN [illegible] DDT: Contains 50% DDT. Makes water suspension spray; also a base for making DDT dusts. Kills Colorado potato beetle, potato leafhopper, onion thrip, codling moth, and several other species of insects on vegetables and fruits. Controls certain insects on cereal and forage crops; forest and shade trees. Kills lice, ticks and flies on livestock.

50 lb. bags—10 lb. bags (5 in case)
4 lb. bags (12 in case)—1 lb. canisters (24 in case)

DDT GRANULAR: A granular insecticide containing 5% DDT; specially formulated for control of European corn borer on corn.

50 lb. bags

CHIPMAN DIELDRIN PRODUCTS

CHIPMAN DIELDRIN [illegible]: Contains 1.5 pounds of Dieldrin per gallon. Used as a water-emulsion spray for control of boll weevil, thrips, cotton fleahopper, tarnished plant bug, rapid plant bug and fall armyworm on cotton; also for control of grasshoppers, alfalfa weevil, and variegated cutworm.

55 gal. drums—30 gal. drums—5 gal. drums
1 gal. jugs (4 in case)

CHIPMAN DIELDRIN [illegible]: A wettable spray powder containing 50% Dieldrin. For control of plum curculio, wireworms and white grubs; also used as a seed protectant.

50 lb. bags—5 lb. bags (10 in case)—3 lb. bags (16 in case)

DIELGRAN [illegible] (Granular Dieldrin) Contain 2%*, 5% and 10% Dieldrin respectively. Recommended for soil treatments to control white grubs, wireworms, corn rootworms in corn and peanuts; also certain other soil-inhabiting insects. Applied as is: Dielgran 10 may also be used in insecticide-fertilizer combinations.

50 lb. bags—*also 3½ lb. bags (14 in case)

Contains 1.6 pounds of Endrin per gallon. For control of cotton insects including boll weevil, bollworm, leafworm and lygus bug. For use on tobacco to control hornworms and grasshoppers. Also for control of webworm on sugar beets. Applied as a water-mixed emulsion spray.

55 gal. drums—30 gal. drums—5 gal. drums
1 gal. jugs (4 in case)

Contains 25% Heptachlor. Used in manufacture of dusts. Applied as water-mixed spray for control of certain soil insects; also for onion thrips and sweetclover weevil.

50 lb. bags

Pasadena, Tex.

Contains 2 pounds of Heptachlor per gallon. For control of boll weevil, thrips, fleahopper, tarnished and rapid plant bugs, grasshoppers, cutworms and garden webworm on cotton; also adult alfalfa weevil in early spring; grasshoppers on range land.

55 gal. drums—30 gal. drums—5 gal. drums
1 gal. jugs (4 in case)

(Granular Heptachlor) Contains 25% Heptachlor. Used in the preparation of insecticide-fertilizer combinations for control of wireworms, grubs, corn rootworms and potato tuber flea beetle.

50 lb. bags

For insecticide-fertilizer combinations. A liquid containing 4 pounds of Aldrin and 2 pounds of Heptachlor per gallon.

55 gal. drums

CHIPMAN HI-TEST LEAD ARSENATE

Greater Safety Plus Added Killing Power

Offers greater safety to crops, plus added killing power against insects. Guaranteed to contain not more than 0.35% water soluble arsenic (leaf-burning form of arsenic), and not less than 21.00% of arsenic as metallic (important ingredient for insect killing). *No other lead arsenate equals this combined guarantee.* Contains at least 98.00% of di-ortho lead arsenate. The di-ortho form is recognized by the U.S. Department of Agriculture as the desirable and pure form of acid lead arsenate..

A standard insecticide for controlling external chewing insects on fruit and shade trees, shrubbery, flowers, many vegetable crops. Also used in the control of certain soil-inhabiting insects.

50 lb. bags—15 lb. bags (3 in case)—6 lb. bags (8 in case)
4 lb. bags (12 in case)—3 lb. bags (16 in case)
1 lb. bags (24 in case)

CHIPMAN LINDANE 16L

Contains 1.6 pounds of Lindane per gallon. Used as a water-emulsion spray for control of house and stable flies in barns and other farm buildings. Also used for certain insects on ornamentals.

30 gal. drums—5 gal. drums—1 gal. jugs (4 in case)

CHIPMAN LINDANE 25

A 25% concentration of Lindane in wettable powder form. Used as dust or slurry for seed treatment of such crops as corn, wheat, oats, barley, sugar beets and peas to control wireworms and seed corn maggot. Also controls grasshoppers and corn rootworms in corn fields. Used as livestock spray or dip. Controls certain insects on ornamentals.

40 lb. drums—2 lb. tins (12 in case)—1 lb. tins (12 in case)

CHIPMAN MALATHION PRODUCTS

Highly toxic contact insecticides for control of spider mites, aphids, leaf miners, leafhoppers, mealybugs, Mexican bean beetle, lace bugs and many other insects. For use on apples and pears; beans, peas, potatoes, tomatoes and other vegetable crops; ornamental trees and shrubs. Sprays are also for fly control in and around buildings.

CHIPMAN [illegible]: Used on vegetables and ornamentals.

50 lb. bags

CHIPMAN [illegible]: Contains 5 pounds of Malathion per gallon. For use as a water-emulsion spray.

55 gal. drums—30 gal. drums—5 gal. drums
1 gal. jugs (4 in case)

CHIPMAN [illegible]: Contains 25% Malathion. A powder for use as a water-suspension spray.

50 lb. bags—4 lb. bags (12 in case)

Granular Malathion

Contain 5% and 10% Malathion. For airplane or ground application to control mosquitoes.

50 lb. bags

**Portland, Ore., Pasadena, Tex.* ***Palo Alto, Calif.*

CHIPMAN [illegible] PARATHION DUSTS [illegible]

Highly toxic contact insecticides; can be used at low dosages. Used for control of many species of aphids and mites; also mealybugs, pear psyllid, bean leafhoppers, onion thrips and certain other insects on fruits, vegetables and field crops.

CHIPMAN [illegible]

50 lb. bags

Note: Chipman DDT-Parathion Dusts are available.

Contains 2 pounds of Parathion per gallon.

55 gal. drums—30 gal. drums—5 gal. drums
1 gal. jugs (4 in case)

CHIPMAN [illegible]: Contains 2 pounds of Methyl Parathion per gallon. For control of boll weevil, cotton leaf perforator, cotton leafworm and spider mites on cotton.

55 gal. drums—30 gal. drums—5 gal. drums

Pasadena, Tex.

[illegible]

Contains 4 pounds of Parathion per gallon.

30 gal. drums—5 gal. drums—1 gal. jugs (4 in case)

CHIPMAN [illegible]

50 lb. drums—5 lb. bags (6 in case)

3 lb. bags (8 in case)—2 lb. bags (12 in case)

CHIPMAN [illegible]

3 lb. bags (8 in case)—2 lb. bags (12 in case)

°*Bound Brook, N. J.* °°*Portland, Ore., Palo Alto, Calif.*

CHIPMAN PARIS GREEN

The particles of Chipman Paris Green, unlike the pellet-shaped particles of ordinary brands, are thin and flat. They stick better to foliage and kill insects quicker. Because Chipman Paris Green is of lighter density, it gives better suspension and plant coverage. Kills potato bugs, cotton leafworms, tobacco hornworms, sugar beet webworms.

100 lb. drums—25 lb. drums—5 lb. canisters (6 in case)

1 lb. canisters (24 in case)—¼ lb. canisters (48 in case)

CHIPMAN [illegible]

Insecticide—Fungicide Combination

Contains 5% DDT, plus 7% metallic copper. Controls potato beetle, flea beetles, leafhoppers and aphids. Also aids in control of early and late blight.

50 lb. bags—4 lb. bags (12 in case)

CHIPMAN [illegible]

For use as spray or dip to control cattle grubs and lice on cattle. For certain species of aphids on fruits and vegetables: also fireworm and fruitworm on cranberries; cherry fruit fly and certain other insects.

40 lb. bags—4 lb. bags (10 in case)

CHIPMAN SODIUM ARSENATE

A dry powder containing over 45% arsenic pentoxide. Used in wood preserving compounds and ant baits.

100 lb. drums

CHIPMAN SODIUM ARSENITE

See Page 20 for Detailed Description.

CHIPMAN STOCK SPRAY

For control of such livestock pests as sheep tick, wool maggots, horn fly, lice and ticks on cattle, horses, hogs, sheep and goats; also sarcoptic mange mites.

CHIPMAN [illegible] Contains 4.17 pounds of toxaphene and .125 pounds of Lindane per gallon. Applied as a water-mixed dip or spray.

5 gal. drums—1 gal. jugs (4 in case)
1 qt. bottles (12 in case)

CHIPMAN [illegible] Contains 6 pounds of toxaphene per gallon. Applied as a water-mixed dip or spray.

5 gal. drums—1 gal. jugs (4 in case)

SYSTOX

A Systemic Insecticide

Highly effective for control of aphids, mites and certain leafhoppers. Recommended for use on a wide variety of crops, including cotton, seed alfalfa, apples, pears, oranges, potatoes, cabbage and others; also ornamentals. Has a long residual effect at relatively low dosages. Contains 2 pounds of active ingredient per gallon. Applied as a water-emulsion spray.

1 gal. cans (6 in case)

CHIPMAN [illegible]

For Insect and Blight Control

Contains 20% calcium arsenate and 7% metallic copper in the form of a micro-fine neutral copper fungicide. For control of tomato hornworm, tomato fruitworm and flea beetles. Also aids in control of early and late blight.

50 lb. bags—4 lb. bags (12 in case)

CHIPMAN TOXAPHENE DUSTS & SPRAYS

Kill by stomach poisoning and contact. Control cotton insects, including boll weevil, bollworm, fleahoppers, leafworm, grasshoppers, rapid plant bug, thrips and other sucking insects. Used on other crops for control of grasshoppers, southern green stinkbug, armyworms, chinch bug and other insects.

CHIPMAN [illegible] Contain 10% or 20% Toxaphene; with or without 40% sulfur or 3% Malathion.

50 lb. bags

CHIPMAN TOXAPHENE [illegible] Contains 6 pounds of Toxaphene per gallon.

55 gal. drums—30 gal. drums—5 gal. drums
1 gal. jugs (4 in case)

CHIPMAN [illegible] Contains 4 pounds of Toxaphene and 2 pounds of DDT per gallon.

55 gal. drums—30 gal. drums—5 gal. drums

Pasadena, Tex., Bessemer, Ala.

CHIPMAN TOXAPHENE [illegible] For use as a spray or as a base for making dusts.

50 lb. bags

Debarking Compounds

ATLAS "D" DEBARKING COMPOUND

Used during sap-flow season to obtain easy removal of bark from standing timber intended for pulpwood, fence posts and poles. Saves labor and equipment. Bark falls off or is permanently loosened. Contains material repellent to deer, cattle and sheep. One gallon is sufficient to treat 125 to 150 trees. Applied on sap-peeled girdle. Colored so treated girdle can be seen.

55 gal. drums—30 gal. drums—5 gal. drums—2 gal. cans

ATLAS [illegible] DEBARKING COMPOUND

Similar to Atlas "D" Debarking Compound, but without animal repellent.

55 gal. drums—30 gal. drums—5 gal. drums—2 gal. cans

Defoliants and Desiccants

Liquid, Spray Powder and Dust

The original chlorate defoliant and desiccant. Outstanding for cotton defoliation; gives excellent results on dry edible beans and tomatoes. Hastens maturity of crops and permits early harvesting. Defoliation of cotton plants facilitates picking, reduces late insect infestation and boll rot. Shed-A-Leaf is also effective as a rice and milo desiccant to reduce head moisture. Applied by airplane or ground applicators. These Shed-A-Leaf products are available:

A water-soluble powder. Used as a spray.
50 lb. bags

A liquid — mixes easily in water.
55 gal. drums—30 gal. drums—5 gal. drums

For dry applications on cotton.
50 lb. bags

Fungicides

Antibiotic Spray Powder

Contains Streptomycin and Oxytetracycline antibiotics. Gives most effective control of fire blight of pears and apples; also certain diseases of tomatoes, potatoes, tobacco and walnuts. Prevents spread of disease — cleans out infection from within the plants. Economical — one jar makes up to 400 gallons of water-mixed spray.

9.34 oz. jars (24 in case)—25 lb. drums

A neutral and chemically stable insoluble copper sulfate. Contains 53% metallic copper. For control of vegetable and fruit diseases, such as early and late blight of potatoes, tomatoes and celery; downy mildew and anthracnose of cucumbers, melons and grapes; scab and melanose of citrus fruits. Applied as a dust or spray. Compatible with insecticides.

50 lb. bags—6 lb. bags (8 in case)

A Better Bordeaux Mixture

For control of downy mildew, blight, leaf spot and many other diseases of fruit and truck crops. Applied as a spray or dust. Contains 13% metallic copper. Has no lime and will not deteriorate.

4 lb. bags (12 in case)
1 lb. bags (24 in case)

For use as a dust or spray to control such diseases as scab, leaf blight and fruit spot of pears; brown rot of peaches; scab of apples; black rot of grapes; fruit rots of cranberries; anthracnose of tomatoes and beans; blue mold of tobacco; downy mildew of cabbage; damping-off of lettuce; certain diseases of ornamentals.

50 lb. bags—3 lb. bags (12 in case)

New Mercury Fungicide

A wettable powder for use as a spray to control apple scab and certain diseases of turf.

2½ lb. bags (18 in case)

A wettable powder for use as a water-mixed spray to control fungus diseases, such as apple scab, bean anthracnose, celery blight, cherry leaf spot, peach leaf curl and brown rot, tomato leaf blight and black spot of roses. Contains 50% Dichlone. Compatible with lead arsenate, rotenone and Chlordane.

100 lb. drums—4 lb. bags (12 in case)—1 lb. bags (12 in case)

See page 19 for use as algicide.

Used on apples, pears, peaches, plums, cherries, asparagus, beans and peas; also flowers and ornamentals. For control of scab, powdery mildew, frog-eye, brown rot, rusts and black spot; also spider mites. Contains 98½% sulfur. Applied as a dust or spray.

50 lb. bags

CHIPMAN POTATO & TOMATO DUSTS

See pages 9 and 10 for Descriptions.

Combined fungicide and insecticide dusts.

Seed Protectants

AGROX

Mercurial Seed Disinfectant

Controls bunt or stinking smut of wheat, covered smut and leaf stripe of barley and oats, stem and covered smut of rye, kernel smut of sorghum; also protects against seed rot and seedling blight. Used to treat seed of other crops including cotton, rice and flax. A practically non-dusty powder; applied dry or as a slurry. Contains 6.70% Phenyl Mercury Urea (equivalent to 4% metallic mercury).

100 lb. drums—50 lb. drums—3 lb. tins (8 in case)
14 oz. tins (12 in case)

AGROX RED

A water-soluble dye which may be added to Agrox and Mergamma when used in slurry treatments. Colors the seed red so it can be more easily identified as treated.

2½ oz. bottles (24 in case)

MERGAMMA

Liquid Seed Disinfectant

Controls seed-borne diseases of wheat, barley and oats (see Agrox above); also cotton, flax and sorghum. Protects against seed rot and seedling blight. Pleasant to use, no odor and no dust. Easy to apply in liquid or slurry treater — no foaming, no settling out and no sludge. Contains 11.4% Methoxy Ethyl Mercury Acetate (equivalent to 0.6 pounds of metallic mercury per gallon).

1 gal. jugs (4 in case)

For Ready-Mix (Automatic) Treaters

A liquid containing 4.88% Methoxy-ethyl-mercury acetate; equivalent to 3.07% metallic mercury. Especially formulated for use in Mist-o-matic and other closed type treaters. No further dilution required. Contains wetting agent and red dye. Controls certain seed-borne diseases of wheat, oats and barley; also seed rot and seedling blight.

55 gal. drums—30 gal. drums—5 gal. drums

Wireworm Killer and Seed Disinfectant

Original 2-*way* seed protectant for wheat, oats, barley, sorghum, flax and corn. (1) Kills wireworms and false wireworms. (2) Controls certain seed-borne diseases, such as bunt or stinking smut of wheat; protects against seed rot and seedling blight. Applied in original dry form or as a slurry. Contains a combination of 40% gamma isomer of BHC and 1.93% Phenyl Mercury Urea (equivalent to 1.15% metallic mercury).

40 lb. drums—5 lb. tins (8 in case)—12 oz. tins (12 in case)

A Non-Mercurial Seed Disinfectant

A wettable powder especially formulated for control of stinking smut or bunt of wheat. Contains 40% Hexachlorobenzene. Applied in dust or slurry treaters.

40 lb. bags—5 lb. bags (8 in case)

Portland, Ore.

Weed Killers

For Weed Control in Cotton

A new liquid pre-emergence weed killer for irrigated cotton. Used as a pre-emergence spray before cotton plants come up; also in established cotton as a directed post-emergence treatment. For control of certain weeds and grasses infesting irrigated cotton areas of West Texas, New Mexico and California.

5 gal. cans—1 gal. cans (4 in case)

Chlorate Weed Killer

A non-selective weed and grass killer, backed by over 25 years of successful use in the United States and foreign countries. Millions of pounds have been used on farm land, along highways and many other places infested with undesirable vegetation. Controls bindweed, Canada thistle, poison ivy, Johnson grass, Bermuda grass, quack grass and many other species of weeds and grasses. Also used to kill trees and stumps. Destroys roots of plants so that permanent eradication can be obtained. Soluble in water for use as a spray or can be effectively applied in its original dry powder form ($1\frac{1}{2}$ pounds treat about 100 square feet). Atlacide contains certain chemicals which both increase the effectiveness of its sodium chlorate content and substantially reduce the fire hazard encountered with the use of "straight" sodium chlorate.

100 lb. drums

Atlacide in combination with 2,4-D Acid (6/10 of 1% equivalent). Has the dual killing action of chlorate and 2,4-D. Particularly effective for controlling Canada thistle. Applied dry or as a spray.

100 lb. drums

Portland, Ore.

Sodium Arsenite Solution

Contains 4 pounds of arsenic trioxide per gallon (equivalent to 5.33 pounds of Chipman Sodium Arsenite). Mixes readily in cold water, is non-inflammable and non-explosive. Highly recommended for eliminating various weeds in fish ponds and lakes; also for selective kill of certain turf weeds. Used to kill annual growth and shallow-rooted perennials. Also used to destroy trees or stumps. Recommended for killing potato vines prior to harvesting. Very effective for control of subterranean termites.

55 gal. drums—30 gal. drums—5 gal. drums

ATLAS "A" [illegible]

Contains 9.5 pounds of arsenic trioxide per gallon. Used for the same purposes as Atlas "A".

30 gal. drums—5 gal. drums

Bound Brook, N. J.

CHIPMAN LOW VOLATILE BRUSH KILLER No. 2

For Mixed Species of Brush and Weeds

Contains a combination of 2,4,5-T and 2,4-D acids (Propylene Glycol Butyl Ether Esters of 2,4,5-T and 2,4-D) in equal parts; equivalent to 2 pounds of each per gallon. Especially formulated for controlling mixed species of woody plants and broad-leaved weeds. Controls such woody plants as poison ivy, alder, birch and blackberry. Applied as a water or oil-mixed spray.

55 gal. drums—30 gal. drums—5 gal. drums
1 gal. cans (4 in case)—1 qt. cans (6 in case)

[illegible]

A *granular* form of Chloro IPC: contains 10% Isopropyl-N-(3-chlorophenyl)-carbamate. Controls annual weedy seedling grasses in established ladino clover and alfalfa; annual seedling grasses and chickweed in onions and asparagus. For post-emergence control of annual seedling grasses in carrots and parsley.

40 lb. bags

CHIPMAN CHLORAX "40"

Non-separating composition of sodium chlorate and sodium metaborate. Does not create fire hazard. May be applied dry or dissolved in water for use as a spray. Used to kill deep-rooted perennials, also annual weeds and grasses. Produces a residual effect which discourages regrowth. Especially suited for use around buildings, along fence rows, and similar locations.

50 lb. bags

CHIPMAN [illegible] "40"

Used for the same purposes as Chlorax "40"; particularly effective as a contact spray for weeds and grasses along ditch banks, fence rows and other similar places.

55 gal. drums—30 gal. drums—5 gal. drums

[illegible]

Weed and Grass Killer

Specially formulated for control of *all* vegetation. Combines the proved effectiveness of sodium chlorate on deep-rooted perennials with the soil-surface action of 3(p-chlorophenyl)-1, 1-dimethylurea (Telvar W) on shallow-rooted grasses, weeds and seedling growth. Has a long residual effect which inhibits new growth. Is non-poisonous. *Does not create a fire hazard.* Used for control of weeds and grasses around buildings, in storage areas, parking areas, along track sidings, fence lines, around granaries, in driveways and other similar locations. *Applied dry or as a water-mixed spray.*

50 lb. bags

[illegible]

Contains 4 pounds of Isopropyl-N (3 Chlorophenyl) Carbamate per gallon. Used for *pre-emergence* weed and grass control in cotton, soybeans, spinach and onions. Controls morning glory, chickweed, purslane and certain other annual weeds and grasses.

55 gal. drums—30 gal. drums—5 gal. drums
1 gal. jugs (4 in case)

[illegible]

Algicide for Ponds, Lakes and Canals

Contains technical abietylamine acetates. Two forms are available:

[illegible] A solution for spray applications.
55, 30, 12, 6 and 1 gal. drums

[illegible] A paste for "float" and "drag" applications.
55, 30, 12, 6 and 1 gal. drums

CHIPMAN IPC 2L

Contains equivalent of 2 pounds technical IPC per gallon. For use in Pacific Northwest to control weedy seedling grasses in established alfalfa, certain clovers, strawberries, cane berries, lotus lilies and daffodils. Controls wild oats and pigeongrass in sugar beets and peas. Also for quackgrass control.

55 gal. drums—30 gal. drums—5 gal. drums

Portland, Ore.

METHOXONE

Selective Weed Killer

A liquid containing 23.20% sodium salt of 2-Methyl 4-Chlorophenoxyacetic acid; equivalent to 2 pounds of MCP acid per gallon. Mixes readily with water. Similar in action to 2,4-D. Used for selective control of broad-leaved weeds in rice, wheat, oats, barley, corn, flax and grasses. Better yields have resulted with Methoxone than with 2,4-D. Also highly recommended for yellow rocket (winter cress) control in *dormant* alfalfa or red clover. Used for non-selective control, particularly on Canada thistle and white top.

55 gal. drums—30 gal. drums—5 gal. drums
1 gal. cans (4 in case)

DICHLONE 50L

Aligicide for Ponds and Lakes

For use in ponds, lakes, irrigation reservoirs and similar bodies of water. Particularly recommended to control bloom-producing, *blue green algae.* A wettable powder used as a spray, or applied by "drag" method. Contains 50% Dichlone.

100 lb. drums—4 lb. bags (12 in case)—1 lb. bags (12 in case)

CHIPMAN SODIUM CHLORATE

Used extensively as a chemical weed killer — 99% pure.

Steel drums

CHIPMAN SODIUM ARSENITE

Weed Killer and Insecticide

A pink powder containing 75% arsenious oxide, the killing ingredient. Easy to handle and economical to use. May be applied dry or mixed in water. Five and one-third pounds are equivalent to 1 gallon of Atlas "A".

WEED KILLER: Used for general weed control and for eradicating crabgrass and certain other weeds in turf. Effective as a tree and stump killer. May be used for eliminating submersed vegetation in fish ponds and lakes.

INSECTICIDE: Widely used for subterranean termite control in soil treatments. Also used in poison baits for grasshoppers, armyworms, cutworms and earwigs.

100 lb. drums

CHIPMAN 2,4-D WEED KILLING

For Selective and General Control

For control of many broad-leaved weeds in small grains, corn, flax, rice, sorghum, sugar cane, pastures and turf areas. Used for non-selective control of various annuals, biennials and perennials, also to prevent seed formation. Leaves no residue harmful to humans or animals. Non-inflammable, non-corrosive and only temporarily affects the soil. To meet requirements for various uses, types of weeds and methods of application, these Chipman 2,4-D Weed Killers are available:

CHIPMAN [illegible] Contains equivalent of 4 pounds of 2,4-D acid per gallon. For selective control in tolerant crops and where volatile esters must be avoided. Mixes readily with water.

55 gal. drums—30 gal. drums—5 gal. drums
1 gal. cans (4 in case)

CHIPMAN [illegible] Contains 3.34 pounds of 2,4-D acid equivalent per gallon. Used for selective control where ester is recommended and for non-selected control where susceptible crops are not growing in the vicinity. Emulsifiable in water and soluble in oil.

55 gal. drums—30 gal. drums—5 gal. drums
1 gal. cans (4 in case)

CHIPMAN [illegible] Contains equivalent of 6 pounds of 2,4-D acid per gallon. Used for selective weed control in small grains. Particularly suited for airplane applications. Applied as a water or oil-mixed spray.

55 gal. drums—30 gal. drums

Chicago, Ill.

CHIPMAN [illegible] Contains 2.67 pounds of 2,4-D acid equivalent per gallon. Used for the same purposes as Chipman 2,4-D Ester.

55 gal. drums—30 gal. drums—5 gal. drums
1 gal. cans (4 in case)

Chicago, Ill.

CHIPMAN [illegible] Contains 6 pounds of 2,4-D acid equivalent per gallon. Especially recommended for airplane application to control weeds in wheat and other grains. Applied as a water or oil-mixed spray.

55 gal. drums—30 gal. drums

**Portland, Ore.*

CHIPMAN [illegible] Contains equivalent of 4 pounds of 2,4-D acid per gallon. Less likely to injure crops near area of treatment than the isopropyl or butyl esters. Applied as a water or oil-mixed spray.

55 gal. drums—30 gal. drums—5 gal. drums
1 gal. cans (4 in case)

[illegible]

Contain 5%, 8% and 10% Ester of 2,4-D; equivalent to 4.2%, 6.7% and 8.4% 2,4-D acid respectively. Used chiefly for selective weed control in grains and grasses; sold only where the use of 2,4-D dust is permitted. For application with *ground* equipment only.

50 lb. bags

Chicago, Ill., Portland, Ore.

CHIPMAN 2,4,5-T LOW VOLATILE ESTER 4L

Kills Woody Plants

Contains 65.3% low volatile Propylene Glycol Butyl Ether Esters of 2,4,5-T; equivalent to 4 pounds of 2,4,5-T acid per gallon. Particularly recommended for 2,4-D resistant plants such as blackberry, osage orange and many other woody plants. May be combined with 2,4-D Low Volatile Ester 4L for control of a wider variety of perennials. Suited for use along fence rows, ditch banks, rights-of-way, in pastures, and other similar areas, Applied as water or oil-mixed spray.

55 gal. drums—30 gal. drums—5 gal. drums
1 gal. cans (4 in case)

Wetting Agent

CHIPMAN ADDITIVE

Spreader, Depositor, Penetrant

For use in agricultural sprays, including insecticides, fungicides, weed killers, defoliants or desiccants. Improves wetting and covering of plants; aids in penetration and sticking actions on vegetation. Reduces foaming in spray tank.

1 gal. cans (6 in case)

CHIPMAN

1957

INSECTICIDES

FUNGICIDES

HERBICIDES

DEFOLIANTS

Christiansen, P. 1995. Personal communication (letter to R. Ferguson, Rhone Poulenc AG Company, Research Triangle Park, NC, dated January 27, 1995, regarding HW – Multnomah County, ORD990659492, NWR-HW-95-010, Notice of Noncompliance). Oregon Department of Environmental Quality, Portland, OR.

Oregon

DEPARTMENT OF
ENVIRONMENTAL
QUALITY

NORTHWEST REGION

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

January 27, 1995

MR ROBERT FERGUSON
RHONE POULENC AG COMPANY
PO BOX 12014
RESEARCH TRIANGLE PARK NORTH CAROLINA 27709

Re: HW - Multnomah County
ORD990659492
NWR-HW-95-010
NOTICE OF NONCOMPLIANCE

Dear Mr. Ferguson:

This Notice of Noncompliance (Notice) is issued in accordance with OAR 340-12-041(1) for hazardous waste violations documented by the Oregon Department of Environmental Quality (DEQ) at the Rhône Poulenc Ag Company (Rhône Poulenc) facility, located at 6200 NW St. Helens Road, Multnomah County, Oregon. The violations were identified during the DEQ's December 22, 1994, inspection. Two copies of DEQ's inspection report are enclosed - the report provides additional information on the violations cited in this Notice.

Violations documented include violations of Oregon's hazardous waste management statutes (Oregon Revised Statutes or ORS) and regulations (Oregon Administrative Rules or OAR). The Oregon Administrative Rules include federal regulations adopted from Title 40 of the Code of Federal Regulations (40 CFR). At the time of DEQ's inspection, Rhône Poulenc was subject to those hazardous waste regulations applicable to large quantity hazardous waste generators (generate over 2,200 pounds of hazardous waste per month).

In addition to hazardous waste regulations governing generator activity, Rhône Poulenc has entered an Order on Consent (Order) and related Addendum to Order on Consent (Addendum) which requires compliance with certain hazardous waste management regulations that would otherwise apply to permitted hazardous waste storage facilities. Violations cited in this Notice also include violations of regulations specified in conditions of the Addendum.

2020 SW Fourth Avenue
Suite 400
Portland, OR 97201-4987
(503) 229-5263 Voice/TDD

The purpose of this Notice is to inform you of violations that have been identified so that you can begin to take action to correct them. Based upon your response to these violations and upon completion of DEQ's investigation, additional violations may be identified. You will be informed in a subsequent Notice of Noncompliance if additional violations need to be corrected.

VIOLATIONS

VIOLATION 1: Rhône Poulenc violated OAR 340-102-011 by failing to perform a hazardous waste determination.

OAR 340-102-011 requires that generators determine whether or not a waste is a hazardous waste. A correct waste characterization includes a determination of whether or not a waste is listed (40 CFR § 261 Subpart D), exhibits a characteristic (40 CFR § 261 Subpart C), or is an Oregon-only hazardous waste (OAR 340-102-033).

During the inspection, DEQ representatives reviewed characterization data for several of Rhône Poulenc's wastestreams that had been shipped off-site. The following wastestreams were improperly characterized:

Wastestream	Rhône Poulenc Waste Code(s)	Additional Waste Code(s)
Wood Tanks	nonhazardous	K099, U240
V501/V262 Tanks	D016	K099, U240
Insecticide Building	P037, U061	P123, U129, U240
Carbon/Quartz	nonhazardous	K099, U240
T24 Solids	unknown	unknown
2,4D Building	nonhazardous	U240
2,4D Ester Area	X001	U240
RI/FS Soil	D016, X001, nonhazardous	K099, U240, D016, D042
WWTU Carbon	nonhazardous	K099, U240

In addition to the above wastestreams, DEQ representatives observed 15 containers of soil cuttings generated during remedial investigation activity conducted pursuant to the Order. The waste in the containers had been stored at the facility since July and August, 1994; a waste characterization had not been performed at the time of the inspection.

VIOLATION 2: Rhône Poulenc violated 40 CFR § 268.7(a) as adopted in OAR 340-100-002 by failing to determine whether or not a waste meets land disposal restriction standards.

40 CFR § 268.7(a) requires that hazardous waste generators determine whether or not hazardous wastes are restricted from land disposal, and whether or not hazardous wastes meet applicable treatment standards. 40 CFR § 268.7(a) also requires generators to either notify off-site hazardous waste management facilities if wastes require treatment or certify that wastes meet treatment standards (as appropriate).

All of the waste streams referenced in Violation 1 (with the possible exception of T24 solids and the uncharacterized soil cuttings stored on-site) are restricted from land disposal. Because Rhône Poulenc failed to perform a correct hazardous waste determination, incorrect land disposal restriction notices were submitted to hazardous waste management facilities. This resulted in landfilling of approximately 92,700 lbs. of spent carbon, approximately 33,000 lbs. of contaminated soil, and an unknown quantity of demolition debris that required treatment prior to disposal.

VIOLATION 3: Rhône Poulenc violated ORS 466.100(1) by disposing of hazardous waste at a facility not permitted to handle the waste.

ORS 466.100(1) requires that hazardous waste be disposed only at a facility that is permitted for hazardous waste disposal.

Several of Rhône Poulenc's hazardous wastestreams were not characterized correctly, as referenced in Violation 1. Most (probably all) of the improperly characterized wastestreams were restricted from land disposal, and Rhône Poulenc did not perform the proper determination of land disposal restriction applicability, as referenced in Violation 2. Wastes referenced in Violations 1 and 2 were landfilled at either Chemical Waste Management of the Northwest (CWMNW), Arlington, Oregon or the disposal location is unknown. CWMNW is not permitted

to landfill hazardous waste that does not meet treatment standards.[1] Hazardous wastes disposed illegally include:

Wastestream	Waste Code(s)	Disposal Location	Approximate Quantity (lbs.)
Spent Carbon	K099, U240	CWMNW	92,700
RI/FS Soil	K099, U240, D016, D042	CWMNW, unknown	33,000

VIOLATION 4: Rhône Poulenc violated 40 CFR § 262.34(a)(2)[2] by failing to label containers with accumulation start dates.

40 CFR § 262.34(a)(2) requires that containers of hazardous waste be labelled with the date upon which waste accumulation began.

During the inspection, DEQ representatives observed a total of nine - 55 gallon containers of soil cuttings from remedial investigation activity stored in the waste storage building. The containers were labelled with the month and year accumulation began, not the complete date.

VIOLATION 5: Rhône Poulenc violated 40 CFR § 264.16(d)(4) as referenced in the Addendum by failing to maintain hazardous waste personnel training records.

Condition III.D. of the Addendum requires compliance with 40 CFR § 264.16, which requires that records of personnel training be maintained in facility files.

During the inspection, DEQ representatives observed that documentation of hazardous waste-specific training was not available for Rhône Poulenc employees. Employees involved in the hazardous waste management program include Mr. Woodworth, Mr. Gitschlag, and Mr. Henshaw.

---

1 Hazardous waste that is prohibited from land disposal may only be land disposed at facilities that have been granted no migration petitions (40 CFR § 268.6).

2 OAR 340-102-034(2) requires compliance with 40 CFR § 262.34(a) - (f). For simplicity, applicable 40 CFR § 262.34 regulations [rather than OAR 340-102-043(2)] are cited.

VIOLATION 6: Rhône Poulenc violated 40 CFR § 264.52(d) as referenced in the Addendum by failing to list emergency coordinator addresses and telephone numbers in the Contingency Plan.

Condition III.F. of the Addendum requires compliance with 40 CFR § 264 Subpart D. 40 CFR § 264.52(d) requires that the Contingency Plan's list of emergency coordinators include home addresses and telephone numbers.

During the inspection, DEQ representatives observed that Rhône Poulenc's Contingency Plan did not list emergency coordinator home addresses and telephone numbers.

REQUESTED ACTION

You are requested to immediately begin addressing the violations cited in this Notice and inform DEQ of the actions you have taken to correct the violations and prevent their recurrence. Please take the following immediate actions:

1. Regarding Violation 1, please properly characterize all hazardous wastes at the facility. Many of the wastestreams referenced in Violation 1 have been disposed and future generation of these wastestreams is not anticipated, so no action is specifically requested on these wastestreams. However, it is anticipated that generation of spent carbon, collection sump sludge, and soil from remedial investigation activity will continue. Please provide a written waste characterization for these three wastestreams.

2. Regarding Violations 2 and 3, many of the wastes referenced have been disposed, so no specific action is requested on these wastes; however, generation of the carbon, sump sludge, and soil wastestreams may continue. Please submit, with your waste characterization referenced above, your analysis of whether or not these wastestreams meet land disposal restriction treatment standards.

3. Regarding Violation 4, please properly label the containers referenced in the violation with complete accumulation start dates. Please provide a written list of the accumulation start date(s) that you have placed upon each of the nine containers.

4. Regarding Violation 5, please take immediate action to institute a program of documenting hazardous waste-specific training. Please provide a list of personnel involved in hazardous waste management and a description of the type of hazardous waste training that each of these persons will receive.

5. Regarding Violation 6, please take immediate action to revise the Contingency Plan to include emergency coordinator addresses and telephone numbers. Please provide a copy of the revised emergency coordinator list.

Please send to my attention all of the items requested above within thirty (30) days of receipt of this Notice.

The violations cited in this Notice include Class I violations, which are considered to be serious violations of Oregon environmental law. Therefore, we are referring these violations to DEQ's Enforcement Section with a recommendation to initiate a formal enforcement action. A formal enforcement action may include a civil penalty assessment for each day of violation.

You may contact me at (503) 229-5556 if you have any questions concerning this Notice or other hazardous waste management issues.

Sincerely,

Paul Christiansen
Environmental Engineer

cc United States Environmental Protection Agency
Enforcement Section, DEQ
Site Response, DEQ
Hazardous Waste Policy and Program Development, DEQ

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8 Waste Characterization Data - Insecticide Building

9 Waste Characterization Data - RI/FS Soil

10 50 FR 31170 - Treatment Standard Promulgation for K099 Wastes

1.0 INTRODUCTION

1.1 Inspection Purpose and Authority

This inspection was performed to determine Rhône Poulenc Ag Company's (Rhône Poulenc's) compliance with Oregon's hazardous waste management regulations [Chapter 340, Divisions 100 - 120 of the Oregon Administrative Rules (OAR)] and statutes [Chapter 466 of the Oregon Revised Statutes (ORS)].

The Oregon Department of Environmental Quality (the Department or DEQ) is authorized by the United States Environmental Protection Agency (EPA) to implement the majority of the federal hazardous waste management program (40 CFR §§ 260 - 270). The Department has also adopted additional hazardous waste regulations to complement the federal program. These regulations include federal regulations that have been adopted by reference by the Department prior to receiving formal authorization from EPA and state-only hazardous waste management regulations.

This inspection examined hazardous waste management practices at the Rhône Poulenc facility; specifically, those practices related to hazardous waste generation, management, and storage. The inspection was performed pursuant to the Department's authorities set forth in ORS 466.195.

Under state cleanup authority, Rhône Poulenc has entered an Order on Consent (Order) for a facility investigation and cleanup. Due to issues related to long-term storage of hazardous waste, an Addendum to the Order (Addendum) was executed allowing Rhône Poulenc to store hazardous waste, without obtaining a hazardous waste storage permit, provided that certain conditions in the Addendum were followed. This inspection also included an evaluation of whether or not Rhône Poulenc met hazardous waste storage requirements of the Addendum.

1.2 Facility Background and Compliance History

1.2.1 Operational History

The facility at the Rhône Poulenc property began as a pesticide mixing and packaging facility operated by Chipman Chemical Company in 1943. In 1964, Chipman Chemical became a division of Rhodia, Inc., and in approximately 1979, the facility was purchased and operated by Rhône Poulenc.

In approximately 1956 a plant was constructed for the manufacture of 2,4 dichlorophenoxyacetic acid (2,4D) and esters. In 1961 a plant was constructed for the manufacture of 2-methyl 4-chloro phenoxyacetic acid (MCPA). In 1960, the facility briefly manufactured 2,4,5 trichlorophenoxyacetic acid (2,4,5T); however, this operation was discontinued shortly after startup. In 1964 a plant was constructed for

the manufacture of 2,4 dichlorophenoxybutyric acid (2,4DB). In 1967 a new MCPA plant was constructed. In 1971, Rhône Poulenc constructed a plant for production of bromoxynil octanoate (BO) pesticide.

In 1982, the production of 2,4D, MCPA, and 2,4DB ceased. From 1982 through 1990, Rhône Poulenc manufactured only BO; however, during this period, other pesticide products were formulated by mixing chemicals manufactured off-site. On the date of the inspection described in this report, Rhône Poulenc had ceased all production operations and was only involved in environmental remediation at the facility.

1.2.2 Water Quality

Prior to 1964, untreated process wastewater from pesticide manufacturing operations was routinely discharged to the Willamette River and Doane Lake. Since approximately 1964, wastewater from pesticide production was treated by carbon adsorption and lime neutralization prior to discharge into Doane Lake and the Willamette River. This treatment and subsequent discharge occurred pursuant to a National Pollutant Discharge Elimination System (NPDES) permit issued by DEQ. In mid-1977, treated process wastewater was discharged to the City of Portland's Publicly-Owned Treatment Works (POTW). Surface water runoff continued to be collected and discharged under the NPDES permit.

During plant operations prior to 1982, Rhône Poulenc had several incidents of untreated or partially-treated process water discharges to the Willamette River or Doane Lake, in violation of the NPDES permit. These releases, along with accidental spills and process leakage typical of chemical manufacturing operations during the 1960's and 1970's, have contaminated soil and groundwater in the vicinity of the Rhône Poulenc facility.

At the time of this inspection, Rhône Poulenc was actively treating groundwater and surface water runoff to NPDES permit conditions for discharge into the Willamette River. Because production operations had ceased, the discharge of process wastewater to the City of Portland POTW was discontinued.

1.2.3 Environmental Remediation

In 1980, Rhône Poulenc installed a series of piezometers to monitor groundwater near the plant. Initially, the wells recovered trace levels of constituents associated with the production of the various chemicals at the facility (primarily chlorinated phenolics). Following installation, groundwater from the wells was pumped continuously for treatment and subsequent discharge under the NPDES permit.

Clinton, C.R. 1982. Personal communication (telephone conversation with B. Briggs, Rhone-Poulenc, Portland, OR, on June 17, 1982, regarding 2,4-D iso octyl ester spill).

- Upset ' iditions -

Lo d: ~~[illegible]~~ To: EMC

MEMORANDUM - Re: Code-A-Phone/Phone Messages

Report received by: CRC

Call received from: Bob Briggs

For Source/Company: Rhone-Poulenc

Phone: _____ County: Multnomah

AQ ____ WQ X NP ____ SW ____ Other ____

Date: 6/17/82

Time: 12:15

Return call: ____

They will call later: ____

Message: Tank of truck cracked when loading 2,4-D isooctyl ester. Approximately 20 to 50 gallon spilled on ~~compre~~ concrete. but some spilled over onto railroad ~~right of way~~ tracks. they will remove dirt from this area.

NWR/6-79

DEQ. No date. Public notice and fact sheet regarding application number 071-OYA-2-000314. File No. 74921. Oregon Department of Environmental Quality, Portland, OR.

PUBLIC NOTICE AND FACT SHEET

Department of Environmental Quality
1234 S. W. Morrison Street
Portland, Oregon 97205
Telephone: (503) 229-5696

Date:

File No. 74921

Application No. 071-OYA-2-000314

This public notice and fact sheet has been prepared to provide public information concerning the following application for a National Pollutant Discharge Elimination System Permit to discharge pollutants to navigable waters pursuant to the provisions of Oregon Revised Statutes (ORS) 449.083 and the Federal Water Pollution Control Act Amendments of 1972, P.L. 92-500, October 18, 1972.

APPLICANT: Rhodia, Incorporated
Chipman Division
600 Madison Avenue
New York, New York 10022
Re: Portland Plant - 6200 N.W. St. Helens Road

DESCRIPTION OF FACILITY AND DISCHARGE:

Rhodia Incorporated, Chipman Division, owns and operates on agricultural chemical manufacturing plant in N.W. Portland. In November 1969 Rhodia completed installation of two carbon absorption/filtration units with lime neutralization for removal of phenols, cresols and product related molecules from waste waters. The company has two waste streams. The total combined flow averages 0.129 MGD. (0.193 cfs) The existing outfall line has become inoperative so that both streams flow to what remains of Doane Lake and overflows to the Willamette River.

TENTATIVE DETERMINATION, APPLICABLE EFFLUENT LIMITATIONS AND WATER QUALITY STANDARDS

The Department of Environmental Quality has reviewed the application and has tentatively determined to issue a permit to discharge subject to lawful rules and regulations, water quality standards for The Willamette River contained in OAR 340-41-045, applicable effluent guidelines and limitations and certain special conditions. A final determination will not be made until after all comments received, pursuant to the public notice, have been evaluated.

The receiving stream has been classified for the following beneficial uses: domestic water supply, industrial water supply, anaoromous fish passage, fishing and water contact sports and navigation.

The effluent limitations are based upon current state programs and acceptable limits. No EPA guidelines are being prepared.

Fact Sheet
Rhodia, Incorporated

PROPOSED EFFLUENT LIMITATIONS

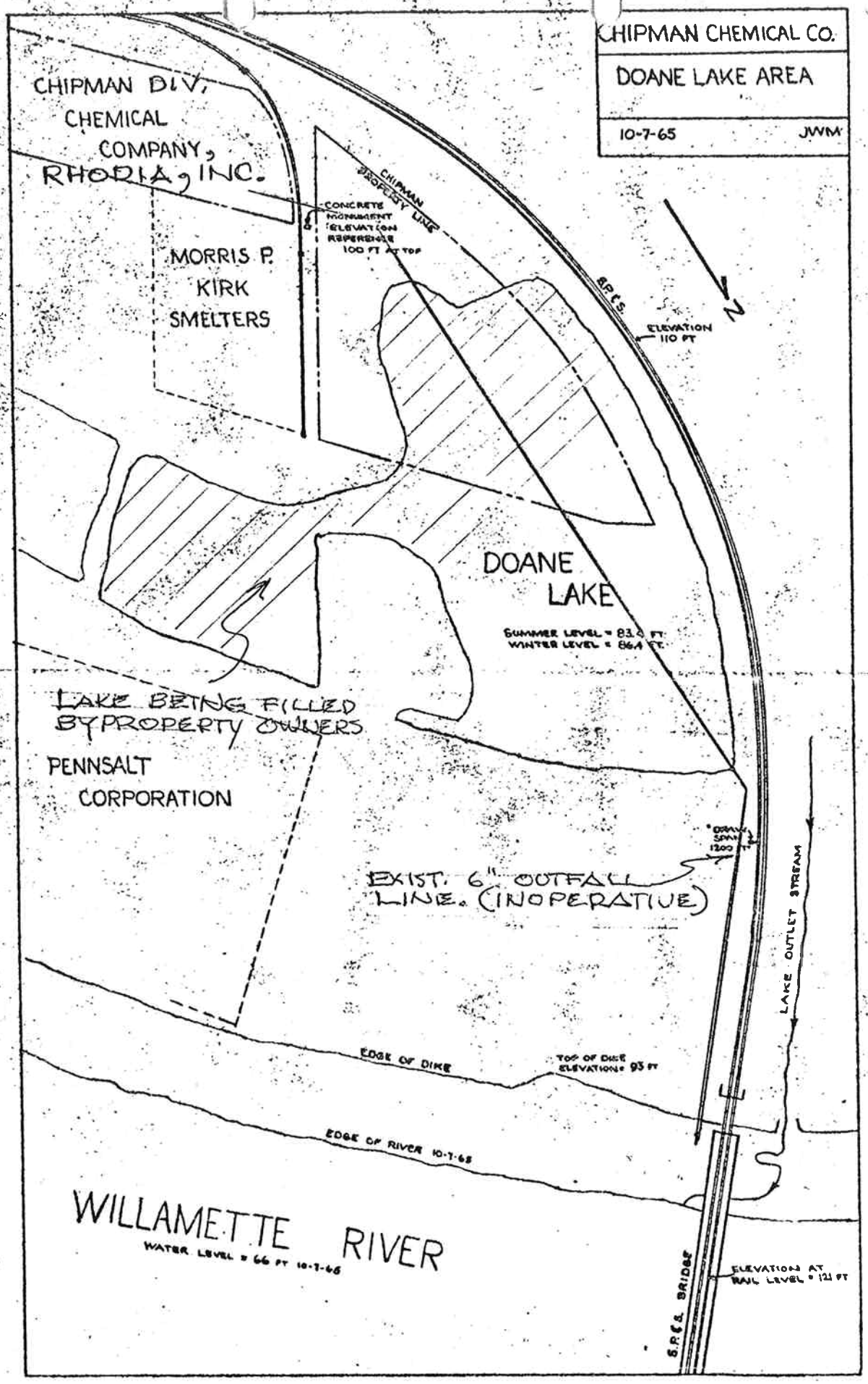
Parameter	Average Discharge per day Now	After April 1, 1976
COD	1800 #/day	275 #/day
Suspended Solids	260 #/day	50 #/day
Dissolved Solids	46,000 #/day	23,000 #/day
Phenols Incl. Chlorohphenols	2.15 #/day	shall not exceed 0.2 mg/l or 0.12 #/day
Chlorophenols Incl. Chlorocresols	1.07 #/day	shall not exceed 0.1 mg/l or 0.06 #/day
Total Chlorinated Hydrocarbons	22.0 #/day	1.5 #/day
pH	Shall not be outside range 6.5 to 8.5	

PROPOSED SCHEDULE OF COMPLIANCE

a. Installation of treated waste outfall line and diffuser in the Willamette River by September 1, 1974.
b. Upgrade waste treatment and take other measures to achieve effluent limits required after April 1, 1976.

PROPOSED SPECIAL CONDITIONS

a. Extensive monitoring and reporting is required.
b. Prepare and implement a spill prevention and contingency plan.
c. A mixing zone the width of the diffuser plus fifty feet on each end and extending twenty five feet upstream of the diffuser to a hundred feet downstream of the diffuser will be allowed.
d. The proposed expiration date is July 1, 1976.


CHIPMAN CHEMICAL CO.
DOANE LAKE AREA
10-7-65
JWM
CHIPMAN DIV.
CHEMICAL
COMPANY,
RHODIA, INC.
CHIPMAN PROPERTY LINE
CONCRETE MONUMENT ELEVATION REFERENCE 100 FT AT TOP
MORRIS P.
KIRK
SMELTERS
S.P.&S.
ELEVATION 110 FT
N
DOANE
LAKE
SUMMER LEVEL = 83.0 FT.
WINTER LEVEL = 86.4 FT.
LAKE BEING FILLED BY PROPERTY OWNERS
PENNSALT
CORPORATION
DRAW SPAN 120.0 FT
EXIST. 6" OUTFALL LINE. (INOPERATIVE)
LAKE OUTLET STREAM
EDGE OF DIKE
TOP OF DIKE ELEVATION = 93 FT
EDGE OF RIVER 10-7-65
WILLAMETTE RIVER
WATER LEVEL = 66 FT 10-7-65
S.P.&S. BRIDGE
ELEVATION AT RAIL LEVEL = 121 FT

DEQ. 1969a. IW 3-0 Chipman Chemical Co. Internal memorandum from Carter to FMB and RCS, dated September 15, 1969. Oregon Department of Environmental Quality, Salem, OR.

State of Oregon

DEPARTMENT OF ENVIRONMENTAL QUALITY

INTEROFFICE MEMO

To: FMB, RCS

Date: Sept. 15, 1969

From: Carter

Subject: IW 3-0 Chipman Chemical Co.

Mr. Vern E. Walker (telephone 285-2301) called here today to report tainted fish. He caught a mess of catfish and crayfish in the Multnomah Channel near the mouth of the Gilbert River (out of Sauvies Island), and they all had a strong flavor like iodine.

He had caught tainted salmon down there at the peak of the Chipman trouble and said the flavor was the same.

Perhaps some of our staff should see how Chipman is handling their wastes these days.

State of Oregon
DEPARTMENT OF ENVIROMENTAL QUALITY
RECEIVED
SEP 22 1989
PORTLAND DISTRICT OFFICE

DEQ. 1969b. IW 3-0 Chipman Chemical Co. Internal memorandum from R. Sherwood to EJW and GDC, dated September 19, 1969. Oregon Department of Environmental Quality, Salem, OR.

State of Oregon

DEPARTMENT OF ENVIRONMENTAL QUALITY

To ~~BCB~~ ~~FMB~~

INTEROFFICE MEMO

To: EJW, GDC cc: ~~FMB~~ Date: Sept. 19, 1969

From: Roger Sherwood

Subject: IW 3-0 Chipman Chemical Co.

Regarding the attached memo from GDC of tainted fish caught in Multnomah Channel I called Tom Henshaw Chipman Chemical on Sept. 17, 1969.

Tom reported that Chipman was not yet on line because of the afterburner on the carbon regeneration furnace. They can regenerate the carbon but the afterburner won't function properly and at a high enough temperature to meet air pollution regulations. After trying to get the existing afterburner to work for the past month the supplier is now installing a new system and Chipman should be on line in two weeks.

Tom stated that they would operate the total system at our request but they would have an air problem. I stated we may request them to fire up the total system but for now make all possible efforts to get the total problem solved.

DEQ. 1971. IW 3-0 Chipman Chemical. Internal memorandum from R. Sherwood to EJW, Portland District, dated April 1, 1971. State of Oregon Department of Environmental Quality, Salem, OR.

State of Oregon

DEPARTMENT OF ENVIRONMENTAL QUALITY

INTEROFFICE MEMO

To: EJW, Portland District

Date: April 1, 1971

From: Roger Sherwood

Subject: IW 3-0 Chipman Chemical

On March 30, 1971, Bob Gilbert and Roger Sherwood visited Chipman Chemical regarding their February data submittal which showed high DCP levels coming out of their activated carbon treatment facility.

The levels turn out high due to an increased flow and higher total phenol levels in-plant. Their check point on carbon regeneration was then out of balance and they ended up saturating the columns quicker than anticipated and ended up with some high levels.

They have straightened out this problem and their March total phenol levels looked good. I asked them to start submitting their data on a weekly basis so we can keep a closer handle on the project.

Their plant drainage is still going into Doane Lake with seepage to Morgan Creek and the River. We need to evaluate this seepage problem.

Chipman is in negotations with the city and they should be hooked in this summer when the sewer becomes available. They may not want to hook to the city, but I think we can force the issue.

Note: Providing their carbon system overload check points are adhered to the system works good.

I have requested Hose to check with Chipman and split some samples. (Reporting DCP should be changed to total phenol and we need to get this straightened out as to the relationship between the two.)

DEQ. 1982. WQ-Rhone-Poulenc Multnomah County File No. 74995. Internal memorandum from C.R. Clinton to TRB, dated February 2, 1982. Oregon Department of Environmental Quality, Portland, OR.

STATE OF OREGON

DEPARTMENT OF ENVIRONMENTAL QUALITY

INTEROFFICE MEMO

TO: File through TRB

DATE: February 2, 1982

FROM: C. R. Clinton

SUBJECT: WQ-Rhone-Poulenc
Multnomah County
File No. 74995

On January 27, 1982, Bob Briggs called to report a spill that occurred at their plant. This spill occurred at approximately 8:00 a.m. when a tank of 2,4-D butyl esther overflowed. Approximately 139 gallons was spilled. The cause of the spill was that a rail car tank truck was overfilled and when the tank car was heated up, the expansion of the material in the tank car caused it to overflow. The tank car must be heated to make the material liquid, as it is a solid at 4°C. Rhone-Poulenc thinks that they cleaned up the majority of the spill. They are removing the dirt in the area of the spill and they found that the material that went to the storm drain solidified in the drain and they are removing it from the drain.

The Coast Guard was at the scene of the spill.

CRC:h
RHD244
cc: Water Quality
Regional Operations

DEQ. 1990. Employee interview. Internal memorandum from Sandra Anderson to The Files, Rhone Poulenc, dated December 28, 1990. Oregon Department of Environmental Quality, Portland, OR.

NEIL GOLDSCHMIDT
GOVERNOR

Department of Environmental Quality

811 SW SIXTH AVENUE, PORTLAND, OREGON 97204-1390 PHONE (503) 229-5696

#155

April 30, 1990

Robert L. Ferguson
Rhone-Poulenc AG Company
6200 NW St. Helens Road
Portland, Oregon 97210

Re: Employee Interviews
Demolition of Buildings

Dear Mr. Ferguson:

In accordance with our agreement, I have enclosed a summary of the employee interviews I conducted on April 24, 1990.

I have also given some thought to our conversation concerning demolition of the buildings on-site after the plant closes. I agree that the demolition is desirable and will help fulfill the purposes of the Consent Order as an "additional measure", as defined in Section 5.B. of the Order. If Rhone-Poulenc proceeds with demolition, DEQ has an interest in the demolition procedures, decontamination, and final disposal of the debris generated, and would like to work with you to develop an acceptable plan of action. Please keep us informed of your progress and plans as this project proceeds.

Thank-you for your cooperation regarding the interviews, and please call me at 229-6744 if I can be of assistance or you have any questions. As you know, Bruce Gilles will be the contact person for DEQ on this project from May 7 through June 6, 1990. You can reach Bruce at 229-6662.

Sincerely,

Sandra Anderson

Sandra Anderson, R.G.
Project Manager

SJA:sja
Enclosure
cc: Bruce Gilles, SRS-DEQ
Tom Miller, SRS-DEQ
Larry Edelman, DOJ
Ann Levine, SRS-DEQ
Chip Humphrey, EPA-OOO

SUMMARY OF INTERVIEWS WITH RHONE-POULENC EMPLOYEES

Three long-time employees with Rhone-Poulenc AG Company were interviewed by Sandra Anderson of the Environmental Cleanup Division of the Oregon Department of Environmental Quality (DEQ) on April 24, 1990 at the Rhone-Poulenc facility on St. Helens Road, Portland, Oregon. Rhone-Poulenc has agreed to conduct a Remedial Investigation/Feasibility Study (RI/FS) pursuant to an Order on Consent with DEQ.

All three employees described the insecticide plant including the colloidal plant, as an area of particular concern. The colloidal plant was on the left side of the insecticide building. The insecticide building is also referred to as the "dust plant". Aldrin, Malathion, DDT, Parathion, Toxaphene, mercury products, Chlordane, Heptachlor, and Dieldrin were formulated in the dust plant. These insecticides were made in a 400-gallon tank and the tank had to be cleaned between batches to avoid contaminating one product with another. The water used to wash the tank drained beneath the building through the floor. Enough water collected at times to give the appearance of a waist-high lake. Mineral spirits were also run through the tank and then discharged to the ground beneath the building. The tank was considered clean when the water ran clean.

The water discharged from the dust plant to the ground followed a natural drainage along the railroad spur to the yard behind the dust plant where it ran into a pit made with a backhoe and designed to receive the excess water. Some of the products handled in the dust plant were colored with a distinctive green dye which may facilitate finding the drainage and the pit.

SoCal, a clear liquid solvent, spilled out the back door of the dust plant when an operator left the pump running. Paint thinner was also used in the dust plant. A case of a drum leaking a mercury product was also mentioned in connection with the dust plant. Asbestos siding was dumped in the elevator shaft in the insecticide plant.

Open barrels containing DCP caustic were buried in the dust plant yard in a hole dug by a cat, probably west of the railroad spur. The yard has been filled since then. Also buried in this yard are insecticides and the contents from four condensation tanks from the 2,4-D plant.

The railroad spur in the dust plant yard was used as a staging area where tank cars containing bleed DCP were unloaded and drummed. There were spills and overfills associated with this operation. The drums were stacked on pallets without containment while filling. The cars were heated with steam to mobilize the waste so it could be poured into the drums.

An incinerator on-site near the insecticide plant was used to burn bags and other wastes from the dust plant.

Don Beckle, now retired, but still in the Portland area, was cited as the person with the most knowledge of the insecticide plant, and I was encouraged to interview him.

Drains in the floor of the 2,4-D building went directly to Doane Lake via an open ditch off the north end of the building. Specific spills mentioned: 900 gallons of butyl ester tech in 1959 or 1960, 2500 gallons of 2,4-D slurry and DCP to the lake also in '59 or '60, and a 1500 gallon HCL tank overfills which drained to lake. For a time, a 50 gallon barrel sat over the ditch and leaked DCP bleed. Four 2500-gallon condensation tanks in the 2,4-D building periodically boiled over and then drained to the lake. DCP, monochloroacetic acid, and caustic soda were mixed in those tanks. The operator would quench the condenser tanks with cold water when they boiled over. Also, at least on some occasions, fall-out batches were dumped into the drain. Later the bad batches were drummed.

For a while, 2,4,5-T was also made in the 2,4-D building using the same process, but with TCP as the stock instead of DCP. TCP was a powder purchased in barrels which went to St. Johns. Less 5-T was made than 2,4-D, and over a shorter period of time. The 5-T was also made in the ester room using a different process. Spills and etc. from the ester room also drained to the lake via the same ditch as the 2,4-D building.

In the formulation area north of the maintenance building, Tank-15 released a mixture of 2,4-D and 2,4,5-T which drained into a low area along the fence line with Kirk Battery and then ran along the fence line towards the lake. In another incident, 55-gallon drums of amine-4 ran along the same drainage. All spills in the formulation area drained this way, although there was not a constructed ditch.

Near T-15, a rail car full of 2,4,5-T ester tech spilled when the Railroad inadvertently dragged the car down the tracks as it was being emptied. The ester then drained behind the maintenance shop and along the property line drainage described above.

The drain under the Pack-Off building went underground to the ditch along the property line. The product lines into the Pack-Off room were rinsed with city water to clean them between different products. The lines were not emptied of product before they were flushed to the drains in the floor. All the products made at the plant, except from the dust plant, came into the Pack-Off building. Eventually the lines were blown with air and the product captured before they were rinsed with water and discharged to the floor drains.

In the late '50s MCA (monochloroacetic acid) wooden barrels were burned at irregular intervals for about a year in the area where the maintenance shop now stands. The barrels which were not burned went to St. Johns landfill. An incinerator was then built

near the 2,4-DB storage (late 50s also). MCA barrels, 2,4,5-T bags, 2,4-D bags and other wastes were burned in this incinerator.

The 2,4-DB building was built on a gravel base, as was the early experimental MCPA plant. In the 50s very cold temperatures resulted in frozen pipes and many spills. An EK-9 boiler was used to heat toxaphene which was then transferred back to the dust plant. One spill incident occurred when the container leaked as it was transferred from the EK-9 area to the dust plant.

2,4-D isobutyl ester tech boiled over and spilled from a tank car on the tracks alongside the office. Also near the office, the underground storage tank stored a product (Atlas A-6) containing arsenic, caustic, sodium chlorate, and lead. There was no concrete around the tank like there is now.

A line ran from the T-31 area through the pole building (where the Haz Waste drums are stored now) to the formulation area. This line broke and amine-4 was lost under the building. The line had to be abandoned. The leak was under the dirt floor of the building.

In the late '60s, 3,000 to 4,000 gallons at a time of MCPA (fall-out batches) were discharged at irregular intervals to the Doane Lake. A gate allowed the lake to discharge to the Willamette River. Overflows and spills in the MCPA tank farm went into the gravel around the tanks. The tanks storing dichloromethylene (DCM) contained 25,000 to 30,000 gallons, some of which escaped into the atmosphere when the tanks were heated. Occasionally the tanks were emptied so they could be cleaned out. A fire hose was put into the tank and left running for 24 hours to clean the tank. The dirty water was discharged to the ground.

The 2,4-DB plant and the MCPA plant were combined and spills and wash/rinse water drained into a sump in the floor about 7-8 feet deep. The sump was to be pumped to the 2,4-D plant, but the sump leaked so badly for many months in the late '60s or early '70s, that they couldn't get enough water in the sump to pump it out. 2,4-DB, MCPA, tars, creosol and any other materials used in the two plants would have been present in the sump. The standard procedure for each shift was to wash down and clean up after the shift going off. All the water went into the drains and sumps in the floors.

Thousands of drums were stacked along the north and east perimeters of the property in the late '60s and early '70s. The drums contained bleeds and insecticides. The drums became very rusted and old and were in bad shape before they were finally removed. Some of these drums (barrels) were buried in Doane Lake, and also in the area where the waste water treatment plant is now.

Crushed barrels and insecticides were dumped intermittently to Doane Lake in the 1960s and prior to 1974. In some instances, the lake, which extended right up to the process area, was filled in,

and then holes were dug and the wastes buried. In others, metal barrels were dumped into the lake, and then the lake was filled over the barrels. The materials were trucked to the lake for disposal. Thousands of drums may have been disposed of in this way.

About this time, (before Alkali Lake would take the waste, and while the drums were sitting around on site and being dumped in the lake), DCP rail cars stored waste products (including DCP bleed) on the Linnton Spur near St. Johns. The cars leaked through the bungs on the bottom. The volume of leakage was on the order of 10s of gallons. These cars were later brought to the dust plant yard and repackaged for shipment to Alkali Lake.

An 8-foot trench was dug along the alleyway near MW-2 to replace a broken water line. The trench revealed caverns big enough to walk under the 2,4-D building.

City water was used to flush lines and tanks. The water lines were hooked directly to the process lines. In one incident in about 1970, the chemicals in the process lines backflushed into the water lines in the buildings which supplied drinking water.

2,4-D was stored in wooden and cardboard barrels along the west side of the lab. The barrels were covered with visqueen, but spills and leaks went to the ground.

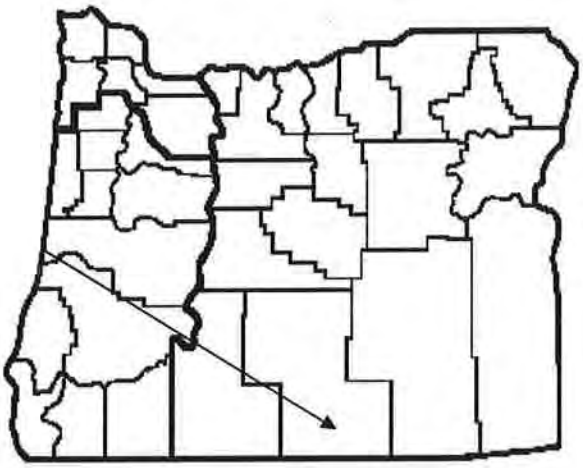
Hot phenol in storage near P101 spilled to ground when the tank was overfilled. This spill was reported to DEQ/EPA.

The dry well didn't work very well. The well was build in 1956 by Sigmaster and Brian near present day P-102.

DEQ. May 2007. Fact sheet regarding Alkali Lake chemical waste disposal site. Oregon Department of Environmental Quality, Land Quality Division, Eastern Region, The Dalles, OR.

Fact Sheet – May 2007

Alkali Lake Chemical Waste Disposal Site



The Alkali Lake Chemical Waste Disposal Site is in Lake County, Oregon, about 60 miles north of Lakeview. The main disposal area occupies about 10 acres just west of Alkali Lake. Alkali Lake is dry most of the year, as are most surface water bodies in this area.

About 25,000 drums of pesticide manufacturing waste were disposed of here in the late 1960s and early 1970s. Despite the large quantity of toxic materials, it does not present a significant risk to the public or the environment because the waste has been buried and fenced, and the site's location is about 35 miles from the nearest town. A small group of people live and work at an ODOT maintenance facility on Highway 395, about three miles from the site.

Background

In 1969, the Oregon Department of Agriculture issued a temporary permit to Chemical Waste Storage and Disposition, Inc. to store herbicide manufacturing wastes at the site. Approximately 25,000 55-gallon drums of these wastes, generated by Rhodia Inc., Portland, Oregon, were disposed of at the site.

The waste products were primarily distillation residues from the production of the herbicides 2,4-D, 2,4-dichlorophenol, and MCPA. These wastes also include dioxins.

In 1971, the Departments of Agriculture and Environmental Quality (DEQ) issued directives prohibiting additional shipments of waste to the site. These directives were in response to improper waste handling practices. Between 1972 and 1974, the State took legal action in an attempt to force Chemical Waste Storage to comply with newly developed hazardous waste regulations. The Circuit Court and then the Court of Appeals sided with the company, however, noting that the company was financially unable to address the new requirements, and that the state had to some extent supported the previous activities. As a result, DEQ has been maintaining the site ever since.

In July 1976, the Oregon Legislature allocated funds for remedial action at the site. In October 1976, the State condemned and took possession of the 10-acre disposal area. By this time, many of the drums, which contained highly corrosive, acidic wastes, had rusted and were leaking. In November 1976, the drums were crushed and buried in 12 shallow unlined trenches in an area referred to as the chemical waste disposal area (CWDA). Each trench was 2 to 2.5 feet deep (the water table in the area is typically only 3 to 6 feet below the ground surface). The trenches were approximately 400 feet long and 60 feet apart. Each mound of crushed drums was covered with two feet of soil, with an additional six inches of crushed rock to prevent wind erosion of the soil cover. The trenches were surrounded with a four-foot barbed wire fence.

Some of the waste has leached through the soils to shallow groundwater. As a result, a groundwater contaminant plume extends about 2,000 feet west-northwest of the CWDA. The edge of the plume is near another primarily dry lake known as West Alkali Lake. Annual groundwater monitoring indicates that the plume has not expanded in the past 15 years.

In the early 1970s, the Oregon State University Environmental Health Sciences Center conducted land application research at the site to determine whether the chemicals could be treated by exposure to sunlight and the natural alkaline conditions. These experiments were done in four soil test plot areas covering about 25 acres south and east of the CWDA. Testing in 2001 did not show phenols and herbicides at these test sites. However, elevated levels of the

State of Oregon
Department of Environmental Quality

Land Quality Division
Eastern Region
400 East Scenic Drive
Suite 2.307
The Dalles, OR 97058
Phone: (541) 298-7255, ext. 30
Fax: (541) 298-7330
(800) 452-4011
Contact: Bob Schwarz,
www.oregon.gov/DEQ/

Last Updated: 5/1/07
By: Bob Schwarz
DEQ 05-ER-003A

more persistent dioxin compounds were found in about a quarter of the samples.

Dioxin levels in soil are in the range of 50 to 100 parts per trillion at the CWDA and the nearby soil incorporation areas and soil test plots. Dioxin concentrations in groundwater just downgradient of the CWDA were measured at about 0.4 parts per trillion. In October 2001, DEQ measured dioxin at several locations a quarter mile and half mile from the site to determine whether wind-blown dioxin might present risk to offsite receptors. No elevated levels of dioxin were found. Dioxin was also measured in rats and mice at the site in 1996, primarily to evaluate potential effects on their predators. No elevated levels were found in these samples either.

Risk to people and animals

A risk assessment completed in 2005 concludes that risk to offsite residents and workers is well below safe levels. Risk to trespassers on the site is also at or below safe levels. Nonetheless, DEQ has placed barbed wire fence around the CWDA and drum mound, and posted warning signs to minimize unnecessary exposure.

Areas surrounding the site are occasionally used for cattle grazing. To prevent cattle from grazing in the most affected areas, DEQ installed an additional 3.9 miles of barbed-wire fence, which encloses the CWDA, the groundwater contamination plume and West Alkali Lake.

The site is about 1.5 miles south of Hutton Springs, which is the sole habitat of the Hutton tui chub. The Hutton tui chub is classified as a threatened subspecies by the U.S. Fish and Wildlife Service. DEQ has therefore sampled water in this spring several times, and concluded that the site contamination does not affect this spring.

Several species of migratory birds, including the snowy plover, also inhabit springs and lakes in the vicinity on a seasonal basis. The risk assessment evaluated risk to migratory birds as well as wildlife living at that the site. The study concluded that these animals are not exposed to unsafe levels.

Current Activities

In April 2007, DEQ prepared a Record of Decision that summarizes site history and site conditions, and specifies future monitoring and maintenance activities. Fencing, signs, soil cover on the CWDA, and gravel roads to the site will be maintained as needed. The site will be inspected annually. Up to 15 groundwater monitoring wells will be sampled six times over the next 20 years, at two and a half-year intervals.

For more information, please contact Bob Schwarz, Project Manager
Phone: 541-298-7255 ext. 30

DEQ-DC1

Ferguson, R.L. 1983. Personal communication (letter to M. Watson, US Environmental Protection Agency, Seattle, WA, dated October 17, 1983, regarding requested information from September 19, 1983 letter). Rhone-Poulenc Chemical Company, Portland, OR.

RHÔNE-POULENC CHEMICAL COMPANY
AGROCHEMICAL DIVISION
6200 N.W. St. Helens Road - Portland, Oregon 97210 - Telephone: (503) 222-3571 - Telex: 36-0329

RLF COPY

bcc: E. L. Clark, CT
R. F. Gitschlag, NBK
R. J. Rosenberg, BHL

October 17, 1983

[RLF-199-83]

Dr. Michael Watson
U. S. Environmental Protection Agency
Region 10
Mail Stop 524
1200 Sixth Avenue
Seattle, Washington 98101

Dear Dr. Watson:

The letter from Dr. Charles Findley, Deputy Director, Air & Waste Management Division, about the production and disposal of wastes that may have contained 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) was received on September 19, 1983. This letter is in reply to your request for information.

Answers to the questions contained on Attachment I of your letter are enclosed. Because of the long time period since the manufacture of technical 2,4,5-T acid at Portland, many records no longer exist. A search of both the Portland and Corporate files and record retention archives in New Jersey have produced only limited written information prior to 1968 because the old files have been disposed of some time ago per Rhone-Poulenc's record retention policy. Some questions are answered on the basis of production and engineering estimates made by current and past employees. Most of this information has previously been reported to management or to an agency such as EPA, NIOSH, or DEQ, State of Oregon.

In January 1982 the National Institute of Occupational Safety & Health conducted a field study at the Portland plant as part of the dioxin registry project. A draft of this report is attached as Exhibit A and is the best summary of information, both factual and verbal, available about 2,4,5-T production in Portland.

The questions are being answered specifically for the Portland plant. Other company plants have received similar requests for information and are being answered for the specific plant location.

Any additional pertinent documents or information discovered will be forwarded to you. If you have any questions, feel free to contact me.

Sincerely,

R. L. Ferguson
[redacted]on
Plant Manager

RLF:sll
Enclosures

RHÔNE POULENC INC

RHÔNE-POULENC INC.
AGROCHEMICAL DIVISION
Portland Plant

EXHIBITS

COVER LETTER

Exhibit A	NIOSH Dioxin Registry Project - Draft Report. R. R. Briggs letter dated 2/17/83.

QUESTION ONE

Exhibit B	Copy of 2,4,5-T labels list. Letter dated 1/19/71; label copy for labels found to-date are included.
Exhibit C	Copies of batch assay cards showing dates of manufacture of batches.

QUESTION TWO No exhibits.

QUESTION THREE

Exhibit D	2,4,5-T Production flow diagram, 7/18/61.

QUESTION FOUR

Exhibit E	2,4,5-T Process description summary.
Exhibit F	2,4,5-T Ester manufacturing; diagram from NIOSH letter 2/17/83.
Exhibit G	2,4-D Process description summary 6/11/79.
Exhibit H	Esterification process description summary 6/11/79.
Exhibit I	MCPA Process description summary 6/11/79.
Exhibit J	Formulations process description summary 6/11/79.
Exhibit K	Bromoxynil octanoate process description summary 6/11/79.
Exhibit L	DEQ State of Oregon letter dated 9/7/79.
Exhibit M	Waste characteristics estimates.

QUESTION FIVE No exhibits.

QUESTION SIX

Exhibit N	Plant history chart.

QUESTION SEVEN

Exhibit O	Waste disposal practices.

QUESTION EIGHT No exhibits.

QUESTION NINE Exhibits 1 through 69 in chronological order.

EXHIBIT A

— EXHIBIT A —

F

DTL - 2457 11 NIOSH STUDY

RHÔNE-POULENC CHEMICAL COMPANY
AGROCHEMICAL DIVISION

6200 N.W. St. Helens Road - Portland, Oregon 97210 - Telephone: (503) 222-3571 - Telex: 36-0329

bcc: R. L. Ferguson
R. F. Gitschlag, NBK
E. Clark
R. J. Rosenberg, BHL

February 17, 1983

[RRB-027-83]

Department of Health & Human Services
Centers for Disease Control
National Inst. for Occupational Safety & Health
Robert A. Taft Laboratories
4676 Columbia Pkwy.
Cincinnati, OH 45226

Attention Marilyn Fingerhut, Ph.D.

Dear Marilyn:

Enclosed is the draft copy of the NIOSH Registry Site Visit Report which has been reviewed for inaccuracies and trade secrets. Inaccuracies have been noted and no trade secrets are claimed.

Answers to the questions you provided are also enclosed.

If you have any questions or comments, please contact R. L. Ferguson who has been appointed Plant Manager effective February 15, 1983.

Yours very truly,

R. R. Briggs

R. R. Briggs
Manager of Industrial Projects

RRB:sll
Enclosures

RHONE POULENC

FEB 22 1983

GOVT. RELATIONS DEPT.

RHONE POULENC INC

RHÔNE·POULENC INC.
AGROCHEMICAL DIVISION
Portland Plant

February 17, 1983

ANSWERS TO QUESTIONS

A-1 Reaction is erothermic.

A-2 The reaction of NaOH with TCP started at a lower temperature than 115-119°C. Starting temperature unknown but solution would heat up during caustic addition due to the erothermic reaction. Temperature would not reach reflux point as the caustic was being dumped into the kettle through an open manway. Otherwise, IPA vapors would be escaping through the opening. After caustic charge was complete, manway closed and jacket heat applied to bring contents up to 115-119°C boiling point.

A-3 Kettle contents heated to its boiling point or "reflux" temperature which happened to be 96°C.

A-4 Caustic solution in kettle heated to its boiling point which was 100-110°C. Heat applied to keep contents boiling while adding the 5T-IPA ester and water. H_2O/IPA boiling off during and after the reaction. Cook temperature unknown but probably in the range of 100-110°C.

A-5 The NaCl and Na_2CO_3 impurities in the slurry being centrifuged are in solution in the water. The impurities go out with the water removal but also stay in the moisture in the wet Na-2,4,5-T cake, the amount being at whatever concentration they are present in the water phase before centrifugation.

A-6 Water is removed continuously by phase separation from the condensed vapors boiled out of the kettle. This takes place in the "splitter" vessel marked in red on the Fig. 2 flow diagram.

B-1 After further research, we find that the information given pertaining to the 2,4,5-T ester production process is erroneous. The process shown in Fig. 4 was used only for 2,4-D esters. 2,4,5-T esters were manufactured using only EK-3 reactor. The process was as follows:

The kettle was charged with "wet" alcohol from the rundown tank and dry alcohol from alcohol storage. Kettle contents heated to approximately 80°C and then wet 2,4,5-T acid cake manually dumped into the kettle. Kettle temperature increased and a water-alcohol mixture boiled out. After condensing the vapors, the water-alcohol liquid ran into a splitter vessel where the water-alcohol liquid phase separated, the alcohol layer returning to the kettle and the water layer draining to the sewer. After water stopped phasing out, boiling continued with the alcohol phase then diverted to the wet alcohol rundown tank. Kettle temperature had risen to 115°C at start of above operation and alcohol removal continued until temperature had risen to 135°C. At this point an additional charge of dry alcohol added to the kettle and alcohol removal continued until temperature had again risen to 135°C. Vacuum was then applied to the system and alcohol removal continued until temperature had risen to 150°C while under 28-29" Hg vacuum. Finished ester in EK-3 was then filtered and transferred to storage tank T-22.

Location of T-22 marked in red on Fig. 1. See attached flow diagram which replaces your Fig. 4

B-2 Process remained the same until 1970.

B-3 Esters pumped to storage tank T-22, then formulated in area 6 on Fig. 1, then pumped to packaging, marked in red on Fig. 1. Packaging was in 1, 5, 30, and 55-gallon containers. One-gallon cans filled on a 4-spout filling machine with automatic shutoff. Balance of containers filled manually to a specific weight, containers having been placed on a platform scale.

B-4 Pressure was atmospheric.

C-1 Temperature was 50-60°C; pressure was atmospheric.

C-2 Amine was made using triethylamine, not triethanolamine. Only triethylamine was used.

C-3 Used vessel T-19 in area 6, Fig. 1, marked in red.

C-4 Drumming operation same as 5-T ester formulations.

C-5 "4-L" refers to the octyl ester formulation.

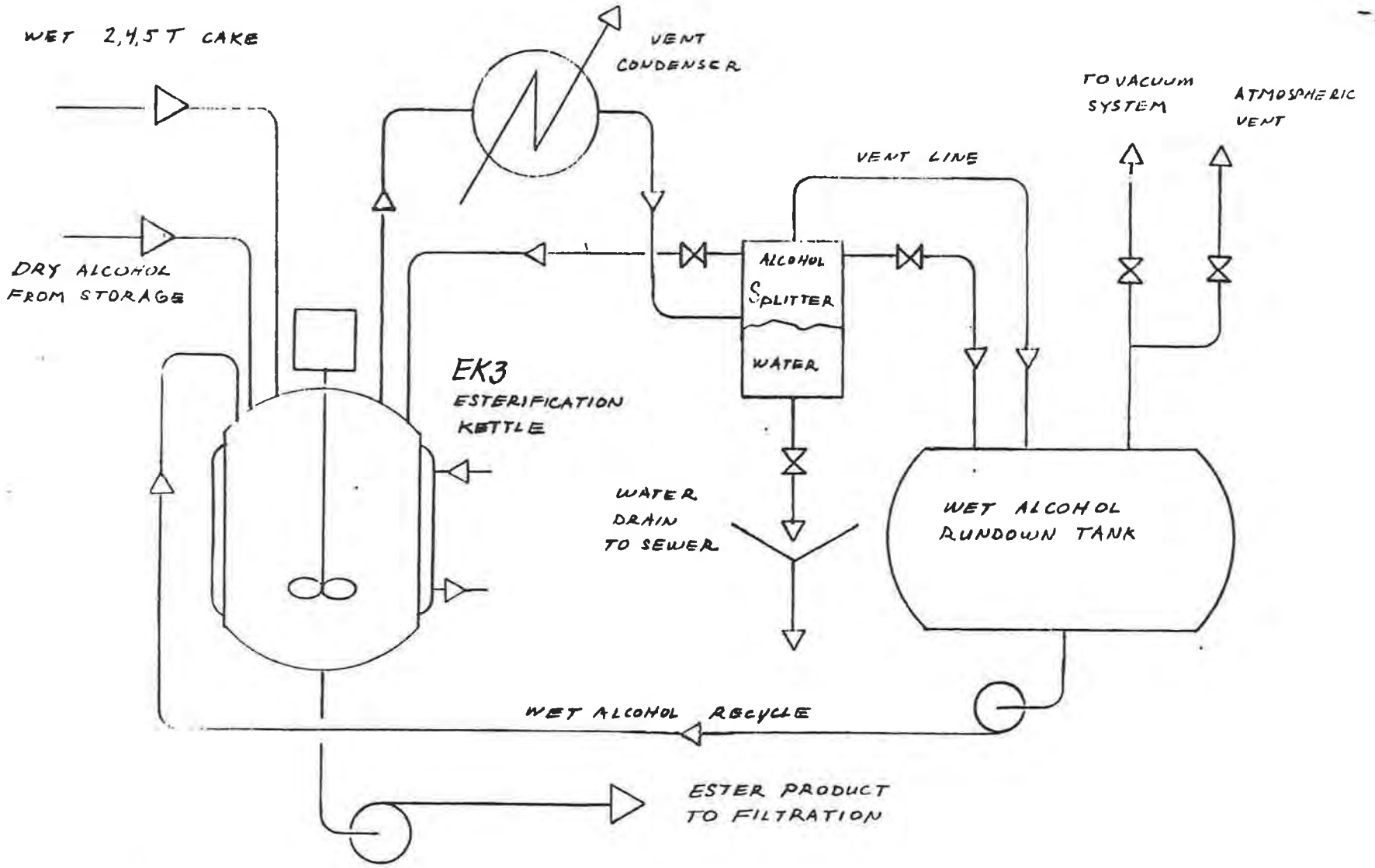
C-6 Process remained the same until 1970.

C-7 Filter bags were changed manually.

D-1 Exact months of operation during 1960, 1961, and 1962 unknown. Probably between 3 and 6 months each year. Probably little or no activity during June, July, August, and September.

D-2 We do not know what 5-T activity might have been going on between August 1960 and February 1961.

Flow Diagram
2,4,5 T. Esterification Process



QUESTION 1

QUESTION ONE

QUESTION: Is your company currently manufacturing or has your company ever manufactured technical grade 2,4,5-trichlorophenol (2,4,5-TCP)* to be used as a feedstock in the manufacture of 2,4,5-TCP formulations or its pesticide derivatives? What 2,4,5-TCP formulations or pesticide derivatives is your company currently manufacturing or processing or has your company ever manufactured or processed, including but not limited to 2,4,5-T, Silvex, Ronnel, Erbon, and Hexachlorophene? For those chemical substances manufactured or processed, provide the dates of manufacture, the quantities produced, and the product names.

ANSWERS to Questions About Manufacturing or Processing of Chemicals That May Have Resulted in Wastes Contaminated With 2,3,7,8-TCDD.

a. Portland does not manufacture and has never manufactured 2,4,5-TCP to be used as feedstock for formulations or its pesticide derivatives.

b. Portland does not now manufacture any product from 2,4,5-TCP nor handle any pesticide derivative that utilizes 2,4,5-TCP as a raw material.

c. Portland manufactured 2,4,5-T acid from purchased 2,4,5-TCP during the period February 1961 to December 1962. A plant scale test manufactured a small amount of 2,4,5-T acid in August 1960.

d. Portland manufactured esters of 2,4,5-T from either purchased 2,4,5-T acid or from the manufactured 2,4,5-T acid, made during the period February 1961 to December 1962, for an unknown period prior to 1961 to December 1970.

e. Portland formulated 2,4,5-T amine, 2,4,5-T ester formulations, and 2,4,5-TP-Silvex products from purchased esters for a period of time from the mid-1950s until November 1975.

f. Portland never manufactured, formulated, or handled Ronnel, Erbon, or Hexachlorophene.

g. The chemical substances manufactured or processed, the dates of manufacture, and product names follow:

PRODUCT	MANUFACTURING DATES	AMOUNT	TRADE NAME (See Note)
2,4,5-T Acid Technical	August 1960 - December 1962	Not Known	Chipman 2,4,5-T Acid (Tech)
2,4,5-T Isooctyl Ester Technical	February 1961 - December 1970	Not Known	Chipman 2,4,5-T Isooctyl Ester (Tech)
2,4,5-T Isobutyl Ester Technical	February 1961 - April 1966	Not Known	Chipman 2,4,5-T Isobutyl Ester (Tech)

NOTE: After about 1976, the Chipman trademark name was replaced with the Rhodia trademark name. At the time of manufacture in 1961, Chipman Chemical was the owner of the Portland Plant.

PRODUCT	FORMULATION DATES	AMOUNT	TRADE NAME (See Note)
Brush Killer #2	June 1952	Not Known	Chipman Low Volatile Brush Killer #2
2,4,5-T Amine	June 1952 - March 1970	Not Known	Chipman 2,4,5-T Amine 4L
2,4,5-T LV 4L	June 1951	Not Known	Chipman Low Volatile Ester 4L
2,4,5-T LV 6L	June 1961	Not Known	Chipman Low Volatile Ester 6L
LV Brush Killer #3	February 1961	Not Known	Chipman Low Volatile Brush Killer #3
149 Brush Killer #4	March 1964	Not Known	Rhodia Utility Brush Killer #4
141 2,4-3 & 2,4,5-T Isooctyl Ester Tech.	March 1964	Not Known	Chipman 2,4-D & 2,4,5-T Ester Mix
2,4,5-T Isobutyl Ester Technical	May 1966	Not Known	Rhodia 2,4,5-T IBFT Ester Technical
Amine Brush Killer	May 1964	Not Known	Rhodia Amine Brush Killer
Aerosol Special Mix #1	July 1968	Not Known	Chipman Aerosol Special Mix #1
T & C Lawn Weed Killer Mix	July 1968	Not Known	T & C Lawn Weed Killer Mix
Swift Mix #1	October 1968	Not Known	Swift Mix #1
Swift Mix #2	October 1968	Not Known	Swift Mix #2
Silvex 4L	Not Known	Not Known	Chipman Silvex 4L
2:T Blend	Not Known	Not Known	Chipman 2:1 Blend

NOTE: Chipman Chemical was owner of plant prior to 1964. Trademark name Chipman was used prior to 1964. In about 1966, Rhodia trademark name was substituted for Chipman when new labels were printed.

Exhibits B and C attached.

EXHIBIT B

2,4,5-T

January 19, 1971

L. C. Brown
New Brunswick Office

22 products containing 2,4,5-T were registered with the USDA since June, 1952. I could not find any railroad products that contained 2,4,5-T - registered or unregistered.

I have listed all products containing 2,4,5-T and date of USDA approval, and old Chipman products with USDA approval, below

PN#	USDA APPROVAL DATE	
108	March 1961	- CHIPCO TURF HERBICIDE DOT - NKC ONLY
110	Feb.1962	✓ ✓ ✓ T - NKC ONLY
112	June 1952	**** BRUSH KILLER #2.
119	Feb.1961	BK #3
137	May 1958 -	STAMINE HL
138	June 1952	**** ST.LV 6L
139	Jan.1961	ST LV 6L
140		ST 100T
141	May 1966 -	240 ST 245T ESTER MIX
142	May 1966 -	ST 100T ESTER TEAM?
145	May 1967 - finished labels with USDA additions not sent	
148	May 1966 -	D-ST AMINE BRUSH KILLER
149	March 1964 -	UTILITY BRUSH KILLER #4.
160	May 1966 -	TECH ACID
167	Sept.1967	
170	July 1968 -	AEROSOL SP MIX #1 (D, T, PP)
176	July 1968 -	T&C LAWN WEED KILLER CONC.
182	Sept. 1966 -	FERTILIZER MIX (BROADLEAF ANDANT)
183	Sept. 1966 -	✓ ✓
188	Oct. 1968 -	SWIFT MIX #1
189	Oct. 1968 -	SWIFT MIX NO 2.

196 & 197 = withdrew applications/USDA returned files July 1970
359-403 Chipman LV brush killer/Dilute 200:1(Ester Form) October 1960
359-339 Chipman LV Brush killer no.133 Sept. 1957

Lynette Waldron

PN - PRODUCT NUMBER
- WRITTING AFTER DATE BY DFG 12/12/83.

PRODUCT NO.
160

NET WEIGHT
POUNDS

CHIPMAN® 2,4,5-T ACID

FOR FURTHER MANUFACTURING PURPOSES ONLY

ACTIVE INGREDIENT:
2,4,5-trichlorophenoxyacetic acid 98.0%
INERT INGREDIENTS 2.0%

CAUTION: Keep Out of Reach of Children

CAUTION: Causes irritation to eyes and skin. Avoid inhaling dust. Avoid contact with skin, eyes and clothing. In case of contact flush eyes with plenty of water for at least 15 minutes and get medical attention. Wash skin with plenty of soap and water. Do not use same equipment for handling or manufacturing other agricultural chemicals. Avoid contamination of domestic or irrigation water supply. Do not allow this chemical or dilutions of it to come in contact with desirable crop plants, trees, ornamentals, etc. Vapors from this product may injure susceptible plants in the immediate vicinity.

Seller's guarantee shall be limited to the terms of the label, and subject thereto the buyer assumes any risk to persons or property arising out of use or handling and accepts the product on these conditions.

Do Not Store with Seeds, Foodstuffs or near Insecticides, Fungicides, or Fertilizers

U S D A Reg. No 389-578

Port. SC-1-120

Manufactured by
RHODIA INC.
CHIPMAN DIVISION
NEW BRUNSWICK, NEW JERSEY

Atlanta, Ga.
Bound Brook, N. J.
Chicago, Ill.
St. Paul, Minn.
N. Kansas City, Mo.

Palo Alto, Calif.
Pasadena, Tex.
Portland, Ore.
Billings, Mont.

PROPRIETARY INFORMATION
SPECIMEN LABEL

PRODUCT NO.
108

NET CONTENTS
GALLONS

CHIPCO® TURF HERBICIDE "D&T"

For control of many broadleaf weeds on golf course turf, lawns and similar recreational and ornamental turf areas; also for brush control.

ACTIVE INGREDIENTS:
Dimethylamine salt of 2,4-dichlorophenoxyacetic acid 22.4%
Triethylamine salt of 2,4,5-trichlorophenoxyacetic acid 16.2%
INERT INGREDIENTS 61.4%

Acid Equivalent
2,4-Dichlorophenoxyacetic acid 18.6%
2,4,5-Trichlorophenoxyacetic acid 11.6%

CAUTION: Keep Out of Reach of Children

CAUTION: Avoid contact with skin, eyes or clothing. Avoid inhaling spray mist. Avoid spray drift to susceptible plants as this product may injure tomatoes, beans, peas, other vegetables, legumes and ornamentals. (Coarse sprays are less likely to drift.)

Do not use same spray equipment for other purposes if traces of this product in such equipment are likely to be harmful to sprayed vegetation. Do not re-use shipping containers. Do not transport with, or store near, fertilizers, insecticides, fungicides or seeds.

Do not use on newly seeded lawns. Avoid spillage. Dispose of spray wastes in a safe place. Avoid contamination of water intended for irrigation and domestic use.

CONTROLS THESE TURF WEEDS

Bentgrass (see NOTE)
Buttercups
Chervil
Chickweeds
Chicory
Cinquefoil
Clovers
Dandelions*
False Strawberry
Ground Ivy
Henbit
Knotweed
Mallows
Pennywort
Plantains*
Self-Heal or Heal-All
Sheepsorrel
Shepherds Purse*
Sow Thistle*
Speedwell*
Spotted Spurge*
Wild Carrot
Wild Onion
Yarrow
Yellow Rocket*
Many Other Species

DIRECTIONS

TURF WEED CONTROL: How to Use — Use 3 to 5 pints per acre in 50 to 100 gallons of water. Uniform coverage is essential for satisfactory control. For small area applications use 1 to 2 fl. oz. in 3 to 5 gallons of water per 1,000 sq. ft. Repeat applications may be necessary.

Use the lower rate for easy-to-kill species marked* (see list above). Use the higher rate for more effective control of chickweeds and clovers.

When to Use — Use preferably in the spring or fall when weeds are actively growing. The chemical action is more rapid when applied on warm, clear, sunny days than when weather is cool, cloudy or wet.

Effects on Grasses — In some areas Dichondra, St. Augustine and Carpetgrass may be injured. Bentgrass also may be injured by the chemical especially if applied when soil is dry and the grasses stressed by drought and/or heat. For this reason do not apply to Bentgrass turf in periods of hot weather.

NOTE: Unwanted patches of bentgrass may be removed from bluegrass turf by spraying with 1¾ gals. Chipco Turf Herbicide per acre in 50 to 100 gals. water (5½ fl. oz. in 3 to 5 gals. water per 1,000 sq. ft.) Apply in the fall before bentgrass stops growth.

BRUSH CONTROL: Foliage Spray — In thickets, brushy areas in roughs, along fences and similar locations where selective control is not desired. Use 1 to 2 gallons in 100 gallons of water to control blackberry, honeysuckle, poison ivy, poison oak and other species of woody plants. Spray to wet foliage thoroughly when plants are in full leaf and growing actively.

Local conditions may affect the use of this chemical. Consult State agricultural experimental station or extension service weed and turf specialists for specific recommendations as to dosage and time of application and for control of other weeds.

Follow directions carefully. Timing and method of application, weather and crop conditions, mixtures with other chemicals not specifically recommended, and other influencing factors in the use of this product are beyond the control of the seller. Buyer assumes all risks of use, storage or handling of this material not in strict accordance with directions given herewith.

Do NOT Store with Foodstuffs

USDA Reg. No 389-419

N S AC-1-108

Atlanta, Ga.
Bound Brook, N. J.
Chicago, Ill.
N. Kansas City, Mo.

Manufactured by
RHODIA INC.
CHIPMAN DIVISION
NEW BRUNSWICK, NEW JERSEY

Palo Alto, Calif.
Pasadena, Tex.
Portland, Ore.
St. Paul, Minn.

SPECIMEN

PRODUCT NO
140

NET CONTENTS
GALLONS

CHIPMAN®
2,4,5-T ISOOCTYL ESTER
(Technical)

FOR FURTHER MANUFACTURING PURPOSES ONLY

ACTIVE INGREDIENTS:

Isooctyl ester of 2,4,5-trichlorophenoxyacetic acid* 97.0%

INERT INGREDIENTS 3.0%

*Equivalent to 67.4% 2,4,5-trichlorophenoxyacetic acid.

CAUTION: Keep Out of Reach of Children

CAUTION: Harmful if swallowed. Causes irritation to eyes and skin. Do not get in eyes. Avoid contact with skin and clothing. In case of contact flush eyes with plenty of water for at least 15 minutes and get medical attention. Wash skin with plenty of soap and water. Do not use same equipment for handling or manufacturing other agricultural chemicals. Avoid contamination of domestic or irrigation water supply. Do not allow this chemical or dilutions of it to come in contact with desirable crop plants, trees, ornamentals, etc. Vapors from this product may injure susceptible plants in the immediate vicinity.

Seller's guarantee shall be limited to the terms of the label, and subject thereto the buyer assumes any risk to persons or property arising out of use or handling and accepts the product on these conditions.

Do NOT Store with Seeds, Foodstuffs or near Insecticides, Fungicides, or Fertilizers

Batch No. _____

U.S.D.A. Reg. No. 359-580
Port. S C-1-119

Manufactured by
Atlanta, Ga.
Bound Brook, N. J.
Chicago, Ill.
St. Paul, Minn.
N. Kansas City, Mo.
RHODIA INC.
CHIPMAN DIVISION
NEW BRUNSWICK, NEW JERSEY
Palo Alto, Calif.
Pasadena, Tex.
Portland, Ore.
Billings, Mont.

PRODUCT NO.
110

NET CONTENTS
GALLONS

CHIPCO®
TURF HERBICIDE "T"

For control of broadleaved weeds in turf, including golf courses, park grounds and other non-crop turf areas; also brush control in areas such as fence rows, vacant lots and similar non-crop areas where sprays cannot damage valued plants.

ACTIVE INGREDIENT:

Triethylamine salt of 2,4,5-Trichlorophenoxyacetic acid* 56.9%

INERT INGREDIENTS 43.1%

*Equivalent to 40.8% of 2,4,5-trichlorophenoxyacetic acid, or not less than 4 lbs. of 2,4,5-trichlorophenoxyacetic acid per gal. at 68°F.

CAUTION:

Keep Out of Reach of Children

CAUTION: Avoid contact with skin, eyes, or clothing. Avoid inhaling spray mist. Avoid spray drift to susceptible plants as this product may injure tomatoes, beans, peas, other vegetables, legumes, ornamentals, etc. (Coarse sprays are less likely to drift). Do not use same spray equipment for other purposes; traces of this product in such equipment are likely to be harmful to sprayed vegetation. Do not transport with or store near fertilizers, insecticides, fungicides or seeds. Avoid contamination of water intended for irrigation and domestic use. Do not re-use shipping containers; destroy by crushing and burying in a safe place.

CONTROLS THESE TURF WEEDS & WOODY PLANTS

Buttercups	Shepherdspurse*	Many species of Oak
Cherril	Sowthistle*	Shagbarkhickory
Chickweeds	Speedwell*	Perennial Groundcherry
Chicory	Spotted Spurge	Pine
Cinquefoil	Wild Carrot	Poison Ivy
Clovers	Wild Onion	Poison Oak
Dandelions*	Yellow Sorrel*	Southern Waxmyrtle
False Strawberry	Blackberries, Raspberries, related brambles	Sweetgum
Ground Ivy	Blackgum	Wild Roses
Henbit	Ground Ivy	Many other species
Oxalis	Horsenettle	
Pennywort	Maples	
Plantains*		
Self-Heal or Heal-all		
Shepherd's		

DIRECTIONS

TURF WEED CONTROL - How to Use - Use 2 to 3 pts. per acre in 25 to 30 gals. water. Uniform coverage is essential for satisfactory control. For small areas use ½ to 1 fl. oz. in 2 to 3 gals. water per 1,000 sq. ft. Repeat applications may be necessary. Use lower rate for easy-to-kill species marked * (see list). Use higher rate for more effective control of other weeds.

When to Use - Use preferably in the spring or fall when weeds are actively growing. The chemical action is most rapid when applied on warm, clear, sunny days and when weather is cool, cloudy or wet.

Note: Do not use on a newly seeded lawn. Do not mow lawn for several days before or after treatment. Bent grasses and fescues may be injured. Try on a small area first before using extensively. In some areas, Dichondra, St. Augustine grasses and carpetgrass may be injured.

BRUSH CONTROL - Foliage Spraying is suggested as the method best suited for the control of masses of brush and brambles. Complete control of all brush seldom results from a single spray. Spot spraying survivors and seedlings during successive years will control all susceptible species. When present, grasses quickly replace the brush.

Woody Plants and Weeds in General - Use 2 to 3 qts. per 100 gals. water and spray to completely wet leaves and stems to ground level, when plants are in full leaf and actively growing. In the case of herbaceous weeds, make first application when plants are coming into bloom. Large brush and trees should be cut and the first year's regrowth sprayed when 2 to 4 feet tall. Repeat application as needed.

Poison Ivy: Use 2 qts. per 100 gals. water and spray to wet foliage and stems to point of run-off when in full leaf, preferably while making rapid growth. Do not burn after spraying as ivy fumes are poisonous. Retreat the following year if necessary to destroy remaining live shoots.

Local conditions may affect the use of this chemical. Consult State Agricultural Experimental Station or Extension Service weed and turf control specialists for specific recommendations as to dosage and time of application and for control of other weeds.

Follow directions carefully. Timing and method of application, weather and crop conditions, mixtures with other chemicals not specifically recommended and other influencing factors in the use of this product are beyond the control of the seller. Buyer assumes all risks of use, storage or handling of this material not in strict accordance with directions given herewith.

Do NOT Store with Foodstuffs

USDA Reg. No
359-490

H 8 -SC-1 100

Manufactured by
Atlanta, Ga.
Bound Brook, N. J.
Chicago, Ill.
N. Kansas City, Mo.
RHODIA INC.
CHIPMAN DIVISION
NEW BRUNSWICK, NEW JERSEY
Palo Alto, Calif.
Pasadena, Tex.
Portland, Ore.
St. Paul, Minn.

SPECIMEN

PRODUCT NO
141

NET CONTENTS
GALLONS

CHIPMAN®

2,4-D & 2,4,5-T ESTER MIX

(Technical)

FOR FURTHER MANUFACTURING PURPOSES ONLY

ACTIVE INGREDIENTS:

Isooctyl ester of 2,4-dichlorophenoxyacetic acid*	65.7%
Isooctyl ester of 2,4,5-trichlorophenoxyacetic acid*	31.3%
INERT INGREDIENTS	3.0%

*Acid Equivalent
Equivalent to 43.58% 2,4-dichlorophenoxyacetic acid.
Equivalent to 21.75% 2,4,5-trichlorophenoxyacetic acid

CAUTION: Keep Out of Reach of Children

CAUTION: Causes irritation to eyes and skin. Do not get in eyes. Avoid contact with skin and clothing. In case of contact flush eyes with plenty of water for at least 15 minutes and get medical attention. Wash skin with plenty of soap and water. Do not use same equipment for handling or manufacturing other agricultural chemicals. Avoid contamination of domestic or irrigation water supply. Do not allow this chemical or dilutions of it to come in contact with desirable crop plants, trees, ornamentals, etc. Vapors from this product may injure susceptible plants in the immediate vicinity.

Seller's guarantee shall be limited to the terms of the label and subject thereto the buyer assumes any risk to persons or property arising out of use or handling and accepts the product on these conditions.

Do Not Store with Seeds, Foodstuffs or near Insecticides, Fungicides, or Fertilizers

U.S.D.A. Reg. No. 359-582 Port SC 1-138

Manufactured by
RHODIA INC.
CHIPMAN DIVISION
NEW BRUNSWICK, NEW JERSEY

Atlanta, Ga. Bound Brook, N. J. Chicago, Ill. St. Paul, Minn. N. Kansas City, Mo. Palo Alto, Calif. Pasadena, Tex. Portland, Ore. Billings, Mont.

PRODUCT NO.
138

NET CONTENTS
GALLONS

CHIPMAN®

2,4,5-T LOW VOLATILE ESTER 4L

A BRUSH AND WEED KILLER

For control of woody plants and noxious weeds in established grass pastures*, forest management areas, rights of way, rangeland*, roadsides, wastepiece, and other areas where sprays cannot damage valued plants. Recommended where growth is comprised chiefly of species susceptible to 2,4,5-T. In mixed stands containing species susceptible to both 2,4,5-T and 2,4-D, a combination of these materials is more satisfactory.

ACTIVE INGREDIENT:

Isooctyl ester of 2,4,5-Trichlorophenoxyacetic acid*	64.2%
INERT INGREDIENTS	35.8%

*Equivalent to 44.8% by weight of 2,4,5-trichlorophenoxyacetic acid, or not less than 4 lbs. of 2,4,5-trichlorophenoxyacetic acid per gallon at 68°F.

CAUTION: Keep Out of Reach of Children

CAUTION: Avoid contact with skin, eyes or clothing. Harmful if swallowed. In case of contact flush eyes with plenty of water; wash skin with soap and water. Avoid breathing spray mist. Do not allow solution or spray drift to contact desirable plants. Among crops highly susceptible to 2,4,5-T injury are cotton, tobacco, blackeyed peas, beans, tomatoes, onions, other vegetables, grapes, fruit trees and some ornamentals. (Coarse sprays are less likely to drift than are fine mist sprays.) It is difficult to completely clean 2,4,5-T from sprayers or other equipment, therefore do not use 2,4,5-T sprayers and other equipment for purposes where even trace amounts of this chemical may cause injury. Do not re-use shipping containers; destroy by crushing and burning. Avoid contamination of water intended for irrigation and domestic use. Do not transport with or store near seeds, fertilizers, insecticides or fungicides. Vapors from this product may injure susceptible plants in the vicinity. Do not store in freezing temperature. Do not use or store near heat or open flame.

DIRECTIONS FOR USE

FOLIAGE SPRAYING is suggested as the method best suited for control of most of brush and brambles. Complete control of all brush seldom results from foliage spray. Spot spraying survivors and seedlings during successive years will control all susceptible species. When present, grasses quickly replace the brush.

WOODY PLANTS AND WEEDS IN GENERAL: Use 2 to 3 ounces per 100 gallons water and spray to completely wet leaves and stems to ground level. When plants are in full leaf and growing actively. In the case of herbaceous weeds, make first application when plants are coming into bloom. Large brush and trees should be cut and the first year regrowth sprayed when 2 to 4 feet tall. Repeat application as needed.

POISON IVY: Use 3 quarts per 100 gallons water and spray to wet foliage and stems to point of run-off when in full leaf, preferably while growing rapidly. Or use basal bark spray as given below. Do not burn after spraying as fumes are poisonous. Retreat the following year if necessary to destroy regrowth from live shoots.

MESQUITE: For airplane spraying of dense stands use ¼ quart in 3 gallons water plus 1 gallon fuel oil per acre. Agitate continuously. Apply during heavy foliage period in the spring or 50 to 60 days after the first leaves appear. For application with ground equipment to scattered plants 3 to 5 ft. tall, use 2 quarts in 100 gallons water and spray during the heavy foliage period to thoroughly wet plants. Repeat treatments may be needed. Ground spraying is not suggested for large trees or dense thickets.

BASAL BARK AND CUT-SURFACE TREATMENTS: Use 2 to 4 gallons in 100 gallons fuel oil or kerosene and apply a band 12 to 20 inches wide encircling the base of the tree to the point of run-off. Trees with stumpage value should be cut first, then the tops, sides and exposed roots of the freshly cut stumps sprayed to the point of run-off to prevent sprouting of undesirable trees. Application may be made at any time of year.

FRILL KILLING is a practical and economical way of killing trees larger than 5 inches in diameter. Make single-hack girdle or overlapping axe cuts encircling the tree at convenient chopping height. Mix 2 gallons of this material in 100 gallons fuel oil, and pour into the girdle as much of the mixture as the frill will take without wasting. One gallon of the mixture will treat approximately 38 trees 6 inches in diameter to 13 trees 17 inches in diameter. Application may be made at any time of year. Trees are killed rather slowly.

CONTROL THESE SPECIES

Poison Ivy	Sassafras, wax myrtle	Mesquite
Poison Oak	Persimmon, Greenbriar	Blackgum
Wild Roses	Blackberries, mulberries and related brambles	Honeysuckle
Gallberry	Hairy vetches of oak	Pine

Local conditions may affect the use of this chemical. Consult State agricultural extension or Experiment Station weed specialists for specific recommendations for local weed problems and for information on possible lower dosages.

Pesticides sometimes, timing and method of application, weather and crop conditions, interaction with other chemicals not specifically recommended, and other influencing factors in the use of this product are beyond the control of the seller. Buyer assumes all risks of use, storage or handling of this material not in strict accordance with directions given herewith.

Do NOT Store with Foodstuffs

U.S.D.A. Reg. No. 359-179 Port 138-1-49

Atlanta, Ga. Bound Brook, N. J. Chicago, Ill. St. Paul, Minn. N. Kansas City, Mo.

Manufactured by
RHODIA INC.
CHIPMAN DIVISION
NEW BRUNSWICK, NEW JERSEY

Palo Alto, Calif. Pasadena, Tex. Portland, Ore. Billings, Mont.

2,4,5-T LOW VOLATILE ESTER 6L

(Brush and Weed Killer)

For control of woody plants and noxious weeds in established grass pastures*, forest management areas, rights-of-way, rangeland* roadsides, wasteplaces and other areas where sprays cannot damage valued plants. This material is recommended where the growth to be controlled is comprised chiefly of species susceptible to 2,4,5-T. In mixed stands containing species susceptible to both 2,4,5-T and 2,4-D a combination of these materials is more satisfactory

ACTIVE INGREDIENT:	
Isooctyl ester of 2,4,5-Trichlorophenoxyacetic acid*	87.3%
INERT INGREDIENTS	12.7%

*Equivalent to 60.72% by weight of 2,4,5-Trichlorophenoxyacetic acid, or not less than 6 lbs. of 2,4,5-Trichlorophenoxyacetic acid per gallon at 68°F

CAUTION: Keep Out of Reach of Children

CAUTION: Avoid contact with skin, eyes or clothing. Do not take internally. In case of contact flush eyes with plenty of water; wash skin with soap and water. Avoid breathing spray mist. Do not allow solution or spray drift to contact desirable plants. Among crops highly susceptible to 2,4,5-T injury are cotton, tobacco, blackeyed peas, beans, tomatoes, melons, other vegetables, grapes, fruit trees and some ornamentals. (Coarse sprays are less likely to drift than are fine mist sprays.) It is difficult to completely clean 2,4,5-T from sprayers or other equipment, therefore do not use 2,4,5-T sprayers and other equipment for purposes where even trace amounts of this chemical may cause injury. Do not re-use shipping containers; destroy by crushing and burying. Avoid contamination of water intended for irrigation and domestic use. Do not transport with or store near seeds, fertilizers, insecticides or fungicides. Vapors from this product may injure susceptible plants in the vicinity. Do not store in freezing temperatures. Do not use or store near heat or open flame.

DIRECTIONS FOR USE

FOLIAGE SPRAYING is suggested as the method best suited for the control of masses of brush and brambles. Complete control of all brush seldom results from a single spray. Spot spraying survivors and seedlings during successive years will control all susceptible species. When present, grasses quickly replace the brush.

WOODY PLANTS AND WEEDS IN GENERAL: Use 2½ fluid pints per 100 gallons water and spray to completely wet leaves and stems to ground level, when plants are in full leaf and growing actively. In the case of herbaceous weeds, make first application when plants are coming into bloom. Large brush and trees should be cut and the first year regrowth sprayed when 2 to 4 feet tall. Repeat application as needed.

POISON IVY: Use 2½ pints per 100 gallons water and spray to wet foliage and stems to point of run-off when in full leaf, preferably while growing rapidly, or use basal bark spray as given at right. Do not burn after spraying as fumes are poisonous. Re-treat the following year if necessary to destroy remaining live shoots.

MESQUITE: For airplane spraying of dense stands, use ½ quart in 3 gallons water plus 1 gallon fuel oil per acre. Agitate continuously. Apply during heavy foliage period in the spring or 50 to 80 days after the first leaves appear. For application with ground equipment to scattered stands 3 to 5 ft. tall use 1½ quarts in 100 gallons water and spray during the heavy foliage period to thoroughly wet plants. Repeat treatments may be needed. Ground spraying is not suggested for large trees or dense thickets.

BASAL BARK AND CUT SURFACE TREATMENTS: Use 1½ to 2½ gallons in 100 gallons fuel oil or kerosene and spray a band 12 to 20 inches wide encircling the base of the tree to the point of run-off. Trees with stumpage value should be cut first, then the tops, sides and exposed roots of the freshly cut stumps sprayed to the point of run-off to prevent resprouting of undesirable trees. Application may be made at any time of year.

FRILL METHOD is a practical and economical way of killing trees larger than 5 inches in diameter. Make single-hack girdle or overlapping axe cuts encircling the tree at convenient chopping height. Mix 1½ gallons of this material in 100 gallons water, or oil, and pour into the girdle as much of the mixture as the frill will take without washing. One gallon of the mixture will treat approximately 38 trees 6 inches in diameter to 13 trees 17 inches in diameter. Application may be made any time of year. Trees are killed rather slowly

CONTROLS THESE SPECIES

Poison Ivy	Southern waxmyrtle	Blackberries, raspberries and related brambles	Maples
Poison Oak	Perennial Groundcherry	Many species of oak	Blackgum
Wild Roses	Mesquite	Sweetgum	Horsenettle
Gallberry	Osageorange		Pine

*Do not permit dairy animals to graze within 7 days after application.

Local conditions may affect the use of this chemical. Consult State agricultural extension or Experiment Station weed specialists for specific recommendations for local weed problems and for information on possible lower dosages.

Follow directions carefully. Timing and method of application, weather and crop conditions, mixtures with other chemicals not specifically recommended, and other influencing factors in the use of this product are beyond the control of the seller. Buyer assumes all risks of use, storage or handling of this material not in strict accordance with directions given hereunto

Do NOT Store with Feedstuffs

USDA Reg No. 359-413

Part. 5C-1-78

Atlanta, Ga.
Bound Brook, N. J
Chicago, Ill
N. Kansas City, Mo.

Manufactured by
RHODIA INC.
CHIPMAN DIVISION
NEW BRUNSWICK, NEW JERSEY

Palo Alto, Calif
Pasadena, Tex.
Portland, Ore
St. Paul, Minn.

PRODUCT NO.
148

NET CONTENTS
GALLONS

CHIPMAN®
AMINE BRUSH KILLER

For selective control of mixed species of woody plants and broad-leaved weeds in established grass pastures,* forest management areas, rangelands, roadsides, rights of way, abandoned fields and other areas.

ACTIVE INGREDIENTS:	
Triethylamine Salt of 2,4-Dichlorophenoxyacetic acid*	30.2%
Triethylamine Salt 2,4,5-Trichlorophenoxyacetic acid*	29.0%
INERT INGREDIENTS	40.8%

*Equivalent to 30.7% 2,4-Dichlorophenoxyacetic acid and 28.7% 2,4,5-Trichlorophenoxyacetic acid or not less than 3.80 lbs. each per gallon at 68°F.

CAUTION: Keep Out of Reach of Children

CAUTION: Avoid contact with skin, eyes or clothing. Do NOT take internally. In case of contact flush eyes with plenty of water; wash skin with soap and water. Avoid breathing spray mist. Do NOT allow solution or spray drift to contact desirable plants. Among crops highly susceptible to 2,4-D and 2,4,5-T injury are cotton, tobacco, blackeyed peas, beans, tomatoes, melons, other vegetables, grapes, fruit trees and some ornamentals. (Coarse sprays are less likely to drift than are fine mist sprays.) It is difficult to completely clean 2,4-D and 2,4,5-T from sprayers or other equipment, therefore do not use such sprayers and other equipment for purposes where even trace amounts of this chemical may cause injury. Do not reuse shipping containers; destroy by crushing and burying. Do not transport with or store near seeds, fertilizers, insecticides or fungicides. Vapors from this product may injure susceptible plants in the vicinity. Do not use or store near heat or open flame.

Toxic to fish. Do not contaminate any body of water intended for irrigation and domestic use.

CONTROLS THESE BRUSH AND WEED SPECIES

Cottonwood	Chokecherry	Elderberry
Aspens	Sassafras	Wild Grapes
Wild Gooseberries	Wild Roses	Plums
Blackberries	Sweetgum	Prickly Pears Brush
Raspberries and related brambles	Willows	Milkvetch
Oaks	Locust	Sumac
Poison Ivy	Perennial Groundcherry	Maples
Honeysuckle	Horsenettle	Many other species
Poison Oak	Currants	

*Do not graze dairy animals within 7 days after application.

DIRECTIONS

FOLIAGE SPRAYING: Spray woody plants up to 6 to 8 ft. tall, when in full leaf, preferably in early summer while actively growing. Spray to wet plants thoroughly with 3 to 4 quarts per 100 gals. of water. Taller trees can be sprayed although basal treatment may be more desirable. Will also control many broadleaved herbaceous weeds. Complete control seldom results from one spraying. Retreatment during successive years will control all susceptible species. When present, grasses quickly replace brush and weeds.

PINE RELEASE: To control hardwoods, such as oak, hickory, maple, pecan, elm, sumac and hornbeam in Southern pine stands, use Chipman Amine Brush Killer undiluted in a concentrate tree injector calibrated to apply 0.75 ml. per injection. Space injections 2" apart, edge to edge, completely around the tree, and close to the ground. The injector bit must penetrate the inner bark. On hard-to-kill species such as hickory, dogwood, red maple, blue beech and ash, make injections 1" to 1½" apart, edge to edge. Treatment may be made at any time of year.

Local conditions may affect the use of this chemical. Consult State Agricultural Extension or Experiment Station Weed specialists for specific recommendations for local weed problems and for information on possible lower dosages.

Follow directions carefully. Timing and method of application, weather and crop conditions, mixtures with other chemicals not specifically recommended, and other influencing factors in the use of this product are beyond the control of the seller. Buyer assumes all risks of use, storage or handling of this material not in strict accordance with directions given hereunto

Do NOT Store with Feedstuffs

U S D.A Reg No 359-349

Atlanta, Ga.
Bound Brook, N. J.
Chicago, Ill.
St. Paul, Minn.

Manufactured by
RHODIA INC.
CHIPMAN DIVISION

Palo Alto, Calif
Pasadena, Tex.
Portland, Ore

LOW VOLATILE BRUSH KILLER NO. 2

ESTER FORM

For control of mixed species of woody plants and broad-leaved weeds in established grass pastures*, forest management areas, rangelands*, roadsides, rights of way, abandoned fields and other areas where desirable plants will not be injured.

ACTIVE INGREDIENTS	
Isooctyl ester of 2,4-dichlorophenoxyacetic acid	34.0%
Isooctyl ester of 2,4,5-trichlorophenoxyacetic acid	32.5%
INERT INGREDIENTS	33.5%

Acid Equivalent:

2,4-dichlorophenoxyacetic acid	22.59% — 2 lb./gal
2,4,5-trichlorophenoxyacetic acid	22.59% — 2 lb./gal

CAUTION: Keep Out of Reach of Children

CAUTION: Avoid contact with skin, eyes or clothing. Harmful if swallowed. In case of contact flush eyes with plenty of water; wash skin with soap and water. Avoid breathing spray mist. Do NOT allow solution or spray drift to contact desirable plants. Among crops highly susceptible to 2,4-D and 2,4,5-T injury are cotton, tobacco, blackeyed peas, beans, tomatoes, melons, other vegetables, grapes, fruit trees and some ornamentals. (Coarse sprays are less likely to drift than are fine mist sprays.) It is difficult to completely clean 2,4-D and 2,4,5-T from sprayers or other equipment, therefore do not use such sprayers and other equipment for purposes where even trace amounts of this chemical may cause injury. Do not reuse shipping containers; destroy by crushing and burying. Avoid contamination of water intended for irrigation and domestic use. Do not transport with or store near seeds, fertilizers, insecticides or fungicides. Vapors from this product may injure susceptible plants in the vicinity. Do not use or store near heat or open flame.

CONTROLS THESE BRUSH AND WEED SPECIES

Cottonwood	Poison Ivy	Willows	Wild Grapes
Aspens	Honeysuckle	Locust	Palms
Wild Gooseberries	Poisonoak	Perennial	Coyote Brush
Blackberries	Chokecherry	Groundcherry	Milkvetch
Raspberries and related brambles	Sassafras	Horsenettle	Sumac
Oaks	Wild Roses	Currents	Maples
	Sweetgum	Elderberry	Elm
			Many other species

*Do not graze dairy animals within 7 days after application.

DIRECTIONS

FOLIAGE SPRAYING: Spray woody plants 3 to 6 to 8 ft. tall, when in full leaf preferably in early summer while actively growing. Spray to wet plants thoroughly with 3 to 4 quarts per 100 gals. of water. Taller trees can be sprayed although basal treatment may be more desirable. Will also control many broadleaved herbaceous weeds. Complete control seldom results from one spraying. Retreatment during successive years will control all susceptible species. When present grasses quickly replace brush and weeds.

BASAL BARK SPRAYING will control larger woody plants and also several species that are tolerant to foliage spray. Basal spraying may be done at any season of the year, however, the dormant season is usually preferred when selective killing is the aim or when susceptible crops are grown in the vicinity. Use 4 to 8 gals. per 100 gals. of oil (1 to 2 pts. in 3 gals.). Spray the basal 12 to 20 inches around each stem or trunk, also the exposed roots and crown area. Completely wet these areas to the point of run-off. Treated trees and shrubs die rather slowly and should not be cut for a full season following treatment. If new growth appears on hard-to-kill woody plants, a second application may be necessary.

STUMP TREATMENT: Use above oil solution and spray to thoroughly wet the tops, sides and exposed roots of freshly cut stumps, to prevent sprouting. Trees with stumpage value and trees which will have to be removed can be treated by this method.

Note: Keep spray tank agitated.

Local conditions may affect the use of this chemical. Consult State agricultural extension or Experiment Station weed specialists for specific recommendations for local weed problems and for information on possible lower dosages.

Follow directions carefully. Timing and method of application, weather and crop conditions, mixtures with other chemicals not specifically recommended, and other influencing factors in the use of this product are beyond the control of the seller. Buyer assumes all risks of use, storage or handling of this material not in strict accordance with directions given herewith.

DO NOT Store with Foodstuffs

U.S.D.A. Reg. No. 359-179

Port. 11B-1-79

Manufactured by
RHODIA INC.
CHIPMAN DIVISION
NEW BRUNSWICK, NEW JERSEY

Atlanta, Ga.
Grand Brook, N. J.
Chicago, Ill.
St. Paul, Minn.
N. Kansas City, Mo.

Palo Alto, Calif.
Pasadena, Tex.
Portland, Ore.
Billings, Mont.

PRODUCT NO. 176

T & C LAWN WEED KILLER
CONCENTRATE
(FOR FURTHER MANUFACTURING PURPOSES ONLY)

NET CONTENTS POUNDS

ACTIVE INGREDIENTS:	
Isooctyl Ester of 2,4-Dichlorophenoxyacetic Acid*	59.8%
Isooctyl Ester of 2,4,5-Trichlorophenoxyacetic Acid*	28.2%
INERT INGREDIENTS	12.0%

*Equivalent to 39.70% 2,4-Dichlorophenoxyacetic Acid or not less than 3.781 pounds of 2,4-D Acid per gallon at 68° F. and 19.62% 2,4,5-Trichlorophenoxyacetic Acid or not less than 1.869 pounds of 2,4,5-T Acid per gallon at 68° F.

CAUTION: Keep Out of Reach of Children

CAUTION

Harmful if swallowed. Avoid contact with skin, eyes or clothing. In case of contact, flush with plenty of water. For eyes, get medical attention. Keep children and pets off treated areas until this material is washed into the soil and grass is dry.

Avoid breathing dust or spray mist. Avoid contamination of feed and foodstuffs. Do not transport or store near fertilizers, seeds, insecticides, fungicides or live plants. Vapors from this product may injure susceptible plants in the immediate vicinity. Thoroughly clean equipment before using for other purposes.

Do not contaminate water used for irrigation or domestic purposes or waters inhabited by fish.

Do NOT Store with Foodstuffs

Seller's guarantee shall be limited to the terms of the label, and subject thereto the buyer assumes any risk to persons or property arising out of use or handling and accepts the product on these conditions.

Manufactured by
RHODIA INC.
CHIPMAN DIVISION
NEW BRUNSWICK, NEW JERSEY

Atlanta, Ga.
Grand Brook, N. J.
Chicago, Ill.
N. Kansas City, Mo.

Palo Alto, Calif.
St. Paul, Minn.
Pasadena, Tex.
Portland, Ore.

U.S.D.A. Reg. No. 359-612

N.B. 1C-1-68

170 UTILITY BRUSH KILLER NO. 4

For control of woody plants and weeds, including mixed brush species along highways, utility rights-of-way and other noncultivated areas.

ACTIVE INGREDIENTS:

Isooctyl ester of 2,4-dichlorophenoxyacetic acid*	45.8%
Isooctyl ester of 2,4,5-trichlorophenoxyacetic acid*	21.8%
INERT INGREDIENTS	32.4%

*Acid equivalent.
2,4-dichlorophenoxyacetic acid—30.36%, or 2.67 lbs. per gal.
2,4,5-trichlorophenoxyacetic acid—15.13%, or 1.33 lbs. per gal.

CAUTION: Keep Out of Reach of Children

CAUTION: Avoid contact with skin, eyes or clothing. Harmful if swallowed. In case of contact with eyes, flush eyes with plenty of water; wash skin with soap and water. Avoid breathing spray mist. Do NOT allow solution or spray drift to contact susceptible plants as this product may injure cotton, beans, peas, grapes, ornamentals, etc. (coarse sprays are less likely to drift.) Thoroughly clean spray equipment with a suitable chemical cleaner before using for other purposes (or do not use same spray equipment for other purposes). Do not re-use shipping containers; destroy by crushing and burying. Avoid contamination of water intended for irrigation or domestic purposes. Do not transport with or store near seeds, fertilizers, insecticides or fungicides. Vapors from this product may injure susceptible plants in the vicinity. Do not use or store near heat or open flame.

Toxic to fish. Do not contaminate any body of water by direct application, cleaning of equipment or disposal of wastes and containers.

CONTROLS THESE BRUSH AND WEED SPECIES

Cottonwood	Poison Ivy	Willows	Milkweed
Aspens	Honeysuckle	Locust	Sassafras
Wild Gooseberries	Poison Oak	Persimmon	Maples
Blackberries	Chokecherry	Hawthorne	Elm
Raspberries and related brambles	Sumacs	Carrots	Many other species
Oaks	Wild Roses	Pines	Elderberry
	Sassafras	Coyote Brush	Wild Grapes

Local conditions may affect the use of this chemical. Consult State agricultural extension or Experiment Station weed specialists for specific recommendations for local weed problems and for information on possible lower dosages.

DIRECTIONS

FOLIAGE SPRAYING: Spray woody plants up to 6 to 8 ft. tall when in full leaf preferably in early summer while making active growth. Spray to wet plants thoroughly with 2 to 4 qts. per 100 gals. water. Taller trees can be sprayed although basal treatment may be more desirable. This treatment will also control many broadleaf herbaceous weeds. Complete control seldom results from one spraying. Spot-treating survivors and seedlings during successive years will control all susceptible species. When present, grasses quickly replace brush and weeds.

BASAL BARK SPRAYING: To control larger woody plants and also several species that are tolerant to foliage sprays. Basal spraying may be done at any season of the year, however, the dormant season is usually preferred when selective killing is the aim or when susceptible crops are grown in the vicinity. Use 2 to 4 gals. per 100 gals. of diesel oil (1 to 2 pts. in 3 gals.) Spray the basal area up to 12 to 20 inches high around each stem or trunk, also the exposed roots and crown area. Completely wet these areas to point of run-off. Treated trees and shrubs die rather slowly and should not be cut for a full season following treament. Woody plants hard to kill may require repeat applications for effective control when new growth appears.

STUMP TREATMENT: Use 2 to 4 gals. per 100 gals. diesel oil (1 to 2 pts. in 3 gals.) —spray thoroughly to wet the tops, sides and exposed roots of freshly cut stumps to prevent sprouting. Trees with stumpage value and trees which will have to be removed can be treated by this method.

FRILL TREATMENT: Make frill by using an axe to cut overlapping notches in a continuous ring around trunk near the base. Cut through the bark but do not remove the chips. Recommended for cull trees 6 inches in diameter and larger. Mix as for stump treatment and pour in as much of this solution that frill will hold without waste.

Note: Keep spray tank agitated. Apply only to areas that will not be grazed after treatment by milking animals or animals being finished for slaughter.

Follow directions carefully. Timing and method of application, weather and crop conditions, mixtures with other chemicals not specifically recommended, and other influencing factors in the use of this product are beyond the control of the seller. Buyer assumes all risks of use, storage or handling of this material not in strict accordance with directions given herewith.

Do NOT Store with Foodstuffs

U.S.D.A. Reg. No. 259-540

Part. SC-1-78

Atlanta, Ga.
Bound Brook, N. J.
Chicago, Ill.
N. Kansas City, Mo.

Manufactured by
RHODIA INC.
CHIPMAN DIVISION
NEW BRUNSWICK, NEW JERSEY

Palo Alto, Calif.
Pasadena, Tex.
Portland, Ore.
St. Paul, Minn.

PRODUCT NO.
170

NET CONTENTS
GALLONS

CHIPMAN®
AEROSOL SPECIAL MIXTURE NO. 1

For Further Manufacturing Purposes Only

ACTIVE INGREDIENTS:

Triethanolamine salt of 2,4-dichlorophenoxyacetic acid*	27.12%
Triethanolamine salt of 2,4,5-trichlorophenoxyacetic acid**	10.17%
Triethanolamine salt of 2-(2-methyl-4-chlorophenoxy) propionic acid***	13.56%
INERT INGREDIENTS	49.15%

*Equivalent to 16.19% 2,4-D acid or 1.5867 lb. 2,4-D acid per gallon
**Equivalent to 6.42% 2,4,5-T acid or 0.6294 lb. 2,4,5-T acid per gallon
***Equivalent to 8.00% MCPP acid or 0.7839 lb. MCPP acid per gallon

CAUTION: Keep Out of Reach of Children

Seller's guarantee shall be limited to the terms of the label, and subject thereto the buyer assumes any risk to persons or property arising out of use or handling and accepts the product on these conditions.

CAUTION: Causes irritation to eyes and skin. Do not get in eyes. Avoid contact with skin and clothing. In case of contact flush eyes with plenty of water for at least 15 minutes and get medical attention. Wash skin with plenty of soap and water. Do not use same equipment for handling or manufacturing other agricultural chemicals. Do not reuse shipping containers; destroy by crushing and burying. Avoid spillage. Avoid contamination of domestic or irrigation water supply. Do not allow this chemical or dilutions of it to come in contact with desirable crop plants, trees, ornamentals, etc.

Do NOT Store with Foodstuffs

U.S.D.A. Reg. No. 259-574

Part SC-1-78

Atlanta, Ga.
Bound Brook, N. J.
Chicago, Ill.
N. Kansas City, Mo.

Manufactured by
RHODIA INC.
CHIPMAN DIVISION
NEW BRUNSWICK, NEW JERSEY

Palo Alto, Calif.
Pasadena, Tex.
Portland, Ore.
St. Paul, Minn.

SPECIMEN LABEL
SPECIMEN LABEL

PRODUCT NO

119

NET CONTENTS
GALLONS

CHIPMAN
LOW VOLATILE BRUSH KILLER NO. 3

(ESTER FORM)

For control of mixed species of woody plants and broad-leaved weeds in established grass pastures*, forest management areas, rangelands*, roadsides, rights of way, abandoned fields and other areas where desirable plants will not be injured.

ACTIVE INGREDIENTS

2,4-Dichlorophenoxyacetic acid, isooctyl ester	47.0%
2,4,5-Trichlorophenoxyacetic acid, isooctyl ester	44.9%
INERT INGREDIENTS	8.1%

ACID EQUIVALENT

2,4-dichlorophenoxyacetic acid	31.19% — 3 lbs./gal.
2,4,5-trichlorophenoxyacetic acid	31.19% — 3 lbs./gal.

CAUTION: Keep Out of Reach of Children

CAUTION: Avoid contact with skin, eyes or clothing. Do NOT take internally. In case of contact flush eyes with plenty of water, wash skin with soap and water. Avoid breathing spray mist. Do NOT allow solution or spray drift to contact desirable plants. Among crops highly susceptible to 2,4-D and 2,4,5-T injury are cotton, tobacco, blackeyed peas, beans, tomatoes, melons, other vegetables, grapes, fruit trees and some ornamentals. (Coarse sprays are less likely to drift than are fine mist sprays.) It is difficult to completely clean 2,4-D and 2,4,5-T from sprayers or other equipment, therefore do not use such sprayers and other equipment for purposes where even trace amounts of this chemical may cause injury. Do not reuse shipping containers; destroy by crushing and burying. Avoid contamination of water intended for irrigation and domestic use. Do not transport with or store near seeds, fertilizers, insecticides or fungicides. Vapors from this product may injure susceptible plants in the vicinity. Do not use or store near heat or open flame. **NOTE:** Keep spray tank agitated.

CONTROLS THESE WEEDS

Cottonwood	Poison Ivy	[illegible]	Plums
Aspens	Honeysuckle	Locust	Coyote Brush
Wild Gooseberries	Poison Oak	Perennial Groundcherry	Milkweed
Blackberries	Chokecherry	Horsenettle	Sumac
Raspberries and related brambles	Sassafras	Cornsalad	Maples
Oaks	Wild Roses	Elderberry	Elm
	Sweetgum	Wild Grapes	Many other species

*Do not graze dairy animals within 7 days after application.

DIRECTIONS

FOLIAGE SPRAYING: Spray woody plants up to 6 to 8 ft. tall when in full leaf, preferably in the summer while making active growth. Spray to wet plants thoroughly with 2 to 5½ pints per 100 gallons of water. Taller trees can be sprayed although basal treatment may be more desirable. Will also control many broad-leaved herbaceous weeds. Complete control seldom results from one spraying. Spot-treating survivors and seedlings during successive years will control all susceptible species. When present, grasses quickly replace brush and weeds.

BASAL BARK SPRAYING will control larger woody plants and also several species that are tolerant to foliage spray. Basal spraying may be done at any season of the year, however, the dormant season is usually preferred when selective killing is the aim or when susceptible crops are grown in the vicinity. Use 2½ to 5½ gallons per 100 gallons of oil (½ to 1½ pints in 3 gallons). Spray the basal 12 to 20 inches around each stem or trunk, also the exposed roots and crown area. Completely wet these areas to the point of run-off. Treated trees and shrubs die rather slowly and should not be cut for a full season following treatment.

Woody plants hard to kill may require repeat applications for effective control when new growth appears.

STUMP TREATMENT: Use above oil solution and spray to thoroughly wet the tops, sides and exposed roots of freshly cut stumps, to prevent sprouting. Trees with stumpage value and trees which will have to be removed can be treated by this method.

Local conditions may affect the use of this chemical. Consult State agricultural extension or Department Extension weed specialists for specific recommendations for local weed problems and for information on possible lower dosages.

Seller makes no warranty of any kind, express or implied, concerning the results of use of this product. Buyer assumes all risk of use or handling whether in accordance with directions or not.

DO NOT Store with Foodstuffs

Manufactured by

CHIPMAN CHEMICAL COMPANY, INC.

BOUND BROOK, CALIFORNIA

Atlanta, Ga. Bound Brook, N. J. Chicago, Ill. N. Kansas City, Mo. Palo Alto, Calif. Pasadena, Tex. Portland, Ore. St. Paul, Minn.

USDA Reg. No. 359-412

N.E.C. 3C-1-126

STOP

UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH SERVICE
PESTICIDES REGULATION DIVISION
WASHINGTON, D. C. 20250

RECEIVED APR 13 1970

Chipman Division
Rhodia Inc.
120 Jersey Avenue
New Brunswick, New Jersey 08903

Gentlemen:

Subject: Formulation Change for Chipman 2,4,5-T LOW VOLATILE ESTER 4 L
USDA Reg. No. 359-178
Your application of January 9, 1970

It is our understanding that this product under the new formula is to replace the old product accepted for registration on October 23, 1968. The Regulations for the Enforcement of the Act provide that after the effective date of a change in claims or formula the product shall be marketed only under new claims or formula, except that a reasonable time may be permitted to dispose of properly labeled stocks of old product.

Sincerely,

Harold G. Alford
Assistant Director
for Registration

SWIFT MIX NO. 1

For Further Manufacturing Purposes Only

ACTIVE INGREDIENTS:

Isooctyl ester of 2,4-Dichlorophenoxyacetic acid*	10.25%
Isooctyl ester of 2,4,5-Trichlorophenoxyacetic acid**	4.90%
INERT INGREDIENTS	84.85%

*Equivalent to 6.80% 2,4-Dichlorophenoxyacetic acid or 0.50 lbs. 2,4-D acid per gallon.

**Equivalent to 3.40% 2,4,5-Trichlorophenoxyacetic acid or 0.25 lbs 2,4,5-T acid per gallon.

CAUTION: Keep Out of Reach of Children

Seller's guarantee shall be limited to the terms of the label, and subject thereto the buyer assumes any risk to persons or property arising out of use or handling and accepts the product on these conditions.

Do NOT Store with Foodstuffs

CAUTION: Harmful if swallowed. Avoid contact with skin, eyes or clothing. In case of contact flush eyes with plenty of water, wash skin with soap and water. Avoid breathing spray mist. Do not use or store near heat or open flame.

Do NOT allow solution or spray drift to contact desirable plants. Among crops highly susceptible to 2,4-D and 2,4,5-T injury are cotton, tobacco, black-eyed peas, beans, tomatoes, melons, other vegetables, grapes, fruit trees and some ornamentals. (Coarse sprays are less likely to drift than are fine mist sprays.) It is difficult to completely clean 2,4-D and 2,4,5-T from sprayers or other equipment, therefore do not use such sprayers and other equipment for purposes where even trace amounts of this chemical may cause injury. Do not reuse shipping containers; destroy by crushing and burying. Avoid contamination of water intended for irrigation and domestic use. Do not transport with or store near seeds, fertilizers, insecticides or fungicides. Vapors from this product may injure susceptible plants in the vicinity.

U.S.D.A. Reg. No. 359-615

Port. SC-1-126

Atlanta, Ga.
Bound Brook, N. J.
Chicago, Ill.
St. Paul, Minn.
N. Kansas City, Mo.

Manufactured by
RHODIA INC.
CHIPMAN DIVISION
NEW BRUNSWICK, NEW JERSEY

Palo Alto, Calif.
Pasadena, Tex.
Portland, Ore.
Billings, Mont.

PRODUCT NO.
189

NET CONTENTS
GALLONS

SWIFT MIX NO. 2

For Further Manufacturing Purposes Only

ACTIVE INGREDIENTS:

Isooctyl ester of 2,4-Dichlorophenoxyacetic acid*	6.95%
Isooctyl ester of 2,4,5-Trichlorophenoxyacetic acid**	2.25%
INERT INGREDIENTS	90.80%

*Equivalent to 4.61% 2,4-Dichlorophenoxyacetic acid.
**Equivalent to 1.56% 2,4,5-Trichlorophenoxyacetic acid.

CAUTION: Keep Out of Reach of Children

Seller's guarantee shall be limited to the terms of the label, and subject thereto the buyer assumes any risk to persons or property arising out of use or handling and accepts the product on these conditions.

Do NOT Store with Foodstuffs

CAUTION: Harmful if swallowed. Avoid contact with skin, eyes or clothing. In case of contact flush eyes with plenty of water; wash skin with soap and water. Avoid breathing spray mist. Do not use or store near heat or open flame.

Do NOT allow solution or spray drift to contact desirable plants. Among crops highly susceptible to 2,4-D and 2,4,5-T injury are cotton, tobacco, black-eyed peas, beans, tomatoes, melons, other vegetables, grapes, fruit trees and some ornamentals. (Coarse sprays are less likely to drift than are fine mist sprays.) It is difficult to completely clean 2,4-D and 2,4,5-T from sprayers or other equipment, therefore do not use such sprayers and other equipment for purposes where even trace amounts of this chemical may cause injury. Do not reuse shipping containers; destroy by crushing and burying. Avoid contamination of water intended for irrigation and domestic use. Do not transport with or store near seeds, fertilizers, insecticides or fungicides. Vapors from this product may injure susceptible plants in the vicinity.

U.S.D.A. Reg. No. 359-616

Port. SC-1-126

Atlanta, Ga.
Bound Brook, N. J.
Chicago, Ill.
St. Paul, Minn.
N. Kansas City, Mo.

Manufactured by
RHODIA INC.
CHIPMAN DIVISION
NEW BRUNSWICK, NEW JERSEY

Palo Alto, Calif.
Pasadena, Tex.
Portland, Ore.
Billings, Mont.

EXHIBIT C

Date	Batch	Sp.	MA	FP	%	%	%	%	%	%	
					Total						
Date	Batch	Sp.	MA	FP	4/101	4/501	Cl	Ethyl	AE	Cent	AND
2-28-70	112-02	1.0682			4.07	8.90	16.85	45.32			AK
3-2-70	112-02	1.0658			4.04	8.88	16.76	45.47			CL
3-4-70	112-03	1.0635									[illegible]
3-4-70	112-03	1.0640			4.10	8.90	16.89	46.10			[illegible]
3-6-70	112-03	1.0652			4.04	4.87	16.80	45.58			[illegible]
3-10-70	112-04	1.0660			4.11	8.88	17.06	46.29			[illegible]
3-12-70	112-04	1.0626			4.04	8.55	16.82	45.63			FL
3-23-70	112-05	1.0660			4.13	8.88	17.16	46.04			RW
3-24-70	112-05	1.0610			4.02	8.84	16.76	45.47			CC
3-24-70	112-05	1.0621									D.P.
1-14-71	112-01	1.0656			4.06	8.89	16.85	45.76			FW
1-26-71	112-01	1.0640			4.04	8.86	16.80	45.58			CW
1-28-71	112-02	1.0657			4.07	8.88	16.81	45.88			CW
2-1-71	112-02	1.0633			4.03	8.86	16.78	45.53			CW
2-23-71	112-03	1.0672			4.11	8.89	17.03	46.20			CW
2-16-71	112-03	1.0633			4.04	8.85	16.76	45.63			[illegible]
3-1-71	112-04	1.0660			4.05	8.85	16.83	45.66			FW
3-8-71	112-04	1.0642			4.06	8.86	16.89	45.82			CC
3-9-71	[illegible]	1.0644									FW
3-9-71	[illegible]	1.0642			[illegible]		[illegible]	[illegible]			FW
5-11-71	112-05	1.0660			[illegible]		17.05	46.37			EL
5-17-70	112-05	1.0620			4.07	8.85	16.95	45.99			[illegible]

BK # 2

2,4 D 5T
2:1 Blend

Date	Batch	% Cl	Sp G	% MA	% FA	% H_2O	% DDP	% TCP	% AE	% EC	pH	
12-2-65	4-6A 7-6C	23.209	1.1689	0.00	[illegible]	.03	.617	.393	65.81	97.72	3.88	RM
12-7-65	535EN	23.0665	1.1677	.002	[illegible]	.015	0.83	0.40	65.48	97.20	3.72	CW
6-9-66	6218	23.168	1.1675	0.00	[illegible]	.02	1.268	.588	65.70	97.55	3.90	GM
6-15-66	369A(a)	23.243	1.1679	0.00	46/23	.04	1.21	.580	65.91	97.87	3.85	JB
6-15-66	369A(b)	23.30	1.1675	0.00	47/23	.03	1.48	.72	66.07	98.11	3.81	GM
6-15-66	369B(c)	23.182	1.1678	0.00	47/23	.03	1.89	.90	65.74	97.61	3.90	GM
6-16-66	6241	23.18	1.1703	0.00	47/24	.02	1.31	.64	65.73	97.60	3.86	LH
10-6-66	6301	23.28	1.1676						64.88	96.33		LH
10-11-66	6301	23.190	1.1676	0.00	55/28		1.10	.53	65.21	96.83	3.90	LH
10-13-66	6306	23.175	1.1700	0.00	57/25				65.72	97.58	[illegible]	GM
10-14-66	6X-1	23.17	1.2080						1.6.72	98.02		LH
10-17-66	6309	23.17	1.1684						65.92	97.89		JB
10-19-66	4/6-6C	23.250							64.91	96.39		JA, CC
10-19-66	4/6-6C	23.36	1.1692	0.00	56/28	0.01			66.21	98.36	3.90	LH
10-19-66	4/6-6C	23.106							65.2	97.28		JB
11-1-66	6325	23.200	1.1683	0.00	[illegible]		.352	.168				[illegible]
11-1-66	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	65.81	97.72		[illegible]
6-21-67	7C18	23.192	1.1696	0.00	[illegible]				65.77	97.66		[illegible]
2-21-67	7C71	23.146	1.1683	[illegible]					65.63	97.46		JB
2-24-67	[illegible]	23.23	1.1683	50.43	.52		.15	.07	65.26	97.141		LW & EW

2,4D-5T 2:1 Blend IDET

Tank	Batch	pH	%MA	%FA	%Pa.	%Pa.	%AE	%AE	%EC	%EC	Sp.G.		Anal
					(D)	(T)	(D)	(T)	(D)	(T)			
9-1-65	5296H	3.80	0.00		70.06	33.43	46.18	22.38	70.55	33.65	1.1703		TK
9-1-65	5298H	3.48	0.006							97.42	1.1728		RM
	5298H			Cl = 23.2264						97.075			
9-22-65	5301H	3.50	0.008		% Cl = 23.18					97.60	1.1697		LH
10-11-65	5302H	3.33	0.005		Cl = 22.777		EC = 97.90				1.1682		
10-20-65	5302H	3.15	.03		Cl = 23.4025		EC = 98.54			H_2O = 0.022	1.1728		
10-26-65	5302H	3.20	0.03							H_2O = 0.075	1.1697		
10-25-65	5302				% Cl = 23.156				EC = 97.50				Cl
6-16-65	[illegible]	3.80	0.01		% Cl = 25.903						1.2003		L
10-21-65	5312	3.20	.03	.42	% Cl = 23.175		% EC = 97.58				1.1703		CL
6-8-65	[illegible]	3.80	0.00	.99	% Cl = 23.156		% EC = 97.42				1.1691		J.O
11-1-65	5332	3.48	0.00		% Cl = 23.128		% EC = 97.38				1.1696		CL
11-15-65	5333H	3.89	0.00		% Cl = 23.361		% EC = 98.32				1.1693		LH
11-16-65	5334H	3.82	0.00		% Cl = 23.321		% EC = 97.73			overhead	1.1690	0.435	LH
11-17-65	5341H	3.50	0.004		% Cl = 23.225		% EC = 98.04				1.1706		LH
11-22-65	5347H	3.80	0.00		% Cl = 23.248		% EC = 97.29				1.1698		LH
11-23-65	[illegible]	3.65	0.003		% Cl = 23.155		% EC = 97.47		.160	.03	1.1699	0.438	LH
11-24-65	5352H	4.02	0.00		% Cl = 23.387		% EC = 98.47		.160	.03	1.1710	0.433	LI
11-30-65	5353H	3.52	.005		% Cl = 23.055		EC = 97.34		H_2O =	.03	1.1670	0.438	CL
12-1-65	[illegible]	3.61	.004		% Cl = 23.225		EC = 98.86		EC = 97.79	.03	1.1650		JO
12-4-65	5357H	4.03	0.00		% Cl = 23.18		AE = 65.73		EC = 97.60	H_2O = .0290	1.1702		LH

4D-ST Blend 2:1 IDET X

DATE	BATCH	S.G.	%MA	%FA	%AE	%DRI	%EC	pH	%H_2O	%Cl	%AE	%EC	Anal
											PAR.		
2-1-65	5234H	1.1677	—	.45	67.76	99.85	101.41	3.80	—	—	—	—	JB
6-23-65	5236	1.1677	% Cl = 23.056 %				EC = 97.08 %						JB
6-25-65	5241H	1.1683	% Cl = 22.788				EC = 95.95 %						CW
7-13-65	5244	1.1703	0.00	0.52						23.244		97.65	W
7-14-65	5246H	1.1703	—										RM JB
7-21-65	3	1.1708	0.00					3.82	—	23.266		97.96	RM
8-2-65	5267	1.1708	% Cl = 23.334				EC = 98.25 %						CW
7-1-65	5268	1.1702	% Cl = 23.265		AE = 65.86		EC = 97.84						CW
7-12-65	5252	1.1720	.03	.50				3.65		23.105		97.13	
7-12-65	5256	1.1703	0.00	0.46	—	—	—	3.82	0.016	23.266	65.88	97.87	
9-1-65	5276H	1.1704	trace	0.47				3.75	.022	23.071	65.29	97.14	
8-3-65	5317H	1.1712	—	0.49	17.45	99.42	100.14	4.02	—	23.32	—	98.13	
8-4-65	5319	1.1712	% Cl = 23.387				EC = 98.47						CW
9-14-65	5291H	1.1681	% Cl = 23.114				EC = 97.43 %						
8-16-65	[illegible]	1.1689	% Cl = 23.515				EC = 97.48						CW
7-12-65	5263	1.1685	.005		TCP =	.512 %	DRI =	1.072 %		23.215		97.75	CW
9-17-65	5295H	1.1706	.003		—	—		3.68	—	23.38		98.44	LH
9-8-65	5296	1.1682	.003					3.50	.011	23.35		98.32	JB RD
10-5-65	5298	1.1687	.007					3.50		22.714		95.64	JB
8-25-65	5299	1.1687	.004					3.56	.029				
8-26-65	5326	1.1697		% Cl = 23.100 %			% EC = 97.26 %						CW
9-21-65	5297	1.1696	.004	—	—	—	—	3.71	0.04	23.195		97.66	

4D-ST IDET BLEND 2:1

Date	Batch	Sp. Gr.	%MA	%FA	% Acid eq.	% Purity	% Ester Cont.	%Ph.	%HoH	%Cl	Anal	PARR.	
11-8-64	4324	1.1674	—										
11-16-64	4346	1.1666						3.80	0.015	22.467	TK	65.11	98.18
2-14-64	4040H	1.1697	0					3.80	0.024		CW	66.39	97.55
2-24-64	4041H	1.1696	—						0.0124	23.14	QUAR	66.07	98.10
2-12-64	[illegible]							3.80	.020		CW	65.62	97.58
2-21-64	[illegible]	1.1697	—							23.16	CL	65.51	97.27
7-28-64	Lab Blend	1.1644	0.12					3.85	0.011	23.30	TK RM	65.79	97.65
								1.91	0.02		TK		
8-5-64	4326H	1.1668	—					3.92	—	22.576	JB TK	66.02	95.66
7-12-64	4261H	1.1720							—	—	CL	65.62	97.4
9-14-64	4361H	1.1732	0.00					3.40			RM	66.25	97.3
9-14-64	[illegible]										CL	66.4	97.77
9-4-64	4322H		Pure	Pamb	% Ester Cont.			97.12		% Cl = 23.065 %			
10-8-64	4363H	1.1714	—					3.56	0.015		RM		
10-10-64	4363H	Pure Pamb			% Ester	98.21	% AE	66.21			TK		
10-8-64	4333H	1.1747	—					3.30	—		CL		
10-11-64	4324H	1.1733	0.005					3.74			RM		
10-14-64	4364H	1.1731				98.23	Pure Pamb				CW		
10-14-64	[illegible]	1.1742	0					4.00	0.06		CL		
8-24-64	[illegible]					98.23	Pure Pamb				CW		
[illegible]	[illegible]	1.1716	[illegible]		% Cl	[illegible]		% Ester					

Date	Batch	So. Gr.	%MA	%FA	% Acid eq.	% Purity	% Ester Cont.	%Ph.	%HOH	%Cl	Anal	%AE
												66.15
2-14-63	3303-H	1.1671	0.005					3.73	—		LHCD	66.65
2-15-63		1.1683	0.021					3.66			CWCD LH	
2-15-63		1.1687	0.026					3.65			CWCD LH	65.[illegible]
2-15-63		1.1687	0.016					3.65			LH	65.[illegible]
2-15-63	0-1335-H	1.1696	0.005					3.66 - 3.31			CD	66.37
[illegible]			0.024								LH	64.[illegible]
[illegible]		1.1730	0.004					3.80	0.039		CD	65.32
[illegible]		1.1709	0.005					3.60			LH	
[illegible]	3346-H	1.1711	0.005						0.027	0.47	LH	65.61
[illegible]	3347-H	1.1719	—						0.026		LH	65.25
[illegible]												
[illegible]	3347-H										LH	65.93 97
[illegible]											CW	65.15 97
[illegible]											CW	65.63 97
[illegible]											CW	65.[illegible] 97
[illegible]		1.1708	—					4.05	.009			
[illegible]		1.1711	—					4.10	.006			
[illegible]		1.1716	—					4.00	.016			
12-4-63	3354-H				AVERAGE ICE DETERMINATION %Cl = 23.275						LH	66.00 97
12-4-63	3354-H				LOW ICE DETERMINATION %Cl = 23.165						LH	65.69 97
12-4-63	3354-H	1.1717	—					4.10	0.027		DLH	

2.4-D: 2.4.5-T: IOE Tech (2:1 Blend) 1965 & 66 105

Date	2-21-67	2-21-67	2-24-67	3-21-67		
Batch	7068	7071	GATE 50493	7127-H		
SpG	1.1696	1.1683	1.1688	1.1698		
MA	0.00		0.00	0.00		
FA	.29 o .14 T		.39 o .19 T	.86 o .16 T		
% AE	65.77	65.63	65.86	65.56		
% EC	97.66	97.46	97.79	97.26		
% Cl	23.193	23.146	23.225	23.0985		
H_2O				.018		
DCP-TCP			.15 o .07 T	.86 o .41 T		
ANAL	JB GM	JB	LH-CW	JB GM		

Date	3-22-67	5-22-67	12/5/67	12-6-67	8-2-68	8-5-68
Batch	7128-H	GATE 50493 7128	7411-H	7413-H	8287-H	8288-H
SpG	1.1698	1.1696	1.1646	1.1655	1.1690	1.1700
MA		0.00	0.00	0.00	0.00	0.00
FA		JBD-1.19 T	.98	.94	.72	0.68
% AE	65.79	65.43	64.57	64.48	65.20	65.87
% EC	97.68	97.15	95.87	95.74	97.55	97.86
% Cl	23.20	23.077	22.77	22.74	23.17	23.23
H_2O		.02	.05	.05		
DCP-TCP		0 .82 T .39				
ANAL	LH	JB JM	CC	GM	JB	FW

2.4 D-5T 2:1 Blend IOET

Date	8-16-66	10-6-66	10-7-66	10-13-66	10-14-66	10-15-66
Batch	6240-H	6301	6301	6306	EK-1	6309
SpG	1.1703	1.1675	1.1676	1.1700	1.2080	1.1688
MA	0.00		0.00	0.00		
FA	.47 o .24 T		.55 o .28 T	.50 o .253 T		
% AE	65.73	64.88	65.21	65.72	66.72	65.72
% EC	97.60	96.33	96.83	97.58	96.02	97.59
% Cl	23.18	22.88	22.996	23.175	22.78	23.177
H_2O	.02					
DCP-TCP	1.34 o .64 T		1.10 o .53 T			
ANAL	LH	LH	LH	GM	LH	JB

Date	10-15-66	10-17-66	10-18-66	11-10-66	11-11-66	11-28-66
Batch	UNIX 46026	UNIX 46026	UNIX 46026	6325-H	6325	6335
SpG		1.1692		1.1664	1.1667	1.1682
MA		0.00		0.00	0.00	0.00
FA		.56 o .28 T		.44 o .22 T	.54 o .27 T	.33 o .16 T
% AE	64.91	66.24	65.52	65.64	65.81	65.38
% EC	96.39	98.36	97.29	97.47	97.72	97.63
% Cl	22.892	23.36	23.106	23.1495	23.208	23.234
H_2O		.04		.05		.03
DCP-TCP				.352 o .168 T		.321 o .154 T
ANAL	JB CC	LH	JB	GM	GW TB	GM

[illegible]	4354-H	1.1672		0.72					4.10		22.748	JB	9549
[illegible]	[illegible]	[illegible]											
[illegible]	[illegible]	1.1735	[illegible]	0.56	67.46	99.82	100.29	4.22		0.012		GL	
[illegible]	[illegible]	1.1735	[illegible]	[illegible]	% CL	[illegible]	1.295	%	[illegible]	7.64		GL	
[illegible]	4359	1.1717	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			19.36	GL	
[illegible]	[illegible]	1.1719	[illegible]								22.211	TK RM	9779
12-22-64	4358-H	[illegible]	ON 12-24-64									LM	
12-24-64	[illegible]	1.1724	PARR	BOMB	% CL	22.1355		% EC	97.83			GL	
12-24-64	[illegible]	1.1724	0.00	[illegible]	[illegible]	[illegible]		4.12		0.02		RM GL	
[illegible]		[illegible]											
2-25-65	5034-H	1.1717		% CL	22.4375		EC	98.69	%			GL	
2-26-65	5035	1.1682	0.002	0.68	[illegible]	[illegible]	[illegible]				23.504	JB TK	9247
2-26-65	5035	1.1685		% CL	[illegible]		EC = 57.07					GL	
2-26-65	5035	1.1685	0.002	.67	69.45	102.12	102.13					GL	
3-2-65	[illegible]	1.1704	0.004	1.07	[illegible]	[illegible]	[illegible]		3.66				
[illegible]	[illegible]	—	—	—	—	—	97.47	—		—	23.155	TK	9241
[illegible]	[illegible]	1.1717	[illegible]	0.3[illegible]	[illegible]	[illegible]	[illegible]			—	—		
4-16-65	5107	1.1717	0.00	0.44	68.19	100.54	101.25		3.50			GL HB	9241
4-8-65	5107	1.1725	—	.47	67.46	99.77	100.[illegible]		3.50			JB	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]								

Brush Killer

DATE	BATCH#	SpGr	MA	FA(D)	FA(T)	AE(D)	AE(T)	%GL(D)	%GL(T)	#/GAL	EHUL	ANAL	CKB
15 Dec 64	4384-H	1.0534	—	.41	.41	22.185	22.185	1.992	1.992	8.779	OK	G.L	
12-6-64	4344-H	1.0558	0.00	0.40	0.40	22.715	22.715	1.998	1.998	8.765	OK	GL RM	
					Filed								
1-2-65	5026-H	1.0546	0.00	0.32	0.32	22.70	22.70	1.994	1.994	8.785	Good	RM	
2-12-65	5026-H	1.0426	0.00	0.33	0.33	22.725	22.725	1.9935	1.9935	8.685	Good	RM GL	
2-15-65	5026-H	1.0466	0.00	0.33	0.33	23.345	23.345	2.0345	2.0345	8.718		RM	
[illegible]	5052-H	1.0515	0.00	0.42	0.42	21.125	21.125	1.815	1.615	[illegible]	OK	TK	
3-4-65	5052-H	1.0522	0.03	0.41	0.41	22.59	22.59	2.006	2.006	8.765	OK	GL	
3-13-65	5163-H	1.0584	0.00	0.24	0.12	22.925	22.925	2.021	2.021	8.716	OK	LH	
3-4-65	5211-H	1.0576	0.00	0.12	—	22.98	—	2.0245	—	8.[illegible]		TK	
3-5-65	5211-H	1.0553	0.00	0.165	—	22.91	—	2.004	—	8.797	OK	JB TK	
B Turner 65	5217-H	1.0547	—	.15	.15	22.38	22.38	1.966	1.966	8.786	OK	SW RM	
H Jones 65	5217-H	1.0579	—	.155	.155	22.885	22.885	2.0165	2.0165	8.812	OK	LN	
6-23-65	5234-H	1.0594	—	.165	.165	22.565	22.565	2.0245	2.0245	8.816	OK	LH JM	
[illegible]	[illegible]	[illegible]	[illegible]	.16	.16	[illegible]	[illegible]	[illegible]	1.94	8.94			
[illegible] 1-65	5248-H	1.0577	—	.24	.24	22.745	22.745	2.016	2.016	8.727		RM	
[illegible]	5256-H	1.0615	—	.15	.15	22.465	22.465	2.017	2.017	[illegible]	OK	[illegible]	
[illegible]	[illegible]	[illegible]	—	[illegible]	[illegible]	22.585	[illegible]	[illegible]	[illegible]	[illegible]			
7-11-65	5275-H	1.0657	—	.38	.38	22.95	22.95	2.032	2.032	8.545		LM	
8-13-65	5275-H	1.0591	—	.21	.21	22.985	22.985	2.026	2.026	8.514		GL	
8-19-65	5250-H	1.0622	0.00	.18	.18	23.140	23.140	2.0435	2.0435	8.631	OK	LM	
8-16-65	5260	1.0527	—	[illegible]	[illegible]	22.[illegible]	22.[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	

BRUSH KILLER 2

12-65	5244	1.0577	0.00	3.20	3.20	23.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			TK
[illegible]	5200-H	1.0631	0.00	0.43	0.43	[illegible]				8.007			
[illegible]	5200-H	1.0586	0.00	0.21	0.21	[illegible]				[illegible]			
11-X-65	5354-H	1.0632	0.00	0.16	0.16	22.975	22.975	2.036	2.036	8.264	CK		LH
12-16-65	5364-H	1.0668	0.00	0.23	0.23	22.86	22.86	2.055	2.055	FEED		24 Gal R211	
1-31-66	6021-H	1.0623	0.00	0.55	(%Cl = 16.65 × %H.E. 45.17)					3.447	8.249	CK	LH
2-16-66	6042-H	1.0633	0.00	0.62	(%Cl = 16.742 × %HE 45.50)					4.035	8.651	CK	TK
2-4-66	6040-H	1.0651	[illegible]	[illegible]	%Cl = 16.7225		AE = 45.582						CW
3-2-66	6058	1.0682			%Cl = 16.3955		AE = 45.835						CW
3-1-66	6079	1.0661	[illegible]		%Cl = 16.771		AE = 45.301						TK
4-8-66	4327	1.0528			%Cl = 16.196		A.E. = 43.94			3.853			CW
4-5-66	5062	1.0511			%Cl = 15.7595		AE = 42.757			3.744			CW
4-5-66	5052	1.0511	0.00	.845	.845	23.09	23.09	2.022	2.022				GD TK
4-8-66	4327	1.0528	0.00	.40	.40	23.42	23.42	2.050	2.050				GD TK
4-21-66	6134	1.0631			%Cl 16.582		AE = 44.99			3.944			LH
4-27-66	6194	1.0601			%Cl = 16.724		AE = 45.374			4.022			GM
4-27-66	6144	1.0616			%Cl = 16.28		AE 44.18			3.907			TK
4-29-66	6149	1.0600	0.00	.38	.38	22.14	22.14	3.967					
4-28-66	6145	1.0644	0.00	.58	.58	AE 44.84		%Cl = 16.564					TK
5-2-66	6149	1.0646			%Cl = 16.581		AE = 44.769			3.970			CW
6-5-66	6219	1.0582			%Cl = 16.498		AE 44.761			3.949			GM

BRUSH KILLER #2

Date	Batch	Sp Gr.	MA	FA(O)	FA(T)	AE(O)	AE(T)	#/gal(O)	#/gal(T)	#/gal	Emp	Anal	Chk'd
6-10-66	6219-H	1.0629		%Cl 16.499		AE = 44.621		#/gal	3.951			GD	
[illegible]	[illegible]	[illegible]		%Cl 16.500		AE = 44.309		#/gal	[illegible]	4.010		[illegible]	
6-8-66	6221	1.0644		%Cl 16.688		AE = 45.322		#/gal	4.010	4.010		FW	
6-14-66	6223	1.0667		%Cl 16.897		AE = 45.843		#/gal	4.073	4.04		FW	
[illegible]	[illegible]	1.0646						3.994		[illegible]		CW	
[illegible]	6231	1.0634		%Cl 16.576		AE 44.864		#/gal	3.982			GM	
[illegible]	[illegible]	[illegible]		[illegible]		[illegible]			3.[illegible]10			[illegible]	
[illegible]	[illegible]	[illegible]		[illegible]		[illegible]			[illegible]			[illegible]	
8-16-66	6242	1.0668		16.80		45.58			4.050			LH	
8-17-66	6242	1.0694		16.789		45.55			4.058			CW	
8-22-66	6250	1.0704		16.873		45.77			4.081			JB	
8-26-66	6250	1.0677		16.665		45.21			4.026			CW	
8-26-66	6256	1.0662		16.565		44.943			3.992			CW	
2-22-67	7070	1.0658		17.485		47.28			4.251			GM	
2-23-67	7070	1.0652		16.26		44.12			3.88			CW	
2-23-67	7070	1.0622		16.496		44.76			3.957			FW	
2-24-67	7076	1.0637		16.483		44.39			3.910			GD	
2-23-67	7077	1.0658		16.81		45.61			4.042			LH	
3-2-67	7089	1.0639		16.73		45.39			4.023		OK	LH	
"	7089	1.0648		16.71		45.33			4.021		OK	RM	
3-4-67	7097	1.0633	0.00	16.766	.42	45.49			4.030			JB	
3-6-67	7100	1.0631		16.790		45.65			4.034			JB	

Brush Killer #2

old Card under This one

Date	Batch	Sp gr	% Cl	% AE	# Gal		Anal	#/gal
3-15-67	7118-H	1.0622	16.027 ×	45.11	3.991		GD	
[illegible]	7132-H	1.0640	17.030	46.20	4.110		[illegible]	
3-24-67	7132-H	1.0633	16.755	45.46	4.027		LH	
5-12-67	7209	1.0642	16.666	45.21	4.008		FW	
5-15-67	7214	1.0652	16.776	45.51	4.038		R.S.	
5-16-67	7212	1.0639	16.859	45.74	4.054		R.S.	
5-18-67	7216	1.0638	16.749	45.44	4.027		R.S.	
5-24-67	7220	1.0643	16.405	44.51	3.935		CW	8.84
"	7220	1.0632	16.571	44.96	3.982		CW	8.86
6-15-67	7232	1.0643	16.740	45.42	4.027		R.S.	8.87

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Anal C.
1-2-65	5244	1.0577	0.00	.20	0.20	23.00	23.00	2.27	2.27	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2-24-65	5204	1.0634	0.00	0.28	0.28	[illegible]	—	—	—	—	8.857	—	TK	
2-24-65	5360	1.0566	0.00	0.24	0.24	(Tc Cl = [illegible])								
11-X-65	5554	1.0632	0.00	0.16	0.16	22.975	22.975	2.036	2.036	2.264	9.819	OK	TK	
12-20-65	5564	1.0668	0.00	0.23	0.23	22.86	22.86	2.035	2.035	2.266	OK		L.H.	
1-31-66	6021-H	1.0623	0.00	0.59	(1.00 = 16.65 % A.E. 45.17)						3.997	8.849	OK	LH
2-1-66	6042-H	1.0633	0.00	0.62	(% Cl 16.792 % A.E. 45.56)						4.035	8.857	OK	TK
2-4-66	6040-H	1.0651	2440	.64	% Cl = 16.7225		A.E. = 45.377				%/gal	2.0125		
2-4-66	6058	1.0682			% Cl 16.8955		A.E. = 45.859				%/gal	3.0158		CW
2-4-66	6074	1.0661	2460	.44	% Cl = 16.771		A.E. 45.201				%/gal	3.0194		CW
4-8-66	4337	1.0528			% Cl = 16.196		A.E. = 43.914				%/gal	3.853		TK
4-8-66	5052	1.0511			% Cl = 15.7595		A.E. = 42.757				%/gal	3.744		CW
4-8-66	5052	1.0511	0.00	.34	.34	23.09	23.09	2.022	2.022					CW
4-8-66	4337	1.0528	0.00	.40	.40	23.42	23.42	2.054	2.054					GD TK
4-21-66	6134	1.0631			% Cl 16.582		A.E. = 44.99				%/gal	3.924		GDTK
4-21-66	6144	1.0640			% Cl = 16.724		A.E. 45.374				%/gal	4.022		GTK
4-21-66	6144	1.0616			% Cl = 16.261		A.E. 44.119				%/gal	3.907		GM
4-21-66	6149		0.00	.38	.38	22.19	22.19	3.467						TK
4-26-66	6149	1.0644	0.00	.38	.38		A.E. 44.94		% Cl = 16.564		%/gal	4.037	.03	
5-2-66	6149	1.0646			% Cl = 16.501		A.E. = 44.769				%/gal	3.970		TK
6-9-66	6219	1.0592			% Cl = 16.499		A.E. 44.761				%/gal	3.949		CW
BRUSH KILLER #2														GM

Date	Batch	Sp. Gr.	MA	FA(O)	FA(T)	AE(O)	AE(T)	%/gal(O)	%/gal(T)	%/gal	Emul.	Anal	Blk.
6-10-66	6219-H	1.0624		9.86	16.449	AE = 44.628		%/gal	3.851			GD	
[illegible]	[illegible]	1.0623		[illegible]	16.700	AE = 45.309		%/gal	[illegible]	4.018		GTK	
6-8-66	6221	1.0644		% Cl = 16.688		AE = 45.322		%/gal	4.010	4.010		GW	
6-16-66	6222	1.0667		% Cl = 16.897		AE = 45.863		%/gal	4.073	4.024		FW	
[illegible]	[illegible]	[illegible]						3.959		[illegible]		FW	
[illegible]	[illegible]	1.0654		% Cl 16.581		AE = 44.864		%/gal	3.982			GTM	
[illegible]	[illegible]	[illegible]		[illegible]		[illegible]			3.910			[illegible]	
[illegible]	[illegible]	[illegible]		[illegible]		[illegible]			[illegible]			[illegible]	
8-16-66	6242	1.0668		16.80		45.58			4.050			CW	
8-17-66	6242	1.0694		16.789		45.55			4.058			LH.	
8-24-66	6250	1.0704		16.873		45.77			4.081			CW	
8-26-66	6250	1.0677		16.665		45.21			4.022			JB	
9-26-66	6256	1.0662		16.685		44.943			3.992			CW	
2-22-67	7070	1.0658		17.0485		47.88			4.251			CW	
2-23-67	7070	1.0584		16.26		44.12			3.958			GM	
2-23-67	7070	1.0612		16.490		44.76			3.957			CW	
2-24-67	7076	1.0677		16.483		44.70			3.970			FW	
2-28-67	7077	1.0638		16.81		45.61			4.042			GM	
3-2-67	7089	1.0639		16.73		45.39			4.023		OK	LH	
"	7089	1.0648		16.71		45.33			4.021		OK	GM	
3-4-67	7097	1.0633	0.00	16.76	.42	45.49			4.030			JB	
3-6-67	7100	1.0631		16.790		45.55			4.034			JB HK	

Brush Killer #2

old Card under This one

Date	Batch	Sp. Gr.	% Cl	% AE	% Gal	Anal	#/gal
3-15-67	7119-H	1.0622	16.627	45.11	3.991	[illegible]	
[illegible]	7132-H	1.0630	17.030	46.20	4.110	[illegible]	
3-24-67	7132-H	1.0633	16.755	45.46	4.027	LH	
5-12-67	7209	1.0642	16.666	45.21	4.008	PW	
5-15-67	7214	1.0652	16.776	45.51	4.038	R.S.	
5-16-67	7212	1.0639	16.859	45.74	4.054	R.S.	
5-18-67	7216	1.0638	16.749	45.44	4.027	R.S.	
5-23-67	7220	1.0643	16.405	44.51	3.935	C.W.	8.84
"	7220	1.0632	16.571	44.96	3.982	CW	8.86
6-13-67	7232	1.0643	16.740	45.42	4.037	R.S.	8.87

Date	Batch	SpGr	MA	FA(D)	FA(T)	AE(D)	AE(T)	(D) lb/gal	(T) lb/gal	Lb/gal	Emul	Anal	ck
[illegible]	[illegible]	[illegible]	—	[illegible]	[illegible]	22.28	22.28	1.928	1.998	8.263		[illegible]	
[illegible]	[illegible]	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	
4-6-64	4117-H	1.0495	[illegible]	[illegible]	.121	23.09	[illegible]	[illegible]	[illegible]	8.151		[illegible]	
4-7-64	4127-H	1.0512	0.00	0.14	0.14	22.50	22.50	2.007	2.007	8.263		CW	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	
4-26-64	4156-H	1.0577	0.00	0.13	0.13	23.29	23.29	2.052	2.052	8.211		LH	
4-27-64	4156-H	1.1161	0.00	0.14	0.14	23.025	23.025	2.022	2.022	8.780		LH&CW	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	
[illegible]	[illegible]	1.0558	.065	.265	.265	22.745	22.745	1.991	1.991	8.253	OK	CW	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	
6-4-64	4256-H	1.0641	0.00	[illegible]	.265	22.365	22.365	2.067	2.067	8.864		RWM	
[illegible]	[illegible]	1.0715	—	0.24	0.24	[illegible]	[illegible]	2.077	2.077	[illegible]		[illegible]	
[illegible]	[illegible]	1.0040	[illegible]	[illegible]	0.10	[illegible]	[illegible]	[illegible]	[illegible]	67		[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	
6-25-64	4252-H	1.0564	0.00	0.165	0.165	22.90	22.90	2.015	2.015	8.800	OK	RWM	
7-5-64	4261-H	1.0564	0.00	0.175	0.175	22.93	22.93	2.018	2.018	8.800	OK	RWM	0.04
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	
6-25-64	4296-H	1.0534	0.00	0.19	0.19	22.70	22.70	1.998	1.998	8.870	OK	[illegible]	
10-22-64	4331-H	1.0631	0.00	0.195	0.195	24.34	24.34	2.157	2.157	8.866	OK	TK	
10-27-64	4337-H	1.0631	0.00	0.255	0.255	23.10	23.10	2.026	2.026	8.772	OK	TK	
[illegible]	[illegible]	[illegible]	[illegible]	0.41	0.41	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	

BRUSH KILLER #2 K

Date	Batch	S Gr.	MA	FA(D)	FA(T)	AE(D)	AE(T)	(D) lb/gal	(T) lb/gal	lb/gal	Fmul	Anl by	ck rel b
1-23-63	3310-H	1.0650	—	.26	.26	23.40	23.40	2.07	2.07	9.14	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
4-11-63	3091-H	1.0585	—	0.145	0.145	[illegible]	[illegible]	1.897	1.897	8.817	OK	G.D.&RO.	
4-12-63	3091-H	1.0588	—	[illegible]	.14	[illegible]	[illegible]	1.9555	1.9555	[illegible]	OK	CW	
4-16-63	3095-H	1.0608	—	0.13	0.13	22.885	22.885	2.022	2.022	8.836	OK	CW&GD	
4-17-63	3025-H	1.0600	—	0.14	0.14	22.555	22.555	[illegible]	[illegible]	8.83	OK	G.D.	
4-17-63	3142-H	1.0594	—	0.16	0.16	23.19	23.19	2.046	2.046	8.825	OK	G.D.	
5-2-63	3141-H	1.0597	0.00	.155	.155	22.67	22.67	1.998	1.998	8.815	OK	CW	
5-21-63	3179-H	1.0592	0.0005	.25	.25	23.015	23.015	2.034	2.034	8.815	OK	[illegible]	
7-25-63	[illegible]	1.0825	—	.215	.215	25.255	25.255	2.277	2.277	9.017	OK	[illegible]	
[illegible]	3266	1.0559	[illegible]	0.16	0.13	23.05	23.05	2.033	2.033	8.821	OK	[illegible]	
12-9-63	3353-H	1.0649	[illegible]	0.18	0.18	23.845	23.845	2.115	2.115	8.871	OK	[illegible]	
12-10-63	3265-H	[illegible]	—	0.205	0.205	[illegible]	[illegible]	[illegible]	[illegible]	8.796	OK	TK CW	
12-12-63	3393-H	1.0545	—	0.165	0.165	22.495	22.495	1.98	1.98	8.784	OK	CW&GD	
12-12-63	3355-H	1.0567	—	0.165	0.165	[illegible]	[illegible]	1.997	1.997	8.796	OK	CW	
1-10-64	4051-H	1.0621	—	0.165	0.165	23.895	23.895	2.114	2.114	8.847	OK	TK	
1-13-64	4027-H	1.0574	—	0.175	0.175	23.365	23.365	2.025	2.025	8.808	OK	RW	
2-25-64	4047-H	1.0567	0.00	0.145	0.145	23.145	23.145	2.037	2.037	8.802		CW&RW	
2-26-64	4047-H	1.0538	0.0	0.22	0.22	22.94	22.94	2.014	2.014	8.778		CW&RW	
3-5-64	4062-H	1.0574	0.00	0.28	0.28	23.25	23.25	2.047	2.047	8.765		[illegible]	
3-26-64	4104-H	1.0515	0.00	0.115	0.115	22.685	22.685	1.987	1.987	8.764		TK	

BRUSH KILLER #2

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[illegible]	[illegible]	[illegible]	[illegible]	FA(D)	FA(T)	AE(D)	AE(T)	(D) lb/gal	(T) lb/gal	lb/gal	Fmul	Anl	ck rel b
[illegible]	[illegible]	[illegible]	0.00	0.07	0.02	6.05	[illegible]	[illegible]	[illegible]	[illegible]	OK	TK	
[illegible]	55085	0.8734	—	0.067	0.023	5.257	1.833	0.3824	0.1334	7.275	OK	G.D.	

Date	Batch	SpGr	MA	FA(D)	FA(T)	AE(D)	AE(T)	lb/gal(D)	lb/gal(T)	lb/gal	Emul	Anal	
2-4-64	4019-H	0.8821	NIL	0.046	0.023	6.463	3.232	0.475	0.238	7.335		AP	
2-5-64	4024-H	[illegible]	—	[illegible]	[illegible]	7.244	3.622	[illegible]	[illegible]	7.383		[illegible]	
2-5-64	4026-H	0.8262		0.066	0.033	7.245	3.623	0.575	0.267	7.382		[illegible]	
2-10-64	4037-H	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	TK	
2-12-64	4040-H	[illegible]	[illegible]	.062	0.041	8.024	4.012	0.594	0.294	7.460	[illegible]	TK	
2-12-64	4041-H	0.8614	0.00	.051	0.023	7.674	3.863	0.565	.283	7.312	.13	TKC	
[illegible]	[illegible]	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
2-19-64	4054-H	.8825	—	.054	.027	6.784	3.397	.488	.256	7.351	.014	[illegible]	
[illegible]	[illegible]	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	
2-21-64	4161-H	.8946	—	.08	.04	6.45	3.43	.565	.253	7.369		RMATK	
[illegible]	[illegible]	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	
[illegible]	5216-H	.8980	0.00	.069	.033	7.267	3.633	.5391	.2695	7.426	OK	CW	
3-2-65	5044-H	.8967	0.00	.087	.043	6.99	3.49	0.522	0.261	7.465		RM	
3-6-65	5094-H	.8968	0.00	.087	0.043	6.88	3.44	0.514	0.257	7.468	OK	G.L	
3-12-65	5164-H	.8982	0.00	.047	0.023	6.69	3.34	0.495	0.247	7.399	OK	L.H+RM	
3-12-65	5164-H	.8905	0.00	.047	0.023	7.33	3.67	0.544	0.272	7.418	OK	LH	
[illegible]	5210-H	.8900	0.00	0.033	0.037	6.93	3.41	0.506	0.253	7.414	OK	GL TK	
3/4/65	5210-H	.8892	0.00	0.06	0.03	6.85	3.42	.507	.254	7.407	OK	DM	

BRUSH-KILLER .50 "D" .25 "T"

Date	Batch	SpGr	MA	FA(D)	FA(T)	AE(D)	AE(T)	(D) lb/gal	(T) lb/gal	lb/gal	Emul	Anl	ck. by	rel
3-5-63	3028-H	0.9780	—	0.11	0.11	14.93	14.93	1.175	1.175	8.1467		BF		R
3/11/63	3040-H	0.9825	—	0.10	0.10	15.825	15.825	1.30	1.30	8.226	good	BF		
4-13-63	3041-H	0.9856	—	0.088	0.088	15.538	15.538	1.30	1.30	8.265		BF		
3-13-63	3040-H	0.9858	—	0.096	0.096	15.82	15.82	1.30	1.30	8.212		BF		
3-13-63	3040-H	0.9858	—	0.095	0.095	15.75	15.75	1.293	1.293	8.212		[illegible]		
[illegible]	[illegible]	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]		

BRUSH KILLER #L 25

DATE	BATCH	SpGr	MA	FA(D)	FA(T)	AE(D)	AE(T)	lb/gal(D)	lb/gal(T)	lb/gal	EMUL	ANAL	REL.
6-19-65	3232-H	1.1592	0.006	.21	.21	30.586	30.585	2.938	2.938	9.61	OK	[illegible]	
2-14-64	4031-H	1.1679	—	.20	.20	31.46	31.46	3.005	3.005	9.557	OK	AL	
2-15-64	4031-H RECHECK	1.1673	—	.20	.20	31.685	31.685	3.028	3.028	9.557		[illegible]	
2-17-64	4059-H	1.1852	—	.34	.34	31.775	31.775	3.051	3.051	9.623	OK	[illegible]	
5-26-65	5144-H	1.1565	—	0.20	.20	30.785	30.785	2.990	2.990	9.633	OK	TK	
6-1-65	5202-H	1.1715	0.01	0.215	0.215	31.065	31.065	3.014	3.014	9.775	OK	TK	
6-5-65	5234-H	1.1554	0.00	0.215	0.215	31.075	31.075	2.973	2.973	9.621		TK	
6-11-65	5240-H	1.1545	0.00	0.215	0.215	31.000	31.000	2.982	2.982	9.617		TK	
8-10-65	5244-H	1.1565	0.00	0.220	.220	31.57	31.57	3.042	3.042	9.634	OK	RM	
10-29-65	5326-H	1.1675	0.02	0.59	0.59	34.83	34.83	3.387	3.387	9.725	0.06	GL.LH.RM	
11-1-65	5322	1.1621			Sol.	23.698	AE.	61.58	0.24815 9.24815			CW	

BRUSH KILLER #2

Date	Batch	Sp. Gr.	%MA	%FA	%Purity	%A.E.	%E.C.	%HOM	lbs/gal.	Clar.	Anal.	Ck by

2,4-DB Ester Tech - IUE (Shipment) 603

Date	Batch	Sp. Gr.	%MA	%FA	%Purity	%A.E.	%E.C.	%HOM	lbs/gal.	Clar.	Anal.	Ck by
2-3-64	EK-9	1.0892	0.00	1.67	88.77	62.27	90.12	—	9.077		GW	
2-21-63	EK-9	1.0747	0.00	0.25	95.56	57.24	88.23	—	8.95	—	DZ RO-DJ	
2-4-64	EK-9	1.1203	0.00	0.72	97.31	67.81	98.36	—	9.332	—	CW	
2-5-64	EK-9	1.1122	0.00	0.11	96.59	66.70	96.75	—	9.265	—	CW CMB?	
4-4-63	3006	1.0986	0.00	0.15	95.46	66.12	95.91	—	9.246	—	CW	
5-7-63	EK#2	1.0731	—	0.21	85.17	59.23	85.91	—	8.939	—	G.D.	
6-1-63	3006	1.0957	0.00	0.27	94.20	65.21	94.59	—	9.127		CW RN	
12-2-63	DB-STOCK	1.0956	0.00	0.34	91.67	63.54	92.16	0.063	9.125	—	RGD	
[illegible]	[illegible]	[illegible]	—	[illegible]	94.88	[illegible]	[illegible]	/	[illegible]		[illegible]	
1-3-64	[illegible]	1.1080	0.0	0.56	96.26	66.92	97.07	0.063	9.230		CW GD	
~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~0.0~~	~~[illegible]~~	~~99.06~~	~~[illegible]~~	~~[illegible]~~		~~9.081~~		~~[illegible]~~	
3-4-64	EK#7	1.0991	0.00	1.56	89.12	63.66	91.[illegible]	—	[illegible]		[illegible] D #4 COC	
3-4-64	EK#9	1.0902	0.00	1.60	89.06	63.00	91.38	—			JCB-RWH-AP	
3-10-64	EK-9	[illegible]	0.00	1.25	97.46	65.75	95.41		8.367		LH	
4-3-64	EK-9	1.0898	0.00	0.35	91.38	[illegible]	92.06	0.35	9.078		TK	
4-16-64	EK-9	1.0994	—	[illegible]	[illegible]	[illegible]	[illegible]		9.066		TK GD	
[illegible]	[illegible]	1.1156	—	0.66	65.43	[illegible]	[illegible]	—	[illegible]		[illegible]	
4-27-64	EK#9	1.1161	—	0.56	100.30	69.71	101.11	0.03	9.279		LH GW	
5-4-64	4006	1.1128	0.00	0.43	98.85	68.52	99.42	0.02	9.270		TH TK	
5-21	4007	1.1069	0.02	0.54	97.60	67.23	92.34	0.25	9.216		LH	
3-16	[illegible]	1.1126	0.00	0.24	[illegible]	[illegible]	[illegible]		[illegible]		TK	

X 602 B

DATE	BATCH	SpGr	%MA	%FA	%H2O	%DP	%A.E.	%Rat	%E.C	#/gal	Clarity	ANAL	Ck by
1 MAR	4006	1.1040	—	0.24	—	—	66.70	96.63	96.92	9.232		TK	
[illegible]	[illegible]	1.1199	0.00	0.27	—	—	69.70	102.71	101.10	9.329		LH RM	
1-11-66	8-Gal	1.1183	0.00	.25	.026		68.57	99.10	99.46	9.315		LH + GM	
[illegible]	[illegible]	1.1103	0.00	0.32	.068	.889	67.23	97.05	97.52	9.245		LH RM	
[illegible]	[illegible]	1.1842	0.00	1.51	.08		82.11	98.75	100.60	9.864		LH GM	

Date	Batch	Spg	mg	Fa	#/gal	Total #/gal	S.U	Equal	AE	Cont	Ann
3-7-68	8118	1.0633			4.04	8.86	16.80		45.58		
3-8-68	8122	1.0632			4.00	8.86	16.65		45.17		
3/17/68	8140	1.0642			4.05	8.86	16.83		45.66		
1/1/68	8404	1.0630	C	.4C	4.01	8.86	16.67	.6	45.28		
6/28/68	8316	1.0585			3.91	8.82	16.52		44.82		
7-2-68	8276	~~[illegible]~~ 1.0591			4.00	8.82	16.69		45.28		
7-10-68	8277	1.0590			4.17	8.80	17.35		46.80		
7-11-68	8277	1.0605			4.01	8.83	16.73		45.39		
3-[illegible]-69	9111	1.0642			4.08	8.86	16.98		46.07		
3-24-69	9111	1.0620			4.03	8.85	16.80		45.58		
3-24-69	9111	1.0617			4.00	8.84					
3-26-69	9119	1.0612			4.01	8.84	16.70		45.31		
4-7-69	9142	1.0645			4.02	8.87	16.92		45.91		
4-8-69	9142	1.0612			4.07	8.84	16.82		45.63		
4-22-69	9173	1.0640			4.03	8.84	16.79		45.55		
9-26-69	9335	1.0680			4.23	—	17.59		47.70		
9-29-69	~~9334~~	1.0635	9338		4.10	—	17.04		46.23		
9-30-69	9338	1.0628			4.04	8.85	16.80		45.58		
[illegible]	9[illegible]	1.0644			4.21	8.87	16.65		45.19		
10-[illegible]-69	9376	1.0634			3.98	8.86	16.56		44.93		
10-[illegible]-69	9376	1.0643			4.07	8.87	16.79		45.39		
2-13-70	11201	1.0668			4.04	8.89	16.76		45.47		
BK # 2					22.55	23.05	20 AR	4.0			
					22.55	23.05	8.06	ST			

Date	Batch	Sp.Gr.	%MA	%EA	%A.E.	%.E.C.	%HOH	%TCP	%C~~E~~C.	Clar.	Anal.	Ck by
[illegible]	[illegible]	1.3184	0	[illegible]	[illegible]	98.65	[illegible]	[illegible]	[illegible]		B CEB	
							.0585	0.621				
5-4-61	from [illegible]	1.3215	0.00	0.17	82.34	100.4	20.0159	0.721	11.015		JCB LH	
5-4-61	from [illegible]	1.3178	0.00	0.15	82.88	100.39	.0886	0.219	10.936		JCB LH	
5-5-61	68501	1.2046	.02	1.30	76.86	116.62		4.23			CW SH S.B	
4-26-66	68881	1.2154	.03	2.37	66.29	95.40	.04	4.46			LH	

2,4,5-T Butyl Ester Tech. (Shipment) [redacted]502

DATE	BATCH	Sp.Gr.	%MA	%FA	%A	%AE	%EC	%TCP	%H2O		ANAL
5-19-66	from [illegible]	1.2178	0.00	1.94	28.10	67.50	97.15	4.51	0.04	TOTAL NUMBER OF CHLORINE	LB
5-21-66	from [illegible]	1.2150	0.00	1.35	27.934	67.09	96.58	4.46	.03		[illegible]
7-22-66	[illegible]	1.2105	.005	1.42	27.914	65.38	94.08		.04		[illegible]
7-15-66	[illegible]	1.2178	.005	1.43	28.052	67.38	96.97		.04		CW FW
7-22-66	STORAGE	1.2163	0.00	1.48	27.857	66.91	96.30	4.20	.03		CC LH
4-21-67	Gas [illegible]		0.00	1.10	28.399	68.21	98.17	3.97			CW FA
5-26-67	[illegible]	1.2223	0.00	1.47	28.256	68.11	98.02	4.12	.06		RS. HW
6-23-67	Tank [illegible]	1.2165			28.113	67.525	[illegible]				CC
12-4-67	4-22	1.2040	0.0	1.45	27.23	65.33	94.02		.08		[illegible]
7/1/68	GATX 68437	1.2190	0.0	1.40	28.29	67.95	97.79		.04		CP
8-1-68	[illegible]	1.2192	.002	.96	28.36	68.12	98.04				CC FW
6-20-69	[illegible]	1.2108			27.68	66.48	95.68				[illegible]
12-3-69	[illegible]	1.2110			27.44	66.39	95.55				[illegible]
2-13-70	6.11	1.2224			28.13	67.57	97.25				FW
2-27-70	2.17 703	1.2145			27.66	66.44	95.62				FW
[illegible]	[illegible]	1.2178			27.44	[illegible]	96.56				FW
12-16-70	Estes Refine	1.1196	.04	1.11	23.83	54.84	78.93				D.P.
12-28-70	EKI	1.1440	.02	.30	24.27	55.29	79.59				D.P.
3-16-72	76610	1.2186			28.24	67.83	97.62				FW
3-18-73	84175	1.2154	.00	1.09	28.12	67.54	97.40				D.P.
8-5-73	Shipment	1.2150	0.00	1.07	28.19	67.71	97.45	3.97	.03		D.P.

2,4,5-T ISO-OCTYL ESTER TECH — (SHIPMENT)

DATE	BATCH	SpG.	MA	FA	CL.	AE	EC			ANAL
11-21-75	BBC Shipment	1.2224	0.00	1.34	28.25	67.85	97.65			D.P.

Date	Batch	Sp Gr	% MA	% FA	% H_2O	% TCP	% AE	% Acidity	% EC	lbs/gal	% Cl	Appl	Ck By
[illegible]	[illegible]	1.268	.66	.25			59.95		55.27		24.67	[illegible]	
[illegible]	[illegible]	1.1494	.62	.21			62.45		44.20		27.25	[illegible]	
	Gate						ECT						
4-27-75	766WD	1.2240					28.34	67.83		97.62		CW	

2.4.5.5 IOE Tech

Date	Batch	Sp Gr	% MA	% FA	% H_2O	% TCP	% AE	% Acidity	% EC	lbs/gal	% Cl	Appl	Ck By
11-9-66	6422			% Cl = 27.876			66.91		96.77				JB
11-9-66	STOR 1 BOTS		1.01 = 27.74				% A.E. = 66.63		LE.C. = 95.89				L.H.
11-11-66	GY56	1.216		% Cl = 28.112			AE = 67.52		EC = 97.17				CW
12-7-66	Storage	1.2134	0.00	.63	.02	.43	67.04		96.63		27.952	Gm	JB
1-28-67	Sandy	1.2150	0.00	.69		.61	66.53		95.75		27.70		FW
2-20-67	Thompson Wayne WD	1.2185	0.00	.66		K.C. Sample	67.61		97.30		28.08		Gm
2-20-67	Gate 1816	1.2205	.003	.83			67.66		97.38		28.171		Gm
3-21-67	Thompson Wayne WD	1.2215	(Gate 1816)			3.16	67.75		97.51		28.206		CW
4-3-67	Gate 2416	1.2217					68.21		98.17		28.40		LH
4-17-67	Gate 616	1.2225					68.19		98.14		28.391		CW
5-19-67	T-15	1.2228					56.38		81.14		23.474		J.B
5-25-67	T-Hay	1.2215					67.67		97.53		28.214		CC
1-8-68	T-V		.03	1.77		.23	67.04		96.48		27.91		CW
2-7-68	Gate 616		.02	1.50			67.13		96.61		27.95		HM
2-29-68	T-19	1.2158	.03	.35			67.25		96.79		28.00		T.B
3-5-68	T-19	1.2175	.02	.37			67.37		96.96		28.05		CW
3-7-68	T-15	1.2160	.07	.36			67.19		96.69		27.97		SR
3-7-68	T-19	1.2162	.03	.37			67.13		96.61		27.95		SR
7-2-68	#1	1.1635					62.11		89.37		25.86		CC
12-30-70	ERI 2	1.1372	.04	4.36			56.80	56.80	81.75		23.65		FW
1-15-71	Gate	1.2220					67.49		97.07		28.08		GW

29.5 T Ion-Oth Ester Tech X

DATE	BATCH	SPG	% CL	Form % Gal	Total % Gal	AE			Appl		
3/3/73	280-05	1.0408	19.19	4.00	8.67	46.09			CC		
4-17-73	280-04	1.0471	19.51	4.10	8.72	47.05			DP		
4-18-73	280-04	1.0415	19.29	4.02	8.68	46.38			[illegible]		
3/24/73	280-01	1.1008	21.81	4.50	9.17	52.34			CC		
3-26-74	280-01	1.1068	Q.1530								
3-27-74	280-01	1.0518	19.38	4.08	8.76	46.55			CW		
3-27-74	280-01	1.0482		4.01	8.73	45.93			CW		
4/23/75	280-01	1.0500	19.15	4.02	8.75	46.00			DP		

Date	Batch	Sp.Gr.	%Cl	Form % Gal	Form Total Gal	AE	Anal
2-17-72	138-01	1.0570	19.55	4.13	8.80	46.96	G.W.
2-23-72	138-01	1.0526		4.03	8.77	45.95	C.W.
3-15-72	138-02	1.0542	19.54	4.12	8.75	46.93	D.P.
3-16-72	138-02	1.0487	19.25	4.04	8.74	46.24	C.W.
3-20-72	138-03	1.0545	19.30	4.04	8.78	46.36	G.W.
3-21-72	138-04	1.0531	19.31	4.07	8.77	46.38	D.P.
3-29-72	138-04	1.0528	19.25	4.05	8.75	46.31	D.P.
4-3-72	138-05	1.0527	19.35	4.08	8.77	46.48	C.W.
4-3-72	138-05	1.0496	19.30	4.05	8.74	46.36	D.P.
4-27-72	138-06	1.0525	19.65	4.11	8.77	47.20	[illegible]
4-28-72	138-06	1.0460	19.17	4.01	8.71	46.04	C.W.
5-1-72	138-07	1.0503	19.47	4.06	8.72	46.67	[illegible]
5-15-72	138-07	1.0483	19.24	4.03	8.72	46.21	C.W.
5-21-72	138-08	1.0505	19.50	4.10	8.75	46.84	C.W.
5-21-72	138-08	1.0470	19.12	4.00	8.72	45.92	D.P.
6-11-72	138-01	1.0530	19.34	4.04	8.75	46.21	[illegible]
3-12-72	3810-01	1.0457	19.61	4.12	8.74	47.10	C.W.
3-12-73	3810-01	1.0428	19.35	4.04	8.69	46.48	DP & C.W.
3-12-73	3810-01	1.0455	19.41	4.06	8.71	46.62	C.W.
3-13-73	3810-02	1.0430	19.41	4.05	8.69	46.62	D.P.
3-29-73	3810-03	1.0477	19.61	4.11	8.73	47.10	D.P.
3-13-73	3810-03	1.0496	19.40	4.05	8.69	46.60	D.C.

5TL

DATE	BATCH	SP.GR.	MA	FA	% CL	GAL	TOTAL GAL	AE	EMU	ANL
8/1/70	138-10	1.0705			18.76	4.02	8.92			CC
9-23-70	138-11	1.0685			18.53	3.96	8.90	44.32		CC
1-7-71	138-02	1.0724			18.90	4.06	8.93	45.40		[illegible]
1-8-71	138-02	1.0707			18.85	4.04	8.92	45.28		Am CW
1-15-71	138-03	1.0765			19.22	4.14	8.97	46.16		CW
1-15-71	138-03	1.0710			18.86	4.04	8.92	45.30		CW
1-22-71	138-04	1.0786			18.57	3.98	8.92	44.60		CW
1-24-71	138-04	1.0680			18.76	4.01	8.90	45.06		D.P.
2-12-71	138-01	1.0760			19.06	4.10	8.96	45.78		CW
2-16-71	138-01	1.0725			18.76	4.03	8.93	45.06		[illegible]
3-2-71	138-05	1.0757			19.00	4.09	8.96	45.64		CW
3-1-71	138-05	1.0724			18.76	4.03	8.93	45.06		CW
3-4-71	138-06	1.0730			18.83	4.04	8.94	45.31		[illegible]
3-4-71	138-06	1.0695			18.78	4.02	8.91	45.11		CC
3-11-71	138-07	1.0712			18.84	4.04	8.92	45.25		[illegible]
3-12-71	138-07	1.0713	Calcex		8301	Dem A				CW
3-24-71	138-08	1.0677			18.88	4.03	8.89	45.35		[illegible]
3-25-71	138-08	1.0715			18.99	4.07	8.93	45.61		CW
4-10-71	138-09	1.0717			18.82	4.04	8.93	45.20		D.P.
5-15-71	138-10	1.0717			18.98	4.07	8.93	45.59		CW
5-26-71	[illegible]	1.0695				4.03	8.91	45.23		[illegible]
6-25-71	[illegible]	1.0714			18.91	4.05	8.93	45.42		[illegible]

2-4 STL & 4L 44.62 - 45.12 % AE

DATE	Batch	Sp.Gr.	MA	FA	% Cl	Gal	Total Gal	N.C.	EMU	Anal	
3-26-69	9141	1.0710			18.78	4.02	8.92			[illegible]	AE: 45.11
4-4-69	9141	1.0735			18.95	4.07	8.94			CW	45.52
4-4-69	9141	1.0708			18.76	4.02	8.92			EW	45.06
4-18-69	9166	1.0750			18.94	4.07	8.94			EK	45.89
4-19-69	9166	1.0702			18.73	4.01	8.91			R.S.	44.99
6-13-69	9269	1.0708			18.83	4.03	8.92			CW	45.23
8-1-69	9295	1.0705			18.72	4.01	8.92			[illegible]	44.96
2-10-70	138-01	1.0702			18.55	3.98	8.91			D.P.	44.63
2-11-70	138-01	1.0720			18.62	3.993	8.93		OK	RC	46.72
3-4-70	138-01	1.0730				4.02	8.94			[illegible]	44.97
3-4-70	138-03	1.0716			18.75	4.02	8.93			CW	45.04
3-6-70	138-04	1.0730			18.92	4.06	8.94			[illegible]	45.[illegible]
3-12-70	138-05	1.0737			18.89	4.06	8.91			[illegible]	45.5[illegible]
3-25-70	138-06	1.0736			18.77	4.03	8.94			EW	45.[illegible]
4-22-70	138-06	1.0739			18.96	4.07	8.95			EW	45.54
4-27-70	138-06	1.0710			18.65	4.00	8.92			CW	44.8[illegible]
5-5-70	138-07	1.0755			19.18	4.13	8.96			D.P.	46.07
5-16-70	138-07	1.0723			18.85	4.04	8.93			CC	45.25
6-[illegible]-70	138-08	1.0776			19.18	4.14	8.95			EW	46.[illegible]7
6-17-70	138-08	1.0715			18.44	4.06	8.92			CC	45.49
7-10-70	138-09	1.0716			18.79	4.03	8.93			D.P.	45.13
[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]			[illegible]	[illegible]

Date	Batch	Sp Gr	%MA	%FA	% A.E.	lb 2-4-5T	lb/gal	Emus	Anal	ck by	rel by
2-19-63	36 20H	1.0724	0.00	0.38	45.63	4.076	8.533		LH		
[illegible]	[illegible]	[illegible]	[illegible]	0.32	[illegible]	[illegible]	[illegible]		[illegible]		
3-11-63	20398	1.0715	—	0.352	45.36	4.048	8.926	OK	L.H.		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	OK	DT	(B.+HL 44.5 A?)	
4-11-63	3FFH	1.0721	0.00	0.80	46.96	4.189	8.831		CWHH		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]		
5-19-63	5311H	1.0623	0.009	.47	45.24	4.008	8.849	OK	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]	.57	45.32	2.292	8.535	[illegible]	[illegible]		
2-24-64	4054H	1.0659	0.00	0.33	45.96	4.092	8.904		RCM		
2-24-64	4434H	1.0679	0	0.32	44.79	[illegible]	2.229		GP TK		
2-24-64	4654H	1.0618	0.00	0.32	45.[illegible]	4.099	2.345		LKC		
3-24-64	4668H	1.0627	0.0	0.30	45.67	4.143	8.253		GP CB		
3-24-64	4723H	1.0614	—	0.35	45.39	[illegible]	8.641		L.H.	HL	
4-4-64	4115A	1.0608	0	0.38	45.25	4.042	8.836		JB (HL)		
4-17-64	4147H	1.0621	0.00	0.29	45.96	4.082	8.881		TK		
4-20-64	4147H	1.0620	0.00	0.32	[illegible]	[illegible]	8.646	2	LH CW		
5-26-64	4235H	1.0623	0.00	0.36	46.14	4.096	8.852	OK	CW AH		
5-29-64	4235H	1.0627	0.003	0.70	45.37	4.016	8.852		KW KW TK		
6-22-64	4248H	1.0628	0.00	0.34	45.43	4.061	8.853	OK	TK	HC CW	
		1.0613	0.00	0.35	45.44	4.017	8.841		GL-TK	[illegible]	

2,4-5-T LVE 4L

506 T

Date	Batch	Spg	MA	FA	Total	Total	CL	AE		Cont		Anal
3-26-73	8301	1.0366			4.03	8.63	17.19	46.64		2040-03	Done A	D.
3-30-73	2040-04	1.0400			4.10	8.66	17.46	47.37				D.
[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]				[illegible]
4-3-73	2040-09	1.0347			4.01	8.62		46.52				C.
10-15-75	2040	1.0503			4.17	8.75	17.58	47.70				C.K
10-15-75	2040	1.0464			4.12	8.77	17.11	46.42				
[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]				
11-6-75	2040-02	1.0365			4.00	8.63	17.09	46.361				C

BK-2

DATE	BATCH	SPG	MA	FA	% CAL	TOTAL BAL	CL	AE		CONT			ANAL
6-8-71	1206	1.0635			4.08	8.85	16.95	46.07					RC
6-14-71	1206	1.0595			4.04	8.83	16.88	45.30					RC
7-7-71	1207	1.0619			4.08	8.44	17.01	46.18					EW
8-6-71	1207	1.0558			4.04	8.52	16.69	45.52					DP=G
2-3-72	1201	1.0425			4.08	8.68	17.16	47.[illegible]	46.56			RTA	RC
2-10-72	1202	1.0460			4.00	8.66	17.07	46.20					CW
2-16-72	1203	1.0431			4.06	8.69	17.21	46.69					D.T
2-17-72	1203	1.0425			4.04	8.68	17.15	46.53					D.T
2-29-72	1204	1.0453			4.16	8.71	17.23	47.62					[illegible]
3-1-72	1204	1.0417			4.05	8.65	17.19	46.64					D.T
3-6-72	1205	1.0536			4.27	8.78	17.93	48.65					D.T
3-7-72	1205	1.0395			4.24	8.66	17.18	46.61					[illegible]
3-13-72	1206	1.0460			4.12	8.71	17.41	47.34					[illegible]
3-16-72	1206	1.0463			4.00	8.67	17.02	46.18					[illegible]
3-21-72	1207	1.0449			4.08	8.70	17.27	46.86					HK
3-27-72	1207	1.0420			4.03	8.68	17.11	46.42					D.T
3-15-73	2040-01	1.0370			4.06	8.64	17.31	46.96					D.
3-16-73	2040-01	1.0357			4.01	8.62	17.15	46.52					CC
3-19-73	2040-02	1.0389			4.07	8.65	17.34	47.05					CW
3-19-73	2040-02	1.0356			4.01	8.65	17.14	46.50					D.T
3-20-73	2040-03	1.0374			4.03	8.64	17.21	46.69					D.T
3-21-73	2040-03	1.0376			[illegible]	[illegible]	[illegible]	[illegible]					[illegible]

Date	Batch	SpGr	% HCl	MA	FA	DE	lb/gal	lb/gal	Eval	H_2O	Anal
12/1/63	5378	1.1842	25.28	.012	1.14	66.67	5.586	9.264		.046	RH
[illegible]	6695H	1.1864		.004	1.58	67.08	6.623	9.874		—	GH 11.0
3-24-66	6695H	1.1854	25.298			60.766	6.000	9.874		.07	GW

2,4-5T 6L 60.72-61.22 ZDE

Date	Batch	SpGr	pH	2,4,5-T % ~~72.4~~ 59.	lb/gal	lb/gal 20.4	Fm. No Sol.	Anal	ck by	rel by
12/1/63	5611	1.3561	4.17	70.72	[illegible]	9.294	X	OK	EZ	
6/16/66	7537	1.3410	4.45	72.37	2.315	9.355	—	—	RMF	

2,4,5-T IOE LV2.50 L 505 Z

DATE	BATCH	SpGr	% MA	% FA	% H_2O	% A.E.	lb/gal	lb/gal	EVAL	pH	ANAL	CK.
7/[illegible]/65	5243 N	.9082		.11		14.64	1.104	7.565	N.G.	5.39	GL-RH	[illegible]
[illegible]	"	.9591		.16		25.02	1.997	7.981	OK	5.10	L.H	[illegible]

DATE	BATCH	SP GR	%MA	%FA	%AE	[illegible]	lb/gal	EMUS	ANAL	CL by	TN by	[illegible]
9-1-69	[illegible]	1.1617	0.00	.53	62.04	6.068	9.677	—	TK			[illegible]
1-5-69	[illegible]	1.1548	0.00	1.44	62.44	6.006	9.619	—	CLRM			0.08
[illegible]	[illegible]	1.1667	0.00	.49	62.37	[illegible]	9.669	—	[illegible]			
8/15/68	8203 14											

2,4,5-T IOE LVF 6" Oil Soluble

DATE	BATCH	SpGr	%MA	%FA	%Pure	%AE	%EC	#/gal	%H2O	Clar	Anal	CR by
11 June 65	31145OT	1.1954	C+C	1.54	100.19	72.28	102.37	9.938			LH RM JB	
11-22-66	5.6920	1.1950	.00	1.34	99.91	70.88	99.61		.62		LH CW	
1-9-66	5.6926	1.1950	.00	1.41	98.68	70.66	100.68	9.954			LH TM	
2-23-66	150056	1.1967	.00	.22	99.33	70.85	99.64	9.885			LH TM	
2-23-66	150364	1.1889	.00	.15	99.53	70.82	99.74	9.904			LH TM	
2-23-66	150166	1.1867	.00	.17	98.81	69.92	99.05	9.885			LH TM	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	
—	[illegible]	1.1856	[illegible]	.26	99.13	[illegible]	99.64	9.811			[illegible]	
5-17-66	150066	1.1855	0.00	.19	100.01	70.80	100.24	9.915			LH EM	
5-17-66	150286	1.1860	0.00	.19	98.38	69.65	98.65	9.879			LH EM	
11-14-66	Shipment	1.1894	0.00	.62	98.73	70.33	99.61	9.908	.02		CW	
5-10-67	?	1.1889				68.31	96.75				JB	
4-27-68	[illegible]	1.1898				66.42	94.15	9.74			LH TM	
9-25-68	[illegible]	1.1833	.00	.46		68.92	97.62	9.80		.42	FW	LOT 15009
10-3-68	132198	1.1883	.00	—		69.49	97.57	9.90		.34	CC	LOT 15009
6-11-69	143274	1.1950	.00	.72		69.76	98.81	9.95			LH TM	
7-8-69	102	1.1895				69.43	99.36				CC	LOT LR3
9-11-69	102	1.1910	.002	1.17		69.37	99.18		.04	2.66	CC	
9-29-69	[illegible]	1.1912				69.48	99.41	9.92	TRP	2.66	LH TM	
11-10-69	[illegible]	1.1857				69.58	99.55	9.89	27.46		CW	3.24 JTC
1-15-70	[illegible]	1.1905				69.22	99.00	9.91	27.28		CW	
10-22-70	[illegible]	1.1857				68.55	98.51	9.82	27.45		LH TM	

SILVEX TECH (2-ETHYL-HEXYL SILVEX) 2,4,5-TPIOET X

Date	12-14-71	12-18-71	12-16-71	3-28-72	3-29-72	3-30-72
Batch	198-14	198-14	[illegible]	198-01	198-01	198-02
Sp.G.	1.1611	1.1605	1.1605	1.1617	1.1592	1.1623
MA						
FA						
Cl.	23.01	22.05		23.98	22.85	23.02
% AO	44.40	22.05	Cat A 54941	44.34	44.16	44.42
% Silvex	22.20	44.13		22.17	22.05	22.21
Water	2.00	2.10	2.10			
Anal.	D.P.	LH TM	D.P.	D.P.	D.P.	AK

Date	3-31-72	3-31-72
Batch	198-02	[illegible] 55488
SpG	1.1590	1.1572
MA		
FA		
Cl	22.86	22.39
AE	66.18	66.26
% AO	44.12	44.17
% Silvex	22.06	22.08
Water		
Anal	CW	D.P.

	Gatx 29798	198-05	19		Gatx 48441
DATE	10-25-71	11-2-71	11-3-71		11-4-71
SpG	1.1555	1.1610	1.16		1.1606
MA					
EA					
Cl	22.71				
% HME	43.54	22.71	22.62		22.66
% Silver AE	21.92	43.56	44.24		42.73
AMC	CC	21.91	22.1		21.97
	Ratio 1.98	C.M	Rm		CC
		DD	Ratio 2.05		Ratio 1.97

		198-11	198-12	Gatx 29798	198-1
Date	12-5-71	12-6-71	12-7-71	12-9-71	12-10
SpG	1.1870	1.1610	1.1608	1.1605	1.161
MA					
EA					
Cl	22.75	22.78	22.90	22.50	22.71
% HME	52.57	43.36	44.19	44.19	44.21
% Silver AE	26.20	21.93	22.04	22.09	22.10
Anal	D.P	Rm	Rm	C-M	D.P
Ratio		2.00	2.00	1.99	

Silver 2:1 BLEND

	198-81	198-82	198-02	Gatx 29798	198-03	198-03
Date	9-1-71	9-2-71	9-3-71	9-3-71	9-7-71	9-8-71
SpG	1.1596	1.1607	1.1590	1.1594	1.1603	1.1588
MA						
EA						
Cl	22.71	22.87	22.68	22.59	22.83	22.93
% HME	43.90	44.14	43.77	43.60	44.06	43.86
% Silver AE	21.95	22.07	21.88	21.80	22.03	21.96
Anal	D.P	C.M	Rm	Rm	C.M	Rm
				Ratio 1.98		

Date	9-14-71	9-16-71	9-17-71	9-17-71	9-21-71	10-22-71
Batch	198-04	198-05	198-05	Gatx 84541	198-06	198-07
SpG	1.1600	1.1610	1.1583	1.1583	1.1600	1.1600
MA						
EA						
Cl	22.98	22.84	22.74	22.70	22.77	22.44
% HME	43.96	44.02	43.88	43.80	43.94	44.66
% Silver AE	21.98	22.04	21.94	21.90	21.97	22.33
Anal	Rm	Rm	C.W	C.W	C.W	C.W
Ratio				Ratio 2.07		

Silver 2:1 Blend

Date	10-13-69	10-14-69	10-15-69	10-16-69	10-18-69	
Batch	Gatx 32497	9355	9356	9356	Gatx 52955	
SpG	1.1610	1.1610	1.1634	1.1592	1.1611	
MA						
EA						
Cl	22.94	22.76				
% HME	44.27	43.92		22.77	22.80	
% Silver AE	22.13	21.96		43.54	44.00	
Anal	C.W	C.W	FW	21.97	22.00	
				C.W	C.W	
Ratio	2.06-102	1.98		2.07		
	Assay					
	102.5%					
	10/13/69					

DATE	1-8-70	1-19-70	1-19-70	1-20-70	1-21-70	1-21-70
BATCH	198-01	198-02	Gatx 3093	198-03	198-04	Gatx 5208 198-
SpG	1.1613	1.1613	20	1.1623	1.1622	1.1620 1.155
MA						
EA						
Cl	22.86	22.5	22.54	22.99	22.74	
% HME	44.02	44.12	44.05	44.36	43.96	
% Silver AE	22.00	22.06	22.04	22.18	21.97	
Anal	C.W	C.W	K.C	D.P	FW	DP CC

Date	Batch	% MA	% FA	%Pury.	% A.E.	%E.C.	lbs/gal	%HOH.	Clar.	Anal.	Ck. by.
[illegible]				[illegible]							
[illegible]				9250	[illegible]						
5/10/73	Bayms				68.84	97.50					1.18KG
[illegible]	Lwis	76440	Spec.	1.142	[illegible]	96.37					

Sivlex (2-Ethyl-Hexyl Silvex 2,4,5-TP IUET (Shipmone) [illegible] 01

DATE	BATCH	SPG.	Cl	AE	#/gal	TOTAL #/gal	
9-28-74	2350-01	1.0440	18.89	47.86	4.16	8.70	Ana
3-28-74	2350-01	1.0363		46.53	4.02	8.64	C.W.
3-13-75	2350-01	1.0310	18.53	46.95	4.02	8.59	C.W.
3-13-75	2350-01	1.0297		46.74	4.01	8.55	C.C.
3-14-75	2350-02	1.0245	18.26	46.27	3.95	8.53	D.P.
3-17-75	2350-02	1.0274	18.44	46.72	4.00	8.56	D.P.
3-20-75	2350-03	1.0256	18.18	46.06	3.94	8.54	D.P. C.W.
3-26-75	2350-03	1.0230	18.36	46.52	3.97	8.56	C.C.
3-25-75	2350-04	1.0865	21.32	54.02	4.89	9.05	C.C.
25 Mar 75	2350-04	1.0306	18.30	46.58	4.02	8.58	[illegible]

Silvex 4L

Date	Batch	SPG	% AE	#/gal	Total #/gal	SpG	Anal
4-16-71	117-03	17.91	45.38	4.00	8.50	1.0563	C.C.
4-29-71	117-04	18.93	47.96	4.26	8.58	1.0662	C.C.
4-29-71	117-04	18.16	46.01	4.05	8.78	1.0558	C.C.
5-19-71	117-05	18.48	46.82	4.12	8.81	1.0577	[illegible]
5-19-71	117-05	18.25	46.24	4.07	8.78	1.0536	[illegible]
6-21-71	117-06	18.25	46.24	4.06	8.79	1.0553	[illegible]
6-22-71	117-06	18.19	46.09	4.05	8.79	1.0550	[illegible]
7-13-71	117-07	18.15	45.99	4.04	8.79	1.0543	C.C.
1-14-72	117-01	18.78	47.58	4.09	8.63	1.0332	C.C.
1-15-72	117-01	18.43	46.72	4.02	8.59	1.0315	C.C.
3-9-72	117-02	18.69	47.36	4.09	8.65	1.0379	C.C.
3-9-72	117-02	18.51	46.90	4.04	8.61	1.0334	D.P.
3-13-72	117-03	18.66	47.28	4.09	8.65	1.0385	[illegible]
3-14-72	117-03	18.43	46.70	4.03	8.63	1.0351	[illegible]
3-21-72	117-04	18.66	47.28	4.10	8.63	1.0417	[illegible]
3-22-72	117-04	18.54	46.98	4.06	8.64	1.0369	C.C.
4-7-72	117-05	18.72	47.43	4.09	8.63	1.0360	[illegible]
4-8-72	117-05	18.58	46.88	4.04	8.62	1.0344	[illegible]
4-5-73	2350-01	18.02	45.19	4.16	8.63	1.0360	D.P.
4-6-73	2350-01	18.33	46.57	3.99	8.56	1.0274	C.C.
4-20-73	2350-02	18.82	47.69	4.10	[illegible]	1.0372	[illegible]
4-25-73	2350-02		46.[illegible]	[illegible]	8.55	[illegible]	

Date	Batch	MH	FA	RE	RE #Pol	H2O	Spgr	Tot	#Wt	Final	Anal/Ch
8-6-69	9294	—	—	45.53	4.00		1.0542	17.97	8.18		[illegible]
9-[illegible]-69	9327			46.01	4.05		1.0560	18.16	8.30		[illegible]
9-11-69	9328			45.76	4.02		1.0530	18.06	8.79		[illegible]
3-17-70	117-01			46.22	4.02		1.0559	18.4	8.[illegible]		[illegible]
3-20-70	117-01			45.64	4.33		1.0547	18.09	8.70		[illegible]
3-26-70	117-02			46.98	4.15		1.0595	17.54	8.82		[illegible]
3-29-70	117-02			46.04	4.04		1.0540	18.17	8.78		[illegible]
3-31-70	117-03			46.90	4.14		1.0587	18.51	8.82		D.P.
4-1-70	117-03			45.89	4.02		1.0527	18.11	8.77		[illegible]
4-1-70	117-04			46.09	4.04		1.0525	18.19	8.77		[illegible]
4-2-70	117-05			45.46	4.03		1.0529	18.14	8.77		[illegible]
6-1-70	117-06			46.78	4.11		1.0578	18.43	8.81		[illegible]
6-2-70	117-06			45.76	4.02		1.0542	18.06	8.78		[illegible]
6-22-70	117-07			46.76	4.07		1.0551	18.28	[illegible]		[illegible]
6-23-70	117-07			45.85	4.03		1.0530		8.77		[illegible]
[illegible]	117-[illegible]			46.67	[illegible]		[illegible]		[illegible]		[illegible]
8-11-70	117-08			45.58	4.00		1.0545		8.78		[illegible]
8-31-70	117-09			46.01	4.04		1.0552		8.79		AK
3-25-71	117-01			46.98	4.15		1.0596		8.82		AK
3-26-71	117-01			46.06	4.05		1.0546		8.78		[illegible]
3-26-71	117-02			46.34	4.08		1.0572		8.81		[illegible]
4-16-71	117-03			45.28	3.97		1.0547		8.79		AK

Silvex HL

QUESTION 2a, 2b

QUESTION TWO

QUESTION:

2a. If your company sold technical grade 2,4,5-TCP, provide the names and addresses of those who purchased it and copies of any 2,3,7,8-TCDD analyses performed.

2b. If your company purchased technical grade 2,4,5-TCP to be used as a feedstock, provide the names and addresses of those you purchased it from and copies of any 2,3,7,8-TCDD analyses performed.

ANSWER:

2a. Portland never sold 2,4,5-TCP.

2b. Portland purchased 2,4,5-TCP as the sodium salt from Monsanto Company, St. Louis, MO in July 1960 and from Diamond Alkali Company, Newark, NJ after December 1960.

No records exist of any 2,3,7,8-TCDD analyses performed on the purchased 2,4,5-TCP.

Basis for above information is NIOSH study.

No Exhibits.

QUESTION 3

QUESTION THREE

QUESTION: If you manufacture or process or have manufactured or processed any other chemical substances using equipment that at one time was used in the manufacture of 2,4,5-TCP or its pesticide derivatives, provide a list of those chemical substances including the dates of manufacture, the quantities produced, and the product names.

ANSWER:

The Portland Plant had many processes or operations. It was not unusual that processes would be carried out in more than one operating area. It is then possible that all products made during the early years could have been made, in part, in equipment once used in 2,4,5-T acid manufacture. The exceptions to this were the plant built in 1963 for 2,4-DB production and, after 1971, the unit producing chlorophenol. The answers to this question are based upon this knowledge.

The equipment used for manufacture or processing of a pesticide derivative made in 2,4,5-T equipment can be divided into two lists:

*1. Those products made during the 2,4,5-T products manufacturing period, 1960-1962.

**2. Products made in equipment once utilized for 2,4,5-T product manufacture.

*1. Products manufactured or processed during 1960-62 - simultaneous production period:

PRODUCT	DATES MADE	AMOUNT MADE	PRODUCT NAME
2,4-D Acid	1960-1962	10,400,000 lb	Chipman 2,4-D Acid, Tech.
2,4-D Isopropyl Ester, Technical	1960-1962	Not Known	Chipman 2,4-D Isopropyl Ester, Technical
2,4-D Isobutyl Ester, Technical	1960-1962	3,250,000 lb	Chipman 2,4-D Isobutyl Ester, Technical
2,4-D Isooctyl Ester, Technical	1960-1962	2,370,000 lb	Chipman 2,4-D Isooctyl Ester, Technical
2,4-D Acid & Ester Formulations	1960-1962	Not Known	Chipman-IPE 334E
		"	Chipman-Amine 4
		"	Chipman-BE 334E
		"	Chipman-BE 4E
		"	Chipman-BE 6E
		"	Chipman-LV4L IOET
		"	Chipman-LV6L IOET
		"	Chiptox
		"	Chipman MCPA Amine

**2. Products manufactured in equipment after production of 2,4,5-T ceased in 1962:

PRODUCT	DATES MADE	AMOUNT MADE	PRODUCT NAMES
TECHNICALS			
2,4-D Acid Technical	1963-1982	221,794,000 lb	Most 2,4-D product & formulations. Exact products not known.
2,4-D Isopropyl Ester, Technical	1963-1966 est.	880,000 lb	Ditto
2,4-D Isobutyl Ester, Technical	1963-1982	36,614,000 lb	Ditto
2,4-D Isooctyl Ester, Technical	1962-1982	81,018,000 lb	Ditto
MCPA Acid Technical	1966-1976	22,886,000 lb	Chiptox Rhodia MCPA Amine 4
MCPA Isooctyl Ester, Technical	1975-1982	9,104,000 lb	Rhodia MCPA Ester 4L
2,4-DB Isooctyl Ester, Technical	1975-1981	1,892,000 lb	Butoxone 2L
2,4-DB Isobutyl Ester, Technical	1975-1981	980,000 lb	Embutox E
Bromoxynil Octanoate, Technical	1971 to Date	7,660,000 lb	Buctril Bronate
FORMULATIONS			
2,4-D 6-lb Octyl Ester	1962-1982	1,116,000 gal.	2,4-D LV6L
2,4-D 4-lb Octyl Ester	1963-1973	1,033,000 gal.	2,4-D LV4L
2,4-D Amine	1963-1973	3,436,000 gal.	2,4-D Amine 4; 2,4-D Amine 6
2,4-D Butyl Ester	1963-1973	1,254,000 gal.	2,4-D BE6E
MCPA Sodium Salt	1963-1973	252,000 gal.	Chiptox
MCPA Ester	1963-1973	197,000 gal.	Rhonox
2,4-DB Esters	1973-1975	136,000 gal.	Butoxone Ester, Embutox E
MCPA Amine	1963-1973	328,000 gal.	Rhomene

NOTE: Formulation volumes listed include all production. It is not known what percentage is applicable

Exhibit D attached.

EXHIBIT D

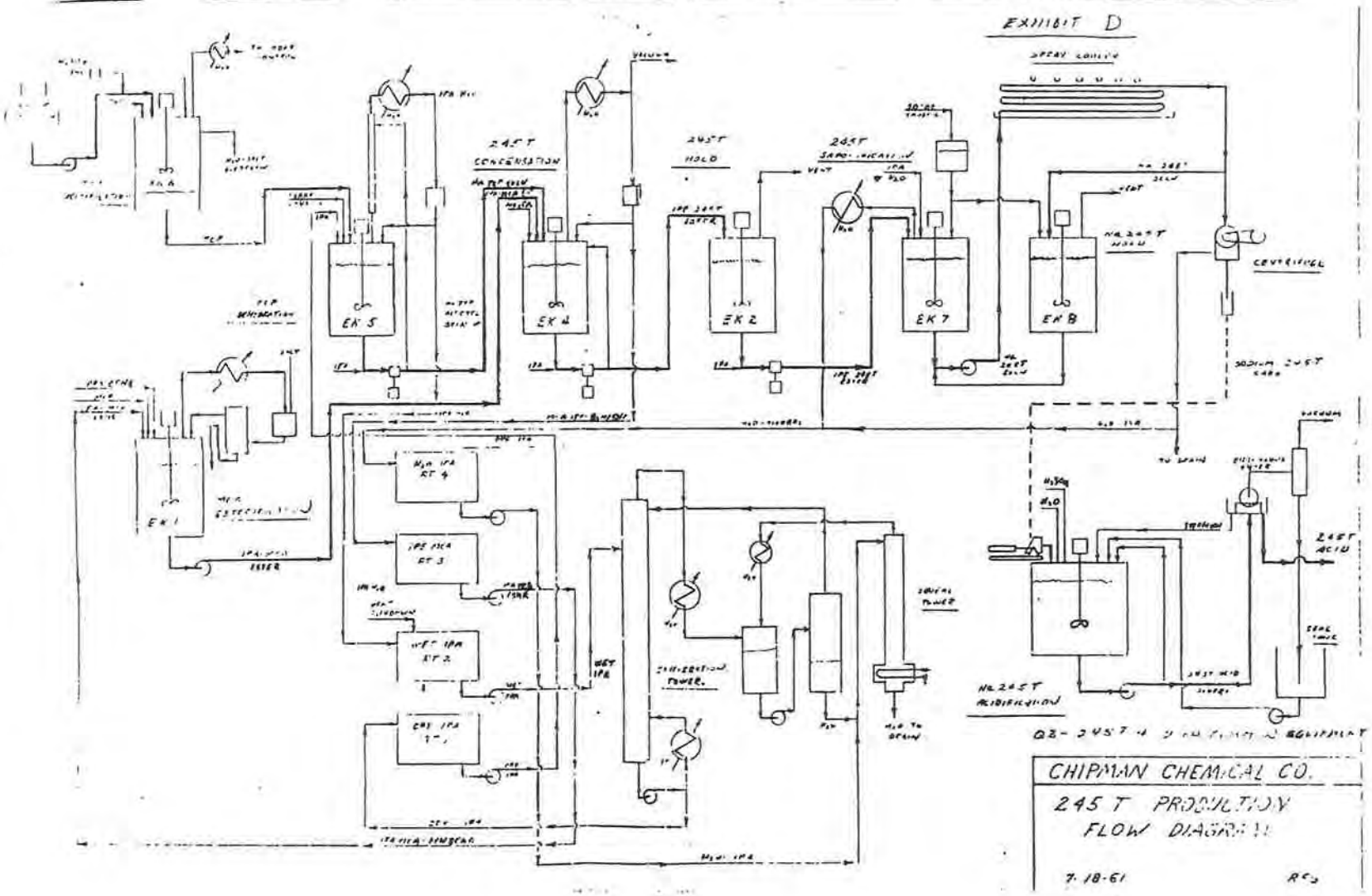


EXHIBIT D

QUESTION 4a, 4b

QUESTION FOUR

QUESTION:

4a. Provide a description of the manufacturing processes for each chemical substance identified in (1) and (3) above.

4b. [1]During what part of the manufacturing/processing are wastes generated, and where are they collected in the manufacturing process? [2]Describe the chemical composition of these wastes and provide copies of any 2,3,7,8-TCDD analyses. [3]What specific refining or distillation process employed to remove 2,3,7,8-TCDD? [4]What amounts of wastes were generated per volume of finished product? [5]Were these wastes combined with wastes from other processes?

ANSWER:

4a. A simplified manufacturing process description is attached for each substance identified in (1) and (3). Note these descriptions are simplified with a block flow diagram showing unit operations only.

PRODUCT	EXHIBIT No.
2,4,5-T Acid	Exhibit E
2,4,5-T Ester	Exhibit F [3 pages]
2,4-D Acid	Exhibit G [3 pages]
Esters: 2,4-D, MCPA, 2,4-DB, MCPP, etc.	Exhibit H [3 pages]
MCPA Acid	Exhibit I
Bromoxynil Octanoate	Exhibit J
Formulations	Exhibit K

4b[1]. The waste generation points are noted on the block flow diagrams.

4b[2]. No 2,3,7,8-TCDD assays were run on products manufactured or wastes generated during the period 1960-1962.

4b[3]. No specific refining or distillation process was employed to remove 2,3,7,8-TCDD.

4b[4]. The amounts of wastes generated per volume of product based upon later production information is estimated to be as follows:

	Lb Solid Waste / Lb Product
2,4-DCP	0.06
2,4-D	None
Esters	None (0.001 lb filter aid w/trace of ester)
MCPA	0.1
Formulation	None (0.001 lb/g filter aid w/trace of formulation)

The only record in existence of waste amounts prior to 1980 is a letter from the DEQ to Rhone-Poulenc [Exhibit L].

4b[5]. Each process generates waste at specific locations as discussed below. There are generally two types of wastes — contaminated water and solid waste. Streams of wastewater are combined for treatment. Solid waste is not now mixed but isolated by type in containers for disposal. Prior to current waste management practices, various solid wastes may have been and probably were mixed in the drum. In addition to normal waste sources, waste can be generated through spillage and/or contamination and by equipment decontamination.

There is little specific data available about chemical composition of the waste streams. Generally, wastewater streams contained traces of the reactants, the products, and any byproducts. Salts formed by reaction are universally present. Exhibit M lists typical composition data.

Sources of Waste:

1. 2,4,5-T ACID PROCESS

a. Contaminated water from TCP acidification decant.

b. Contaminated waste from centrifuge.*

c. Contaminated water from filtration step.

d. Reaction water from MCA esterification step.

e. Water from distillation of IPA.

* Analyses and volumes of these streams are not known. All streams were combined in main plant effluent stream. There were no known solid wastes generated in this process.

2. ESTERIFICATION PROCESS

The following applies to all esterification processes involving phenoxy pesticides and alcohols:

a. Contaminated water of reaction.

The weight of waste per pound of product varies but is consistently one mole of water per mole of product. This stream is blended into main plant effluent stream. No analysis is available but traces of the solvent (alcohol) would be anticipated.

b. Solid waste is generated during the final product filtration step. A diatomaceous earth would contain inorganic salts and would be saturated in the finished product.

Raw material containers represent another source of waste.

3. 2,4-D PROCESS

a. A contaminated water stream was generated at two sources – 2,4-D acidification step and 2,4-D acid filtration step. These streams were combined and treated to remove 2,4-D acid and then combined with main plant effluent. The approximate rate of generation was 0.07 gal. per pound of 2,4-D. Detailed analysis is not available but it is known that the stream contained HCl, NaCl, glycolic acid, 2,4-D, 2,4-DCP, and isooctyl alcohol.

b. Solid waste was generated primarily from empty raw material containers (monochloroacetic acid) at a rate of 0.01 lb/lb.

4. FORMULATION

No wastewater streams are generated as a result of operation.

Solid waste is generated at a very low rate from product filtration (bag filters). Makeup of the resultant waste would be product and dirt.

5. MCPA PROCESS

a. A contaminated water stream was generated at the chlorination step.

b. A liquid waste stream was generated at the cresol purification step. Makeup of stream was cresol and tars.

c. A waste stream was generated at the final product purification step. Makeup of the stream was a mixture of MCPA isomers and dichlorophenol.

6. BROMOXYNIL OCTANOATE PROCESS

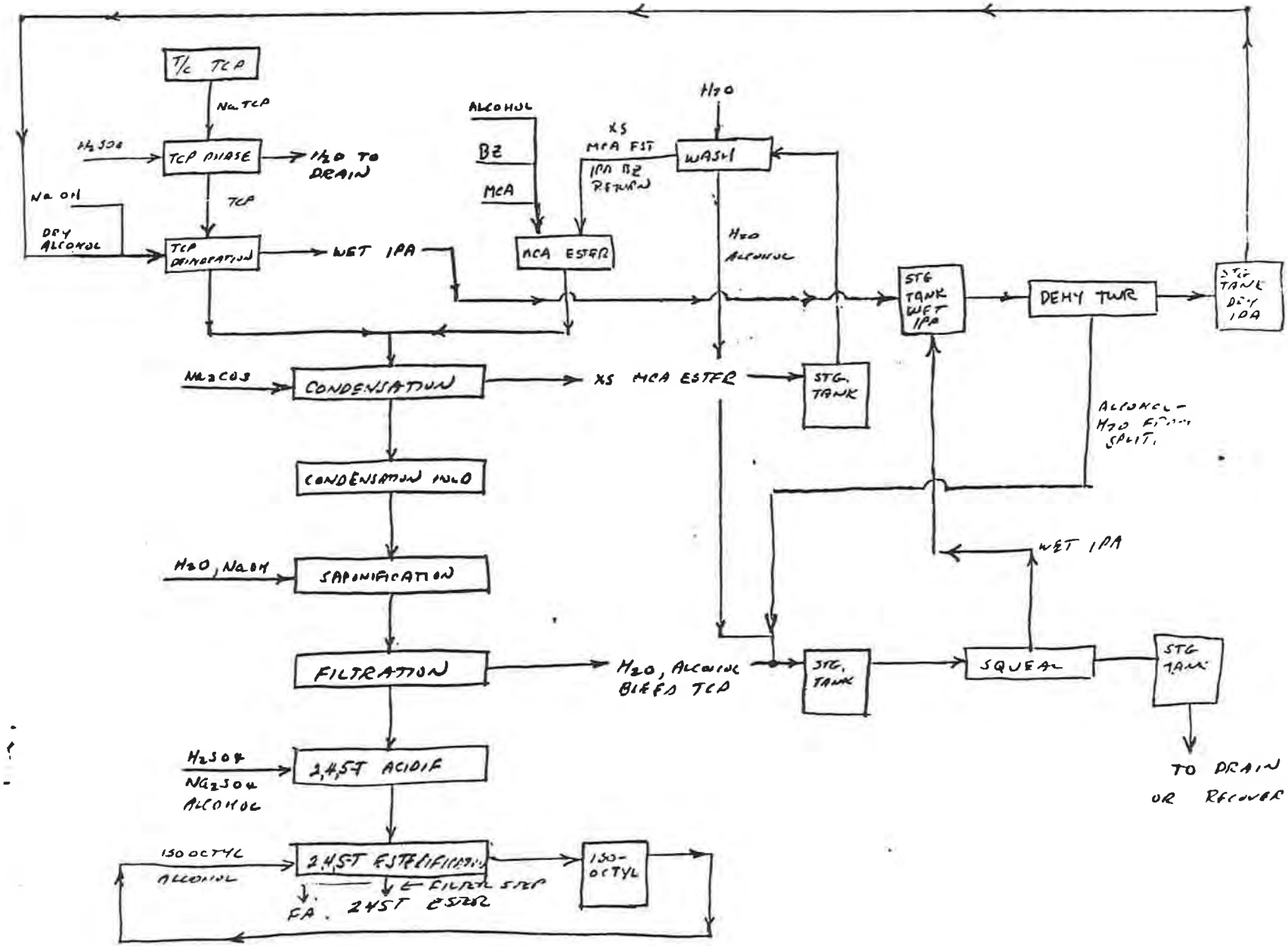
a. A contaminated water stream is generated at two sources – bromoxynil filtration and esterification HCl adsorption. Estimated volume is 0.72 gal. per pound of product. Estimated composition is 3% acetic acid and traces of HCl and various reactant byproducts.

b. Solid waste is generated at the product filtration step. eStimated volume is 0.013 lb/lb of product. Composition is estimated to be 95% filter aid and 5% bromoxynil octanoate.

Exhibits E through M attached.

BLOCK FLOW 2,4 PRODUCTION —

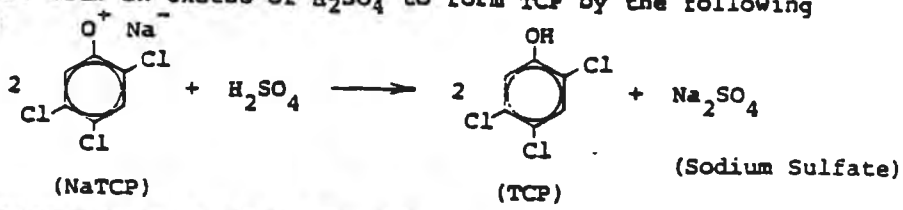
EXHIBIT E



Description of the Process for Production of 2,4,5-T Acid

Chipman Chemical Company produced 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) using the following raw materials: sodium 2,4,5-trichlorophenate (NaTCP) (aqueous solution), sulfuric acid (H_2SO_4), flake caustic soda (NaOH), sodium carbonate (Na_2CO_3), isopropyl alcohol (IPA), and monochloroacetic acid (MCA). Other materials used in the process include benzene and water, each of which were solvents at various points in the process. The following description applies to the production of 2,4,5-T acid during each of the three years of manufacture; there were no significant changes during that time. A flow diagram is provided for this process (Figure 2); also, an equipment location diagram is included (Figure 3). Equipment numbers used in the text correspond to the numbers used in the figures. A plant layout diagram is provided for the entire Portland site (Figure 1).

The first step in the process is known as "TCP (2,4,5-Trichlorophenol) Acidification," and occurs in the agitated, 1000-gal., stainless-steel Ester Kettle (EK) 6. Here, NaTCP in aqueous solution is pumped in from tank cars and reacted with an excess of H_2SO_4 to form TCP by the following reaction:



This reaction occurs at 100°C and near-atmospheric pressure and proceeds until the pH reaches 1. At that time, the reaction is considered complete; a phase separation occurs, in which the TCP forms an organic layer at the bottom of the tank, and an aqueous layer of relatively lower density forms at the top. The aqueous layer, containing the Na_2SO_4 by-product, the unreacted excess H_2SO_4, and the water soluble impurities from the original NaTCP solution, is decanted from the top and drained to the sewer, while the TCP is drained from the bottom into EK 5. This step is included to remove the water and aqueous impurities from the NaTCP.

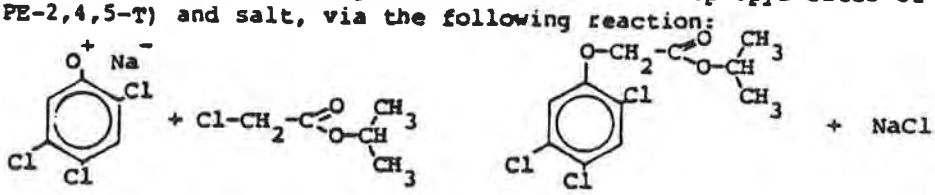
The next step in the process, known as the "TCP Dehydration," occurs in EK 5, an agitated, 1700-gal., stainless-steel tank. After the TCP is transferred to the vessel, isopropyl alcohol (IPA) is pumped in from Recovery Tank (RT) 1, the "Dry IPA" tank. Flake caustic (NaOH), in a quantity equimolar to the quantity of TCP, is manually dumped into the

vessel, and dissolves; IPA is the solvent for the NaOH. An exothermic reaction occurs at near-atmospheric pressure between the TCP and NaOH to form NaTCP and water via the following mechanism:

(TCP) (NaTCP)

The temperature of the mixture rises to 115-119°C and a vapor phase containing water and IPA boils off; simultaneously, more IPA is pumped in, again from RT 1, until the mixture in EK 5 contains NaTCP, IPA, and no water. The IPA-H_2O mixture boiled off is condensed and drained to RT 2, the "Wet IPA" tank, for later recovery of the IPA (to be described later in this section); the NaTCP in IPA solution remaining in EK 5 is then ready to be pumped to EK 4 for further processing.

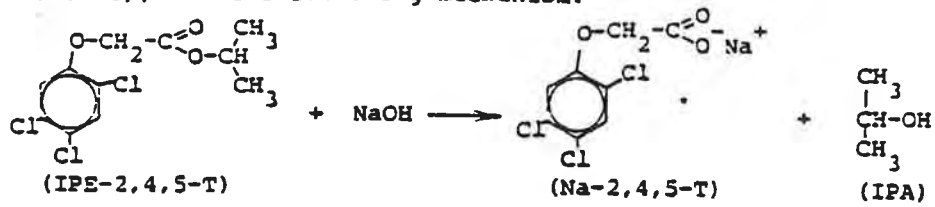
The next step in the process, known as "2,4,5-T (2,4,5-Trichlorophenoxy-acetic Acid) Condensation," occurs in EK 4, which, like EK 5, is a 1700-gal., stainless-steel, agitated reactor. A solution of the isopropyl ester of monchloroacetic acid (IPE-MCA) in benzene solvent is pumped from EK 1, where it is synthesized (see description later in this section), and charged to the reactor; then the temperature is raised to 96°C. Next, the solution of NaTCP in IPA solvent from EK 5 is introduced during a feed period of 1 hour and 20 minutes. The molar quantity of IPE-MCA charged is in excess of that of the NaTCP by a factor of 1.5-2. These two compounds react at near-atmospheric pressure to form the isopropyl ester of 2,4,5-T (IPE-2,4,5-T) and salt, via the following reaction:



(NaTCP) (IPE-MCA) (IPE-2,4,5-T)

After the feed period is completed, this reaction is taken to virtual completion by cooking the mixture at 112°C for 1 hour. When the cooking period is completed, 0.1 mole of Na_2CO_3 per mole of product is manually dumped into the reactor vessel; however, the company is unsure why this addition is included in the process. Finally, the mixture is boiled to 150°C, and a vacuum of 29 in.Hg is applied. This operation removes a vapor phase consisting of the unreacted excess IPE-MCA, the benzene, and the IPA; the vapor is condensed, and routed to RT 3, the "IPE-MCA" tank, for later reuse. The remaining mixture in EK 4, consisting of IPE-2,4,5-T with dissolved NaCl and Na_2CO_3, is pumped to EK 2, a 1000-gal., glass-lined, agitated tank, for the step laped "2,4,5-T Hold," and is stored awaiting further processing. A 96% yield of IPE-2,4,5-T, based on the charge of NaTCP to EK 4, is obtained in the process.

Water is pumped to EK 7, a 3000-gal., steel reactor; then an aqueous solution of 50% NaOH is added in a quantity sufficient to provide an amount of NaOH equimolar to the amount of the isopropyl ester of 2,4,5-T contained in EK 2. The mixture is heated to 100-110°C. Then the contents of EK 2 are pumped into the reactor, followed by more water, and the resulting mixture is cooked for 5 hours at near-atmospheric pressure to promote a reaction between IPE-2,4,5-T and NaOH, forming sodium 2,4,5-trichloropheneoxyacetate (Na-2,4,5-T), via the following mechanism:

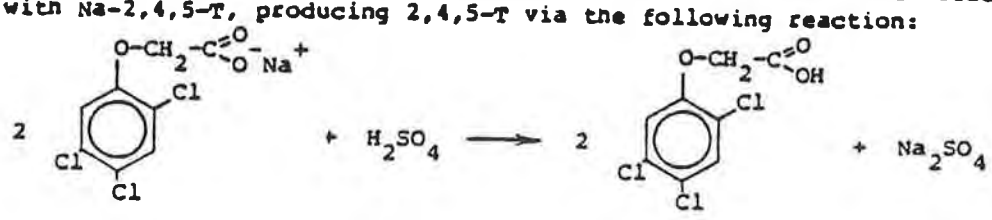


Water and IPA vapor boiled off of the mixture are condensed and drained to RT 4, the "H_2O - IPA" tank, for later recovery of the IPA.

The resulting aqueous solution of Na-2,4,5-T, with NaCl, Na_2CO_3, and IPA as impurities, is then pumped through a spray cooler to reduce its temperature. If the temperature is above 40°C after cooling, the solution is directed to EK 8, an agitated holding tank labelled "Na-2,4,5-T Hold", from where it can be recycled through the spray cooler. At a temperature of 40°C, the Na-2,4,5-T precipitates out of solution and a slurry is created. The slurry can be routed to EK 8 for temporary storage and agitation or can be sent directly to the closed, continuous centrifuge.

The centrifuge removes most of the liquid from the Na-2,4,5-T, leaving a cake of Na-2,4,5-T with a moisture content of approximately 50%. The cake drops out to fiber drums which are positioned and filled manually. The liquid is routed to either the drain or RT 4; the company is not certain which of these alternatives is normal for this process.

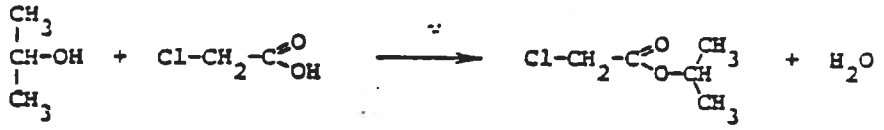
The next step in the process occurs in reactor Q2, a 3000-gal., acid-proof, brick-lined, agitated vessel. Water is added to Q2; then fiber drums containing Na-2,4,5-T cake are manually dumped into this vessel using a barrel dumper. H_2SO_4 is then added in excess to the vessel to react with Na-2,4,5-T, producing 2,4,5-T via the following reaction:



This reaction occurs at a temperature slightly above ambient and at near-atmospheric pressure. When the pH of the reactor contents stabilizes at 1, the reaction is considered complete. The resulting slurry of 2,4,5-T

acid in water, with the unreacted excess H_2SO_4 and the Na_2SO_4 by-product, is then pumped to the "Bird-Young Filter" for the final step of the process. This rotary vacuum filter removes most of the aqueous solution from the 2,4,5-T, leaving a wet cake with a 20% moisture content. The filter is continuous, and the solid automatically drops out to the drumming operation; the positioning and filling of the drums is performed manually. The aqueous solution is collected in a small tank and then drained to the "Seal Tank." From there, it is either recycled to Q2, for reuse of its acid content in another batch, or dumped to the drain when the salt (Na_2SO_4) content gets too high to dissolve more salt.

As noted previously in this section, the isopropyl ester of monochloroacetic acid (IPE-MCA) used in the reaction at EK 4 is synthesized at reactor EK 1. A solution of IPE-MCA, benzene, and IPA is pumped from RT 3 to this vessel. A sufficient quantity of benzene is added to make up for any losses in the system and to insure sufficient solvent at EK 4; also added is the amount of MCA required to make up for both the amount reacted in EK 4 in the previous batch and the amount of any losses in the system. The IPE-MCA synthesis reaction is:



(IPA) (MCA) (IPE-MCA)

Sufficient excess IPA is present in the recycled solution from RT 3 so that no IPA feed is needed here for this reaction. Losses of IPA throughout the system are made up by adding virgin IPA from storage directly to the recovered IPA in RT 1. The water by-product of the IPE-MCA synthesis reaction is continuously boiled off the mixture, condensed, separated from the IPA and benzene by decantation, and sent to the drain.

A system of distillations is used to recover the isopropyl alcohol from the two different strengths of water-IPA mixtures held in RT 4 and RT 2, which were noted previously in this section. Purified, recovered isopropyl alcohol is pumped to RT 1 for reuse, and aqueous waste is sent to the drain.

Description of the Process for Production of the Isooctyl and Isobutyl Esters of 2,4,5-T

Chipman Chemical Company produced the isooctyl and isobutyl esters of 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) using isooctyl or isobutyl alcohol, as appropriate, and the 2,4,5-T product of the process described in the previous section. The isooctyl ester of 2,4,5-T is abbreviated as IOET; the isobutyl ester of 2,4,5-T, also called simply the butyl ester of T, is abbreviated as BET. The production processes for each of these esters are virtually identical except for the alcohol used, and the same equipment was used by Chipman to produce either one, on a time-sharing basis. The following description applies to the synthesis of 2,4,5-T esters during all

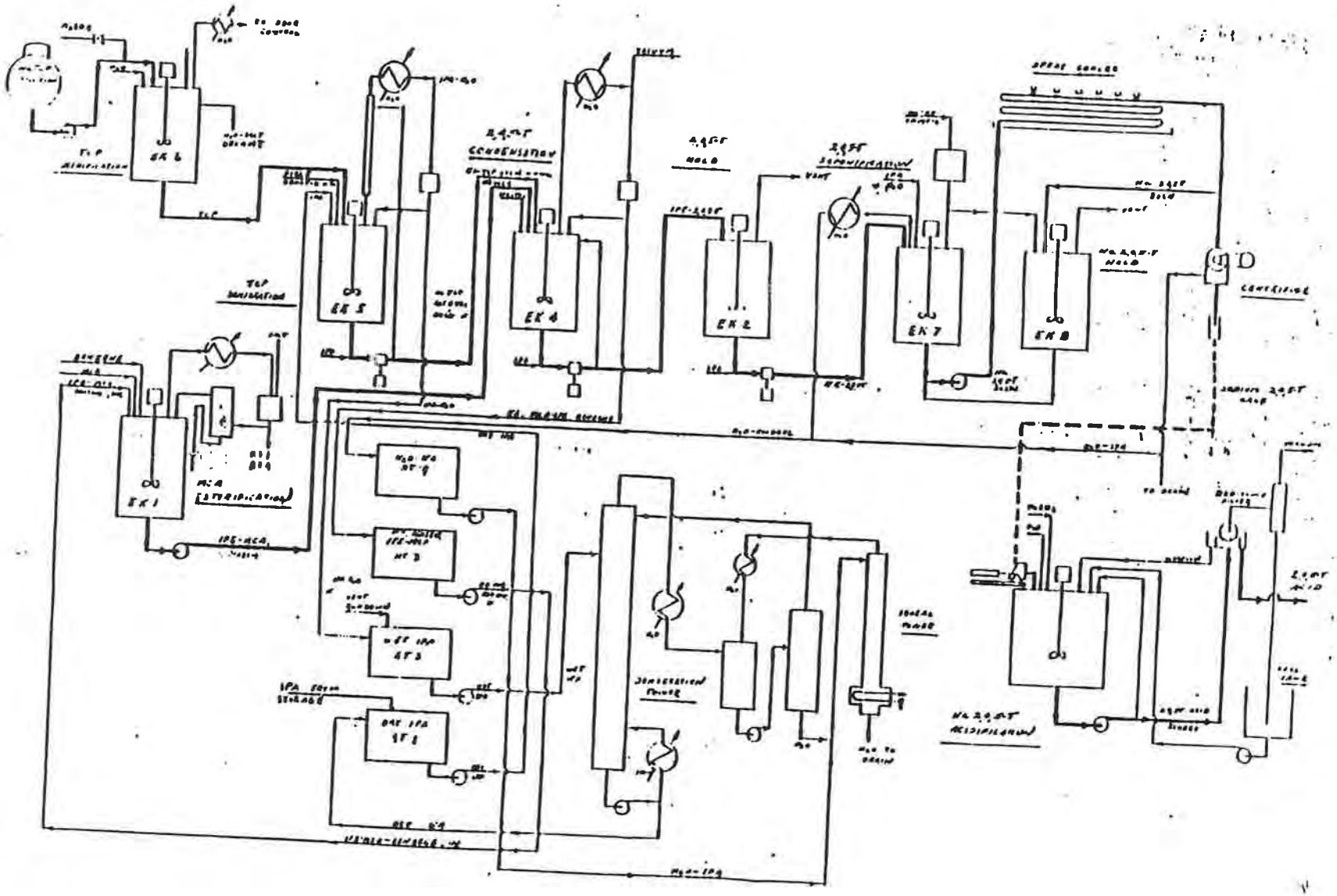


Figure 2: Flow Diagram for 2,4,5-T Acid [illegible]ction Process, Rhone-Poulenc, Incorporated, Por[illegible]d, OR

2,4,5-T ESTER MANUFACTURING PROCEDURE

The kettle was charged with "wet" alcohol from the rundown tank and dry alcohol from alcohol storage. Kettle contents heated to approximately 80°C and then wet 2,4,5-T acid cake manually dumped into the kettle. Kettle temperature increased and a water-alcohol mixture boiled out. After condensing the vapors, the water-alcohol liquid ran into a splitter vessel where the water-alcohol liquid phase separated, the alcohol layer returning to the kettle and the water layer draining to the sewer. After water stopped phasing out, boiling continued with the alcohol phase then diverted to the wet alcohol rundown tank. Kettle temperature had risen to 115°C at start of above operation and alcohol removal continued until temperature had risen to 135°C. At this point an additional charge of dry alcohol added to the kettle and alcohol removal continued until temperature had again risen to 135°C. Vacuum was then applied to the system and alcohol removal continued until temperature had risen to 150°C while under 28-29" Hg vacuum. Finished ester in EK-3 was then filtered and transfered to storage tank T-22.

Esterification

The esterification of phenoxy compounds are all similar for either the isobutyl or isooctyl alcohols and for the various acids, 2,4-D and MCPA, etc.

Acid is charged to alcohol in a glass-lined reactor and boiled. The water of reaction is decanted. Near the end of the cook period, dry alcohol is added to the reaction mass to drive the reaction to completion.

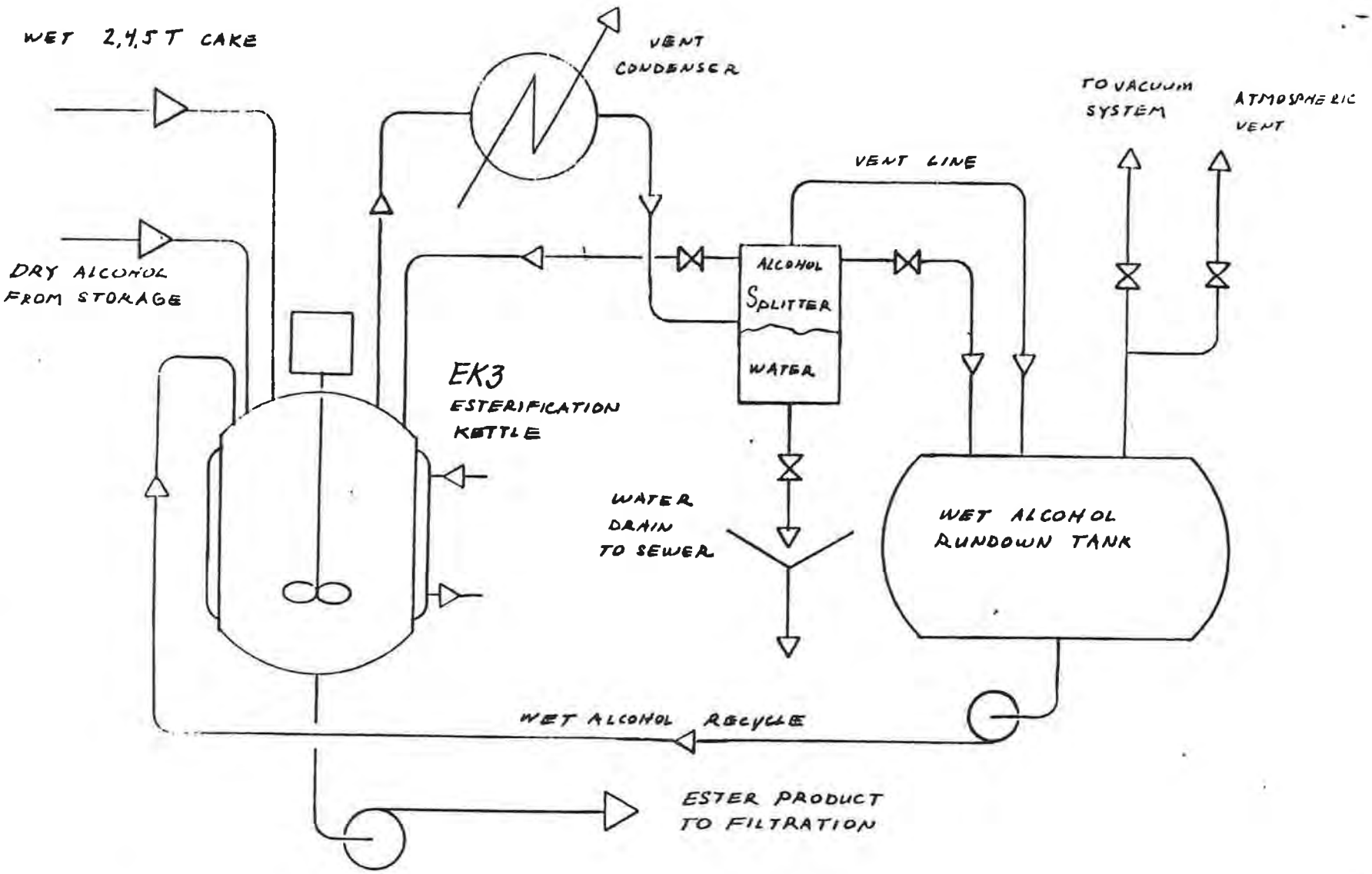
The ester-alcohol solution is vacuum stripped to remove excess alcohol. The ester is cooled and filtered to remove salt and reaction residue.

The water of reaction for butyl esters is azeotropic distilled to recover alcohol. The water then goes to the water treatment system for removal of phenolic chemicals.

The water of reaction for isooctyl esters is pumped to the 2,4-D extract system to recover any alcohol losses.

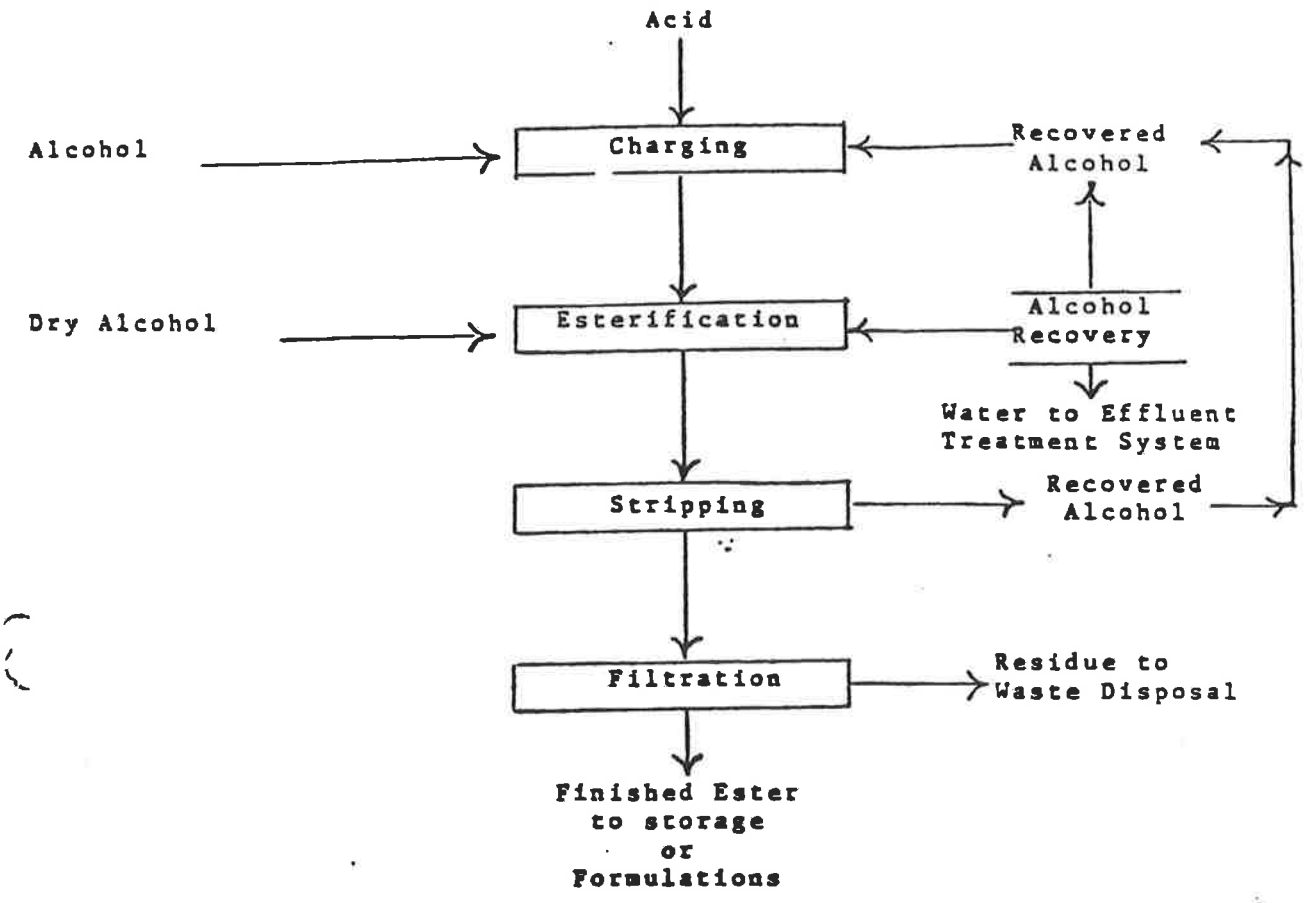
Flow Diagram EXHIBIT F

2,4,5 T. Esterification Process



ESTERIFICATION PROCESS

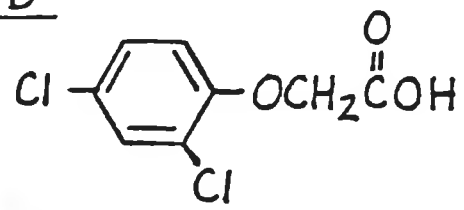
SCHEMATIC FLOW DIAGRAM



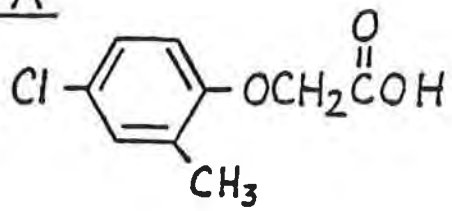
CHEMICAL REACTIONS - ESTERS

ACIDS:

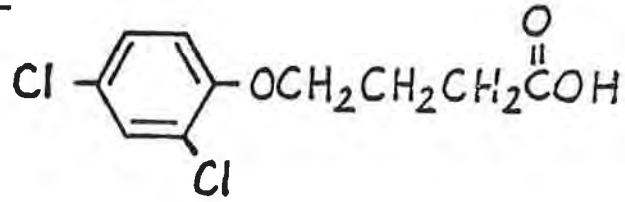
2,4-D



MCPA

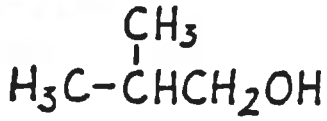


DB



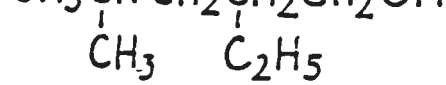
ALCOHOLS:

ISOBUTYL



ISOOCTYL

(~90% 2-ETHYLISOHEXANOL
& ~10% 2-ETHYLHEXANOL)



REACTION:

$$\text{ACID} + \text{ALCOHOL} \xrightarrow[\Delta]{H_2SO_4} \text{ESTER} + H_2O$$

EXHIBIT G

RHONE-POULENC INC.

PORTLAND PLANT

6/11/79

E. R. NO. 35A

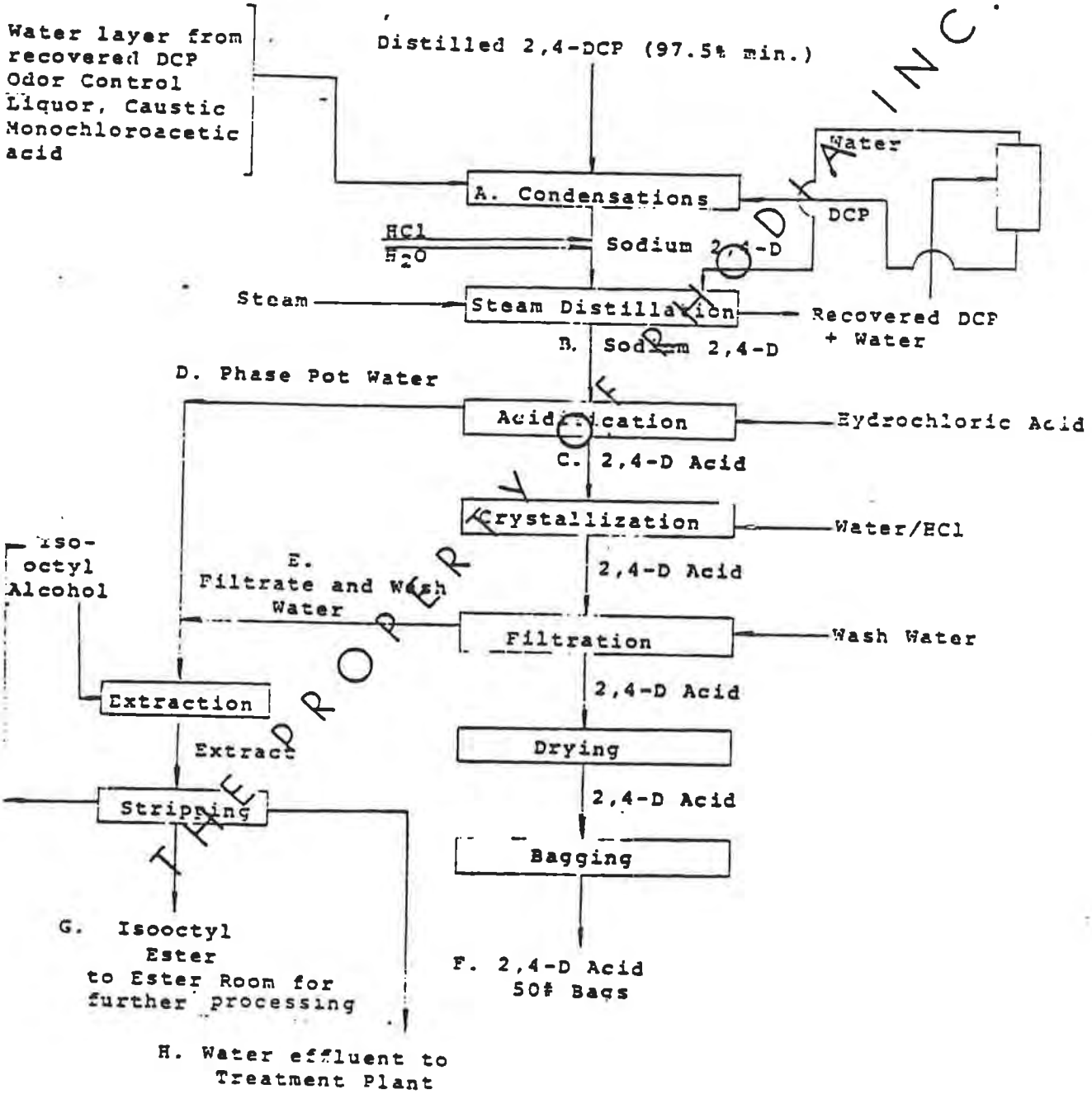
TITLE: 2,4-D PROCESS DESCRIPTION SUMMARY

Monochloroacetic acid is condensed with 2,4-dichlorophenol in aqueous alkaline medium at a pH of 9.0 to 9.3 to produce the sodium salt of 2,4-dichlorophenoxyacetic acid. The completed aqueous reaction mixture is acidified to pH 5.5 and passed through a steam distillation tower to recover excess DCP. The aqueous stream is then acidified to pH 1.0 and the 2,4-D melt is separated from the process water. The melt acid is added to water where the 2,4-D solidifies as granules. The 2,4-D is filtered, washed, dried and then packaged for shipment.

The aqueous plant effluent, which consists of the water from acidification and the filtrate and wash waters, contains ten percent of the total 2,4-D production. The 2,4-D is extracted from this stream by contact with a mixture of isooctyl alcohol/isooctyl ester. The aqueous effluent is then sent to the Water Treatment Plant to remove unwanted organics. The 2,4-D in the IOA Extract is converted to ester for sale.

2,4-D PROCESS

SCHEMATIC FLOW DIAGRAM



E. Filtrate — 1.70 lbs/lb product

NaCl	0.1%
H_2O	99.0%
2,4-D	Trace

F. Finished Product--See product quality.

G. Concentrated Extract

2,4-D	40%
IOA	60%
DCP	Trace

H. Effluent

2,4-D	300 ppm
DCP	100 ppm
NaCl	5%
HCl	0.5%
IOA	500 ppm
H_2O	94.0%
Glycolic acid	0.5%

THE PROPERTY OF RHODIA INC.

PROCESS STREAMS

2,4-D Acid

A. Condensation (charges)	2.47 lbs/lb product
2,4-dichlorophenol	10%
2,6 dichlorophenol	1%
NaDCP (isomer ratio as above)	Trace
Na 2,4-dichlorophenoxyacetic acid	Trace
NaOH	19.8%
Monochloroacetic acid	20%
H_2O	50%
B. Stripped Condensation	10.15 lbs/lb product
2,4-DCP	Trace
2,6-DCP	Trace
2,4-D	5.4%
Na 2,4-D	5.4%
NaCl	4.4%
H_2O	84.0%
Glycolic acid	0.6%
2,6-D	0.1%
C. 2,4-D acid melt	1.03 lbs/lb product
2,4-DCP	Trace
2,6-DCP	Trace
2,4-D	85.5%
2,6-D	2.0%
NaCl	0.5%
HCl	Trace
H_2O	11.9%
D. Phase Pot Water	9.76 lbs/lb product
2,4-D	0.8%
NaCl	7.3%
H_2O	90.9%
HCl	0.3%
Glycolic acid	Trace

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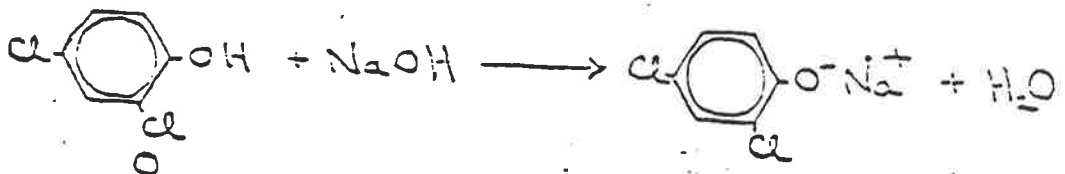
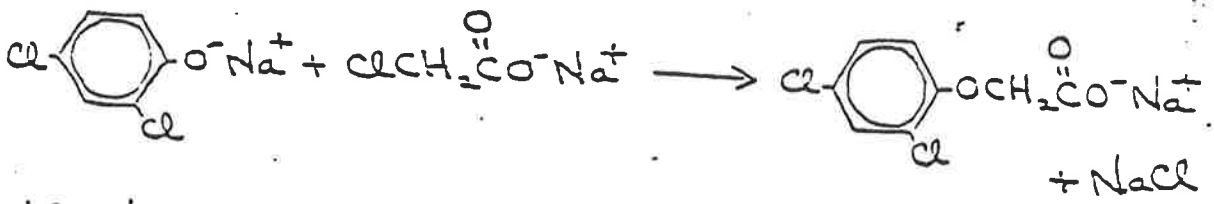
CHEMICAL REACTIONS

2,4-D

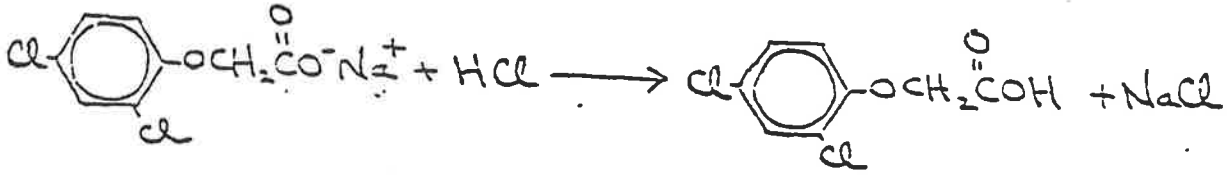
Condensation:



$$ClCH_2\overset{O}{\overset{\|}{C}}OH + NaOH \longrightarrow ClCH_2\overset{O}{\overset{\|}{C}}O^-Na^+ + H_2O$$



Acidification:



2,4-D PROCESS

FINISHED PRODUCT

2,4-D Isomer Content	96.0
2,6-D Isomer Content	2.2
Dichlorophenol	0.5
Moisture	1.0
NaCl	0.15
Color	Light tan to white

Note: Traces of orthochlorophenoxyacetic Acid (0.1 to 0.3%)

RAW MATERIALS

DCP (Dichlorophenol) See 2,4-DCP Process for purity.
NaOH 50%
Monochloroacetic acid
HCl 30%
IOA (Isooctyl alcohol)

THE PROPERTY OF RHODIA INC.

EXHIBIT H

RHONE-POULENC INC.

PORTLAND PLANT

6/11/79

E. R. NO. 39A

TITLE: ESTERIFICATION

The esterification of phenoxy compounds are all similar for either the isobutyl or isooctyl alcohols and for the various acids, 2,4-D and MCPA, etc.

Acid is charged to alcohol in a glass-lined reactor and boiled. The water of reaction is decanted. Near the end of the cook period, dry alcohol is added to the reaction mass to drive the reaction to completion.

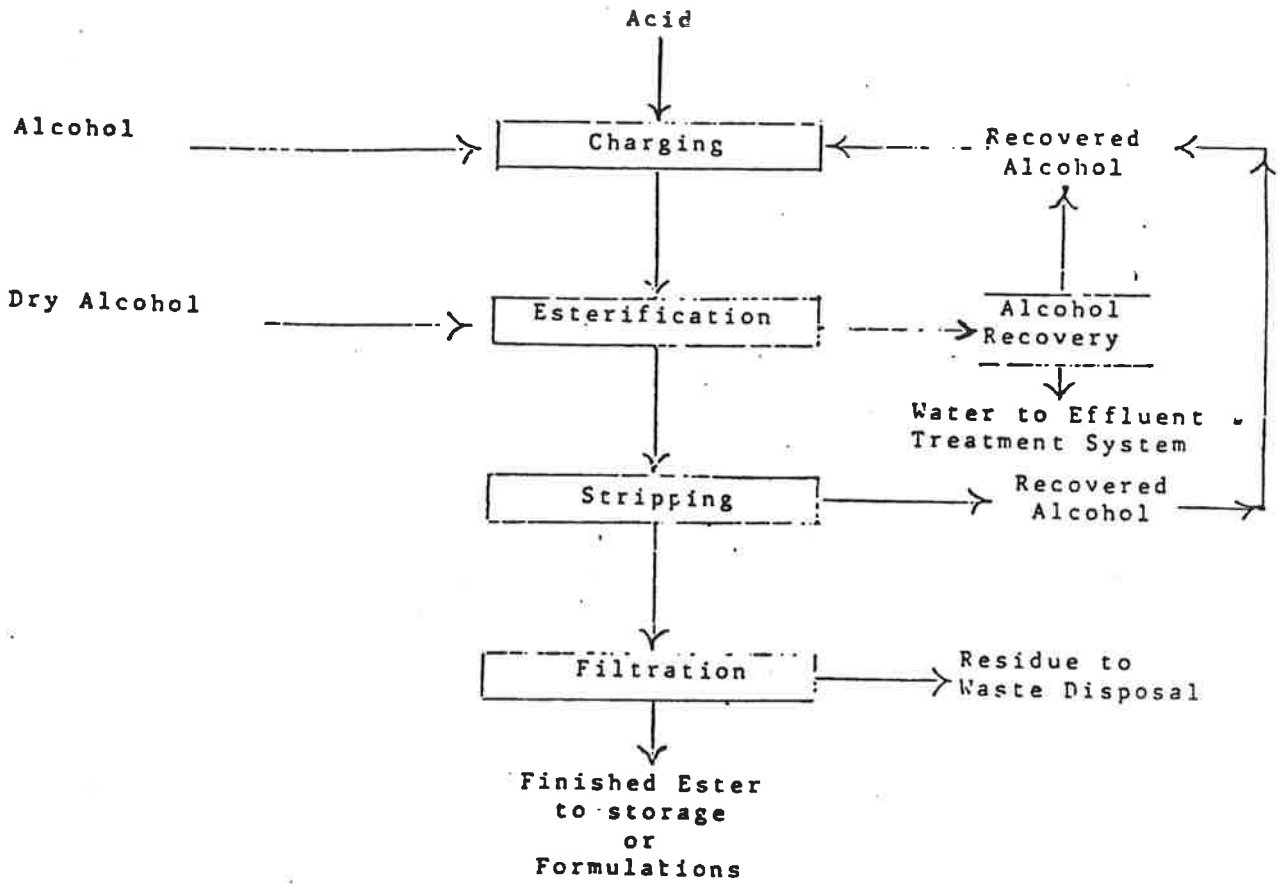
The ester-alcohol solution is vacuum stripped to remove excess alcohol. The ester is cooled and filtered to remove salt and reaction residue.

The water of reaction for butyl esters is azeotropic distilled to recover alcohol. The water then goes to the Water Treatment System for removal of phenolic chemicals.

The water of reaction for isooctyl esters is pumped to the 2,4-D Extract System to recover any alcohol losses.

ESTERIFICATION PROCESS

SCHEMATIC FLOW DIAGRAM

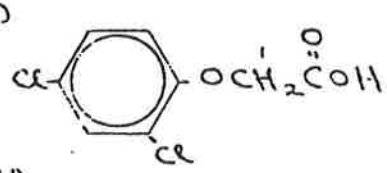


CHEMICAL REACTIONS

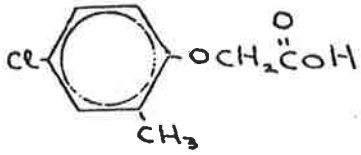
ESTERS

ACIDS:

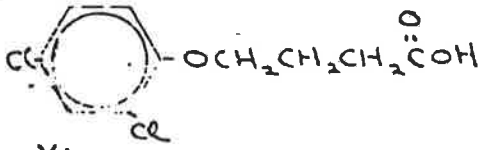
2,4-D



MCPA

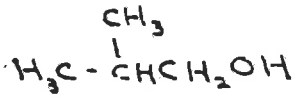


DB

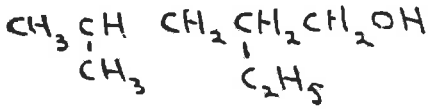


ALCOHOLS:

ISOBUTYL



ISOOCTYL
(~90% 2-ethylisohexanol
and ~10% 2-ethylhexanol)



REACTION:

$$\text{ACID} + \text{ALCOHOL} \xrightarrow[\Delta]{H_2SO_4} \text{ESTER} + H_2O$$

FINISHED PRODUCTS

2,4-D Butyl Ester

	%
Isobutyl-2,4-dichlorophenoxyacetate	96.2
Isobutyl-2,6- "	2.8
Free 2,4-D Acid	0.5
2,4-dichlorophenol	Trace
2,6- "	Trace
Isobutyl Alcohol	0.5
2,4,6-Trichlorophenol	Trace
Isobutyl-2-chlorophenoxyacetate	Trace
Isobutyl-4- "	Trace

2,4-D Isooctyl Ester

Isooctyl 2,4-dichlorophenoxyacetate	93.7
Isooctyl 2,6- "	4.8
Free 2,4-D Acid	0.5
2,4-dichlorophenol	Trace
2,6 "	Trace
Isooctyl Alcohol	1.0
2,4,6-Trichlorophenol	Trace
Isooctyl-2-chlorophenoxyacetate	Trace
Isooctyl-4- "	Trace

2,4-DB Isobutyl Ester

Isobutyl 2,4-dichlorophenoxy-4-butyrate	98.7
2,4-dichlorophenol	0.3
2,6- "	Trace
Free 2,4-DB Acid	0.5
Isobutyl alcohol	0.5
Isobutyl-2-chlorophenoxybutyrate	Trace
Isobutyl-4- "	Trace
Isobutyl-2,6-dichlorophenoxybutyrate	Trace
2,4,6-trichlorophenol	Trace

THE PROPERTY OF RHODIA INC.

	%
2,4-DB Isooctyl Ester	
Isooctyl 2,4-dichlorophenoxy-4-butyrate	98.2
2,4-dichlorophenol	0.3
2,6- "	Trace
Free 2,4-DB Acid	0.5
Isooctyl alcohol	1.0
Isooctyl-2-chlorophenoxybutyrate	Trace
Isooctyl-4- "	Trace
Isooctyl-2,4-dichlorophenoxybutyrate	Trace
2,4,6-trichlorophenol	Trace
2,4-DP Isobutyl Ester	
Isobutyl α-(2,4-dichlorophenoxy)propionate	97.2
Free 2,4-DP Acid	0.5
2,4-dichlorophenol	0.8
Isobutyl alcohol	0.5
Isobutyl- α-(2-chlorophenoxy)propionate	Trace
Isobutyl- α-(4- " "	Trace
Isobutyl- α-(2,6-dichlorophenoxy)"	Trace
Isobutyl- α-bis-(2,4-dichlorophenoxy)propionate	Trace
2,4-DP Isooctyl Ester	
Isooctyl- α-(2,4-dichlorophenoxy)propionate	96.8
Free 2,4-DP Acid	0.5
2,4-dichlorophenol	0.7
Isooctyl Alcohol	1.0
Isooctyl- α-(2-chlorophenoxy)propionate	Trace
Isooctyl- α-(4- " "	Trace
Isooctyl- α-(2,6-dichlorophenoxy)"	Trace
Isooctyl- α-bis-(2,4-dichlorophenoxy)propionate	Trace

THE PROPERTY OF RHODIA INC.

	%
MCPA Isobutyl Ester	
Isobutyl-4-chloro-2-methylphenoxyacetate	97.0
Free MCPA Acid	0.5
Isobutyl alcohol	0.5
Impurities - 2% including	
Isobutyl-2-methylphenoxyacetate	<0.8
Isobutyl-6-chloro-2-methylphenoxyacetate	<0.8
4-chloro-o-cresol	<0.4
4,6-dichloro-o-cresol	<0.4
MCPA Isooctyl Ester	
Isooctyl-4-chloro-2-methylphenoxyacetate	96.5
Free MCPA Acid	0.5
Isooctyl alcohol	1.0
Impurities - 2% including	
Isooctyl-2-methylphenoxyacetate	< 0.7
Isooctyl-6-chloro-2-methylphenoxyacetate	< 0.7
4-chloro-o-cresol	< 0.3
4,6-dichloro-o-cresol	< 0.3
MCPB Isooctyl Ester	
Isooctyl-4-chloro-2-methylphenoxy-4-butyrate	96.0
Isooctyl alcohol	1.0
Impurities - 3% including:	
4,6-dichloro-o-cresol	
Isooctyl-2-methylphenoxybutyrate	
MCPP Isooctyl Ester	
Isooctyl-4-chloro-2-methylphenoxy-2-propionate	97.0
Free MCPP Acid	0.5
Isooctyl Alcohol	1.0
Impurities - 1.5% including:	
4-chloro-o-cresol	
Isooctyl 2-methyl-6-chlorophenoxy-2-propionate	
Isooctyl 2-methyl- 4,6 dichlorophenoxy-2-propionate	

THE PROPERTY OF RHODIA INC.

RHÔNE-POULENC INC.

AGROCHEMICAL DIVISION

Portland Plant

EXHIBIT I

SEE CONFIDENTIAL STATEMENT PACKET

RHÔNE-POULENC

RHÔNE·POULENC INC.

AGROCHEMICAL DIVISION

Portland Plant

EXHIBIT J

SEE CONFIDENTIAL STATEMENT PACKET

RHÔNE POULENC

RHÔNE-POULENC INC.

AGROCHEMICAL DIVISION

Portland Plant

EXHIBIT K

SEE CONFIDENTIAL STATEMENT PACKET

RHÔNE POULENC

EXHIBIT L.

Department of Environmental Quality

522 SOUTHWEST 5TH AVE. PORTLAND, OREGON

MAILING ADDRESS: P.O. BOX 1760, PORTLAND, OREGON 97207

VICTOR ATIYEH
GOVERNOR

CL
PLF
GGG
DR
CLARKE
GJK
9-4-79

September 27, 1979

Richard Gitschlag
Rhone-Poulenc
6200 Northwest St. Helens Road
Portland, OR 97210

The Department of Environmental Quality, at the request of the Environmental Protection Agency (EPA), is undertaking a survey of abandoned or inactive chemical hazardous waste disposal sites. Once identified, an evaluation will be made to determine what action, if any, is needed to minimize or correct any immediate or long-term threat to public health or the environment.

In a July 20, 1979, "brainstorming" session with the EPA, approximately 30 industrial sites were identified which may have locally disposed of hazardous waste in the past. Your plant was selected and analyzed on the enclosed form (to be shared with the EPA). If you have any comments or wish to discuss this further, please contact Fred Bromfeld or myself at 229-5913.

We wou, ike to thank those of you who helped to complete the survey for your k. ssistance.

Rich Reite
Hazardous Wa. ction
Solid Waste Division

FSB:w
SW623
cc: Tom Donaca, AOI

INVENTORY-POSSIBLE SOURCES OF HAZARDOUS WASTE

EPA NUMBER: _____

WASTE CHARACTERISTICS

IGNITABLE:				SOLID:	X
CORROSIVE:		RADIOACTIVE:		SEMI-SOLID:	X
REACTIVE:		INFECTIOUS:		LIQUID:	X
TOXIC:	X	OTHER:		GASEOUS:	

TOTAL WASTE QUANTITIES

VERY LARGE AMOUNT:	X		COUNTED:	
LARGE AMOUNT:		AMOUNT OF WASTE	ESTIMATED:	X
SMALL AMOUNT:		200 tons/yr	REPORTED:	X
VERY SMALL AMOUNT:		TONS, YDS, BBL, ETC	MEASURED:	

WASTE DISPOSAL

REGULATORY CONTROLS: _____

WASTE TRANSPORTED TO SITES #: Chem-Nuclear

WASTE DISPOSED INTO SEWER SYSTEM: X

WASTE DISPOSED IN EFFLUENT: X NPDES: OR-100174-1

WASTE DISPOSED OF ON SITE: Past

ON SITE DISPOSAL

INCINERATION: Some in early 70's LAND SPREADING: _____

SURFACE STORAGE: _____ BURIAL: _____

WELL INJECTION: _____ OTHER: _____

SITE CONDITIONS

GEOLOGIC SETTING

Fill over old lake bed.

HYDROLOGIC CONDITIONS

DISTANCE OF LAKE OR MARINE WATER: _____

DISTANCE TO SURFACE STREAM: 0.45 mi. (Willamette)

DEPTH TO GROUNDWATER: About 5 feet

DISTANCE TO WELLS OR SPRINGS: _____

DISTANCE TO NEAREST RESIDENCE: 150 yards

USE OF SITE IF ABANDONED: _____

PHYSICAL CONTROLS AT SITE

SOURCES OF INFORMATION: Dick Gitschlag, Rhone-Poulenc, plant manager.

COMPILER: Fred Bromfeld DATE: August 20, 1979

Site visit 8/24 with Dennis Stefani (EPA)

INVENTORY-POSSIBLE SOURCES OF HAZARDOUS WASTE

****

EPA NUMBER: _____ NPDES#: 2652-J

SIC CODE BEG: 2870 SIC CODE END: 2870 BASIN CODE: _____

STATE: Oregon COUNTY: Multnomah CO CODE: _____

NAME: Rhone-Poulenc

OWNER:

ADDRESS: 6200 Northwest St. Helens Road ZIP: 97210

CONTACT: Richard Gitschlag PHONE: 222-3571

LOCATION: Portland, Oregon (see map attached)

TOWNSHIP: 1N RANGE: 1E SECTION: 13

USGS MAP NAME: Portland, Oregon - Washington

BUSINESS TYPE

Herbicide Mfg.

WASTE TYPES

Chlorophenols

DISPOSAL ACTIVITIES

Portland sewer, solid waste to Chem-Nuclear

PERIOD OF OPERATION: 1943 to present

HISTORY OF SITE OR PLANT OPERATION

See attached plant history.

DETAILS OF WASTE CHARACTERISTICS, VOLUMES AND DISPOSAL OPERATION

~~600,000 lb/yr materials contaminated with chlorophenols (solid waste).~~ This generally goes to Arlington. About 50% is a sludge from the wastewater treatment plant. Wastewater now goes to sewer, went to Doane L. prior to 1977.

Northwest part of property used as storage/demolition waste site by Atlas Building Wreckers.

SIC CODES

RHONE-POULENC INC.

PORTLAND PLANT

6/12/79

PLANT HISTORY HIGHLIGHTS

The plant has been located in Portland since 1943, starting with a small railroad liquid formulation plant and a warehousing operation for distribut insecticides. Later formulation of 2,4-D and other herbicides were made in Portland. The Technical 2,4-D Plant was built in 1956. Since then various operations have been added.

1956 2,4-D Plant

1958,9 - 2,4-D operations revised to improve product quality and decrease pollution problems.

1960 - MCPA Plant -- used o-dichlorobenzene as a solvent.

2,4,5-T Plant

Continuous ester operation

2,4-DB ester operation

1962 - 2,4,5-T down, continuous ester plant abandoned.

1963 - 2,4-DB Plant

1964 - First major water pollution incident and chlorine oxidation system to treat plant effluent.

1965 - MCPA Plant shut down and dismantled.

1966 - New MCPA Plant - using DCM (dichloromethane) solvent.

1969 - Carbon Treatment System on plant effluent.

1970 - Building Scrub, 2,4-D

1971 - BO Process added to ester plant (bromoxynil octanoate)

1972 - MCPB and 2,4-DP production

1975

1976 - New MCPA Process Plant started and cancelled early in 1976.

1976 - DCP Distillation for high purity 2,4-D

1977 - 2,4-D Optimization, Water Treatment System additions and hookup to City Sewer.

SOLID WASTE DISPOSAL

TO ST. JOHNS FILL (5,000 DRUMS)

TO ALKALI LAKE (STORED TO 1969) (22,000 DRUMS)

TO PASCO

TO CHEM-NUCLEAR

SUGGEST FOLLOW-UP

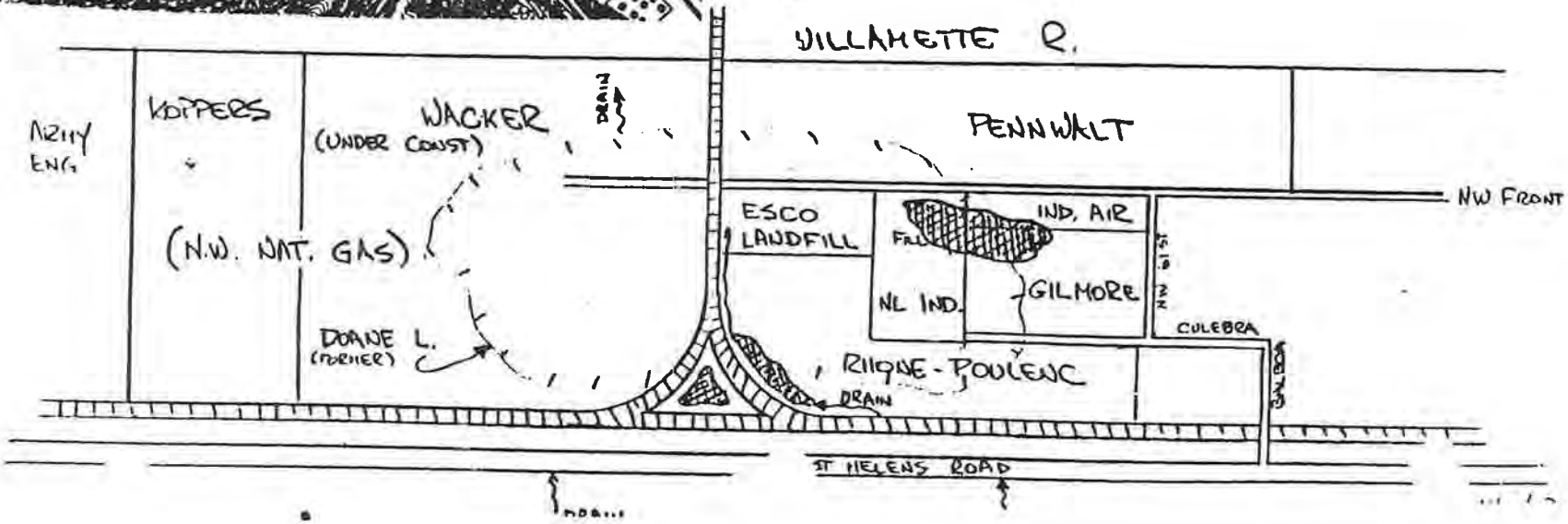
Doane Lake Area

1. It was originally thought that this area consisted of two lakebeds, Doane (east) and Giles (west), created from the old Doane Lake as a result of constructing the railroad bed in 1910. The recognition of Giles Lake as a separate entity, however, never came into common usage and it is not generally referred to on maps. As such, we shall refer to this area simply as Doane Lake.

   This will also avoid confusion with the Guilds Lake area about two miles to the S.E.

2. Almost the entire lake has been covered with 5 - 10 ft. of fill. The area, however, is a natural sump and the water table is only about 5 ft. below the surface. During a wet winter it may surface in some areas. The old Doane Lake fluctuated about 5 ft. in depth.

DOANE LAKE AREA



RHÔNE-POULENC INC.

AGROCHEMICAL DIVISION

Portland Plant

EXHIBIT M

SEE CONFIDENTIAL STATEMENT PACKET

RHÔNE-POULENC

QUESTION 5

QUESTION FIVE

QUESTION: What decontamination procedures were used on the equipment when changing from the manufacturing of 2,4,5-TCP and its pesticide derivatives to the manufacturing of other substances? Describe the chemical composition of the wastes from the decontamination procedures and provide copies of any 2,3,7,8-TCDD analyses. Were these wastes combined with wastes from other processes?

ANSWER:

Technical manufacturing equipment was decontaminated by the following steps.

1. Flush equipment and lines with water or alcohol to remove residual material. Flush water through all equipment in manufacturing sequence through the units' wastewater treatment system. Alcohol flushes were drummed and used in subsequent runs of same product.

2. Clean water was then run through all lines. Jacketed kettles were boiled and steam or condensate-run through vapor piping condensers, etc. Lines and vessels were then steamed to aid in drying equipment.

3. Auxiliary equipment, odor controls, vacuum systems, etc., were drained and washed.

4. The clean water that was run through equipment was assayed. If the liquid contained 500 ppm (.05%) of the previous technical in the water, flushing was stopped.

5. The first batch of the next technical run was checked for contamination (usually by GLC) and if no detectable contamination was found, the run was continued.

The switchover from 2,4,5-T manufacture to other production when 2,4,5-T acid production was ceased late in 1962, entailed considerable piping revision and equipment removal. Much of the equipment was removed from service and not revised. The remaining equipment was switched to 2,4-D ester manufacture after piping, pump, and equipment revisions. Extensive equipment cleanup was conducted to permit burning and welding in and on equipment.

Formulations vessels were and are decontaminated as follows:

Water-base:	Removal of residual material. Washing with alkaline water. Rinsing.
Oil-base:	Removal of residual material. Washing with compatible solvent.

No analytical records exist of any assays conducted during switchovers.

The composition of flushes was not assayed but would contain ppm levels of the specific technical.

No 2,3,7,8-TCDD assays were run.

Any solid or liquid wastes were drummed and not normally mixed with other wastes. Water treatment wastes were piped to the water treatment system as discussed in Question 4b[5].

No Exhibits.

QUESTION 6

QUESTION SIX

QUESTION: Describe the methods of collection, storage, and disposal of the wastes identified in (4) and (5) above including the names and addresses of the waste haulers and the disposal site locations.

ANSWER:

1. Written information about the collection, storage, and disposal of the solid wastes from the various processes listed in answers to questions (4) and (5) are of limited nature. The flow diagrams note the part of the manufacturing process that wastes were generated. During the history of the plant, waste handling practices were revised as changes in processes were made. Generally, the waste handling can be divided into a series of steps dependent upon type of waste and based upon major equipment installations. Exhibit N attached outlines the waste handling changes utilizing the plant history chart as a basis.

2. For solid and liquid drummed wastes —

   a. From startup 1956 to 1960: St. John's Landfill, Portland, OR.
      Hauler: Glanz Brothers (now Metropolitan Disposal Service),

   b. From 1960 to about 1966 - Stored on plant in drums and in tankcars.

   c. From 1966 to 1971 - Chemical Waste Storage & Disposition, Inc.,
      Alkali Lake, OR

      Hauler: Ditto

   d. From 1972 to 1975 - Resource Recovery Corp.
      P. O. Box 2431
      Olympia, WA 98507

      Hauler: Ditto

   e. From 1975 to date - Chem-Nuclear (now Chem-Security Systems)
      Star Rte.
      Arlington, OR 97812

      Haulers: Chem-Security Systems
      - Ditto -

      Time DC
      2720 Royal Lane, Suite 100
      P. O. Box 59931
      Dallas, TX 75229

      From 1975 to date - Wes Con (now Envirosafe Services of Idaho, Inc.)
      P. O. Box 936
      Mountain Home, ID 83647

      Hauler: Time DC [Address above]

3. All aqueous waste generated in the various manufacturing processes are collected in an equalization tank, passed through activated carbon, and then neutralized prior to discharge to the publicly-owned treatment works.

From 1968 to 1975 the spent carbon was thermally regenerated on-site. Beginning in 1975, the carbon has been provided by Calgon Adsorption Service and all carbon has been returned to Calgon reactivation centers in Texas, Kentucky, or Pennsylvania.

Carrier: Calgon Corporation
4800 W. 34th St.
Suite B-8
Houston, TX 77092

Disposal Locations:

Calgon Corporation
9640 Bayport
Pasadena, TX 77507

Calgon Carbon Corp.
P. O. Box 664
Cattlettsburg, KY 41129

Calgon Corporation
200 Neville Rd.
Neville Island, PA

Exhibit N attached.

EXHIBIT N

RHONE-POULENC INC.

PORTLAND PLANT

PLANT HISTORY HIGHLIGHTS

6/12/79
Revised 10/83

The plant has been located in Portland since 1943, starting with a small railroad liquid formulation plant and a warehousing operation for distributing insecticides. Later formulation of 2,4-D and other herbicides were made in Portland. The Technical 2,4-D Plant was built in 1956. Since then various operations have been added.

1956 - Plant Started

1958 - 2,4-D operations revised to improve product quality and
1959 water reuse systems installed to decrease pollution problem.

1960 - MCPA Plant -- o-dichlorobenzene as solvent

2,4-5-T Plant

Continuous ester operation

2,4-DB ester operation

1962 - 2,4-5T down, continuous ester plant shutdown

1963 - 2,4-DB Plant

1964 - Chlorine oxidation system to treat plant effluent

1965 - MCPA Plant shutdown and dismantled

1966 - New MCPA Plant - DCM as solvent

1969 - Carbon Treatment System on plant effluent

1970 - Building Scrub, 2,4-D

1971 - BO Process added to ester plant

1972 - MCPB and 2,4-DP production in MCPA/DB area

1975 - Tri-production started

1976 - New MCPA Process Plant started and cancelled early in 1976. MCPA shutdown late 1976.

1976 - DCP Distillation for high purity 2,4-D

1977 - 2,4-D Optimization, Water Treatment System additions and water effluent hookup to City Sewer.

1982 - 2,4-D, 2,4-DB, Technical Acid production shutdown.

QUESTN. 7a,7b,7c

QUESTION SEVEN

QUESTION:

7a. Provide the total amount of wastes described in (4) and (5) above that is currently in storage, including the amount of wastes added from other processes. Provide the total amount of such wastes generated during the history of your facility.

7b. Provide the total amount of wastes described in (4) and (5) above that has been disposed of including the amount of wastes added from other processes. Provide the dates of disposal, the amount disposed of on each occasion, the waste hauler, and the disposal location.

7c. If any wastes from your facility have been transported or disposed outside the boundaries of Region 10 (Washington, Oregon, Idaho, Alaska), provide a listing of the types of wastes, quantities and disposal locations.

ANSWER:

a. No waste described in (4) and (5) is in storage.

b. The total waste generated from the facility is not known. An estimate has been made from the Exhibit N chart and percent production records.

1. Water effluent total volume no known.

2. Solid waste disposal volumes estimated on attached table [Exhibit O].

3. Trash (not known).

c. Wastewater treatment utilizing activated carbon has been in operation since 1968. Prior to 1975, the carbon was regenerated on-site.

After 1975, the activated carbon has been provided by Calgon Adsorption Service and all spent carbon has been returned to Calgon reactivation centers in Texas, Kentucky, or Pennsylvania.

Disposal locations:

Calgon Corp. 9640 Bayport Blvd. Pasadena, TX 77507	Calgon Corp. 200 Neville Rd. Neville Island, PA	Calgon Carbon Corp. P. O. Box 664 Cattlettsburg, KY 41129

Carrier: Calgon Corporation
4800 W. 34th St.
Suite B-8
Houston, TX 77092

Exhibit O attached.

EXHIBIT O

WASTE DISPOSAL PRACTICES

Time Period	Disposal Location	Carrier	Quantity	Comments
1956-1960	St. John's Landfill	Glanz Brothers	Est. 5,000 drums	Mixed Wastes; identification unknown.
1960-1966	- - - - - WASTE STORED ON PLANT SITE -			
1966-1971	Alkali Lake	Hunt Disposal Co.	Est. 22,000 drums	Mixed wastes.
1972-1975	Western Processing Pasco, WA	Western Processing	Est. 2,770 drums	Mixed Wastes
1975-Current	Envirosafe (Wes-Con) Mountain Home, ID	Time DC	Est. 7,930 drums	MCPA tars. Mixed pesticide wastes.
1975-Current	Chem-Security (Chem-Nuclear) Arlington, OR	Time DC Chem-Security Serv.	818,340 lb 5,575 drums	MCPA tars. Waste carbon. Mixed pesticide wastes.
1975-Current	Calgon, Pasadena, TX	Calgon	2,767,886 lb	Spent carbon.
1975-Current	Calgon, Cattlettsburg, KY	Calgon	205,500 lb	Spent Carbon
1975-Current	Calgon, Neville Island, PA	Calgon	679,250 lb	Spent Carbon

QUESTION 8

QUESTION EIGHT

QUESTION:

If testing was done to determine the 2,3,7,8-TCDD content of wastes prior to disposal, provide the dates of the sampling, the sampling and analytical methods used, and the results of the analyses.

ANSWER:

No testing was done to determine 2,3,7,8-TCDD content of wastes prior to disposal.

No Exhibits.

QUESTION 9

DOCUMENTS 1-69

QUESTION NINE

QUESTION:

Provide all other documents of your facility that relate to 2,3,7,8-TCDD including all 2,3,7,8-TCDD analyses of groundwater, surface water, ambient air, and any other environmental media.

ANSWER:

Exhibits 1 through 69 are listed chronologically on the attached list.

9. DOCUMENTS ATTACHED AS FOLLOWS:

1.	Memo - C. Holstein to B. J. Smith	5/ 6/59
2.	Memo - R. A. Guidi to B. J. Smith	10/14/60
3.	Memo - B. J. Smith to File	11/10/60
4.	Purchasing Record Cards Beginning 1968 - 1969	
5.	Dow Chemical 2,4,5-T Sales Spec	2/27/69
6.	Memo - C. Fritsch to B. J. Smith	6/ 1/70
7.	Memo - J. B. Vernetti to C. Fritsch	6/12/70
8.	Analysis of Plant MCPA Flakes	6/19/70
9.	Memo - L. VanGrodon to H. D. Crist et al	8/27/70
10.	Memo - E. Clark to H. D. Crist et al	11/13/70
11.	Memo - E. Upton to L. VanGordon	11/17/70
12.	Memo - L. VanGordon to Dist. Sales Managers	11/30/70
13.	Memo - J. B. Vernetti to L. Minsuk	10/20/71
14.	Telex - R. F. Gitschlag to L. Minsuk	11/10/71
15.	Analysis of Rhodia 2,4-D, MCPA, 2,4-DB	5/22/72
16.	Memo - L. Brown to L. T. Hargett	12/11/72
17.	Memo - J. B. Vernetti to L. Minsuk	6/18/73
18.	Memo - L. VanGordon to E. Schroder	7/15/75
19.	Memo - E. Schroder to R. F. Gitschlag	7/30/75
20.	Memo - R. F. Gitschlag to L. VanGordon	8/ 1/75
21.	Memo - R. F. Gitschlag to R. E. Commins et al	9/22/75
22.	Memo - R. D. Wilson to J. E. Davies	9/15/77
23.	Memo - R. F. Gitschlag to L. Patterson	12/ 5/77
24.	Memo - J. E. Davies to M. P. LaValleye	4/12/78
25.	Memo - J. B. Vernetti to R. F. Gitschlag	4/20/78
26.	Memo - M. P. LaValleye to J. E. Davies	4/27/78
27.	Memo - J. B. Vernetti to E. Schroder	6/14/78
28.	Memo - J. E. Davies to J. B. Vernetti	6/22/78
29.	Wright State Report on TCDD in 2,4-DB, 2,4-D, 2,4-DCP	5/22/79
30.	Memo - J. B. Vernetti to E. L. Clark	6/ 4/79
31.	Memo - R. F. Gitschlag to P. E. Davis et al	7/ 5/79
32.	Memo - R. F. Gitschlag to J. E. Davies	7/ 6/79
33.	Memo - J. E. Davies to E. Clark et al	7/18/79

34. Memo - R. L. Ferguson to R. F. Gitschlag 7/19/79
35. Memo - R. F. Gitschlag 7/27/79
36. Memo - R. Reiter to R. F. Gitschlag 9/27/79
37. Memo - J. B. Sibeud to R. F. Gitschlag 10/18/79
38. Letter - M. L. Leng to A. Guardigli 11/ 9/79
39. Wright State Report on TCDD in DCP Tar 6/10/80
40. Memo - R. F. Gitschlag to B. Bawden 6/30/80
41. Memo - J. B. Vernetti to E. L. Clark 7/ 3/80
42. Memo - R. F. Gitschlag to J. Peabody 7/28/80
43. Memo - J. B. Vernetti to J. Sibeud 8/25/80
44. Wright State Report on Dioxin in Spent Carbon 1/ 7/81
45. Memo - R. D. Wilson to J. B. Vernetti 1/15/81
46. Telex - P. H. Wicks to R. R. Briggs 4/ 8/81
47. Telex - R. Briggs to P. Wicks 4/ 8/81
48. Wright State Report on TCDD in DCP Mud and Tar 4/29/81
49. Memo - J. B. Vernetti to R. R. Briggs 5/14/81
50. Memo - R. R. Briggs to J. P. Sibeud et al 5/15/81
51. Memo - A. Guardigli to R. R. Briggs 5/20/81
52. Memo - R. R. Briggs 6/ 2/81
53. Memo - P. M. Boisde to R. R. Briggs 10/26/81
54. Memo - R. D. Wilson 11/ 2/81
55. AG Canada Report 11/30/81
56. AG Canada Report 11/30/81
57. Memo - L. D. Spicer to R. J. Rosenberg 12/ 4/81
58. Memo - J. B. Vernetti to J. E. Davies 1/25/82
59. Report GRSI to J. B. Vernetti 2/12/82
60. Memo - L. Spicer to A. Guardigli 2/23/82
61. Memo - R. R. Briggs to R. L. Ferguson - A. D. Little Study 3/2/82
62. Memo - M. McMullen to R. J. Rosenberg 4/20/82
63. Report - GRSI to J. B. Vernetti 6/17/82
64. Memo - M. A. McMullen to J. B. Vernetti 7/ 2/82
65. Memo - R. R. Briggs to R. J. Rosenberg - M.Watson EPA Dioxin Insnect. 9/30/82
66. Letter EPA to R. R. Briggs 10/15/82
67. Memo - M. McMullen to J. B. Vernetti 10/22/82
68. Info - M. McMullen to R. R. Briggs 11/ 9/82
69. NIOSH Dioxin Registry Site Visit-Draft Report w/Correction 2/17/83

Carlson

1

CHIPMAN CHEMICAL COMPANY, INC.

INTER-OFFICE CORRESPONDENCE

SUBJECT : 2,4,5-Trichlorophenol Poisoning
(Interview at Diamond Alkali)

Bound Brook, N. J.

cc: I. W. Bales

PERSONAL

May 6, 1959

MR. B. J. SMITH
PORTLAND OFFICE

Summary -

(a) Supersedes previous memos.
(b) "Acnegens" is coined word to describe by-product impuritied causing chloracne.
(c) Severe chloracne problems are associated with the synthesis of trichlorophenol. (2,4,5)
(d) The manufacture of 2,4,5-Trichlorophenoxyacetic acid is free of chloracne problems if such manufacture is based on purchased TCP from reliable sources.

Trichlorophenol (TCP) and Chloracne

Three major producers of TCP experienced many chloracne cases following the expansion of an autoclive during synthesis of TCP. That is, the synthesis of TCP from tetrachlorobenzene and caustic soda in a medium of methanol or glycol. Explosion resulted when operators were unable to check exothermic reaction. Such overheating of batch of TCP automatically increases the amounts of acnegens present. On a normal operating basis, it might be expected that 50% of the personnel in TCP manufacture or its subsequent purification would be likely to have problems with chloracne. This is probably due to small leaks at pump glands, small amounts of vapor from various sources, and, for example, the cleaning of chemical lines. Here wish to repeat as described above, following an autoclave explosion, both the personnel in the area of the explosion and the clean-up personnel following them had a very high incidence of chloracne in severe amounts.

Practical experiences at Diamond confirm the experience reported by Hamburg that the acnegens are obnoxious by-products of the TCP synthesis. Pure TCP or commercial TCP (as purified) does not show chloracne properties.

Test for Acnegens

The six weeks test with rabbit ears is the only known positive test. Brief attempts were made to utilize the infrared to isolate this impurity and identify it, but these were unsuccessful.

Hygiene (TCP)

Hygiene begins with plant operations in the sense that a slight vacuum is maintained on operating equipment wherever possible.

Dermatologists having experience with this chemical are as follows:

Dr. Bleiberg (has had experience during the war with similar
31 Lincoln Place chemicals)
Newark, N.J.

A second dermatologist claiming to have some experience in this field is:

Dr. Edelson
Newark, N. J.

Personnel at Newark do not have the confidence in this man that they do in Bleiberg, whether justified or not.

Personnel

It is important that the personnel be men of excellent hygiene habits. A worker who has sloppy personal habits will most surely get in trouble with this chemical. Operating employees must have a new change of clothes each day. Employee should use a protective skin cream. Could use the following skin cream: Kerodex, Ayest Labs, New York City. The employee should always wash before eating, smoking, and urinating, or attending to personal habits.

2,4,5-Trichlorophenoxyacetic acid

Chloracne problems are unlikely if the manufacturer of subject herbicide begins with purchased TCP, obtained from reliable sources. However, occasional off-grade TCP, inadvertently supplied, may cause spot difficulties. The manufacture of this herbicide as outlined above is not considered to be a difficult problem from personnel point.

Hygiene

Hygiene for employees engaged in manufacturing 2,4,5-trichlorophenoxyacetic acid is the same as for TCP workers as outlined above.

continued.....

2,4-D Manufacture

No precautions as described above are taken or needed in the manufacture of 2,4-D products.

C. H

Chris Holstein

CH/w

Diamond Alkali Company

GENERAL OFFICES - [illegible] COMMERCE BUILDING - CLEVELAND 14, OHIO - TELEPHONE MAIN 1-8100

DIAMOND ALKALI COMPANY
60 LISTER AVENUE
NEWARK 5, N. J.

October 14, 1960

Chipman Chemical Company
6200 West St. Helen's Road
Portland 10, Oregon

Attention: Mr. Blanchard Smith
Vice President

Dear Mr. Smith:

At the request of Mr. M. F. Wilkerson, our Sales Manager, I am writing you concerning handling procedures of trichlorophenol and sodium trichlorophenate. It is my understanding that you are negotiating with [illegible] concerning the purchase of [illegible] number of the above [illegible]

No doubt, you are fully [illegible] handle [illegible] quantities [illegible] desirable. I [illegible] either or both of the [illegible] of the TCP process [illegible] tank car quantities. [illegible] chlorine [illegible]. [illegible] our plant, we did [illegible] result of [illegible] number of process [illegible] conditions. [illegible] bodies relating [illegible] chlorine [illegible] last four years, [illegible] which result from the [illegible]

[illegible] TCP or Na-TCP [illegible] has been [illegible] a full [illegible] to all

exposed parts of the skin. Immediately on completion his task, he is required to shower thoroughly and change work clothes.

4. In the event of an equipment failure, or accidental splash onto any portion of a man's body, we urge immediate washing with copious quantities of water for an extended period of time (15-20 minutes). This has occurred on occasion. The usual result is a mild chemical burn; however, if the prescribed remedy is not delayed, there is little, if any, damage.

5. Generally, all our equipment is of the closed type; where air vents are required, the line is extended to a remote location. The plant area is washed daily. However, no special detergents or procedures have been outlined at this time. In retrospect, we might say that the precautions taken in this unit are no more demanding than those of an acid plant or a caustic plant.

It is an established fact that chlorinated compounds such as biphenyls, naphthalenes, diphenyl oxides, crude phenols and others have been reported to cause acneform dermatitis when applied to rabbit ears (Ind. Med. 10, Ind. Hyg. Sect. 2, 1-4 (1941)). The Chemistry of Industrial Toxicology by Harvey B. Elkins also reviews the toxicity of chlorinated hydrocarbons. An analysis of the possible side products leads us to conclude that the chlorinated diphenyl ether is the [illegible] product in the manufacture of trichlorophenol. We [illegible] effectively control the formation of this compound, but are eliminating it [illegible]ately.

[illegible] mentioned a previous case [illegible] to the [illegible] and developed severe [illegible] and [illegible]. [illegible] difficult for us to [illegible] though it may be possible that the excess caustic [illegible] have caused a severe [illegible] for the [illegible] This [illegible] generally [illegible] [illegible] reasonable [illegible] [illegible] found that [illegible] generally [illegible] chemically [illegible] they attack the [illegible]

[illegible] this opportunity to [illegible] in [illegible] outlining [illegible] safety and hygiene [illegible] our [illegible]

Very [illegible]

[illegible]

R. A. [illegible]
Plant Manager

RFH confidential

3

CHLORACNE

November 10, 1960

MEMORANDUM FOR S.H. FILE:

In discussion this date with Mr. Harry S. Weiner, Operations Manager, Chlorinated Products Division, Diamond Alkali Company, the following points were brought out by Mr. Weiner.

During the period 1950-1956, Diamond Alkali had several chloracne cases at their 2,4,5-T Plant in Newark, New Jersey. Because of this problem, they spent over $50,000 working with the American Medical Association and private test laboratories, as well as with some German doctors, to define the cause of this problem. As we already know, this chloracne is a result of physical contact with chlorinated di-phenyl ether. Mr. Weiner stated that after finding the cause of this problem in 1956, they have had no cases, even minor, of chloracne at their Newark location.

He further goes on to say that their level of chlorinated di-phenyl ether in the aqueous solution of sodium trichlorophenate is in the level of a few parts per million--lower, he says, than any competitive manufacturer.

His specific recommendations [illegible] in handling TCP are:

1. A good shower [illegible]
2. The use of [illegible] to any other.
3. Clean clothing [illegible]
4. Separate [illegible] the face, hands, and [illegible] eyes.
5. Use rubber gloves.
6. Do not eat in the operating area.
7. Shower thoroughly [illegible] before taking [illegible] to eat [illegible].
8. A physician should be [illegible] handling TCP.

Generally speaking, he said [illegible] chloracne in regard to [illegible] of the sodium trichlorophenate. These [illegible] of gases, [illegible] some for [illegible] of the [illegible] of the hair follicles, [illegible] sweat glands, and sebaceous swelling.

He specifically recommend that anyone suffering from this problem not be given any duty of any kind involved in their sodium trichlorophenate, as well as to stay away from chemical [illegible], dust or chemicals, etc.

The name of Diamond Alkali's company doctor in Newark, New Jersey, is Dr. Conley, and I think we should [illegible] talk with Dr. Conley and get his suggestions for [illegible] tests, etc.

R. [illegible]

RH:dm

Litadlog.

OCCUPATIONAL ACNE
(Chloracne, so-called)
By Kimmig & Schulz
Dermatologica 115,540, 1957

Translated from German
by J. Barandy
3/59

Among the different chemical and physical toxicants which cause skin acne and folliculitis to a pathogenic extent, chlorinated products and byproducts have been playing an important role.

The first such cases of illnesses, induced by chlorinated materials, were observed around the end of the century in connection with the newly-introduced process of obtaining chlorine through electrolysis. The opinion which Herxheimer expressed, but later changed, was that free chlorine was the cause of illnesses, and led to the widespread misuse of the word "chloracne" in German literature.

Since the introduction of chlorinated naphthalene, which, due to its advantageous technical properties (like acid resistance, fire-water repellency, good isolation capacity, etc.) appeared in different industrial applications, the occurrence of chloracne also has increased. (Taleki, Ramm, Grimmer, et al). Wauer & Taleki identified these illnesses with the quite inappropriate word "Dermadisease".

More contemporary are the observations of intoxications from pentachlorophenol production, where pentachlorophenol in contact with the skin, caused chloracne. Although for these cases, the pentachlorophenol itself can be responsible, we will have to carry on further investigations.

The actual observations to which we by experiments could achieve, were performed on workers of one of the chemical factories in Hamburg, engaged in the production of 2,4,5-TCP and its end product, the herbicide 2,4,5-trichlorophenoxyacetic acid and its esters. A total of 31 persons became sick, from which 9 showed widespread, heavy deformations; 14 persons' general conditions deteriorated, and 8 persons showed only minor changes.

The clinical appearances developed in summer and autumn of 1954. On one worker, obviously heavily exposed, symptoms appeared first as a dermatitis on the face, accompanied by erythema (redness) and swelling of the face, after which conditions on the face same (like deformations) developed. Still later, other types of pustules formed.

In most cases, the symptoms appeared as blackheads in the beginning, while in the latter stage, boils developed on the shoulder region, without acute dermatitis.

As far as the first observations of these skin deformations are concerned, they could be composed of innumerable blackheads, and/or retention cysts with size varying from pinheads to hazel size; of follicular head hyperkeratosis, of inflamed boils, or of furuncles. In all cases, the symptoms spread on the chest, back, abdomen, sides, upper leg and on genitals.

In general, the allocations of these eruptions were unusually thick, to such an extent that hardly a follicle remained unaffected. While most blackheads and retention cysts have been observed on the face, boils of secondarily infected eruptions (furuncles) were quite frequent on the neck and on the trunk of the body.

Several patients--besides these skin deformations--developed chronic eyelid conjunctivitis. Generally, the other complaints of the patients were loss of appetite, weakness in the legs, and other symptoms which indicated an overall intoxication.

The further clinical examinations reported damage of the liver, damage of central nervous system and damage of the blood-recovery system, also. Several patients suffered hypoacidity (less acid) in their stomach juice. A week or so later, due to aggravated cases, internal and neurological examinations were resumed on several patients. This time, indications proved liver damage, in three cases. We will not describe here the details of this clinical report.

The duration of the illness proved to be long and enduring. Although there was not any contact with the toxic substances, despite intensive internal and external therapy, even 15-20 months after the beginning, marks of skin deformations kept appearing.

INVESTIGATIONS OF THE CAUSE (ETIOLOGY)

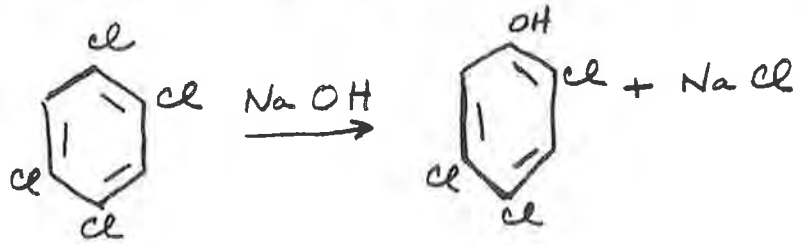
Animal experiments have been conducted in order to find the toxic agent causing the illness. As test objects, the rabbit's ear was found the most suitable, on which Hoffman, Neumann, Brown, Landes, et al., had already worked with chlorinated naphthalene, having induced appearances similar to that of human chloracne. The internal surface of one ear was daily treated by the substance suspected as the cause of chloracne. The substance was dissolved in polyglycol. The other ear as control was treated only with the solvent (polyglycol).

In positive cases, the tests resulted first (within 2-4 weeks) in flat spread inflammation and days later, swollen follicle, hyperkeratosis and small cysts.

Histological findings have been: Acanthus, like widening of the epidermis, edema and sharply developed cell infiltrations in the cuticle, the enlarged follicles were filled with keratoid material; in later phases these developed themselves into even larger cysts.

As the almost two years long research, carried on with more than 100 substances with the rabbit ear test finished, one can safely make statements about the chloracne-causing effect of certain materials.

The first results presented by us, had been reported at the 23rd German Dermatological Congress in Wien (Vienna). The report first pointed out that it is not the 2,4,5-trichlorophenol which is the cause as was originally believed, because treatment with pure 2,4,5-trichlorophenol (5% polyglycol solution) did not show any observable appearances on rabbit's ear, but treatment with technical product did cause chloracne. Because the starting product, 1,2,4,5-tetrachlorobenzene spread on the rabbit's ear has been without effect, we had to assume that the tendency we are searching for must be one of the byproducts generated by alkaline hydrolysis from 1,2,4,5-tetrachlorobenzene to form 2,4,5-trichlorophenol.



Because it wasn't possible to isolate the byproducts from the residue, we looked for compounds, with reason, that could form from the saponification of tetrachlorobenzene at 180°C. At first, there was made available to us some chlorinated products of diphenyl ether and dibenzofuran.

While the chlorinated derivations of diphenyl ether, monosubstituted and monochlorinated dibenzofuran in the animal test proved ineffective, the trichloro and tetrachlorodibenzofuran in a concentrate of 0.05% already induced described deformations. Both of these compounds have strong liver poisoning capacity. One dose of 0.5 to 1.0 mg. per kg. body weight taken orally by the rabbits resulted in serious liver injuries. But so far, no one could detect chlorinated dibenzofuran in the byproducts.

The clinical observation of one worker, who after the exposure to tetrachlorodibenzodioxine became seriously ill of chloracne, pointed to chlorinated dibenzodioxine (diphenylenedioxide) as an important causing agent. As further studies indicated, tetrachlorinated dibenzodioxine, especially 2,3,6,7-tetrachlorodibenzodioxine, infected the rabbit's ear with an unusually strong vigor. Three to four times brushings with 0.01 - 0.005% solution within 3-4 days were sufficient to cause serious swellings, also abnormalities of follicles, accompanied by hyperkeratotic deformations. One orally administered dose of 0.05 - 0.1 mg/kg body weight resulted in heavy liver injuries. Most of the animals treated as above expired within 8-20 days after treatment. Autopsy found extensive necrosis and fatness of the liver.

Meanwhile, it was chemically proven that 2,3,6,7-tetrachlorodibenzodioxine itself forms from two molecules Na-trichlorophenate, splitting off two molecules NaCl. Furthermore, we succeeded in isolating 2,3,6,7-tetrachlorodibenzodioxine from the byproducts produced by the technical saponification of tetrachlorobenzene to trichlorophenol. On the ground of this finding, we are able to conclude that this tetrachlorodibenzodioxine is responsible, if not entirely, at least essentially, for the observed illnesses due to chloracne.

In conclusion, be reminded that application of pure 2,4,5-trichlorophenol and pentachlorophenol on rabbit's ear did not induce any described symptoms whatsoever. Therefore, it is highly probable that the published chloracne cases caused by pentachlorophenol (Hunter & Bauer) actually were not caused by the compound itself, but illness by toxic byproducts. These byproducts were in the submitted substance (pentn.) because the manufacturing process of pentachlorophenol is similar to the process of trichlorophenol, an alkaline hydrolysis of hexachlorobenzene.

SUMMARY

Amongst workers who are employed in the preparation of 2,4,5-trichlorophenol and its transformation to 2,4,5-trichlorophenoxyacetic acid or its esters, 31 cases of so-called chloracne were seen. It could be shown experimentally by brushing into a rabbit's ear, that it is not trichlorophenol itself but a toxic product formed by the alkaline hydrolysis of 1,2,4,5-tetrachlorobenzene to 2,4,5-trichlorophenol which is the cause of the chloracne. From the synthesized combinations, which might come in question, 3 and 4 times chlorinated dibenzofuran and also tetrachlorodibenzodioxine proved very active. 2,3,6,7-tetrachlorodibenzodioxine was isolated out of the byproducts and the possibility of its formation from Na-trichlorophenate is proved.

2,4,5-T ACID [illegible]
PRODUCT 98%

190600
CODE

Also Called: [illegible]

Major Chemical For: SPEC.: NO SOD. SALT T ACID; NO MORE THAN .5% MAX. SOD. CHLORIDE

Minor Chemical For: STAUFF

Suppliers — Shipping Pt.

1 Thompson-Hayward Chemical Co. — Kansas City, Kans.
3/11/71 - Per B. Munger - Don't have any!!
4/28/72 - Per LVG Resolves on list from Dow 2/2/73 - NO LONGER MFG.

2 Dow Chemical Co.
RP - Per robie 4/15/71 - Currently not manufacturing
TRANSVAAL - 10/1/70 - CL-TL = $1.22* 2,000# - TL $1.28* LESS 2,000# - 1.38*

3 Riverdale Chemical

4 Hercules Canada - Do not offer - Offer 10E, 2,4-D Butyl Butyl, 2,4-D 10E, Mat Bigs Inc.

5 Monsanto / Hercules / Diamond Shamrock / Chipman Canada - No. } out of the business

Remarks: DOW-IE 7-1-71 ETT 4/71
CL-TL (SD = BAG) 1.12*
" 200# DRUMS 1.135
TON-TL-BAGS 1.18
" " DRUMS 1.195
LT TON-BAGS 1.28
" " DRUMS 1.295
FOB Indianapolis, Ind. (Ad Feb Rebuttal) less 10%
3/5/74 E. Clark T

Munger, TH 3/30/71 - Only bought one bunch T Acid couple yrs. ago - Heavies were big in it. Do not anticipate buying any more

TRANSVAAL - 7/15/74 - CL/TL 260 2,000# - TL $2.66 LT 2000# 2.76* FOB JACKSONVILLE ARK. FRT EQUAL.

9	19	6/1/74 - 19 NC	19	19	19	19	19	19	19

7. Transvaal, Inc. - as of 3/15 - Price - Incr. $.10* NKC 1971 [illegible] - 29 [illegible] Clark 3/1/73 Price Incr. to $[illegible]* T/L
NC TRP 2/73 - DO NOT MFG. REFERRED TO: OSTERREICHISCHE STICKSTOFFWERKE, AUSTRIA; CELA INGELHELM, GERMANY

4

Date	Order	Supplier	Quantity	Price	F.O.B.	
/5/69	10180	1	20,000 lbs.	$/.	Kansas City	NKC 3
/27/69	10310	2	160 x 50 lb bags	$.988 lb.	Midland, Mich.	Portland 10
/26/70	4038	2	61 x 230# drums	$.90 lb.	Delivered	NKC 10
/16/71	4667	3	24/M lbs (Dismoll)	$1.05 lb.	Chicago Heights Ill.	NKC 10
/20/72	12259	2	6,000 lbs.	$1.195 lb. less 10%	Midland, Mich	NKC 3
12/4/72	3-13511	7	8,800 lbs.	$1.18 lb.	Jacksonville, Arkansas	NKC 3

2,4,5-T ISOOCTYL ESTER TECHNICAL 97% 67.5% Acid Equivalent ~~280000~~ 191000

PRODUCT CODE

Also Called:

Major Chemical For: Approx. 10#/GAL

Minor Chemical For: STAIN

Suppliers

1 Dow Chemical Co. Shipping Pt. Midland, Mich.

2 Thompson-Hayward Chemical Co., Inc. Kansas City, Kans.

3 Chipman Chemicals Ltd

4 Chipman-Canada

5 *THOMPSON-HAYWARD TANK CARS DRUMS

Remarks: NKC: CB&Q Delivery Portland: SP&S Delivery

MONSANTO & HERCULES — NO LONGER OFFER

19	19	19	19	19	19	19	19	19	19
6/71 - PER L.M. TOTAL POE REQ FOR CHEVRON ORDER 331,170#									
8,000 gal. TC - PORTLAND									
1 - ARR 7/15	1 - ARR 1/15				NKC				
1 - ARR 10/1	1 - ARR 3/1				PORTLAND				

2/26/69	10307	2	8,000 gal. T/C.	$.71 lb.	Kansas City, Kans	Portland 8
3/18/69	01696	2	10,000 gal T/C	$	" " frt ald	NKC 3
4/17/69	10469	2	10,000 gal T/C	$.68 lb.	Portland, Ore.	Portland 8
4/23/69	10475	2	10,000 gal	$.68/lb.	NKC, Mo.	NKC
1/12/70	11067	1	8,000 gal TC	$.66 lb.	NKC, Mo.	NKC
2/19/70	11193	1	8,000 gal T/C	$.66 lb.	NKC, Mo.	NKC 10
~~2/11/70~~	~~11158~~	~~1~~	Cancelled 2/16/70 ~~8,000 gal TC~~	~~$.66 lb.~~	~~NKC, Mo.~~	~~Portland 8~~
2/17/70	11187	2	8,000 gal TC	$.68 lb.	Portland	Portland 8
5/19/70	4167	2	3,000 gal.	$.68 lb.	NKC Mo	NKC 10
8/18/70	02322	2	10 drums (500#)	$.68 lb.	NKC	NKC NKC
12/28/70	4522	2	8,000 gal. T/C	$.68/#	Delivered	Portland 10
1/5/71	4605	2	79,000 8,000 gal T/C	$.68/#	Delivered	NKC 10
2/25/71	4638	2	10,000 gal T/C	$.76 lb.	Delivered	NKC 10
3/11/71	4646	2	3,500 gal T/T	$.76 lb.	Delivered	Portland 8
~~3/26/71~~	Cancelled ~~4657~~	~~2~~	~~4/22/71 10,000 gal T/T~~	~~$.76 lb.~~	~~Delivered~~	~~NKC 10~~
4/13/71	41,000 4666	45,320 3	81,120 20,000 gal T/T/C	$.5454#	Moosejaw, Sask	NKC 10
5/28/71	4724	2	23,440 2,400 gal.	$.76/#	Delivered	NKC 10
11/15/71	5205	2	Approx. 3,000 gal Not teexceed 3,200	$.76/#	Delivered	NKC 3
12/6/71	5215	2	10 drums	$.76/lb.	Delivered	NKC 3

Date	Order	Supplier	Quantity	Price	F. O. B.	Plant
12/15/71	5221	2	10,000 gal.	$.76/lb.	Delivered	NKC 3
1/31/72	12269	2	55,300 lbs.	$.76/lb.	Delivered	Portland 8
2/23/72	12301	2	10,000 gal.	$.76/lb.	Delivered	NKC 3
NO PRICES						
3/17/72	12091	2	10,000 gal.	$.785/#	Delivered	NKC 3
4/17/72	10-12805	2	10,000 gal.	$.785/#	Delivered	NKC 3
4/20/72	10-12834	2	10,000 lbs. drum	$.815/#	Delivered	Portland 8
4/28/72	10-12861	2	10,000 gallons	$.785/lb.	Delivered	NKC 3
10/11/72	10-15809	2	5,000 gallons	$.785/lb.	Delivered	NKC 3
2/1/73	16861	2	10,000 gallons	$.805 lb.	Delivered	NKC 3
2/1/73	16862	2	~~5,200 gallons~~	"	"	Portland 8
2/13/73	16862-1	2	9,300-10,000 gal.	"	"	Portland 8
4/5/73	27728	2	10,000 gal.	$.805/lb.	Delivered	NKC 3
8/30/73	28171	2	91 x 550# drums	$.825/lb.	Delivered	Van Gordon
8/23/73	17512	2	15 x 550# drums	$.835/lb.	Delivered	NKC ASAP

2,4,5-T ISOOCTYL ESTER TECHNICAL 97% — 1910-00

PRODUCT — CODE

Also Called:

Major Chemical For: Aver 2000 gal 79,000 lb; 10,000 gal 101,000 lb

Minor Chemical For:

Suppliers — Shipping Pt.

1 Thompson-Hayward Chemical Co. 1974 - Approx 400-45,000 lb. 11/9/73 - Bulk $.86 lb. del. DRUMS $1.88 — Kansas City, Kansas

2 Dow Chemical Co. — 1/10/74 - Don't have any more, trichlorophenol impossible to get. Not asked for 2,4,5-T [illegible]

3 Uniroyal - Canada

4 TRINSVAAL - 10/1/73 2,4,5T LV Ester — Bulk 1.09; C/L-TL 1.11; 2,000-TL 1.17; Less Truck 1.2

5

Remarks:

19	19	19	19	19	19	19	19	19	19

2/1/73	16861	1 102,000	10,000 gallons	$.805 lb.	Delivered	NKC
2/1/73	16862	1 100,940	9,300-10,000 gal.	$.805/lb.	Delivered	PTL
4/5/73	27728	1 101,600	10,000 gallons	"	Delivered	NKC
8/30/73	28171	1 50,050	91 x 550# drums	$.825/lb.	Delivered	Van Gordor
8/23/73	17512	1 8,250	15 x 550# drums	$.835/lb.	Delivered	NKC
11/5/73	28389	~~1~~ 435,440	72,600 lbs.	$.825/lb.	Delivered LKC	PTL Ship 11/9/73
11/6/73	28391	1	90,750 lbs.	$.88/lb.	Delivered LKC	PTL Ship 11/16/73
12/4/73	28511	1	66,000 lbs.	$.88/lb.	Delivered	PTL At Once
12/26/73	17638	1	10,000 gal	$.86/lb	Delivery	STJ 1st Qu 1974

3,4,5-T ISOOCTYL ESTER TECHNICAL 97%

PRODUCT

1910-00

CODE

ALSO CALLED

STORAGE TANK SIZE

POUNDS PER GAL. Approx. 10

SUPPLIERS

1 Thompson-Hayward Chemical Co.

2 Dow Chemical Co.

3 Uniroyal - Canada

4 Transvaal ~~4/17/74~~ 6/1/74-NC

Bulk	CL-TL	2,000#-TL	LT 2,000
1.80	1.82	1.88	1.98

4/30/74 - Price [illegible] of product in June.

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REMARKS

1971	1972	1973	1974	19
NKC 57,525 gal PTL 11,500 gal ~~68,250#~~	NKC 45,000 gal PTL 65,000 lbs 515,000	NKC 211,850 lbs PTL ~~330,290~~ 400,940 lbs Van Gor ~~50,500~~ 312,400 # ~~PTL 101,000 gal~~ 526,190#	PTL - 94,710 # STS. - 139,800 #	

DATE	ORDER	PLIER	QUANTITY	PRICE	F. O. B.	LOCATION	DATE DUE	DATE REC'D
~~2/26/72~~	~~176.39~~		~~10,000 gal~~	~~$.86/lb.~~	~~Delivered~~	~~STJ~~		
1/17/74	17585	1	10,000 gal	$.86/#	Delivered	STJ	Advise	5/5
2/25/74	39330	1	100,000 lbs.	.89/Lb.	Delivered	STJ	Advise	6/1
3/22/74	35901	1	13,750 lbs.	$.91/lb.	Delivered	PTL	ASAP	5/6
~~11/19/74~~	~~35022~~	~~1~~	~~5,000 gal.~~	~~1.42/lb.~~	~~F.C.~~	~~PTL~~	~~week~~	
~~11/15/74~~	~~42372~~	~~1~~	~~50 x 55 gal.~~	~~1.42/lb.~~	~~Delivered~~	~~PDR~~	~~12/2~~	
~~11/8/74~~	~~39407~~	~~1~~	~~70 Drums 38,500#~~	~~1.42/lb~~	~~Kansas City~~	~~STJ~~		1975
2/3/75	12015	1	70 drums	1.42/lb.	Kansas City,	STJ	2/14/5	3/21/75
4/3/75	12133	~~2~~ 1	4,001 gal	$1.42/lb	" "	STJ	4/3/75	4/2/75
4/3/75	12134	~~2~~ 1	4,000 gal	$1.42/lb	" "	STJ	4/9/5	4/16/75

2,4,5-T ISOOCTYL ESTER TECHNICAL 97%

PRODUCT

CODE 1910-00

ALSO CALLED:

STORAGE TANK SIZE

POUNDS PER GAL. Approx. 10 (9.9#/gallon)

SUPPLIERS

1 Thompson-Hayward Chemical Co.

2 Dow Chemical Co. - DONT PRODUCE

3 Uniroyal - Canada

Transvaal 4/1/75 BULK 1.84 CL/TL 1.86 FOB JACKSONVILLE ARK. EQ. W/PRODUCING PT.

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REMARKS

1972	1973	1974	1975	19
NKC - 450,000 lbs	NKC - 211,850 lbs	STJ - 139,800 lbs.		
PTL - 65,000 lbs	PTL - 100,940 lbs	PTL - 94,710 lbs.		
	VanGor- 213,400 lbs			

DATE	ORDER	PLIER	QUANTITY	PRICE	F. O. B.	TION	DUE	REC'D
11/19/74	38022	1	8,000 gal.	$1.42 lb.	Kansas City	PTL	First Week Jan.	
11/8/74	39907	1	70 Drums	$1.42 lb.	Kansas City	STJ		
2/3/75	12015	1	70 Drums	$1.42 lb.	Kansas City	STJ	2/14/75	3/.
4/3/15	12133	1	4001 gal	$1.42 lb.	Kansas City	STJ	4/3/75	4/2/75
4/3/75	12134	1	4000 gal	$1.42 lb.	Kansas City	STJ	4/9/15	4/16/75
12-22-75	12762	1	16,000 gal	$1.500#	105,100 Kansas City	STJ	ASAP	1/30/76
2-4-76	12905	1	approx 4,000 gal.	$1.500#	41,630 " "	STJ	2/6/76	2/6/76
2-18-76	12945	1	4,000 gal	$1.500#	41,530 " "	STJ	ASAP	2/20
2-26-76	12996	1	4,000 gal.	$1.500#	41,470 " "	STJ	3/2/76	3/1
2-26-76	12997	1	4,000 gal.	$1.500#	41,570 " "	STJ	3/2/76	3/2
~~2-27-76~~	~~12998~~	~~1~~	~~70 drums~~	~~1.753#~~	~~Bellwood, Ill.~~	~~STJ~~	~~3/2/76~~	
4/15/76	56508	4	40 x 525# = 21,000#	1.84/#	shipping point	STJ	WK OF 4/28/76	5/10/76
1/24/77	56244	1	30 x 500 lbs.	$1.843 lb	" "	STJ	1/28/77	
3/3/77	C7-5 x 500	1	109 x 550 lbs	1.750/lb	" "	STJ	3/10/77	

PRODUCT 2,4, 5-T Isooctyl Ester Technical ~~97%~~ 91% ([redacted]) LOCATION St. Joseph

CODE No. 2-1910-00 LBS/GAL 10# STG. CAP. (GALS)

VENDOR No.	No. 1	No. 2	No. 3
Vendor	Transvaal, Inc.	St. Jos. Feed & Supply	Thomprox - Hayward
Street	P.O. Box 69, Marshall Rd.		P.O. Box 3383
City	Jacksonville,	St. Joseph,	Kansas City, Kansas 66110
State (Zip)	Arkansas 72076	Missouri	
Phone Number	901-7[illegible]	[illegible]	
Contact	[illegible]	[illegible]	GLEN MUNGER
	JOHN [illegible]		(913) 321-3151
F.O.B.	Shipping Point		Shipping Point
Mode			
Ship Via &	~~Best Method~~ TANK CAR		100,000 # T/C
Routing	VIA MOPAC		DRUMS
Terms	Net 30		N30
Description or Remarks	INTRAC CONSOLIDATED (525# [illegible])		
	5100 POPLAR ST. SUITE 2414		
	Memphis, Tenn 38137		
	attn: John Callaway		
	(901) 767-6851		
Annual Quantities Purchased 1976	FOB : Jacksonville, Ark.		
1977	SHIP VIA: 100,000# T/C 525# DRUM T/L 36,000 #MIN		
1978	TERMS : N30		
1979	SPECIFICATIONS TO BE SHOWN ON ALL ORDERS: FREE 2,4,5-T ACID: LESS THAN 1%		
	FREE ALCOHOL : LESS THAN 1.5%		
1980	FREE MINERAL ACID : 0.5 - 1.0% MATERIAL TO CONTAIN NO DETECTABLE (LESS THAN 0.1 PPM) 2,3,7,8 TCDD. ~~YOU ARE TO PROVIDE THE ANALYTICAL DESCRIPTIONS AND CHROMATOGRAPHIC CHARTS FOR EACH LOT WITH THE SHIPPING PAPERS.~~		

SO TO REPORT ON A LEVEL OF ANAL.

P. O. No.	DATE	BLKT	SPOT	VNDR	QUANTITY	UNIT	UNIT PRICE	EFFEC. DATE	DATE RECD.	QTY. RECD.	SELLING PRICE
NBK56508	4/15/76		X	1	40x525#	#	$1.84/#		5/18/76	21,000#	
stock trans.	12/17/76			2	4				12/17/76	120gal	
56244	1/24/77		X	3	30x500#		$1.84/#		1/28/77	16,500#	
C756306	3/3/77		X	3	109x550	#	1.750/#		3/10/77		
C759768	11/14/77		x	1	100.4# TK 114x525# F/L		1.601# 1.651#	IMMEDIATE SEPAR. INVOICES		63,800#	
C86409	2/10/78		x	1	62500	#	1.65/#	REC'D 2/20/78	2/24/78	62,300#	
quote	9/21/78			1	BULK		1.85/F	1978 year end surcharge			
C9-87173	1/9/79		x	1	85,000	#	1.95/#	1TT 1/12/79 1TT 1/16/79	1/17/79	83,860#	

SALES SPECIFICATION

AGRICULTURAL PRODUCTS

THE DOW CHEMICAL COMPANY
AGRICULTURAL PRODUCTS DEPARTMENT
MIDLAND, MICHIGAN 48640

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SPECIFICATION		SUPERSEDES		METHOD OF ANALYSIS
NUMBER	DATE	NUMBER	DATE	87523
87523	2/13/70	87523	2/27/69	

2, 4, 5-TRICHLOROPHENOXYACETIC ACID

2, 4, 5-Trichlorophenoxyacetic acid, minimum	98.0%
Freezing point, minimum	148.5° C
2, 3, 7, 8-Tetrachlorodibenzo-p-dioxin	< 1 ppm

File Dow

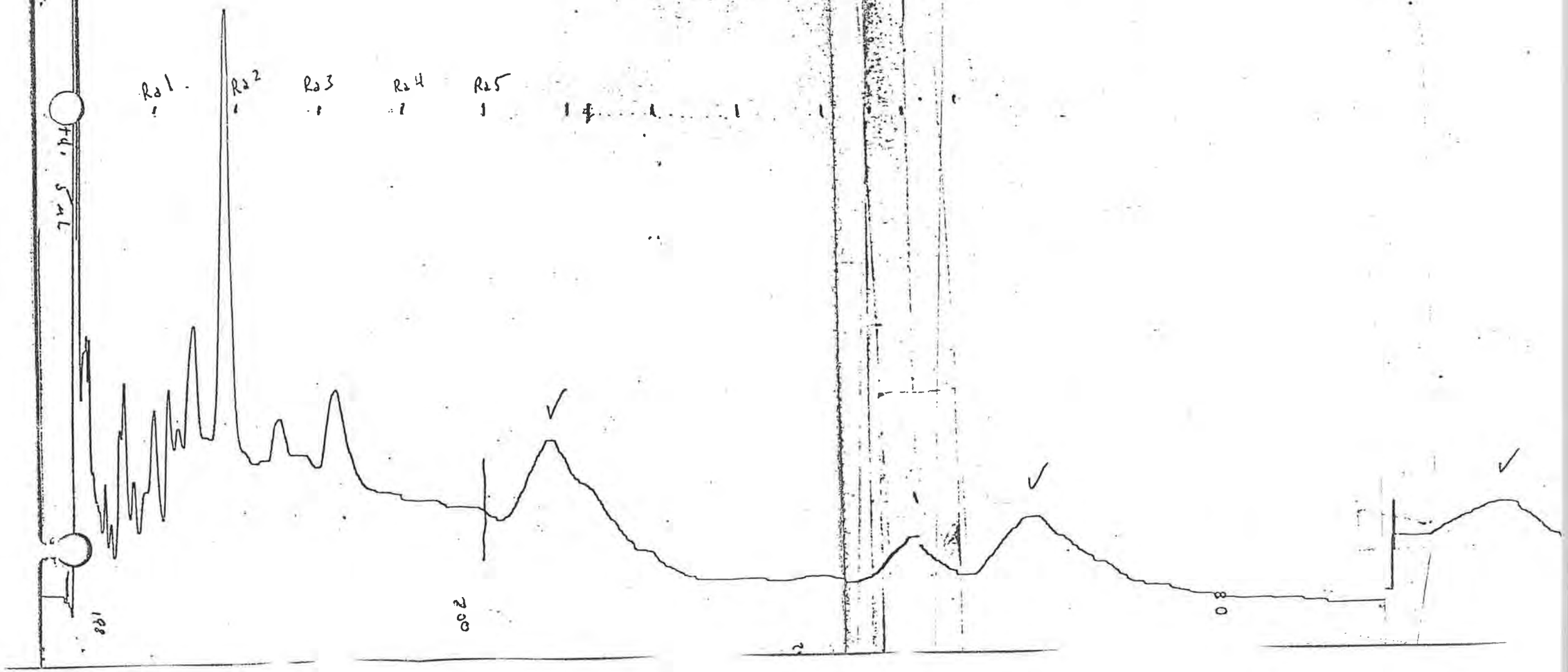
THE POLICY OF THE DOW CHEMICAL COMPANY IS ONE OF CONTINUED IMPROVEMENTS BY RESEARCH AND MANUFACTURING WHEREVER POSSIBLE TO ASSURE A STILL FINER PRODUCT HENCE, SPECIFICATIONS ARE SUBJECT TO CHANGE WITHOUT NOTICE.

FORM C-15770 PRINTED IN U.S.A. R5-68

III. Standard, Chick Edema Factor FDA Code F-726
(Toxic Ref. Standard Fat) (1966)

FDA Procedure (1970)

5 µL inj.; SE 52 2½% on Aerapak 30;
5 ft glass column; E.C. Dect.; Varian 11 Fy
Temp. 198°. 0-100 scale = ~20% of standing current



FDA Code F-726
(1966)

% on Apiezon, 30;
ect.; Varian Hi Fy
e = ~ 20 % of Standing Current

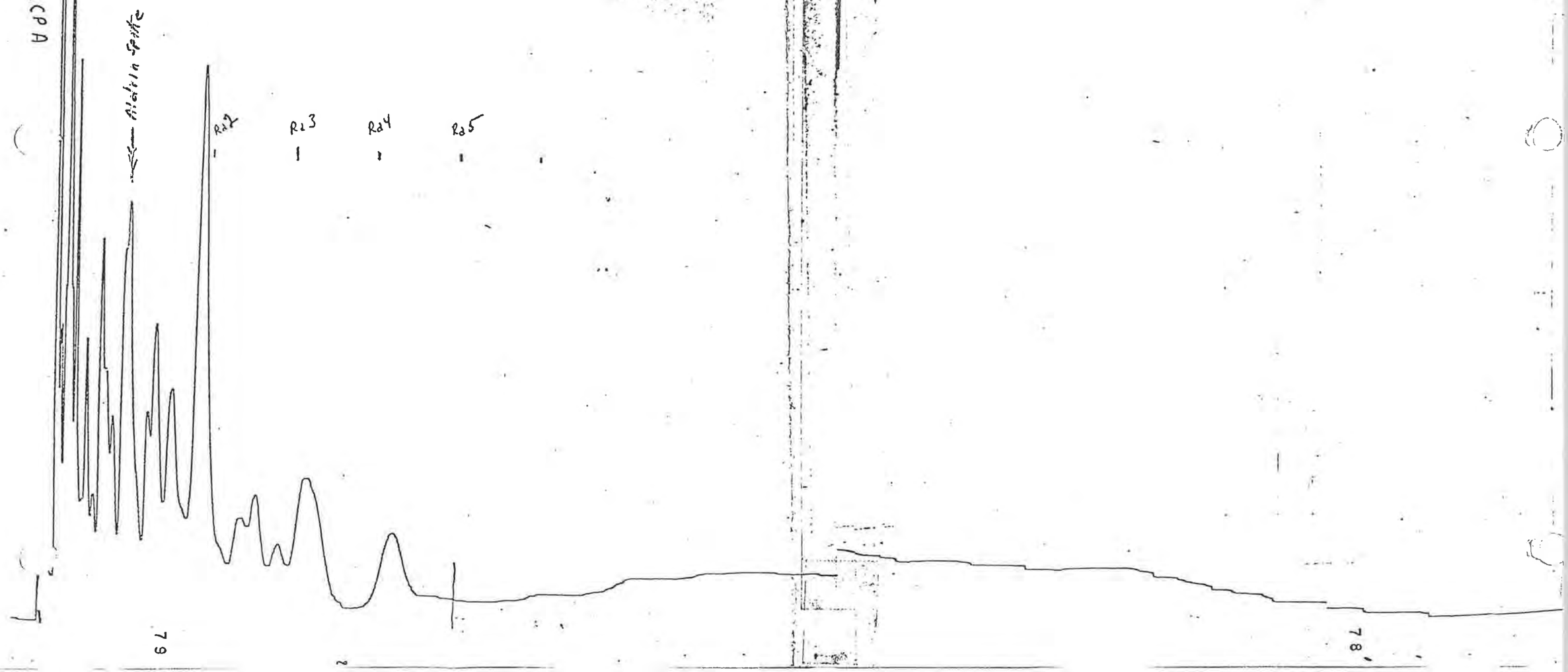
II. Plant MCPA Flakes, Composite late 1969, and 1970

FDA Procedure (Jan 1970)

5 yL inj.; SE 52 2½% on Aeropak 30;

5 ft glass col., E.C. Dect.; Varian Aerograph

Temp 198°C; 0-100 Scale = ~ 20% of Standing Current



posite late 1969, and 1970
Acropolis 30,
is Acrosiph
= ~ 20% of standing current

I. Blank; Cottonseed Oil, used to make up FDA Chick Edema Factor standard

Ra 1 = Aldrin retention time

FDA Procedure (Jan. 1970)

5 µL inj.; SE 52, 2 1/2 % on Aeropak 30, 5 ft Column, Electron Capture Detector, Varian Hi Fy, Temp 200°C; 0-100 scale = 20 % of standing current

Ra44 — 61

Ra43 — 60

Ra42 — 59

Ra41 — 58

Ra40 — 57

Ra39 — 56

Ra38 — 55

Ra37 — 54

200°C — 53

Ra36 — 52

Ra35 — 51

Ra34 — 50

200°C — 49

Ra33 — 48

Ra32 — 47

Ra31 — 46

200°C — 45

Ra30 — 44

Ra29 — 43

Ra28 — 42

Ra27 — 41

Ra26 — 40

Ra25 — 39

200°C — 38

Ra24 — 37

Ra23 — 36

Ra22 — 35

Ra21 — 34

Ra20 — 33

200°C — 32

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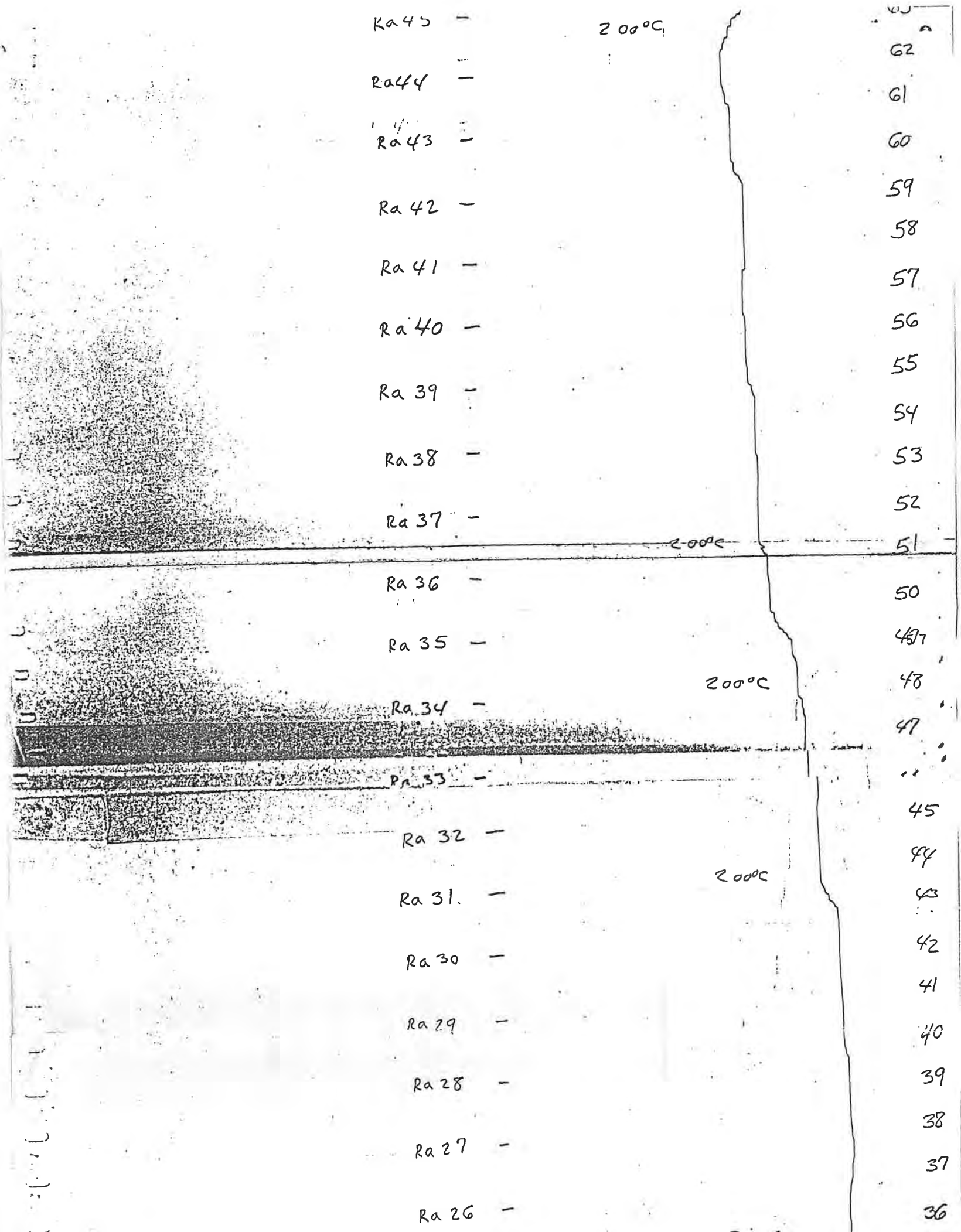
Ra 45
Ra 44
Ra 43
Ra 42
Ra 41
Ra 40
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Ra 32
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Ra 30
Ra 29
Ra 28
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Ra 26
200°C
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JE

RHODIA INC., CHIPMAN DIVISION

INTER-OFFICE CORRESPONDENCE

SUBJECT: ANALYSIS OF POLYCHLORO DIBENZO-P-DIOXIN IN MCPA AND 2,4-D

Toxicology

June 1, 1970

TO: Mr. B. J. Smith
NEW BRUNSWICK

Attached is a letter from Jack Vernetti concerning the analysis of Polychloro Dibenzo-P-Dioxin in MCPA and 2,4-D.

For the MCPA, the case is clear, and we can say that there is no Tetrachlorodibenzo-P-Dioxin in our MCPA.

For the 2,4-D, the results are questionable, and it seems that the method used is not appropriate.

We received an analytical method from Dow which was set up by them for the "determination of 2,3,7,8-Tetrachlorodibenzo-P-Dioxin in 2,4-5-Trichlorophenoxyacetic Acid by Gas-Liquid Chromatography". This method was forwarded to Jack Vernetti and also, a sample of the 2,3,7,8-Tetrachlorodibenzo which, it was requested, is to be used as standard.

As soon as I get an answer to our question, I will let you know.

C. H. Fritsch

CHF/njl

Att. (1)

Rhodia
CHEMICALS FOR AGRICULTURE AND INDUSTRY

RHODIA INC., CHIPMAN DIVISION

INTER-OFFICE CORRESPONDENCE PORTLAND

SUBJECT: ANALYSIS OF POLYCHLORO DIBENZO-P-DIOXIN IN MCPA AND 2,4-D

cc: Mr. R. F. Gitschlag

May 28, 1970

Dr. C. H. Fritsch
New Brunswick

Examination of plant MCPA flakes, composite of late 1969 and early 1970 batches (Color 1 and 2) by the FDA procedure, January, 1970, reveals that the polychloro dibenzo-p-dioxins shown in the FDA reference standard is not present. Specifically, there is no evidence in our work that shows the presence of tetrachloro dibenzo-p-dioxin under the conditions of the FDA procedure used. A CLR will follow.

The work on plant 2,4-D acid composites both before and after plant usage of distilled DCP show the presence of GLC peaks in the area attributed to polychloro dibenzo-p-dioxins. The exact retention times, which do not appear to be consistent between 2,4-D samples, do not generally correspond to the FDA standard. Whether or not these peaks are dioxin type compounds remains questionable. We feel that the procedure as such is not applicable for determination of dioxins in 2,4-D unless appropriate standards are used.

Jack B. Vernetti

Jack B. Vernetti

JBV:dvh

Rhodia
CHEMICALS FOR AGRICULTURE AND INDUSTRY

RHODIA INC., CHIPMAN DIVISION

INTER-OFFICE CORRESPONDENCE PORTLAND

SUBJECT: PROPOSAL AND COSTS OF ANALYTICAL METHODS FOR POLYCHLORO-DIBENZO-P-DIOXIN IN TECHNICAL HERBICIDE ACIDS.

June 12, 1970

cc: Mr. R. F. Gitschlag

Dr. C. H. Fritsch
NEW BRUNSWICK

Introduction

Examination of Chipman 2,4-D acid by the prescribed FDA procedure has revealed the presence of several peaks in the range attributed to CDPD (chlorinated dibenzo-p-dioxins). The peaks do not correspond in general to the standard (also supplied by the FDA). The questions are (1) are these peaks in the 2,4-D acid, CDPD materials or other impurities (2) if CDPD present, which derivatives, and (3) if CDPD present, are they toxic?

Without proper standards, Item (1) above cannot be answered. The preparation of the standards, separation, and identification are very difficult. Once this is done, Items (1) and (2) can then be answered. It then remains for toxicological studies to determine Item (3).

Current Work Plan

To do this work, the present plan will be to prepare the derivatives by reacting the various chlorophenols in caustic medium at high temperatures (200 - 270°C). According to the literature, the resulting reaction masses are dark viscous materials containing small amounts of the desired products (10% yields). Reactions will be run on various combinations of chlorophenols, two at a time, or singly, and the products isolated by recrystallizations. Identification will be by total chloride analysis, infrared spectra and C, H, O analysis or possibly mass spectroscopy. These latter two items will have to be done by commercial laboratories.

If the above work is successful, we will not need any additional equipment. The only cost would be $300 - $500 for C, H, O and mass spectroscopic analysis.

The miscellaneous items (chemicals, glassware, etc.) would probably cost less than $200.00.

Alternative Work Plan

If the above work runs into problems of separation and purification due to very low yields and complex reaction products, then fractionation will have to be done with a g.l.c. preparatory instrument, which would be costly.

Quantitative Analysis

Quantitative analysis of the 2,4-D and 2,4-DB acids for CDPD will be run using a procedure described by Dow Chemical or one of our own. With the standards, the procedures can be checked for efficiency and verified by using different g.l.c. columns.

Costs of Study

The costs of the study as can be seen will vary considerably The attached table lists the possibilities and use of this equipment in other work.

We should be able to determine by June 30 if the current work plan will be sufficient or whether the new g.l.c. approach will be needed.

Jack B. Vernetti

JBV:dvh

Jack B. Vernetti

Attach.

Item	Purpose	Cost	OTHER USES for Purchased Equip.
		CURRENT WORK PLAN	
Outside Lab. Analysis	C, H, O Analysis for verification of standards	$300-500	-
Chemicals Glassware	Preparation Analysis	$200	-
		$500-700	
		ALTERNATIVE WORK PLAN	
New g.l.c.	Fractionation of products and purification	$7,000-7,500	1. Process Work. 2. Impurity Studies. 3. Standard Preparations. 4. Quality Control. 5. Tar Work.
Rotary Evaporator, Septum cap bottles or vials and Misc. glassware.		$ 300-400	1. Process Work. 2. Quality Control.
Chemicals		$ 100	
	TOTAL COST ------	$7,400 - $8,000	

LAB. - [redacted] NEW FILE
DIOXIN -

8

RHODIA INC.
CHIPMAN DIVISION
PORTLAND, OREGON
June 19, 1970

To: Dr. C. H. Fritsch
Mr. R. F. Gitschlag
Mr. R. W. Clarke
Mr. T. B. Henshaw
Laboratory

CLR NO. 165

TITLE: ASSAY OF PLANT MCPA FLAKES FOR POLYCHLORO DIBENZO-P-DIOXINS

INTRODUCTION: Interest in the birth defect factors found in 2,4 5-T by the FDA has led to investigation of other chloro aryloxy alkanoic acid herbicides for similar substances. These toxic materials were identified by the FDA as polychloro-dibenzo-p-dioxins, specifically prominent is 2,3,7,8 tetra-chloro dibenzo-p-dioxin. Although the presence of these materials in MCPA are unlikely, it is of prime importance that we examine our product acid flakes for this possibility.

ABSTRACT: The composite of plant MCPA flake acid was analyzed and compared with an FDA toxic reference standard containing polychloro dibenzo-p-dioxins. The results revealed that the toxic materials in the standard were not present in the plant MCPA.

In particular, there is no evidence for the presence of 2,3,7,8 tetrachloro dibenzo-p-dioxin.

PROCEDURE: For these details, please refer to the procedure entitled, "DETECTION OF CHICK EDEMA FACTOR (POLYCHLORO-DIBENZO-P-DIOXINS) IN FATS, OILS: AND FATTY ACIDS BY ELECTRON CAPTURE GAS CHROMATOGRAPHY" By G. R. Higginbotham, John Ress, and David Firestone (Division of Food Chemistry and Technology, Bureau of Science, Food and Drug Adm., Public Health Service, U.S. Department of H.E.W., January, 1970.

The materials used in the described method are shown below:

RECEIVED
JUN 23 '70

Reference Standard Toxic Fat ----------FDA, Code F-726

Cottonseed Oil ----------MCB, refined

Conc. H_2SO_4 ----------B and A A.R. Grade

CCl_4 ----------MCB Pesticide Grade

Ethyl Ether ----------Malinkrodt, Nanograde quality, redistilled in glass by this lab.

Isooctane	Malinkrodt, Nanograde quality
Petroleum Ether (30-60°)	Malinkrodt, Nanograde quality
Al_2O_3	Fisher, Chromatography grade, A-540
Na_2SO_4	Malinkrodt, A.R. grade, anhydrous
$NaHCO_3$	Malinkrodt, A.R. grade
NaOH	MCB, A.R. grade
Aldrin	Shell, Reference Standards

In assay of the MCPA a preliminary step was found to be necessary. The acid (2.5 grams) was dissolved in 0.6N NaOH (25 mls.) and extracted three times each with 50 cc of petroleum ether. The petroleum ether fractions were combined and then treated as described in the procedure The reason for this step was that the MCPA dissolved slowly in H_2SO_4 forming a dark-colored solution and precipitating tar-like substance indicating some degradation. The NaOH extraction step is not detrimental to the procedure as a similar treatment is used in AOAC method (26.092) for the dioxins.

DATA: Three samples were run as follows:

I. Blank; Cottonseed oil was run through the FDA procedure as described.

II. MCPA Acid; Composite of late 1969 and early 1970 samples. The sample was treated with NaOH as described above and then run through the FDA procedure.

III. Ref. Toxic Standard Fat; The standard (1.5 grams) was dissolved in cottonseed oil (98.5 grams) as described in the FDA technical sheet, code F-726 (also the FDA assay procedure). In addition, the standard (1.5 grams) was dissolved in CCl_4 (98.5 grams). Both standard

solutions were run through the FDA Procedure. The results were the same.

Scans I, II and III are attached to this report. The CCl_4 standard solution is shown, rather than the cottonseed solution because the former was run on the g.l.c. the same day as the MCPA sample.

DISCUSSION: The peaks checked on Scan III, reference standard, are those due to the polychloro dibenzo-p-dioxins and have a Ra value (multiple of Aldrin reference peak retention time) greater than 5. As can be seen, no peaks are seen in Scan I (blank) and Scan II (MCPA flakes) past Ra 5. This shows that the toxic materials described in the FDA procedure are not present.

We are not certain which polychloro dibenzo-p-dioxins are separated by the peaks. Specifically, the tetrachloro derivative cannot be identified by this work. According to the FDA procedure peaks above Ra 5 have been assigned to penta and higher derivatives. The tetra-chloro is given a 3.2 Ra value. As seen on all three scans, a peak corresponding to this Ra value appears but in the same relative peak size. This shows the peak is most likely due to an interfering substance in one of the reagents. If the tetra material were present, and this is the correct Ra value for our g.l.c. column and instrument conditions, then one of the requirements for establishment would be that the peak must be much larger in the standard than in the blank g.l.c. scan.

Although the column used in the g.l.c. for our work was prepared with the same liquid phase (SE 52), and the same amount (2 1/2%), there may be differences in the reported retention times, as we had to use a 1/8" column instead of a 1/4" column as used by the FDA. Also, the solid support we used was similar (acid washed, silanized chromosorb) to that described but consisted of smaller mesh size. This factor could also cause column differences in retention times.

In view of the above, direct comparison of the FDA Ra values with ours is not wholly valid. We need a known polychloro derivative of dibenzo-p-dioxins for

differentiation of the scans.

CONCLUSION: The toxic materials (greater than Ra 5) found in the FDA reference standard are not present in the MCPA composite flakes. Specifically, there is no evidence that tetrachloro dibenzo-p-dioxin is present.

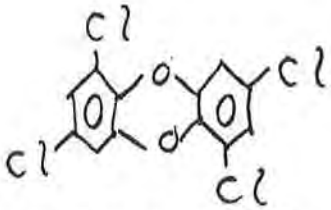
Gary R. Miller
Gary R. Miller

Jack B. Vernetti
Jack Vernetti

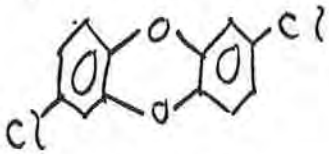
JBV:dvh

LAB / DIOXIN

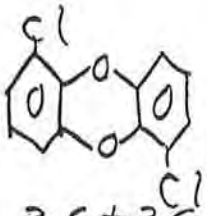
Possible Dibenzo-p-dioxin Compounds from Chlorinated Phenols Derived in 2,4-D Manufacture



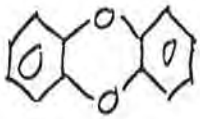
2,4,6 + 2,4,6



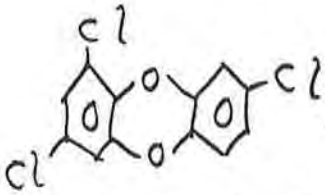
2,4 + 2,4



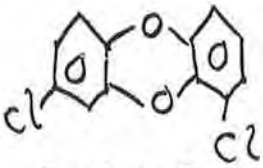
2,6 + 2,6



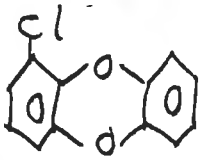
2 + 2



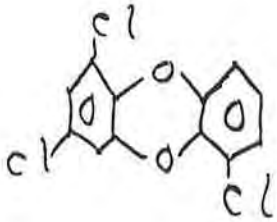
2,4,6 + 2,4



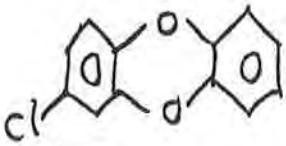
2,4 + 2,6



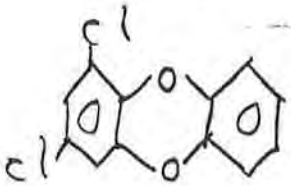
2,6 + 2



2,4,6 + 2,6



2,4 + 2



2,4,6 + 2

Note! No dibenzo-p-dioxins formed from 4-chlorophenol or phenol.

JB

9

August 27, 1970

2,4-D VS DIOXIN CONTAMINANTS

Messrs.

H.D. Crist	- Atlanta	O.G. Otwell	- Pasadena
H.I. Brewer	- Bound Brook	B.W. LeSuer	- Portland
W.L. Jones	- Chicago	C.B. Holm	- St. Paul
I.W. Bales	- Palo Alto	W.R. Hawk	- Palo Alto

These days everyone seems to be talking about the dioxin content in the phenoxy compounds and to help you fend off or field questions concerning this subject, please be advised of the following:

> "The dioxin content of our 2,4-D Parent Acid is less than .2 p.p.m. using ~~USDA~~ AOAC approved detection methods."

From the above, you can readily see that if the parent acid contains less than .2 p.p.m., a finished formulation such as our 2,4-D Low Vol Ester 4L Product #133, which is a 69.6% Iso Octyl Ester of the 2,4-D Parent Acid, then certainly the dioxin content would be far, far less by the percentage of acid involved in the formulation. It is highly doubtful that it could be detected even with our new sophisticated method of analysing for the dioxins.

As far as "Silvex 4L" Product #117 (2,4,5 TP) is concerned, this is a .65% Iso Octyl Ester formulation and we have been advised that the concentrated Tech Ester of 2,4,5 TP showed no dioxin content when using USDA approved methods of detection which is sensitive down to ½ to 1 p.p.m.

We feel sure competition, primarily Dow Chemical, will be making a big issue of guaranteeing or certifying low dioxin content of their products in the ensuing sales period. Therefore, it will be well to be informed on the subject.

L.P. Van Gordon

LVG:mp
CC-Mr. B.J. Smith
Dr. E. Clark
Mr. F. Illnick
Dr. D. Billie

10

Chlorodioxin Contaminants
PR Notice 70-22

November 13, 1970

Messrs.
H. D. Crist - Atlanta Office
H. I. Brewer - Bound Brook Office
W. L. Jones - Chicago Office
O. G. Otwell - Pasadena Office
W. R. Hawk - Fresno Office
I. W. Bales - Fresno Office
B. W. LeSuer - Portland Office
Carl Holm - St. Paul Office

Some of you have already received inquiries from your customers regarding this notice and requesting information as to whether our products contain any chlorodioxin contaminants.

Attached is a statement on the Company's official position regarding this subject. You may make any use you desire of this statement in communicating with your customers personally or putting it out as a general announcement.

E. L. Clark

Attached

cc: Messrs. R. J. Smith
L. T. Hargett
F. J. Hinick
R. Rich
L. P. Van Gordon

Note to Mr. Brewer: Your letter of 11/11/70 to your customers is excellent. I see no need for you to modify it.

ELC

RHODIA INC.
chipman
DIVISION

120 JERSEY AVENUE, NEW BRUNSWICK, NEW JERSEY 08903 • (201) 846-

November 13, 1970

TO OUR CUSTOMERS

Subject: Chlorodioxin Contaminants in Economic Press
Reference USDA PR Notice 70-22

We became concerned with the "dioxin problem" when the presence and toxicity of 2, 3, 7, 8-tetrachlorodibenzo-para-dioxin were first reported to the scientific community over a year ago. Recognizing the problem in connection with 2, 4, 5-T and Silvex and anticipating a possible problem with other phenoxy compounds, we immediately set to work to incorporate the most sensitive analytical methods available into our quality control program for all of our phenoxy products.

Utilizing the methods developed, we have not found any chlorodioxins in our products and thus they conform with PR Notice 70-22.

11

THOMPSON-HAYWARD CHEMICAL COMPANY

8200 SPEAKER ROAD • KANSAS CITY, KANSAS • 913 342-6600 / REPLY TO P. O. BOX 2303 • KANSAS CITY, KANSAS 66110

November 17, 1970

Mr. L. P. Van Gordon
Products Manager
Rhodia Inc.
Chipman Division
120 Jersey Avenue
New Brunswick, New Jersey 08903

Dear Mr. Van Gordon:

In reply to your letter dated November 3, 1970, the U.S. Department of Agriculture has issued PR Notice 70-22, dated September 20, 1970, regarding the presence of chlorodioxin contaminates, such as 2,3,7,8-tetrachloro-dibenzo-para-dioxin, in the basic materials used in formulating 2,4,5-T and SILVEX. This notice establishes that products containing such contaminates will be considered to be in violation of the Federal Insecticide, Fungicide, and Rodenticide Act.

The results of our tests show that our technical isooctyl 2,4,5-T ester and our technical isooctyl SILVEX ester do not contain any detectable chlorodioxins and that these products comply fully with this USDA notice.

Attached are copies of our specification No. PS-1A for our technical isooctyl 2,4,5-T ester and our specification No. PS-21B for our technical isooctyl SILVEX ester for your information.

We appreciate your concern in this matter, and we submit the above statement for your information.

Yours very truly,

THOMPSON-HAYWARD CHEMICAL COMPANY

By: Edwin T. Upton

Edwin T. Upton
Laboratory Administrator

ETU:jd
Attachment
cc: Mr. Frank J. Illnick

THOMPSON-HAYWARD CHEMICAL COMPANY
PRODUCT SPECIFICATION

PRODUCT ISOOCTYL ESTER OF SILVEX SPEC.NO. PS-21B DATE October 28,197
FORMULA NO.

PROPERTY	SPECIFICATION	T-H METHOD
1. Appearance	Free from sediment or tarry substances	A-96
2. Solubility	No sediment in benzene dilution	A-155
3. Sp. Gr. @ 68°F.	1.180 - 1.195	Westphal Balance
4. Free 2,4,5-TP Acid	0.8% Maximum	A-221
5. Free trichlorophenol	2.5% Maximum	A-221
6. Isooctyl ester of SILVEX	97% Minimum	A-224
7. Moisture	0.4% Maximum	A-200
8. Chlorodioxins	Not detected	A-279

Prepared by: E. E. Chalmers

Approved by: E. J. Wain

THOMPSON-HAYWARD CHEMICAL COMPANY

PRODUCT SPECIFICATION

TECHNICAL

PRODUCT ISOOCTYL 2,4,5-T ESTER SPEC.NO. PS-1A DATE October 28, 1

FORMULA NO.

	ROPERTY	SPECIFICATION	T-H METHOD
1.	Appearance	Clear, free from sediment or tarry substances	A-96
2.	Solubility	No sediment in benzene dilution	A-155
3.	Odor	Characteristic	A-97
4.	Sp.Gr. @ 68°F.	1.217 minimum	Westphal Balance
5.	2,4,5-T Isooctyl Ester	97.0% by wt.minimum	A-117
6.	2,4,5-T Acid Eqivalent	67.4% by wt.minimum	A-117
7.	Free 2,4,5-T Acid	0.5% by wt. maximum	A-135
8.	Free 2,4,5-Trichloro-phenol	2.5% by wt. maximum	A-135
9.	Mineral Acid(as H_2SO_4)	0.1% by wt. maximum	A-135
10	Chlorodioxins	Not detected	A-254

Prepared by: E. E. Chalman

Approved by: E. J. Lyst

A1
12

RHODIA INC., CHIPMAN DIVISION

INTER-OFFICE CORRESPONDENCE

SUBJECT: 2,4,5-T ISO OCTYL ESTER TECH.
2,4,5-TP ISO OCTYL ESTER TECH.

CONFIDENTIAL

November 30, 1970

TO ALL DISTRICT SALES MANAGERS:

The attached photostatic information from Thompson-Hayward relative to chlorodioxin contaminates of their technical products, Silvex and 2,4,5-T, assures us of good quality material in keeping with USDA PR Notice 70-22.

This information is classified "confidential".

L.P. Van Gordon

LVG:mp
Attachments 3

CC-Dr. E.L. Clark
Mr. F. Illnick
Dr. C. Fritsch

cc Dr Sue Portaire

THOMPSON-HAYWARD CHEMICAL COMPANY

5200 SPEAKER ROAD • KANSAS CITY, KANSAS • 913 342-6600 / REPLY TO P. O. BOX 2303 • KANSAS CITY, KANSAS 66110

November 17, 1970

Mr. L. P. Van Gordon
Products Manager
Rhodia Inc.
Chipman Division
120 Jersey Avenue
New Brunswick, New Jersey 08903

Dear Mr. Van Gordon:

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The results of our tests show that our technical isooctyl 2,4,5-T ester and our technical isooctyl SILVEX ester do not contain any detectable chlorodioxins and that these products comply fully with this USDA notice.

Attached are copies of our specification No. PS-1A for our technical isooctyl 2,4,5-T ester and our specification No. PS-21B for our technical isooctyl SILVEX ester for your information.

We appreciate your concern in this matter, and we submit the above statement for your information.

Yours very truly,

THOMPSON-HAYWARD CHEMICAL COMPANY

By: Edwin T. Upton

Edwin T. Upton
Laboratory Administrator

ETU:jd
Attachment
cc: Mr. Frank J. Illnick

NOV

L. P. VAN GORDON

THOMPSON-HAYWARD CHEMICAL COMPANY

PRODUCT SPECIFICATION

PRODUCT ISOOCTYL ESTER OF SILVEX SPEC. NO. PS-21B DATE October 28, 19

FORMULA NO.

PROPERTY	SPECIFICATION	T-H METHOD
1. Appearance	Free from sediment or tarry substances	A-96
2. Solubility	No sediment in benzene dilution	A-155
3. Sp. Gr. @ 68°F.	1.180 - 1.195	Westphal Balance
4. Free 2,4,5-TP Acid	0.8% Maximum	A-221
5. Free trichlorophenol	2.5% Maximum	A-221
6. Isooctyl ester of SILVEX	97% Minimum	A-224
7. Moisture	0.4% Maximum	A-200
8. Chlorodioxins	Not detected	A-279

Prepared by: E. E. Chadman

Approved by: E. J. Wystrom

THOMPSON-HAYWARD CHEMICAL COMPANY

TECHNICAL PRODUCT SPECIFICATION

PRODUCT ISOOCTYL 2,4,5-T ESTER SPEC.NO. PS-1A DATE October 28, 1976

FORMULA NO.

PROPERTY	SPECIFICATION	T-H METHOD
1. Appearance	Clear, free from sediment or tarry substances	A-96
2. Solubility	No sediment in benzene dilution	A-155
3. Odor	Characteristic	A-97
4. Sp.Gr. @ 68°F.	1.217 minimum	Westphal Balance
5. 2,4,5-T Isooctyl Ester	97.0% by wt.minimum	A-117
6. 2,4,5-T Acid Eqivalent	67.4% by wt.minimum	A-117
7. Free 2,4,5-T Acid	0.5% by wt. maximum	A-135
8. Free 2,4,5-Trichloro-phenol	2.5% by wt. maximum	A-135
9. Mineral Acid(as H_2SO_4)	0.1% by wt. maximum	A-135
10. Chlorodioxins	Not detected	A-254

epared by: E. E. Chapman

Approved by: E. J. Upson

ack
B

RHODIA INC., CHIPMAN DIVISION

INTER-OFFICE CORRESPONDENCE PORTLAND

SUBJECT: WASHINGTON D.C. ACS MEETING REPORT

October 20, 1971

cc: Mr. R. F. Gitschlag ✓
Mr. R. W. Clarke

Mr. L. M. Minsuk

Attached is the report of the sessions I attended at the Washington D.C. ACS Meeting concerning the chloro dibenzo-p-dioxins.

Also attached is a paper given at the exposition center in which some interesting work with herbicide polymers (including 2,4-D) was presented. I included this in case Dr. Hargett's group might be interested. The color slides of treated, vs. untreated corn plots looked very good.

J B Vernetti
J. Vernetti (by ch.)

JBV:dvh
Attach.

Rhodia
CHEMICALS FOR AGRICULTURE AND INDUSTRY

SUMMARY OF PAPERS ON THE CHLORO DIBENZO-P-DIOXINS
AT THE ACS WASHINGTON D.C. MEETING, SEPTEMBER, 1971

Preparation of CDPD's (Chloro Dibenzo-p-Dioxins)

Most preparations reported (77, 78, 79) were by methods similar to our own procedure for 2,7-di-CDPD and the unchlorinated species DPD . This is the pyrolysis type reaction of potassium or sodium salt of chlorophenols in the presence of copper at temperatures of 250-300°C (83). The yields are poor, in the order of 10-20%. Purification of the product was by sublimation or recrystallization from anisole. 2,3,7,8-TCDPD was prepared by chlorination of DPD or 2,7-diCDPD to the tetra state. The symetrical product 2,3,7,8-TCPD was the largest fraction and the only tetra isomer formed. The product had to be separated from the tri and penta CDPD. Another method used for preparation of specially-substituted CDPD's was the use of bromo nitrophenols to form the dibenzo-p-dioxin structure, and subsequent reduction of the nitro groups, diazotization, and replacement with chlorine via the Sandmeyer reaction. Reactions with catechols was another method discussed. Radioactive C^{14} labelled CDPD's were prepared by using uniformly labelled DCP and chlorination of the pyrolys product to 2,3,7,8-TCDPD (78). Tritium labelled compounds were prepared by the reduction reaction between tritium and chlorine of 1,6-diCDPD using a palladium/carbon catalyst. The resulting tritium labelled DPD can then be chlorinated to the desired product (79).

Properties of the CDPD's

As a class, the dioxins appear very stable to heat, for example, 2,3,7,8-TCDPD is stable at 700°C but decomposes at 800°C (92).

The CDPD's are sensitive to u.v. light, 2,3,7,8-TCDPD decomposes completely in solution after irradiation for 16 hours. 6-hour irradiation of methanol solutions containing a few ppm each of octa, 2,3,7,8-T and 2,7-di CDPD resulted in a 10%, 50%, and 70% disappearance of the compounds respectively (85). The products formed in the case of octa and tetra CDPD were lower chlorinated dioxins showing that the photolytic reaction was replacement of chlorine by hydrogen. It was theorized that in water the replacement reaction may be hydroxyl, rather than hydrogen. 2,7-diCDPD and 2,3,7,8-TCDPD were also found by other workers (92) to rapidly degrade upon irradiation with artificial sunlight.

Photolysis of dioxins on adsorbed surfaces (Hagerstown soil, dry or wet) did not occur (85). Studies with chlorodioxins adsorbed on leaf surfaces show that upon irradiation 2,3,7,8-TCDPD is somewhat degraded, but the effect on 2,7-diCDPD is not known, due to a volatility problem that arose (90). One factor in the difference between soils and leaf surfaces as a mediae for photodecomposition is that the waxy articles of the leaf surface contains hydrogen donors necessary for the reaction, whereas the soils are limited in this re:

Soil behavior studies of the CDPD's revealed that the materials are relatively immobile and persistent (90). Investigations using

Lakeland sandy and Hagerstown silty clay soils with 2,3,7,8-TCDPD in concentrations of 1-18 ppm showed that after 350 days, 73% of the compound was recovered from the Lakeland soil and 52% was recovered from the Hagerstown soil. One field soil test (91) was made on Lakeland soil that had been treated with 2,4,5-T acid between 1963-1969 with a total of 912 lbs/acre. No 2,3,7,8-TCDPD could be found to a depth of 3 feet. Sensitivity of the test was 5 ppb. The question of biological synthesis of the CDPD's from herbicides or chlorophenols was investigated (90). None was found in the study and the statement issued that this problem seemed very remote.

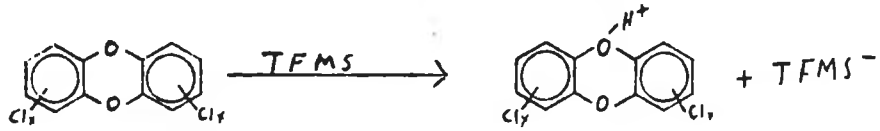
Analysis for the CDPD's

Development of a bioassay method using chick embryos increased the sensitivity 100 fold over the previous chick heart method. GLC methods proved to be even more sensitive. Combination with mass spectrometry increased the reliability of the analysis (80).

Extraction and clean-up methods described were the general FDA procedure with variations to suit specific problems. Briefly the basic procedure is to dissolve the sample in concentrated H_2SO_4 after pretreatment and extract the CDPD with pet ether, elute the material through an activated alumina column followed by another H_2SO_4 - pet ether treatment. Analysis by GLC combined with mass spectrometry was used as the detection system. One paper (81) used an ion exchange column (Dowex) which allowed neutral compounds, including CDPD, to elute retaining phenolic material. This was followed by liquid-liquid chromatography and GLC-MS analysis. Highly sensitive analysis was accomplished by use of GLC and MS with computer analysis (89). This was done by injecting several samples (after clean-up) and summing up the scans by a computer system to increase peak sensitivity several fold. The analysis was sensitive to one picogram (10^{-12}g) and was also able to distinguish between CDPD and interfering substances.

One paper used the decomposition of CDPD by u.v. light for confirmation.(91). After the sample was run, the sample was irradiated for 16 hours. The sample was then rescanned, and if the dioxin peak disappeared, this was regarded as confirmation. Interfering substances did not decompose.

Chlorodioxins were found to produce a blue color in conc. H_2SO_4 with an oxidizing agetn or in Trifluoro methyl sulfonic acid (84). The reaction causes a cation to form as below



The application to analytical work has not been fully investigated as yet.

Toxicity of the CDPD's

Rather than describe the papers, the data is presented in the following table. Source of the data from the abstracts is given in the last column.

Test Animal	CDPD	Dosage	LD 50	Fetal Effects	Abstract Source
Rats, Female	2,3,7,8-T	Single oral	44.7ug/Kg	-	86
Rats, Male	2,3,7,8-T	Single oral	22.5ug/Kg	-	86
Guinea Pigs	2,3,7,8-T	Single oral	0.72ug/Kg	-	86
Rabbits	2,3,7,8-T	Single oral	30 ug/Kg	-	86
Dogs	2,3,7,8-T	Single oral	30-300ug/Kg	-	86
Rats, Female	2,3,7,8-T	0.1ug/Kg/day	-	detrimental	86
Wistar Rats	2,3,7,8-T	0.125ug/Kg/day	-	no effects	87
Wistar Rats	2,3,7,8-T	1 ug/Kg/day	-	Significant reduction in fetal size	87
Wistar Rats	2,3,7,8-T	4 ug/Kg/day	-	All embryo dead	87
Hampsters	2,3,7,8-T	Single 30ug/Kg	73% Mortality	47% Teratogenic effects	*
Rats	2,7-di	Single	2g/Kg No effect	-	86
Rats	2,7-di	Single	-	No effect	86
Wistar Rats	2,7-di	Single 2mg/Kg	Heart Lesions found		87
Hampsters	2,7-di	-	No effect	No effect	*
Hampsters	1,2,4-Tri	Single 1450ug/Kg	-	Very slight	*
Hampsters	Hexa	Single 250ug/Kg	40% Mortality	5% Teratogenic	*
Hampsters	Hexa	Single 625ug/Kg	72% Mortality	22% Teratogenic	*

*Extra paper given by Dr Collins of the FDA.

In his paper (86) Dr. Rowe emphasized the point that the deaths were quite delayed, as long as 6-7 weeks.

Dr. Collins (paper not in the program, given as an extra feature) rated the chloro dioxins with regard to mortality and teratogenic effects as follows:

2,3,7,8-TCDPD > Hexa CDPD >> Octa CDPD > 1,2,4-Tri CDPD > 2,7-diCDPD.

He considered the 1,2,4-Tri CDPD and 2,7-Di CDPD as rather innocuous.

Regarding the heart lesions caused by 2,7-diCDPD(87), there was some concern by the Dow people (Dr. Blair) and Dr. Kearney of the Department of Agriculture. There was a press conference at the ACS building regarding this along with other information in the papers presented.

Questions arose during discussions as to the degree of sensitivity that samples representing environmental problems would require Mr. Baughman of Harvard felt that 1 ppb should be required whereas others felt that higher levels ~ 10 ppb would be adequate; the latter in view of adsorption effects. It was generally accepted that the minimum levels of 2,3,7,8-CDPD that would cause death in animals and birds is below many assay methods (non-isotope) currently used.

Miscellaneous

Impurities found in chlorinated phenols other than CDPD were chlorophenoxy phenols and furans. The latter structures are of the form:

I talked briefly with Dr. Blair about 2,7-diCDPd presence in 2,4-D acid. He said that none had been found. This is similar to our findings with Rhodia 2,4-D acid.

One incident occurred during the talks relating to pyrolysis of 2,4,5-T acid. During a discussion period in the first session Roger Baughman (Chem.Department, Harvard) described a paper (French) indicating that 2,4,5-T acid heated to 500°C can form 2,3,7,8-TCDPD in yields of 20%. The inference being that the burning of brush that has been sprayed could form the toxicant in dangerous quantities The next session was one in which Dow Personnel (after reading the paper) criticised the work as being poorly done, non-duplicated, biased, and untrue inasmuch as similar experiments of their own did not show this result.

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Comments from the

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phate derivatives in a variety of gas chromatographic column situations will be presented. The rationale used in the selection of the specific derivative and conditions will be discussed. Data illustrating the application of the new method to a human monitoring program will be provided.

76. GC/MS TECHNIQUES TO IDENTIFY INTERFERENCES IN PESTICIDE ANALYSIS by Ernest J. Bonelli, Finnigan Corporation, 595 North Pastoria Avenue, Sunnyvale, California 94086.

Recently, compounds which are structurally similar to chlorinated hydrocarbon pesticides have interfered with the electron capture gas chromatographic analysis of these pesticides. In many cases this has led to misinterpretation of the compounds present. Some workers have attempted to separate polychlorinated biphenyls (PCB's) and chlorinated naphthalenes by column chromatography prior to gas chromatographic analysis. This paper describes a method for the identification and quantitation of pesticides in the presence of interferences. Mass spectra of leading and trailing edges of GC peaks identified the various interferences. Quantitation can be achieved by monitoring mass peaks of interest and comparing to standards. In peak monitoring the mass spectrometer is used as a highly specific gas chromatographic detector.

THURSDAY AFTERNOON - SECTION B - SYMPOSIUM ON THE ORIGIN AND FATE OF THE CHLORODIOXINS - SESSION I. CHEMISTRY OF THE CHLORODIOXINS - E. H. Blair, Presiding

77. THE PREPARATION AND CHARACTERIZATION OF CHLORINATED DIBENZO-p-DIOXINS. A. E. Pohland, G. C. Yang and E. A. Hansen, Division of Chemistry and Physics, Food and Drug Administration, Department of Health, Education and Welfare, Washington, D. C. 20204.

A series of twelve chlorinated dibenzo-p-dioxins containing from one to eight chlorine atoms has been prepared for use as standards in the development of analytical methodology for the chlorinated dibenzo-p-dioxins and for use in toxicological studies. The various synthetic pathways to these materials will be reviewed and discussed from the standpoint of yield, convenience and purity of product. During the course of these studies the chemical and physical properties of the various chlorinated dibenzo-p-dioxins, including their stability, their color reactions and their infrared, ultraviolet, nuclear magnetic resonance and phosphorescence spectra, were investigated. It was noted that the wavelength associated with the observed phosphorescence and the triplet state lifetime were dependent upon the number of chlorine atoms and their positions on the dibenzo-p-dioxin nucleus. The use of such information for confirmation of the presence of chlorinated dibenzo-p-dioxins detected by available analytical methods will be discussed.

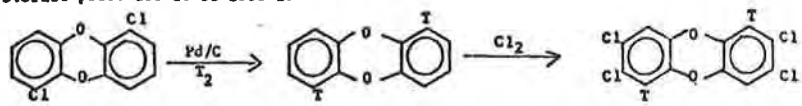
78. THE PREPARATION OF UNIFORMLY LABELED ^{14}C 2,7-DICHLORODIBENZO-p-DIOXIN AND 2,3,7,8-TETRACHLORODIBENZO-p-DIOXIN. Wesley W. Muelder Lewis Shadoff, Chemical Physics Research, The Dow Chemical Company, Midland, Michigan 48640.

2,7-Dichlorodibenzo-p-dioxin was prepared from isotopic potassium 2,4-dichlorophenate uniformly labeled with ^{14}C. "Ullman" conditions as reported by Brewster and Groening (Org. Syn. Coll. Vol. II, 445, 1943) gave a 20.5% yield. Small amounts of dichlorophenoxy chlorophenol were removed from the product by extraction with sodium hydroxide before purification by fractional sublimation and recrystallization from anisole. Chlorination of 2,7-dichlorodibenzo-p-dioxin in chloroform solution containing trace amounts of $FeCl_3$ and I_2 yielded a mixture of tri-, tetra- and penta-chlorosubstitution products. Purification by digestion in boiling chloroform, fractional sublimation, and recrystallization from anisole was effective in refining this product to 92% 2,3,7,8-tetrachloro isomer, which also contained 7% of the tri- and 1% of the penta-substituted dibenzo-p-dioxin. Mass spectroscopy was used exclusively to monitor the quality of the products during the synthesis.

79. PREPARATION OF TRITIUM-LABELED 2,3,7,8-TETRACHLORODIBENZO-p-DIOXIN (TCDD) AND STRUCTURE-ACTIVITY INVESTIGATIONS OF TCDD AND OTHER RELATED DIBENZO-p-DIOXINS. J. Howard Vinopal, I. Yamamoto, and John E. Casida, Division of Entomology, University of California, Berkeley, California 94720.

Work is underway on the synthesis of tritium-labeled 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). Several different approaches for the possible incorporation of tritium into TCDD are being investigated, including the tritiation of 2,4-dichlorophenol or 2,4,5-trichlorophenol, the lithium-metalation and subsequent aqueous hydrolysis of a

suitable chlorinated dibenzo-p-dioxin, and the catalytic reduction of a suitable chlorinated dibenzo-p-dioxin. The latter approach is the most promising. The proposed overall procedure to be used is as follows:



Various analogs of TCDD are being synthesized and characterized using GLC and TLC methods. The toxicity of these compounds are being determined, using mice and insects, including the house fly.

80. DETERMINATION OF POLYCHLORODIBENZO-p-DIOXINS (DIOXINS) IN CHLOROPHENOLS AND LIPIDS. David Firestone, Division of Chemistry and Physics, Food and Drug Administration, Department of Health, Education and Welfare, 200 "C" Street, S.W., Washington, D.C. 20204.

The current status of chemical and biological methods for determination of dioxins in chlorophenols and lipid materials is reported and discussed. Results of a study of four procedures for dioxins in chlorophenols are presented. Detection of dioxins and related compounds in commercial chlorophenols is discussed and the use of combined gas chromatography-mass spectrometry for confirmation is described. With adequate sample cleanup, the use of high resolution mass spectrometry may offer a sensitive technique for detection of specific dioxins.

81. DETERMINATION OF NON-PHENOLIC IMPURITIES IN CHLORINATED PHENOLS AND RELATED COMPOUNDS. R. H. Stehl, E. Wilke, R. R. Papenfuss, R. Matalon, Analytical Laboratories, The Dow Chemical Company, Midland, Michigan 48640.

The determination of neutral impurities in chlorinated phenols and related compounds is subject to considerable uncertainty because of the wide variety of chemically or structurally similar compounds which can be present. Various analytical methods will be discussed which have been employed for the determination of chlorinated dibenzo-p-dioxins. Both the development of maximum separation methods as well as the employment of maximum specificity in detection will be described. Maximum separation has been achieved by the combination of ion-exchange chromatography for removal of the matrix, liquid-liquid chromatography for separation of the various neutral components followed by gas chromatographic examination of the separated components using electron capture detection. Details and results of various species will be reported with recovery and detection limit data for the individual steps. The use of maximum specificity has been obtained by the use of GC-MS. This has resulted in 50 ppb detection of various species with virtual elimination of chromatographic interferences. Details of the identification and quantitation of components will be reported.

82. X-RAY DIFFRACTION STUDIES OF CHLORINATED DIBENZO-p-DIOXINS. F. P. Boer, M. A. Neuman, F. P. vanRemoortere, P. P. North, H. W. Rinn, Chemical Physics Research, The Dow Chemical Company, Midland, Michigan 48640.

The crystal structures of 4 chlorinated derivatives of dibenzo-p-dioxin have been determined by X-ray diffraction from diffractometer data (MoKα radiation). The compounds, their formulae, cell dimensions, space groups, the number of molecules per unit cell, the crystallographic R-factors, and the number of observed reflections are:

Compound	2,7-Dichloro	2,8-Dichloro	2,3,7,8-Tetrachloro	Octachloro
Formula	$C_{12}H_6O_2Cl_2$	$C_{12}H_6O_2Cl_2$	$C_{12}H_4O_2Cl_4$	$C_{12}O_2Cl_8$
a	3.878Å	5.983Å	3.783Å	12.009Å
b	6.755Å	7.114Å	9.975Å	3.828Å
c	10.265Å	24.637Å	15.639Å	16.297Å
α	99.46°	90.00°	94.14°	90.00°
β	100.63°	90.00°	95.20°	101.14°
γ	99.73°	90.00°	92.77°	90.00°
Space Group	$P\bar{1}$	Pnam	$P\bar{1}$	$P2_1/c$
Z	1	4	2	2
R	5.7%	6.4%	3.6%	5.8%
NR	1030	293	2381	1549

The dioxin crystal structures were performed to provide absolute standards for assignment of isomeric structures and have been of considerable practical use in combination with X-ray powder diffraction analysis.

83. THERMAL CHEMISTRY OF CHLORINATED PHENOLS. H. G. Langer, T. P. Brady, L. A. Dalton, T. W. Shannon, P. R. Briggs, The Dow Chemical Company, Eastern Research Laboratory, Box 400, Wayland, Massachusetts 01778.

The thermal properties of several chlorinated phenols and derivatives were studied by differential thermal analysis, mass spectrometry and also in bulk reactions. Special emphasis was placed on conditions which might facilitate the formation of stable dioxins. In summary, it was found that no two of the chlorinated phenols behaved alike. For a given compound the decomposition temperature and rate as well as the product distribution varied considerably with reaction conditions. The phenols themselves seem to pyrolyze under equilibrium conditions slowly at temperatures above about 250°. For their alkali salts the onset of decomposition is sharp and around 350°. The reaction itself is exothermic. At the decomposition temperature the following conditions are favorable for dioxin formation:

High concentration of the phenol
High degree of chlorination of the phenol
Presence of base.

Preliminary results indicate that heavy-metal ions such as cupric ion may decrease the decomposition temperature.

84. CATION RADICALS FROM CHLORINATED DIBENZO-p-DIOXINS. G. C. Yang and A. E. Pohland, Division of Chemistry and Physics, Food and Drug Administration, Department of Health, Education and Welfare, Washington, D. C. 20204.

Previous studies have indicated that dibenzo-p-dioxin and some of its derivatives form cation radicals in the presence of various oxidizing agents when dissolved in concentrated H_2SO_4. Using a series of chlorinated dibenzo-p-dioxins containing from one to eight chlorine atoms, we have found that the characteristic blue color and ESR spectra of these cation radicals could be obtained readily by dissolution in CF_3SO_3H. An oxidizing agent was needed only for the generation of the cation radical of the octachloro isomer. The lifetime of the cation radical was found to increase several orders of magnitude when oxygen was eliminated from the sample tube. The g-factor for dibenzo-p-dioxin itself was found to be 2.0038; the linewidths were sufficiently small (~ 90 mG) so that the C^{13} hyperfine couplings were easily resolved. The optical absorption band was found at 672 mμ. The mono- and dichloro-dibenzo-p-dioxins showed well resolved ESR hyperfine lines; the tetrachloro analogs, on the other hand, exhibited single broad ESR lines. Detailed data on the visible and ESR spectra of the cation radicals generated from chlorinated dibenzo-p-dioxins will be discussed.

85. PHOTOCHEMISTRY OF DIBENZO-p-DIOXINS. J. R. Plimmer, D. G. Crosby*, A. S. Wong* and Ute I. Klingebiel. PSR, ARS, U.S. Department of Agriculture, Beltsville, Md. 20705. *Department of Environmental Toxicology, University of Calif., Davis, Calif. 95616.

The dibenzo-p-dioxins can be synthesized by ring closure of o-chlorophenols. Photochemical reaction of o-chlorophenols gives measurable yields of dioxin only in the case of pentachlorophenol. A number of lesser chlorinated phenols give diphenyl ethers or biphenyls by irradiation. Dibenzo-p-dioxins are decomposed in solution by light of wavelengths ~ 300 nm or by sunlight. In methanol, chlorine substituents on the aromatic ring are replaced by hydrogen. Ultimately the heterocyclic ring is disrupted. It is proposed that replacement of chlorine by hydroxyl will take place on irradiation in water. The effect of chlorine substitution on the dioxin ring is to shift the absorption maxima to longer wavelengths. Adsorption of a dioxin on soil reduces its rate of photodecomposition. Examination of the spectrum of dibenzo-p-dioxin adsorbed on silica indicates that it does not interact strongly with the adsorbent. Unsubstituted dibenzo-p-dioxin is decomposed in cyclohexane by light of ~ 310 nm. A precipitate of polymeric material is rapidly formed. Ring-opened products, including phenoxyphenol, are present in solution and may be intermediates in a condensation reaction. The relative rates of dechlorination and ring-opening will be important in determining the ultimate nature of the photodegradation products of chlorinated dioxins.

FRIDAY MORNING - SYMPOSIUM ON THE ORIGIN AND FATE OF THE CHLORODIOXINS - (Concluded) - SESSION II. TOXICOLOGY AND ENVIRONMENTAL ASPECTS OF THE CHLORODIOXINS - A. D. Campbell, Presiding

86. TOXICOLOGY OF CHLORINATED DIBENZO-P-DIOXINS. V. K. Rowe, J. M. Norris, G. L. Sparschu, B. A. Schwetz and P. J. Gehring. Chemical Biology Research, 1803 Building, The Dow Chemical Co., Midland, MI 48640.

Specific chlorinated dibenzo-p-dioxins (CDPD's) may be formed in the production of certain of the chlorinated phenols. In order to assess the hazard incurred in the manufacture, handling and use of these products, it is essential to determine the toxicity of particular CDPD's.

2,3,7,8-Tetrachlorodibenzo-p-dioxin(TCDPD) is the most potent CDPD studied. The single oral LD 50 values for TCDPD in various species is as follows: female rats, 44.7; male rats, 22.5; male guinea pigs, 0.72; rabbits, <30; dogs between 30 and 300 µg/kg. Delayed death, sometimes as long as 40 days following treatment is characteristic of intoxication. Daily doses of approximately 0.1 µg/kg/day TCDPD are detrimental to the development of rat fetuses. TCDPD is a potent chloracnogen to rabbits. Other CDPD's that have been studied include 2,7-dichlorodibenzo-p-dioxin (DCDPD), hexachlorodibenzo-p-dioxin (HCDPD) and octachlorodibenzo-p-dioxin (OCDPD). The largest single oral doses fed, 2.0 g/kg of DCDPD and 4.0 g/kg OCDPD were not lethal to rats. HCDPD is less toxic than TCDPD. HCDPD produces chloracne in rabbits. DCDPD and OCDPD do not. DCDPD and OCDPD have little, if any, fetotoxicity whereas HCDPD causes fetotoxic effects at doses of 1 and 10 µg/kg and causes teratogenic effects at doses of 100 µg/kg.

87. PERINATAL EFFECTS OF DIBENZODIOXINS IN WISTAR RATS. K. S. Khera, J. A. [illegible]ick, Pharmacology Division, Research Laboratories, Food & Drug Directorate, Ottawa, Ontario, Canada.

2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDB) suspended in anisole-corn oil (1.5:100) mixture was administered orally in daily doses ranging from 16 - 0.125 ug/kg from 6 through 15 days of gestation. Post-mortem examination at term showed resorptions and no live embryos in dams at dose levels of 16, 8 and 4 ug/kg. Dams treated with 2 ug/kg showed significant depression in viable litter size and a high incidence of resorptions. Gravidas from 1 ug/kg dose-level had fetuses of reduced body weight as compared to the controls. Histology of fetuses obtained from dams treated with 2, 1, 0.5 and 0.25 ug/kg revealed hemorrhages in brain and intestine and edema of subcutaneous tissues. No fetopathic effects were noticed at the 0.125 ug/kg level. The incidence of skeletal anomalies in viable embryos at all doses was comparable to that in controls. The viability and rate of body weight gain observed until weaning were adversely affected in the offspring of mothers treated with 1 and 0.5 ug/kg. The effects appeared to be due to a prenatal fetotoxic effect. A preliminary distribution study with ^{14}C TCDB, in females revealed higher levels of label in liver and body fat, than in blood, brain, muscle, kidney and duodenum. Similar studies with 1,2,3,4-tetrachlorodibenzo-p-dioxin and 2,7-dichlorodibenzo-p-dioxin will be presented.

88. THE EXCRETION AND TISSUE DISTRIBUTION OF 2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN IN THE RAT. W. N. Piper and J. Q. Rose, The Chemical Biology Research Laboratory, The Dow Chemical Company, Midland, Michigan 48640.

2,3,7,8-Tetrachlorodibenzo-p-dioxin ^{14}C (3 µc/mg) was administered in a single oral dose, 50 µg/kg, to male rats to study excretion rate and tissue distribution. Urine, feces and expired air were collected over 24-hour intervals. Groups of three animals were sacrificed at 3, 7, and 21 days after dosing, and the tissues collected for ^{14}C analysis. Urine, feces and tissues were combusted and $^{14}CO_2$ collected and counted for radioactivity. Respiratory CO_2 was trapped in ethanolamine and counted directly for radioactivity. The results indicate that the major excretion route for radioactivity was feces. After 21 days, the mean amount recovered in the feces of 3 rats was 53.4%, the urine 13.4% and expired air 3.2%. The liver content of radioactivity declined from 45% (4.5%/g) at 7 days to 11% (1.3%/g) by 21 days. Fat declined from 3.2%/g at 7 days to 0.43%/g by 21 days, and testes from 1.4% (0.36%/g) at 7

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89. AN IMPROVED ANALYSIS FOR 2,3,7,8-TETRACHLORODIBENZO-p-DIOXIN (TCDBD). Robert W. Baughman, Department of Chemistry, Harvard University, Cambridge, Ma 02138 and Matthew Meselson, Depart of Biochemistry and Molecular Biology, Harvard University, Cambridge, Ma 02138.

Due to the extraordinarily high toxicity of TCDBD, (for example, the single oral dose LD_{50} in guinea pigs is 0.6 mg/kg,) current analytical methods are of limited use in detecting potentially hazardous levels of this compound. We will describe the results of our efforts to devise a procedure for analysis of TCDBD with sufficiently increased sensitivity to be useful in a monitoring program for man and the environment. Modifications in extraction concentration, and detection were investigated. As in the past, gas chromatography was found to be important. Mass spectroscopy was also found to be a particularly useful tool. The resulting technique may offer substantial improvement over existing methods of analysis. Advantages and limitations of the procedure will be discussed.

90. ENVIRONMENTAL SIGNIFICANCE OF CHLORODIOXINS. P. C. Kearney, A. Isensee, C. S. Helling, E. A. Woolson and J. R. Plimmer, PSR, ARS, Department of Agriculture, Beltsville, Maryland 20705.

An environmental protocol has been developed to assess the significance of newly discovered hazardous substances that might enter soil, water and the food chain. Based on a series of established laboratory procedures and the use of ^{14}C-labeled 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), gas chromatography and mass spectrometry, it was possible to determine (a) the mobility of TCDD by soil TLC in five soils; (b) the rate and amount of plant uptake in oats and soybeans; (c) the rate of photodecomposition and the nature of the products; (d) the persistence in two soils at 1, 10, and 100 ppm; and (e) the rate of metabolism in soils and by soil microorganisms. The study revealed that TCDD is immobile in soils, not readily taken up by plants, subject to photodecomposition, persistent in soils, and slowly degraded in soils to polar metabolites. Subsequent studies revealed that the environmental contamination by TCDD is extremely small and not detectable in biological samples. The sequence of experiments, however, served as a useful model for designing research programs to determine the significance of future environmental contaminants.

91. DIOXIN RESIDUES IN LAKELAND SAND AND EAGLE SAMPLES. E. A. Woolson, ARS, USDA, Beltsville, Md. 20705. W. L. Reichel, Bureau of Sport Fisheries and Wildlife, Patuxent Wildlife Research Center, Laurel, Md. 20810. A. L. Young, Air Force Armament Laboratory, Eglin Air Force Base, Fla. 32542.

2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD) is a possible contaminant of 2,4,5-trichlorophenoxyacetic acid (2,4,5-T). Higher chlorinated dioxins are possible contaminants of pentachlorophenol. In order to assess the ecological importance of chlorinated dioxins in the environment, samples of eagle tissue were examined by electron-capture gas chromatography for the presence of dioxins. No dioxins were found at a minimum detection limit of 50 ppb. Eagle samples, representative of various geographic regions in the U.S., were included in the analysis. Soil samples from Lakeland sand in Florida were analyzed for TCDD after application of up to a total of 912 lb 2,4,5-T/acre. Applications were made between 1962 and 1969. No TCDD could be detected at a minimum detection limit of 5 ppb in core samples to a depth of 3 feet. Small amounts (≤20 ppb) of 2,4,5-T were found at all depths.

92. THE STABILITY OF PENTACHLOROPHENOL AND CHLORINATED DIOXINS TO SUNLIGHT, HEAT, AND COMBUSTION. R. H. Stehl, R. R. Papenfuss, R. A. Bredeweg and R. W. Roberts, The Dow Chemical Company, Analytical Laboratories, 574 Building, Midland, Michigan 48640.

Pentachlorophenol in field-use conditions is subjected to various environmental factors leading to degradation of the compound. Theoretically, this degradation could result in the possible formation of chlorinated dibenzo-p-dioxins. Analysis

of the combustion products of wood and paper treated with pentachlorophenol indicate no increase, and possibly a decrease in octachlorodibenzo-p-dioxin concentration, while paper treated with sodium pentachlorophenate shows a slight increase in octachlorodibenzo-p-dioxin concentration following combustion. Photolysis of sodium pentachlorophenate under different sources of artificial sunlight as well as natural daylight resulted in severe degradation of the pentachlorophenate with only trace amounts of octachlorodibenzo-p-dioxin being formed. Both 2,7-dichloro- and 2,3,7,8-tetrachlorodibenzo-p-dioxins are subject to rapid photolytic decomposition under artificial sunlight, while octachlorodibenzo-p-dioxin exhibits considerably more stability. 2,3,7,8-Tetrachlorodibenzo-p-dioxin is somewhat stable at temperatures up to 700°C, while decomposition is complete at 800°C.

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Water-Degradable Polymers for Controlled Release of Herbicides and Other Agents

M. L. Beasley and R. L. Collins

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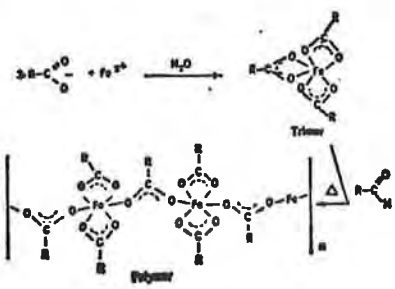
Water-Degradable Polymers for Controlled Release of Herbicides and Other Agents

Abstract. *A new class of polymeric substances that degrade in the presence of water are formed by the reaction of carboxylic acids with metal ions in the presence of an aldehyde catalyst. Possible uses may be found in agricultural chemicals, packaging, and medicine. Important antipollution aspects are present in many of these applications.*

We have found that water-degradable polymers can be formed by the addition of a carboxylic acid and a metal ion in the presence of an aldehyde catalyst. On exposure to water, these polymers depolymerize more or less slowly to release the original carboxylic acid and the hydrous metal oxide gel. The substance whose controlled release is sought may itself be a carboxylic acid, as in the herbicide 2,4-D (*1*), or the substance may be dissolved in a water-degradable polymer formed with any convenient carboxylic acid plus metal. In either case, the desired substance is released on contact with water at a controlled rate which can be varied from days to years.

Water-degradable polymers may have been prepared previously but without an appreciation for the water-degradability. In 1904, for example, Joannis (*2*) prepared a copper benzoate "salt" which did not crystallize well. Purposeful attempts to form polymers incorporating metals have not been very successful. Pitts and Hurley (*3*) have sought unsuccessfully to polymerize bidentate and other ligands with aluminum, cadmium, and nickel. To the best of our knowledge, then, these unique materials are described here for the first time.

The structures and molecular weights of these polymers have not yet been determined. The polymers are thermoplastic and are not cross-linked, as they dissolve wholly in organic solvents such as acetone and methyl ethyl ketone. A proposed structure is:



On heating, the sticky resin is changed into a hard, glassy material which breaks with conchoidal fracture. Metals other than iron which yield these polymers include cobalt, copper, nickel, titanium, manganese, and chromium. The nature of the R-group on the aldehyde is not critical. However, it has been found that if the R-group on the aldehyde is similar to the R-group on the acid, the reaction proceeds more readily.

For example, 2-4-D was polymerized with ion as follows. To an aqueous solution of 3 moles of the amine salt of 2,4-D, sufficient nitric acid was added to lower the *p*H of the solution to about 4. An aqueous solution containing 1 mole of ferric nitrate and 2 ml of concentrated cinnamic aldehyde, in which some nitric acid was included to assist the dissolution of ferric nitrate, was also prepared. The ferric nitrate solution was added to the amine solution quickly after the *p*H of 4 was reached to preclude precipitation of 2,4-D. The addition of the ferric nitrate solution

resulted in a further reduction of the pH to 3. Stirring of the combined solution at room temperature resulted in the formation of a precipitate in the form of a resinous, tacky composition which settled. The supernatant liquid was decanted, leaving the precipitated material. This material upon heating at a temperature of 38° to 93°C converted to a hard, brittle composition which broke with conchoidal fracture. The material was soluble in acetone, ethyl acetate, alcohols, and similar solvents. The composition also degraded when the material was placed in water.

Acids that have been polymerized include the herbicides 2,4-D, 2,4,5-T, Silvex, Dicamba, and Picloram (*1*). Others, without appreciable biological activity, include benzoic acid, acetic acid, stearic acid, salicylic acid, tartaric acid, and adipic acid. The rate of degradation can be decreased by heating the polymer, which increased its molecular weight and its hardness. The rate of degradation can also be controlled by varying the surface-to-volume ratio. Hydrophobic acids, such as stearic acid, slow the rate at which degradation occurs.

Initial emphasis has been placed on herbicidal uses for the polymers. Pollution of water supplies commonly accompanies the application of herbicides at useful concentrations. Rain or irrigation water washes away much of the herbicide; hence an overapplication by an order of magnitude is required for effective control. Furthermore, several additional applications per year are needed to maintain the herbicide concentration at an effective level. Polymerized 2,4-D and iron at a rate of 1 pound/acre (1.12 kg/ha) has given exceptional control of weeds in field tests on grazing lands in Kansas, and the control continues for more than 1 year. In other tests control of ironweed and Canadian thistle has been achieved. Further, no evidence for migration of herbicide was found, despite the sloping terrain and heavy rains (*4*).

The increase in efficiency for control of resistant plant species suggests that the concentration of herbicide at the root level is enhanced. This may be due in part to the hydrous ferric oxide gel, which minimizes leaching of the herbicide. Some applications were made from an acetone solution, and others were coated onto granules of diatomaceous earth which were then scattered onto the ground.

In the management of grazing land it is essential that the herbicide not be ingested by animals. The use of granules is an effective way of controlling herbicide ingestion, as they fall to the ground.

Preemergent soil treatment with a wide variety of herbicides and other agents is now possible with the advent of controlled release. The slow release of herbicides has been coupled with beneficial fertilization. Deliquescent 10-30-0 fertilizer prills (*1*) have been coated with polymer, and the fertilizer release was spread over several weeks.

These polymers are expected to improve the effectiveness of defoliation techniques. When sprayed as a solute in an organic solvent, the defoliant forms a sticky resin which clings to foliage. Even heavy rain does not appreciably wash it off. Hence, it is expected to stay where it is placed and do its job, with minimium runoff pollution of water supplies. It is expected that the amount of defoliant required can be reduced by an order of magnitude, with corresponding savings in money, time, and ecological upset.

Medical applications can also be expected. Benign polymeric formulations will be sought as encapsulating materials for pharmaceuticals, such that a slow release can be achieved by way of an implant.

These polymers have appreciable structural strength. As packaging for dry materials, or, with liners, for aqueous materials, the water-degradability feature is highly desirable. As an alternate to the use of nondegradable liners, a local cross-linking at exposed surfaces may impart an extremely slow rate of degradation. When the container is broken, the more readily degradable material will be exposed to moisture.

This wide class of water-degradable polymers offers great promise for the controlled release of herbicides, insecticides, nematocides, slimicides, fungicides, rodenticides, defoliants, and pharmaceuticals. They may also find utility in the packaging industry, since they speedily break down after use.

M. L. Beasley
Austin Science Associates, Inc., P.O. Box 7728, Austin, Texas 78712

R. L. Collins
Austin Science Associates, Inc., and *Physics Department, University of Texas, Austin 78712*

References and Notes

1. 2,4-D: (2,4-dichlorophenoxy)acetic acid; 2,4,5-T: (2,4,5-trichlorophenoxy)acetic acid; Silvex: 2-(2,4,5-trichlorophenoxy)propionic acid; Dicamba: 2-methoxy-3,6-dichlorobenzoic acid; Picloram: 4-amino-3,5,6-trichloropicolinic acid; 10-30-0 fertilizer contains 10 percent (by weight) nitrogen, 30 percent phosphoric acid, and no potash.
2. A. Joannis, *C. R. Hebd. Acad. Sci. Paris* 138, 1498 (1904).
3. J. J. Pitts and T. J. Hurley, *U.S. Govt. Res. Develop. Rep.* 67 (1967), p. 24.
4. M. L. Beasley and R. L. Collins, in preparation.

13 April 1970; revised 5 June 1970

LAB FORM

14

SENT NOV 10 RHODIA CHIPMAN DIV. PORTLAND

VM +

CHIPMAN NBK

CHIPMAN PTL

11-10-71 3:40PM NBK

L MINSUK

THE CAR OF SILVEX ESTER WE RECEIVED FROM THOMPSON-HAYWARD, GATX 76640, ON 10/21/71 HAS BEEN CHECKED FOR DIOXANE CHEMICALS AND WE FIND THAT IT CONTAINS 0.3 PPM. JBV INDICATES THAT THIS MATERIAL IS "DIRTY" MEANING THAT IT CONTAINS A LOT OF ODD COMPOUNDS. THIS COMPLICATES THE ASSAY CONSIDERABLY... THE DETECTION LEVEL FOR DIOXANE IS 0.1 PPM. WE HAVE SHIPPED CAR GATX 29798 CONTAINING APPROXIMATELY 8000 GALLONS OF BLEND, PART OF WHICH WAS MANUFACTURED WITH THIS SILVEX. THE MOST PROBABLE CONCENTRATION IS 0.06 PPM DIOXANE. A SECOND CAR HAS BEEN MANUFACTURED, GATX 14141, CONTAINING 18,900 GALLONS OF BLEND ALL MANUFACTURED UTILIZING THIS SILVEX WITH A MOST PROBABLE CONCENTRATION OF 0.1 PPM. THIS SECOND CAR IS ON OUR PLANT SITE. I NEED YOUR ADVICE AND HELP ON THIS PRODUCT. IS THERE A SPECIFICATION ON DIOXANE ? AND IF THERE IS, WHAT SHOULD WE DO ABOUT THE MATERIAL NOW AT CHEVRON AND THE MATERIAL THAT WE HAVE MANUFACTURED ? PLSE ADVIS

R F GITSCHLAG

CHIPMAN NBK

0.25
0.30

CHIPMAN PTL

< NO DETECTABLE

RHODIA INC.
CHIPMAN DIVISION
PORTLAND, OREGON
May 22, 1972

CLR NO. 179

DISTRIBUTION: Mr. L. M. Minsuk
Mr. R. F. Gitschlag
Laboratory

TITLE: ANALYSIS OF RHODIA 2,4-D, MCPA, 2,4-DB ACIDS FOR CHLORO-DIBENZO-p-DIOXINS

INTRODUCTION

The analysis of the product acids were run in 1970 and reported separately. It was decided to consolidate the results into one report.

ABSTRACT

The analysis of composites from 1970 production of MCPA, 2,4-DB, and 2,4-D for 2,3,7,8-tetrachloro-dibenzo-p-dioxin revealed that none of this substance was present. Analysis of 2,4-D and 2,4-DB for 2,7 dichloro-dibenzo-p-dioxin was also run. None was found in either product. Limit of assay sensitivity was 0.05 ppm for 2,3,7,8-TCDPD and 0.02 ppm for 2,7-DCDPD.

BASIC PROCEDURE

The composite acids were dissolved in aqueous sodium hydroxide and extracted with high purity petroleum ether. The extract was evaporated to a small volume and washed with concentrated sulfuric acid. The extract was then placed on an alumina column and eluted with petroleum ether-ethyl ether mixtures. The appropriate elution fraction was treated again with concentrated sulfuric acid. The final extract was reduced to dryness and dissolved in carbon disulfide and aliquots injected into a gas chromatograph fitted with hydrogen flame detectors. The columns used were Silicon SE 30 and OV 225 (a polar Silicon type).
For each acid, the standard used was highly purified acid with the appropriate amount of 2,3,7,8-TCDPD and 2,7-DCDPD added. Blanks on the purified acid and reagents were also run. All blanks, reagents, and standards were run through the same procedure as the sample.

RESULTS

The MCPA, 2,4-D and 2,4-DB were examined for 2,3,7,8-TCDPD and none was found. The standard used was 1.0 ppm of the toxicant. The minimum measurable peak response corresponded to 0.05 ppm. The 2,4-D and 2,4-DB were, in addition, examined for 2,7-DCDPD and none was found. The limit of sensitivity was 0.02 ppm in these assays.

DISCUSSION

Difficulty with interfering peaks or high background was encountered as would be expected. By varying the basic procedures or adding cleanup steps, these were eliminated. In all cases, pains were taken to ensure that none of the dioxins would be inadvertently removed if present.

The composites taken for the assay work were from production processes which are the same at the current time. No step has been added which would promote the formation of dioxins.

CONCLUSION

The current production of herbicides does not contain the highly toxic 2,3,7,8-TCDPD. In addition, 2,4-D and 2,4-DB does not contain 2,7-DCDPD.

Gary R. Miller

Gary R. Miller

Jack B. Vernetti

Jack B. Vernetti

JBV/GRM/dvh

16 4 12/

RHODIA INC., CHIPMAN DIVISION

INTER-OFFICE CORRESPONDENCE

RECEIVED DEC 12 1972 L.T.H.

SUBJECT: Silvex

December 11, 1972

TO: Dr. L.T. Hargett
Office

cc: Mr. J.B. Clapp, Jr.

The previous interim tolerances for Silvex have, in effect, been "cancelled by-omission" from the most recent notice of interim tolerances published in the Federal Register of December 2, 1972. This rather unique, and unexpected, attempt at cancellation does not mean that the current registrations of Silvex products have been cancelled. If applicable, the EPA will cancel certain uses of specific Silvex products on an individual basis.

At the moment, the legal council of Dow Chemical does not feel that they can ask for a public hearing on the basis of the current EPA notice; if applicable, they prefer to request a public hearing after the cancellation notice is issued. If a public hearing is granted, all registered uses would continue in effect until disposition of the subject.

Dow Chemical will submit evidence in an attempt to reestablish an interim tolerance before the end of the year; however, I doubt that Dow will be successful.

In any event, we will not lose our recommendations for non-crop uses and we will keep our EPA registration of Silvex products in effect. Our potential loss could be recommendations for use on rangelands, pastures, forest management areas, and aquatic uses.

The problem is now primarily legal rather than realistic or scientific. The subject will be "sticky" in 1973 with dirty words like dioxin being tossed about.

continued...

I strongly suspect that Dow Chemical will shortly begin to move their stocks of Silvex into the channels of trade to avoid possible relabeling and/or other problems. I suggest that we seriously consider the same strategy. Even if we do not lose our present label recommendations in 1973, we can more easily convince our customers that they can use our Silvex with assurance after they have purchased the product.

Also, Dow has more to lose with their present inventory of Silvex labeled for use in rice and sugarcane; and, I suspect that a Dow campaign to market Silvex will materialize shortly.

Our affected products are PN 117, Chipman Silvex 4L and PN 709-A and G, Visko-Rhap Low Volatile Ester 2TP.

Thanks.

Lamar C. Brown

Lamar C. Brown

LCB:lp
attachment

(47)

LAB / DIOXINS

PORTLAND

June 18, 1973

cc: R. F. Gitschlag

Mr. L. M. Minsuk
New Brunswick

I reviewed the papers on dioxans by Roger Baughman, by Woolson (NIEHS), and the report written by myself covering the 1971 ACS meeting in Washington D.C. The only new items are as follows:

1. Cumulative effects of TCPD (2,3,7,8 tetrachloro dibenzo-p-dioxan) in monkeys.

2. Finding of TCPD in fish and crustaceans in Vietnam near areas of heavy wartime spraying with 2,4,5-T.

3. The finding of TCPD in young oat and soybean plants grown in soil contaminated with TCPD although none was found in mature plants. Somewhat contradictory but useful to environmentalists.

At the Washington ACS meeting (1971) Roger Baughman was the leader (self-imposed I gathered) of the discussions expounding the extreme environmental hazards of the dioxans. The data above would appear to lend proof to his contention of cumulative effects in the food chain and the need for limitation of 1 ppb TCPD in the soil. I think that this group has a little firmer leg to stand on than in 1971.

The analytical work in Baughman's paper was being developed during the period of the 1971 meeting and I felt that his was the most sophisticated and thorough work presented. It was certainly one of the most sensitive.

Jack B. Vernetti

Jack B. Vernetti

JBV:bc

Rhodia

OFFICE MEMORANDUM

DIVISION AGRICULTURAL

18

To: E. Schroder

Date: July 15, 1975

From: L. P. Van Gordon

Subject: Silvex: TCDD Contamination
Weed-B-Gon Conc.--IOE Mix
Chevron Chemical Company

The attached letter from Chevron, San Francisco, requires a careful reply. Before I do reply, I want us to be absolutely sure of our ground. Will you therefore, please request our supplier of Silvex IOE, Thompson-Hayward, to clarify this question of dioxin contamination in writing.

When you recieve Thompson-Haywards' reply, would you please send me a photo copy for my records?

Thank you.

RECEIVED
JUL 16 1975
PURCHASING

L. P. Van Gordon

LPVG:bjw

CC: R. P. Rich

Rhodia

RHODIA INC. CHIPMAN DIVISION
23 Belmont Drive, Somerset, New Jersey 08873
Telephone: 201-469-9680 • Telex: 833414

July 15, 1975

RECEIVED
JUL 16 1975
PURCHASING

Mr. Barry O'Connor
Chevron Chemical Company
200 Bush Street
San Francisco, CA 94104

Dear Barry:

We acknowledge with thanks your recent letter with the following subject:

Silvex: TCDD Contamination
File: Weed-B-Gon Conc.--IOE Mix

As soon as I recieve the necessary information from our technical people, I will advise you in a follow-up letter.

Cordially,

RHODIA INC. AGRICULTURAL DIVISION

Larry Van Gordon

L. P. Van Gordon
Market Supervisor, Bulk & Export

LPVG:bjw

CC: R. P. Rich
E. Schroder

Rhodia

19

OFFICE MEMORANDUM

DIVISION AGRICULTURAL

PAULY

To: R. F. Gitschlag, Somerset Date: July 30, 1975

From: E. Schroder, Somerset Subject: Dioxin Contamination of Silvex and 2,4,5-T Products

Attached are copies of correspondence between Larry Van Gordon and Chevron Chemical regarding their sudden concern re Dioxin content of subject materials. According to Lamar Brown the maximum allowable is .1 p.p.m.

I discussed the various questions raised by Chevron with Glen Munger of Thompson-Hayward who supplies us with these products.

1. As far as the levels of Dioxin present, Thompson-Hayward indicates they are in "non-detectable" amounts.

2. A routine quality control analysis is maintained for the presence of Dioxin "in every batch" per Thompson-Hayward.

3. Thompson-Hayward guarantees that the Dioxin present is in "non-detectable limits".

On the basis of the above, it would appear that if any products sold "as is" meets the regulations, any of our formulations also would meet the regulations. I do not know, however, what type of routine quality control analysis is exercised at our plants to insure the validity of the above statements. Therefore, I am addressing my reply to you rather than Mr. Van Gordon in the event you wish to comment further.

E. Schroder

E. Schroder

ES/sfg

Rhodia

RHODIA INC. CHIPMAN DIVISION
23 Belmont Drive, Somerset, New Jersey 08873
Telephone: 201-469-9680 · Telex: 833414

July 15, 1975

RECEIVED
JUL 16 1975
PURCHASING

Mr. Barry O'Connor
Chevron Chemical Company
200 Bush Street
San Francisco, CA 94104

Dear Barry:

We acknowledge with thanks your recent letter with the following subject:

Silvex: TCDD Contamination
File: Weed-B-Gon Conc.—IOE Mix

As soon as I recieve the necessary information from our technical people, I will advise you in a follow-up letter.

Cordially,

RHODIA INC. AGRICULTURAL DIVISION

Larry Van Gordon

L. P. Van Gordon
Market Supervisor, Bulk & Export

LPVG:bjw

CC: R. P. Rich
E. Schroder

Rhodia

OFFICE MEMORANDUM

DIVISION AGRICULTURAL

To: E. Schroder

Date: July 15, 1975

From: L. P. Van Gordon

Subject: Silvex: TCDD Contamination
Weed-B-Gon Conc.--IOE Mix
Chevron Chemical Company

The attached letter from Chevron, San Francisco, requires a careful reply. Before I do reply, I want us to be absolutely sure of our ground. Will you therefore, please request our supplier of Silvex IOE, Thompson-Hayward, to clarify this question of dioxin contamination in writing.

When you recieve Thompson-Haywards' reply, would you please send me a photo copy for my records?

Thank you.

Greg

L. P. Van Gordon

RECEIVED
JUL 16 1975
PURCHASING

LPVG:bjw

CC: R. P. Rich

Chevron Chemical Company
200 Bush Street, San Francisco, CA 94104

July 8, 1975

R. P. Elliott
Manager, Purchasing

Silvex: TCDD Contamination
File: Weed-B-Gon Conc.--IOE Mix

Mr. L. P. Van Gordon
Chipman Division
Rhodia, Incorporated
23 Belmont Drive
Sommerset, NJ 08873

JUL 11 1975
L. Van
7/14

Dear Larry:

The March 5 issue of Pesticide Chemical News states the following about TCDD, an extremely toxic impurity in 2,4,5-T.

> ". . . one pattern of use worthy of special mention at this time is that involving potential exposure of women of child-bearing age to house and garden herbicides which may contain TCDD. Since silvex may also contain TCDD, it too may cause human exposure to TCDD."

We were not aware that silvex could contain TCDD (dioxin). TCDD is the most toxic synthetic chemical tested and is also one of the most potent teratogenic agents known in mammalian systems. When the herbicide 2,4,5-T was canceled for use around the home (because of TCDD contamination), silvex was immediately substituted as a replacement—we are now concerned about the potential presence of TCDD in any of our G&H products.

Max allow .1 P.P.M.

Please advise:

1. Has TCDD ever been found in your preparations of ~~Weed-B-Gon Conc.~~ IOE Mix (ratio by weight of 2,4-D I.O.E. and 2,4,5TP I.O.E.—2:1 on free acid basis) and also silvex? If so, at what levels?

2. Is routine quality control analysis maintained for presence of TCDD in these products?

3. What guarantee do we have from Rhodia that TCDD is not present in these products?

May we please receive your reply by August 11, 1975? Thank you.

Very truly yours,

R. P. Elliott

By B. L. O'Connor
B. L. O'Connor

BO'C:taj

Rhodia

OFFICE MEMORANDUM

DIVISION AGRICULTURAL

To: L. P. Van Gordon

Date: August 1, 1975

From: R. F. Gitschlag

Subject:

Recently you requested some information about the dioxin content of the Silvex formulation that we supply Chevron Chemical. When this question first came up on dioxin content of 2,4,5-T, we determined that the dioxin level of the tetrachloro dioxide was below the detectable level which is below 10 parts per billion. During the early days of the dioxin problem, we revised delivery of several batches of Silvex from Thompson-Hayward because the dioxin level was too high.

By carbon copy of this letter, I am asking the Portland lab to confirm our test work on the dioxin level of Silvex compounds.

I am also asking Eleanor Schroder by carbon copy to check with Thompson-Hayward on their control procedures so that we can insure our customer that there is no dioxin present.

R. F. Gitschlag

RFG:lvw

cc: R. W. Clarke
E. Schroder
J. S. Vernetti

Rhodia

OFFICE MEMORANDUM

DIVISION AGRICULTURAL

21

To: R. E. Cummins, J. C. Herren
E. Schroder, J. A. Toner

Date: September 22, 1975

From: R. F. Gitschlag

Subject: TCDD Analysis

EPA is continuing to look at 2,4,5-T or Silvex in respect to dioxin content. Recently EPA requested information from our Product Development Group. The various correspondence on this subject is attached for your information. There is a strong feeling within our group that both 2,4,5-T and Silvex will be banned again. Our planning should be such that we minimize our inventories. It would be my suggestion that we do not run a whole year's product at one time but instead manufacture during the season utilizing the most economical order level. Example: instead of tank car use a truck load, instead of a truck load use 20,000 lbs., etc.

RFG

R. F. Gitschlag

RFG/pm
attachments

Rhodia

RHODIA INC. AGRICULTURAL DIVISION
23 Belmont Drive, Somerset, New Jersey 08873
Telephone: 201-469-9680 • Telex: 833414

September 15, 1975

Mr. Edwin L. Johnson
Deputy Assistant Administrator
for Pesticide Programs (WH-566)
United States Environmental Protection Agency
Washington, D.C. 20460

Dear Mr. Johnson:

Subject: TCDD Analysis

We have not manufactured any technical 2,4,5-T or silvex during the preceding 12 months. Therefore, we do not have any chemical analysis to report or any samples to submit for analysis.

Sincerely,

RHODIA INC. AGRICULTURAL DIVISION

Ronald D. Wilson

Ronald D. Wilson, Ph. D.
Senior Project Leader
Biological Data Systems

RDW:hkg
cc: Dr. Han Tai
bcc: Mr. M.P. Lavalleye/with backup
Mr. L.C. Brown/ " "
Mr. R.F. Gitschlag/ " "

RECEIVED
SEP 16 1975
SCHLAG

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

11 SEP 1975

Dr. Ronald Wilson
Rhodia, Inc.
Agriculture Division
23 Belmont Drive
Somerset, New Jersey

Dear Dr. Wilson:

Attached is a copy of a memorandum dated August 5, 1975, to me concerning the 2,4,5-T residue monitoring program currently in progress. In view of the results of this program as reported in this memorandum, I hereby request that your company submit to me a report of any quantitative chemical analysis (parts per million and percentage) conducted during the preceding 12 month period for TCDD in any technical grade 2,4,5-T manufactured by your company.

If these analyses are available on a monthly or periodic basis, please submit reports of all such analyses conducted during the preceding twelve months.

In addition, we request that a sample of the technical materials which may contain TCDD be made available to EPA for chemical analysis by our laboratories. We request at least two samples of each technical material, samples which should be taken from separate manufacturing "batches." Questions about this sampling should be addressed to and the actual samples should be sent to:

Dr. Han Tai
U. S. Environmental Protection Agency
Pesticide Monitoring Laboratory
National Space Technology Laboratory
Bay St. Louis, Mississippi 39520

We request that these samples be submitted to Dr. Tai no later than September 30, 1975.

In addition, please submit to me any studies not previously submitted to this Agency on TCDD concerning residue monitoring, environmental chemistry and toxicology. If work is in progress in these areas, please submit preliminary status reports. All submissions should be sent to me by September 30, 1975.

Sincerely yours,

Edwin L. Johnson

Edwin L. Johnson
Deputy Assistant Administrator
for Pesticide Programs

cc: Dr. Han Tai

Enclosure

SUBJECT: Interim Results of 2,4,5-T/TCDD Residue

DATE: AUG 5 1975

FROM: Dioxin Program Coordinator
Office of Pesticide Programs (WH-569)

TO: Deputy Assistant Administrator
for Pesticide Programs (WH-566)

I. INTRODUCTION

Subsequent to the withdrawal of the 2,4,5-T cancellation proceeding in June 1974 due to the lack of residue and analytical methodology, 100 beef fat samples from cattle rangeland treated with 2,4,5-T have been collected. In June 1975 analysis of the samples was begun utilizing improved analytical techniques sensitive to detection of tetrachloro-p-dibenzodioxin (TCDD), the extremely toxic contaminant of 2,4,5-T, at the parts per trillion level. Approximately one-third of the samples have been analyzed, and all samples will be analyzed by the end of September. Residues of TCDD have been found in approximately one-half of the thirty-four samples analyzed at levels which may be above the normal margin of safe dietary exposure.

II. BACKGROUND

The 2,4,5-T proceeding has its origins in 1970 when the United States Department of Agriculture in April, 1970 suspended use of 2,4,5-T around lakes, ponds and ditch banks and also suspended liquid formulations for use around the home and recreation areas after animal studies demonstrated that 2,4,5-T contaminated with TCDD was teratogenic to mice. Subsequently, USDA canceled use of all granular formulations of 2,4,5-T around the home and recreation areas. USDA on the same date canceled all 2,4,5-T uses on food crops intended for human consumption. Four registrants challenged the cancellation notice as to use of 2,4,5-T on rice. All other food uses were not challenged and were finally canceled.

One of the registrants of the contested rice uses, Dow Chemical Company, obtained an injunction in 1972 against EPA, the successor to USDA, enjoining further administrative action against 2,4,5-T. In 1973, the United States Court of Appeals for the Eighth Circuit overturned the injunction and administrative proceedings were allowed to go forward. On July 19, 1973, EPA issued a notice of an information gathering hearing under Section 6(b)(2) of the Act to include all registered uses of 2,4,5-T other than the rice use.

This informational hearing included rangeland, rights of way and forests. The July 19, 1973, notice also stated that the start of the hearing was being delayed to allow completion of the residue monitoring program in the parts per trillion range. 38 F.R. 19869, July 24, 1973. On May 10, 1974, the informational hearing was again expanded to include all herbicides having in their manufacturing processes 2,4,5-trichlorophenol, including Silvex and Erbon. All of these herbicides have the potential of containing TCDD.

On July 24, 1974, the Agency withdrew cancellation and information gathering proceedings initiated against the herbicide 2,4,5-T. The proceeding was withdrawn because of the inability of the Agency to monitor food for residues of 2,4,5-T's highly toxic contaminant TCDD with the necessary analytical precision. The lack of evidence that 2,4,5-T use results in exposure of man to TCDD made a final determination on the "unreasonable adverse effects" caused by the use of 2,4,5-T to be extremely difficult, if not impossible. Accordingly, while the 2,4,5-T notice of hearing was withdrawn, the Agency stated that it

> "will continue its TCDD residue monitoring program and will take such further action as it deems appropriate once the results of the monitoring project are available." 39 F.R. 24050, June 28, 1974.

III. CURRENT RESIDUE MONITORING PROGRAM

Following the withdrawal of the proceeding, a residue monitoring program was established by EPA utilizing improved analytical methodology capable of TCDD detection at the parts per trillion level. The Environmental Defense Fund, USDA, and Dow Chemical Company agreed to participate in the establishment of the monitoring program and, in addition, Dow Chemical Company agreed to perform analysis of some of the EPA samples. Initially, 100 beef fat samples from cattle grazed on rangeland previously treated with 2,4,5-T were collected. In addition, 25 beef samples from cattle grazed on non-treated rangeland were collected as control samples.

To date, 34 samples have been analyzed by two laboratories and approximately 15 of these samples have been analyzed by a third laboratory. (By the completion of the first collection phase of this program in mid-September, all samples will have been analyzed by at least two laboratories.) The results of the analysis so far are as follows:

Approximately half of the 34 samples analyzed show positive residue data for TCDD by one or more of the participating analytical laboratories. Dioxin residue levels varied from no detection to approximately 110 parts per trillion. Substantial numbers of the

samples containing dioxin showed levels ranging from 50-60 parts per trillion.

Although the Agency has made progress toward developing an analytical technique for quantitating dioxins at the parts per trillion level it must be pointed out that this is a pioneering effort in applying sophisticated analytical methodology for obtaining sensitivities which has never been achieved before and the analytical technique applied to a routine monitoring program where a large number of samples are to be examined. Therefore, with the limited number of analyses accomplished so far, it is premature for the Agency to completely assess the exact state of the art of the methodology until samples collected are analyzed. Also, it is essential that the collaborating chemists have an opportunity to review these data before any conclusions are drawn.

IV. SIGNIFICANCE OF RESIDUE LEVELS

Studies including teratogenic and other toxicity effects indicate that the residue levels mentioned above may present a health hazard to man based on the application of normal margins of safety.

V. RECOMMENDATION

The analytical methodology being utilized in the program is a pioneer effort to determine residue levels at the parts per trillion level. Although the analytical scientists are confident with the analytical technique and the results obtained from the initial samples, because only about one third of the samples have been analyzed, and because we anticipate that the analysis of the remaining samples will be completed by mid-September, 1975, I recommend that the Agency complete the residue analysis of all 100 collected beef samples including confirmation by more than one laboratory before a final decision is made with respect to the registration of 2,4,5-T and other pesticides containing TCDD.

Pending receipt of the analysis of the remaining samples, I recommend that the Agency take the following action:

1) Take appropriate action to expedite completion of the analysis of the remaining samples.

2) Request from the manufacturers samples of the technical grade products of other pesticides which show potential for containing TCDD. These samples are to be analyzed by EPA laboratories. Also, request the manufacturers' analysis of the technical grade products.

3) Request from Dow any additional information with respect to human health hazards of 2,4,5-T.

In addition, I have requested that the following programs be funded and implemented immediately.

1) Additional analytical facilities in order to expedite sample analysis.

2) Residue monitoring of human tissue samples and other food samples potentially contaminated with TCDD including rice, fish and milk;

3) Residue monitoring studies for the presence of TCDD in wildlife, rights of way uses and its persistency in the environment; and;

4) Confirmatory analysis by additional analytical techniques of positive samples containing high levels of TCDD.

Ralph T. Ross

Ralph T. Ross, Ph.D.

22

AGRICULTURAL

J. E. Davies

September 15, 1977

RECEIVED
SEP 15 1977
T. J. LOVENBACH

R. D. Wilson

2,4,5-T

I received a telephone call from Mr. Harvey Warnick, OSPR, EPA, Project Manager for 2,4,5-T RPAR. (Telephone Number 202/755-5754).

He requested two items of information concerning Rhodia 2,4,5-T products. 1) Do we make or who do we purchase from and 2) What is the level of TCDD (Dioxin) in the Rhodia Products?

He is in the process of writing the position document for the 2,4,5-T RPAR and wants to verify the information included in the document.

I discussed this problem with Dr. E. L. Clark and we propose to answer to the effect that we purchase the 2,4,5-T that we use from Thompson-Hayward and 1) the level of dioxin should be obtained from them or 2) the level of dioxin is certified to us as being below the level of detection.

We recommend that T-H be notified that we received the EPA request and see if they have any objection to the proposed answer, as approved by you.

I was told that the answer could be submitted by either phone or letter, whichever we felt the most comfortable in doing.

R. D. Wilson

RDW:ngc

cc: E. L. Clark
H. P. Lavelleye
T. J. Lovenbach

12/12/77 23

NEEDS ADDITIONAL REPLY ON CERTAIN POINTS –

Rhodia
A SUBSIDIARY OF RHONE-POULENC

RHODIA INC.

6200 N.W. St. Helens Road, Portland, Oregon 97210
Telephone 503-222-3571 Telex 360329

December 5, 1977

Mr. Larry Patterson
Dept. of Environmental Quality
1234 SW Morrison St.
Portland, OR 97205

Dear Mr. Patterson:

We wish to respond to the report issued by Messrs. Sims and Stefani of their EPA visit to Rhodia's Portland Plant on April 22, 1977.

2,4,5-T was found in two soil samples and was present because we had sprayed for blackberry and brush recently. Their conclusion that it is present from past manufacturing practices is simply not true.

In general, there are numerous statements throughout the report which confuse the time frames. At the time of the visit (April 1977), the new process and rainwater facilities were under construction and not in use. Subsequently, the facilities were completed and are now in use. This confusion appears on pages 1, 2, 8, 9 and 12.

Individual comments of specific sentences also need clarification or changing as listed:

Page 1 "identified nationally as a potential" is a little strong. In fact, we are but one of a number of facilities which manufacture the herbicide products as listed in the Federal Register. Industry as a whole was required to respond to potential. This report makes it appear to be pointing the finger at us when we are but one of a large group.

Page 2 Add "product" to the fourth line in front of "samples."

Page 2 add "after treatment" in the third line of Section II...after "Wastewater discharges." Also, this sentence needs the timing clarified for readability.

Page 4 1.a. needs rewording to match the actual permit requirement.

Page 4 1.c. again to match the actual permit requirement.

Page 4 — At the bottom, Item 1. "too restrictive" is not true. It should state that we are trying to match true emission levels with the state of the art and correlate this to the emission levels stated in the permit.

Page 5 — at the bottom, both boilers have 50,000 lbs of steam per hour capacity and their stack flow rates are variable depending on the steam usage in the plant. They are not "unknown." Maximum fan rates for each are: #6 - 12,000 cfm, and #7 - 12,000 cfm.

Page 8 — D.3. "potential for fugitive hydrocarbon emissions is great." This is a bad statement. The odor threshold for some of our materials is very low, therefore, a small amount is very odorous. Just because the odor is present, doesn't automatically mean that the potential is great.

Page 8 — V.A. Again, the time frame.

Page 9 — First paragraph, the open ditch was present in April, but not now.

Also, "on the west boundary" now encompasses only that outside the plant fence.

Page 9 — Third paragraph, the time frame again in discussing the runoff and seepage collections.

Page 9 — Fourth paragraph, this is a bad conclusion based upon soil samples showing Brush Killer in our clean areas.

Page 10 — Second paragraph. Their conclusion needs to be reworded.

Page 11 — The pretreatment parameters shown at the top of the page are not the ones required by the City of Portland.

Page 11 — bottom line, the TOC numbers need to be corrected.

Page 12 — First paragraph, the time frame discussion should include that some (10 gpm) of the rainwater sump was carbon treated in April.

Page 12 — Second paragraph, there were two neutralization tanks. The furnace was shut down because of chloride corrosion and higher usage than the furnace had capacity, not for the reason shown in the report.

Page 13 — last sentence of the third paragraph. "Completion" means timing only. The funds were available and this work was done.

Page 14 Item 3. I think this is a bad assumption because of the 2,4,5-T error.

Page 14 Item 5. Wrong conclusion again.

Page 15 Item 4. There are no dioxins in our present processes, therefore monitoring is superfluous. Periodic checking might be done annually, but continuous monitoring is not warranted.

Page 15 Item 5. This is valid only if we can limit the rainwater that falls on the plant site. They are mixing up the process and rainwater streams as well as their discharge points.

Page 15 We agree with your comments on items 1 and 3.

If you wish any further clarification, please call on us.

Very truly yours,

P. E. Davis
Technical Manager

PED:bjf

cc: Mr. R. F. Gitschlag
Dr. E. L. Clark
Mrs. T. Lumapas
Mr. J. Vernetti

cc: FED
JPS
T. Lumatz

Department of Environmental Quality

ROBERT W. STRAUB
GOVERNOR

1234 S.W. MORRISON STREET, PORTLAND, OREGON 97205 Telephone (503) 229-6955

November 17, 1977

Rhodia, Inc.
6200 NW St. Helens Road
Portland, Oregon 97210

Attention: Mr. Phil Davis

Gentlemen:

Enclosed is a copy of the EPA surveillance report that we discussed during our recent telephone conversation.

Please review that report and submit any comments you may have so that we can draft a response to EPA.

If you have any questions, please feel free to contact this office at 229-6955.

Sincerely,

Larry D. Patterson

Larry D. Patterson
Regional Engineer
Portland Region

LDP/mlw
Enclosure

Contains Recycled Materials

DEQ-1

Rhodia

13.5

April 22, 1977 Multimedia Survey
Rhodia, Inc
Portland, Oregon

Larry Sims, Surveillance & Analysis
Dennis Stefani, Enforcement Division

I. Introduction

In the past few years, there has been an increasing national concern regarding the effect of toxic materials on our health and environment. This is reflected in the recent passage of the Toxic Substances Control Act and the Resource Conservation and Recovery Act as well as the issuance of the NRDC Consent Decree, which requires that effluent guidelines for NPDES permits contain restrictions on toxic materials.

In response to this concern, EPA established a multimedia toxics task force whose purpose was to assess toxic problems, such as nitrosamines, and coordinate the agency's response to them. In EPA Region X, the task force decided to perform a preliminary multimedia toxics survey on a plant in order to determine what problems will be encountered in a multimedia toxics approach, the resources required for an in depth survey, and if there is a potential problem at the specific plant surveyed which would warrant an in depth survey. An in depth survey was not done initially due to the large resource committment that would be required and the fact that the regional laboratory was overburdened already.

The choice of Rhodia, Inc. at Portland as the site for this initial survey was made because of it being an herbicide manufacturing plant and because it had been identified nationally as a potential source of

TRUE BUT STRONG

nitrosamines. However, even though nitrosamines were part of the original reasons for selecting Rhodia, it was decided not to sample for them because the EPA Region X laboratory does not have the capability to do a nitrosamine analysis and PRODUCT samples had already been taken by a national contractor and were to be analyzed in Cincinnati. It should be noted that Region X has still not received the results of that analysis.

NOW DONE

After the decision was made to survey Rhodia, the Oregon Department of Environmental Quality was contacted by Dr. Gary O'Neal of the Region X office in Seattle, and John Vlastelicia of the EPA Oregon Operations Office. Arrangements were made for the survey to be coordinated with Larry Patterson of the DEQ Portland Regional Office. Larry Sims and Dennis Stefani were assigned from EPA to conduct the survey.

II. Plant Description

Rhodia, Inc., operates an herbicide manufacturing plant in Portland, Oregon. The plant is located in NW Portland in a heavily industrialized area adjacent to the Willamette River. Wastewater discharges are made AFTER TRC to the Willamette River and to the city of Portland STP. (TIMING)

The products manufactured at the facility include 2,4-D, 2,4-DB, MCPA, MCPB, and Bromoxynil Octanoate. The plant operates on a 24 hour basis with seasonal fluctuations depending upon the demand for the products.

III. Survey Description

The first day was spent in the DEQ Portland Regional Office examining the State's files to obtain additional background material on Rhodia. The

second day Dennis Stefani and Larry Sims of EPA and Larry Patterson of DEQ met with Richard Gitschlag, the Plant Manager for Rhodia to perform the survey of Rhodia's Portland Facility. Ken Covert, EPA's Oregon pesticides officer, also was present.

Mr. Gitschlag provided each person with a resource book on the facility which gave the history of the plant in addition to information on the processes used and the methods of waste treatment. After a brief discussion of the basic operation of the plant, a walk through inspection was made with Mr. Gitschlag as the guide. Samples were taken after the initial tour.

IV. Air Emissions

A. Odor Compliants

The review of the DEQ files indicated that they consider the only air emission problem to be odors. In the files are large number of odor complaints, many from the same person. The complaints are accompanied by notes on DEQ follow up action such as contacting the source or tracking down the elusive odors.

B. Air Discharge Permit Limitations and Monitoring

The Air Contaminant Discharge Permit, issued to the Company September 23, 1975, contained emission limits and monitoring requirements for the processing operations at the plant and for the fuel burning equipment. Following is a brief outline of some of the permit requirements:

1. Herbicide manufacturing
   a. No odors in residential areas
   b. Fugitive emissions kept at lowest practicable levels
   c. Maintain odor control equipment and operate continously
   d. Specific emission limits
      (1) 2.0 mg/m dicresolopheno (DCP) from 2,4-D process building scrubber
      (2) 20.0 mg/m o-cresol from MCPA process scrubber
      (3) 12.0 mg/m DCP from 2,4-DB process scrubber
   e. Ambient air monitoring

2. Fuel burning equipment
   a. Opacity - less than 20%
   b. Particulate emission limit taken from graph in standards
   c. Smoke spot # 4
   d. Sulfur content of fuel less than 1.75%

According to an internal DEQ memo, the source is considered by DEQ to be capable of operating in compliance with applicable regulations. The same memo indicates that there are some problem areas in the sample collection and analysis procedures. At the present time the company has a contractor working on this problem. The consultant's tasks are:

1. To review odor scrubber stack emissions to see if the limits are too restrictive or unnecessary
2. To review sampling equipment and procedures to verify reported emssions.
3. To study scrubber efficiencies.

The Company reports the following daily air pollution information to DEQ:

1. 2.4-D plant scrubber DCP discharge concentration
2. 2,4-D process scrubber DCP discharge concentration
3. 2,4-DB process scrubber DCP discharge concentration
4. MCPA process scrubber o-cresol discharge concentration
5. East ambient air sampling station phenol concentration
6. East ambient air sampling station cresol concentration
7. West ambient air sampling station phenol concentration
8. West ambient air sampling station cresol concentration
9. Wind speed and direction.

Temporarily NOT!

C. Emission Sources and Loads

DEQ's permit application review (2-4-75) gave the following estimated annual emissions for this facility:

Organics	5.3T
Particulate	5.9T
NO_x	47.2T
SO_2	25.5T

During the tour of the facility, particular attention was paid to stacks, vents, and other potential sources of air emissions. There are seven identificable stacks:

1. Boiler #6 - flow rate unknown
2. Boiler #7 - flow rate unknown
3. Formulations ~~scrubber~~ 5,000 CFM

NOT TRUE

4. 2,4-DB Process scrubber 5,000 CFM
5. MCPA Process scrubber 5,000 CFM
6. 2,4-D Process scrubber 15,000 CFM
7. 2,4-D Plant scrubber 45,000 CFM

In addition to the above sources there are several storage tank vents. According to Mr. Gitschlag, those tanks storing odorous chemicals are vented to one of the major odor control scrubbers. The others are vented to the atmosphere. All vents are equipped with silica gel to prevent the introduction of water into the chemical. Other potential sources of air emissions are those process buildings not provided with building ventilation.

Mr. Gitschlag indicated that some of their odor problems are being eliminated through improved procedures, more operator training, and rebuilding some of the processes.

NEDS (updated 4-28-76) lists the following information for the plant's emission points.

Point	Source	TSP	SO_2	NO_x	HC	CO
1	Gas Fired boiler	0	0	14	0	1
2	Oil fired boiler	10	109	36	1	1
3	Incinerator*	0	0	0	0	0
4	Chemical Process	0	0	0	0	0
5	Chemical Process	0	0	0	1	0
6	Chemical Process	0	0	0	0	0
7	Chemical Process	0	0	0	0	0
	Total (Tons/year)	10	109	50	2	2

*Not operating as per permit requirement

The previous update of NEDS gave hydrocarbon emissions from point 7 as 9 tons/year. The rest of the emissions were the same as in the current update.

To check the accruacy of the emission given for the boilers, AP-42 emission factors were used to calculate the following numbers for 1976. The figures indicate that the NEDS data may be high but certainly not out of the question.

Fuel	Annual Consumption	TSP	SO_2	NO_x	HC	CO
Gas	1.266X106 therms	0.6	0.04	1.3	0.2	1.1
Oil	5.428X105 gallon	5.7	75.9	16.6	0.3	1.4
	Total (Tons/year)	6.3	75.9	17.9	0.5	2.5

Using the emission data generated by the Company for the scrubber stacks and some approximate flow rates given by Mr. Gitschlag, the following hydrocarbon emissions were calculated.

Date March 16, 1977

Stack	Emissions	Flow Rate	Mass Emissions
1. 2,4-D Process	0.38 mg DCP/m3	15,000 CFM	0.51 lb/day
2. 2,4-D Plant	1.25 mg DCP/m3	45,000 CFM	5.05 lb/day
3. 2,4-DB Plant	0.44 mg DCP/m3	5,000 CFM	0.20 lb/day
4. MCPA Plant	--	--	--

Assuming that the above figures are correct and the processes operate 365 days per year, DCP emissions are less than 1 ton per year for each of the three points listed above. Because of the nature of the process, little would be expected in the way of other emissions (particulate, SO_2, NO_x, CO).

D. Conclusions

1. The NEDS emission summary is inadequate. It does not list all of the emission points and lists zero emissions for many of them.
2. Hydrocarbon emissions from the plant are, with the exception of DCP, not characterized.
3. The plant has a lingering pesticide smell indicating that the potential for fugitive hydrocarbon emissions is great.
4. Hydrocarbon emissions from the plant, on a yearly basis are probably quite small based on the limited sampling done now.
5. The plant manager appears to be desirous of solving his problems.
6. According to data submitted by the company to DEQ, the plant appears to be operating in compliance with its Air Contaminant Discharge Permit.

V. Water Discharges

A. Process and Runoff Water Sources and Characteristics

All process wastewater is collected and sent to the new wastewater treatment plant. A specific discussion of the processes employed is not included in this report as it is intended to be only a preliminary survey. However, the information is available from the authors if required.

The major toxic contaminants found in the wastewater are chlorinated phenols, phenols, dichloromethane, acetone, and the products made by the facility, including 2,4-D, 2,4-DB, MCPA, and Bromoxynil. Cresols (4-Chlorp-2-methylphenol) were not found in other than trace amounts. The process flows vary according to the production, which is seasonally dependent.

The runoff water from the main plant area is collected and routed to a rainwater sump through a series of drains. On the east side of the plant an open ditch is used to collect surface runoff and ground seepage from the laboratory area and the area where the 2,4-D esters, amines, phenols, caustic, and alcohols are stored. The drainage on the west boundary of the main plant appears to generally dissipate in the direction of the railroad tracks.

The southern portion of the plant consists of the parking lot, a warehouse, and large open storage areas for equipment and material. The parking lot is drained by a storm drain which discharges into a storm sewer. The other areas, including an area adjacent to the warehouse where empty drums which formerly contained herbicides were stored, have no obvious drainage routes.

The pollutants found to be present in the rainwater sump which collects most of the runoff from the main plant area, are shown on the attached table of results under sample numbers 16303 and 16304. As can be seen the runoff and seepage collected and routed to the rainwater collection sump is very contaminated. Substantial levels of 2,4-D, 2,4,5-T, 2,4-DB, MCPA, chlorinated phenols, and Bromoxynil are present. In addition, methylene chloride (dichloromethane) was recorded at levels of 9 ppm.

Further, the soil contamination present in the areas sampled is also an indication of the potential runoff contamination. Samples taken of the soil in the outside storage area near the south warehouse where the empty product drums are stored(16305) and of the soil in the ditch

on the east boundary of the plant(16306) indicate definite contamination by chlorinated phenolics and the herbicides produced by the plant.

Ground water at time

It should be noted that 2,4,5-T also is present, even though the company has not manufactured it since 1962. Although no 2,4,5-T was reportedly stored at the facility at the time of the inspection, information in the EPA Pesticides Branch files indicates that a brush killer containing technical 2,4,5-T was formulated at the plant after 1962.

Flow Recorded

B. Wastewater and Runoff Water Treatment and Control

The NPDES permit for Rhodia, Inc., which expired June 30, 1977, required the following effluent limitations in condition 10 prior to July 1, 1977:

Parameter	Monthly Average	Maximum
COD		
July 1-Sept 30	4660 mg/l & 5600 lb/day	7070 mg/l & 5600 lb/day
Oct 1-June 30	4660 mg/l & 5600 lb/day	7070 mg/l & 9000 lb/day
BOD		
July 1-Sept 30	2600 mg/l & 2000 lb/day	3600 mg/l & 3000 lb/day
Oct 1-June 30	4000 mg/l & 2500 lb/day	5000 mg/l & 3500 lb/day
Suspended Solids	6000 mg/l & 3000 lb/day	10,000 mg/l & 6000 lb/day
Total Dissolved Solids	72,000mg/l & 60,000 lb/day	96,000 mg/l & 100,000 lb/da
Temperature		
(June 1-Oct 31)	140° F	160° F
(Nov 1-May 31)	130° F	140° F
Total Phenolics	1.0 mg/l & 1.2 lb/day	2.0 mg/l & 2.4 lb/day
Chlorinated Hydrocarbons	20 mg/l & 24 lb/day	30 mg/l & 36 lb/day
pH	6.0-11.0	
Flow	Shall not exceed 0.144 MGD	

After July 1, 1977, Rhodia committed to connecting the process wastewater to the City of Portland sewer system. The connection was made and the facility is now operating under the following pretreatment requirements from the city:

Parameter	Limitation
COD	1000 mg/l
BOD	400 mg/l
TSS	100 mg/l
Phenol	10. mg/l
Chlorinated Hydrocarbon	2.7 mg/l
pH	6.0 to 9.0

No

Condition 11 of the NPDES permit required that all other discharges to the Willamette River after July 1, 1977, comply with the following limitations:

Parameter	Monthly Average	Maximum
COD	500 mg/l & 600 lb/day	1000 mg/l
BOD-5	200 mg/l & 240 lb/day	400 mg/l
Suspended Solids	50 mg/l & 60 lb/day	100 mg/l
Temperature		
(June 1-Oct 31)	120° F	130° F
(Nov 1-May 31)	105° F	115° F
Total Phenolics	0.5 mg/l & 0.6 lb/day	1.0 mg/l
Chlorinated Hydrocarbons	1.35 mg/l & 1.6 lb/day	2.7 mg/l
pH	6.0 - 9.0	

At this time the new permit for Rhodia has not been issued. However the proposed effluent limitations are as follows:

Outfall Number 001 (plant runoff, boiler & cooling tower blowdown)

	Concentrations	
	Monthly Ave. mg/l	Daily Max. mg/l
Suspended Solids	50 mg/l	100 mg/l
Total Phenolics (chlorinated & unchorlinated)	0.5 mg/l	1.0 mg/l
Chlorinated Hydrocarbons (Dichloromethane)	1.35 mg/l	2.7 mg/l
TOC	163 mg/l	360 mg/l

Other Parameters	Limitations
pH	Shall not be outside the range 6.0 - 9.0
Temperature	
(November 1 - May 31)	Shall not exceed 95 F
(June 1 - October 31)	Shall not exceed 100 F

The inspection was made prior to completion of the new treatment plant. At that time Rhodia collected and treated all process water in the facility and collected and treated runoff water from the MCPA plant and the 2,4-D building. All other drainage water from the plant site north of the office was piped to the rainwater sump and then discharged, without treatment, to the Willamette River with the treated effluent. Drainage water to the south of the office entered the storm drain system directly.

The old treatment facility consisted of three equilization tanks, two carbon absorption columns, a neutralization tank and a final holding tank prior to discharge. A furnance originally installed for regeneration of the carbon was shut down because it was not reliable. The final holding tank had a capacity of 12,000 gallons and was used to return treated effluent to the carbon columns if the effluent did not meet the specified standards.

The Company has had difficulty in the past two years meeting the interim permit limits specified for phenolics, pH, temperature, and solids. The cause was reported to be the lack of raw water and treated water holding capacity. This made it impossible to recycle any inefficiently treated effluent prior to discharge. Another problem area was the contaminated area drainage which had been discharged without treatment in the past. This water leaches spilled chemicals from the soil and is generally much more contaminated than the treated effluent.

In an attempt to obtain consistent treatment, Rhodia constructed an additional treatment facility which provides adequate holding capacity for the process wastewater. The new facility, located north of the original facility, consists of a 160,000 gallon equilization tank, two carbon absorption columns, neutralization tanks, and four 60,000 gallon holding tanks. Treated process waste effluent is discharged to the city of Portland sewage treatment plant. This facility was completed August 23, 1977, and is reportedly meeting the permit limits.

At the same time, the area drainage water is collected in the original system and sent to two 100,000 gallon holding tanks where it is sampled. If the sampling indicates unacceptable levels of contamination, it is treated in the 2 carbon columns of the original treatment facility and then discharged to the Willamette River.

Plans have also been made to make the ground within the diked storage areas impermeable and route the collected water to the drainage water treatment facility. Completion of this project will depend upon the availability of funds and priority with other projects.

C. <u>Conclusion</u>

1. By increasing the holding and treating capacity of the plant's process wastewater treatment facility, it is assumed there is adequate control for meeting the pretreatment requirements of the city of Portland. Analysis of the treated process water sampled during the survey shows no levels of measured toxics which represent serious problems, considering the presently available information.

2. The runoff and seepage water represents a substantial source of pollutants. The values in the sample analyses show a total chlorinated hydrocarbon concentration of 43.5 mg/l and a total phenolic concentration of 41.6 mg/l. Due to the extensive soil contamination shown in the soil sample analyses, this problem can be expected to continue.

3. Insufficient information was obtained in the survey to determine the fate or quality of the runoff in the south part of the plant. It is assumed, however, that the water is also contaminated based upon the soil sample from the empty drum storage area.

4. The proposed limits for the discharge of runoff water and boiler and cooling tower blowdown place limitations on the concentrations only with no quantity limitations. Assuming lower concentrations during high runoff periods, this makes it possible to meet the effluent limitations by dilution through holding during low runoff and discharging during high runoff.

5. The presence of 2,4,5-T in the soil samples was not expected at the levels shown in the analyses (30-1000 ppb). As a result no analysis for dioxins was made. The presence of 2,4,5-T is evidently due to past handling in addition to the previous manufacturing activities, since it was not detected in the process effluent. The survey performed was not adequate to identify the potential problems associated with the 2,4,5-T other than to verify its presence in the runoff water and the soil.

VI. Solid Waste Disposal

All contaminated solid waste material is collected in bins and shipped for disposal to the Chem-Nuclear Facility at Arlington, Oregon. The quantity and type of material was not determined.

VII. Recommendations

1. Air samples should be taken from each of the scrubber stacks and analyzed for total hydrocarbon content and for specific organic compounds. The specific compounds searched for should include all the products manufactured at each location as well as by-products. No urgency for doing this - may be something to do under Toxic Substance Act -
2. An attempt should be made to do a mass balance over the plant to see what the chemical losses are.
3. EPA should secure or at least ask to read the report by the Company's consultant before doing any work mentioned above. Larry is following up to obtain copy of report re 11-3-77
4. An additional survey should be performed concentrating on determining the extent of the soil contamination, the fate of the runoff in the the south area of the plant and the west boundary, and the extent of the contamination in the soil along the discharge ditch, Doane Lake and the outfall area in the Willamette River. In addition, the performance of the runoff water treatment system should be monitored. The parameters measured for should include 2,4-D, 2,4-DB, MCPA, 2,4,5-T, Bromoxynil, phenols, cresols, and dioxins.

IT IS No. 111

5. The effluent limits in the proposed permit should be changed to include a quantity limitation. The limitation should be calculated on the basis of the concentration limit at a maximum flow of 100,000 gallons per day (gpd)

A review of the past two years monitoring reports, indicates a maximum flow of approximately 130,000 gpd. From the available background information, the process flow contribution ranged from approximately 40,000 to 80,000 gpd. The 199,000 gpd figure allows for considerable error in these figures plus unusually periods of rain.

If concern still exists regarding loadings during periods of exceptionally heavy rainfall, a clause should be included which drops the load limitations when the flows exceed 100,000 gpd due to the heavy rainfall. The concentration limitations would, of course, still be in effect.

6. The quantity and type of solid waste should be determined. Samples should be taken of appropriate materials and analyzed for the same parameters as indicated in recommendation number 4.

TYPES LISTED.

Results of Sample Analyses

Survey of Rhodia, Inc, Portland, Oregon
April 22, 1977

Parameter	#16302 (treated effluent) ppb	#16304 (runnoff water) ppb	#16305 (soil from storage area) ppb	#16306 (soil from east ditch) ppb
Monochlorophenol	trace	ND	ND	ND
Dichlorophenol	trace	6200.	ND	ND
Trichlorophenol	ND	23000.	3200.	ND
Tetrachlorophenol	0.73	18.	120.	2.
Pentachlorophenol	ND	ND	100.	2.
2,4-D	142.	26000.	31000.	10000.
2,4-DB	39.	7100.	6000.	50.
2,4,5-T	ND	30.	420.	1000.
MCPA	137.	10400.	4900.	1900.
4-Chloro-2-methylphenol	trace	ND	ND	ND
Phenol	24.	7400.	1400.	200.
Bromoxynil	33.	1600.	.01	.06
	24. AV=29	1300. AV=1450		

ND=Not Detected

VOLATILE ORGANICS

Parameter	#16301 (treated effluent) ppb	#16303 (runnoff water) ppb
Acetone	41.	8880.
Methylene Chloride(dichloromethane)	172.	9145.
Carbon Tetrachloride	FID - did not show	FID - did not show
Toluene	5.K	55.
Xylenes and ethyl benzene	5.K	25.

K=less than

Rhodia
A SUBSIDIARY OF RHONE-POULENC

RHODIA INC.
6200 N.W. St. Helens Road, Portland, Oregon 97210
Telephone 503-222-3571 Telex 360329

July 1, 1977

Mr. J. Scott Warner
Senior Research Chemist
BATTELLE
505 King Avenue
Columbus, OH 43201

Dear Mr. Warner:

In response to your letter of May 24, my apologies for the long delay.

You have permission to include the data on our process samples obtained by L. Sims and D. Stefani on April 22.

Very truly yours,

R. F. Gitschlag

R. F. Gitschlag
Plant Manager

RFG:bjf

cc
JBV
Mr-P -
Do you think it is OK + should NEW SAMPLES BE TAKEN AFTER SYSTEM REVISION
RB 5-31
5/31/77

Battelle

Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201
Telephone: 614-424-6424
Telex 24-5454

May 24, 1977

Mr. R. F. Gitschlag
Plant Manager
Rhodia, Inc.
Agricultural Division
Box 10224
Portland, Oregon 97210

Dear Mr. Gitschlag:

Battelle's Columbus Laboratories would like to enlist the aid of you and your company to help develop a data base on organic compounds being discharged to surface waters. This effort is under contract with the U.S. Environmental Protection Agency's Office of Toxic Substances, Washington, D.C., and Environmental Research Laboratories, Athens, Georgia.

We would like your permission to include in our program the process effluent sample collected from your facilities by Larry Sims and Dennis Stefani of Region X EPA on April 22.

All data generated on the samples from your plant will be sent to you by EPA as soon as possible. You will also be sent a copy of the final report on this project when it is published.

We do not have a predefined list of compounds that we are looking for but are utilizing a general separation methodology with gas chromatography-mass spectrometry to identify and semiquantify the organic components present in final aqueous effluents from various types of process industries. The spargeable volatiles and extractable neutral, acidic, and basic fractions will be analyzed separately. We will attempt to identify as many as possible of the organic components that we find.

If you need further information, please call either me at (614-424-5643) or Dr. Pauline A. Clarke (614-424-5590), at Battelle Columbus Laboratories. We look forward to hearing from you in the very near future.

Sincerely,

J. Scott Warner

J. Scott Warner
Senior Research Chemist
Organic, Analytical, and
Environmental Chemistry

JSW:jeb

RECEIVED
MAY 31 1977
PORTLAND

MISSOURI-KANSAS-TEXAS RAILROAD COMPANY

6/20/77

RZS —

Didn't send Sims a copy — did not have address for him.

OK Done 7/1/77

Rhodia
A SUBSIDIARY OF RHONE-POULENC

RHODIA INC.
6200 N.W. St. Helens Road, Portland, Oregon 97210
Telephone 503-222-3571 Telex 360329

June 16, 1977

Mr. George Jett
U. S. Environmental Protection Agency
Washington, DC 20460

Dear Mr. Jett:

This spring we received a report from Environmental Science and Engineering, Inc., (ESE) about our water treatment system. Although a good report, I wish to make comment to several details in this report. Some of the data reported does not agree with actual operations for 1977 and/or with our data.

1. Page 1, paragraph 3.

   During the visit three plants were operating, that is, dichlorophenol, 2,4-D and esters.

2. Page 1, paragraph 4.

   HCl being dumped is up to 3000 gallons per day.

3. Page 1, paragraph 5.

   Would it be possible to obtain a copy of page 6221 of the confidential file?

4. Page 1, paragraph 6.

   We monitor total phenols, not just phenol.

5. Page 5, paragraph 1.

   The tanks referred to are not redwood, they are Douglas Fir, and the tanks contain 15,000 lbs of carbon and are approximately 18,000 gallon tanks.

6. Page 5, paragraph 2.

   Stored effluent will be recycled only in our new system. We have not had to do this in our old system.

7. Page 5, paragraph 6.

The 2.3 milligrams per liter reported does not agree with our lab data. I would appreciate your discussing this with Mr. Vernetti to determine a more probable number, test method, etc.

8. Page 10, paragraph 1.

The daily maximum pretreatment requirements table is not correct. These specifications are interim specifications set by the State for the release of our effluent to the river. The only specifications for pretreatment required by the city are pH 6 - 9, chlorophenolic compounds at 1 mg/l maximum, and sulfate ion of 500 mg/l maximum. Any other compound is on an excess charge basis and/or a sewage plant activity index.

Attached is my copy which shows the pages and paragraphs noted for your ease in reference.

Sincerely,

R. F. Gitschlag
Plant Manager

RFG:bjf

Attachment

cc: Mr. L. Sims
Mr. L. Patterson

INTRODUCTION

Environmental Science and Engineering, Inc., (ESE) visited and sampled the Rhodia Chipman (Portland, Oregon) facility during December 13 through 17, 1976. Key participants were: Gary Konkel (Rhodia Environmental Supervisor); George Jett (EPA); Jim Cowart (ESE Project Manger); Erik Olson (ESE Team Chief); and Larry Johnson (ESE Sampling Technician).

Two groups of samples were collected. Group one consisted of 24-hour composites taken at the influent, mid-point, and effluent of the activated carbon columns for five consecutive days (The fifth day was abbreviated to 8 hours). This group was analyzed for BOD, COD, TOC, TSS, Phenol, and 2,4-D. Group two consisted of one 24-hour composite of intake water, influent to activated carbon, and effluent from neutralization (See Figure 1). This group has been extracted for future analysis of priority pollutants. Flow was measured by a permanently installed magnetic meter. Analytical methodology is presented in Appendix 1.

PROCESS

The plant produces 2,4-D, 2,4-DB, MCPA, MCPB, Octyl esters of the above, and Bromoxynil Octanoate. During the plant visit only 2,4-D acid was produced.

WASTEWATER CHARACTERISTICS

Historical data indicated that the waste would be high in chlorides, phenol, glycolic acid, acetic acid, and pesticides. Several conditions were noted which should be taken into consideration when interpreting present and previous data. During the sampling period, and since June 1976, approximately 150 gal of HCL was being dumped three times per day, due to lack of market. In addition, the steam stripping unit utilized for phenol recovery was down from May 10 through October 20, 1976, thereby elevating phenol concentrations considerably.

Tables 1 and 2 present the concentrations and mass loadings for the raw waste load sampling. Each of the daily flows (expressed in terms of gal/1000 lbs produced) was well within the range of monthly average flows shown in Table VII-5 of the Pesticide Development Document. This demonstrates the similarity of wastewater generation from 2,4-D acid only, when compared to previous data taken during the production of from three to seven different products (See page 6221, confidential file).

The only raw waste parameter monitored by Rhodia is phenol, and the average of 77.9 mg/l was within expected levels. Problems did develop in measuring BOD by using a dissolved oxygen meter. After five days an oily, volatile substance developed causing an interference. The three samples with sufficient volume remaining were re-analyzed using the Winkler Titrametric Method (Azide Modification), and satisfactory results were obtained.

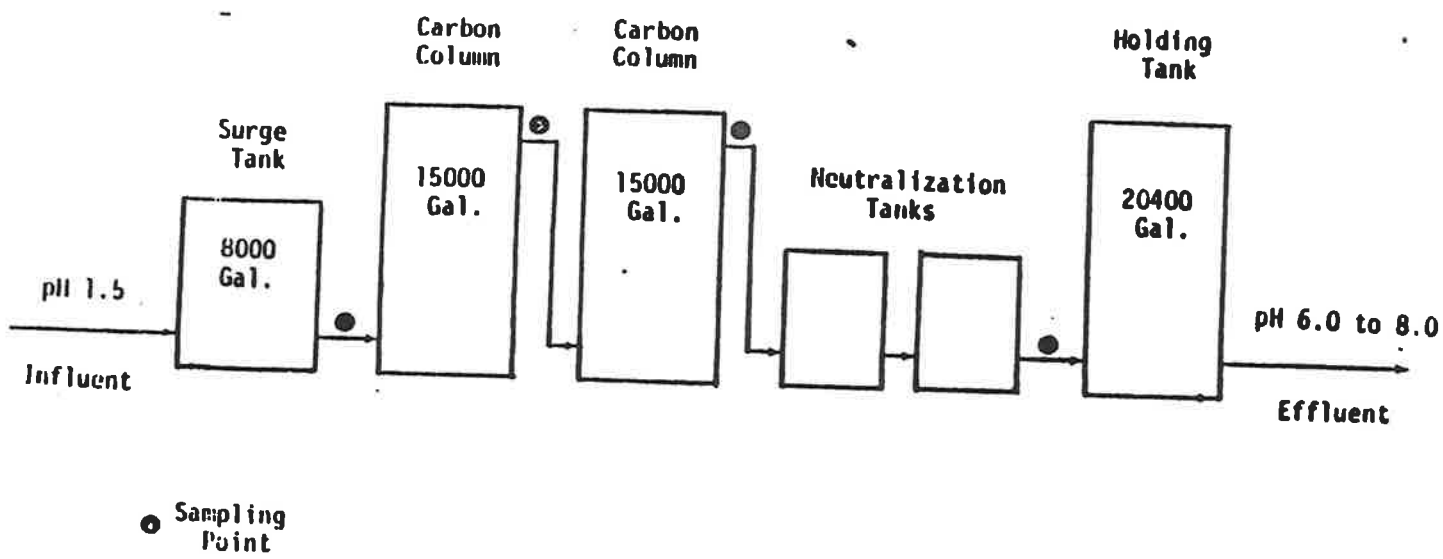


Figure 1
Treatment System Diagram
Rhodia (Portland, Or)

Table 1

Wastewater Characteristics

Influent to Activated Carbon

Date	Flow (MGD)	BOD (mg./l)	TOC (mg./l)	TSS (mg./l)	TDS	COD (mg./l)	Total Phenol (mg./l)	2,4-D (mg./l)
12/13-14/76	.0756	1890	2327	63	—	5028	49.4	136.6
12/14-15/76	.0594	2130	2779	76	—	4879	*	63.8
12/15-16/76	.0637	*	2609	93	—	4751	184.5	0.14
12/16-17/76	.0551	870	1281	72	—	10,243	40.0	57.7
12/17/76	.0880	*	2128	40	—	3983	38.0	33.6
AVERAGE	.0684	1630	2225	69	—	5777	77.9	58.4

* Analytical Interference

MGD IS MILLION GAL/DAY.
OR 75,000 G/D OR ~60 GPM.

? - WHAT WAS RUNNING → DCP ESTERS - OR BC -

Table 2

Wastewater Characteristics

Influent to Activated Carbon

Date	Flow (gal/1000lbs)	BOD (lb/1000lbs)	TOC (lb/1000lbs)	TSS (lb/1000lbs)	TDS (lb/1000lbs)	COD (lb/1000lbs)	Total Phenol (lb/1000lbs)	2,4-D (lb/1000lbs)
12/13-14/76	1984	31.4	38.6	1.05		83.4	0.820	2.27
12/14-15/76	1142	20.3	26.5	0.724		46.5	*	0.608
12/15-16/76	1517	*	33.0	1.18		60.1	2.33	0.00177
12/16-17/76	1147	8.33	12.3	0.689		98.0	0.383	0.552
12/17/76	1912	*	33.9	0.638		63.5	0.606	0.536
AVERAGE	1540	20.0	28.9	0.856		70.3	1.03	0.703

* Analytical Interference

2000
50
100,000

TREATMENT AND CONTROL TECHNOLOGY

As noted in Figure 1, the wastewater enters an 8000 gal surge tank at pH 1.5, passes upflow in series through two open? 15,000 gal redwood tanks charged with carbon, is neutralized by lime to pH 6.0-8.0, and then goes to a 20,400 gal holding tank prior to discharge to the Willamette River.

Operating procedures for Rhodia are to monitor for phenol every four hours between the columns, and after neutralization in order to maintain maximum levels of 10 mg/l and 1 mg/l, respectively. Stored effluent is recycled through the system until established goals are achieved. If effluent quality can not be met, the lead bed is flushed, charged with new carbon, and plated in the trail position. When sampling commenced on December 13 the lead bed was seven days old, the trail bed was two days old.

Concentrations and mass ratios for samples taken between and after carbon columns are presented in Tables 3, 4, 5, and 6. Expressed as percent reductions, the performance of the columns was as follows:

Percent reduction	BOD	COD	TOC	TSS	Phenol	2,4-D
	NA	62.2	78.0	*	97.5	99.9

* Due to the location of our effluent sampling point at the top of the column, carbon fines were responsible for an apparent increase in solids.

In terms of effluent guideline development several factors are worthy of note:

1. Whereas the halogenated organic guideline is based in part on the Rhodia chlorinated hydrocarbon level of 0.99 mg/l (expressed as dichloromethane), the actual level of pesticide in the wastewater is closer to 0.037 mg/l. This equates to 0.000505 lb/1000 lbs compared to the 30 day maximum recommended guideline of 0.00306 lb/1000 lbs. These data indicate that Rhodia can meet the pesticide limitation with current treatment.

2. COD reductions through activated carbon, not previously available for the HO subcategory, were higher than anticipated. The Rhodia effluent of 26.6 lbs/1000 lbs comes close to meeting the 30 day maximum of 21.2 lbs/1000 lbs, without the biological treatment recommended for the model plant.

3. Phenol effluent of 2.32 mg/l exceeded Rhodia's internal standards and permit discharge limits, and presumably these volumes were recycled before discharge. The level previously attributed to Rhodia was 1.58 mg/l, which is still applicable.

PROPOSED SYSTEM MODIFICATIONS

After July 1, 1977 all wastewater and contaminated area drainage will be treated, tested, and discharged to the City of Portland with the

Table 3

Wastewater Characteristics

Between Primary and Secondary Carbon Columns

Date	Flow (mg/l)	BOD (mg/l)	COD (mg/l)	TOC (mg/l)	TSS (mg/l)	Total Phenols (mg/l)	2,4-D (mg/l)
12/13-14/76	0.0756	----	----	----	----	----	----
12/14-15/76	0.0594	1740	4071	2128	88	20.4	< 0.005
12/15-16/76	0.0637	1200	3510	1902	76	2.9	5.2
12/16-17/76	0.0551	*	5797	2185	90	9.8	6.8
12/17/76	0.0880	*	5065	2214	97	7.2	4.7
AVERAGE	0.0684		4611	2107	87.7	10.1	4.100

* Analytical Interference

Table 4

Wastewater Characteristics

Between Primary and Secondary Carbon Columns

Date	Flow (gal/1000lbs)	BOD (lb/1000lbs)	COD (lb/1000lbs)	TOC (lb/1000lbs)	TSS (lb/1000lbs)	Total Phenols (lb/1000lbs)	2,4-D (lb/1000lbs)
12/13-14/76	1984	----	----	----	----	----	----
12/14-15/76	1142	16.6	38.8	20.3	0.838	0.194	0.000047
12/15-16/76	1517	15.2	44.4	24.1	0.962	0.0367	0.065800
12/16-17/76	1147	*	55.5	20.9	0.861	0.0938	0.065000
12/17/76	1912	*	80.8	35.3	1.150	0.115	0.074900
AVERAGE	1540	----	54.9	25.1	0.953	0.110	0.051400

* Analytical Interference

Ta. . 5

Wastewater Characteristics

Effluent At Secondary Carbon Column

Date	Flow (gal/1000lbs)	BOD (lb/1000lbs)	COD (lb/1000lbs)	TOC (lb/1000lbs)	TSS (lb/1000lbs)	Total Phenols (lb/1000lbs)	2,4-D (lb/1000lbs)
12/13-14/76	1984	*	45.4	5.28	1.66	0.0083	0.000829
12/14-15/76	1142	7.43	21.2	10.30	0.972	0.0505	0.0000476
12/15-16/76	1517	*	18.4	9.77	1.59	0.0557	0.00152
12/16-17/76	1147	*	27.8	2.24	0.919	0.0105	0.0000477
12/17/76	1912	*	20.5	4.19	1.93	0.00478	0.0000797
AVERAGE	1540		26.6	6.35	1.42	0.0259	0.000505

* Analytical Interference

Table 5

Wastewater Characteristics

Effluent At Secondary Carbon Column

Date	Flow (mg/l)	BOD (mg/l)	COD (mg/l)	TOC (mg/l)	TSS (mg/l)	Total Phenols (mg/l)	2,4-D (mg/l)
12/13-14/76	0.0756	*	2739	318	100	0.5	0.05
12/14-15/76	0.0594	780	2226	1081	102	5.3	<0.005
12/15-16/76	0.0637	*	1455	772	126	4.4	0.120
12/16-17/76	0.0551	*	2910	234	96	1.1	<0.005
12/17/76	0.0880	*	1285	263	121	<0.3	<0.005
AVERAGE	0.0684		2123	533.6	109	2.32	0.037

* Analytical Interference

following daily maximum pretreatment requirements:

COD - 1000 mg/l
BOD - 400 mg/l
TSS - 100 mg/l
Phenol - 1.0 mg/l
Chlorinated hydrocarbon - 2.7 mg/l
pH - 6.0 to 9.0

NOT CORRECT

In order to comply with these requirements Rhodia is constructing effluent storage tanks equal to approximately one day's flow, so that effluent may be recycled through the carbon. Certain studies have been performed which are reported below.

Rhodia commissioned a study by Bryan M. Johnson and Associates of Portland to determine if the proposed hook-up would interfere with the city's system. Based upon a projected 500:1 dilution factor (compared to a 10:1 factor at a similar plant in Jacksonville, Arkansas) no deleterious effects were predicted. Rhodia conducted a small pilot study to verify this conclusion.

Certain organics generated by Rhodia, such as glycolic and hydroxy propionic acids, create COD loads which are not readily absorbed by activated carbon. Alternative strategies for treatment are: (1) wet oxidation (Lockheed); or (2) electrolytic oxidation (Pepcon).

APPENDIX 1
ANALYTICAL PROCEDURES

BOD - Originals by dissolved oxygen meter with semi-permeable membrane. Due to interference, re-analyzed by Winkler titrametric method (Azide modification).

COD - Chromic acid reflux method.

TOC - Beckman infra-red analyzer.

TSS - Gravimetric analysis with glass fiber filter.

Phenols - Gas chromatograph analysis for eight isomers.

2,4-D - Extraction with methylene chloride-hexane mixture then derivatization with diazo ethane. Gas chromatographic methods with electron capture detector used for quantification.

Rhodia

OFFICE MEMORANDUM

DIVISION AGRICULTURAL

cc: JFV 24
4-17-78

To: M. P. Lavalleye

Date: April 12, 1978

From: J. E. Davies

Subject: Dioxines

To confirm our conversation on the above subject I would like you to form a task force to define our course of action as far as dioxine analysis is concerned. The task force should define all products produced, purchased or handled at any degree within the Division that have the capability of forming dioxines. Once this is defined we should find alternative methods of analyzing for dioxine content and the cost of each alternative so that we can make a decision that will give us assurance that we are meeting all legal and moral requirements at the lowest possible cost.

J. E. Davies

J. E. Davies

JED/dju
cc: E. Clark
R. F. Gitschlag
D. Tevebaugh
R. Wilson

MIKE TO VISIT TUESDAY

1. DIOXINES — SCOPE PROBLEM FOR ALL PRODUCTS — ASSAY METHOD & OPTIONS
2. NITROSOAMINES
3. PROCESS CHEMISTRY — NEW ASSAY COMP.
4. EPA AND 100 OR 1000 PPB GUIDELINES
5. PRODUCT QUALITY CENTRAL TASK FORCE
6. ORGANIZATION OF TECHNICAL LABS & PLANT PROCESS LABS & DIRECTORS —
7. [illegible]

RECEIVED PORTLAND

Rhodia

OFFICE MEMORANDUM

DIVISION Agricultural

To: R. F. Gitschlag

Date: April 20, 1978

From: Jack B. Vernetti

Subject: DIOXIN REVIEW, PROPOSED ANALYTICAL PROGRAM & LABORATORY FACILITIES NEED

cc: J. E. Davies
M. Lavalleye

I. Review of Dioxin possibility in Rhodia Products.

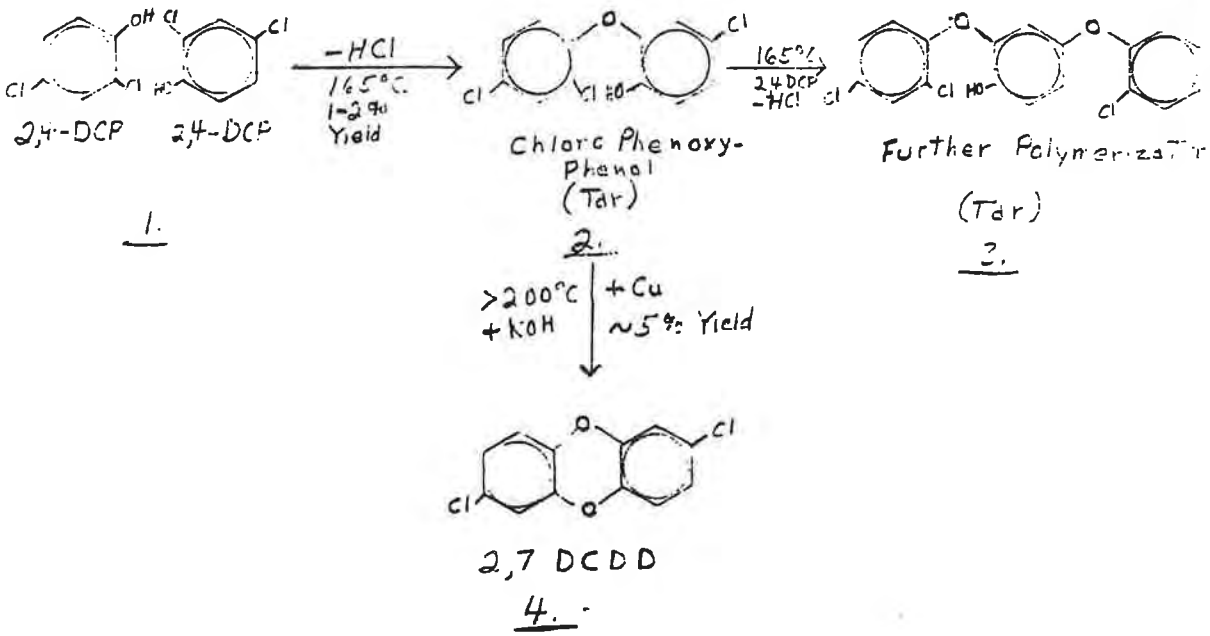
With the exception of purchased 2,4,5-T and 2,4,5-TP products, our technical phenoxyacids should not contain the highly toxic and publicized 2,3,7,8 TCDD (2,3,7,8 tetra chloro dibenzo-p-dioxin). This toxicant arises during the manufacture of 2,4,5-TCP. The 2,4,5-TCP is used in production of 5-T and TP acids. In our process the possibility of making the 2,3,7,8 TCDD is virtually non-existent for the following reasons:

1. 2,4,5-TCP is not in our system, only ortho-para substitution occurs producing the 2,4 and 2,6 and 2,4,6 chlorophenols; thus 2,3,7,8 TCDD cannot be made. The lab has examined distilled DCP for 2,4,5-TCP and none was found at a 200 ppm minimum detection level.

2. The conditions of manufacturing the chlorophenols do not anywhere near approach the conditions (high temperature, high pressure, and high alkalinity) of 2,4,5-TCP manufacture.

3. The conditions of 2,4-D production from 2,4-DCP are in an alkaline media but the temperature and pressures are much lower than the nearly pyrolytic conditions needed to produce dioxin.

If dioxins could be made in our system the most likely ones would be, among others, 2,7 DCDD and 1,3,6,8 TCDD and not 2,3,7,8 TCDD. These would be in our tar bottoms (DCP tower) if formed, not in the product acids. The only probable cause for the dioxins to form would be the temperatures reached during chlorination and in the still bottoms at about 160 - 165°C. However, since this temperature is lower than pyrolysis conditions and with the absence of caustic, the formation is very limited, if at all. We do make tars in the chlorination system which are concentrated in the tower bottom. The tars are principally chlorophenoxyphenols. The reactions are shown on page two.



In our system step 3 occurs instead of step 4 because there is always chlorophenols present and the conditions favor the polymerization. We have examined our tars produced on the old still (around 1973) and did not find any 2,7 DCDD. Sensitivity of the test was 200 ppm.

The possible dioxins that could be made in the still bottoms besides 2,7 DCDD are 3,6 DCDD (2,4 and 2,6 DCP); 1,6 DCDD (2,6 and 2,6-DCP); 2,4,7 tri CDD (2,4-DCP and 2,4,6-TCP); 1,6,8 tri CDD (2,6-DCP and 2,4,6-TCP); and 1,3,6,8 TCDD (two 2,4,6-TCP's).

The toxicology of the above materials are for the most part not known except for 2,7 DCDD. In the reports examined 2,7 DCDD has an LD_{50} of about 1 gram/kilogram in rats. In the only comparison seen (Nature, Vol. 220, p 703, 1968) a 2,4,6-TCP pyrolysate, which is presumably 1,3,6,8 TCDD, killed 50% of chick embryos at 5 ug/egg compared to 2,3,7,8 TCDD 100% kill of 0.25 ug/egg. 2,7 DCDD in the same report listed 500 ug/egg necessary to kill 70%.

The result indicates that 1,3,6,8 TCDD is less potent than 2,3,7,8 TCDD which has a LD_{50} in rats of around 1 ug/kg. Even though the 1,3,6,8 TCDD appears to be some 20 - 40 times less toxic from the embryo test, it still can be classified as strong toxicant.

I discuss these tars as a possible future solid waste problem could also exist, principally in that we don't know for sure if any of these exist

in our tars at the low levels of ppm or ppb. We do not have the standards, except 2,7 DCDD, to check these out. We did not synthesize any of the above (except 2,7 DCDD) since the toxicology is not known, and our lab is not equipped to do so under current regulations. In truth, at present we are not even supposed to have any 2,3,7,8 TCDD standard about (we had 25 mg several years ago to do the work on our technical acids).

The possibility that dioxin is found in chlorination or distillation may get into the product acids is not probable as dioxin boiling points are very high and they must pass through a 50 plate still. However, we have no data supporting the hypothesis.

Our examination of the technical acids did not show any 2,3,7,8 TCDD nor 2,7 DCDD. The summary report CLR 197 (attached) shows the results on 1970 composite samples. In addition, we ran assays on 2,4-DP (our production) and found none of the above dioxins. Since all of this work is so old, it should be repeated.

In summary: (1) we are reasonably sure that 2,3,7,8 TCDD is not present in our technical acids; (2) there is a very remote possibility of other dioxins of which: one is not toxic, one which is toxic (1,3,6,8 TCDD), and four possibilities in which toxicology is not known, and (3) since the work done is several years old it should be repeated and should include all the dioxin possibilities.

II. Proposed Work and Cost

If we elect to go ahead and look for all the possible dioxins in our products, the standards would have to be prepared here. Thus more precautions will have to be made. Also, if continuous monitoring is a necessity, the lab needs a permanent setup.

To do the work of synthesis of the dioxins and analysis of products would require a special lab that can meet regulations (am currently looking into this). We would, as a first step, convert Lab 3 (our most isolated) into a fully ventilated room with a modification of the current hood (which can be lined with plastic for synthetic reactions and purification). The plastic would be removed after use and properly disposed of. The hood and room exhaust should pass through a carbon filter to remove organic compounds. Our conventional caustic scrubber will not remove neutral compounds such as dioxins. The carbon used for venting should be stored in drums and shipped to Arlington for burial. The equipment used in the experiments will have to remain in this lab. If we have to do continued monitoring, this would be necessary anyway. The work benches would have to have new non-porous washable tops. The floor, walls and ceiling would have to be sealed and easily washable. A new sink with side lips is necessary, also the work bench tops should have lips to contain spillages. An electron capture detector GLC and balance would be purchased for the work. Glassware and miscellaneous items would bring the total cost to approximately $14,500. This is providing that the State DEQ does

not require special systems such as separate water waste treatment. I don't know whether we would have to use disposable work clothes.

Outside work may be necessary such as mass spectrometry. There is a lab in Seattle that can do this for us when needed. For instance, the Rohm & Haas method for 1,3,6,8 TCDD and 2,3,7,8 TCDD in 2,4,6-TCP requires mass spectroscopy. If we do the work, sample preparation, and cleanup, the cost would be about $200 - $300/sample initially and around $100 for succeeding samples.

III. The Speculative Future

The above (II) is a first step estimate, based on dioxin procedures only. It may be that in conjunction with other work such as nitrosoamines, future TOSCA, OSHA, EPA, Oregon DEQ, etc., the best course is to develop a much more sophisticated instrument setup to handle these problems. Assuming that what has been suggested, threatened, or anticipated by government agencies for new standards of regulations and monitoring requirements will come to pass, the following list of equipment and costs is prepared.

Please see page five

Item	Purpose	Approx. $ Cost
Atomic absorption	Fe,Na,Ni,Cr in water effluent and products	10,000
Liquid Chromatography	AOAC isomer assay Proc. Impurity isolation (TOSCA - OSHA)	20,000
GLC Mass Spectroscopy	Dioxins, Nitrosoamines, Impurity identification and quantity in products, Monitoring ambient air (OSHA), others?	70,000
Lab Conversion	Convert Retain Room into new Quality Control Lab; Chemist office into instrument room, and Lab 3 to toxic hazard and clean room	40,000
Increased Operational Costs/year	Extra Chemist, another technician (Technician total 6 - 7), lab supplies, utilities	50,000
Contingency	Automation, Misc. Instruments and equipment	20,000
	TOTAL	210,000

The problem in all this is that it is highly subject to government regulations, but let's discuss it. Also, the St. Joseph Plant will need its "list." Right now the Portland production system is subject to more items or regulations than St. Joseph since actual production for end use materials is done here and therefore the stricter surveillance. However, when new regulations for finished goods monitoring go into effect St. Joseph will have a similar list, if not more.

Jack B. Vernetti

Jack B. Vernetti

JBV:bjf

Attachment

RHODIA INC.
CHIPMAN DIVISION
PORTLAND, OREGON
May 22, 1972

CLR NO. 179

DISTRIBUTION: Mr. L. H. Minsuk
Mr. R. F. Gitschlag
Laboratory

TITLE: ANALYSIS OF RHODIA 2,4-D, MCPA, 2,4-DB ACIDS FOR CHLORO-DIBENZO-p-DIOXINS

INTRODUCTION

The analysis of the product acids were run in 1970 and reported separately. It was decided to consolidate the results into one report.

ABSTRACT

The analysis of composites from 1970 production of MCPA, 2,4-DB, and 2,4-D for 2,3,7,8-tetrachloro-dibenzo-p-dioxin revealed that none of this substance was present. Analysis of 2,4-D and 2,4-DB for 2,7 dichloro-dibenzo-p-dioxin was also run. None was found in either product. Limit of assay sensitivity was 0.05 ppm for 2,3,7,8-TCDPD and 0.02 ppm for 2,7-DCDPD.

BASIC PROCEDURE

The composite acids were dissolved in aqueous sodium hydroxide and extracted with high purity petroleum ether. The extract was evaporated to a small volume and washed with concentrated sulfuric acid. The extract was then placed on an alumina column and eluted with petroleum ether-ethyl ether mixtures. The appropriate elution fraction was treated again with concentrated sulfuric acid. The final extract was reduced to dryness and dissolved in carbon disulfide and aliquots injected into a gas chromatograph fitted with hydrogen flame detectors. The columns used were Silicon SE 30 and OV 225 (a polar Silicon type). For each acid, the standard used was highly purified acid with the appropriate amount of 2,3,7,8-TCDPD and 2,7-DCDPD added. Blanks on the purified acid and reagents were also run. All blanks, reagents, and standards were run through the same procedure as the sample.

RESULTS

The MCPA, 2,4-D and 2,4-DB were examined for 2,3,7,8-TCDPD and none was found. The standard used was 1.0 ppm of the toxicant. The minimum measurable peak response corresponded to 0.05 ppm. The 2,4-D and 2,4-DB were, in addition, examined for 2,7-DCDPD and none was found. The limit of sensitivity was 0.02 ppm in these assays.

DISCUSSION

Difficulty with interfering peaks or high background was encountered as would be expected. By varying the basic procedures or adding cleanup steps, these were eliminated. In all cases, pains were taken to ensure that none of the dioxins would be inadvertently removed if present.

The composites taken for the assay work were from production processes which are the same at the current time. No step has been added which would promote the formation of dioxins.

CONCLUSION

The current production of herbicides does not contain the highly toxic 2,3,7,8-TCDPD. In addition, 2,4-D and 2,4-DB does not contain 2,7-DCDPD.

Gary R. Miller

Gary R. Miller

Jack B. Vernetti

Jack B. Vernetti

JBV/GRM/dvh

26

Rhodia

OFFICE MEMORANDUM

DIVISION AGRICULTURAL

To: J. E. Davies

Date: April 27, 1978

From: M. P. Lavalleye

Subject: Minutes of the April 25, 1978 Portland Plant Visit

cc. JBV 5-9-78

The initial subject was dioxine analysis as per your April 12, 1978 memorandum. Many other subjects came up.

I. PRODUCT QUALITY COMMITTEE

In the past, a Product Quality Committee had been organized to the effect of writing a Manufacturing Procedure Manual. I believe that the first thing to do is to resurrect this committee and to give it authority to keep the manual up-to-date, to establish quality rules, to determine the procedure to be followed, and to propose, decide, and follow-up work pertinent to product quality.

This committee, responsible to J. E. Davies, should be small. It is suggested to be composed of J. Vernetti (Chairman), R. Collins, L. Walaski, and an Agricultural Division Product Manager. They should have the right to call upon the occasional help of Product Development, Purchasing, or any other Rhodia specialists as the need arises.

Should this committee be operational and effective, we should have less "crises" such as the N-Nitroso, dioxine, and related ones.

II. N-NITROSO IMPURITIES PROBLEM

1. Purchasing should include the following in their specifications:

   a. The total amount of N-Nitroso impurities has to be below the level of 1 ppm (1 ppm) for DMA, triethylamine, diethanolamine, DMTOD, and Stephan Agent 39457. However, before having this level put into action, M. P. Lavalleye will check with R. Collins to verify whether the Visco-Rhap adjuvants (DMTOD and Stephan adjuvants) will not have an additive effect upon DMA. Also, the 1 ppm level is subject to revision, once the EPA regulations will be published (Action: M. P. Lavalleye).

2. The Product Quality Committee should take care of the following: $ 63000

   a. To determine the procedure for N-Nitroso sampling and analysis, once the St. Joseph personnel training is accomplished.

   b. To look at causes of the relatively high (1.5 to 3.0 ppm) content in N-Nitroso of the 2,4-D amine 6 batch, as revealed

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by the Thermo-Electron analysis report.

c. To elucidate the effect of nitrogen atmosphere on top of the DMA in the storage tank and to propose alternatives.

d. To follow-up upon any possible source of contamination of our products with N-Nitrosamine.

III. DIOXINE

1. Purchasing should buy 2,4,5-T with specifications of 2,3,7,8 tetrachlorodioxine content of less than 0.1 ppm.

2. J. Page, the corporate toxicologist, should produce an update on the toxicological properties of the various dioxines (2,3,7,8 tetrachlorodioxine; 1,3,6,8 tetrachlorodioxine; 1,6 and 2,7 dichlorodioxine, etc.) and of the chloro-phenoxy/phenol impurities (Action: M. P. Lavalleye).

3. Once Point 2 is completed, a decision should be made about putting a dioxine limit restriction on the other "phenol" compounds that we buy outside.

4. To be able to answer the buyer's request, we should proceed toward a Q.C. control of dioxine for our Rhodia manufactured compounds. The Product Quality Committee is to determine the number of analyses to be performed, the equipment, personnel, or alternative approaches, and the cost. The dioxine content of the tar should not be forgotten. The equipment needed should also be part of the impurity determination project defined later.

5. Please note that J. Vernetti has worked with the dioxine subject around 1972 and has broad experience in this matter.

6. A cost of $32.00 to $35.00 per sample for dioxine analysis seems to be quite low. J. Vernetti will contact R. Collins.

ISOMER LAB - $1000 @ 100/SAMPLE - 80/MO.
JBV TO GIVE EST OF COST

IV. ISOMER CONTENT

The decision to manufacture on an isomer content basis should be confirmed and properly diffused. The next steps are:

1. For Purchasing to buy on that basis.

2. For the Product Quality Committee to:

a. Write the assay procedure.

b. Establish the formulation procedure.

rhône-poulenc inc.

OFFICE MEMORANDUM

DIVISION TECHNICAL UNIT

To: Dick Gitchlag **Date:** October 18, 1979

From: J. P. Sibeud **Subject:** DIOXINE ANALYSIS

As I told you on the phone, I have discussed with Pierre Dufey the possibility of having some of the products that are manufactured in Portland routinely analysed by Decines. It was agreed that samples will be send to Decines from Portland every three months for a duration of three years.

I suggest that the following samples be sent:

- Crude D.C.P.
- D.C.P.
- 2,6 Tri-Chlorophenol mixture
- 2,4 D.C.P. tar
- 2,4-D Acid
- 2,4-D Extract
- 2,4 DB
- Spent carbon

BROMOXYNIL

As per our phone conversation of last week, Division Phyto has requested a report be written on the last Bromoxynil campaign from POBN imported from Japan. They are also interested in the purity of Bromoxynil obtained from that raw material.

Pierre Dufey would like to receive as soon as possible an analysis of the CPA received from Europe compared with the one from the POBN imported from Japan.

Thank you very much.

Jacques

J. P. Sibeud

cc: J. Davies
G. Kanner
M. Lavalleye

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THE DOW CHEMICAL COMPANY

POST OFFICE BOX 1706
MIDLAND, MICHIGAN 48640

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November 9, 1979

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DR. A. GUARDIGLI

AD
11/14/79

Dr. A. Guardigli
Manager, Analytical Services
Rhone-Poulenc, Inc.
P.O. Box 125, Black Horse Lane
Monmouth Junction, NJ 08852

Dear Al:

Thank you for your letter of October 19 requesting a copy of the paper Comparative Toxicology of Various Chlorinated Dioxins as Related to Chemical Structure which I presented at the CIPAC meeting last June. Ron Wilson had requested a copy some time ago but the enclosed manuscript was not finalized until just recently. It will be published in proceedings of the meeting, probably not until next year.

Sincerely,

Marguerite

Marguerite L. Leng, Ph.D.
Senior Registration Specialist
Product Registrations
Regulatory and Legislative Issues
Health and Environmental Sciences

Kate please xerox 11/14/79

cc M. Bugs
C Guyton
E. Clark
R. Wilson
M. McMullen
M. Lavallee
J. Vernetti

jh

Enclosure

cc: Dr. Ronald D. Wilson

A. Guardigli

COMPARATIVE TOXICOLOGY OF VARIOUS CHLORINATED DIOXINS AS RELATED TO CHEMICAL STRUCTURE *

Marguerite L. Leng

Health and Environmental Sciences
The Dow Chemical Company
Midland, Michigan
U.S.A. 48640

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DR. A. GUARDIGLI

SUMMARY

The generic term "dioxin" pertains to a family of compounds which are structurally similar but vastly different in toxicity. It is often used incorrectly to designate one member of the family, 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). There are 75 possible polychlorinated dibenzo-p-dioxins (PCDDs) with a million-fold spread in the dosage level required to kill laboratory animals. Those with four or five chlorines located at all four lateral positions (2,3,7 and 8) are extremely toxic. The toxicity is progressively decreased by moving one or more chlorines to peri positions (1,4,6 or 9), and/or by having fewer or more positions substituted. Data are reviewed from a number of studies demonstrating this relationship. The relative hazard from potential exposure to the highly toxic 2,3,7,8-TCDD is also discussed.

FORMATION OF DIOXINS

Low levels of polychlorinated dibenzo-p-dioxins (PCDDs) can be formed as byproducts during the manufacture of chlorophenols under alkaline conditions at elevated temperatures and high pressures. The reaction is a two-step process involving bimolecular condensation of chlorophenates followed by internal ring closure. The number and position of the chlorine substituents on the dioxins depend on the chlorophenates present in the reaction mixture.

For example, trace amounts of the highly toxic 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) are formed during the manufacture of 2,4,5-trichlorophenol by alkaline hydrolysis of 1,2,4,5-tetrachlorobenzene (Figure 1). This TCDD can be carried through into products made from 2,4,5-trichlorophenol, such as 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) and hexachlorophene [2,2'-methylene bis (3,4,6-trichlorophenol)]. Similarly, condensation of 2,4,6-trichlorophenate during its manufacture under alkaline conditions produces the expected 1,3,6,8-TCDD, as well as the isomeric 1,3,7,8-TCDD by Smiles rearrangement (Figure 2). On the other hand, the expected 2,7-dichloro isomer is not likely formed by condensation of 2,4-dichlorophenate under the acid conditions used in its manufacture by chlorination of phenol (Figure 3).

* Presented at symposium of Collaborative International Pesticide Advisory Council (CIPAC), Baltimore, Maryland, June 7, 1979

In all, 75 possible PCDDs could originate from condensation of chlorophenols with two to five chlorine substituents (Table 1).. Of these, 22 are tetrachloro isomers. However, as shown in Figures 1, 2 and 3, only symmetrically substituted isomers with an even number of chlorines are likely to be formed from reaction mixtures containing predominantly one chlorophenol such as in manufacturing processes.

Other isomers could also result from progressive chlorination or dechlorination of lower or higher analogs (Figure 4). However, photolysis in solution appears to preferentially remove chlorines from the lateral positions (Buser and Rappe, 1978). Thus isomers substituted at the 2,3,7,8-positions are not likely to be formed from higher PCDDs by the action of light.

TOXICOLOGY OF CHLORODIOXINS

Acute Oral Toxicity

The acute oral toxicity of several PCDDs has been investigated in guinea pigs, rats and mice (Schwetz et al., 1973; McConnell et al., 1978b). Table 2 lists the amount of chemical which would be expected to cause death of 50% of the animals within 30 days after administration of various isomers as a single dose by stomach tube in each species which has been tested. (Large numbers mean low toxicity and small numbers indicate high toxicity.) In all cases, guinea pigs were more sensitive than rats, and rats were more sensitive than mice.

The degree of toxicity is highly dependent on the number and position of the chlorine atoms. The lateral positions at 2,3,7 and 8 must be chlorinated to achieve the greatest toxicity. Additional chlorine atoms at the peri positions 1,4,6 and 9 reduce toxicity but not nearly to the degree caused by deletion of one or more chlorines at the lateral positions.

The toxic symptoms produced by single doses of the various isomers are similar if not identical — the only difference is the amount of the isomer required to produce a given effect. The effects of single lethal doses of TCDD in guinea pigs, mice and female monkeys are compared in Table 3 (McConnell et al., 1978a,b; Moore 1978). Typically there was an almost immediate dose-related effect on body weight, with loss of up to 50% in weight prior to death. Only monkeys exhibited cutaneous lesions comparable to the chloracne observed in humans, such as in some of the children accidentally exposed to TCDD following a runaway reaction in a trichlorophenol plant at Seveso in Italy in 1976 (Reggiani, 1978).

Enzyme Induction

The ability of various PCDDs to induce enzyme production is also correlated to structure in much the same way as acute toxicity. The 2,3,7,8-TCDD has been shown to be a potent inducer of δ-aminolevulinic acid

synthetase (ALA) and aryl hydrocarbon hydroxylase (AHH). ALA is the rate limiting enzyme in the synthesis of heme and porphyrins while AHH is an enzyme which catalyzes hydroxylation of compounds such as benzo[a]pyrene, a known carcinogen in humans.

The effect of PCDDs on these enzyme systems has been investigated by injection of p-dioxane solutions of 15 congeners into chick embryos (Poland and Glover, 1973b). Data outlined in Table 4 show a well-defined structure-activity relationship, requiring halogen atoms in at least three of the four lateral positions and at least one nonhalogenated ring position to cause induction of both enzymes in chick livers. The 2,3,7,8-TCDD has been reported to be at least three orders of magnitude more potent than any other compound known to produce experimental porphyria (Poland and Glover, 1973a). However, there was no significant increase in ALA synthetase activity nor porphyrin accumulation in mice given four weekly doses of 1 or 5 µg/kg TCDD (Goldstein et al., 1973).

Induction of AHH by 23 halogenated isomers has also been studied in vitro using rat hepatoma cell cultures (Bradlaw et al., 1976). Table 5 compares the concentration in picomoles required to cause 50% of maximum induction of AHH activity in this system.

The dose-response relationship for 2,3,7,8-TCDD induction of AHH in liver of female rats has also been studied (Kitchin et al., 1978). The single oral dose ED_{50} was 0.62 µg/kg and the lowest dose which significantly increased AHH activity was 0.002 µg/kg. Radiotracer experiments using ^{3}H-TCDD indicated that 1.1% of this minimal dose was incorporated per gram of liver at 3 days after administration. The authors estimated that this amounted to about 65 molecules per hepatocyte. Induction of AHH activity per se may not be a toxic response, but its correlation with toxicity suggests that this response is in some way a clue to the mechanism of the toxic action of 2,3,7,8-TCDD and its congeners (Poland and Gover, 1978).

Chick Edema Disease

An extensive outbreak of a disease in broiler chickens in 1957 led to the discovery that PCDDs in toxic fat added to feed could cause excessive fluid to collect in the heart sac (pericardium) and the abdominal cavity of chicks (Firestone, 1973). Table 6 summarizes the results of bioassays for chick edema in which the test chemicals were fed to chicks for 21 days beginning at 3 days of age (Schwetz et al., 1973). Positive effects were produced by 2,3,7,8-TCDD at 1 and 10 µg/kg per day, and by mixed hexachloro isomers at ten times these levels, with all chicks dying at the higher dose in each case. On the other hand, little effect was produced by the octachloro isomer, even at 0.5% in the diet equivalent to about 500 mg/kg/day.

Chloracne

Classical chloracne is a hallmark of exposure to certain PCDDs in humans (IARC 1978). It is a form of acneform dermatitis which is occupationally related to the manufacture of chlorophenols, chloronaphthalenes, polychlorinated biphenyls (PCBs), and related compounds. A bioassay to evaluate the potential for a substance to cause chloracne is conducted by painting solutions of the test substance on the inner ear of rabbits and observing the degree of hyperkeratosis produced.

Table 7 summarizes the results obtained with PCDDs containing from two to eight chlorines. A solution containing 0.04 ppm 2,3,7,8-TCDD caused a positive response when 0.1 ml was applied five days per week for four weeks. However, a concentration of 5000 ppm was needed to elicit a positive response with a mixture of 1,3,6,8 and 1,3,7,9-TCDDs (Dow unpublished data). The reaction produced by a 10 ppm solution of mixed hexachloro isomers was likely due to the presence of isomers substituted at three or four key positions. The 2,7-dichloro and octachloro isomers were negative when tested as chloroform extracts from 10% suspensions indicating they have little or no acnegenic activity (Schwetz et al., 1973).

Fetotoxicity and Teratogenicity

The relative potential of several PCDDs to cause teratogenic or fetotoxic effects has also been studied. In these investigations, the chemicals were administered to pregnant animals by stomach tube daily during the critical period of development of the fetuses. In rats, this was generally on days 6 through 15 or 16 of the 21 day gestation period. Table 8 compares the findings in studies conducted in rats in Canada (Khera and Ruddick 1973) and by Dow (Schwetz et al., 1973; Sparschu et al., 1971). The absolute values for 2,3,7,8-TCDD in the two studies depend on the strains of animals used and on minor differences in experimental conditions. It is apparent that the 2,7-dichloro and the octachloro isomers are relatively innocuous. The potential for 2,3,7,8-TCDD to cause felotoxic effects is relatively great, provided there is significant exposure to this specific isomer.

Effects in Monkeys

Studies have also been conducted in a limited number of female monkeys. The results of three studies by Allen's group in Wisconsin are summarized in Table 9 for 15 adults fed 2,3,7,8-TCDD at 500 parts per trillion (ppt) in the total diet for 9 months (Allen et al., 1977; Barsotti et al., 1979), or at 50 ppt for up to 2 years (Schantz et al., 1979); and for two juveniles fed the 1,2,3,6,7,8-hexa isomer at 5000 ppt for up to 10 months (Allen et al., 1979).

Preliminary data have also been reported for a study in Oregon where eight pregnant monkeys were given 2,3,7,8-TCDD by intubation three times per week for three weeks with little or no food during the critical stages of gestation (McNulty, 1978). Total doses administered ranged from 0.2 to 5 μg/kg of body weight as nine relatively large doses at two to three day intervals. These were equated by the author to levels of 200 to 5000 parts per trillion in the diet (Table 10). However, the effects from individual large doses without food are likely exaggerated compared to what might occur from slow assimilation of the same total dose from the diet.

Carcinogenicity Studies

The International Agency for Research on Cancer (IARC, 1978) listed 24 ongoing long-term carcinogenicity studies on PCDDs (Table 11). To date, only two of these studies have been reported (Kociba et al., 1978; NCI, 1979).

The results of biassays conducted with 2,7-DCDD in rats and mice were reported recently by the U.S. National Cancer Institute (Table 12). Under the conditions of the study, it was not carcinogenic at 5000 or 10,000 parts per million in the diet of rats of either sex or for female mice. The marginal increased incidence of combinations of tumors in only male mice was considered "suggestive" of a carcinogenic effect in these animals. Thus, 2,7-DCDD has an extremely weak potential for causing cancer (NCI, 1979).

Table 12 also summarizes the results of an extensive study by Dow on 2,3,7,8-TCDD in a total of 472 rats of both sexes (Kociba et al., 1978). It is interesting that continuous administration of TCDD at 0.1 μg/kg/day for 2 years caused an increased incidence of tumors in the liver, lungs, palate, nasal turbinates and tongue, and a dramatic decrease in the incidence of tumors in mammary glands, uterus, adrenals, pituitary and pancreas compared to the normal incidence for these sites in Sprague Dawley rats.

Positive findings were also reported for TCDD in rats in a study conducted by Allen's group at the University of Wisconsin (Van Miller et al., 1977). However, they used only 10 male animals per dosage level and their experimental design was deficient in many respects. Thus, their conclusions about effects produced at dosage levels below 1000 ppt TCDD in the diet are not valid (U.S. EPA, 1979).

Mutagenicity Studies

Available data on the genetic toxicology of chlorinated dibenzo-p-dioxins have been reviewed (Wassom et al., 1977/1978). No definite conclusions could be made about potential mutagenicity since only four compounds were evaluated: unsubstituted dibenzo-p-dioxin, the 2,7-dichloro isomer,

2,3,7,8-TCDD, and the octachloro isomer. However, the positive mutagenicity and cytological effects reported seemed to depend on the position of chlorine substitution, and the most active form was 2,3,7,8-TCDD, as in other studies.

Metabolism

Primary metabolism of dibenzo-p-dioxins in rats is by hydroxylation, and appears to take place exclusively at the 2,3,7, or 8 position in the molecule (Tulp and Hutzinger, 1978). Thus, detoxification by hydroxylation would likely be delayed by substitution of chlorines at all four key positions.

In the case of 2,3,7,8-TCDD, little or no metabolism has been noted in studies reported to date (Piper et al., 1973; Vinopal and Casida, 1973; Fries and Marrow, 1975; Rose et al., 1976; Allen et al., 1975; Van Miller et al., 1976). Unchanged compound was excreted in the feces with a whole-body half-life of about one month. Most of the total body burden was found in the liver and fat, and was unchanged TCDD. Data from a ^{14}C study in rats indicate that a steady state concentration of about 20 times the dosage level would be reached with 13 weeks of continuous administration (Rose et al., 1976).

Analyses for TCDD in tissues of rats from the Dow 2-year feeding study suggests that TCDD levels are higher in liver than in fat when dosage levels are high enough to cause toxic symptoms (Table 13). It should be noted that the amount accumulated in liver was only about 2.5% of the total amount fed to the animals over the 2-year treatment period.

PERSPECTIVE ON HAZARD FROM EXPOSURE TO DIOXINS

The relative toxicity of various dioxins has been reviewed. The hazard due to the presence of these compounds in the environment is also relative, and is a function of exposure to them as well as of their inherent toxicity.

Available data indicate that 2,3,7,8-TCDD may be the most toxic simple molecule known to man -- perhaps ten times more toxic than aflatoxin B_1 (Harris, 1978). Thus, great care should be taken to avoid human exposure, particularly during synthesis or experimental investigations involving the chemical itself. However, as reported by others in this symposium, the potential for exposure to residues of 2,3,7,8-TCDD in the environment is extremely low.

Dr. Bosshardt has discussed the work of Rappe et al., and of the need to differentiate among the various polychlorinated dibenzodioxins (PCDDs) and dibenzofurans (PCDFs) which can form during burning of chlorophenols or polychlorobiphenyls (PCBs). Dr. Harless has also discussed the need for great specificity and sensitivity of analytical methods used in analyzing for TCDD in samples collected for monitoring purposes.

Dr. Crummett has reported negative findings in monitoring studies for TCDD in a variety of likely substrates using a GC/MS method developed by Stehl et al., with low part per trillion sensitivity. The results of these analyses have been reported for samples of beef fat (Kocher et al., 1978); cow's milk, (Mahle et al., 1977); fish, human milk, rice, water, and soil (Shadoff et al., 1977), all collected from areas where the herbicide 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) had been used for up to 30 years for control of weeds and brush.

Dr. Wipf has reported the levels of TCDD in soil and crops from the Seveso area in Italy, both shortly after accidental release of a relatively large quantity of this toxic chemical during a runaway manufacturing reaction in 1976, and one and two years later. His data demonstrate that there is little potential for uptake of residues by plants from soil contaminated with TCDD.

The relative hazard from exposure to TCDD near Seveso is infinitely greater than from potential low level exposure in areas treated with 2,4,5-T. For example, the maximum residue found in Seveso was 15.8 parts per <u>million</u> TCDD in a sample of grass collected near the factory. In contrast, application of 2,4,5-T containing the maximum permissible level of 0.1 ppm TCDD at a rate of 1 lb/A (1.1 kg/ha) would result in a residue of only about 10 parts per <u>trillion</u> TCDD in/on the grass at the time of treatment, and such residues would decrease with a half life of less than one week (Getzendaner and Hummel, 1975). Numerous studies have demonstrated that TCDD undergoes photodegradation within a few hours in the presence of hydrogen donors such as the herbicide carrier (Crosby et al., 1971; Crosby, 1977; Crosby and Wong 1977; Botré, 1978; Plimmer, 1978).

Contamination of soil would also be orders of magnitude less than at Seveso. For example, the maximum amount of TCDD deposited during treatment with 2,4,5-T at 1.1 kg/ha would not exceed 0.01 <u>microgram</u> per square meter of horizontal surface, amounting to less than 0.1 part per <u>trillion</u> TCDD in the top 3 inches (7.6 cm) of soil. On the other hand, the highest level of contamination at Seveso was 5000 $\mu g/m^2$, equivalent to about 50 parts per <u>billion</u> TCDD in soil. Similarly, analyses of soil from a horse arena in Missouri revealed a level of 33 parts per <u>million</u> TCDD, as a result of spraying waste oil containing more than 300 ppm TCDD and very large quantities of 2,4,5-trichlorophenol.

Symptoms of toxicity were observed in humans exposed to these high levels of TCDD. The chief symptom at Seveso was chloracne in 22 children who were heavily exposed (Reggiani, 1978). Similarly, one child was affected in Missouri (Carter et al., 1975). In both cases a large number of animals died from exposure to the toxicant. However, it is highly unlikely that the extremely low levels which might result from use of 2,4,5-T herbicide would cause any significant effect.

CONCLUSION

A number of studies with various PCDDs confirm that the inherent toxicity of the compounds is greatly enhanced by substitution at the four lateral positions. Since hydroxylation is generally a detoxification process, and takes place exclusively at the 2,3,7 and 8 positions in dioxins, substitution of chlorine at all four key positions in TCDD may prolong its half life sufficiently in animals so that much smaller doses are toxic. It should also be noted that, although TCDD tends to bioaccumulate in liver and fat, the amount retained by animals is only a small fraction of the total dose ingested over a long period of time. Thus the hazard from eating immeasurably small residues in food would be infinitely slight.

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Table 1. Number of Polychlorinated Dibenzo-p-dioxins (PCDDs) Possible from Condensation of Polychlorinated Phenols.

Chlorophenols	Dioxins [a]	Number Possible
Di + Di	Di	10
Tri + Di	Tri	14
Tri + Tri	Tetra	22
Tetra + Tri	Penta	14
Tetra + Tetra	Hexa	10
Penta + Tetra	Hepta	2
Penta + Penta	Octa	1
	TOTAL	75

[a] Total number of chlorines minus the two which are removed during bimolecular condensation of chlorophenates to predioxins and internal ring closure to form dioxins.

Table 2. Acute Oral Toxicity of Polychlorinated Dibenzo-p-dioxins as Dose Expected to Cause Death of 50% of the Animals within 30 Days.

PCDD	Acute Oral LD50, µg/kg Body Weight		
	G. pig [a]	Rat [b]	Mouse [a]
Di 2,7		>1,000,000	>2,000,000
2,8	>300,000		
Tri 2,3,7	30,000		>3,000
Tetra 1,3,6,8 / 1,3,7,9 mixed		>100,000 [c]	
2,3,7,8	0.6 [b]	22 (M)	
	2.1 [b]	45 (F)	
	2		280
Penta 1,2,3,7,8	3		340
1,2,4,7,8	1,100		>5,000
Hexa 1,2,3,4,7,8	73		825
1,2,3,6,7,8	70-100		1,250
1,2,3,7,8,9	60-100		>1,440
Mixed isomers		100,000	
Hepta 1,2,3,4,6,7,8	>600		
Octa 1,2,3,4,6,7,8,9		>1,000,000	>4,000,000

[a] McConnell et al, 1978.
[b] Schwetz et al., 1973.
[c] Dow unpublished data.

Table 3. Comparison of the Effects Produced by a Single Lethal Dose of 2,3,7,8-TCDD in Guinea Pigs, Mice and Female Monkeys. [a]

Effect Noted	G. pigs	Mice	Monkeys
Body weight loss	+++	++	+++
Thymus involution	+++	+++	+++
Spleen reduction	+	+	+
Bone marrow hypoplasia	++	±	+
Liver degeneration	-	+++	-
Bile duct hyperplasia	±	±	+++
Testicle degeneration	+++	++	b
Renal pelvis hyperplasia	++	-	+
Urinary bladder hyperplasia	++	-	-
Adrenal cortical atrophy	++	-	-
Intestinal hemorrhage	+	+	-
Adrenal hemorrhage	++	-	-
Peritoneal edema	-	++	+
Cutaneous lesions	-	-	+++

[a] McConnell et al., 1978 a,b; Moore, 1978.

[b] Not applicable for female monkeys.

Table 4: Induction of δ-Aminolevulinic Acid Synthetase (ALA) and Aryl Hydrocarbon Hydroxylase (AHH) in Liver of Chick Embryos by Injection of Chlorodioxins into Eggs. [a]

Chlorodioxin	ALA	AHH
Unsubstituted	-	-
Mono 1	-	-
Di 2,3	-	-
2,7	-	-
2,8	-	-
Tri 1,2,4	-	-
2,3,7	++	++
Tetra 1,2,3,4	-	-
1,3,6,8	-	-
2,3,7,8	++++	++++
Penta 1,2,3,4,7	++	++
Hexa 1,2,3,4,7,8	++	++++
1,2,4,6,7,9 (90%)	±	+
Octa 1,2,3,4,6,7,8,9	-	-

[a] Poland and Glover, 1973b.

Table 5. *In Vitro* Induction of AHH in Rat Hepatoma Cell Cultures by PCDDs, as Picomoles Required to Cause 50% of Maximum Response. [a]

Chlorodioxin	ED50 (p mol)
Unsubstituted	Negligible at 5,000
Di 1,3 or 1,6	Negligible at 5,000
2,3 or 2,8	Negligible at 5,000
2,7	Detectable at 500
Tri 2,3,7	4,600
Tetra 1,2,3,4	Negligible at 5,000
1,3,6,8	Negligible at 5,000
1,2,3,8	3,300
1,3,7,8	114
2,3,7,8 chloro	1.08
2,3,7,8 bromo	3.64
Penta 1,2,4,7,8	Detectable at 500
1,2,3,4,7	121
1,2,3,7,8	20.5
Tri 4,5,6 / Di 2,4 Predioxin	Negligible at 50,000
Hexa 1,2,4,6,7,9	Negligible at 5,000
1,2,3,6,7,9	Detectable at 500
1,2,3,6,7,8	701
1,2,3,7,8,9	84.5
1,2,3,4,7,8	49.9
Hepta 1,2,3,4,6,7,9	3,790
1,2,3,4,6,7,8	129
Octa 1,2,3,4,6,7,8,9	3,400

[a] Bradlaw et al., 1976.

Table 6. Production of Chick Edema Disease by Feeding PCDDs to Chicks for 21 Days. [a]

Chlorodioxin	µg/kg/day 21 Days
Tetra 2,3,7,8	positive at 1 or 10
Hexa (2 isomers)	positive at 10 or 100
Octa 1,2,3,4,6,7,8,9	negative at 0.1 or 0.5 x 10^6 (0.1 or 0.5% in diet)

[a]Schwetz et al., 1973.

Table 7. Chloracnegenic Potential of PCDDs as Measured by Concentration Required to Cause Rabbit Ear Hyperkeratosis. [a]

Chlorodioxin	Response	ppm
Di 2,7	-	>100,000
Tetra 1,2,3,4	-	50
1,3,6,8 } mixed [b]	-	50
1,3,7,9 } mixed [b]	+	5000
2,3,7,8	-	0.004
	+	0.04
Hexa (2 or 3 isomers)	+	10
Octa 1,2,3,4,6,7,8,9	-	>100,000

[a] Schwetz et al., 1973.

[b] Unpublished data for mixture of 1,3,6,8 and 1,3,7,9-TCDD isomers.

Table 8. Comparison of Effects Produced by PCDDs in Two Teratologic Studies in Rats (in Canada [a] and by Dow [b]).

Chlorodioxin	µg/kg/day	Effect
Mono 2	2,000	Slight
Di 2,7	2,000	Slight
2,3	2,000	None
Tetra 1,2,3,4	800	None
2,3,7,8	0.125	None
	>0.25	Edema, hemorrhage
	>1	Fetotoxic
		Toxic to dams
	4	Embryolethal
Di 2,7	100,000	None
Tetra 2,3,7,8	0.03	None
	>0.125	Loss in weight
	–	Edema, hemorrhage
Hexa (2 isomers)	>10	Fetotoxic
Octa 1,2,3,4,6,7,8,9	100,000	None

[a] Khera and Ruddick, 1973.

[b] Sparschu et al., 1971; Schwetz et al., 1973.

Table 9. Observations in Female Monkeys Fed 2,3,7,8-TCDD or 1,2,3,6,7,8-HCDD in Diet for up to 2 Years.

ppt in Diet	Months Fed	Total µg/kg	Effects Noted
Tetra 2,3,7,8			
50 [a]	24	1	2/8 showed slight effect around eyes; 6/8 conceived; only 2 bore normal young
500 [b]	9	3	5/7 died; 2 aborted; 3 failed to conceive; 1 unaffected, bore normal infant; 1 recovered and later bore normal infant
Hexa 1,2,3,6,7,8			
5000 [c]	7-10	80-85	2/2 died. Symptoms similar to 500 ppt 2,3,7,8-TCDD but less severe. Animals were juveniles so not bred.

[a] Schantz et al., 1979.
[b] Allen et al., 1977; Barsotti et al., 1979.
[c] Allen et al., 1979.

Table 10. Effects of 2,3,7,8-TCDD in Pregnant Monkeys Given Thre Doses per Week for Three Weeks by Intubation. [a]

Dosage Rate (ug/kg/dose)	Total Dose in 3 weeks ug/kg)	Dietary Equivalent (ppt)	No. of Abortions vs. total	Maternal Effects
0	0	0	0/4	None
0.022	0.2	200	1/4	None
0.11	1.0	1000	3/4	None in 3. One had slight chloracne months later.
0.55	5.0	5000	2/2	Both well at end of 3-week treatment period. One died 7 weeks later and one died 14 weeks later. Both had chloracne and other signs of toxicity due to TCDD exposure.

[a] McNulty, 1978.

Table 11. Long-Term Carcinogenicity Studies on PCDDs Currently Underway or Recently Reported. [a]

Chlorodioxin	Diet	Gavage	Skin
Unsubstituted	Mouse Rat		Mouse +DMBA [d]
Di 2,7	Mouse [b] Rat [b]		Mouse +DMBA
Tri 2,3,7		Mouse Rat	Mouse
Tetra 2,3,7,8	Rat [c]	Mouse Mouse Rat	Mouse
Hexa 1,2,3,6,7,8		Mouse Rat	Mouse
1,2,3,7,8,9		Mouse	Mouse
Octa 1,2,3,4,6,7,8,9	Mouse Rat		Mouse

[a] IARC, 1978.
[b] U.S. National Cancer Institute, 1979.
[c] Kociba et al., 1978; Van Miller et al., 1977.
[d] Dimethylbenzanthracene.

Table 12. Results of Lifetime Feeding Studies with 2,7-DCDD and 2,3,7,8-TCDD.

µg/kg/Day 2 Years	ppt in Diet	Total µg/kg	Lifetime Observation
2,7-DCDD in Rats and Mice [a]			
	5×10^{9}	?	Neg. Rats (M + F) Neg. Mice (F) ± Mice (M)
	10×10^{9}	?	Extremely weak potential for causing cancer.
2,3,7,8-TCDD in Rats [b]			
0.001	22	0.73	No significant effect
0.01	210	7.3	Signs of toxicity
0.1	2200	73	Increased mortality Multiple toxicologic effects Carcinogenic

[a] U.S. National Cancer Institute, 1979.
[b] Kociba et al., 1978.

Table 13. Comparison of Levels of 2,3,7,8-TCDD in Diet, Liver, and Fat of Rats Fed the Compound for 2 Years. [a]

ppt TCDD in Diet 2 Years	ppt in Tissues at 2 Years		TCDD in Liver vs Fat	TCDD in Liver vs Total Fed [b]
	Liver	Fat		
22	540	540	1:1	2.4%
210	5,100	1,700	3:1	2.8%
2200	24,000	8,100	3:1	2.3%

[a] Kociba et al., 1978.

[b] Calculated from individual weight of liver and parts per trillion TCDD in liver of three female rats at each dosage level at the end of the 2-year feeding period.

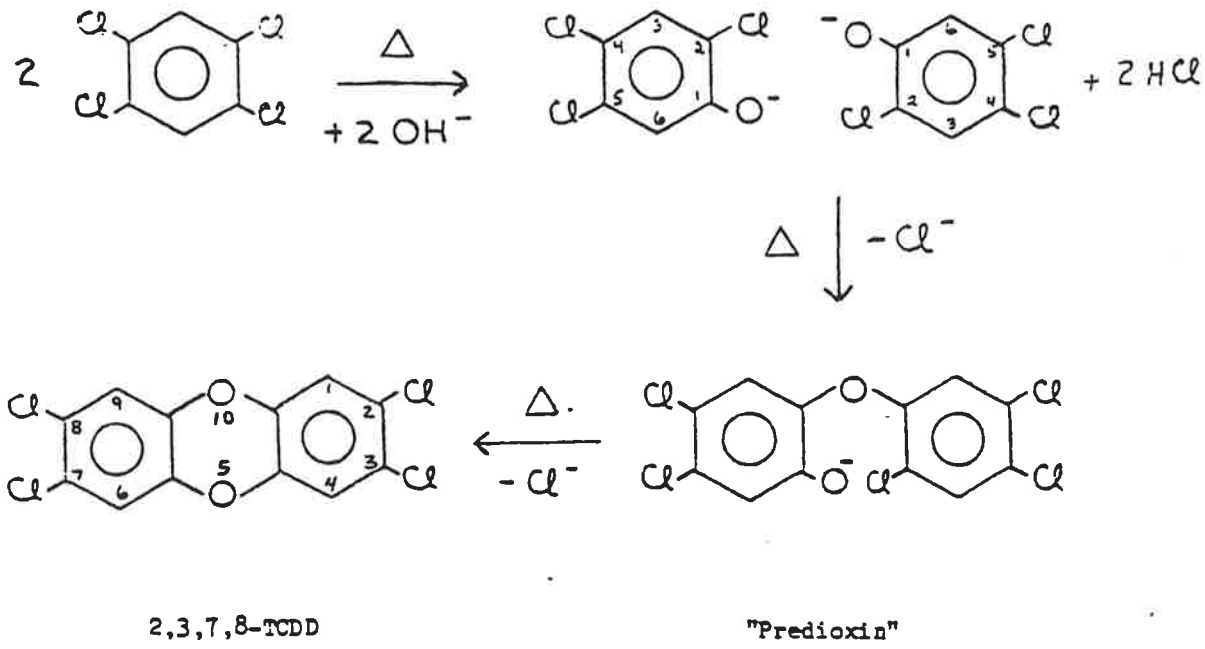

Figure 1. Traces of 2,3,7,8-tetrachlorodibenzo-p-dioxin can form during manufacture of 2,4,5-trichlorophenol from 1,2,4,5-tetrachlorobenzene under alkaline conditions at high temperature and pressure. (Note: According to a numbering system sometimes used in Europe, this isomer may be designated as 2,3,6,7-TCDD.)

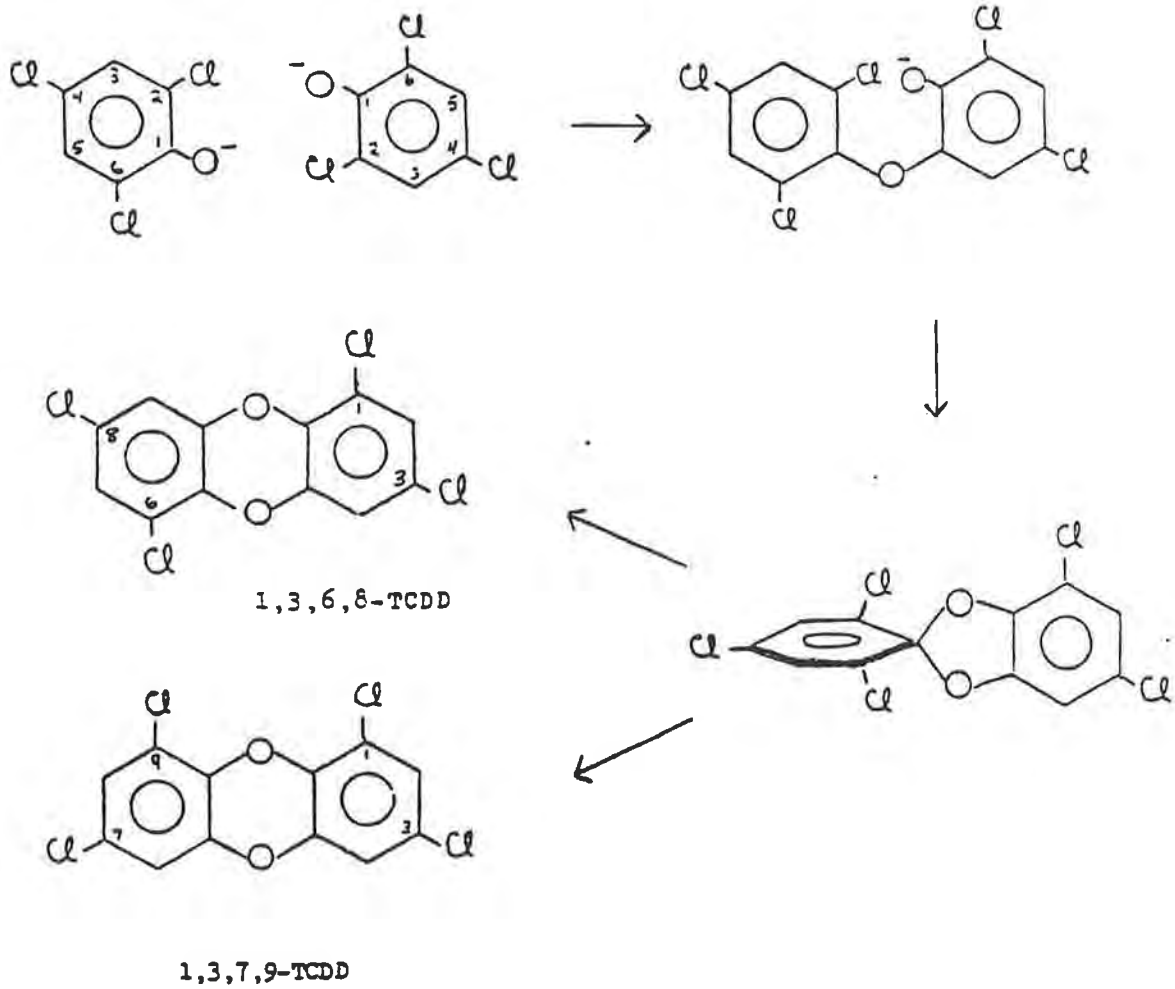

Figure 2. Condensation of 2,4,6-trichlorophenate leads to mixture of 1,3,6,8- and 1,3,7,9-TCDDs by Smiles rearrangement of intermediate. (Gray, et al., 1975; Kende and DeCamp, 1975.)

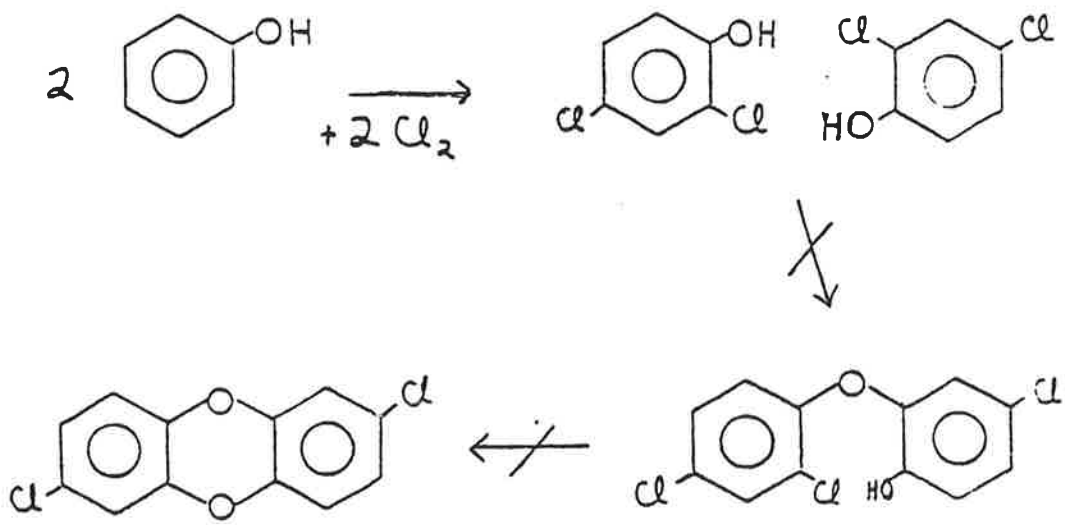

Figure 3. Condensation of 2,4-dichlorophenol to form 2,7-dichlorodibenzo-p-dioxin is not likely to occur under the acid conditions, low temperature and pressure used for manufacture of DCP by chlorination of phenol.

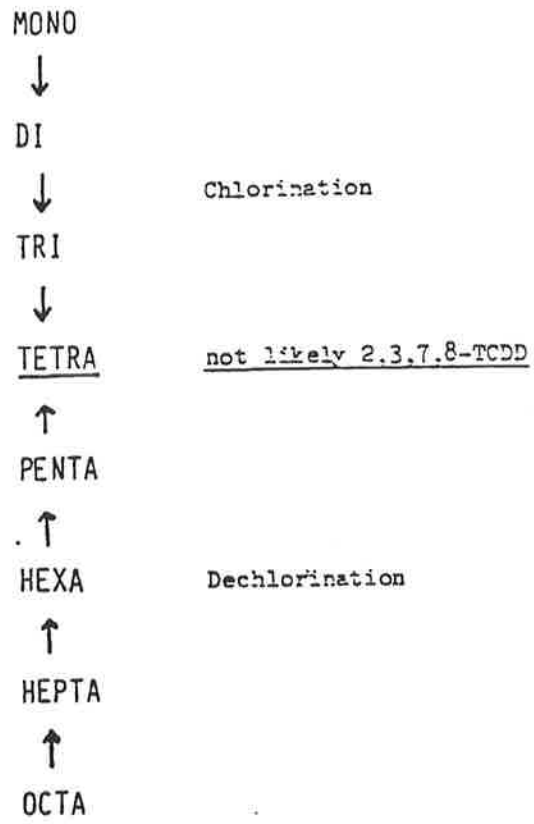

Figure 4. Formation of tetrachlorodibenzo-p-dioxins by progressive chlorination of lower analogs or progressive dechlorination of higher analogs.

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REPORT ON

ANALYSIS OF DI- AND TRICHLOROPHENOL DISTILLATION BOTTOMS FOR TETRACHLORODIBENZO-p-DIOXIN

Prepared By

WRIGHT STATE UNIVERSITY
BREHM LABORATORY
DAYTON, OHIO 45435

Thomas O. Tiernan, Joseph G. Solch, Garrett F. VanNess,
and Michael L. Taylor

Work Accomplished Under Rhone-Poulenc Purchase Order No. PTL-11093

Submitted to

Mr. Jack Vernetti
Rhone-Poulenc, Inc.
Agricultural Division
6200 N.W. St. Helens Rd.
Portland, Oregon 97210

June 10, 1980

I. INTRODUCTION

A sample of chemical waste material, representative of the distillation bottoms from di- and trichlorophenol manufacturing processes, was submitted by Rhone-Poulenc, Inc., under Purchase Order No. PTL-11093, to the Brehm Laboratory of Wright State University for determination of tetrachlorodibenzo-p-dioxin (TCDD) content. The extraction and cleanup procedures to be utilized for this determination were to be developed by Wright State, while the method of detection to be employed was Capillary column gas chromatography-High resolution mass spectrometry, as prescribed by the U. S. Environmental Protection Agency in the Federal Register announcement of March 11, 1980. The methods developed and implemented for this analysis and the results obtained are described below.

II. EXPERIMENTAL PROCEDURES

A. Sample Extraction and Cleanup.

After several preliminary tests using various extraction and cleanup procedures similar to those employed for other samples in our laboratory, a method was developed which gave quite satisfactory results. The procedures finally implemented are as follows. A two (2) gram aliquot of the chemical waste sample as received was transferred to a screw-capped glass bottle. A quantity of $^{37}Cl_4$-2,3,7,8-TCDD was added as an internal standard. Methanol (~10 ml.) and petroleum ether (~40 ml.) were then added to the bottle, to dissolve the waste material. Finally, fifty (50) milliliters of doubly distilled water were added to the sample solution, and the bottle was sealed and agitated vigorously for several minutes. The aqueous layer was then removed and discarded.

The residual organic solution was next subjected to a series of washings, which entailed, (1) adding 50 ml. of 20% potassium hydroxide and agitating the

mixture for ten minutes, followed by removal and discarding of the basic layer; (2) adding 50 ml. doubly distilled water to the solution, agitating for 2 minutes and discarding the aqueous layer; (3) cautiously adding 50 ml. of concentrated sulfuric acid, agitating for 10 minutes, allowing the mixture to stand for an additional 10 minutes, and removing and discarding the acid layer; (4) repeating the acid washing step until the acid layer exhibited no visible color; (5) adding 50 ml. of doubly distilled water, agitating 2 minutes, and discarding the aqueous layer. The washed extract was then placed over 10 g. of anhydrous sodium sulfate to remove residual water.

The dried organic extract was concentrated to near dryness in a glass test tube and transferred to an alumina micro-column. The column was constructed from the lower section of a disposable Pyrex pipet, into which a plug of silanized glass wool was inserted, followed by 2.8 g. of Woelm basic alumina, previously activated at 600°C for several hours and cooled in a desiccator just prior to use. The micro-column was eluted first with 10 ml. of 3% methylene chloride-in-hexane, then with 15 ml. of 20% methylene chloride-in-hexane and these effluents were discarded. The column was then eluted with 15 ml. of 50% methylene chloride-in-hexane, and this entire effluent was retained and concentrated to a volume of 0.3-0.5 ml. using a stream of dry nitrogen. The concentrated residue was transferred to a preconditioned Reacti-Vial, the solution was then evaporated to dryness, the vessel was tightly capped, and stored at +5°C until analysis. Just prior to analysis, the residue in the vial was redissolved in tridecane.

B. GC-MS Instrumentation and Procedures.

The sample extract prepared as described above was analyzed using an instrument which consists of a Varian 3740 Gas Chromatograph coupled through a silicone membrane separator to an AEI Double-focusing, Double-beam MS-30 Mass Spectrometer. The gas chromatograph is equipped with a 60-meter OV-101 capillary (WCOT) column,

and hydrogen is used as the carrier gas. The column is operated isothermally at 190°C for 1 min. following splitless injection of the sample, and the temperature is then increased at a rate of 1°C/min. to a final temperature of 220°C. The injector is maintained at 300°C and the transfer line at 320°C. The mass spectrometer is equipped with a unique electrostatic analyzer (ESA) step-scan circuit developed by Wright State. This circuit permits as many as four mass peaks to be monitored, essentially simultaneously, by alternately stepping and scanning the ESA voltage, so that four distinct, narrow portions of the mass scale (each typically 0.07 AMU wide) are sequentially scanned. Data acquisition and control of the step-scan sequence is accomplished using Nicolet 1074 Signal Averaging Computer. With this instrument, sensitivity adequate to detect 10 pg. or less of TCDD is routinely achieved, with a signal/noise ratio of 10/1. A static mass spectrometric resolution of 12,500 is achieved under optimum conditions. The ions usually monitored in a typical analysis are m/e 319.8966, m/e 321.8936, m/e 325.8805, and m/e 327.8846. The first two masses are major peaks in the mass spectrum of 2,3,7,8-TCDD, the third is a prominent ion in the mass spectrum of some polychlorinated biphenyls (PCB's), and the last is indicative of the $^{37}Cl_4$-2,3,7,8-TCDD internal standard.

III. RESULTS AND DISCUSSION

A preliminary analysis of the sample extract using low resolution (Packed column) GC-High resolution MS showed that the recovery of the $^{37}Cl_4$-2,3,7,8-TCDD internal standard using the methods described is essentially 100%. The method is therefore entirely adequate for the samples of interest here.

The results of the capillary column GC-high resolution MS analysis are shown graphically in Figures 1 and 2. Figure 1 shows the mass chromatogram (m/e 322) for a mixture of the eleven (11) TCDD isomer standards currently on hand, which was obtained using the procedures described. It is apparent that good resolution

is achieved for most of these isomers. In particular, it can be seen that the 2,3,7,8-TCDD isomer is well separated from the other isomeric components of the mixture. Figure 2 shows the analogous mass chromatograms (for the four ions mentioned above) obtained for the sample extract. Note that each mass chromatogram is displaced slightly on the horizontal axis with respect to the other chromatograms. As can be seen, there are sizable peaks at the retention time of the 2,3,7,8-TCDD isomer in both the m/e 320 and m/e 322 displays. There is also another peak evident in both of these mass chromatograms, but it does not correspond in retention time to any of the eleven isomers for which we have standards. By relating the peak heights of these signals to that of the corresponding m/e 328 signal resulting from the $^{37}Cl_4$-2,3,7,8-TCDD internal standard, the quantity of native 2,3,7,8-TCDD in the still bottom sample can readily be determined. The results of this calculation are summarized in Table 1, and indicate that the still bottom sample contains a TCDD isomer which corresponds in retention time to the 2,3,7,8-TCDD isomer, at a concentration of 40.3 parts-per-billion. The good agreement obtained for the TCDD concentration calculated on the basis of both the m/e 320 and m/e 322 peaks, by assuming that the m/e 320/ m/e 322 ratio is 0.78, as theoretically predicted, lends further credibility to the results.

TABLE 1

RESULTS OF CAPILLARY-COLUMN GC-HIGH RESOLUTION MS DETERMINATION OF TCDD IN RHONE-POULENC SAMPLE

Rhone-Poulenc Sample Designation	TCDD Isomer Indicated By Retention Time of Component in Sample	Native TCDD Found (parts-per-billion) or ng. TCDD/g. sample)			Minimum Detectable Concentration for This Analysis (parts-per-billion
		m/e 320	m/e 322	Average	
Di- and Trichlorophenol Distillation Bottoms	2,3,7,8-TCDD	40.1	40.4	40.3	1.7

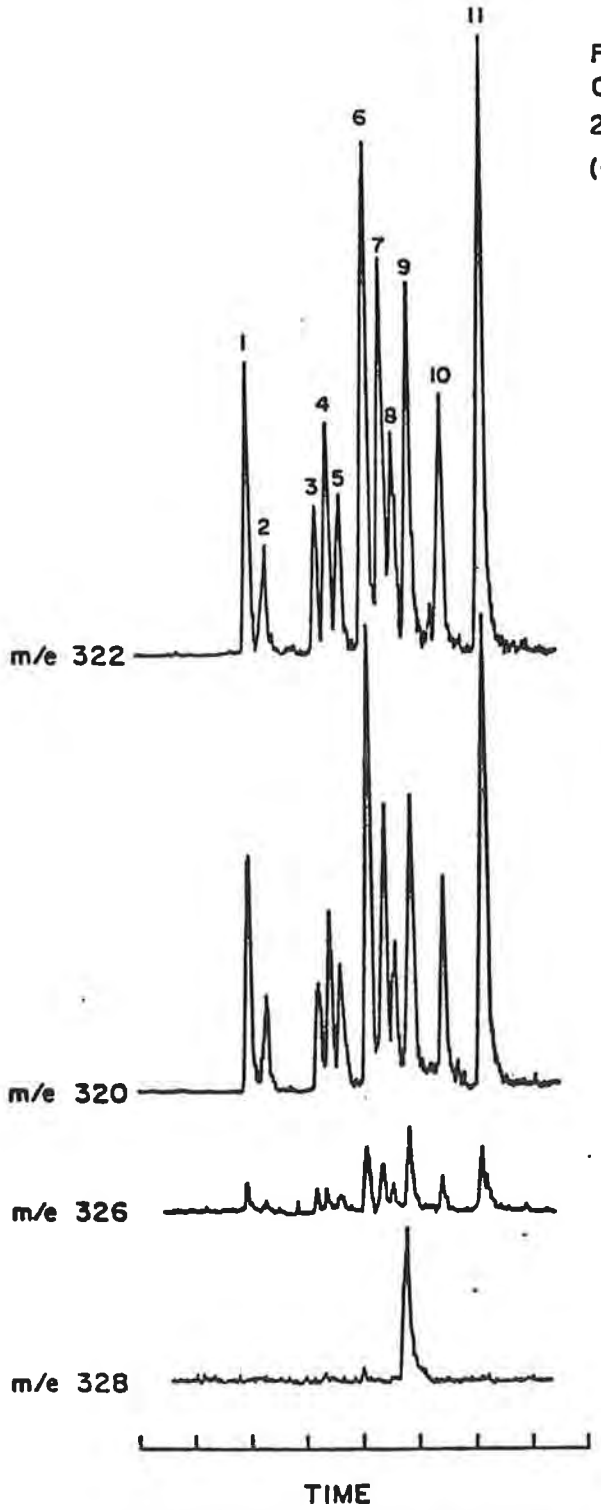

Fig. 1
Capillary HRMS Chromatogram for 2.0μl TCDD Isomer Mix
(Contains 2.0ng $^{37}Cl_4$-TCDD)

TCDD ISOMERS

1) 1,3,6,8
2) 1,3,7,9
3) 1,4,6,9
4) 1,3,7,8
5) 1,2,6,8
6) 1,2,7,9
7) 1,2,6,9
8) 1,2,3,4
9) 2,3,7,8
10) 1,2,6,7
11) 1,2,8,9

50mV Full Scale for all Ions

Effective Resolution = 9200

c. Request EPA notification of the formulation change.

V. IMPURITIES

The EPA Draft Guidelines states that the impurities of a compound have to be established down to the 0.1% level. The 1978 revision anticipates a 0.01% level, but that proposal is being fought by industry.

At the time being, it appears advisable to:

1. Work on the basis of the 0.1% level.

2. Define the minimum and maximum level of formulation adjuvants (i.e. formulation work with carrier, adjuvant, sticker, etc.).

3. Limit our concern for impurities to the technical material only, (i.e. 2,4-D acid, 2,4-D amine, etc.).

4. For Product Development to provide the Product Quality Committee with the product composition submitted to the EPA.

5. Have Purchasing buy from U.S. or overseas (including May & Baker and Rhone-Poulenc) producers with the request to provide analysis of the material for a.i. and impurities down to the 0.1% level. This is to be started now.

6. Once the impurities of the incoming materials are known, we should detect the impurities appearing in the finished technical material. This two step approach (impurities in raw material provided by the seller; impurities in the finished technical material provided by Rhodia) will help to reduce the workload.

7. In order to get some experience, HBN will be selected as the first target. Determination and description of impurities will be done, with maximum amount, representative analysis, and variability of the method. It will concern the "phenol" and the "octanoate."

VI. MISCELLANEOUS

1. Product Complaint. The procedure followed is not well known in Portland. The concern is to be able to help and also to take any appropriate measures, should a formulation not be adequate.

2. Product Manager. It is not very clear in Portland as to which Product Manager is in charge of what product. It could be advisable to notify.

3. Formulation Work Request. Portland wonders about the proper approach to be taken in order to get formulation work done (for example: the formulation of active isomer phenoxies).

4. R. Gitschlag exposed the waste problems and some of the outside research done in trying to solve the problem.

M. P. Lavalleye

MPL/mem

cc: R. Gitschlag

Rhodia

OFFICE MEMORANDUM

DIVISION Agricultural

To: E. Schroder

Date: June 14, 1978

From: Jack B. Vernetti

Subject: DIOXIN TESTING

cc: J. Davies
R. Collins
S. Greenfield
A. Guardigli
L. Walaski

At the Quality Control Committee Meeting in St. Joseph it was decided that the specification for 2,4,5-T and 2,4,5-TP technicals will be less than 0.1 ppm 2,3,7,8 TCDD and that the analytical calculations and chromatographic charts for each lot or tank car are to be included with the shipping papers or sent to the plant receiving the material. The Plant Chemist will review the data before formulating the material.

Jack B. Vernetti

Jack B. Vernetti
Chairman, Quality Control Committee

JBV:bjf

Rhodia

OFFICE MEMORANDUM

DIVISION AGRICULTURAL

To: J. B. Vernetti

Date: June 22, 1978

From: J. E. Davies

Subject: Quality Control Meeting

Thank you for sending the reports on your first Quality Control Committee meeting. I have the following comments.

A. Dioxin

I agree with your conclusion to set < 0.1 ppm spec from our suppliers of 2,4,5-T and insist upon analysis and chromatographic charts. I also agree with spot check analyses performed outside.

I feel it is prudent to analyze our 1978 2,4-D production, even though our tests were negative. If the in-house tests are negative again, is it necessary to have them confirmed at a commercial lab?

B. Nitrosoamine

I agree with all the actions you defined. However, I am not clear on what your plan is for analyzing Portland formulations prior to a decision on equipment. Please clarify this point.

C. Formulations Handbook

The review and up-date is essential. At the same time you should review and up-date specifications for technical products. For example, I don't believe our current production of 2,4-D Acid meets the spec sheet that Larry VanGordon is giving to his customers.

D. 2,4 Isomer Content

On my next trip to Portland I want to discuss this situation with you. In the interim I want Steve Greenfield and Dick Buhn to develop a recommendation from the standpoint of marketing.

Please copy me on the agenda for your August meeting. If possible I will attend part of the discussions.

Jack Davies

J. E. Davies

JED/dju
cc: R. F. Buhn
R. Collins
S. Greenfield
A. Guardigli
M. P. Lavalleye
L. Walaski

Wright State University

Dayton, Ohio 45431

29

May 22, 1979

Mr. Jack Vernetti
Rhodia, Inc.
6200 N.W. St. Helens Road
Portland, Oregon 97210

Dear Mr. Vernetti:

Presented herewith is Wright State University's report on work accomplished under Rhodia Purchase Order No. PTL 81454, for the determination of tetrachlorodibenzo-p-dioxin (TCDD) in samples of 4(2,4-dichlorophenoxy) butyric acid, 2,4-dichlorophenoxyacetic acid and dichlorophenol submitted by your firm. The procedures utilized in accomplishing these analyses are as follows:

Analytical Methods:

A. Dichlorophenol

1. Dissolve 0.5 g of dichlorophenol in 1.0 ml benzene.
2. Spike a separate aliquot of the sample with a known quantity of an authentic 2,3,7,8-TCDD standard.
3. Prepare a 30 cm glass column and pack with 4.0 g of silica gel, followed by 4.0 g of alumina (Fisher A 540).
4. Transfer the sample to the top of the column, and elute with a mixture of 20% benzene-in-hexane.
5. Discard the first 5 ml of eluant.
6. Collect the next 6 ml of eluant, and concentrate this fraction to near dryness, by directing a stream of dry, purified nitrogen across the top of the liquid.
7. Analyze the extract using a gas chromatograph-quadrupole mass spectrometer.

B. 2,4-D Acid and 2,4-DB Acid

1. Place a 20 gram sample of the acid in a teflon capped bottle, and add portions of Pesticide Quality methanol and hexane, and double distilled water. Spike a separate aliquot of the sample with a known quantity of 2,3,7,8-TCDD standard, and process similarly.

2. Shake the mixture overnight, then allow the aqueous and organic layers to separate fully before removing the aqueous layer.
3. Extract the organic layer with sulfuric acid and discard the acidic layer.
4. Extract the organic layer with double distilled water and discard the aqueous layer.
5. Dry the remaining organic layer over anhydrous sodium sulfate.
6. Quantitatively transfer the organic material to another vessel and reduce the volume by directing a stream of dry, purified nitrogen across the top of the liquid.
7. Prepare a glass column with Woelm basic alumina.
8. Transfer the organic residue to the top of the column and elute with a mixture of 3% methylene chloride-in-hexane and 50% methylene chloride-in hexane.
9. Collect the second eluate fraction and concentrate to near dryness as before.
10. Analyze the extract on a gas chromatograph-quadrupole mass spectrometer.

The samples and corresponding spiked aliquots of these were analyzed on a specially constructed apparatus consisting of a Varian Model 2740 Gas Chromatograph coupled directly to an Extranuclear Quadrupole Mass Spectrometer (GC-QMS). Both the TCDD molecular ion (m/e 322) and a major fragment ion (m/e 320) were monitored (essentially simultaneously) utilizing the dual ion selection mode on the QMS. Quantitation of the levels of TCDD in the samples was accomplished by comparing the signal response for the sample with that for an authentic 2,3,7,8-TCDD standard which was run, both preceding, and following the analyses of the unknown samples. The GC-QMS parameters for these analyses are listed below.

Gas Chromatograph

Column:	2 meter x 3 mm ID glass, packed with 3% OV-7 coated on Supelcoport
Carrier Gas:	Helium at 65 ml/min
Temperatures:	Injector 255°C Column 275°C Transfer line 295°C

Mass Spectrometer

Ionizing Voltage:	23.5 eV
Multiplier Voltage:	3200 V
Masses Monitored:	m/e 320 and m/e 322
Resolution:	1:350

The concentrations of TCDD determined in the samples are listed in Table 1. The results for the corresponding spiked samples are shown in Table 2. The Minimum Detectable Concentration listed for each sample reflects the percent recovery realized for that sample.

This report completes our work under this Purchase Order and our invoice in the amount of $600.00 has been forwarded to your New Jersey office, as directed by the Purchase Order.

If there are any further questions, please don't hesitate to contact us.

Sincerely,

Thomas O. Tiernan, Ph.D.
Professor of Chemistry and
Director of the Brehm Laboratory

Thomas Mazer
Research Associate

/ps

Enclosures
Tables 1 and 2

Table 1

RESULTS OF ANALYSES OF RHODIA SAMPLES FOR TCDD BY GC-QMS

Sample Identification	TCDD Found[a]	Minimum Detectable Concentration[b]
809252	ND	10 Ng/g (ppb)
809251	ND	10 Ng/g (ppb)
Dichlorophenol	ND	10 Ng/g (ppb)

a. ND means no TCDD detected in excess of the Minimum Detectable Concentration.

b. Values are corrected for recovery.

Table 2

RESULTS OF ANALYSIS OF RHODIA SAMPLES SPIKED WITH KNOWN QUANTITIES OF AUTHENTIC 2,3,7,8-TCDD STANDARD

Sample Identification	TCDD Added	TCDD Found	Recovery
809252-S	20 Ng	18 Ng	88%
809251-S	20 Ng	15 Ng	75%
Dichlorophenol-S	5 Ng	2.7 Ng	53%

rhône-poulenc inc.

OFFICE MEMORANDUM

DIVISION Agricultural

30

To: Dr. E. L. Clark

Date: June 4, 1979

From: J. B. Vernetti

Subject: DIOXIN

cc: J. E. Davies
R. F. Gitschlag

Attached are copies of various Dioxin items you requested. To summarize:

1. TCDD in 2,4-D, 2,4-DB, and 2,4-DCP Distilled.

   Referring to the Wright State University Report on 1978 2,4-D 2,4-DB and 2,4-DCP (Distilled Product) composites for 2,3,7,8 TCDD, none detected in any of the above. Minimum detectability, 10 ppb.

2. 2,7 DCDD in 2,4-D Acid

   The only 2,7 DCDD data is on the 1970 2,4-D composite acid run by this lab. Figure I shows a possibility of 20 ppb. This was not verified as the tetrachloro was the objective of the work.

3. Dioxins in 2,4,6 Trichlorophenol. (No attachments)

   We assayed a sample of 2,4,6 Trichlorophenol (1975) prepared in our pilot plant from plant tar bottoms for a shipment to Rohm & Haas (198 pounds) for Dioxin. We found 20 ppb of 2,7 DCDD but could not detect any 2,3,7,8 TCDD. This was reported to Rohm & Haas. Unfortunately, I do not have the GLC scans and the person doing the work was laid off in the October 1976 layoff. I do have the procedure used. At a later date Rohm & Haas set as a specification, total 1,3,6,8 and 2,3,7,8 TCDD's at 20 ppb. maximum.

4. Dioxin Literature, Toxicology

   Several chapters from the Dioxin book mentioned are attached along with content index. In Chapter 15 is a statement that 2,7-DCDD shows some teratogenic activity and also indicates 1,3,6,8 TCDD is toxic. Also in the attached letter (4/20/78) reference is made to an article indicating 1,3,6,8 TCDD as toxic to chick embroyos. There was a statement in the Chemical & Engineer News, Feb. 26, 1979 (p. 21) that 2,7 DCDD "increases certain cancers in male mice but not in females or rates of either sex". NCI statement.

5. Dioxin Possibilities in the Plant Process.

Attached is a letter (4/20/78) reviewing isomers of Dioxins possible in our plant. Mostely it concerns DCP tars where it is expected that most of the dioxins could form due to the high termperature in the still bottoms. Also attached is a sheet, Fig. II, showing the dioxin possibilities from various chlorophenol isomers. The most likely ones are check marked.

There are all kinds of possibilities that one could theorize as to making any dioxin in our process. Principally, the main theory could go like this:

> Unchlorinated dibenzo-p-dioxin could be made (but very unlikely) from o-chlorophenol and in the continuing chlorination to dichlorophenol the dioxin can be chlorinated to various chlorodioxins including 2,3,7,8 TCDD. Also 2,7 DCDD could be formed which can be chlorinated further. At present we don't have any evidence of this; mainly (concerning unchlorinated dioxin), we have noted that very little tar is formed during the monochlorination stage, and because this is a reaction that should occur before the more drastic pyrolytic dioxin reaction can happen.

6. Future Dioxin Work.

We should examine our products 2,4-D, 2,4-DB, 2,4-DP tars and chlorophenols for the various dioxin isomers mentioned in the 4/20/78 letter. (I don't think we need to examine our esters, but -.) This will be difficult as some of the dioxin standards may be difficult to obtain. In particular the DCP tars should be examined thoroughly as this could be a target for environmentalist concerning solid waste disposal.

I have talked to Wright State University about this work. They will do it but have not committed on price. I suppose it will be expensive.

J. B. Vernetti

J. B. Vernetti

JBV:bc

Attachments

Rhodia

A SUBSIDIARY OF RHÔNE-POULENC

OFFICE MEMORANDUM

DIVISION Agricultural

31

To: See Distribution Below

Date: July 5, 1979

From: R. F. Gitschlag

Subject: 2,4,6-TCP AND DIOXIN

Distribution: P. E. Davis
R. L. Ferguson
J. B. Vernetti
K. S. Trogdon

On June 26 a meeting was held at BHL to discuss the potential hazards from the handling of 2,4,6-TCP and/or D/T chlorophenol mix.

It was decided that:

1. Portland would prepare a flow diagram (map) of potential locations for our dioxin-type chemicals in our products. We are also to include side streams such as water effluent, carbon, etc.

2. We are to update our SOP for the flushing of the full chlorination DCP distillation sy stem. We are to eliminate the potential employee contact with chlorophenol compounds.

3. The SOP for the tar drumming operation is to be reviewed - again, no contact is the objective.

4. D/T chlorophenol handling is to be reviewed - again, no contact is the objective.

5. The use of a rubber suit in any operation of potential contact is to be reviewed and recommendation made.

6. A sampling and testing program is to be established on our various products for dioxin on a six-months interval. The cost is to be developed.

We have received a call from Monsanto who has had an OSHA type inspection and was cited for bad industrial hygiene practices - primarily in the handling of chlorophenols. OSHA was particularly interested in TCDE. Because Monsanto makes pentas the presence of TCDE is guaranteed. I will check with Monsanto and obtain further information.

This project has a high priority and is to be completed by 7/20.

R. F. Gitschlag

RFG:bjf:bc

Rhodia

A SUBSIDIARY OF RHONE-POULENC

OFFICE MEMORANDUM

DIVISION Agricultural

To: J. E. Davies

Date: July 6, 1979

From: R. F. Gitschlag

Subject: Plant Safety

cc: Dr. E. Clark
G. J. Kanner
Negotiations File

Per your request of June 26, I suggest the additional questions on plant safety and dioxins:

1. Toxicology of other dioxins, particularly 1,3,6,8 TCDE and the trichlorophenol and dichlorophenol isomers. We are also interested in the comparative safety of these dioxins with other compounds we are handling, specifically chlorophenols, 2,4-D, 2,4-DB, HBN, BX acid, MCPA and MCPP Products.

2. The chance of any of the dioxin isomers being present in other pesticides. The 60-Minute program that sparked one of our union employee's fear of dioxin exposure suggested dioxin present in Toxaphene, DDT, etc. Approximately ten years ago we formulated most common pesticide products in Portland.

3. Has any long-range effect of contact with pesticides, particularly dioxin, been determined?

4. What is the Dow system of employee exposure record system? P. Davis has indicated that the Dow safety man in Freeport suggested that Dow maintains a record of the exposure of their employees.

5. Does Dow use rubber suits? If they do, what type and where are they available? Worker acceptance would also be of interest.

6. Has Dow developed a map of their process and determined concentration levels at various steps? If so, is there any information that could be made available to us?

7. Where has Dow done their testing? What is the reliability of the tests on product, lab animals or on humans?

8. Does Diamond through their physical exam protocol determine pesticides in body tissue?

As a result of the meeting held on June 26 about dioxins and tar handling an Action Plan has been prepared for studying the potential of dioxin in Portland. A copy of this letter is attached.

R. F. Gitschlag

RFG:bjf
Attachment

rhône-poulenc inc.

OFFICE MEMORANDUM

33

DIVISION AGRICULTURAL

To: See Distribution

Date: July 18, 1979
Ref. No. JED-79-260

From: J. E. Davies

Subject: Plant Safety

Distribution:

E. L. Clark
R. F. Gitschlag
D. A. Rotunno
J. P. Sibeud

I discussed the above subject with Dr. Perry Gehring who is in charge of toxicology, industrial hygiene and employee health surveillance for Dow to learn their experience. Specifically, regarding dioxin exposure he offered the following comments.

1. The only specific program they have involving dioxin is the close monitoring of approximately 60 people who developed chloracne in the late 1950's. All of these people worked in Dow's TCP or 2,4,5-T plant.

2. They monitor for dioxins in the TCP/2,4,5-T plants by doing wipe sampling and using a rabbit bioassay from the sample. If they got a positive response they would clean the plant until the assay was negative. They wipe sample once a year.

3. They do not wipe sample their DCP or 2,4-D plants. They have done periodic checks and have never found the presence of dioxins.

4. Regarding employee relations, they utilize the plant supervisors to talk with the employees about the safety of the work environment. Dr. Gehring says they do not have a problem of employee concern.

Continued .....

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5. Their employees receive normal, regular physicals, but no special tests or procedures specifically directed toward dioxins.

6. As far as records and long term medical histories, they have a procedure where they ask employees to answer a health questionnaire and the responses are then tabulated and stored. Dr. Gehring said the system was far from perfect.

Jack Davies
J. E. Davies

JED/dju
cc: D. G. Harris

Rhodia

A SUBSIDIARY OF RHÔNE-POULENC

OFFICE MEMORANDUM

DIVISION Agricultural

To: R. F. Gitschlag **Date:** July 19, 1979

From: R. L. Ferguson **Subject:** DIOXINS

cc: P. E. Davis
J. B. Vernetti

If dioxin is generated in our chlorophenol system we would expect it to be a fairly high boiling point material. As a result it would concentrate in the tar bottoms and be handled as DCP tar. A very small quantity may go overhead in the tar still with the finished D/T chlorophenols.

The tar distillation system vacuum jets seal into the 2,4-D dilution water tank, so if any dioxin is carried over in the D/T chlorophenol, minute quantities could also be found in the dilution water and throughout the 2,4-D process.

It has been and continues to be our goal to eliminate contact with chlorophenols because of the potential for chemical and/or thermal burns. Potential toxicological effects have not been a major motivator but perhaps should be.

Because of this, most of our efforts have been in the area of reduced contact with solids and liquids. Chlorophenol vapors have not received much attention except from a fugitive emmission viewpoint.

The six key items in your letter of 7/5/79 are discussed below:

1. Flow Map - A block diagram is attached showing potential flow of dioxin materials. This is discussed in paragraphs 1 & 2 above.

2. The current still flush procedure calls for rubber gear and face shield while drumming tar bottoms material. This will be reviewed to determine if a mask will be required. A procedure has been prepared and is ready for issue requiring the same gear be worn whenever a line is broken unless it is <u>known</u> that the line is clear.

   Along the same lines, I am prepared to recommend that the quick-disconnect type hose fitting be eliminated. Neither of these address the problem of vapor contact.

3. The tar drumming procedure has been reviewed. It will be modified to stress use of protective gear while changing tar drums.

4. D/T chlorophenol handling has been reviewed. There has been 2 or 3 instances of accidents that resulted in D/T contact. One was R. Alloway when a gasket failed under pressure. A second when the bottom broke out of the PCP tank and RFG, PDL, everyone in plant were trying to stop the leak. A third was when a T/C was run over. There may be other cases. In the area of chlorophenol handling (T/C loading, etc.) the first step to take is valve labeling to reduce the potential for accidental release. This will be done. Safety gear need will be reviewed.

5. Rubber suits. I have no comment at this time. Needs study.

6. Sampling and testing. No comment except to recommend that we start sampling program with tar and D/T chlorophenol.

R. L. Ferguson

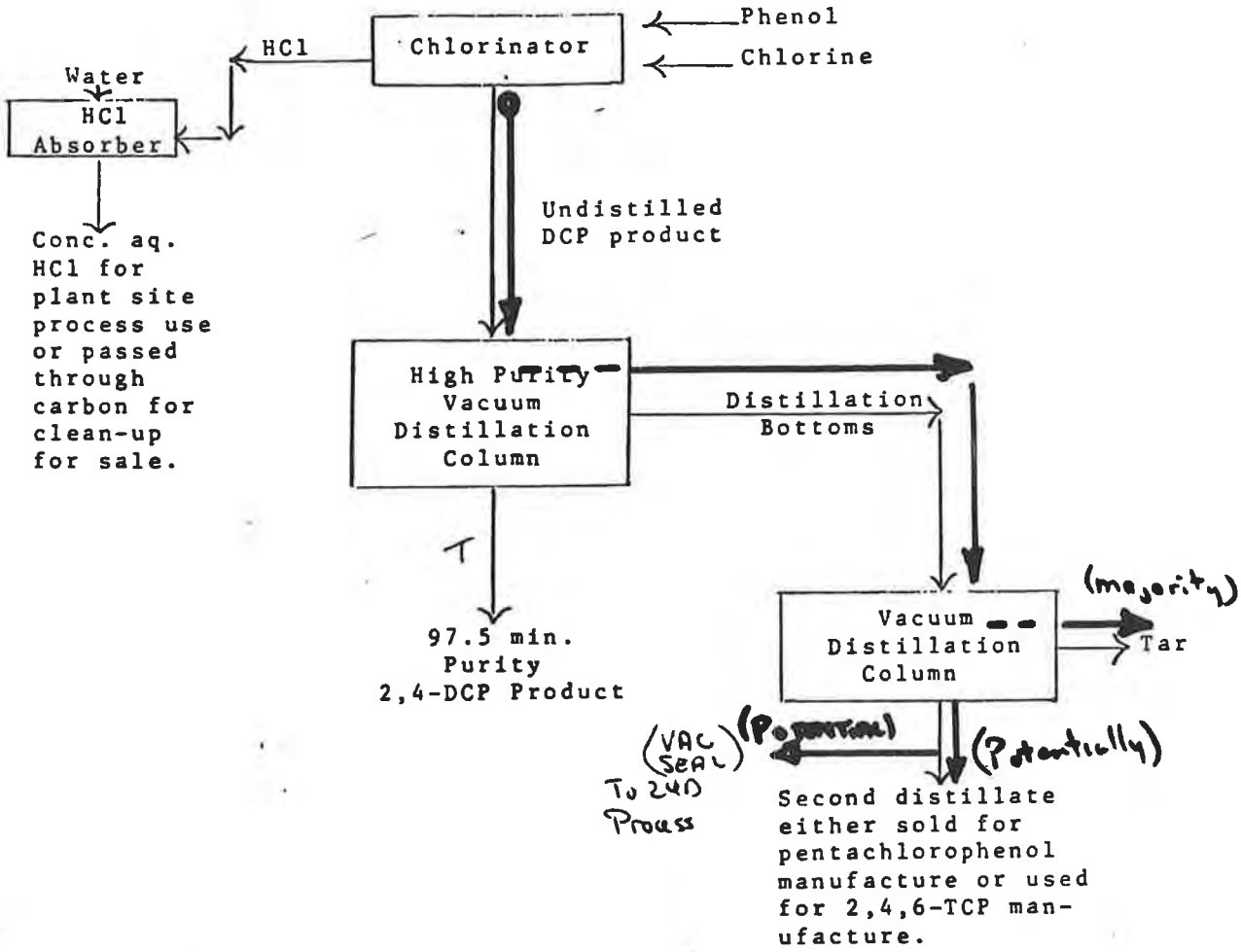
R. L. Ferguson

RLF:bc

2,4-DICHLOROPHENOL PROCESS

SCHEMATIC FLOW DIAGARAM

POTENTIAL DIOXIN FLOW



Rhodia rP
A SUBSIDIARY OF RHÔNE-POULENC

OFFICE MEMORANDUM

DIVISION Agricultural

To: See Distribution Below **Date:** July 27, 1979

From: R. F. Gitschlag **Subject:** OCCUPATIONAL HEALTH & DIOXINS

Distribution:

E. L. Clark
J. E. Davies
P. E. Davis
R. L. Ferguson
G. J. Kanner ✓ MAILED 7/27 WITH NOTE TO MAKE
D. C. McLaughlin NO COPIES ETC & JED
K. S. Trogdon + DRAWINGS —
J. B. Vernetti

COVER ONLY } DR. GALLO

On July 5 an in-plant letter was written on the dioxin subject. R. Fergus has prepared a reply to some of the points of this letter. I wish to comment further:

FLOW DIAGRAMS

The following 'maps' are being prepared of which the completed ones are attached.

A. 2,4-D Block Flow Diagram.
B. 2,4-DB Flow Diagram.
C. Ester Block Flow including Special Esters.
D. Bromoxynil Octanoate Block Flow.
E. Water Plant Block Flow.
F. Formulations Block Flow.

Critical review is being made of the potential locations of dioxin-type chemicals. All diagrams should be completed by July 20.

TESTING LISTS

The following testing list is recommended at this time:

1. Crude DCP.*
2. D/T Chlorophenols.
3. Tar.
4. 2,4-DCP 97.5%.
5. 2,4-D*.
6. 2,4-D Extract.
7. 2,4-DB*

*Testing should be for the several isomers potentially present, including mono, Di, Tri, and Tetra, probably 4 to 8 in number. Testing will be done on the three starred primary products to determine if dioxins are present. If found, the remaining samples would be done.

8. MCPA Ester.
9. MCPP Ester.
10. 2,4-D Amine 6.
11. Carbon, spent composite of 3 - 4 loads.

Testing could be done at Wright State University who did our previous work. The cost is estimated to be $200 per sample per dioxin isomer. Testing could be done at Oregon State University as an alternate location. On 7/18 Dr. Freed called, asking for samples of our products, 2,4-D, MCPA, MCPP, etc. Apparently OSU now has a mass spec and the capability to test for dioxins at the level needed. OSU is planning to determine the dioxin content of phenoxy compounds to prove that these products do not have dioxins in them. The cost for testing is being estimated and will be forwarded when received. This could be worked out as part of a general study between R-P and OSU on our product streams. OSU is going to test 2,4-D acid for dioxins and predioxins on its own. A sample has been forwarded to Dr. Freed.

DIOXIN CHEMISTRY

Part of the study on dioxins will include the updating of the chemistry of dioxin formation prepared by the lab. This update will include chemistry of formation and known toxicology. Various correspondence is attached that refers to dioxins.

EDUCATIONAL PROGRAM

A new topic is going to be the development of a training and/or educational program on the dioxin levels in our products. This program could include toxicology information.

I have contacted Dr. Mike Gallo (an ex-R-P employee), of Booze, Allen and Hay, who is Director of Life Sciences, and will be developing a program with his company to provide R-P toxicology information and help. A cost proposal is being prepared. Conceivably, this could take several months.

We will also contact the Company doctor to determine the avialability of expertise in this area.

MONSANTO

I have received a call from a Don Escabon, supposedly of Monsanto. He had indicated that Monsanto had been visited by OSHA and had received a citation for environmental health practices. I have been in touch with Monsanto and have found this name to be inaccurate. The local sales manager has put me in contact with Bob Nelson who is Director of Environmental Control for Industrial Chemicals, Monsanto, St. Louis (314-694-2025). Monsanto has been visited by OSHA and has been cited. Apparently the citation has been appealed and the information has not been released as general knowledge and he does not know how I got the information.

Bob Nelson put me in contact with a Roger Garrett. Mr. Garrett is the Director of Industrial Hygiene for Monsanto and has worked for Monsanto for approximately 25 years. He indicated that they have done a lot of work with dioxin chemicals but have not been able to find any in the current operation, which is mono and dichlorophenol. The tests that OSHA ran were "wipe" tests. The only areas that suspected dioxins have been found were in the old penta production area. It is Monsanto's feeling that the data is not valid.

They have had no incidences of chloroacne in the chlorophenol area. They feel the symptom of chloroacne is the most accurate indicator of dioxin presence. Monsanto does not monitor its workers for dioxin exposure. They do an annual physical as we do, but conduct no special tests. Monsanto hesitates to take any extraordinary blood samples or tissue samples other than that taken at the annual physical. They do conduct metaglobulin tests for workers in the PVC and nitrile areas. They also have conducted cholinesterase for workers in the parathion operation. Monsanto has run a number of other types of tests to determine if there would be an easy test method that indicated exposure to pesticides or dioxins, etc. They have indicated that the tests have been very inconclusive because an employee can be on legal drugs, illegal drugs, or a strange diet--and cause unusual urine samples, blood samples, or tissue samples. In other words, there is no "pat" answer.

Monsanto has taken the approach of ambient air testing and control to ensure no exposure instead of employee monitoring. They feel that this method is more sure because of the many variables.

I will be in contact with Mr. Garrett again as our program develops. He seems most cooperative. He recommended that we be in touch with Vanderbilt University who has been working with EPA, OSHA, and industry on dioxins. Dr. Robert Neal is the expert on dioxins per Mr. Garrett. This will be done.

PLANT PROCEDURES

Written procedures to eliminate employee contact will be issued by July 20. The list is outlined in my July 5 letter. Our program on dioxin may need to be modified based upon the discussion to be held between J. E. Davies, Diamond Shamrock, and Dow.

If you have any questions, please feel free to contact me.

R. F. Gitschlag

RFG:BJF

Enclosures

VICTOR ATIYEH
GOVERNOR

Department of Environmental Quality

522 SOUTHWEST 5TH AVE. PORTLAND, OREGON

MAILING ADDRESS: P.O. BOX 1760, PORTLAND, OREGON 97207

CL
RLF
GQG
DR
CLARKE
GJK
10-4-79

September 27, 1979

Richard Gitschlag
Rhone-Poulenc
6200 Northwest St. Helens Road
Portland, OR 97210

The Department of Environmental Quality, at the request of the Environmental Protection Agency (EPA), is undertaking a survey of abandoned or inactive chemical hazardous waste disposal sites. Once identified, an evaluation will be made to determine what action, if any, is needed to minimize or correct any immediate or long-term threat to public health or the environment.

In a July 20, 1979, "brainstorming" session with the EPA, approximately 30 industrial sites were identified which may have locally disposed of hazardous waste in the past. Your plant was selected and analyzed on the enclosed form (to be shared with the EPA). If you have any comments or wish to discuss this further, please contact Fred Bromfeld or myself at 229-5913.

We wou ike to thank those of you who helped to complete the survey for your k ssistance.

Rich Reite
Rich Reite pervisor
Hazardous Wa ction
Solid Waste Divisio

FSB:w
SW623
cc: Tom Donaca, AOI

BOB ECKMAN
5?

RECEIVED
OCT 3 1979
PORTLAND

DEQ-2

INVENTORY-POSSIBLE SOURCES OF HAZARDOUS WASTE

****

EPA NUMBER: _____ NPDES#: 2652-J

SIC CODE BEG: 2879 SIC CODE END: 2879 BASIN CODE: _____

STATE: Oregon COUNTY: Multnomah CO CODE: _____

NAME: Rhone-Poulenc

OWNER:

ADDRESS: 6200 Northwest St. Helens Road ZIP: 97210

CONTACT: Richard Gitschlag PHONE: 222-3571

LOCATION: Portland, Oregon (see map attached)

TOWNSHIP: 1N RANGE: 1E SECTION: 13

USGS MAP NAME: Portland, Oregon - Washington

BUSINESS TYPE

Herbicide Mfg.

WASTE TYPES

Chlorophenols

DISPOSAL ACTIVITIES

Portland sewer, solid waste to Chem-Nuclear

PERIOD OF OPERATION: 1943 to present

HISTORY OF SITE OR PLANT OPERATION

See attached plant history.

DETAILS OF WASTE CHARACTERISTICS, VOLUMES AND DISPOSAL OPERATION

~~400,000 lb/yr materials contaminated with chlorophenols (solid waste).~~ This generally goes to Arlington. About 50% is a sludge from the wastewater treatment plant. Wastewater now goes to sewer, went to Doane L. prior to 1977.

Northwest part of property used as storage/demolition waste site by Atlas Building Wreckers.

SIC CODES

INVENTORY-POSSIBLE SOURCES OF HAZARDOUS WASTE

****

EPA NUMBER: _____

WASTE CHARACTERISTICS

IGNITABLE:				SOLID:	X
CORROSIVE:		RADIOACTIVE:		SEMI-SOLID:	X
REACTIVE:		INFECTIOUS:		LIQUID:	X
TOXIC:	X	OTHER:		GASEOUS:	

TOTAL WASTE QUANTITIES

VERY LARGE AMOUNT:	X		COUNTED:	
LARGE AMOUNT:		AMOUNT OF WASTE	ESTIMATED:	X
SMALL AMOUNT:		200 tons/yr	REPORTED:	X
VERY SMALL AMOUNT:		TONS,YDS,BBL,ETC	MEASURED:	

WASTE DISPOSAL

REGULATORY CONTROLS: _____

WASTE TRANSPORTED TO SITES #: Chem-Nuclear

WASTE DISPOSED INTO SEWER SYSTEM: X

WASTE DISPOSED IN EFFLUENT: X NPDES: OR-100174-1

WASTE DISPOSED OF ON SITE: Past

ON SITE DISPOSAL

INCINERATION: Some in early 70's LAND SPREADING: _____

SURFACE STORAGE: _____ BURIAL: _____

WELL INJECTION: _____ OTHER: _____

SITE CONDITIONS

GEOLOGIC SETTING

Fill over old lake bed.

HYDROLOGIC CONDITIONS

DISTANCE OF LAKE OR MARINE WATER: _____

DISTANCE TO SURFACE STREAM: 0.45 mi. (Willamette)

DEPTH TO GROUNDWATER: About 5 feet

DISTANCE TO WELLS OR SPRINGS: _____

DISTANCE TO NEAREST RESIDENCE: 150 yards

USE OF SITE IF ABANDONED: _____

PHYSICAL CONTROLS AT SITE

SOURCES OF INFORMATION: Dick Gitschlag, Rhone-Poulenc, plant manager.

COMPILER: Fred Bromfeld DATE: August 20, 1979

Site visit 8/24 with Dennis Stefani (EPA)

RHONE-POULENC INC.

PORTLAND PLANT

6/12/79

PLANT HISTORY HIGHLIGHTS

The plant has been located in Portland since 1943, starting with a small railroad liquid formulation plant and a warehousing operation for distributing insecticides. Later formulation of 2,4-D and other herbicides were made in Portland. The Technical 2,4-D Plant was built in 1956. Since then various operations have been added.

1956 2,4-D Plant

1959 - 2,4-D operations revised to improve product quality and decrease pollution problems.

1960 - MCPA Plant -- used o-dichlorobenzene as a solvent.

2,4,5-T Plant

Continuous ester operation

2,4-DB ester operation

1962 - 2,4,5-T down, continuous ester plant abandoned.

1963 - 2,4-DB Plant

1964 - First major water pollution incident and chlorine oxidation system to treat plant effluent.

1965 - MCPA Plant shut down and dismantled.

1966 - New MCPA Plant - using DCM (dichloromethane) solvent.

1969 - Carbon Treatment System on plant effluent.

1970 - Building Scrub, 2,4-D

1971 - BO Process added to ester plant
bromoxynil octanoate

1972 - MCPB and 2,4-DP production

1975

1976 - New MCPA Process Plant started and cancelled early in 1976.

1976 - DCP Distillation for high purity 2,4-D

1977 - 2,4-D Optimization, Water Treatment System additions and hookup to City Sewer.

SOLID WASTE DISPOSAL

TO ST. JOHNS FILL (5,000 DRUMS)

TO ALKALI LAKE (STORED TO 1969) (22,000 DRUMS)

TO PASCO

TO CHEM-NUCLEAR

SUGGEST FOLLOW-UP

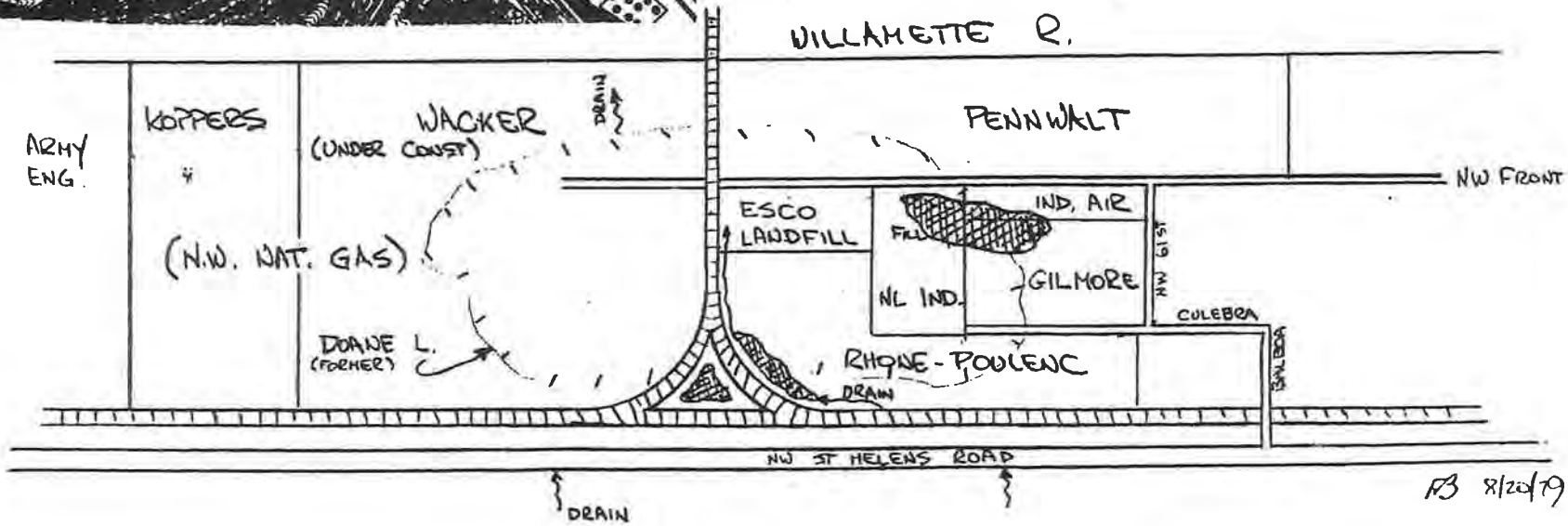
Doane Lake Area

1. It was originally thought that this area consisted of two lakebeds, Doane (east) and Giles (west), created from the old Doane Lake as a result of constructing the railroad bed in 1910. The recognition of Giles Lake as a separate entity, however, never came into common usage and it is not generally referred to on maps. As such, we shall refer to this area simply as Doane Lake.

   This will also avoid confusion with the Guilds Lake area about two miles to the S.E.

2. Almost the entire lake has been covered with 5 - 10 ft. of fill. The area, however, is a natural sump and the water table is only about 5 ft. below the surface. During a wet winter it may surface in some areas. The old Doane Lake fluctuated about 5 ft. in depth.

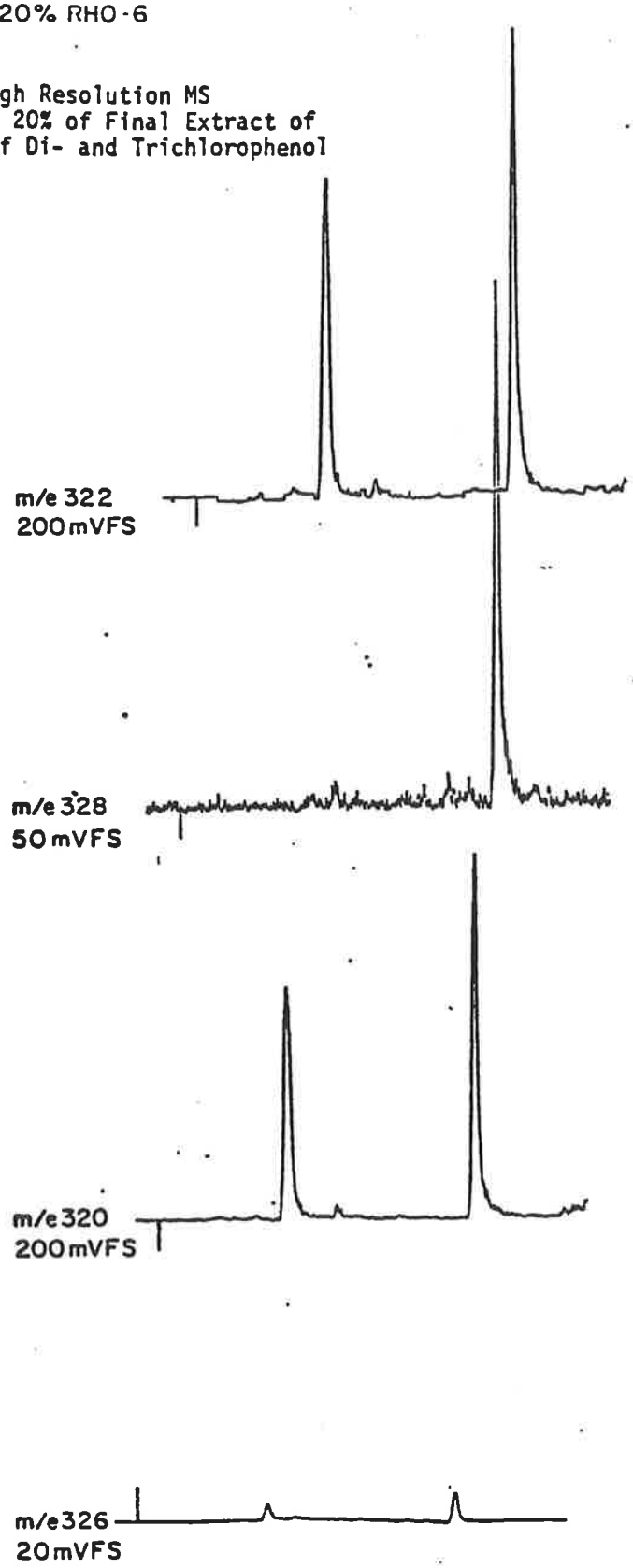
DOANE LAKE AREA



RB 8/20/79

20% RHO-6

Fig.2
Capillary Column GC-High Resolution MS
Mass Chromatograms for 20% of Final Extract of
Rhone-Poulenc Sample of Di- and Trichlorophenol
Distillation Bottoms



Wright State University

Dayton, Ohio 45431

May 1, 1980

Mr. David Watkins
U. S. Environmental Protection Agency
Industrial Environmental Research Laboratory
5555 Ridge Avenue, Rm. 218
Cincinnati, Ohio 45268

Dear Mr. Watkins:

It has recently come to my attention that the Federal Register issued on Tuesday, March 11, 1980 (Vol. 45, No. 49, Page 15592) contained a directive and a Proposed Rule from the U. S. Environmental Protection Agency, bearing on the disposal of chemical process wastes containing 2,3,7,8-TCDD. This directive (a copy of which is appended) specifically prohibits Vertac, Inc. from disposing of wastes located at their Jacksonville, Arkansas facility, but also required any person intending to dispose of wastes which might contain TCDD to notify EPA at least sixty days prior to the planned action. The directive further indicates that persons subject to this rule would be exempt if they showed that their wastes contained "no" detectable levels of TCDD, by employing the methodology established by the Dioxin Monitoring Program. The latter was asserted to entail use of capillary column gas chromatography interfaced with high resolution mass spectrometry (GC/HRMS), and the announcement referenced a paper by R. Harless, A. Dupuy, and others, which has not yet been published.

The proposed rule, as presented in the Federal Register announcement discussed above, is inadequate to accomplish the intended objectives and the methods specified there cannot actually be implemented to assess chemical wastes for TCDD. The first serious shortcoming of the proposed rule is the requirement to demonstrate that "wastes contain no detectable levels of TCDD ---", although no detection limits are specified. This requirement, as stated, has no meaning because detection limits for the analysis are not specified. Even using the methodology which is indicated, a wide range of detection limits is possible, depending upon the manner in which the methodology is implemented. Thus, a given industrial producer of wastes contaminated with TCDD might choose to set his detection limits at the gram level, and therefore be able to assert that all his wastes are "clean". Clearly, a detection limit for the TCDD analysis must be defined by EPA, and, a level of 50-100 ppt of TCDD in industrial wastes would be a reasonable lower limit to achieve for most samples, based on our extensive experience with such materials.

The second major error in the Federal Register announcement in question is the assertion that methodology for determining TCDD in chemical wastes was established by the Dioxin Monitoring Program. This is, in fact, not correct.

The analytical methodology which has been proven to be applicable for determining TCDD in chemical wastes was developed by Wright State University, and this methodology was applied for characterization of all the chemical wastes and environmental samples collected by EPA at the Vertac site. While Wright State has also been a participant in the EPA/OTS-sponsored Dioxin Monitoring Plan, (under Cooperative Agreement No. CR806846-01), as you are aware, the development of the analytical methods for determining TCDD in chemical process wastes and related samples, and the analyses of some 115 critical samples from the Vertac facility site were accomplished separately by, Wright State under Contract Nos. 68-03-2659 and 68-03-2830 with the EPA's Industrial Environmental Research Laboratory, for which you served as Project Officer. Additional environmental samples from Vertac were analyzed by Wright State under EPA Region VI, Order Nos. 9T-1501-NTEX and OT-0267-NAEX. As you know, a Final Report describing the development of analytical methodology for chemical wastes is currently being published by EPA/IERL, and a Final Report of the analytical data on Vertac samples has just been submitted to you and to EPA Region VI. The analyses of Vertac samples by Harless et al, were accomplished subsequent to Wright State's analyses and were intended to provide confirmatory data on samples also analyzed by our laboratory.

It should be further emphasized that the manuscript by Harless, Dupuy et al, to which the Federal Register announcement refers, does not even describe extraction and clean-up methods which are applicable for determination of TCDD in chemical waste samples. Moreover, the extraction and clean-up procedures which are described in this paper by Harless et al for determining TCDD in other types of samples are not effective for chemical wastes. This fact was acknowledged by Harless in his letter of December 3, 1979 to Mike Dellarco of EPA (a copy of which is attached). On the second page of this memorandum, Harless notes (under item 2. of the "Discussion and Results") that "a problem did exist in the analytical clean-up procedure", and that the data he obtained using the EPA procedures was "qualitative only". He subsequently analyzed the crude samples without cleanup, and achieved some success for samples containing very high levels of TCDD (ppb to ppm), but such procedures would clearly be inadequate for reliable low-level TCDD determinations (ppt levels) in chemical wastes. The reasons for the inadequacy of the EPA-Toxicant Analysis Laboratory's extraction and clean-up procedures, as described in the referenced paper, for analyzing TCDD in chemical wastes have been demonstrated by our work. The complex nature of such chemical wastes and the presence of large concentrations of many chemicals other than TCDD result in alteration of the elution characteristics of the liquid chromatography columns used to clean-up extracts of these samples. Methodology which is adequate for processing such samples must include provisions for assessing these factors (by preliminary screening of various column eluate fractions) prior to GC-high resolution MS analysis, as is the case with the Wright State analytical method.

The instrumental methods which are specified in the Federal Register announcement, namely, capillary column GC-high resolution MS, and which are attributed to Harless et al, are indeed state-of-the-art methods, and Harless' laboratory is highly qualified for such measurements. However, Wright State also accomplishes TCDD analyses using capillary column GC-high resolution MS, and in addition, our laboratory also uses packed column GC-high resolution MS, and capillary column GC-low resolution MS. The latter methods, while less definitive than the capillary column GC-high resolution MS, are less costly to implement and are desirable for screening cleaned-up extract fractions in order to check the clean-up methods, as noted above. To some extent, each type of chemical waste or effluent represents a unique case, and the extraction and clean-up methodology must be tailored specifically for each of these matrices.

In summary, we feel that the Federal Register announcement of March 11, 1980 is rather misleading, and that a corrected or amended rule should be published by EPA. We would hope that any new announcement will reference Wright State's methodology for determination of TCDD in chemical wastes, and site the reports submitted to EPA by our laboratory, one of which is currently being published by IERL. Reference to the instrumental methods used by Harless et al is also appropriate, of course. Publication of such an amended rule will facilitate industry's compliance with the Agency's requirements for safe handling and disposition of chemical wastes which may be contaminated with highly toxic TCDDs.

We look forward to receiving your comments on these matters. We would also suggest that you forward our comments to other appropriate EPA officials, such as Mr. Gordon Olson, OPTS, who is mentioned in the published Federal Register announcement. Perhaps it would also be appropriate to forward copies of our reports to Mr. Olson and other EPA personnel who are concerned with these problems.

Sincerely,

Thomas O. Tiernan, Ph.D.
Professor of Chemistry and
Director of the Brehm Laboratory

TOT/ch

SAMPLE PREPARATION PROCEDURES

AND

GAS CHROMATOGRAPHY MASS SPECTROMETRIC METHODS OF ANALYSIS

FOR

2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN (TCDD) RESIDUES

R. L. Harless, E. O. Oswald, and M. K. Wilkinson, U.S. Environmental Protection Agency, HERL, ETD, ACB, MD-69, Research Triangle Park, NC 27711

A. E. Dupuy, Jr., D. D. McDaniel, and H. Tai, U.S. Environmental Protection Agency, Pesticides Monitoring Lab, Office of Pesticide Programs, Office of Toxic Substances, Bay St. Louis, MS 39529

ABSTRACT

Analytical extraction, clean-up procedures, and capillary column gas chromatography/high resolution mass spectrometric methods of analysis for low concentrations (pg/g levels) of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) are presented. The application of these procedures and methods in the analysis of human milk, beef liver, fish, water, and sediment is discussed.

INTRODUCTION

The highly toxic compound 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) may be formed as a by-product in manufacturing processes utilizing tetrachlorobenzene to produce trichlorophenol. Under very basic high temperature, high pressure conditions 1,2,4,5-tetrachlorobenzene is hydrolyzed to the 2,4,5-trichlorophenate. Acidification yields the phenol. Unfortunately, a condensation can take place in this reaction which results in the formation of TCDD. Herbicides containing esters of 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) manufactured from trichlorophenol have been found to contain trace amounts of TCDD. TCDD has been recognized as an extremely toxic (LD_{50} 600/parts per trillion[1]) mutagenic[2] and teratogenic[3] compound which is stable in biological systems.

Because of its toxicity and occurrence as a trace contaminate in chemical products, it is necessary to analyze for TCDD at the low parts per trillion (ppt) concentration range, which is below the usual limits of detection for pesticide residue analysis. Methods for determining ppt TCDD in environmental extracts using high resolution mass spectrometry (HRMS)[4,5], packed column gas chromatography

(GC) in conjunction with low and high resolution MS[6,7,8], high resolution gas chromatography with low resolution MS[9], and GC - electron capture (EC)[10], have been reported.

The analysis of human, biological, and environmental samples for possible TCDD contamination in the ppt concentration range is complicated by the presence of many interfering components ranging from naturally occurring compounds to industrial pollutants, such as PCBs and agricultural chemicals such as DDT, DDE, etc. A recent paper[11] reports chlorinated benzyl phenyl ethers as possible interferences in the determination of chlorinated dibenzo-p-dioxins in 2,4,5-trichlorophenol and its derivatives.

An extremely efficient and specific analytical clean-up procedure is a pre-requisite for ppt TCDD analysis utilizing GC/MS detection techniques. The GC/MS detection technique must be ultra-sensitive and highly specific because of the required low ppt detection limits. High resolution glass capillary column GC interfaced with medium and high resolution MS specific mass detection provides the required GC resoltuion, MS sensitivity, and specificity for TCDD analysis in the 0.02 to 100 ppt concentration range.

This paper will describe the current sample preparation procedures and capillary column GC/HRMS techniques developed and applied by EPA laboratories for isolation, detection, quantification, and confirmation of TCDD residues in human, biological, and environmental sample extracts. TCDD results generated in EPA laboratories are evaluated and released by designated EPA officials. Therefore, only the results of quality assurance samples and samples with unusual contamination are discussed in this paper.

EXPERIMENTAL

Safety

TCDD is toxic and can pose grave health hazards if used improperly. Techniques used for handling radioactive and infectious materials are applicable to TCDD. Only qualified individuals who are trained in laboratory procedures and familiar with the hazards of TCDD should handle this substance. Females of childbearing age should not work with this material.

A good laboratory practice involves routine physical examinations and blood checks of employees working with TCDD. Also facial photographs using oblique photoflood lighting should be periodically taken to detect chloroacne, which is an early sign of TCDD exposure.

Instrumentation

A Varian Model 2700 GC interfaced with a Varian 311A MS was utilized for these analyses. The interface design[12] ensured maximum transfer efficiency. The GC was equipped with a 30 m x 0.25 mm i.d. SE-30 WCOT glass capillary column. Capillary column resolution measured at the TCDD peak was calculated to be 113,000 effective plates.

The MS was equipped with a turbo-molecular vacuum pumping system combination chemical ionization (CI) electron impact (EI) ion source (operated in the EI mode), and a Varian eight channel hardware (manual control) Multiple Ion Selection (MIS) device. The vacuum system easily accommodated the 5 ml/min helium flow from the GC/MS interface and did not contribute detectable background contamination.

The MIS device was operated in the normal coupled electric mode (jumping the acceleration voltage). Each MIS channel was equipped with individual controls for selecting a specific acceleration voltag measuring range, out-put signal bandwidth, compensation for background contamination, and integration rate. The intensities of the selected masses were monitored in a time-division multiplex system, setting alternatively to each of the selected masses and recording their intensities simultaneously on an eight channel Soltec recorder. The adjustable integration rate, 0.01 sec to 1 sec was sufficient to accurately reproduce capillary column peaks two seconds wide at half height.

Capillary Column GC/HRMS Multiple Ion Selection Analysis

The magnet current was tuned to perflorokerosene (PFK) m/e 318.9793 and the MS was adjusted for 5000 to 9000 mass resolution. The ESA voltage was monitored and used in calculating the exact acceleration voltage required for the masses, m/e 327.8847 $C_{12}H_4O_2{}^{37}Cl_4$, m/e 321.8936 $C_{12}H_4O_2{}^{35}Cl_3{}^{37}Cl$, and m/e 319.8965 $C_{12}H_4O_2{}^{35}Cl_4$. The calculated values were introduced to MIS channels 2,3, and 4. Two microliters of quantification standard, 500 pg/uL ^{37}Cl-TCDD* and 1 pg/uL TCDD, and 0.5 uL of n-tetradecane were injected into the capillary column (on column splitless injection) maintained at 80°C. The GC oven manual temperature control was rapidly turned to 265°C exactly six minutes after injection of sample. The manual control provided an accurate and rapid heating rate of 34°C/min. The solvent vent valve was closed exactly 14 min. after injection of sample. The MS sensitivity was optimized for the source operating pressure

* ^{37}Cl-TCDD= Labeled 2,3,7,8-tetrachlorodibenzo-p-dioxin, ^{37}Cl-TCDD isotopic purity greater than 98%.

(6×10^{-6} Torr) using PFK m/e 318.9793. The MIS analysis was initiated 16 min. after injection of sample. The GC/HRMS experimental retention time for TCDD was determined to be 23 min. $\pm$ 15 sec, adhering to a strict (stop watch) time schedule of events.

The GC/HRMS parameters were: GC Parameters-- Injection port temperature 260^{0}C; GC transfer line into MS ion source was maintained at 255°C. MS Parameters-- Ion Source temperature 240°C; Specific and variable acceleration voltage, 3kV maximum; Electron energy 70 eV; Filament emission 1 mA; Mass resolution 5,000 to 10,000; Multiplier gain greater than 10^{6}.

COCl Loss Analysis

The magnet current was tuned to PFK m/e 254.9856 and the exact acceleration voltages required for TCDD masses m/e 256.9327, m/e 258.9298, m/e 319.8965, m/e 321.8936, and the m/e 327.8847 corresponding to ^{37}Cl-TCDD, were introduced into respective MIS channels. The analysis was performed adhering to the previously described time schedule of events. The GC/HRMS MIS five channel simultaneous responses for ^{37}Cl-TCDD and TCDD were observed and recorded at the correct GC retention time for TCDD.

Elemental Composition Analysis

The MS was adjusted for 10,000 mass resolution utilizing PFK m/e 318.9793 as reference. The capillary column GC/HRMS peak matching analysis was initiated adhering to the exact time schedule of events utilized in the GC/HRMS MIS analyses. The reference mass and the exact mass range of interest were displayed alternately and were visible simultaneously on the MS oscilloscope.

The MIS device was operated in the normal coupled electric mode (jumping the acceleration voltage). Each MIS channel was equipped with individual controls for selecting a specific acceleration voltag measuring range, out-put signal bandwidth, compensation for background contamination, and integration rate. The intensities of the selected masses were monitored in a time-division multiplex system, setting alternatively to each of the selected masses and recording their intensities simultaneously on an eight channel Soltec recorder. The adjustable integration rate, 0.01 sec to 1 sec was suffici to accurately reproduce capillary column peaks two seconds wide at half height.

Capillary Column GC/HRMS Multiple Ion Selection Analysis

The magnet current was tuned to perflorokerosene (PFK) m/e 318.9793 and the MS was adjusted for 5000 to 9000 mass resolution. The ESA voltage was monitored and used in calculating the exact acceleration voltage required for the masses, m/e 327.8847 $C_{12}H_4O_2{}^{37}Cl_4$, m/e 321.8936 $C_{12}H_4O_2{}^{35}Cl_3{}^{37}Cl$, and m/e 319.8965 $C_{12}H_4O_2{}^{35}Cl_4$. The calculated values were introduced to MIS channels 2,3, and 4. Two microliters of quantification standard, 500 pg/uL ^{37}Cl-TCDD* and 1 pg/uL TCDD, and 0.5 uL of n-tetradecane were injected into the capillary column (on column splitless injection) maintained at 80°C. The GC oven manual temperature control was rapidly turned to 265°C exactly six minutes after injection of sample. The manual control provided an accurate and rapid heating rate of 34°C/min. The solvent vent valve was closed exactly 14 min. after injection of sample. The MS sensitivity was optimized for the source operating pressure

* ^{37}Cl-TCDD= Labeled 2,3,7,8-tetrachlorodibenzo-p-dioxin, ^{37}Cl-TCDD isotopic purity greater than 98%.

column peaks, and the small amount of TCDD analyzed in the presence of minor amounts of contamination. The MS precision values (reproducibility of peak height response and chlorine isotope ratio) obtained for repeated injections of TCDD standards was significantly improved over those values obtained during analysis of actual samples.

Due to the widespread distribution of PCBs, the accuracy of ^{37}Cl-TCDD determination primarily depends on the sample preparation procedure efficiency and specificity, and the capillary column GC resolution of components. The MS mass resolution, ca. 45000, required to separate ^{37}Cl-TCDD m/e 327.8847 and PCB m/e 327.8758 is not feasible due to MS limitations. For occasional and highly contaminated sample extracts, the ^{37}Cl-TCDD m/e 328 peak height was determined utilizing the PCB m/e 326 peak height to calculate the PCB contribution to the m/e 328, a mixture of ^{37}Cl-TCDD and PCB.

The GC/HRMS peak matching accuracy for known elemental compositions was determined to be $\pm$ 2 millimass units at 9500 mass resolution with PFK as reference. The PFK reference mass, m/e 318.9793, and TCDD mass were observed to be exactly superimposed on the MS oscilloscope in real time at the exact GC/HRMS retention time of TCDD. The TCDD isomers were also confirmed in these analyses.

Fingerhut, M. and L. Blade. 1982. NIOSH Dioxin Registry Site Visit Report of Rhone-Poulenc, Incorporated, Portland, OR, Site Visit Dates January 19-25, 1982. Centers for Disease Control, Industrywide Studies Branch, Division of Surveillance, Hazard Evaluations, and Field Studies, National Institute for Occupational Safety and Health, Cincinnati, OH. May 21, 1982.

NIOSH Dioxin Registry Site Visit Report

of

Rhone-Poulenc, Incorporated

Portland, Oregon

Site Visit Dates

January 19-25, 1982

Report Written by

Marilyn Fingerhut, Ph.D.

Leo M. Blade

Date of Report

May 21, 1982

Industrywide Studies Branch

Division of Surveillance, Hazard Evaluations, and Field Studies

National Institute for Occupational Safety and Health

Centers for Disease Control

Cincinnati, Ohio

Place Visited: Rhone-Poulenc, Incorporated
Portland, Oregon

Dates of Visit: January 19-25, 1982

Attendees: Rhone-Poulenc, Incorporated:

Robert Briggs, Plant Manager
Thomas Henshaw, Plant Engineer
John Vernetti, Quality Control Manager
Douglas Nye, Site Safety and Personnel Representative

NIOSH:

Leo Blade, Industrial Hygiene Engineer
Marilyn Fingerhut, Ph.D., Epidemiologist

Additional help was received by telephone from Richard Gitschlag, Corporate Director of Environmental Engineering, who is currently located in the New Brunswick, N.J., office, but who was the plant manager in Portland during the early 1960's, which is the period of interest.

Purpose: To evaluate the feasibility of including in the Dioxin Registry Rhone-Poulenc workers who were involved with the synthesis of 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) formerly produced at this site, to discuss the details of the synthesis and formulation processes for 2,4,5-T and related compounds, and to microfilm all pertinent records.

Summary of Activities: An opening conference was held on January 19, 1982, with all of the attendees to review the nature and purpose of the study and to explain the purpose of the visit. The discussion dealt with the products of this facility and the dates these products were made. Meetings were held with Mr. Henshaw to discuss the pertinent production processes. Mr. Henshaw conducted a tour of the present facilities for the NIOSH personnel, and explained the relationship of the equipment used for the 2,4,5-T products to the current use and location of much of the same (or similar replacement) equipment for 2,4-dichlorophenoxyacetic acid (2,4-D) production and formulation. The personnel records were reviewed, and appropriate personnel files were collected and microfilmed.

Introduction

The National Institute for Occupational Safety and Health (NIOSH) is currently conducting an investigation of health effects resulting from occupational exposure to 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). This study, initiated in 1979, was prompted by animal studies showing TCDD to be acutely toxic and a chloracnegen, as well as a carcinogen and teratogen. TCDD is a contaminant of 2,4,5-trichlorophenol (TCP) and materials synthesized from it such as 2,4,5-trichlorophenoxyacetic acid (2,4,5-T).

Because of the widespread production and use of 2,4,5-T as a commerical herbicide since the 1940's, a registry of all workers from 2,4,5-T synthesis sites in the United States is being compiled. This registry contains data from the personnel and medical records of these workers, in addition to process information to define exposure. A retrospective cohort mortality study is planned and morbidity surveys may be conducted.

History of the Plant

In 1943, Chipman Chemical Company began the manufacture of various railroad herbicides on the site in Portland now occupied by Rhone-Poulenc, Incorporated; in 1956, the production of phenoxyalkanoic acids was initiated, and 2,4-dichlorophenoxyacetic acid (2,4-D) was the first of these produced. Portland was Chipman's only technical manufacturing site, but other locations in which "formulating" (the mixing and packaging of marketable products) was conducted were maintained across the country. At the formulating sites, a wide variety of Chipman products were handled. In 1965, Chipman was purchased by Rhone-Poulenc, Incorporated, a French company. All of Rhone-Poulenc's operations in the United States used the name Rhodia, Incorporated, until 1977, when they began to use the parent company's name. Currently, all technical manufacturing of herbicides by Rhone-Poulenc in the United States occurs at the Portland plant, and one formulating site remains in St. Joseph, Missouri.

The products and their dates of production and/or formulation, as determined from limited records, are listed here.

Synthesis and formulation:

2,4-Dichlorophenol (2,4-DCP)	1956 to ~~present~~ JULY 198[illegible]
2,4-Dichlorophenoxyacetic acid (2,4-D)	1956 to ~~present~~ JULY 1982
N-Butyl ester of 2,4-D	1956 to present
Isobutyl ester of 2,4-D	1956 to present
Isooctyl ester of 2,4-D	1956 to present
Isopropyl ester of 2,4-D	1956 to ~~present~~ 1960 ?

2,4-Dichlorophenoxybutyric acid (2,4-DB)	1964 to ~~present~~ JULY 19[illegible]
2,4-Dichlorophenoxypropionic acid (2,4-DP)	1973 to 1976
2-Methyl-4-chlorophenoxyacetic acid (MCPA)	March 1961 to 1976
4-(2-Methyl-4-chlorophenoxy)butyric acid (MCPB)	1972 to Jan. 1973
2,4,5-Trichlorophenoxyacetic acid (2,4,5-T)	Feb. 1961* to Dec. 1962
Isooctyl ester of 2,4,5-T	Feb. 1961* to Dec. 1970
Isobutyl ester of 2,4,5-T	Feb. 1961* to April 1966
3,5-Dibromo-4-octanoyloxybenzonitrile (Bromoxynil octanoate)	1971 to present

*Test batches were run in July or August 1960.

Formulation only

2,4,5-T amines	Feb. 1961 to March 1970
Isooctyl ester of 2,4,5-T	Dec. 1970 to Nov. 1975
Silvex and its esters	Late 1950's to March 1975

No 2,4,5-trichlorophenol (TCP) was ever synthesized by Chipman, Rhodia, or Rhone-Poulenc in any location in the United States. There are no production records dating back to the period from 1960 to June 1968, but laboratory and other auxiliary records indicate that the synthesis of 2,4,5-T acid and esters occurred predominantly from February 1961 to December 1962. Test batches were run in July or August 1960. After 1962, only small amounts of 2,4,5-T esters and amines were occasionally produced from purchased T-acid and esters. These activities occurred in the ester unit of the 2,4-D Building and in the smaller Specialty Ester Building.

Purchases were made of an aqueous solution of the sodium salt of TCP from Monsanto Company in July 1960 and from Diamond Alkali Company after December 1960. Available records indicate that assays of content were made of the following: 2,4,5-T acid from Monsanto in 1962 and 1964 and from Dow Chemical Company in 1964 and 1969; 2,4,5-T isooctyl ester from Diamond Alkali in 1960 and Thompson-Hayward Chemical Company in 1964; and Silvex ester from Thompson-Hayward in 1975. The records do not state whether these substances were actually purchased. YES WE DID PURCHASE 2,4,5-T IOE FROM P.C.G

Annual production summaries dating back to July 1968 indicate that formulation of 2,4,5-T esters and amines ceased in 1970. The formulation of Silvex and the inclusion of 2,4,5-T in herbicide mixtures ended in 1975. During the 1968-75 period, only small amounts of products containing 2,4,5-T or other TCP-derived products were made: 1500 gal. of 2,4,5-T esters, 3500 gal. of 2,4,5-T amines, 250,000 gal. of herbicide mixtures containing 2,4,5-T esters, 75,000 gal. of liquid formulations containing Silvex and its esters, and 55,000 lbs. of solid formulations containing Silvex. As a point of comparison, the company estimates that 90 million pounds of 2,4-D were produced during this time. Since 1971, bromoxynil octanoate has been produced by the company.

From the 1950's until 1971, Chipman formulated a variety of insecticides, arsenicals and mercury compounds, but the company did not synthesize any of them. These products were formulated in the Insecticide Building, and included DDT, aldrin, endrin, Malathion, Toxaphene, parathion, hexachlorobenzene, arsenicals, mercury compounds, sodium chlorate/~~and~~ sodium borate, MIXTURES (BFG)

Department Operations and Personnel

Between mid-1960 and the end of 1962, the phenoxyalkanoic acid herbicide activities were funded from cost center 602 and were located in the same buildings in use today plus one small building, no longer present, which housed the MCPA production. A plant layout diagram (see Figure 1) is provided for reference. Four shifts worked on production and formulation of 2,4-D and its esters and amines, 2,4,5-T and its esters and amines, various blends of these products, and, after March 1961, the production of MCPA. The work was seasonal, and there was frequent shifting of workers from one to another of the jobs within the 602 cost center; each job had specific assigned duties, such as packaging or operating certain kettles. The synthesis of 2,4,5-T took place in the Ester Room of the 2,4-D Building and also in the rear area of the 2,4-D building. Synthesis of T-esters occurred in two locations, the Ester Room of the 2,4-D Building and also in the Specialty Ester Building. Formulations of the T-acid, esters and amines were made in two locations, the Formulations Building and the Specialty Ester Building. The production of MCPA was initiated in March 1961 and was located at the site labeled "New MCPA Plant" in the plant layout diagram. After March 1961, therefore, MCPA exposure was involved for cost center 602 employees who were transferred or hired for the MCPA plant startup. Individuals working in the MCPA Building cannot be separately identified. Mr. Briggs estimated that MCPA production utilized perhaps 4 persons per shift out of a total of perhaps 25 production and formulation workers per shift. (No existing records provide actual figures.)

The walk-through tour of the current facility allowed the NIOSH personnel to make the following observations: the job locations of the personnel in areas formerly housing both 2,4,5-T and 2,4-D production operations were in close physical proximity to one another; also, there was manual handling of some of the materials in these areas. Therefore, a worker doing any job in the herbicide production buildings, except in the MCPA plant, had a

reasonable likelihood of exposure to the 2,4,5-T and related products. After March 1961, the transfer of cost center 602 workers occurred regularly among the 2,4,5-T, 2,4-D, and MCPA jobs, so it is very probable that all workers employed in the 602 cost center from February 1961 to December 1962 were exposed to 2,4,5-T acid, esters and amines.

The Insecticide Building was at the opposite end of the plant site from the buildings in which the phenoxyalkanoic acid herbicides were handled; it is currently used as a warehouse (see Figure 1). The review of the personnel record system and discussions with Mr. Henshaw and Mr. Gitchlag indicate that the insecticide workers can be distinguished from the phenoxyalkanoic acid herbicide workers in the personnel records for the July 1960 to December 1962 period, because the cost centers for the two operations were distinct. Additionally, there was little transfer from one cost center to the other at that time. Therefore, it is possible to exclude the insecticide workers from the Dioxin Registry.

It is probable that any individual who worked at the site after 1962 may have never been exposed to 2,4,5-T or other TCP-derived products, because of the small amounts of 2,4,5-T and related TCP-derived products handled at this site after 1962 compared with 2,4-D and other products (as noted in the History of the Plant section of this report), because the 2,4,5-T related products were handled only intermittently, and because only a few workers were assigned to the processes involving these products.

Description of the Personnel Records

A perpetual seniority list of all workers employed even for one day was prepared by Chipman in 1960 and has been updated since then. This was used to identify exposed individuals. The personnel records of all persons who worked at any time between July 1960 and December 1962 were collected and microfilmed.

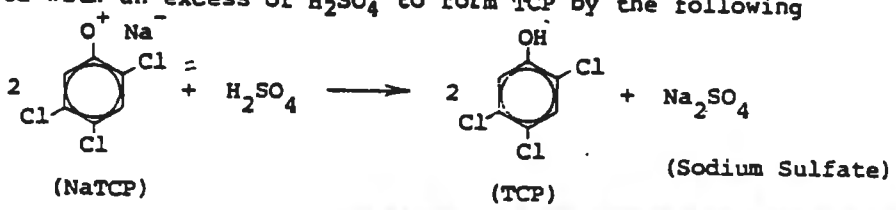
The personnel files are quite complete. They contain application forms, personnel sheets detailing rate and job changes, accident reports, Workers' Compensation claims, and medical insurance forms. Cost center notation is written on many personnel sheets, so that the 602 (phenoxyalkanoic acid herbicide) workers can be selected from the total group. From these records, it is possible to identify those hourly workers and salaried workers who worked in the 602 cost center during this period of time. Maintenance workers, who were also exposed to the insecticide formulations, can be identified. There is no way to separate formulators from operators because the union contract of the 1960-62 period identified all of the cost center 602 production workers as operators. It is also impossible to identify the particular tasks performed by each of the workers in synthesis or formulation. Additionally, for the period after 1962 the records do not identify the workers assigned to jobs involving 2,4,5-T or other TCP-derived products; however, as noted in the preceding section, these individuals composed a small percentage of the workforce.

Limited medical information is available for the workers. The medical insurance records which are in the files are not useful because they contain only monetary information and do not describe the medical condition involved. Neither Chipman, Rhodia, nor Rhone-Poulenc ever had a medical office, so there are no dispensary records. The services of local physicians were utilized.

Description of the Process for Production of 2,4,5-T Acid

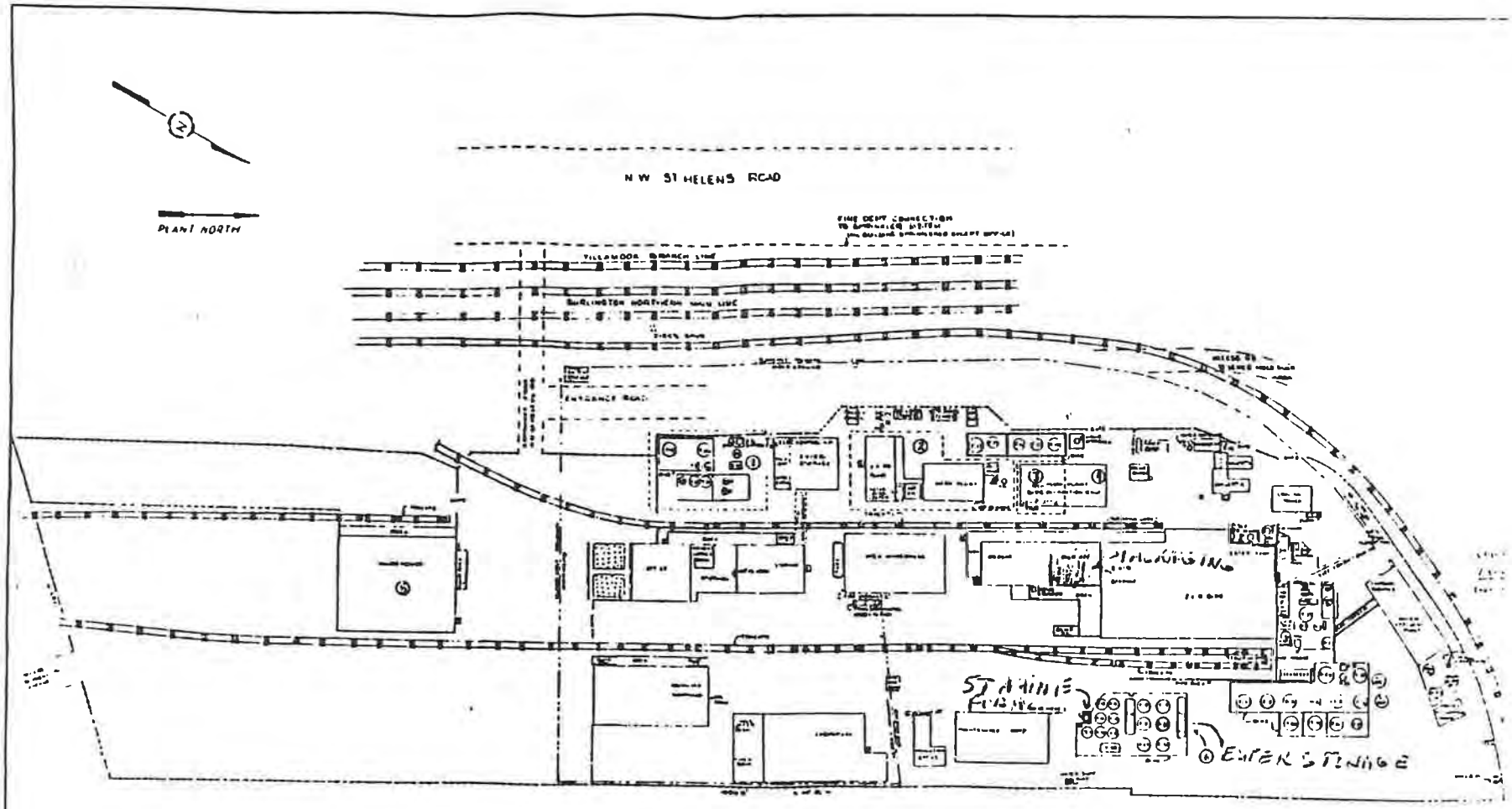
Chipman Chemical Company produced 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) using the following raw materials: sodium 2,4,5-trichlorophenate (NaTCP) (aqueous solution), sulfuric acid (H_2SO_4), flake caustic soda (NaOH), sodium carbonate (Na_2CO_3), isopropyl alcohol (IPA), and monochloroacetic acid (MCA). Other materials used in the process include benzene and water, each of which were solvents at various points in the process. The following description applies to the production of 2,4,5-T acid during each of the three years of manufacture; there were no significant changes during that time. A flow diagram is provided for this process (Figure 2); also, an equipment location diagram is included (Figure 3). Equipment numbers used in the text correspond to the numbers used in the figures. A plant layout diagram is provided for the entire Portland site (Figure 1).

The first step in the process is known as "TCP (2,4,5-Trichlorophenol) Acidification," and occurs in the agitated, 1000-gal., stainless-steel Ester Kettle (EK) 6. Here, NaTCP in aqueous solution is pumped in from tank cars and reacted with an excess of H_2SO_4 to form TCP by the following reaction:



This reaction occurs at 100°C and near-atmospheric pressure and proceeds until the pH reaches 1. At that time, the reaction is considered complete; a phase separation occurs, in which the TCP forms an organic layer at the bottom of the tank, and an aqueous layer of relatively lower density forms at the top. The aqueous layer, containing the Na_2SO_4 by-product, the unreacted excess H_2SO_4, and the water soluble impurities from the original NaTCP solution, is decanted from the top and drained to the sewer, while the TCP is drained from the bottom into EK 5. This step is included to remove the water and aqueous impurities from the NaTCP.

The next step in the process, known as the "TCP Dehydration," occurs in EK 5, an agitated, 1700-gal., stainless-steel tank. After the TCP is transferred to the vessel, isopropyl alcohol (IPA) is pumped in from Recovery Tank (RT) 1, the "Dry IPA" tank. Flake caustic (NaOH), in a quantity equimolar to the quantity of TCP, is manually dumped into the



(1) Dashed line surrounds Specialty Ester Area.
(2) Dashed line surrounds 2,4-DB Plant and current MCPA Plant which were nonexistent during 1960-62 period.
(3) Dashed line indicates location of MCPA Plant during 1960-62 period.
(4) New MCPA Plant Bldg. (Foundation Only) was nonexistent during 1960-62 period.
(5) Insecticide Formulation Area during 1960-62 period.
(6) Former 2,4,5-T products Formulation Area.

Figure 1 : Plant Layout Diagram, Rhone-Poulenc, Incorporated, Portland, OR

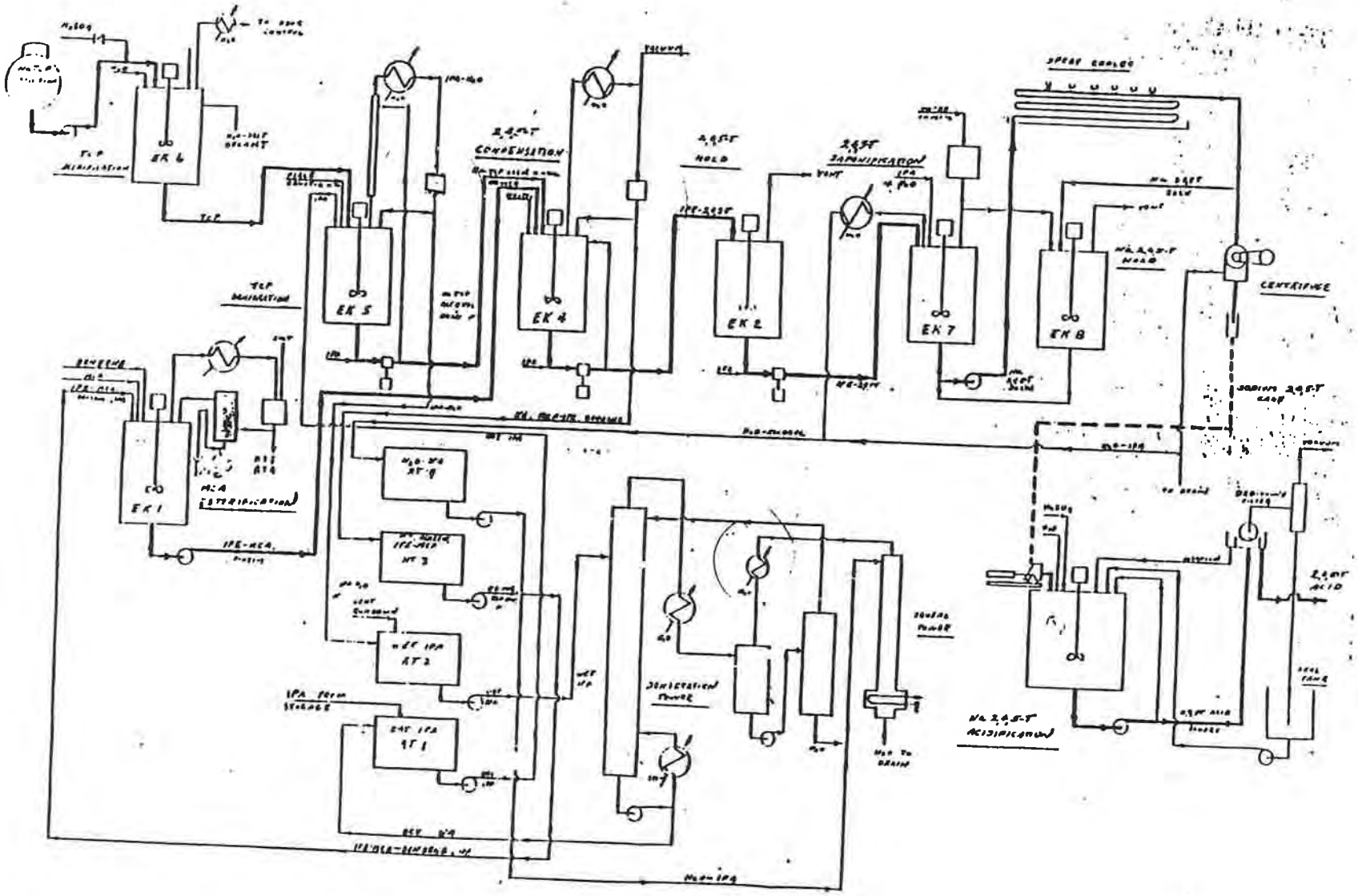


Figure 2: Flow Diagram for 2,4,5-T Acid P ction Process, Rhone-Poulenc, Incorporated, Portland, OR

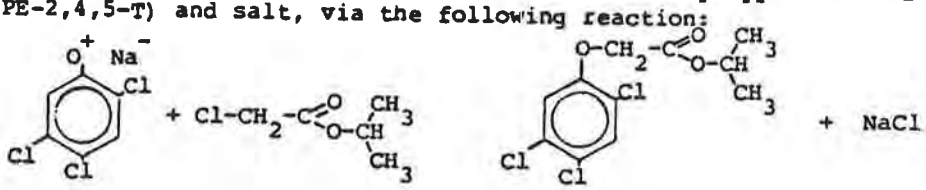
vessel, and dissolves; IPA is the solvent for the NaOH. An exothermic reaction occurs at near-atmospheric pressure between the TCP and NaOH to form NaTCP and water via the following mechanism:

(TCP) (NaTCP)

The temperature of the mixture rises to 115-119°C and a vapor phase containing water and IPA boils off; simultaneously, more IPA is pumped in, again from RT 1, until the mixture in EK 5 contains NaTCP, IPA, and no water. The IPA-H_2O mixture boiled off is condensed and drained to RT 2, the "Wet IPA" tank, for later recovery of the IPA (to be described later in this section); the NaTCP in IPA solution remaining in EK 5 is then ready to be pumped to EK 4 for further processing.

The next step in the process, known as "2,4,5-T (2,4,5-Trichlorophenoxyacetic Acid) Condensation," occurs in EK 4, which, like EK 5, is a 1700-gal., stainless-steel, agitated reactor. A solution of the isopropyl ester of monchloroacetic acid (IPE-MCA) in benzene solvent is pumped from EK 1, where it is synthesized (see description later in this section), and charged to the reactor; then the temperature is raised to 96°C. Next, the solution of NaTCP in IPA solvent from EK 5 is introduced during a feed period of 1 hour and 20 minutes. The molar quantity of IPE-MCA charged is in excess of that of the NaTCP by a factor of 1.5-2. These two compounds react at near-atmospheric pressure to form the isopropyl ester of 2,4,5-T (IPE-2,4,5-T) and salt, via the following reaction:

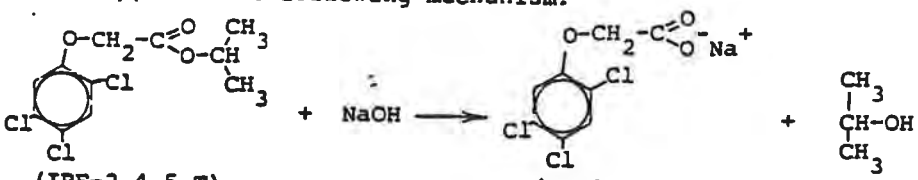
originally as 1000 b



(NaTCP) (IPE-MCA) (IPE-2,4,5-T)

After the feed period is completed, this reaction is taken to virtual completion by cooking the mixture at 112°C for 1 hour. When the cooking period is completed, 0.1 mole of Na_2CO_3 per mole of product is manually dumped into the reactor vessel; however, the company is unsure why this addition is included in the process. Finally, the mixture is boiled to 150°C, and a vacuum of 29 in.Hg is applied. This operation removes a vapor phase consisting of the unreacted excess IPE-MCA, the benzene, and the IPA; the vapor is condensed, and routed to RT 3, the "IPE-MCA" tank, for later reuse. The remaining mixture in EK 4, consisting of IPE-2,4,5-T with dissolved NaCl and Na_2CO_3, is pumped to EK 2, a 1000-gal., glass-lined, agitated tank, for the step labed "2,4,5-T Hold," and is stored awaiting further processing. A 96% yield of IPE-2,4,5-T, based on the charge of NaTCP to EK 4, is obtained in the process.

Water is pumped to EK 7, a 3000-gal., steel reactor; then an aqueous solution of 50% NaOH is added in a quantity sufficient to provide an amount of NaOH equimolar to the amount of the isopropyl ester of 2,4,5-T contained in EK 2. The mixture is heated to 100-110°C. Then the contents of EK 2 are pumped into the reactor, followed by more water, and the resulting mixture is cooked for 5 hours at near-atmospheric pressure to promote a reaction between IPE-2,4,5-T and NaOH, forming sodium 2,4,5-trichlorophenoxyacetate (Na-2,4,5-T), via the following mechanism:



(IPE-2,4,5-T) (Na-2,4,5-T) (IPA)

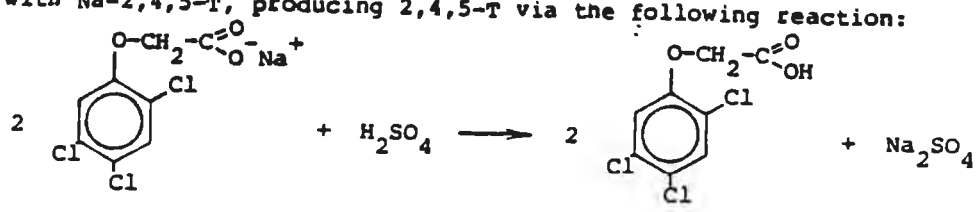
Water and IPA vapor boiled off of the mixture are condensed and drained to RT 4, the "H_2O - IPA" tank, for later recovery of the IPA.

The resulting aqueous solution of Na-2,4,5-T, with NaCl, Na_2CO_3, and IPA as impurities, is then pumped through a spray cooler to reduce its temperature. If the temperature is above 40°C after cooling, the solution is directed to EK 8, an agitated holding tank labelled "Na-2,4,5-T Hold", from where it can be recycled through the spray cooler. At a temperature of 40°C, the Na-2,4,5-T precipitates out of solution and a slurry is created. The slurry can be routed to EK 8 for temporary storage and agitation or can be sent directly to the closed, continuous centrifuge.

TUBE EXCHANGER

The centrifuge removes most of the liquid from the Na-2,4,5-T, leaving a cake of Na-2,4,5-T with a moisture content of approximately 50%. The cake drops out to fiber drums which are positioned and filled manually. The liquid is routed to either the drain or RT 4; the company is not certain which of these alternatives is normal for this process.

The next step in the process occurs in reactor Q2, a 3000-gal., acid-proof, brick-lined, agitated vessel. Water is added to Q2; then fiber drums containing Na-2,4,5-T cake are manually dumped into this vessel using a barrel dumper. H_2SO_4 is then added in excess to the vessel to react with Na-2,4,5-T, producing 2,4,5-T via the following reaction:



(Na-2,4,5-T) (2,4,5-T)

This reaction occurs at a temperature slightly above ambient and at near-atmospheric pressure. When the pH of the reactor contents stabilizes at 1, the reaction is considered complete. The resulting slurry of 2,4,5-T

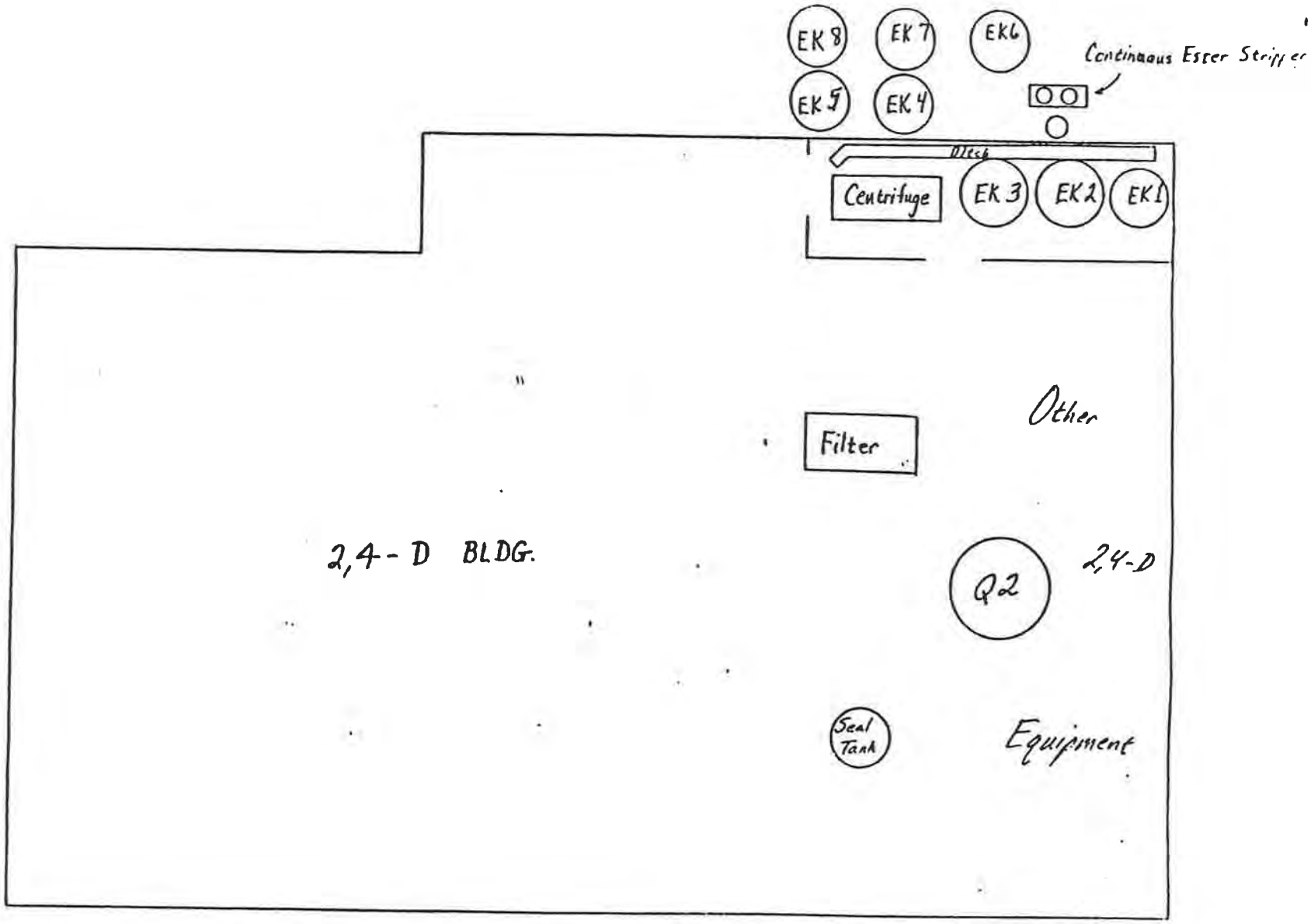


Figure 3: Equipment Location Diagram, Rhone-Poulenc, Incorporated, Portland, OR

acid in water, with the unreacted excess H_2SO_4 and the Na_2SO_4 by-product, is then pumped to the "Bird-Young Filter" for the final step of the process. This rotary vacuum filter removes most of the aqueous solution from the 2,4,5-T, leaving a wet cake with a 20% moisture content. The filter is continuous, and the solid automatically drops out to the drumming operation; the positioning and filling of the drums is performed manually. The aqueous solution is collected in a small tank and then drained to the "Seal Tank." From there, it is either recycled to Q2, for reuse of its acid content in another batch, or dumped to the drain when the salt (Na_2SO_4) content gets too high to dissolve more salt.

As noted previously in this section, the isopropyl ester of monochloroacetic acid (IPE-MCA) used in the reaction at EK 4 is synthesized at reactor EK 1. A solution of IPE-MCA, benzene, and IPA is pumped from RT 3 to this vessel. A sufficient quantity of benzene is added to make up for any losses in the system and to insure sufficient solvent at EK 4; also added is the amount of MCA required to make up for both the amount reacted in EK 4 in the previous batch and the amount of any losses in the system. The IPE-MCA synthesis reaction is:

(IPA) (MCA) (IPE-MCA)

Sufficient excess IPA is present in the recycled solution from RT 3 so that no IPA feed is needed here for this reaction. Losses of IPA throughout the system are made up by adding virgin IPA from storage directly to the recovered IPA in RT 1. The water by-product of the IPE-MCA synthesis reaction is continuously boiled off the mixture, condensed, separated from the IPA and benzene by decantation, and sent to the drain.

A system of distillations is used to recover the isopropyl alcohol from the two different strengths of water-IPA mixtures held in RT 4 and RT 2, which were noted previously in this section. Purified, recovered isopropyl alcohol is pumped to RT 1 for reuse, and aqueous waste is sent to the drain.

Description of the Process for Production of the Isooctyl and Isobutyl Esters of 2,4,5-T

Chipman Chemical Company produced the isooctyl and isobutyl esters of 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) using isooctyl or isobutyl alcohol, as appropriate, and the 2,4,5-T product of the process described in the previous section. The isooctyl ester of 2,4,5-T is abbreviated as IOET; the isobutyl ester of 2,4,5-T, also called simply the butyl ester of T, is abbreviated as BET. The production processes for each of these esters are virtually identical except for the alcohol used, and the same equipment was used by Chipman to produce either one, on a time-sharing basis. The following description applies to the synthesis of 2,4,5-T esters during all

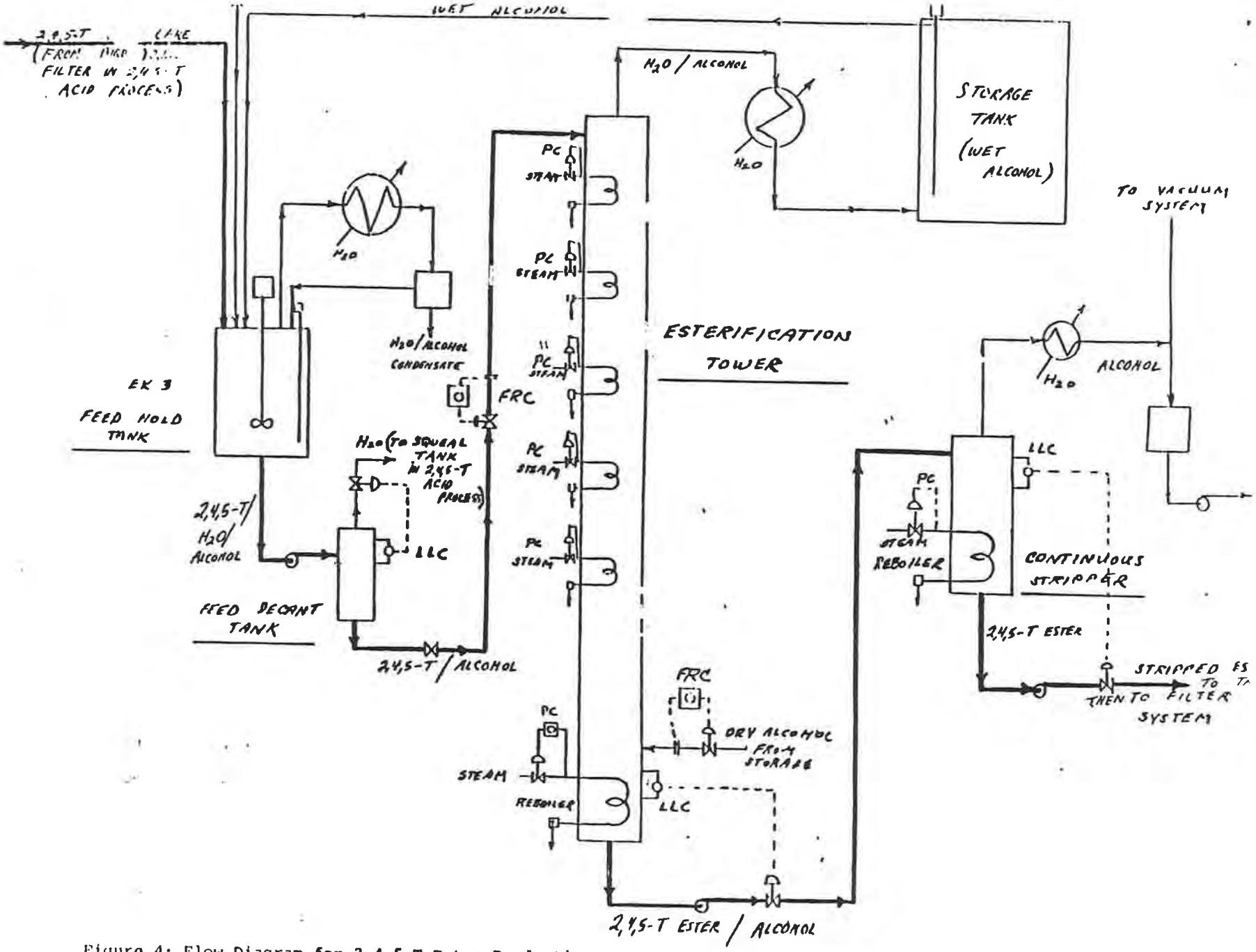


Figure 4: Flow Diagram for 2,4,5-T Ester Production Process

years of manufacture; there were no significant changes during that time. A flow diagram (Figure 4) is provided for this process; the equipment location diagram (Figure 3) and plant layout diagram (Figure 1) also apply to this process. As in the preceding section, the equipment numbers used in the text correspond to the numbers used in the figures.

The first step in this process is the dissolving of 2,4,5-T into a water-alcohol mixture. The appropriate alcohol is introduced into the agitated "Feed Hold" tank (EK 3) by adding "stripper alcohol" recovered from the continuous vacuum stripper at the end of the process, and by adding "wet alcohol," an alcohol-water mixture which is the condensed overhead product from the "Esterification Tower" described later in this section. After the liquid is introduced to the vessel, the temperature is raised to 100°C, and the wet 2,4,5-T acid cake is manually dumped into the vessel and dissolved into the mixture. A vapor containing water and alcohol is boiled off and condensed; some of the condensed mixture is drawn off and sent to storage for reuse while the remainder is recycled to EK 3.

The next step in the process occurs in the "Feed Decant" tank. The mixture of water, alcohol, and 2,4,5-T held in EK 3 is pumped into the decanting tank, and allowed to separate into aqueous and organic layers. The aqueous layer forms at the top while the organic layer, consisting of alcohol with 2,4,5-T dissolved in it, forms at the bottom. The water is decanted from the top and sent to the "Squeal Tower" (see figure 2) for removal of residual alcohol, which will be reused. The alcohol layer, containing 2,4,5-T, is routed to the "Esterification Tower" for the next step in the process. Each batch of alcohol-water-2,4,5-T mixture from EK 3 is run continuously through the "Feed Decant" tank to the tower (which is also a continuous-flow unit). The liquid phase separation level in the "Feed Decant" tank is maintained by automatic control.

The "Esterification Tower" serves two purposes: the reaction between 2,4,5-T and alcohol to form 2,4,5-T ester and water occurs there, and removal of water from the T ester stream is done there. It contains a steam-coil reboiler as well as several steam-coil heaters at various levels which provide heat for the endothermic reaction. Company representatives are uncertain what the correct bottom temperature is for this column, but they believe it is in the 120°C - 130°C range. The water-alcohol-2,4,5-T mixture enters at the top of the column, while "dry" alcohol from storage enters at the bottom. The 2,4,5-T reacts with the alcohol, which is present in excess, to form the ester via the following mechanism:

(2,4,5-T) (alcohol) (2,4,5-T ester)

(where R is an isobutyl group, $CH_3(CH_3)CH-CH_2-$, or an isooctyl group, any group of the formula $C_8H_{17}-$.)

The water and a portion of the alcohol are taken off the top of the column, while the 2,4,5-T ester and the remainder of the alcohol are drained from the bottom. The alcohol-water overhead product is condensed and sent to a storage tank for later reuse at EK 3. The 2,4,5-T ester and alcohol bottoms product is pumped to the "Continuous Stripper" for the next step in the process.

The "Continuous Stripper" has a steam-coil reboiler and operates under high vacuum. The bottoms temperature is approximately 150°C or higher; company officials are uncertain of the correct temperature. The vacuum system provides 29 in.Hg of vacuum. The liquid level in the stripper vessel is maintained by automatic control. The stripper boils the alcohol off the top; this alcohol vapor is condensed and collected in a surge tank, where it is ready to later be pumped to EK 3 for reuse. The 2,4,5-T ester is drained from the bottom of the tank and pumped to a storage tank to await further processing.

The final step in the process is the filtration of the 2,4,5-T ester product. This step is necessary for removal of "dirt" from the ester to provide a clear product; this is known as "polishing." A horizontal filter press is used for polishing; changing filter paper is a manual operation.

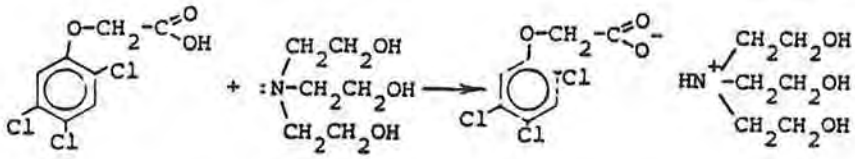
After filtration, the 2,4,5-T ester is ready for formulation or shipment.

Description of the Process for Production of the Triethanolamine Salt of 2,4,5-T

Chipman Chemical Company and Rhodia, Incorporated, produced the triethanolamine salt of 2,4,5-trichlorophenoxyacetic acid (2,4,5-T triethanolamine), using triethanolamine and the 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) from the 2,4,5-T production process as raw materials. Other materials used in the process included: water, which is the solvent; a sequestering agent "crystal inhibitor," which prevents crystal formation by the product if the solution is mixed with "hard" water by the user; and a silicone antifoam agent. The method used to produce this amine salt is very similar to the method currently used by Rhone-Poulenc, Incorporated, to synthesize and formulate 2,4-dichlorophenoxyacetic acid (2,4-D) amine salt. The major difference between the two processes is the use of the 2,4-D and dimethylamine in the current process in place of the 2,4,5-T and triethanolamine. The process for 2,4,5-T amine salt production is a batch process utilizing a single vessel and a filter. It was conducted in the "Formulation Area" (see Figure 1).

The process consists of several steps. The first step is addition of water to the vessel. Then 2,4,5-T is manually dumped from drums through a manhole into the vessel; simultaneously, an aqueous solution of triethanolamine is pumped into the vessel. Next, a sample of the resulting solution is collected and analyzed for pH and percent 2,4,5-T acid content. More triethanolamine is added if the pH is below 8.5 - 9.0; more 2,4,5-T or water

is added as necessary to achieve the desired strength. The triethanolamine and 2,4,5-T react to form the triethanolamine salt of 2,4,5-T, via the following reaction mechanism:



(2,4,5-T) (triethanolamine) (triethanolamine salt of 2,4,5-T)

The salt product is written above in the ionic form, as it exists in solution. The next step in the process is the addition of relatively small quantities of the sequestering agent described previously in this section. After that addition, similar quantities of the antifoam agent are added. The final step is the pumping of the product solution through a 50u-pore-size bag filter, to the drumming operation. The drummed product is ready for shipment.

Supplemental Information About the Production of 2,4,5-T and Related Products

For the 2,4,5-T (as well as 2,4-D) and esters, formulation included blending the completed acids and/or esters, and mixing solutions to the proper strengths. For the amines, the synthesis from the appropriate acid, dilution, addition of additives, and filtering were all considered part of the formulation operation, as noted in the previous section.

The esters of 2,4,5-T and 2,4-D were synthesized in the same equipment on a time-sharing basis. Conversely, 2,4,5-T acid and 2,4-D acid were not synthesized with analogous routes, and different equipment was used for these two syntheses. However, they did share between them the final acidification and vacuum filtration steps, and the acidification vessel (Q2) and the Bird-Young vacuum filter were time-shared by them (see Figures 2 and 3).

There have never been any "pressure releases" or "blowouts," which can result in occupational overexposures, in the processes producing 2,4,5-T or related products. This is because the processes were operated at near-atmospheric pressures, or under vacuum, and over-pressure conditions did not develop.

The aqueous sodium 2,4,5-trichlorophenate solution which was purchased by Chipman Chemical for use as a raw material in 2,4,5-T production was used exclusively for this purpose; none was resold. Conversely, 2,4,5-T acid and 2,4-D acid were both used as raw materials for ester and amine production, as well as formulated and sold in the acid form.

No industrial hygiene data characterizing worker exposure to materials found in the 2,4,5-T and related-product processes are available. No analyses of Na 2,4,5-TCP or any Chipman, Rhodia, or Rhone-Poulenc product for dioxin contamination are available.

Conclusions

Although the personnel records do not identify which jobs were held by each individual (see Personnel Records section), it is very probable that all workers assigned to Cost Center 602 during the 1961-62 period were exposed to 2,4,5-T or other TCP-derived products. Therefore, the cohort of workers employed in Cost Center 602 by Chipman Chemical between February 1961 and December 1962, which includes approximately 140 people, should be included in the Dioxin Registry. The concurrent exposure to 2,4-D and MCPA should be recognized.

The personnel records are well organized and complete, and permit identification of employees assigned to the 602 cost center between February 1961 and December 1962. The other workers at the plant, who formulated insecticides, can be separated out by their cost center assignment of 600. Hourly workers, salaried employees and maintenance personnel can be identified.

Workers employed at this site after December 1962, when syntheses of TCP-derived products were discontinued, should not be included in the Registry. The reason for this conclusion is that there is a relatively good chance that any individual employed after 1963 may never have been exposed to 2,4,5-T or other TCP-derived products, as noted in the Department Operations and Personnel section of this report; additionally, there is no way to identify which workers were exposed to these products, as noted in the Personnel Records section.

Formulators at Chipman, Rhodia, or Rhone-Poulenc sites other than Portland should not be included in the Dioxin Registry because of their mixed exposures to a wide variety of products and the likelihood that any particular individual may not have been exposed to 2,4,5-T products or derivatives.

Claims for Workers' Compensation benefits are in the personnel files. Chloracne was not a frequent problem at this plant.

Acknowledgements

Mr. Robert Briggs, Plant Manager, and Mr. Thomas Henshaw, Plant Engineer, spent many hours researching information. We appreciate their pleasant and helpful cooperation.

Questions Addressed To Rhone-Poulenc, Incorporated

Concerning Production Processes For 2,4,5-T And Its Derivatives

Contents

A) 2,4,5-T Acid Production

B) 2,4,5-T Ester Production

C) 2,4,5-T Triethanolamine Production

D) Production Times

May 21, 1982

A) 2,4,5-T Acid Production

1) At EK6, "TCP Acidification," is the reaction exothermic or endothermic?

2) At EK5, "TCP Dehydration," was the refluxing performed during the reaction, or after it was completed? Was the 115-119°C temperature that the mixture was refluxed at also the same as the reaction temperature?

3) At EK4, "2,4,5-T Condensation," the IPE-MCA was added and the mixture was heated to reflux at 96°C. What is meant by this description, i.e., was it simply heated to 96°C which happens to be the reflux temperature, or was there some recyling occurring?

4) At EK7, "2,4,5-T Saponification," again, what is meant by "heat to reflux at 100-110°C" after the vessel is charged? Is the cook temperature the same? Was H_2O/IPA boiled off during or after (or both) the reaction?

5) At the centrifuge, are the NaCl and Na_2CO_3 impurities from EK4 still in the solution? Do they go to RT4 from here with the H_2O/IPA or do they stay in the Na-2,4,5-T cake?

6) At EK1, is there continuous removal of the water by-product accomplished by decanting the condensate in a settling tank?

B) 2,4,5-T Ester Production

1) At EK3, why is the water/alcohol mixture boiled off, condensed, and recycled and/or removed? Where is the removed stream sent (i.e., to storage tank)?

2) Was this process changed after the cessation of 2,4,5-T acid production in 1962, or did it remain the same until 1970 when it was shut down?

3) Were the esters pumped directly to formulation or to tank cars, or were they packaged? If they were packaged, describe the packaging operation.

4) What pressure was the esterification tower operated at?

C) 2,4,5-Triethanolamine Production

1) What temperature and pressure is the reaction run at?

2) Please verify that the only amine used was triethanolamine.

3) Which vessels were used for 2,4,5-T amine formulation?

4) Describe the T amine drumming operation.

5) Was the T amine formulation also called "4-L"?

6) Was the process the same during the entire period of production, from its initiation by Chipman Chemical in 1960 to its conclusion in 1970?

7) Was there a manual operation to change the bag filter?

D) Production Times

1) During which months of 1960, 1961, and 1962 were 2,4,5-T-related compounds synthesized and formulated? If the exact months are not known, can you make an estimate of minimum and maximum number of months during those 3 years in which 2,4,5-T-related compounds were synthesized and formulated?

2) We must decide whether to include in the study worker involvement during July and/or August 1960 when test runs of 2,4,5-T and its derivatives were made; can you give us any helpful information? Did any production of 2,4,5-T or its derivatives occur between August 1960 and February 1961, when full production was initiated?

Gitschlag, R.F. 1968. Personal communication (letter to K. Spies, Oregon State Sanitary Authority, Portland, OR, dated December 10, 1968, regarding effluent treatment plant). Rhodia Inc., Chipman Division, Portland, OR.

RHODIA INC.
chipman
DIVISION

6200 N.W. ST. HELENS ROAD, PORTLAND, OREGON 97210 • (503) 226-6221

December 10, 1968

Mr. Kenneth Spies
Secy. & Chief Engineer
Oregon State Sanitary Authority
P. O. Box 231
Portland, Oregon 97207

Dear Mr. Spies:

Since the spring of 1965 when a number of off-flavor salmon caught in the Multnomah Channel were attributed to Chipman's effluent, extensive work and study have been done by all concerned parties toward eliminating this problem. As you know, a treatment system was installed in February 1966 to improve our effluent. This system has reduced the concentration of offensive phenolic compounds from 100 - 500 ppm to 5 - 15 ppm and has greatly reduced the number of off-flavor salmon complaints. During the 1968 salmon run, there were two complaints; one of which was later shown to be probably caused by material other than Chipman effluent.

We all agree, however, that further improvement is necessary and that essentially complete elimination of phenolic compounds discharged to the Willamette River is the goal. Fortunately, new technology is available which now makes this goal attainable and is within the realm of economic feasibility.

Unfortunately, the new technology has been slow in developing and has required extensive laboratory, pilot plant and engineering study to prove its feasibility. This ground work is now complete and the engineering-construction phase of the project has been entered. It is doubtful that we can attain 100% completion of this project by the deadline of March 1 specified in our current Waste Discharge Permit. Partial operation is proposed by March 15.

PROJECT DESCRIPTION

The new effluent treatment plant will utilize charcoal adsorption for removal of phenolics and most other organic compounds (with a marked reduction in BOD and COD). The new installation will include a neutralization system with automatic pH control.

Continued.....

A process flow diagram for the new installation is attached.

The effluent will contain essentially no phenolics (after treatment, occasionally a maximum of 1.0 ppm) and will have 7.0 to 9.0 pH and will contain about 400 ppm suspended solids. The effluent will be held in existing storage tanks after treatment prior to its release. Samples will be taken routinely to ensure effectiveness of treatment.

It is planned that the effluent will eventually be discharged to the City sewer but this will not be possible until City sewer construction is complete sometime in 1969. A copy of Mr. Drulard's letter (City Engineer) is attached for your information.

To make the charcoal adsorption system economically feasible, a facility will be included for regeneration of the charcoal. Charcoal regeneration will take place in a multiple hearth furnace, which will be equipped with an afterburner for prevention of air pollution. This furnace is of a special design for this specific application. Up to five months may be required for delivery and one month for construction after the engineering is complete.

ENGINEERING TIME SCHEDULE

The following is the best estimate of our construction schedule which may be made at this time:

Detailed Engineering started	Nov. 1, 1968
Furnace ordered	Nov. 4, 1968
Furnace Engineering complete	Dec. 13, 1968
Detailed Engineering complete	Dec. 20, 1968
Construction started (foundation)	Dec. 23, 1968
All Equipment ordered	Dec. 28, 1968
Completion of Neutralization System and Adsorption System (Except regeneration)	Mar. 15, 1969
Startup (partial operation)	Mar. 15, 1969
Furnace delivery	May 1, 1969
Completion of Regeneration System	May 31, 1969

PARTIAL OPERATION

It is proposed that the new treatment plant be started March 15 even though the regeneration system would not be complete. The charcoal that is saturated during this partial operation would be stockpiled for regeneration later.

Continued.....

It is not planned that the entire effluent would be treated by charcoal adsorption during this period. To do so would require an expense of over $600 per day for fresh charcoal and this expense would be prohibitive for an operation the size of Chipman. It is proposed that only the MCPA Plant effluent be charcoal treated and that the existing treatment system be utilized for all remaining effluents.

After one salmon taste complaint during the 1968 salmon run, the MCPA Plant was shut down. No further taste complaints were received even though Willamette River flow was far below normal. (Experience from previous years indicates that the MCPA Plant contributes chemicals to the effluent that are the severe taste causers.)

Charcoal treating of the MCPA Plant effluent will have the same effect that shutting down the plant would have since all phenolic chemicals are removed. Pilot plant charcoal treating of mixed effluent (including MCPA Plant effluent) has been very successful. MCPA Plant effluent alone presents less of a problem and we are very confident that it can be successfully handled in this way.

Very truly yours,

RHODIA INC., CHIPMAN DIVISION

R. F. Gitschlag
Plant Manager

RFG:plg
Attachments

cc: Mr. Jack Weathersbee
Mr. Roger Sherwood
Dr. C. H. Fritsch
Mr. N. D. Allworth
Mr. T. B. Henshaw
Mr. J. B. Vernetti

Holm, D. 1969. Big Game Suffer, But Coho Prosper. The Oregonian. May 6, 1969.

To: [redacted]

From: Rich

Re: I.W 3-0
Chipman Chemical

Nature's Ways

Big Game Suffer, But Coho Prosper

By DON HOLM
Wildlife Editor, The Oregonian

Wildlife biologists have once again proved (but almost nobody will accept it) that you can't stockpile game, and you can't artificially "protect" animals from nature's ways.

Last winter at the Oregon Game Commission's blacktail deer research center on Cedar Creek in the Tillamook Burn, the deer herd suffered a 56 per cent loss since last June, with a 45 per cent mortality in the winter months. Bill Hines, biologist there for 10 years, said the die-off took place in spite of supplemental feeding.

However, a generation brought up on Bambi and Gentle Ben is not likely to accept the raw facts of nature — especially when they see a cute little fawn standing beside the road "without its mommy."

The Game Commission is having much success with its coho project at the Wallowa Fish Hatchery near Enterprise. Coho eggs placed in the gravel of an experimental "incubation channel" in Spring Creek, have an extremely high hatch ratio.

Gary Anderson there said that of the 300,000 eggs introduced into the gravel beds under man-made environmental conditions, almost 231,300 fry were counted during the past month a phenomenal record. Guy on the telephone accuses me of killing the steelhead game fish bill in the Oregon Legislature, because I "exposed the maneuvering and politicking going on behind the scenes."

If I had kept quiet, he said, he and his group would have gotten the Southern Oregon legislators, "who hate northern Oregon," to go along and salvage what was left of HB 1302. Now they are offended, he asserted, and will go home pouting and not do anything.

Well, I'm a newspaperman (I hope) and not a cheer leader, and I happen to believe the public has a right to know the maneuvering and politicking going on behind the scenes at Salem against the public interest and in favor of the special interests.

Second, as my old dad often told me: Son, never try to beat a man at his own game.

Election Needed

What we need in Salem, are fewer amateurs trying to outspend and out-maneuver the professional lobbyists and hired hands of the special interests and more public exposure. As for the steelhead bill — it died the day after it was introduced. It just hadn't had a proper burial. Most observers believe the only effective way around a lobby-controlled legislature is the initiative petition route.

Letter from Jerry Arnold, Bend: "Containers and pollution have been in the news lately. On Opening Day I parked near a camper outfit on the Deschutes above Bend. I noticed that they were keeping a clean camp and I was glad, because that particular spot is very pretty. The owner of the camper was gone and an empty boat trailer gave evidence of his whereabouts. A few hours later the boat appeared with two fishermen. They pulled the boat out, and I didn't notice anything more until a flotilla of beer cans passed.

"I asked my brother and he described the parting ritual of those two. After packing they carefully launched each dead soldier like Oriental votive boats. I saw it, but I still find it hard to believe.

Leaves Lights

"On leaving I noticed one other thing the pair had overlooked. At the base of a sagebrush was the boat trailer lights. Worth $15 or $20. I will gladly send the boat lights to the owner. All he has to do is send a signed, notarized statement identifying himself by describing the littering and the brand of can. I plan to use the lights until I get such a statement. But I really hope he sends it."

Which brings up the subject of Rep. Paul Hanneman's so-called "bottle bill," for the last time. As you know this bill was easily killed by the beverage lobby, by the simple technique of tacking on amendments that would create another tax — to be paid by the public — which of course aroused immediate opposition, for after all, "this would be nothing but a license to litter."

Funny, but no one seemed to think of putting the tax on the source of the litter, instead of the consumer, with the money earmarked for cleaning up our out-of-doors.

Gerald L. Warnock, M.D., of Portland, writes: "I wanted to tell you that I had caught a 24 - pound chinook at Swan Island on Thursday, April 17, and unfortunately the meat was strongly tainted with some chemical. I hope we are not back in the swing of that chemical company's pollution, but wondered if other people had had similar experiences. Two other fish were caught the same day and several taken before and after have been quite good but this fish was very strongly tainted. I have written letters to the State Sanitary Authority and Game Commission."

Gil Pye down Silvies way, wrote that he's been making good catches of trout and bass from shore, using a black eel on the Maple Creek Arm (east side of lake).

"I caught six bass all about 1½ pounds in 30 minutes. Some of the other campers stood and watched me do it, they all tried it and took bass too. I lost two big ones that I'm sure would hit four pounds."

Oregonian
5-6-69

McHugh, R.A. 1976. Recollections of the 1966 Doane Lake (Chipman Chemical) Brouhaha. Document received by the Department of Environmental Quality, Portland, OR, on March 24, 1976.

Recollections of the 1966 Doane
Lake (Chipman Chemical)
Brouhaha
by Robert A. McHugh

WQ - RHODIA

1. All tainted salmon were caught below Oregon City, with one exception - one salmon went past the falls and was caught off the mouth of the Clackamas River. Most were caught in the Multnomah Channel.

2. The D.E.Q. installed live - boxes containing hatchery steelhead and rainbow trout of about two pounds each at sites from the Sellwood Bridge upstream to St. Helens downstream. Fish were removed for tasting each 24 hour period of exposure to the river water.

3. No tainted fish were ever found at the Sellwood Bridge (Most upstream live - box), or at St. Helens. All fish in the three live - boxes in the Multnomah Channel were tainted, as were fishes exposed at the Corps of Engineers dock and at a fire - boat dock in lower Portland Harbor.

4. Fish became tainted in 24 hours (least time tested) and lost the taste after 24 hours in water at Sellwood Bridge.

5. Both those test fish which were exposed to effluent - containing water and salmon caught by fishermen in contaminated water had the taste - producing substance (-es) concentrated in the head end of the body. The tail end had little or no off - taste.

6. Caged fish ceased to become tainted after a considerable rise in the river flow, which probably diluted the taste producing substance (-es) to a point at which they were no longer effective. An increase in suspended materials in the river following the increased flow may also have acted to absorb the taste - producing materials.

7. Doane Lake received a variety of materials from Chipman Chemical, mostly 2, 4 D and materials used in its manufacture. The company had a large order from the U.S. government for defoliants to be used in the Viet Nam War, then in progress. The lake itself was a black, stinking mass of chemical wastes, some of which had doubtless interacted within the lake. D.E.Q. analysis of river water were for phenol, a probable constituent of many if not all of these wastes.

8. The Northern end of Doane Lake was blocked by a rock railway embankment. It was through this rock fill that material from the lake leaked into a small creek, which emptied into the Willamette River. As the river is tidal at this point, the tainting materials spread for some distance upstream as well as downstream.

RAM:akh

Dept. of Environmental Quality
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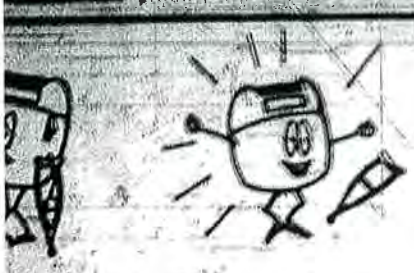
MAR 24 1976
PORTLAND REGION

The Oregonian. 1965a. Fish Investigated for Odd Flavor. March 31, 1965. p. 5.



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highway 410, will be done a month later for a Professional Golfers Association tourney over the dates June 10-13.

After the Wednesday engagement, the Bucks will leave Thursday on a bus ride to Vancouver where they will play the Canucks again Friday night.

Their next appearance at the Coliseum will be Sunday evening, with Vancouver once more appearing as the opponent.

Fish Count

By The Associated Press

The upriver movement of fish at Columbia River dams

	Chinook	Steelhead
Bonneville	[illegible]	6
The Dalles	30	46

and conditions at 6:46.

ACE

SEASIDE — Harry Sankela, Portland, 6th hole, 147 yards, 8 iron. In foursome with Alfred C. Jackson of Seaside and Ken Brown and Jess C. Hesmark of Portland. Second ace at this hole in less than two weeks.

Fish Investigated For Odd Flavor

Numerous reports to Oregon's fishery agencies of unpalatable spring chinook appearing in the annual Willamette River run, has prompted a meeting of representatives of the Oregon State Sanitary Authority, the U.S. Public Health Service and the fish and game commissions.

All of the agencies have been receiving inquiries from anglers regarding some of the prime chinook which exhibit an unpleasant odor or flavor when cooked.

Reports have also stated that the salmon have the odor when pulled from the river.

A cooperative investigation is now underway to obtain samples of both tainted and untainted fish. Water analysis will be handled by the Oregon State Sanitary Authority, with technical assistance in the complex analytical procedures being provided by the U.S. Public Health Service.

The causative agent, whether from natural or unnatural sources, is presently unknown and therefore all avenues of investigation will be explored by the committee.

The Renault R-8 is a lot

MILLER M

Davis Gets 5-Year Pact

OAKLAND, Calif (AP) — Intense Al Davis got a five-year contract Tuesday from the Oakland Raiders making him one of the two most secure coaches in the American Football League.

Hank Stram's contract with Kansas City equals that won by the 35-year-old Davis, who also acts as Oakland general manager.

Davis still had one more year left in a three-year pact he got when he joined the Raiders in 1963. After winning only three games in the previous two seasons, the Raiders finished second in the AFL Western Division with a 10-4 record.

Terms of the contract were unannounced, but they are believed to include a percentage of the gate receipts when the Raiders move into their new 48,500-seat stadium after the next season.

"You know, I just realized that I'll be 40 years old at the time this contract has come to an end," said Davis. "A man ought to get a lot done of what he sets out to do by the time he is 40."

The Brooklyn-born Davis, although independently wealthy, makes the normally hard working coach look like a malingerer. This includes 20-hour workdays that finish with game movie watching at 3 a.m.

But hard work has paid off for Davis, who never had been a head coach in college or pro before Oakland. After making 17 different player deals in 1963, he led the Raiders to their greatest season in 1963.

There was a mild depression in 1964 (5-7-2), but the Raiders then signed their first five draft choices, including All America end Fred Biletnikoff of Florida State.

Oakland co-owners Wayne Valley and E. W. McGah, who ran through three coaches in the Raiders' first three years, smilingly posed with Davis and the contract.

There are better contracts in the National Football League but not many. With less worries than their colleagues are Tom Landry of Dallas, Vince Lombardi of Green Bay, Joe Kuharich of Philadelphia and George Halas of Chicago, who has the advantage of owning the club.

More Fink 1st At Golden Gate

ALBANY, Calif (AP) — More Fink, the four-year-old daughter of Nashville, came within one-fifth of a second of the track record Tuesday in winning the featured Santa Rosa day purse at Golden Gate Fields.

More Fink ran the five and a half furlongs in 1:03 3-5, compared with the track mark of 1:03 2-5 set Oct 13, 1959 by Radium Rays.

More Fink returned $5.60, $3.40 and $2.80. Pikhale paid $7.40 and $4.40 and third place Royal Currage returned $3.40.

Sunset Tops Lakers, 3-1

BEAVERTON (Special) — Sunset's Apollos utilized the slugging of Tim Gleason and the base daring of Steve Crow as they ran up their sixth win of the season over Lake Oswego, 3-1, here Tuesday. Gleason banged a home run in the second inning and Steve Crow scored the winning tally after a wild pitch in the first.

Lake Oswego 010 000 0—1 [illegible]
Sunset 210 000 x—3 [illegible]
Richards, Curtis 4 and Breckenridge; Knapp 2, Baird, Neeley 5 and Gleason.

GRESHAM 11, REYNOLDS 1

GRESHAM (Special) — Steve Scott hurled his second win in two days, striking out 13 in six innings, as Gresham pasted Reynolds, 11-1, in a non-league encounter Tuesday. Doug Kidder and John Milne each collected a pair of hits for the victors.

Reynolds 100 000—1 [illegible]
Gresham 320 51x—11 [illegible]
Hancock, Barkley and Michels; Scott, Scott 7 and Milne.

GRANT 8, BRONCHOS 2

PARKROSE (Special) — Grant took advantage of two Parkrose errors for four unearned runs in the fifth inning and defeated the Bronchos, 8-2, here Tuesday. Randy Casey doubled twice, scored once and drove in a run for the winners.

Grant 010 042 1—8 6 2
Parkrose 000 001 1—2 5 5
Hatch, Gleason 5 and Hedges, Oliver 7; Courtenier, Joachims 5, Schulley 7 and Gellman, Payne 5.

Valley Rink Opens Friday

Valley Ice Arena, newest addition to the Valley sports complex southeast of Beaverton, will open its doors Friday night.

The rink will offer two sessions, one beginning at 6:30 p.m. and the other at 9:30.

"We should be able to accommodate 600 people on the ice per session," manager Walt Ruecker reports.

The arena is 200 feet long and 85 feet wide or 15 feet longer than Memorial Coliseum.

The official grand opening of the structure will be postponed until the restaurant and lounge are completed sometime in early May.

Valley Lanes, also located at the Beaverton - Hillsdale Highway site, will be host a month later for a Professional Bowlers Association tournament, the dates June 10-13.

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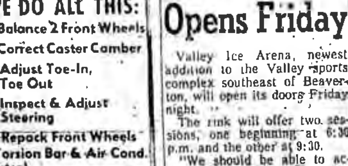


Don't Throw Out that Old Electric Shaver.

Winner's Circle

TRACK AND FIELD mementos from the early 1900s are displayed by retired attorney, Oliver B. Huston, who has been named honorary referee for Saturday's 15th Willamette Relays at Salem.

Relays Honor 'Judge' Huston

WILLAMETTE UNIVERSITY, Salem (Special) — Oliver B. Huston, Salem, 13 years a judge of the Willamette Relays, has been named Honorary Referee of this year's 15th annual track spectacle slated for McCulloch Stadium Saturday at 1 p.m.

A great trackman for the late Bill Hayward at the University of Oregon from 1907 to 1910, Huston has had a lifelong love for athletics.

He lettered in five sports (track, baseball, basketball, football and tennis) at Tualatin Academy (part of Pacific University in the early 1900s) before going on to star at Oregon.

A sprinter, Huston never lost a college 100-yard dash or low hurdle race. He was also an adept high hurdler and broad jumper and was named captain of the 1909 Oregon track team.

His best clocking in the 100 of 9.8 seconds was only two tenths of a second off the world record at the time and was accomplished on loose cinders without the use of starting blocks.

Aside from three years of study at Yale law school and two years in the Army during World War I, Huston has lived in Oregon all his life.

After seven years of private law practice, Huston became an attorney for the State of Oregon in the Department of Motor Vehicles as manager of the certificate of title division. He held this post for 32 years before retiring in 1957.

Once at the age of 18 when he was running for the Multnomah Athletic Club, Huston and three others—Ben Greenhaw, (Coco) Holman and Dan Kelly—combined to set a mile-relay standard that endured for 35 years.

Huston, at 30, was the 100-yard dash champion at Ft. Lewis where 35,000 men were stationed during the war. In his final race at 43, Huston joined ex-OSU athletic director Spec Keene, the late Frisco Edwards, former Salem Senator manager, and the late Douglas McKay, former Oregon governor, to win an 880-yard relay on the streets of Baker, Oregon, and pick up the $200 State American Legion cash prize.

Still very active at 77, Huston yearly harvests four tons of produce from his acreage on North River Road in Salem, a ton each of apples, pears, grapes and walnuts.

A fan of every sport, Huston has seen all but five Oregon-Oregon State football games since 1904.

He played in the 1909 game and ran back a punt 70 yards to the seven yard line to set up one Duck touchdown in a 12-0 victory.

While Honorary Referee status doesn't entail any work, Huston isn't going to get off that easy. Meet director Ted Ogdahl has him lined up as a finish judge.

Entries continue to flow in for the show with 45 high schools, 16 colleges and seven junior college or frosh teams registered.

Action opens with the Statesman Invitational Mile and concludes at 5:45.

Bucks Await Playoff Test

(Continued From Page 1)

playoff jitters he might own, the Buck skipper reiterated an earlier decision to place Dave Kelly in the Portland net.

He emphasized, however, that Don Head will be available if anything happens to the 21-year-old Irish flash.

Laycoe plans little or no juggling of his lines, relying on Larry Leach, Bill Saunders, the Schmautz boys, Arnie and Cliff, Dick Van Impe, Art Jones, Andy Hebenton, Tommy McVie, Bob Ertel and Gerry Goyer to carry the war to the enemy while leaving the heavy defensive chores to Pat Stapleton, Doug Messier, Mike Donaldson, Jim Hay and Connie Madigan.

Jack Bionda will be in mufti but primed to don Buck spangles if any of the back line crowd falters or gets hurt.

After the Wednesday engagement, the Bucks will leave Thursday on a bus ride to Vancouver where they will play the Canucks again Friday night.

Their next appearance at the Coliseum will be Sunday evening, with Vancouver once more serving as the opponent.

Fish Count

By The Associated Press

The upstream movement of fish at Columbia River dams:

	Chinook	Steelhead
Bonneville	134	4
The Dalles	30	16

ACE

SEASIDE — Harry Sankela, Portland, 5th hole, 147 yards, 4 iron. In foursome with Alfred C. Jackson of Seaside and Ken Brown and Jess C. Hestmark of Portland. Second ace at this hole in less than two weeks.

Fish Investigated

Bullets Win, Gain Finals

BALTIMORE (AP) — Kevin Loughery scored 31 points as the Baltimore Bullets defeated the St. Louis Hawks, 109-103, Tuesday night and advanced to the Western Division finals of the National Basketball Association playoffs.

Loughery, seldom the high scorer for Baltimore, hit 11 of 22 shots from his backcourt position and also assisted on six other baskets while turning in one of his best offensive performances of the season.

Three quick baskets by Baltimore with five minutes remaining snapped a 94-94 tie, and although the Hawks pulled to within two points in the last minute of play, Baltimore remained ahead for keeps.

With the score deadlocked at 94-all, Loughery assisted on a goal by Walt Bellamy, the 6-foot-11 center who made only nine points in the game.

Don Ohl, who tallied 19, then hit a field goal off a Bellamy pick and then added another goal after picking up a loose ball and driving almost the entire length of the court.

St. Louis, which enjoyed a 14-point lead early in the game, rallied to within 105-103 with 37 seconds left to play.

Cliff Hagan, who started in place of Bob Pettit, connected on only one of three free throws, but the Hawks controlled the rebound and Zelmo Beaty was fouled and he sank two more free throws.

Two foul shots by Gus Johnson and two more by Loughery closed out the scoring in the final 23 seconds.

St. Louis, which finished in second place, eight games ahead of Baltimore, led 77-70 with two minutes left in the third period. But the Bullets rallied behind Loughery and Ohl to pull even at 82-82.

St. Louis went ahead 86-84 on four points by player-Coach Richie Guerin, only to have Baltimore rally again to tie it at 84-all.

Pettit played only 14 minutes and scored six points to close out a brilliant 11-year career. He finished with 23,344 points in regular season, All-Star and playoff competition.

Johnson scored 18 points for Baltimore and Bailey Howell added 14 before fouling out. Hagan topped St. Louis with 24, while Guerin had 20.

Baltimore opens the division finals playoff in Los Angeles Saturday against the Lakers.

★ ★ ★ ★ ★ ★

ST. LOUIS	G	F	T	BALTIMORE	G	F	T
Hagan	10	4-6	24	Howell	[illegible]	[illegible]	14
Bridges	[illegible]	[illegible]	[illegible]	Johnson	[illegible]	[illegible]	18
Beaty	[illegible]	[illegible]	[illegible]	Kellarg	[illegible]	[illegible]	[illegible]
Wilkins	[illegible]	[illegible]	[illegible]	Ohl	[illegible]	[illegible]	19
Guerin	[illegible]	[illegible]	20	Lo'gh'y	11	9-10	31
Pettit	[illegible]	[illegible]	6	Hi'f'w'r	[illegible]	[illegible]	[illegible]
Vaughn	[illegible]	[illegible]	[illegible]	Green	[illegible]	[illegible]	[illegible]
Silas	[illegible]	[illegible]	[illegible]	Jons	[illegible]	[illegible]	[illegible]
Barnhill	[illegible]	[illegible]	0	Ferry	[illegible]	[illegible]	[illegible]
Totals	[illegible]	[illegible]	103	Totals	[illegible]	[illegible]	109

St. Louis [illegible]—103
Baltimore [illegible]—109
Fouled out—St. Louis, Bridges; Baltimore, Howell.
Total fouls—St. Louis [illegible], Baltimore [illegible]. Attendance [illegible].

Bosox Buy Len Green

PHOENIX, Ariz. (AP) — The Boston Red Sox purchased outfielder Lennie Green from the Baltimore Orioles Tuesday.

Boston Vice President Mike Higgins made the deal with Oriole General Manager Lee McPhail for an estimated $25,000.

Green signed a Red Sox contract immediately. He had been on the Rochester roster while trying out with the Sox.

Straight Bourbon Whiskey • 86 Proof • Frankfort Dist. Co., Lawrenceburg, Indiana

Ours is probably the first bourbon somebody's great-grandfather didn't make.

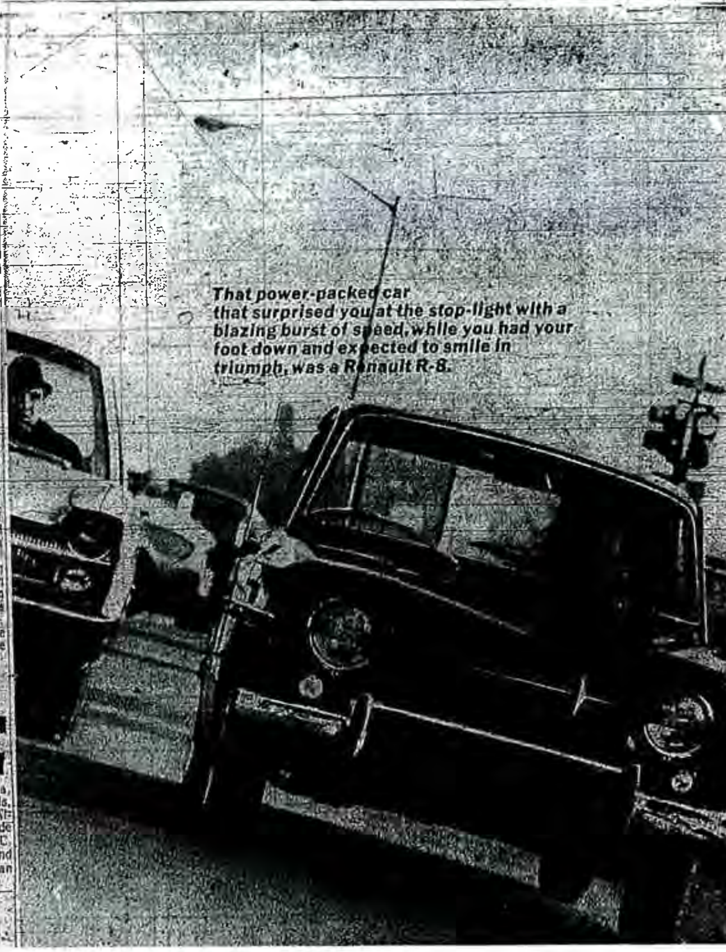
The old-time distiller stuck to the easy, "all-at-once" way of making bourbon. We don't.

We "build" our bourbon slowly, through several distilling stages—each with its own storing and aging requirements.

This gives us a 5-year-old straight bourbon whiskey just right for those who want it mild and mellow.

Proof? When we put it on the market recently, we sold over one million bottles the first year. And more than twice that the second year. Of course, our price helped too. 5 years old $2.75 pint $4.25 4/5 qt
Code No. 4440 Code No. 1441

Mattingly & Moore



The Oregonian. 1965b. Cause of Tainted Fish Still Mystery. April 6, 1965. p. 19.

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Weathersbee said portions of fish sent to the Public Health Service laboratory in Cincinnati for analysis showed contamination in taste tests but a gas chromatography failed to show contamination.

However, scientists are continuing to study fish in qualified laboratories.

Weathersbee said the contamination may be related to the current low level of the water, which is lower than normal for this time of year. If an industrial waste discharge is the cause of the contamination, the low river flow would tend to maximize itts effect, the engineer stated.

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REPEAL URGED

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ort

RIVER BULLETIN

Range of stages at Portland last 24 hours: Highest 5.8; lowest 2.7.

RIVER FORECAST

Little change all streams Western Oregon next two days.

TIDE TABLES

HIGH TIDES AT ASTORIA

Apr. 5—	3:04 a.m., 8.8;	4:12 p.m.,	6.8
Apr. 6—	3:44 a.m., 8.7;	5:09 p.m.,	6.3
Apr. 7—	11:46 a.m., 8.2;	11:21 p.m.,	5.4
Apr. 8—	5:30 a.m., 8.1;	7:33 p.m.,	6.1
Apr. 9—	6:45 a.m., 7.8;	8:49 p.m.,	6.4
Apr. 10—	8:00 a.m., 7.6	9:54 p.m.,	6.9
Apr. 11—	9:27 a.m., 7.6;	10:48 p.m.,	7.5
Apr. 12—	10:36 a.m., 7.8;	11:35 p.m.,	8.1

LOW TIDES AT ASTORIA

Apr. 5—	9:54 a.m., -0.4;	9:35 p.m.,	2.4
Apr. 6—	10:46 a.m., 0.4;	10:20 p.m.,	2.9
Apr. 7—	4:31 a.m., 8.5;	6:17 p.m.,	6.2
Apr. 8—		12:57 p.m.,	0.0
Apr. 9—	0:53 a.m., 3.7;	2:10 p.m.,	0.0
Apr. 10—	2:26 a.m., 3.5;	3:20 p.m.,	-0.1
Apr. 11—	3:45 a.m., 3.0;	4:21 p.m.,	-0.2
Apr. 12—	4:51 a.m., 2.2;	5:14 p.m.,	-0.2

Deduct these hours and minutes from the tables: Long Beach 1:10, Clatsop Beaches: 25 Tillamook 0:45; Yaquina 1:00, Newport and Lincoln 1:15.

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With the new "FIRST TIME" Permanent by Helena Curtis. Written guarantee.

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-Obituary-

[AR]THUR P. KERRON

[F]uneral was at 1 p.m. Mon[day] at Edw. Holman & Son, [for] Arthur Portious Ker[ron], 11200 SW Riverwood Rd., [who] died Saturday in a Port[land] hospital.

[B]orn July 13, 1877, in Port[land], he retired 20 years ago [as] cashier for Pacific North[wes]t Bell.

[H]e is survived by a daugh[ter], Mrs. Virginia Lovejoy of [Por]tland.

[R]emembrances may be made [in t]he form of contributions to [the] American Red Cross or American Cancer Society. [In]terment was in Portland [Me]morial Cemetery.

[JOH]N SCHNEIDER

[P]rivate funeral for John [Sch]neider, a Sellwood-area [resi]dent for 74 years, will be [at 1]1 a.m. Wednesday in the [Chap]el of McGinnis and Wil[lamett]a Funeral Directors, Mil[wau]kie.

[M]r. Schneider, whose home [add]ress was 8534 SE 13th, died Monday in a Mil[wau]kie nursing home.

[B]orn 84 years ago in [Oma]ha, Neb., Mr. Schneider [spen]t the first 20 years in Ore[gon] at the town of Laurel. He [join]ed the Portland fire de[part]ment May 17, 1908, and [retir]ed from the department [...] 30, 1931.

[S]urvivors include two [dau]ghters, Leta Rooklidge of [Port]land and Eva Heiny of [...]on, Ariz.; a sister, Retta [Sch]nidt of Laurel; three [gran]dchildren and 11 great-[gran]dchildren.

[In]terment will be in Mil[wau]kie Cemetery.

[MON]A LAWLER

[M]rs. Mona Lawler, of 2444 [NE] Grant St., died Saturday in [a Po]rtland hospital.

[Re]quiem Mass will be said [Wed]nesday at 9:30 a.m. at St. [Phil]ip Neri Church. Recitation [of th]e Rosary will be at 7:30 [p.m.] Tuesday at Zeller Chapel [of R]oses.

[B]urial will be in Mt. Cal[vary] Cemetery.

[M]rs. Lawler, a Portland [resi]dent since 1927, was born Nov. 15, 1902 in Chicago. [She] had been employed as [a] mapping clerk for Port[land] General Electric Co.

[S]urvivors include two [dau]ghters: Mrs. Wayne El[...], The Dalles, and Mrs. [Geo]rge Bocci, Portland; two [siste]rs, Mrs. Roseleen Dwan, [Chic]ago, and Mrs. Roland [Morr]ison, Daly City, Calif.; three brothers, Kevin R. [Mor]rison, Los Angeles, P.J. [Mor]rison and J.C. Morrison, of Chicago.

[Al]so surviving are six [gran]dchildren.

[Th]e family suggests that remembrances be in the [form] of contributions to the [Ame]rican Cancer Society.

[CLA]RENCE J. DEMUTH

[F]uneral will be Tuesday at [...] m. from the Little Chapel [of] the Chimes for Clarence [Jaco]b Demuth, 78, of 1105 NE [...]ster St., who died Sunday [in a] local rest home.

[M]r. Demuth was born in [th]e Belt Township, Minn., [and] came to Portland in 1943. [H]e was sexton of Highland [Bap]tist Church.

[S]urvivors include two [dau]ghters, Mrs. Carol Fire[bau]gh, Cannon Beach, and [Mrs.] Wanda Blanding, Eu[gen]e; a son, John, of Cedar [Rap]ids, Iowa, and six grand[chil]dren and four great-grand[chil]dren.

[In]terment will be at Rose [City] Cemetery.

[AR]TIE A. TURNER

[F]uneral for Artie A. Turner [will] be Wednesday, April 7, at [1:3]0 p.m. at the Skyline [Me]morial Funeral Home. He [died] Friday at age 69.

[B]orn in Effingham, Ill., he [live]d in Montana before com[ing] to Portland in 1943. He [wa]s a retired carpenter and a [me]mber of the Park Rose [Hei]ghts Methodist Church. He [als]o held memberships in the [Ru]sselville Grange and Car[penters Union Local 583.]

[Car]penters Union Local 583.

Survivors include the widow, Esther; three sons, David, Donald and Norman, all of Portland; one daughter, Helen, Seattle, one brother Earl, Kalispell, Mont.; two sisters, Mrs. Mae Nasby, Wolfe Point, Mont., and Mrs. Grade Deiner, Poplar, Mont.; and five grandchildren.

Burial will be in Skyline Memorial Gardens.

MARGARET STIRBER

Requiem Mass for Margaret Stirber will be Tuesday at 9:30 a.m. in St. Francis Catholic Church.

Mrs. Stirber, 1318 SE 24th Ave., died Saturday in a local hospital.

Born on May 10, 1872, in Ypsilanti, Mich., she had been a Portland resident 75 years.

Survivors include one son, Jack, Los Angeles; one daughter, Mrs. Margaret Akre, Portland; one brother, Michael Murphy, South Bend, Ind.; and three grandchildren.

Burial will be in Mt. Calvary Cemetery.

M. EDWARD HUNSPERGER

A former Portland resident, M. Edward Hunsperger, 63, died April 3 of a heart attack in his home in Arlington, Va., according to word received by relatives.

Born in Alberta, Canada, Mr. Hunsperger moved to Corvallis at the age of 10. After completing high school, he was in the automotive business for several years in Corvallis, Portland and Vancouver, Wash.

In 1950 he moved to New York and later to Arlington.

He was a member of The First Christian Science Church of Arlington.

Survivors include the widow in Arlington; a sister, Mrs. N. Violet Simpson of Salem; three nephews and a niece in Portland and Salem.

Interment will be in Arlington.

GEROULD T. WINTERS

Funeral for Gerould T. Winters, 4215 NE 29th Ave., will be Tuesday, April 6, at 3 p.m. in Ross Hollywood Chapel. He died Saturday in a local hospital from a heart attack.

Born in Portland July 25, 1903, he was a retired salesman for the J. H. Heinz Co., and a semi-retired custodian of Friendship Temple.

He was a member of Friendship Chapter No. 160, AM&FM; an ex-high priest, Royal Arch Mason Friendship Chapter No. 48; past commander, Tancred Commandery No. 23, Knights Templar; and past patron, Friendship Chapter OES No. 115.

Mr. Winters also held memberships in Christina Court, Order of Amaranth; Oregon Shrine No. 1, White Shrine of Jerusalem; Friendship Chapter, DeMolay; Al Kadar Shrine; Sons and Daughters of Oregon Pioneers; and Sons of the American Revolution.

Survivors include the widow, Marjorie; one son, Jerome; and one daughter, Mrs. Robert Kuinge, all of Portland; and seven grandchildren.

Vault burial will be in Lincoln Memorial.

LLOYD LAWSON

Private graveside services for Lloyd S. Lawson, 74, of 3725 SW Idaho Terrace, will be Wednesday at 10 a.m. at Willamette National Cemetery. Caldwell's Colonial Mortuary is in charge.

Mr. Lawson, a retired salesman, died Sunday at the Veterans Hospital. He was born Jan. 30, 1891, in Ottumwa, Iowa. He was for many years in the insurance business in Portland and was a Navy veteran of World War I. He was a life member of the Multnomah Athletic Club and Hurlburt-Worsham American Legion Post No. 94.

Surviving are a son, Gatlin L. Lawson, Portland; a brother, William D. Lawson, San Diego, and one granddaughter,

Increase Phone

CROSSWORD PUZZLE

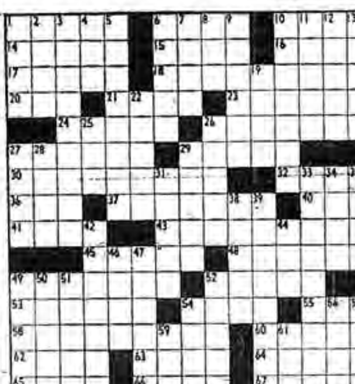
ACROSS

1 "Out of the mouths of —"
6 Cut
10 Actuality
14 Respond
15 Hedgehodge
16 Turkish army parade
17 Debate
18 Universal
20 Tibetan gazelle
21 Thrall
23 More extended
24 Wrongful acts
26 Fractions of time
27 Ball of the thumb
29 Bride's portion
30 Banished
32 Father
36 Ailing
37 "— in Gaza"
40 Born
41 Request
43 Brine: 2 words
45 Smart
48 On few occasions
49 Fellow feeling
52 Connections
53 Member of welcome committee
54 Samples
55 Account
58 Conductors
60 Papal vestment
62 Round cheese
63 Flask
64 Famous
65 Have confidence
66 Advantage
67 Sifters

DOWN

1 Glory oneself
2 Prefix: air
3 Mere nothing
4 Old French coin
5 Lowly ship accommodations
6 Dresses
7 African lily
8 Title of address
9 Empty
10 Sycophants
11 Straighten
12 West Pointer
13 Stadium sections
19 Cupola
22 Wander
25 Individual
26 Paragon
27 Journey
28 Utter misery
29 Postpone
31 Cranky
33 Without a will
34 Stagger
35 Like a haunted house
38 Denude
39 Final appearance: 2 words
42 Human body
44 Clumsy craft
46 Solar disk
47 Prosper
49 Charred bit
50 General at Gettysburg
51 Flower part
52 Thread for hose
54 Affair for men
56 Rustic drinkfests
57 "Adam —"
59 TV's Caesar
61 Caviar

Puzzle of Monday, April 5, Solved



City News In Brief

ECONOMIST TO SPEAK

H. DeWayne Kreager, consulting industrial economist of Seattle, will speak on "The Pacific Northwest — the Economic Base on Which We Build" at the Rotary Club of Portland meeting Tuesday noon in the Mayfair ballroom of the Benson Hotel.

PRINCIPAL BOOKED

Ray Steed, principal of Portsmouth Elementary School, will discuss disadvantaged youth before the Peninsula Kiwanis Club at the Portsmouth Club, 5264 N. Lombard Ave., at noon Wednesday.

U.G.N. REPORT DUE

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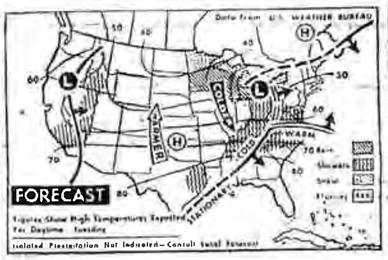
Weather Report



THUNDERSTORMS are forecast Tuesday for the Ohio and Mississippi valleys, Great Lakes, central Atlantic states, southern Idaho and maybe western Oregon. (AP)

FORECASTS

Portland, Vancouver, and Willamette Valley—Mostly cloudy with showers Tuesday and Tuesday night. Partial clearing Wednesday, but with a few showers. High, 50; low, 36.

Oregon Coast—Cloudy Tuesday morning, becoming partly cloudy Tuesday afternoon and night. High, 52 to 56; low, 37 to 42. Coastal winds west to northwest, 10 to 22 miles an hour.

Eastern Oregon—Mostly cloudy with showers or snow showers Tuesday and Tuesday night, becoming partly cloudy Wednesday. High, 38 to 55; low, 22 to 35.

Western Oregon—Mostly cloudy with occasional showers Tuesday and Tuesday night, but with partial clearing Tuesday night. Partly cloudy Wednesday. High, 43 to 56; low, 32 to 42.

Eastern Washington—Partly cloudy through Wednesday, with a chance of a few showers Tuesday and Tuesday night. High, 50 to 60; low, 25 to 35.

Western Washington—Few showers and partial clearing Tuesday night and Wednesday. High, 43 to 52; low, 28 to 42.

WEATHER TABLE

Precipitation (P), highest (H) and lowest (L) temperatures for 24 hours ending at 4 p.m. Monday, April 5. M-missing, T-trace.

NORTHWEST

	H	L	P
Astoria	[illegible]	[illegible]	.61
Baker	[illegible]	[illegible]	—
Bellingham	[illegible]	[illegible]	.64
Boise	[illegible]	[illegible]	—
Brookings	[illegible]	[illegible]	—
Burns	[illegible]	[illegible]	—
Eugene	[illegible]	[illegible]	[illegible]
Hoquiam	[illegible]	[illegible]	T
Klamath Falls	[illegible]	[illegible]	[illegible]
Lakeview	[illegible]	[illegible]	[illegible]
Medford	[illegible]	[illegible]	T
Newport	[illegible]	[illegible]	—
North Bend	[illegible]	[illegible]	.10
Olympia	[illegible]	[illegible]	—
Pendleton	[illegible]	[illegible]	—
Portland	[illegible]	[illegible]	.01
Redmond	[illegible]	[illegible]	[illegible]
Salem	[illegible]	[illegible]	.03
Seattle	[illegible]	[illegible]	[illegible]
Spokane	[illegible]	[illegible]	[illegible]
The Dalles	[illegible]	[illegible]	[illegible]
Walla Walla	[illegible]	[illegible]	—
Yakima	[illegible]	[illegible]	T

NATIONAL

	H	L	P
Albany, N.Y.	[illegible]	[illegible]	—
Albuquerque	[illegible]	[illegible]	—
Amarillo	[illegible]	[illegible]	—
Anchorage	[illegible]	[illegible]	[illegible]
Asheville	[illegible]	[illegible]	[illegible]
Pittsburgh	[illegible]	[illegible]	—
Portland, Me.	[illegible]	[illegible]	—
Raleigh	[illegible]	[illegible]	—
Rapid City	[illegible]	[illegible]	.55
Red Bluff	[illegible]	[illegible]	—
Reno	[illegible]	[illegible]	—
Richmond	[illegible]	[illegible]	—
Sacramento	[illegible]	[illegible]	—
St. Louis	[illegible]	[illegible]	[illegible]
Salt Lake City	[illegible]	[illegible]	[illegible]
San Antonio	[illegible]	[illegible]	—
San Diego	[illegible]	[illegible]	—
San Francisco	[illegible]	[illegible]	—
S. Ste Marie	[illegible]	[illegible]	—
Shreveport	[illegible]	[illegible]	—
Tampa-St. Petersburg	[illegible]	[illegible]	—
Thermal	[illegible]	[illegible]	—
Tucson	[illegible]	[illegible]	—
Washington	[illegible]	[illegible]	—
Wichita	[illegible]	[illegible]	[illegible]
Yuma	[illegible]	[illegible]	—

CANADIAN

	H	L	P
Calgary	[illegible]	[illegible]	—
Edmonton	[illegible]	[illegible]	—
Montreal	[illegible]	[illegible]	—
Ottawa	[illegible]	[illegible]	—
Regina	[illegible]	[illegible]	.04
Toronto	[illegible]	[illegible]	—
Winnipeg	[illegible]	[illegible]	—
Vancouver	[illegible]	[illegible]	[illegible]

SUNRISE AND SUNSET

Sunrise Tuesday, 5:42 a.m., sunset 6:45 p.m. PST. Sunday maximum temperature 61, minimum 34, mean 48, degree days 17; precipitation —.

TEMPERATURE EXTREMES

Monday lows—12 degrees at Bradford, Pa., and 14 degrees at Oneonta, N.Y.; Monday highs—100 degrees at Laredo, Tex., and [...] degrees at Cotulla, Tex.

SUNRISE AND SUNSET

Sunrise Tuesday, 5:42 a.m.; sunset 6:45 p.m., PST.

SHIPPERS BULLETIN

Shippers protect shipments from following minimums next 24 hours: Portland, 35; north, 35; northeast, 30; east, 33; southeast, 30; south via Klamath Falls, 35; south via Medford, 30.

RIVER BULLETIN

Range of stages at Portland last 24 hours: Highest 3.5; lowest 2.7.

RIVER FORECAST

Little change all streams Western Oregon next two days.

TIDE TABLES

HIGH TIDES AT ASTORIA

Apr. 5	3:34 a.m.	[illegible]	4:52 p.m.	[illegible]	[illegible]
Apr. 6	3:44 a.m.	[illegible]	5:57 p.m.	[illegible]	[illegible]
Apr. 7	11:46 a.m.	[illegible]	11:21 p.m.	[illegible]	[illegible]
Apr. 8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Apr. 9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Apr. 10	[illegible]	2.4	9:54 p.m.	[illegible]	[illegible]
Apr. 11	9:27 a.m.	7.6	10:48 p.m.	[illegible]	[illegible]
Apr. 12	10:36 a.m.	7.8	11:35 p.m.	8.1	

LOW TIDES AT ASTORIA

Apr. 5	9:54 a.m.	-0.4	9:35 p.m.	[illegible]
Apr. 6	10:46 a.m.	-0.4	10:20 p.m.	[illegible]
Apr. 7	4:31 a.m.	6.5	6:17 p.m.	[illegible]
Apr. 8	—		12:57 p.m.	[illegible]
Apr. 9	0:53 a.m.	3.7	2:10 p.m.	[illegible]
Apr. 10	2:26 a.m.	3.5	3:20 p.m.	[illegible]
Apr. 11	3:45 a.m.	3.0	4:21 p.m.	[illegible]
Apr. 12	4:51 a.m.	2.2	5:14 p.m.	[illegible]

Deduct these hours and minutes from the tables: Long Beach 1:10; Clatsop Beaches 35; Tillamook 0:41; Yaquina 1:00; Newport and Lincoln 1:15.

FIRST TIME EVER IN A

OSBH. 1963. IW 3-0 Chipman Chemical Company. Internal memorandum from EJW to KHS, HEM, REH, and GDC, dated August 19, 1963. Oregon State Board of Health, Salem, OR.

S-5A 5/49

original to

Office Memorandum

OREGON STATE BOARD OF HEALTH

To : KHS, HEM, REH, GDC

Date: August 19, 1963

From : EJW

Subject: IW 3-O Chipman Chemical Company

Tom Henshaw, Engineer with Chipman Company, called today to inquire about the possibility of disposing of their liquid waste effluents by deep well injection into the salt water aquifer. He had checked with Bruce Foxworthy, District Geologist, USGS, and had been advised that the general area is underlain by basalt formation which extends down to approximately the 600 foot level and which generally contains fresh water. The basalt layer is underlain by sedimentary layers which generally contains salt or brackish water which sometimes protrudes up into the basalt layer through fissures.

Pennsalt Company, located near Chipman, has 2 wells, one which is approximately 700 feet deep produces fresh water, and the other, which is approximately 865 feet deep, produced brackish water and was therefore abandoned.

Mr. Henshaw would like to have our reactions to this proposed method of liquid waste disposal. I would like your comments regarding this and, in the meantime, I will check with the State Engineer's Office and further with Bruce Foxworthy. Mr. Henshaw also told me that they are presently operating their MCP processe for approximately 10 days and he is arranging to obtain and submit to us quantata tive and qualitative data on their liquid waste effluents from this process. The 2 4D process is shut down until sometime in September or October.

A small scale bleed DCP waste recovery process is in operation. He will submit data on the liquid waste effluent from this process.

8-19-63 report of inquiry from Bruce Foxworthy. He will send copy for our files.

Ph. conf. with Jack Scova, St. Eng's Office 8/26/63.
He thinks idea O.K. if:
1) can find pervious enough layer in sedimentary deposit to enable disposal?
2) Can prevent infusion of waste up into fresh water bearing Basalt stratum.
He would like to review any proposal we may get.

EJW

(over)

Both Scova and Topworthy thought that the only way to test the feasibility of this proposal would be to try it — which would be quite expensive.

OSBH. 1965. Tainted Spring Chinook—Multnomah Channel. Internal memorandum from ELQ to KHS, EJW, HEM, GDC, and BMJ, dated March 16, 1965. Oregon State Board of Health, Salem, OR.

S-5A 5/49

Office Memorandum • OREGON STATE BOARD OF HEALTH

To : KHS, EJW, HEM, GDC, BMJ cc: JAJ Date: 3/16/65

From : ELQ

Subject: Tainted Spring Chinook -- Multnomah Channel

IW 3-0 CHEM - PETROL. CHIAMAN CHEM.

Mr. Carl Struck, 4325 N. E. 24th, (AT 1-0307), called this morning to register a complaint on the taste of two spring chinooks he caught in the vicinity of Gray's Moorage near the head of Sauvies Island on Friday March 12, and Monday, March 15. He stated that the fish caught on Monday did not contain as strong an odor as the fish caught last Friday. His description of the taste was medicinal in character.

This is probably the first complaint we have received on tainted fish this year.

OSBH. 1967. IW 3-0 Chipman Chemical Co. Internal memorandum from LOC to KHS, EJW, and GDC, dated August 31, 1967. Oregon State Board of Health, Salem, OR.

S-5A—5-49

Office Memorandum • OREGON STATE BOARD OF HEALTH

To : KHS, EJW, GDC cc: JAL Date: 8-31-67

From : LOC

Subject: IW 3-0 Chipman Chemical Co.

Yesterday (8-30) about 3 p.m. the Harbor Patrol called me and said that they had observed an unusual amount of foaming and strong odors at the mouth of Morgan Creek near Chipman Chemical Co.

I went out immediately to check on this and did find some foaming at the mouth of the creek and there was some odor. I could not judge that it was an unusual situation as I have not seen this drainage for several months. I started at the mouth of the creek and followed it upstream to the point where it becomes a pond or lake of sorts. Up to this point the creek exhibited some foaming at points where it was getting aeration (small falls, etc.) and was rusty brown in appearance. The pond area was then checked out closely and it appears that the only source of water is seepage from Doane Lake across the railroad fill. There was very definite signs of this occurring all along the railroad side of the pond. Apparently because of the long dry spell any runoff, etc., has been drained away and the drainage to the river is straight seepage from Doane Lake. This evidently accounts for the foaming and stronger odors.

Contacted Gitschlag, Chipman Chemical, and he indicated that to the best of his knowledge the tests on Morgan Creek have not shown any unusual changes.

OSBH. 1968a. IW 3-0, Chipman Chemical Co. Internal memorandum from LOC to KHS, EJW, JAJ, and GDC, dated August 5, 1968. Oregon State Board of Health, Salem, OR.

S-5A—5-49

To ~~EAS~~ FGK ~~FMR~~

Office Memorandum • OREGON STATE BOARD OF HEALTH

To : KHS, EJW, JAJ, GDC. cc: ~~FMB~~ Date: August 5, 1968

From : LOC

Subject: IW 3-0, Chipman Chemical Co.

On August 1, 1968, a Mr. Tom Kirtland (phone 222-3357) called and said he caught some tainted fish near Sauvies Island. (Cross Sauvies Island bridge and turn to left and near first boathouse.) He caught bass, perch, catfish and crappies. Some of the catfish were fairly good but rest of catch was tainted.

EJW called Dick Gitschlag, Chipman Chemical, on 8/2/68 to determine the status of their treatment plans. Calgon Engineering is designing the Carbon Adsorption system and propose to have final design completed in September. Their target date for connecting to the city sewer is December 1, 1968. EJW requested they tighten up their controls and accelerate their control program as much as possible.

I contacted Mr. Kirtland on 8/2/68 to relay the above information and asked that he call in again if he caught more tainted fish.

Water Supplies & Swim Pools
Oregon State Board of Health
RECEIVED
AUG 5 1968
DNF | TEMP | PERM

OSBH. 1968b. IW 3-0 Chipman Chemical. Internal memorandum from RCS to EJW, JAJ, LOC, and GDC, dated August 23, 1968. Oregon State Board of Health, Salem, OR.

S-5A—5-49

To ~~EGK~~ FMB

Office Memorandum • OREGON STATE BOARD OF HEALTH

To : EJW, JAJ, LOC, GDC cc: ~~FMB~~ Date: August 23, 1968

From : RCS

Subject: IW 3-0 Chipman Chemical

On August 21, 1968, Dick Gitschlag called and asked that someone come down as soon as possible. He related that he had a serious problem. On August 22, 1968, I visited the plant. His reason for alarm was his new testing procedure in which he is analyzing for total phenol. This would include DCP (dichlorophenol), TCP (trichlorophenol) and cresol. The value of total phenol is in the neighborhood of 20-25 mg/1. In the past he has only analyzed for DCP and this has been under 10 mg/1; however, in recent flavor tests it was shown that TCP had an effect on fish flavor.

The percentage of DCP, TCP and cresol in the total phenol test is approximately 50, 40, and 10, respectively, therefore DCP is over our specified level.

I couldn't speak for the staff as I have never worked on this problem, but I told him to send in the reports with a detailed letter on his new testing procedure with each % broken down and we would evaluate from there. I stated we were at the beginning of the fall salmon run and this could have some effect on our evaluation.

Water Supplies & Swim. Pools
Oregon State Board of Health
RECEIVED
AUG 26 1968
DNF | TEMP | PERM

Rhone-Poulenc AG Company. 1987. Rhone-Poulenc AG Company, Portland Plant, Environmental Status Review. Rhone-Poulenc AG Company, Corporate HS & EA Department, Portland, OR. July 7, 1987.

RHÔNE·POULENC

RHONE-POULENC AG COMPANY

PORTLAND PLANT

ENVIRONMENTAL STATUS REVIEW

EXHIBIT

2627

CORPORATE HS&EA DEPARTMENT

7 - 7 - 87

RHONE-POULENC AG COMPANY
PORTLAND PLANT

ENVIRONMENTAL ASSESSMENT

SECTION I - Plant/Operational History Highlights
Operating History Discussion

SECTION II - Environmental History Outline
Environmental Discussion

SECTION III - Environmental Assessment

- Introduction

Part One - South Plant Area

Part Two - Central Plant Area

Part Three - North Plant Area

Part Four - Waste Storage Practices

Part Five - Doane Lake Area

Part Six - Groundwater Monitoring & Removal Processes

A - General
B - Water Bearing Units & Water Transport
C - Monitoring System Analytical Results
D - Groundwater Removal System

Part Seven - Dioxins

SECTION IV - Summary and Recommendations

RHONE-POULENC - AG COMPANY

PORTLAND PLANT

SECTION ONE

PLANT/OPERATIONAL HISTORY HIGHLIGHTS

1943 - Railroad liquid formulations & pesticide warehousing established.

1956 - 2,4D Acid & Ester operations started.

1958 & 1959 - 2,4-D operations revised to improve product quality and decrease pollution problems.

1960 - MCPA Plant with o-dichlorobenzene as a solvent. 2,4,5-T Plant, Continuous 2,4D ester operation, and 2,4-DB plant operation, an started.

1962 - 2,4,5-T & continuous ester plant shutdown.

1963 - 2,4-DB Plant started.

1966 - New MCPA Plant using DCM as solvent started.

1968 - Insecticides production shutdown.

1971 - Bromoxynil Octanoate process added to ester plant.

1972 - MCPB and 2,4-DP production added to 2,4DB operation.

1975 - Tri-production started.

1976 - MCPA plant shut down.

1976 - DCP Distillation for high purity 2,4-DCP started.

1982 - 2,4-D, DCP, 2,4-DB processes shut down.

1983 - Ester operation shut down.

- Bromoxynil Octanoate production continues.

The 2,4 D technology was purchased from PPG with much of the equipment being from PPG's Pittsburgh plant. The 2,4 D plant was built and started without pollution control equipment.

The 2,4 D Acid and Ester operations were built in 1956 and expanded and revised a number of times until these operations were shutdown in 1982, and in 1983 respectively.

The year 1960 saw the addition of operations to esterify 2,4 DB Acid, product MCPA Acid, and 2,4,5-T Acid and Esters. A continuous 2,4 D Ester operation was part of the expansion of the 1960 improvements that allowed 2,4,5-T Acid production in the 2,4 D Ester equipment. The 2,4,5-T Acid operations and the 2,4 D continuous Ester operations were shutdown in 1962.

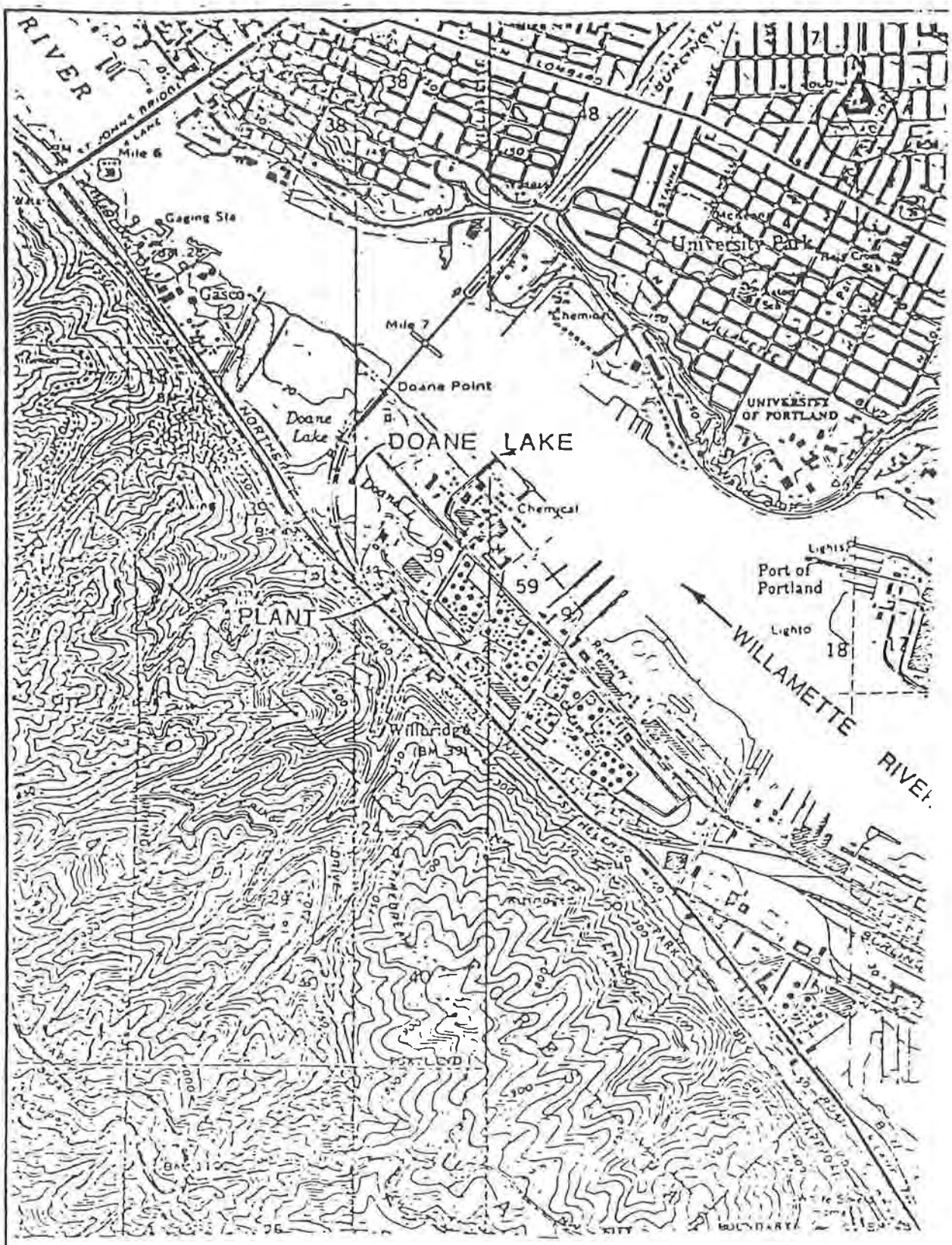
A plant was built in 1963 to produce 2,4 DB Acid. Land was leased from the Northern Pacific RR on the west side of the plant to gain access to the purchased "Lake Property." Part of the 2,4 DB plant is on leased land. During 1965-1966 a new MCPA plant was built, expanding and replacing the 1960 plant, built with wooden tanks and structure. The 2,4 DB and MCPA plants were built adjacent to each other to allow production of MCPA Acid, utilizing all of the 2,4 DB equipment in addition to the specialized chlorination and crystallization equipment in the MCPA plant building.

The Chipman Chemical Company was purchased by Rhodia, Inc. in 1964. It should be noted that many of the products sold by Chipman were made and sold by RP of May & Baker outside the United States.

During the late 1960's and early 1970's operations were

revised and upgraded in the 2,4 DB and MCPA buildings to permit manufacture of MCPB and 2,4 DP acids on a campaign basis.

The Bromoxynil Octanoate operation was added to the 2,4 D Ester operation in 1971. Changes in both marketing, environmental and regulatory conditions lead to major revisions to the 2,4 D acid production process in 1976. Sale of 2,4 DCP was started. The MCPA plant was shutdown in 1976 for strategic and marketing reasons. The production of 2,4 D and 2,4 DB acid and esters was stopped in the early 1980's. At this time Bromoxynil Octanoate is continuing to be manufactured at Portland.



REFERENCE:

U.S.G.S. 7½ MINUTE
QUADRANGLES FOR:
1. LINNTON, 2. PORTLAND.

FEET

2000 1000 0 2000 4000

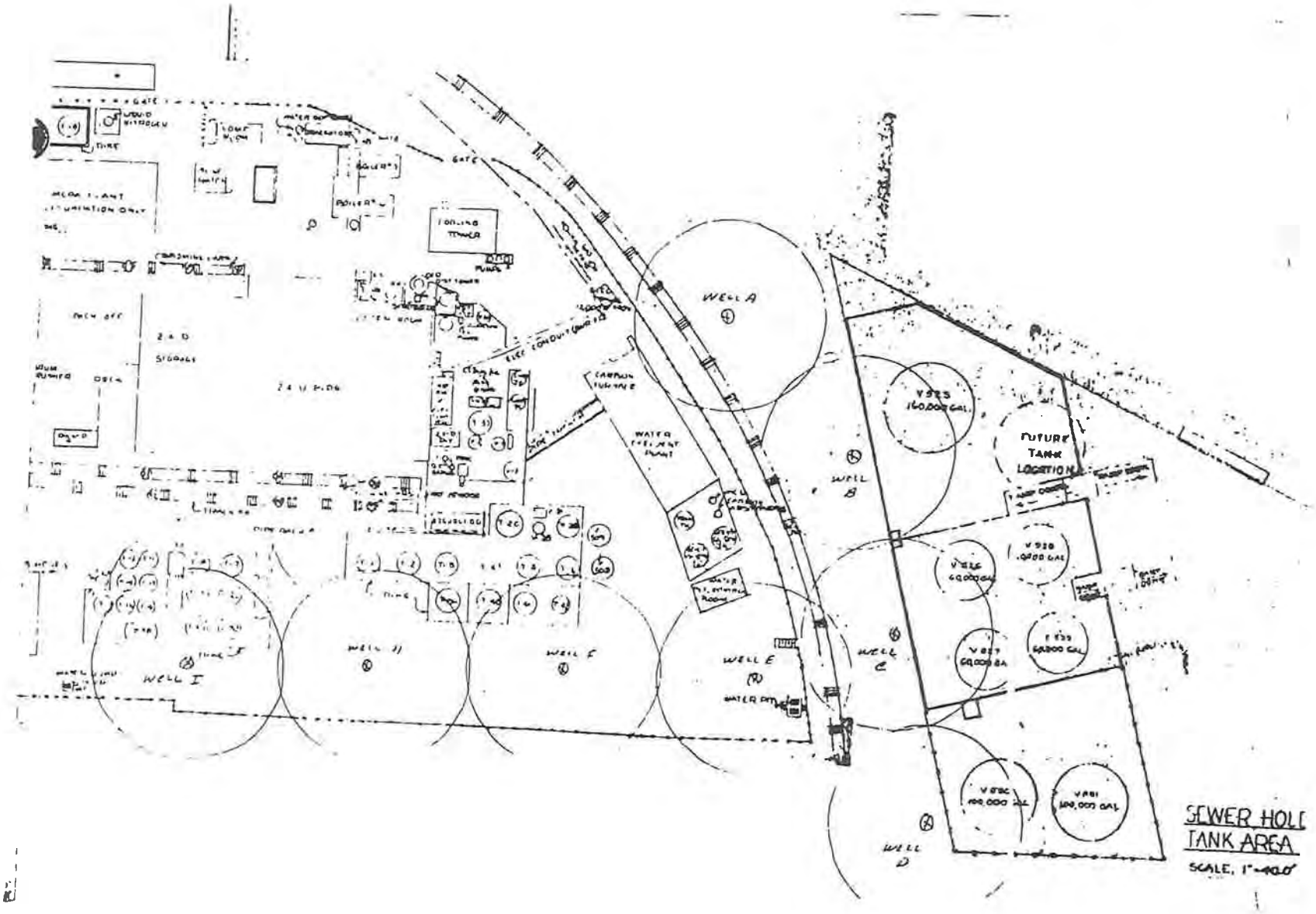
VICINI
MAI

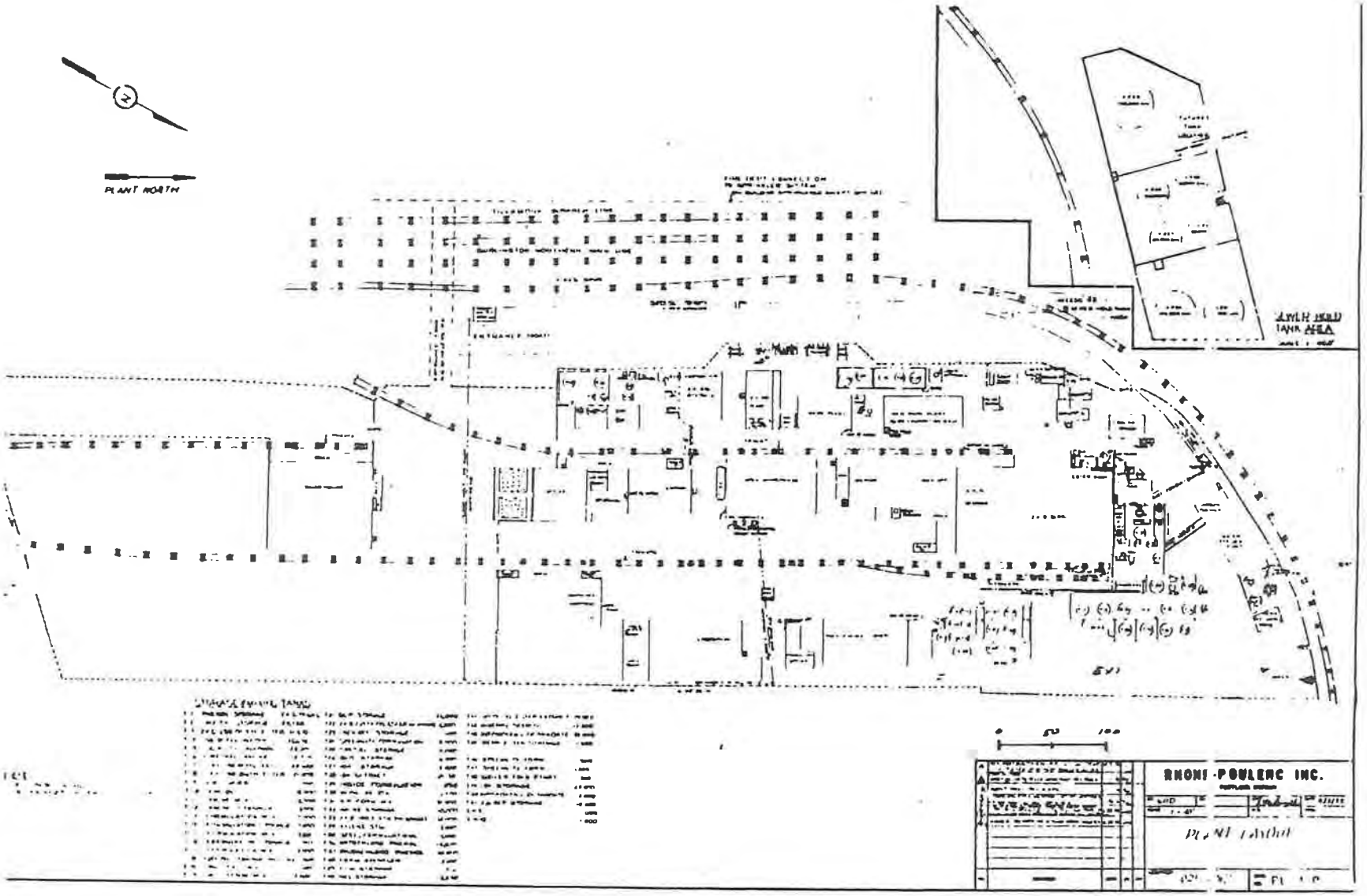
DAMES & MO

CHECKED BY _____ FILE 12088 002-04 BY _____ DATE _____

PRODUCTION CAPACITIES FOR VARIOUS OPERATIONS

2,4-DCP	50,000# per day
2,4-D	43,000# per day
MCPA	10,000# per day
2,4-DB	7,000# per day
Esters	5,000 gallons per day or
	50,000# per day
Formulations	10,000 gallons per day


WELL A
WELL B
WELL C
WELL D
WELL E
WELL F
WELL I
FUTURE TANK LOCATION
SEWER HOLE
TANK AREA
SCALE, 1"=40.0'


PLANT NORTH
RHONE-POULENC INC.

RHONE-POULENC AG COMPANY
PORTLAND PLANT

SECTION II

ENVIRONMENTAL HISTORY OUTLINE

1956 - 2,4D Acid & Ester Plants built with no pollution controls.

1958 - Water reuse systems installed.
Fish kill reported at north outlet Doane Lake.
(1 mile north).

1959 - 2,4D process odor control installed.
2,4D water effluent extraction system installed.

1964 - First major water pollution incident.
Fish in river had chemical taste.
Chlorine oxidation water treatment system installed.

1964 & 1965 - Doane Lake biological treatment and pumpout to river during spring 65 during high river flow.

1965 - MCPA plant shutdown because of its contribution to fish taste problem.

1966 - New MCPA plant built with environmental controls & no process water effluent.

1969 - Calgon Carbon Adsorption effluent treatment started.
Direct effluent discharge to river started.

1970 - 2,4D building odor control installed.

1976 - DCP distillation system installed to reduce waste amounts.

1977 - Plant effluent treatment upgraded to comply with CWA.
Surface water treatment and seepage collection & treatment started.

1980 - Doane Lake found contaminated from failure in seepage water collection system. Standpipes installed & limited pumping started.

1981 - Doane Lake biological treatment started.

1981 - Engineering studies started mud treatment.

1982 - Area monitoring system installed.

1983 - Continuous ground water collection & treatment started.

1987 - Well 4 pumping started on test basis.

SECTION II

ENVIRONMENTAL DISCUSSION

The early history of the Portland plant emphasizes the sales operations of Chipman and the seasonal nature of production. Technical staffing was very limited until the mid-60's. Installations were generally chosen based upon fast installation & short term return-on-investment considerations, to take advantage of special market needs or entrepreneural sales.

Environmental systems were generally installed only in response to public pressure or agency mandates. Because the Environmental systems were installed after-the-fact their effectiveness was sometimes limited. Existing processes, plant layout & utilities, along with limited capital, made effective installation & operation difficult. The seasonal nature of manufacturing created operating problems & environmental accidents.

A comparison made between the operations history and environmental history show a considerable engineering & construction activity. A plant was built then water environmental controls were installed. The first plant built with suitable environmental control in the design was the 2,4DB plant in 1963. All later operations included environmental controls in the design. At various later times, Environmental systems were installed largely in response to changes in regulations (1977 -CWA) Economic reasons (1976 DCP Distillation) or continuing problems with the 2,4D plant (1970-Building odor control). The present environmental problems are the result of a

number of past practices. Initial installations operating processes, waste handling and equipment maintenance have all caused contamination of the soils in the plant and the area. Remedial activities should be intensified particularly in light of present environmental regulations.

RHONE-POULENC AG COMPANY
PORTLAND PLANT

SECTION III

ENVIRONMENTAL ASSESSMENT

Introduction:

The operating & environmental practices at Portland have left a number of problems, most of which are not sufficiently defined to permit a good remedial assessment. Efforts have been made in the past to document potential problems. Discussions in 1980 with plant personnel lead to the development of a listing of areas that potentially will require remediation, if determined to be a problem. Investigations conducted by Dames and Moore, also starting in 1980, coupled with the known effects of past practices gives a general definition of the environmental problems existing at Portland.

It is obvious that Portland operations will stop at sometime in the near future. This premise dictates that an accelerated investigation, leading to an active remedial effort, be started. The Portland plant is on the Oregon Superfund list and on the EPA National Priorities Candidate list, giving importance to a proactive position on Portland environmental problems.

The Oregon Dept. of Environmental Quality, Site Regulatory Manager, Larry Patterson has stated recently that the treatment of Doane Lake and pumping and treating of ground water, has helped RP considerably with the agencies. He also indicated that continued & increased activities are recommended, particularly with enactment of the Oregon's Superfund Law and the revised Ground Water Policy due to be promulgated in the fall of 1987.

This policy will require the clean up of Class II ground water, such as that in the Doane Lake area. Mr. Patterson has indicated a number of times over the years that RP chemicals must not be identified in the river. The state is monitoring river quality. If chemicals are found in the river, the state will order immediate remedial action to stop any chemicals entering the river.

The past investigations have lead to a logical separation of the plant environments problems into main area.

Part One - South Plant Area

Part Two - Central Plant Area

Part Three - North Plant Area

Part Four - Waste Storage Practices

Part Five - Doane Lake Area

Part Six - Groundwater Monitoring & Withdrawal

It is proposed that a low key remedial investigation be undertaken using Dames & Moore as the consultant to do limited additional ground water testing in the lower part of the shallow aquifer; a soils investigation under the insecticide warehouse & the 2,4D formulation packoff building; and a soils boring program around the 2,4D plant. These investigations will be used to better define the problems in the plant areas. Monitoring of the well network should continue with emphasis on sampling & laboratory QA/QC to assure good data acquisition.

The discussions that follow are based upon the Dames & Moore studies of 1980 thru 1983 & ground water monitoring results, ground water pumping information and in some cases either the recollection of employees or past state regulatory actions.

SECTION III

ENVIRONMENTAL ASSESSMENT

Part One

South Plant and Cells

The South Plant was used for the formulation of a full range of insecticide and fungicide products as either a liquid, granular, wettable powder or colloidal product. Production volume was limited and produced in the spring for the western market. Equipment wa[illegible]ut (or spillage) was drained to the ground south of the plant or to the area under the warehouse building (later use for colloidal products manufacture).

During installation of a groundwater monitoring well in the vicinity of the old insecticide formulation plant (now used as a warehouse), soil samples were taken that were assayed and found to contain detectable levels of Lindane, Aldrin, and Endrin. This information and the review of old aerial photographs led the DEQ to request a study to determine if any "cells" of chemicals had been deposited in the area south of the insecticide plant. An extensive soil sampling program was conducted during 1983 in the south plant area, with samples assayed for specific pesticides and phenolics. The results of the study were:

No "cells" of chemicals were located.

Low levels of pesticides (primarily 2,4D) were found at several locations.

High levels of phenolics were found throughout the study area.

Since no cells of contamination were found and since those chemicals that were found were not easily extractable, and apparently not resulting in groundwater contamination, the DEQ indicated that for the time being they are not immediately concerned about this area.

The study did not consider the area under the insecticide warehouse. Soil and groundwater samples south of the building did not reveal the presence of DDT or HCB from colloidal manufacture. The bucket elevator pit in the building was used to encapsulate some pesticides.

11/14/83

SOUTH PLANT SOIL & GROUND WATER SAMPLING PROGRAM

References: A. Soil sampling results attached:
1. Samples taken during well installation.
2. Soil samples taken during first half of 1983.

B. Ground water samples - Wells 1,2,3,L2,PP3.

In accordance with our NPDES permit, a south plant soil sampling program was developed and executed in an effort to determine the extent of soil contamination. This data is analyzed below along with the results of soil samples taken during the ground water well installation and the actual ground water results.

During installation, the soils from wells 2 and 3 were sampled and analyzed by EP toxicity protocol. These results are shown on the following page.

Although analysis of these soil samples did not show higher-than-permissable concentrations of the target contaminants, subsequent ground water tests in well #2 showing detectable levels of Lindane, Aldrin and Arsenic led the DEQ to request an extensive soil sampling program throughout the south plant area. Of primary concern to the DEQ was the potential for a localized cell of chemical to leach into the surrounding soil and ground water.

This program was undertaken during the first half of 1983 with all the results in by the end of the third quarter.

Pesticides were analyzed using the EPA EP Toxicity Test and the chlorophenols were run using total extraction. Total extractions of chlorophenols were required because there is no EP toxicity protocol for chlorophenol. Rhone-Poulenc chose to run chlorophenol by both total extraction and the EPA toxicity because it was felt that EP toxicity data would be relevant to the transmission of contaminants through the soil.

The results of the soil sampling can be broken down into two categories: pesticides and chlorophenols.

Pesticides

Of 250+ separate pesticide assays (see Table I), three showed levels of pesticides greater than EPA toxicity limits of the drinking water standards. These were:

Location/Depth	Pesticide	ppb Concentration	ppb Max. Allowed
Boring 13 - 1 foot	Lindane	3057	400
Boring 14 -10 feet	Lindane	554	400
Boring 17 - 1 foot	Arsenic	2200 ppm	5.0 ppm

Of these samples, borings #13 and #17 are of some concern because of the observed high levels of pesticides. While the observed level of sample from boring #14 is slightly above allowable concentrations, it is questionable whether the variance justifies removal of 10 feet of soil. Locations #13 and #17 should be confirmed by resampling and reassaying. If duplicated samples show similarly high levels, action should be taken.

Chlorophenols

As noted above, dichlorophenols were analyzed using two different recovery techniques. Solvent extraction was used to determine the total quantity of material present. IP toxicity extraction was used to determine how much of the material present was likely to be transmitted through the soil by the ground water.

As shown in Table II, the differences between the two techniques were dramatic with detectible levels of chlorophenols found throughout the sample area using the total extraction method and almost insignificant levels of chlorophenols using the EPA EP toxicity method. The one exception to this was boring #5 at the one foot level where detectable levels were found using both methods.

Sample Quality

The soil sample data as listed in Tables I and II are as reported and need to be corrected for analytical recovery. The laboratory has determined the following percent recoveries:

2,4-D	19%
Lindane	95%
Aldrin	32%
Phenol	16%
2,4-DCP	27%
2,4,6-TCP	41%

In a few instances, duplicate recoveries were run on the same sample location. Significant variances were found, for example:

B13-S2X	55.0 ppb 2,4-D
B13-S2Y	5.9 ppb 2,4-D
B22-S2X	2500 ppb 2,4-DCP
B22-S2Y	11,810 ppb 2,4-DCP

These order of magnitude variances leads one to question the overall data reliability.

Conclusions and Recommendations:

1. In general, the south plant area does not show significant pesticide contamination. What contamination does exist appears to be absorbed strongly on the soil. Locations 13-S1 and 17-S1 should

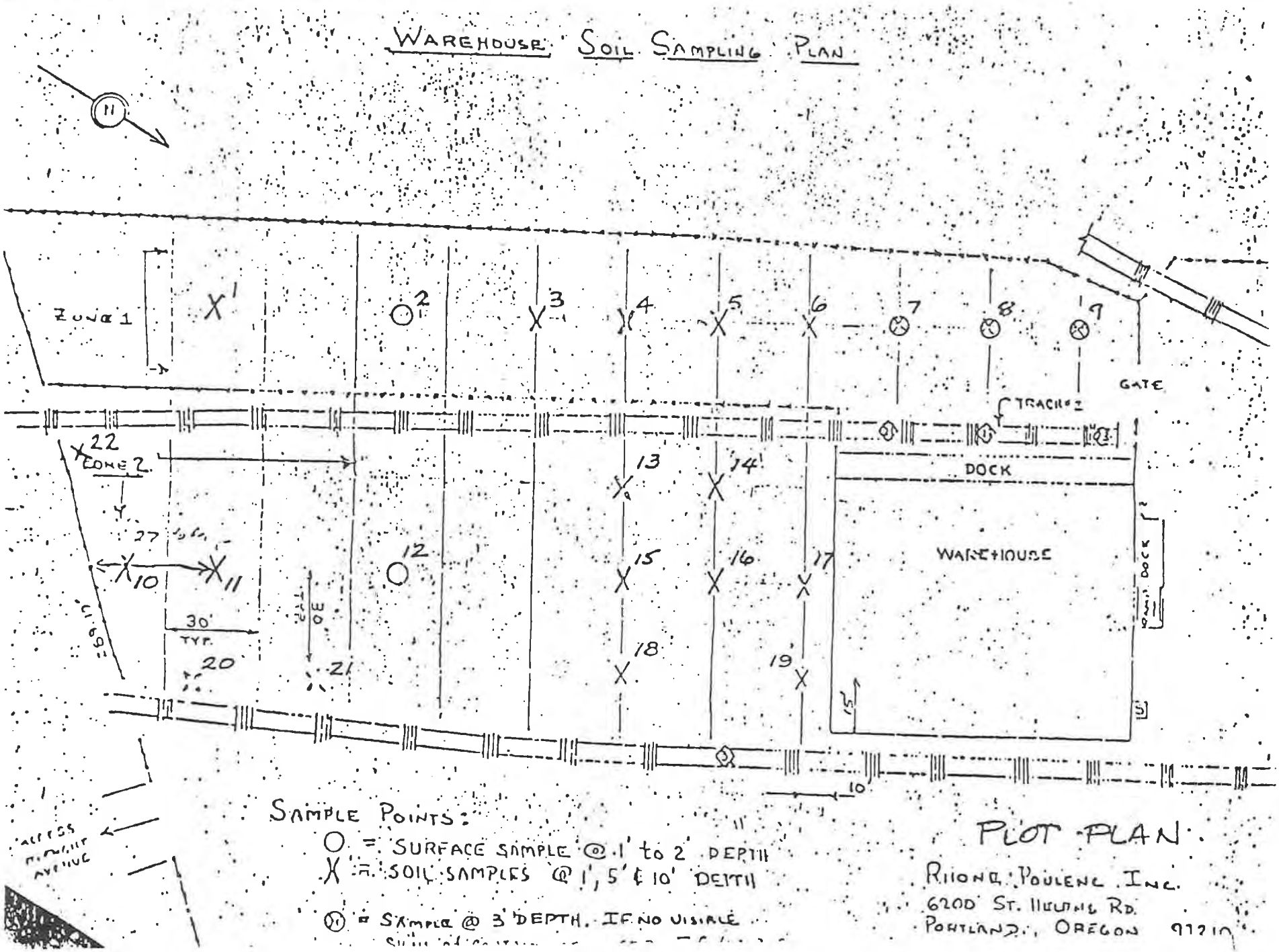
be resampled for Lindane and Arsenic respectively.

2. Chlorophenols are detected throughout the area but the EP toxicity tests and the absence of chlorophenols in well 3 indicate strong absorption on the soil. The area of B5-S1 requires action, the extent to be determined in the field.

R. L. Ferguson
Plant Manager

RLF:kst
Attachments

WAREHOUSE SOIL SAMPLING PLAN



SECTION III

ENVIRONMENTAL ASSESSMENT

Part Two

Central Plant Area

The north end of the office building was used for the manufacture of Shed-a-Leaf and Chlorax dusts. These were chlorate-borate mixtures or chlorate-soda ash mixtures. The underground tank (T-31) was used for railroad liquid manufacture and Atlas formulations (sodium arsenite solutions). No known problems exist in this area.

The 2,4DB MCPA and the specialty ester operations have not been demonstrated to be an environmental problem. Studies in this area have not been made.

SECTION III

ENVIRONMENTAL ASSESSMENT

Part Three

North Plant Area

The soils in the 2,4D plant area, Herbicide formulation area, railroad tracks, and raw material storage tanks, all have shown the presence of organic contamination. Excavation for construction of underground pipe repair would be show soils that were obviously contaminated and at times the excavations would collect free organics. Testing has never been conducted on soils around the 2,4D plant.

The fact that a seepage collection system was installed in 1977, then monitoring, then pumping and treatment of shallow ground water in 1983 all attest to a soil problem in the 2,4D Acid & Ester plant area. This subject will be discussed in Part Five that follows. Studies to date have not addressed the 2,4D granular elevator pit which is reported to contain decontaminated waste pesticides. The soil under the 2,4D formulation pack off was the drainage sump for equipment washout & spillage until this area was connected to the water treatment system. Soil contamination is probable but has not been detected in the monitoring wells system.

When the plant was built in 1956 an open topped Cistern was installed in the T-20 area that was about 4 feet in diameter and about 25 feet deep. Plant effluent ran into this Cistern. The unit soon filled with solids and overflowed. This Cistern was

filled early in 1958. It is suspected that this Cistern is, in part, responsible for contaminants being found in the ground water withdrawl wells.

SECTION III

ENVIRONMENTAL ASSESSMENT

Part Four

Solid Waste Handling, & Storage & Disposal Practices

The handling of plant waste byproducts has been a troublesome and long standing operating and environmental problem for Portland. Initially all wastes were disposed of at the Portland City dump. As production increased, the number of waste drums also increased and the City Manager became concerned that the drums would "lift" the dump's fill. Disposal was discontinued in about 1961.

Wastes from the 2,4D, 2,4,5T & MCPA operations accumulated for a period of time. The drums were stored in all empty plant locations. Tank cars were also used for waste storage. In about 1969 the state approved the disposal of the accumulated wastes at Alkali Lake. The waste material was repackaged and shipped to the Alkali Lake site in south central Oregon (Alkali Lake is a dry lake primarly composed of Trona, contaminated with arsenic).

Political action in 1971 caused the disposal site to be closed. For a period of time (about 4 years) we disposed of waste at a site near Pasco Washington . Fear of damage to grapes in the area caused the state to stop disposal at this site. Waste was again accumulated on the site. A state approved site was opened in 1976 at Arlington, Oregon (now Chem Waste Management and off site waste disposal started again, and is continuing.

The accumulation of liquid & solid wastes has been a major cause of the surface contamination found in various areas of the plant. This storage practice may have had an effect on the ground water.

SECTION III

ENVIRONMENTAL ASSESSMENT

Part Five

Doane Lake Area

General: The Doane Lake was one of a number of lakes extending over a six mile stretch from about 19th street to about the 66th street area, about 1 mile north to the old Portland Gas & Coke plant. Filling of these lakes started in the 1890's and has continued until the last few years, with only 3 lakes remaining; one on each side of the Burlington northern main line and one east of the Gould site.

The Doane Lake property immediately north of the plant was sold to Chipman and Esco in 1963. Property was leased from the railroad, west of the Chipman plant to give access to the "Lake" property.

At the present time the Gould site is a Superfund site and under Remedial Investigation for lead contamination. Gould & NL Industries are the Principle Responsible Parties. The plant was a lead reclamation operation. Battery cases contain a lot of lead have been used for fill on RP'S Lake property and are presenting thought to be Gould's/NL Industries responsibility per their consent order with EPA.

ESCO (Electric Steel Foundry Company) used part of the lake area for disposal of foundry casting sand. ESCO later ran a recovery operation for stainless and specialty alloy metals remaining in the sands. The sand has a low level radioactivity in addition to metal contamination and is being monitored by the

state.

The property north of the railroad track was used for tar setting ponds by the gas company over many years. This land was gradually filled with the final fill being placed in the mid-1960's, with river dredge. This land is now the site of Wacker Silitronics, a high purity silicon crystal manufacturing operation.

The "Doane Lake" area has been of concern both to the EPA & State for a long period of time in part from our operations. But also related to the long history of manufacturing operations in the area.

Doane Lake Property

The lake was about thirty acres in 1956 and has been slowly filled by the various property owners adjacent to the lake. The sketch attached shows the fill boundaries over time. The treatment of Doane Lake in 1965 and again in 1981 are the result of specific environmental events:

1: Fish taste problem in the river in 1964.

2: A major leak in the Ester plant effluent collection system draining to Doane Lake in 1981.

The 1965 fish taste problem was caused by the excavation of a deep ditch north of the railroad mainline fill, the ditch was to be the drainage parth for surface water runoff from the west hills and as a drain point for water from the dredge filling operation conducted in 1965 & 1966. This ditch was about 8 feet wide and six feet deep. 1964-1965 was a dry year and river levels were the lowest in years during the salmon migration

period in the spring. The lake level dropped about five feet in less than 2 months. This water volume represented a doubling of effluent volume to the river when flows were as low as 5000 to 8000 second feet, with tide effects, concentrations of 5PPB, 8 PPB will be calculated. Fish Bioassay tests determined that salmon would have a chemical taste from water containing something less than 1 PPB of Phenolics (Orth Chloro Cresol at 1 PPB causes fish taste). RP was ordered late in 1965 to put in a treatment system to achieve 10 PPM Phenolics discharge to the river, and pump & treat Doane Lake.

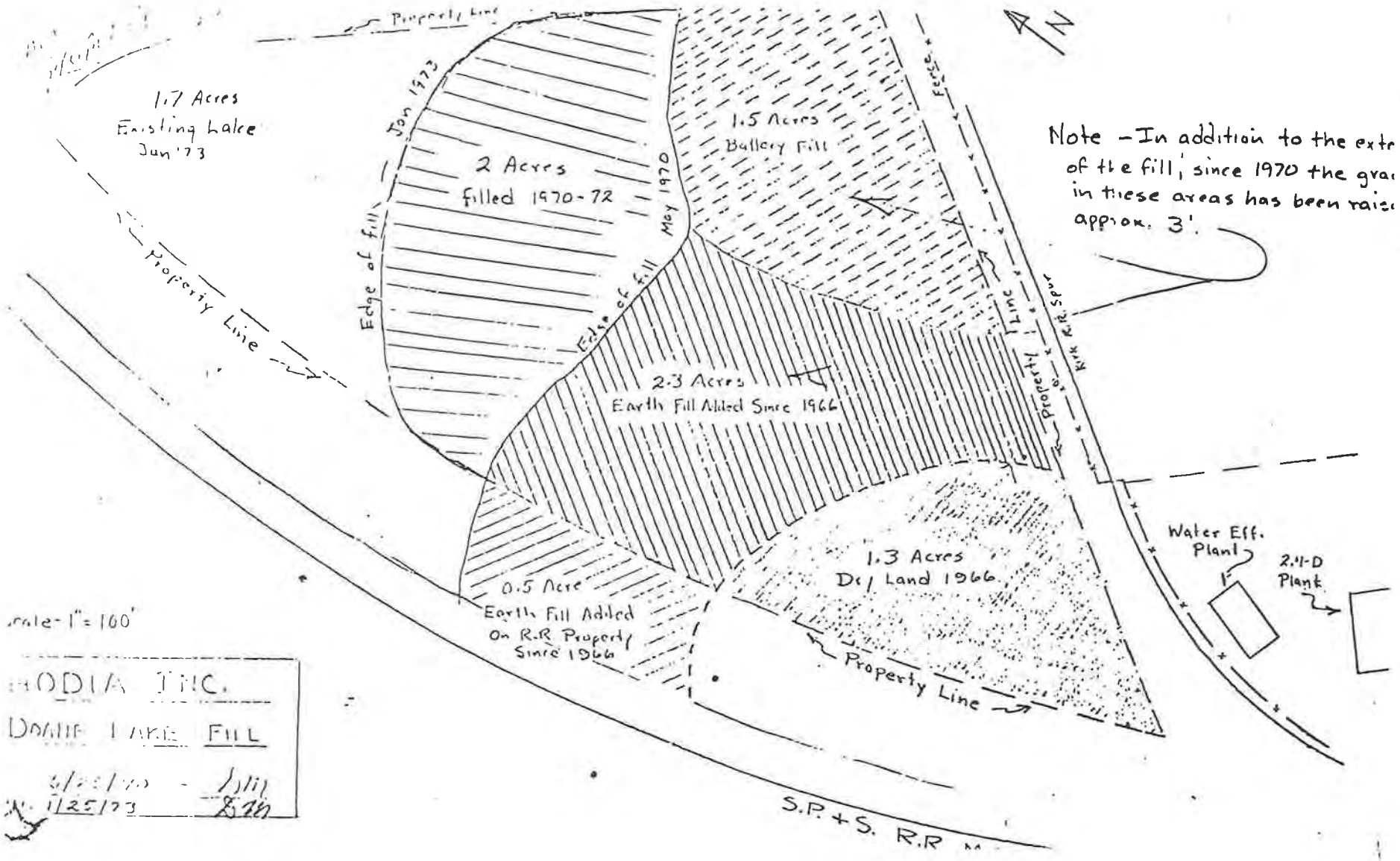
A Chlorine Oxidation System was installed (in 60 days or shutdown); biological treatment was used (although simple); and pumping was conducted in the winter of 1965-1966. 3000 to 4000 GPM was pumped continuously for about 60 MMS. The lake dropped about five feet and stopped going down, a recharge of 3000 to GPM. The lake now has been filled, leaving one acre of water.

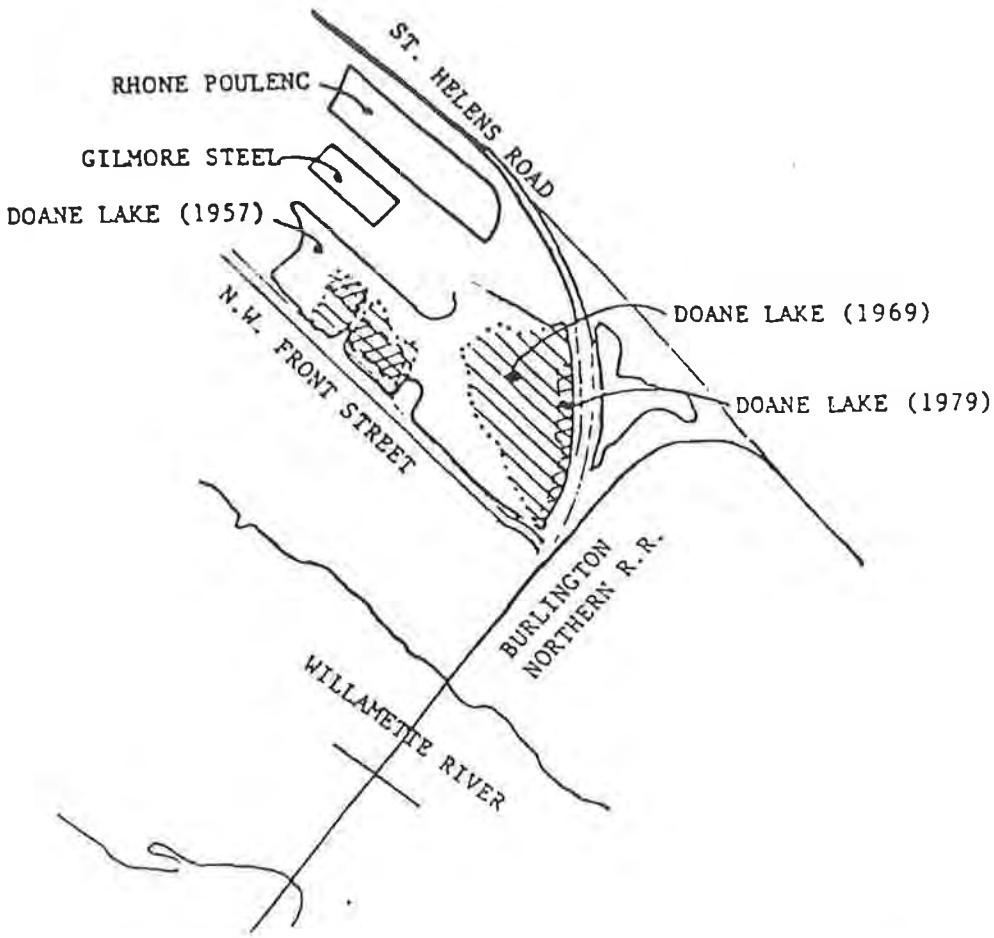
The 1981 recent biological treatment scheme for the lake was developed with the help of Sybron. In situ-biological treatment of the lake has been .continued since 1981 with undetectable levels of 24D and DLP being achieved. Mud treatment, by use of a dredge in 1981 & again in 1982 showed a dramatic reduction in chemicals in the lake muds. However, testing of lake muds continue to show elevated levels of strongly adsorbed chemicals. It has been postulated by Dames & Moore that the lake is a ground water discharge/and recharge point, with ground water migrating into and out of the lake depending upon one time of year (wet or dry season). Several times when treatment acting was low

because of aerator failure or low temperatures, DCP levels go up in the lake water.

Monitoring results show limited, low pesticide chemical levels in the monitoring wells in the lake area when because of well screen placement may not be accurate.

Copies of analysis reports for mud & lake water samples are attached.

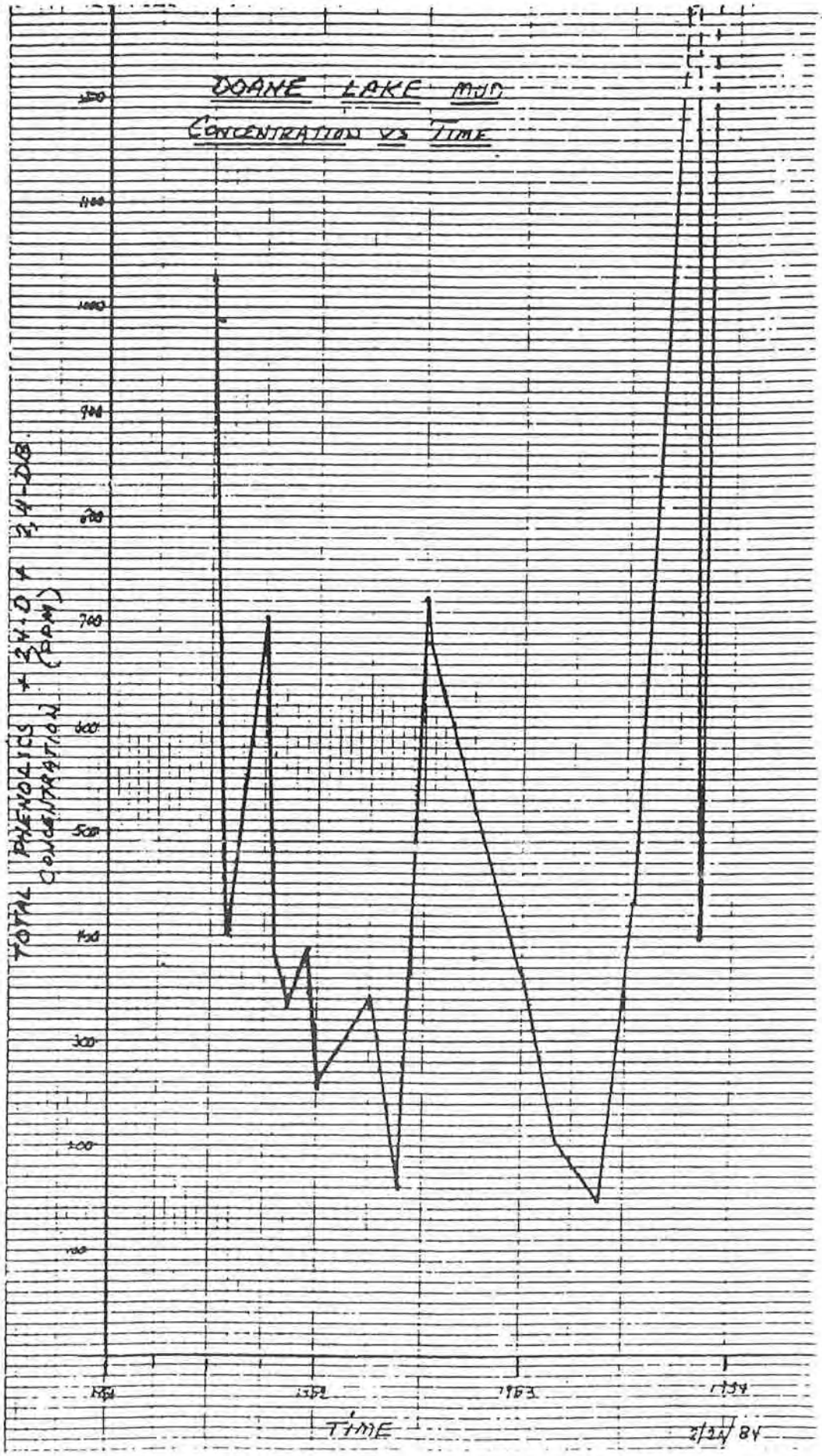

Property Line
1.7 Acres
Existing Lake
Jun '73
Jan 1973
2 Acres
filled 1970-72
May 1970
Edge of Fill
Edge of Fill
1.5 Acres
Battery Fill
Fence
Property Line
Property Line
Kirk R.R. Spur
2.3 Acres
Earth Fill Added Since 1966
1.3 Acres
Dry Land 1966
0.5 Acre
Earth Fill Added
On R.R. Property
Since 1966
Property Line
Water Eff.
Plant
2.4-D
Plant
S.P. + S. R.R
Note - In addition to the extr
of the fill, since 1970 the grai
in these areas has been raise
approx. 3'.
Scale - 1" = 100'
ODIA INC.
DOANE LAKE FILL
1/25/73



(Approximate Scale 1 in. = 1,000 ft)

SKETCH ILLUSTRATING FILLING OF DOANE LAKE, 1957-1979, BASED UPON REVIEW OF CORPS OF ENGINEERS' AERIAL PHOTOGRAPHS.

James J. Moore


DOANE LAKE MUD
CONCENTRATION VS TIME
TOTAL PHENOLICS + 2,4-D + 2,4-DB
CONCENTRATION (PPM)
1200
1100
1000
900
800
700
600
500
400
300
200
100
1951
1952
1953
1954
TIME
2/24/84

SECTION III

ENVIRONMENTAL ASSESSMENT

Part Seven

Dioxins

The Portland plant manufactured 2,4,5T acid from purchased 2,4,5TCP (Monsanto, Diamond) from 1960 through 1962. The ester based production product gave a predicted yield and was hard to run. Thompson-Hayward made an offer to sell 2,4,5T acid to Chipman at costs below our standard costs and happily the plant was shut down.

The Portland plant, having produced 2,4,5T acid, has received considerable attention. Samples of soils, waste products and finished goods have been tested for dioxins. Ditch soil contained 0.8 ppb TCDD; process tars contained about 100 ppb of TCDD; finished goods contained 100+ ppb amounts of DICDD and less than 0.5 ppb TCDD (pp.6-7 of attached report).

Dioxins will continue to be of some concern but the environmental risk is, hopefully, low.

FOUR MUD SAMPLE ASSAYS
(Doane Lake)
Taken February 29, 1984

Wet Mud mg/1000 gr.

Location	Xylene*	IOA**	OCP	Phenol	2,6-DCP	2,4-DCP	PCP	2,4-D	2,4-DB	
1	4.0	11.5	-	-	Trace	9.0	6.3	12.7	5.4	
2	4.0	248	0.9	5.0	Trace	7.0	39.0	216	145	
3	6.6	138	-	2.5	Trace	14.1	40.2	122	84.7	
4	7.0	46.2	1.5	-	Trace	9.7	34.4	22.2	56.1	

Note: 2,4,6-TCP not detected.

Mud Dry Basis mg/1000 gr.

1	10	28.8	-	-	Trace	22.5	15.8	31.8	13.5	
2	13.8	856.9	3.1	17.2	Trace	24.1	134.5	745	500	
3	16.9	354.1	-	6.4	Trace	36.1	103.1	313	217	
4	8.3	193.4	6.2	-	Trace	40.1	142.1	92	232	

Note: 2,4,6-TCP not detected.

*Xylene figures are estimates as interferring peaks present.

**IOA is reported as IOA equivalent from IOE phenoxy esters and free IOA found.

—Detection level: In all cases except xylene, 1 ms/1000 grams.

MCPA found in four mud samples (mg/1000g dry basis):

Location	MCPA
#1	5
#2	172
#3	57.2
#4	15.3

RHÔNE·POULENC INC.
AGROCHEMICAL DIVISION
Portland Plant

July 12, 1985

SERVICE REPORT No. 246

Rhone Poulenc Inc.
JUL 15 1985
Govt. Relations Dept

To: R. L. Ferguson

cc: R. R. Briggs, NBK
[redacted]
D. R. Meyer
Laboratory [3]

Subject: ANALYSIS OF MUD AND WATER FROM DOANE LAKE

Mud Sample:

Location	Middle of Lake
Date Sampled	June 12, 1985
Assay Work	6/23/85 - 7/10/85
Weight of Sample Extracted	100 grams
Moisture	68%
pH	7.7

Mg / 1000 grams Mud

	Xylene	IOA	Phenol	OCP	PCP	2,4-DCP	2,6-DCP	2,4,6-TCP	Acid 2,4-D	Equiv. 2,4-DB
Wet Mud	12	28 [1]	2.7	1.0	12.5 [2]	11.1 [3]	°	°	111	116
Detection Level - Wet Mud	2.0	3.0	1.0	1.0	1.5	1.5	1.5	2.0	3.0	3.0
Dry Mud	37	87	9.0	3.0	39.0 [2]	35	°	°	347	362

[1] Not detected in unesterified sample. Value shown is amount found after transesterification of sample.

[2] Interference in GLC. Assay by HPLC.

[3] Recovery of 2,4-DCP from spiked sample was 49%; normally is 80-90%.

Lake Water Samples:

Location	North (West End) pH 8.2
Location	South (East End) pH 7.4
Date Sampled	June 12, 1985
Date Assayed	June 20, 1985

ppm Components

	Xylene	IOA	Phenol	OCP	PCP	2,4-DCP	2,6-DCP	2,4,6-TCP	Acid 2,4-D	Equiv. 2,4-DB
North	°	°	°	°	°	°	°	°	°	°
Middle	°	°	°	°	°	°	°	°	°	°
Detection Level	0.2*	0.3*	0.3	0.2	0.2	0.4	0.3	0.3*	0.3	0.5

° Not detected.

* By GLC; others by HPLC.

JBV:sll

RHÔNE POULENC

J. B. Vernetti

Jack B. Vernetti, QC Manager

MANUFACTURING DIVISION

6200 N W St Helens Road - P O Box 10224 - Portland, Oregon 97210-0224 - Telephone (503) 222-3571 - Telex: 36-0329

Rhone Poulenc Inc.

MAY - 7 1987

Govt. Relations Dept

TO: R. L. Ferguson
cc: R. Briggs - NBK
R. Gitschlag - NBK
D. Meyer
Laboratory (3)

SUBJECT: Mud and Water Analysis - Doane Lake

Samples for Month of April 1987

MUD SAMPLE:
Location: Middle of Lake
Sample Date: 4/7/87
Assay Work: 4/22 - 4/24/87
Moisture: 62%
pH: 9.1

All GLC Data

* Measured after transesterification of sample.

Mg/1000 grams mud:

	Xylene	Equiv. IOA*	Phenol	OCP	PCP	2,6 DCP	2,4 DCP	2,4,6 TCP	Acid Equivalent* 2,4-D	Acid Equivalent* 2,4-DB
Wet Mud	26	177	16	1.6	84	0	19	0	175	126
Detection Level Wet Mud	1.0	2.5	>1	1.0	3	2	2	2	2	2
Dry Mud	68	466	42	4.2	221	0	50	0	460	331

LAKE WATER SAMPLE:
Location: North (west) end, south (east) end
Sample Date: 4/7/87
Assay Work: 4/8/87

Phenolics, phenoxy herbicides not detected. Detection level of 0.2 - 1.0 ppm.

0 = Not Detected

SECTION III

ENVIRONMENTAL ASSESSMENT

Part Six

Ground Water Monitoring & Removal

A. General A ground water monitoring network of 45 wells has been installed by RP and Dames & Moore over a period of time. A formal study was conducted from August 1981 through June 1983. These studies showed detectable levels of pesticide compounds (and certain metals). The results of these studies lead to the the NPDES requirement of 1983 for a ground water pumping and treatment system. The executive summary of the Dames & Moore report of Oct. 3, 1983 is attached.

A review of the information developed by Dames & Moore and outlined in their executive summary are discussed in the following parts using the D&M sequence for organization.

DAMES & MOORE PHASE II INVESTIGATION REPORT

OCTOBER 3, 1983

EXECUTIVE SUMMARY

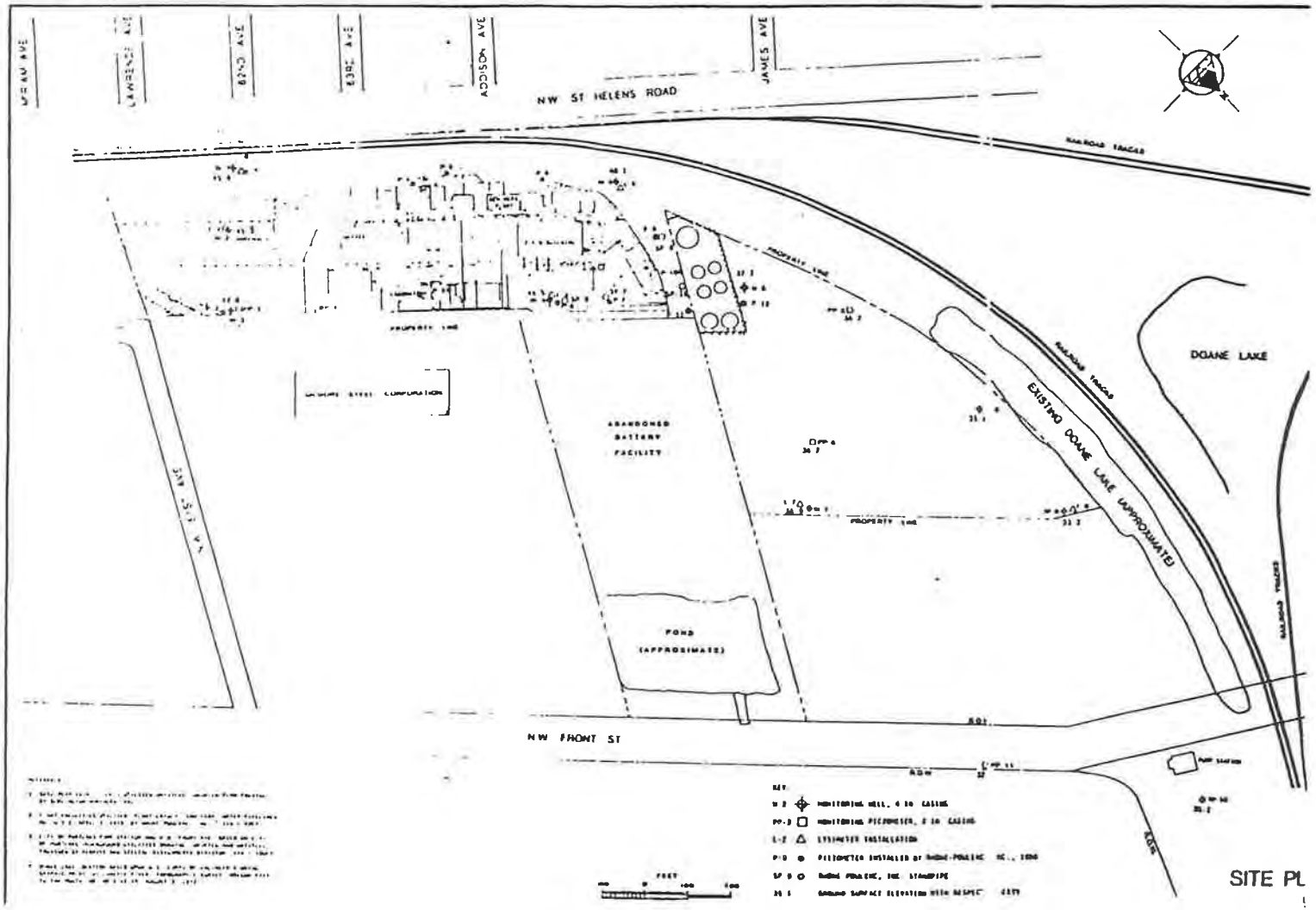
This report presents the results of the groundwater monitoring program undertaken for the Phase II Geohydrologic and Waste Management Investigation. During the summer of 1981, Dames & Moore installed 10 deep sampling wells, 4 shallower piezometers and 6 lysimeters. Subsequently, groundwater samples were obtained and analyzed during five sampling rounds.

Geologically, the plant and Doane Lake area are underlain by Columbia River basalt that accumulated as successive flows to a total thickness of 500 to 1,000 ft. The basalt is underlain by lacustrine (lake formed) and fluvial (river deposited) deposits of predominantly sands, silty sands and sandy silts. The surficial, predominantly silty, materials are young alluvium (water deposited) and man-made fill.

Groundwater beneath the site occurs within a lower aquifer consisting of the fractured interflow zones of the basalt and upper aquifer consisting of the overlying predominantly sandy soils. It is our opinion that generally upward seepage from the basalt inhibits migration of contaminants to this lower aquifer. The monitoring program was directed toward evaluating contamination of the overlying sandy aquifer.

A substantial quantity of groundwater analytical data has been collected using the system installed by Dames & Moore, and by Rhone-Poulenc, Inc., from piezometers installed in 1980. The results exhibit variability and inconsistency, but when considered as a whole, do indicate the widespread presence of some of the targeted contaminants. The most significant contamination, with respect to water quality standards, occurs south of the dust plant/warehouse, within the northerly plant area in the vicinity of the 2,4-D plant and in portions of the Doane Lake fill area. The identified contaminants include herbicides, insecticides, chlorinated phenols and heavy metals.

The most severe contamination occurs within the uppermost portion of the groundwater column in the northerly plant area. To address this contamination, we recommend a remedial plan that consists of eight shallow wells for the withdrawal of groundwater and subsequent treatment. Our other recommendations include continued groundwater monitoring and continued in situ treatment of Doane Lake water.


LAWRENCE AVE
ADDISON AVE
JAMES AVE
NW ST HELENS ROAD
RAILROAD TRACKS
PROPERTY LINE
ABANDONED BATTERY FACILITY
POND (APPROXIMATE)
EXISTING DOANE LAKE (APPROXIMATE)
DOANE LAKE
NW FRONT ST
FEET
SITE PL

SECTION III

ENVIRONMENTAL ASSESSMENT

Part Six

Groundwater Monitoring

B. Water Bearing Units & Water Transport

The Dames and Moore Report outlines the waterbearing units under the site:

1. Basalt
2. Troutdale gravels
3. Alluvium deposits (river muds & clays)
4. Industrial fill

The Basalt is a significant waterbearing aquifer in the Portland area. Recharge to this aquifer covers a wide area, but recharge in this area is the hills west of the plant. The Basalt is apparently under artesian pressure in the plant area.

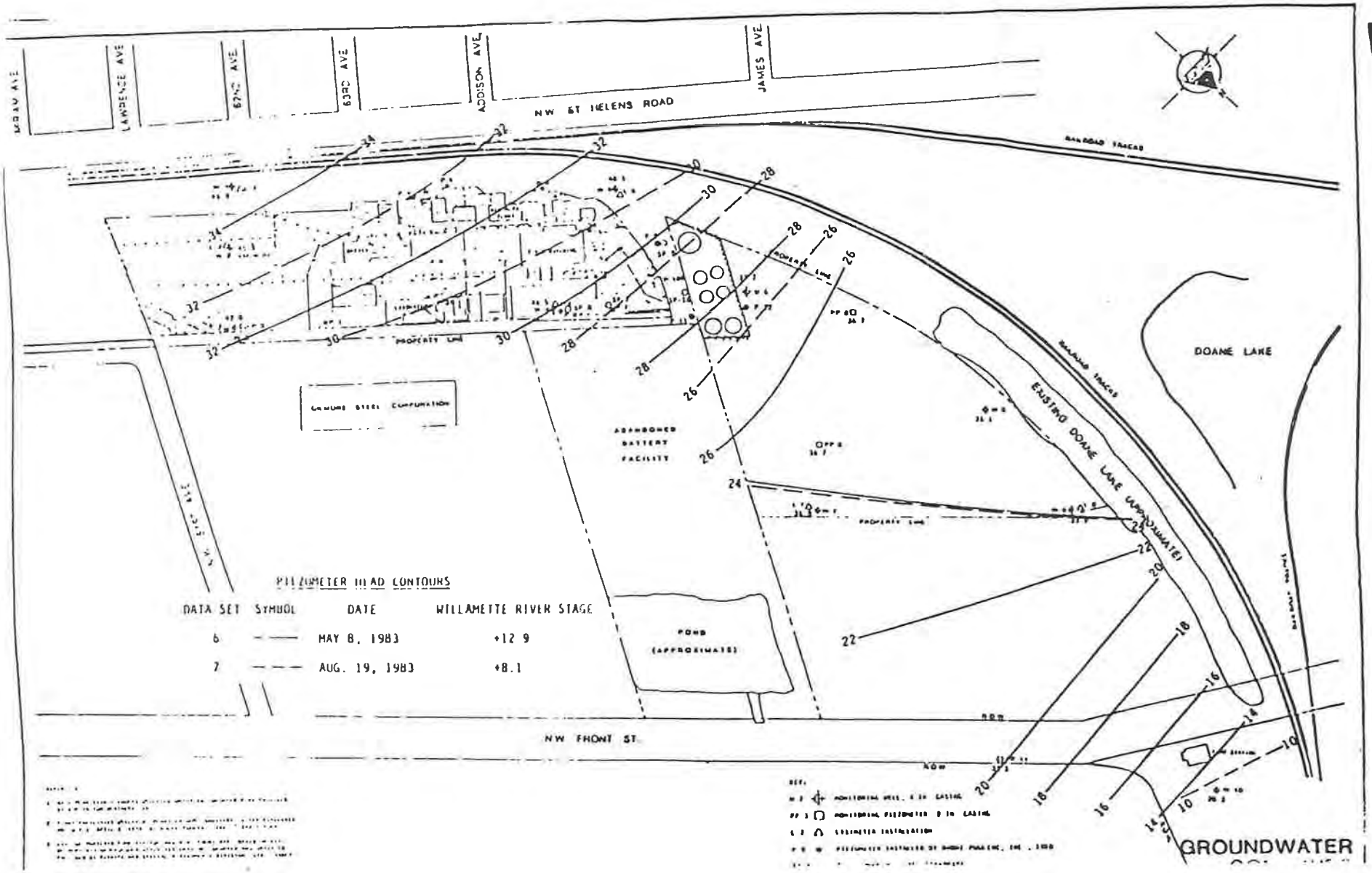
The Troutdale formation is also a significant waterbearing aquifer east of the river and may be under some parts of the Doane Lake Area.

The alluvium deposits contain usable water from surface infiltration with most coming from the west hills. Springs have been encountered in the area.

The industrial fill is fairly shallow, ranging from a few feet to 15 feet in thickness. The fill contains a number of lenses as has been observed from water flow into pit excavations in the plant area.

Groundwater migration toward true north has been determined from hydraulic gradients. Soil & drawdown tests give an estimated eight year transit time for ground water to reach the river from the plant. Retardation coefficients for the contaminants are not known, but if monitoring data is used as a guide, high retardation can be expected (about 20% of groundwater flow rates). The strong adsorption of chemicals on lake muds tends to confirm the high retardation coefficients. Th is important. It has been assumed that chemicals are reaching the river at some low equilibrium level.

Limited testing in 1980-81 by RP has detected very low DCP & 2,4D levels in river muds. State testing of the river has not detected chemicals. Fish bioassay tests by the state at various points in the river report dioxins in fish caged at mile seven (RR Bridge) and also caged up river, south of the Portland harbor.


LAWRENCE AVE
ADDISON AVE
JAMES AVE
NW ST HELENS ROAD
RAILROAD TRACKS
PROPERTY LINE
ABANDONED BATTERY FACILITY
POND (APPROXIMATE)
EXISTING DOANE LAKE (APPROXIMATE)
DOANE LAKE
NW FRONT ST
PIEZOMETER HEAD CONTOURS
DATA SET SYMBOL DATE WILLAMETTE RIVER STAGE
6 MAY 8, 1983 +12.9
7 AUG. 19, 1983 +8.1
GROUNDWATER

SECTION III

ENVIRONMENTAL ASSESSMENT

Part Six

C. Monitoring Systems Analytical Results

The data from the monitoring program conducted during 1981-1983 exhibits variability and inconsistency but does indicate the widespread presence of contaminants. In general the results show:

1. Upgradient water (W1, L1, W5, P5) is generally of good quality with drinking water criteria being met except for low PPB levels of herbicide and phenolic compounds being reported.
2. South Plant (W2, W3) data is highly variable showing certain insecticides on some sampling rounds and less than detection on others. Herbicides and phenolics also show variability but generally are higher, particularly on W3.
3. North Plant (W4) data shows high levels of 2,4D and phenolics. This well is a "deep" well with the screen at 28.5 to 38.5 feet below the surface. This well has been of concern to the state and recently we have started a test pumping of this well. After one month of pumping (at 2 gpm) no decrease in contamination has been noted.
4. Doane Lake (W6, 7, 8, 9) data is variable but generally shows W6 and 8 to be at low contaminant levels. W7 shows higher assay numbers. This is consistent with observed water flow patterns in the past

through the battery case area, but W7 was installed deep (44 to 54 feet) at the bottom of a 35 foot sand layer. W8 is below the lake muds layer in alluvial deposits at 44 to 54 feet. W9 is installed well below the lake muds in a sand layer.

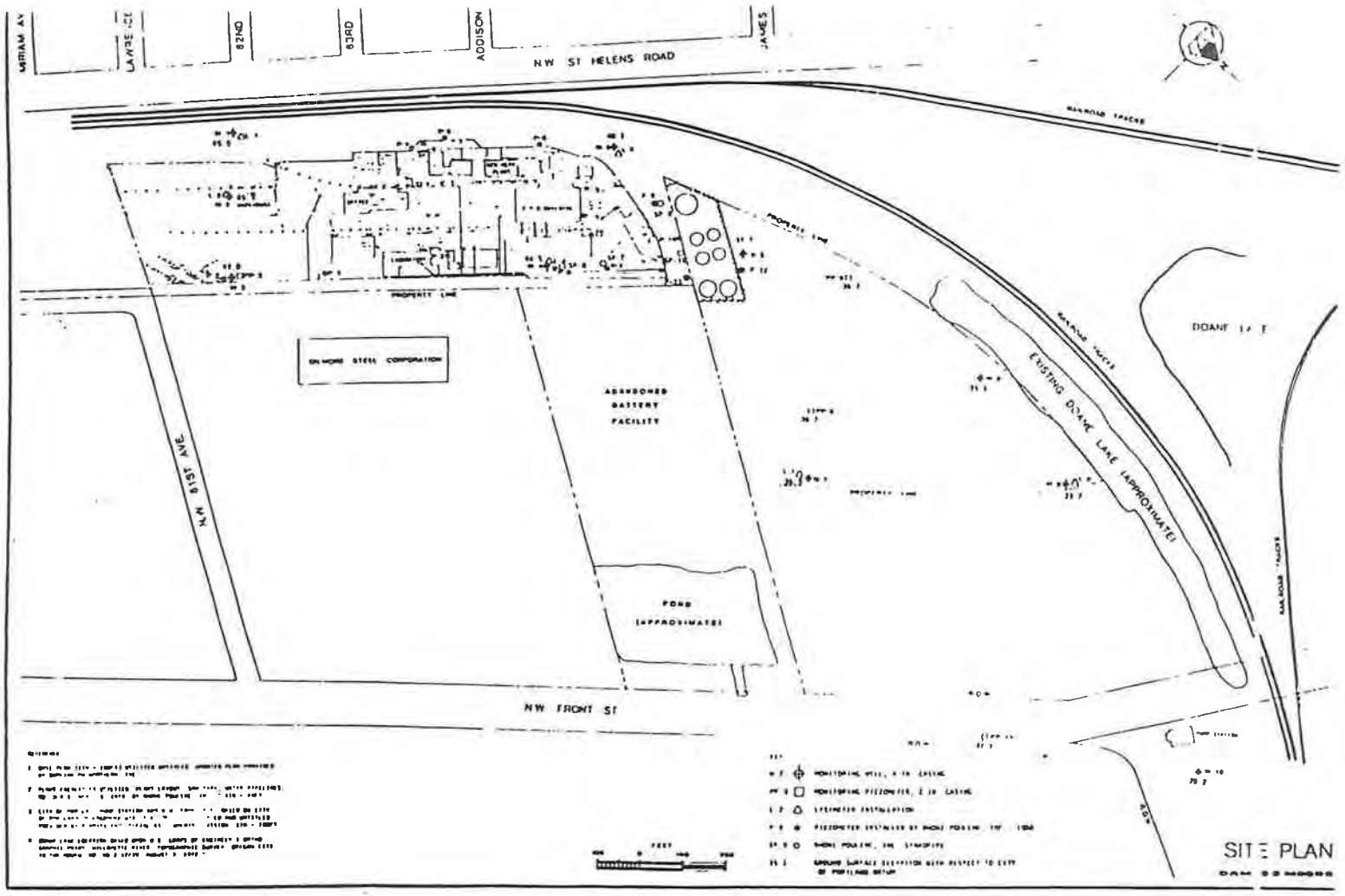
5. Well 10 is 1500 feet north of plant and contains low levels of phenolic compounds in most of the samples with 2,4D reported high on the fifth sampling round. This well is screened at 60 feet, probably near the normal midpoint of river elevations.

6. The Lysimeters and monitoring piezometers were not tested consistently and only a few samples showed contaminants. L2 at the insecticide plant tested for lindane and aldrin on one sample. L4 at W4 location near the 2,4D plant gave low 2,4D and TOX levels. At the lake L9 showed PPB levels of 2,4D and TOX. PP3 at the SE propert, line gave detectable PPB levels on 2,4D, Silvex, 2,4,5T and chlorophenols. PP6, 8 and 11 in the lake showed low 2,4D and phenolic levels. The piezometers were installed moderately deep, 20 to 30 feet. PP6 was in the battery cases; the others were installed below the old lake muds.

7. RP piezometers have been sampled since 1980, consistently giving test results that show widespread low levels of 2,4D and solvents in most plant grade piezometers. P7, 8 and 9 along the NE corner of the plant show the highest levels of 2,4D, phenolics and solvents. These

piezometers were installed at about 10 feet. Perched water is found at a few feet below grade. The results of the sampling round for March 1987 is attached.

The review made of all of the data after several years suggests that the monitoring well network is a poor one. The rather random placement of wells at varying depths cannot give a good areal extent of the contamination nor its potential movement. The gross variation of analytical data further clouds the true conditions in the area. The only sure conclusion we can reach is that the plant is contaminated and contaminated groundwater is migrating off site. Plume location is not known. The informa- about the lake area is so limited that no reasonable evaluation can be made about this potential problem.


NW ST HELENS ROAD
ADDISON
JAMES
PROPERTY LINE
ON-MORE STEEL CORPORATION
ABANDONED
BATTERY
FACILITY
POND
(APPROXIMATE)
NW 61ST AVE
NW FRONT ST
EXISTING DOANE LAKE (APPROXIMATE)
DOANE LAKE
SITE PLAN

Rhone-Poulenc, Inc.
Manufacturing Division
Portland Plant

Date Sampled: 3/11-12/87

Date Assayed: 3/23-26/87

PIEZOMETER SAMPLE ASSAY

Components Present (000 ppm)

- = Not Detectable
NR = Not Run

Sample	Xylene	Isooctyl Alcohol	Phenol	o-Chloro-phenol	p-Chloro-phenol	2,6-Di-chloro-phenol	2,4-Di-chloro-phenol	2,4,6-Tri-chloro-phenol	2,4-D	2,4-DB	Comments
1	0.5	NR	-	-	-	-	-	-	-	-	
2	-	NR	-	-	-	-	-	-	-	-	
3	~~[illegible]~~ 41	NR	-	-	-	-	-	-	2.9	-	
4	-	NR	-	-	-	-	-	-	-	-	
5	0.5	-	-	-	-	-	-	-	-	-	
6	-	-	-	-	-	-	-	-	-	-	
7	24	170	6.2	5.1	33	5.0	55	-	53	-	
8	1.8	94	0.4	-	-	-	5.3	-	23	-	
9	149	97	-	-	-	-	11	-	69	-	← mow
10	0.9	90	-	-	-	-	0.9	-	3.2	-	
11	0.3	NR	-	-	0.6	-	0.8	-	-	-	
12	-	NR	-	-	-	-	0.9	-	-	-	
14	-	NR	-	-	-	-	0.5	-	-	-	
Lake	-	NR	-	-	-	-	-	-	-	-	
Lake	-	NR	-	-	-	-	-	-	-	-	
101	NR	NR	14	4.8	8.2	3.6	28	-	200	NR	
102	NR	NR	4.4	5.2	21	6.5	54	-	171	NR	
103	NR	NR	19	9.4	14	7.3	59	-	220	NR	2,4D is estimate
104	NR	NR	-	-	-	-	-	-	-	NR	
105	NR	NR	2.4	3.6	17	7.5	45	-	211	NR	
Detection Limits:	<0.5	<1.0	<0.5	<0.5	<0.5	<1.0	<1.0	<1.0	<1.0	<1.0	

cc RF6

RRB

rhône-poulenc inc.

OFFICE MEMORANDUM

DIVISION AGROCHEMICAL

To: R. J. Rosenberg

Date: August 15, 1984

From: R. L. Ferguson

Subject: NPDES Ground Water Testing [RLF-149-84]

We have finally received the results of the March ground water samples. These are attached, along with a summary of key data.

The results are mixed. There are unreasonably high results in Well 4 and PP8. Well 10 (at the river) shows a drop.

Also attached is a non-rigorous cross-check by our lab. It generally confirms the high chlorophenol figures except TCP. (The wells are not purged for the lab cross-check; higher results would be expected.)

The quality of the data is again open to question and the timing on return of information is unacceptable. Prior to the next round of sampling, scheduled for September, we should discuss alternate labs, GC-MS confirmations, and whether or not we wish to continue to use Dames & Moore.

R. L. Ferguson

RLF:kst
cc: RRBriggs
DRMeyer
JBVernetti

REC...
AUG 22 1984
R. R. BRIGGS

RHÔNE·POULENC INC.
AGROCHEMICAL DIVISION
6200 N W SL Helens Road - P O. Box 10224 - Portland, Oregon 97210-0224 - Telephone (503) 222-3571 - Telex: 36-0329

August 15, 1984 [RLF-148-84]

Mr. Charles Clinton
Department of Environmental Quality
P. O. Box 1760
Portland, Oregon 97207

Dear Mr. Clinton:

Subject: Ground Water Testing

Attached are the results of the ground water samples taken in March as required by our NPDES permit.

I have summarized the specific data required by the permit of the current and prior test results for easier comparison.

I apologize for the unreasonable delay in the receipt and transmittal of the results. We will be setting up the next round of sampling in September. I will advise you of the timing so the DEQ can take samples if desired.

Sincerely,

R. L. Ferguson
Plant Manager

RLF:kst
cc:
R. J. Rosenberg, BHL

RHÔNE POULENC

GROUND WATER SAMPLE TESTING RESULTS

Sample # PP6

PARAMETERS		SAMPLE DATES										
			1/26/82		1/27/83	6/10/83	MAR '84					
2,4-DCP	µg/l											
2,6-DCP	µg/l											
2,4-6-TCP	µg/l											
2,4-D	µg/l											
2,45-T	µg/l											
2,4,5-TP	µg/l											
ph					6.7		7.09					
Pb	mg/l				9.2		1.9					
As	mg/l				0.46		0.057					
Ground Water Level-ft			30.7		28.1		27.5					
Depth to Water-ft							9.2					

RHÔNE POULENC

GROUND WATER SAMPLE TESTING RESULTS

Sample # W-7

PARAMETERS		SAMPLE DATES										
		8/27/81	1/21/82	8/30/82	1/27/83	6/9/83	Late Mar 84					
2,4-DCP	µg/l	< 5.0	329	1740	765	643	1060					
2,6-DCP	µg/l	443	< 20.0	1550	286	191	57.3					
2,4-6-TCP	µg/l	< 5.0	26.9	209	17	115	605					
2,4-D	µg/l	< 0.30	< 1.0	1360	GCMS 424/1100	221	200					
2,45-T	µg/l	< 0.1	7.03	44.2	2.25/ND	0.90	2.50					
2,4,5-TP	µg/l	< 0.1	0.1	10.2	9.95/ND	109	9.70					
ph		3 8	3.6	7.1	3.6	3.6	3.63					
Pb	mg/l			0.30	1.0	0.32	0.34					
As	mg/l	0.8	2.6	0.40	3.0	0.025	1.3					
Ground Water Level-ft		22.3	26.3	22.6	25.8	--	27.2					
Depth to Water-ft							9.7					

RHÔNE POULENC

GROUND WATER SAMPLE TESTING RESULTS

Sample # PP8

PARAMETERS		SAMPLE DATES										
			1/26/82		1/27/83	.6/10/83	MAR '84					
2,4-DCP	µg/l				669	1560	3820					
2,6-DCP	µg/l				342	1480	3560					
2,4-6-TCP	µg/l				< 6.0	550	151,000					
2,4-D	µg/l				2010	987	12,840					
2,45-T	µg/l				503	414	629					
2,4,5-TP	µg/l				339	160	474					
ph					6.7		6.78					
Pb	mg/l											
As	mg/l											
Ground Water Level-ft			28.7		27.7		27.8					
Depth to Water-ft							8.9					

Dames & Moore

1220 S.W. Morrison Street
Portland, Oregon 97205
(503) 228-7688
TWX: 910-464-4790 Cable address: DAMEMORE

August 3, 1984

Rhone-Poulenc, Inc.
6200 N.W. St. Helens Road
Portland, Oregon 97210

Attention: Mr. R. L. Ferguson

Gentlemen:

Summary Re:
Groundwater Sampling and
Chemical Analyses
March, 1984
Agrochemical Facility
Portland, Oregon

The letter summarizes groundwater sampling performed in late March 1984 and presents the results of chemical analyses of the groundwater samples. The sampling and analytical requirements were documented in the October 6, 1983 letter to Rhone-Poulenc, Inc. from the Department of Environmental Quality (DEQ). A copy of this letter is provided as an attachment.

The sampling was performed in accordance with the following procedure.

1. Measure static groundwater level.

2. Purge well or sampling piezometer by removing 3 to 5 times the volume of water in the casing or by pumping the casing dry. The submersible pump and attached hoses were thoroughly cleaned following use at each well or piezometer and prior to use at the next installation.

3. Commence groundwater sampling following at least 90 percent recovery of the groundwater level.

4. Obtain samples utilizing a stainless steel bailer-type sampler. The bailer was lowered and raised using monofilament fishing-line. New monofilamet line was utilized for the sampling of each well or piezometer.

5. The sample was slowly and carefully poured from the bailer into the sample containers to avoid aeration. The sample containers utilized for the various analytical requirements are summarized in the following tabulation. Sample containers were provided by Amtest, Inc.

Analyses	Sample Container
2,4-DCP	2.0 liter jug
2,6-DCP	2.0 liter jug
2,4,6-TCP	2.0 liter jug
2,4-D	2.0 liter jug
2,4,5-T	2.0 liter jug
2,4,5-TP	2.0 liter jug
pH	50 ml bottle
Pb	200 ml bottle
As	200 ml bottle

6. Each sample container was labelled with the following information.

   - Well or piezometer identification.
   - Date and time.
   - Dames & Moore job project number.
   - Rhone-Poulenc, Inc.
   - Sample container number.

   Each sample container was sealed in a zip-lock polyethylene bag and placed on ice in an ice chest.

7. Between sampling locations, the bailer-sampler was cleaned utilizing the following procedure.

   a) Acetone rinse
   b) Tap water rinse
   c) Soap and water wash
   d) Tap water rinse
   e) Acetone rinse
   f) Distilled water rinse
   g) Air dry

8. The samples were shipped to Amtest, Inc. of Seattle, Washington for analyses. Chain-of-custody documentation was maintained during transport and handling of samples.

Groundwater levels measured on March 27, 1984 are summarized in the following tabulation.

Location	Depth to Groundwater* (ft)	Groundwater Elevation
W-4	12.3	34.2
W-7	9.7	27.2
W-10	13.2	15.0
PP-6	9.2	27.5
PP-8	8.9	27.8

* Below ground surface.

The chemical analyses were performed by Amtest, Inc. and the test results are attached. Please contact us if you have any questions.

Yours very truly,

DAMES & MOORE

Dwight J. Hardin

Dwight J. Hardin,
Project Manager

88416
DJH:lld
12088-005-04
3 copies submitted
Attachments: DEQ Letter
Amtest, Inc. Letter

am test inc.
4900 9TH AVENUE N.W., • SEATTLE, WASHINGTON 98107-3697 • 206/783-4700

ANALYSIS REPORT

LIENT: Dames & Moore

EPORT TO: Mr. Dwight Hardin
1220 S.W. Morrison
Portland, OR 97205

DATE RECEIVED: 3/28/84

DATE REPORTED: 4/31/84

DATE REVISED: 5/17/84

JOB NO. 12088-005-04

ANALYSIS OF WATER MONITORING WELL AT RHONE POULENC

aboratory Sample No.	75159	75160	75161	75162	75163	75164	75165
	W-4	W-7	W-10	PP-8	-1	PP-6	PP-6
lient Identification	S-1/1	S-1/3	S-1/2	S-1/2	S-1/2	S-2/2	S-1/2
arameters	Concentration µg/l						
,4-Dichlorophenol	10,700.	1,060.	0.80	3,820.	<0.5	NA	NA
,6-Dichlorophenol	63,700.	57.3	2.31	3,560.	<0.5	NA	NA
,4,6,-Trichlorophenol	3,100.	605.	5.36	151,000.	<1.0	NA	NA
,4-D	135,000.	200.	17.1	12,840.	<1.0	NA	NA
ilvex	3,680.	9.70	3.92	474.	<0.1	NA	NA
,4,5-T	2,210.	2.50	<1.0	629.	<0.1	NA	NA
H	NA	3.63	5.64	6.78	NA	7.09	NA
ead	NA	NA	NA	NA	NA	NA	1.9
rsenic	NA	NA	NA	NA	NA	NA	0.057

A - Not Analyzed For

cont . . . . . .

SECTION III

ENVIRONMENTAL ASSESSMENT

Part Six

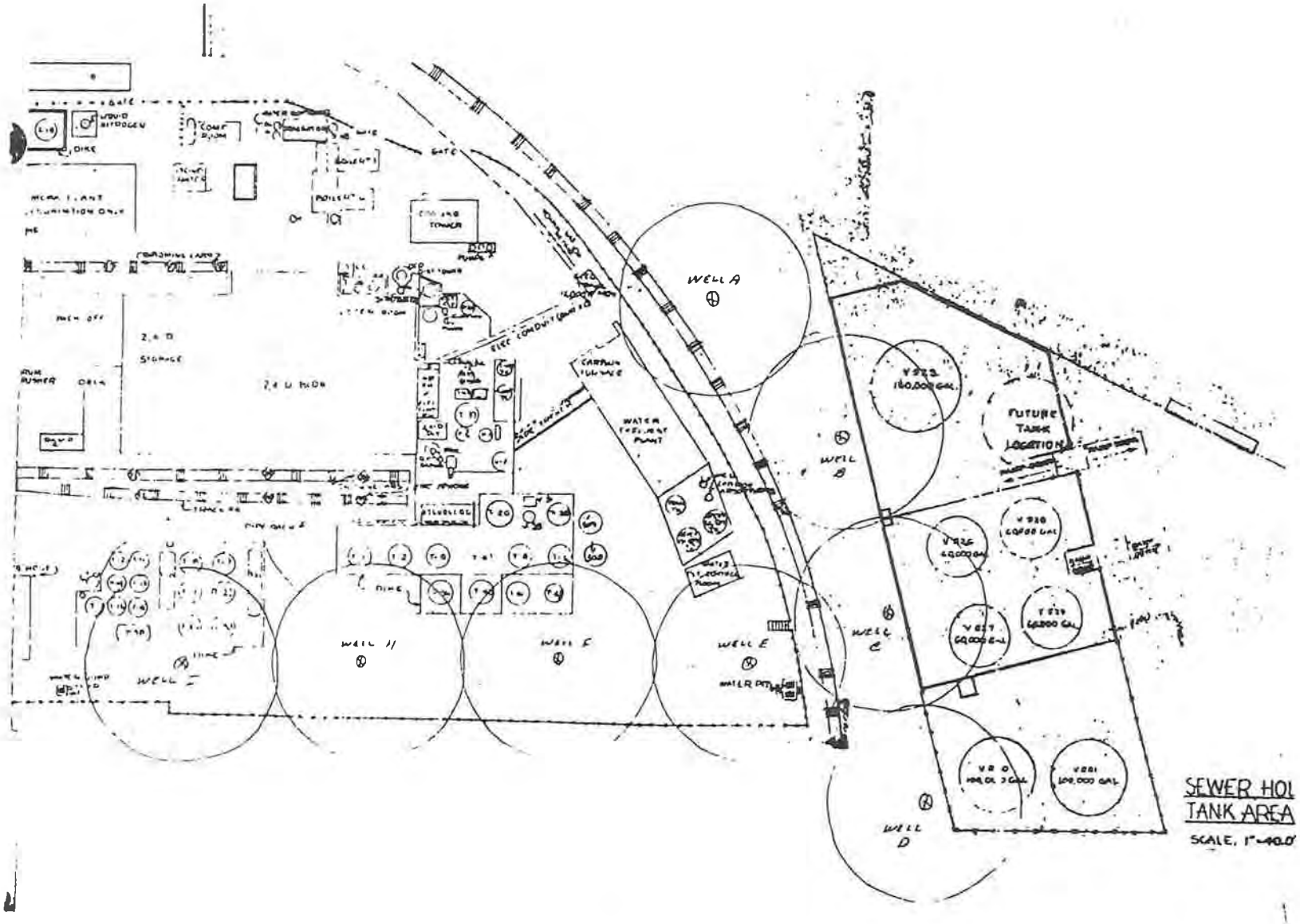
D. GROUND WATER WITHDRAWAL SYSTEM

The ground water pumping data accumulated since 1984 gives the most consistent analytical results for ground water quality that we have.

Eight ground water pumping wells (twelve inch casing in an eighteen inch boring) were installed in early 1984 along the north and east part of the 2,4 D plant. These wells have been installed to 25 ft. with the case slotted at least five ft. above the static water table. A 15 ft. sand pack was generally utilized. Well spacing of 100 ft. was used because drawdown testing showed a potential cone of depression 100 ft. in diameter. A sketch showing the well locations is attached. The range of contaminants in the water from the eight wells follows:

Range of Contaminants in Groundwater

	Range ppm
Total Organic Carbon	500-900
Bromoxynil Acid	12-30
Phenol	15-29
Orthochlorophenol	10-20
Parachlorophenol	18-31
2,6-Dichlorophenol	9-22
2,4-Dichlorophenol	65-155
2,4 D Acid	190-300
pH	6.4-6.7


WELL A
WELL B
WELL C
WELL D
WELL E
WELL F
WELL H
WELL I
FUTURE TANK LOCATION
WATER TREATMENT PLANT
2,4 D STORAGE
COOLING TOWER
DIKE
GATE
SEWER HOL
TANK AREA
SCALE, 1"=40.0'

The amount of water pumped and treated has been summarized as follows:

	1984	1985	1986	Total
Gallons Removed (000)	1991.7	2901.2	3297.3	8190.0
Phenolics (pounds)	2339	4719	4186	11244
2,4-D (pounds)	2595	5944	6438	14977
TOC (pounds)	14546	37088	33065	84699
Avg Phenolic Conc (ppm)	144	193	188	165
Avg 2,4-D Conc (ppm)	157	231	260	219
Avg TOC Conc	892	1497	1314	1241

Individual well data shows that the end wells (A & H) have decreased in contaminant levels. All other wells have shown only a slight decrease in average composition.

Discussions were held with a third party consultant about the effectiveness of the pumping program. It was his opinion that we need at least eight more wells (50 ft. centers) to satisfactorily capture the water from the plant site.

Plant History

1. The chemical manufacture of phenoxy and HBN herbicides, and various insecticides from 1943 to present entailed the generation, storage, treating, transporting, disposal, or otherwise handled at the site.

Answers to questions 3,4,5 together

Acetic Acid 64197	is a by-product of our production of Bromoxynil Octanoate. This unit has been in operation from 1971 to present. It appears in our process waste water and is treated in our POTW treatment system. The volume of this material that was treated since 1971 is estimated to be 2,974,158 lbs.
Acetone 67641	has been and is still currently used as a laboratory chemical for cleaning glassware, etc. We use a total of 8 55-gallon drums per year or 2856 lbs per year. Over the years we have handled an estimated 86,000 lbs of this material. This material has appeared in our treated effluent released for the POTW at 13 ppm or approximately 54 lbs. per year.
Aldrin 309002	This material was used prior to 1972 in the insecticide manufacturing building. Records are only available for 1965-1966,68-71 of insecticides which used 171,939 lbs of this chemical.
Arsenic 7440382	This material was used prior to 1971 in the formulation of herbicides in our insecticide plant. Production records are only available for the years 1965-1969. During these years we handled 681,000 lbs of this chemical.
Asbestos 1332214	Has been used as an insulation material for pipes, vessels, siding,etc. from 1943 to approximately 1976. As this asbestos deteriorates it is being removed. From 1980 to 1988 we have shipped 326 55-gallon drums or approximately 33 tons of this material to Arlington, Oregon Waste Disposal Site using their Chem-Securities System, Inc. as the transporter. We have approximately an additional 33 tons of asbestos at this site to be removed at some point.

EXHIBIT
2626A

Benezene 71432	Was handled in the late 1950's and early 1960's in the dehydration of Iso-Propyl Alcohol used for Iso-Propyl Esters. It may also have been used in the early 2,4-D process from 1956 to 1958. It appears in our untreated ground water at a level of 0.3 ppm. Approximate usage is 40,000 lbs + 1960-1964
Chloro-Benzene 108907	Is found in our groundwater at 0.1 ppm. The source is from production of MCPA from 1960-1964. The amount handled was 910,681 lbs.
Bromoform 75252	Appears in our process water effluent on an average of .137 ppm and is a by-product of our Bromoxynil [illegible]anoate production process. A total of 39 lbs of this material was processed from 1971-January 1988 and released to the POTW.
n-Butyl Alcohol 71363	This was a raw material of our 2,4-DB process from 1964 through July 1982. During this time 134,695 lbs of this material was used in the manufacture of 2,4-DB. This material was also used in the production of MCPB and a total of 6753 lbs was used from 1971 through 1974. Also material was used in making 2,4-DB Esters to add to Embutox 1973 and 1974. Total used for this purpose was 60,000 lbs. Lastly was used to make 2,4-D esters in 1966, 1967 and 1968 and total used was 870,202 lbs. Total lbs used was 1,071,650 lbs.
Chlorodane 57749	This material was used prior to 1971 in our insecticide plant. Records are only available for 1965-1966, 1968-1971 where 245,950 lbs were used to manufacture a variety of insecticides.
Chlorine 75003	This material was used in the manufacture of 2,4-DCP which in turn was used to make 2,4-D or sell commercially. It was also used to make 2,4-DCP, 2,4,6-TCP and parachlorophenol. 2,4-D and DCP manufacture took place from 1956-July 1982 in the 2,4-D plant building area. Total usage in the 2,4-D building area was 198,729,738 lbs. This material was also used in the manufacture of 2,4-DB, MCPA, and MCPB. Total usage in these areas was 22,331,861 lbs. Total overall usage since 1956-July 1982 was 221,061,599 lbs.

Chloroform 67663	This material appears in our treated process water at an average level of .03 ppm. It is suspected that this chemical may be a by-product of the making of Bromoxynil Octanoate. Maximum production since 1971 to Jan. 1988 would be 10 lbs.
O-Cresol 95487	This material was used in the manufacture of MCPA from 1961-1976 and MCPB from 1971-1974 in the MCPA manufacturing facility. The quantity used was 21,826,448 lbs. Material was recieved in tank cars, pumped to a storage tank , then charged to the process.
DDT 50293	This material was used prior to 1970 in the insecticide manufacturing building. Records are only available for 1965-1966,1968-1969 of insecticide. For this period 435,743 lbs of material was used to formulate insecticides.
2,4-D Acid 94757	This material was produced from 1956-July 1982. Total lbs manufactured was 268,305,356 lbs in the 2,4-D manufacturing unit.
2,4-D Esters 94111	These materials were produced from 1960-April 1983. Most of the production took place in our ester facility next to the 2,4-D plant with some production occurring in our specialty ester facility. The total production by product is as follows:

2,4-D n-Butyl Esters	4,151,015 lbs
2,4-D propyl Esters	1,958,097 lbs
2,4-D IBET Esters	47,702,326 lbs
2,4-D IOET Esters	96,148,854 lbs

2,4-Dichlorophenol 120832	This material was made in our 2,4-D plant as a material used in making 2,4-D, 2,4-DB and for sale to outside customers from 1956-July 1982. Total production over this period of time was 205,877,596 lbs
2,6-Dichlorophenol 87650	This material was a by-product of the manufacture of 2,4-DCP and normally was converted to 2,4-DCP if possible. In 1976 we produced 116,000 lbs of this material for sale.

2,6-Dichlorophenol Waste from 2,4-D Production 87650	This material appeared in tar bottoms material which was shipped as bleed to : Hunt Disposal Co., Alkali Lake, 1966-1971 Western Processing, Pasco, WA, 1972-1975 Environ Safe, Mountain, ID, 1975-1977 Chem Security, Arlington, OR 1977-1982
Dichlorobromomethane 75274	This material appears in our process water at a level of 1 ppm. It is thought to possibly be a by-product of production of Bromoxynil Octanoate. Estimated amount produced since 1971 is 600 lbs.
Dimethylamine 124403	This material was used in the formulation of MCPA Amine 5, Rhomene, 2,4-D Amine 4, and 2,4-D Amine 6. Records prior to 1965 are not available. Usage from 1965-1982 of this material was 5,470,981 lbs.
Endrin 72208	This material was used prior to 1971 in the manufacture of insecticides in the insecticide manufacturing building. Records are only available for 1965-1966, 1968-1971 manufacture of insecticides using this material. Total material used 1965-1966, 1968-1971 was 15,190 lbs.
Ferrous Sulfate 7720787	This material was purchased in 1982 in the amount of 6000 lbs. It was used to aid in the remedial treatment of Doane Lake.
Heptachlor 74448	This material was used in formulating insecticides prior to 1970 in our insecticide manufacturing building. Records are available for 1965-1966, 1968-1971 production. During this time span 29,148 lbs. of this material was used.
Hexachlorobenzene 118741	This material was used in the manufacture of insecticides prior to 1972 in the insecticide manufacturing building. Production records exist for the years of 1965-1966, 1968-1972 which show 160,647 lbs used to manufacture various insecticides.

Iso Butyl Alcohol 78831	This material was used up to 1982 to make 2,4-D, 2,4-DB, and MCPP butyl Esters. The amount used was 9,874,596 lbs.
Isopropyl Alcohol 67630	This material was used in making 2,4-D Propyl Ester, Heptagram, and Spreader Activator. In addition, the laboratory used approximately four drums per year of this chemical. Usage in Heptagram and Spreader Activator is taken from 1965-66, 1968-71 production records and amounts to 49,495 lbs. for this period. Usage for the lab is estimated to be 45,720 lbs. Usage in 2,4-D propyl ester 391,619 lbs. Total usage is 486,656 lbs.
Lindane 58899	This material was used in the formulation of insecticides in our insecticide manufacturing building. Production records are available for 1965-66, 1968-71. During this time we used 19,284 lbs. of this material.
Malathion 121755	This material was used in the formulation of insecticides in our insecticide manufacturing building. Production records are available for 1965-66, 1968-71. During this time 222,971 lbs. of this material was used.
Mercury 7439976	This material was used in the formulation of insecticides prior to 1969 in our insecticide formulation plant. Lbs of finished product containing mercury compounds for years 1965-66 and 1969 were 39,070. Gallons of finished product produced containing mercury were 1,276 gallons.
Chlorodibromomethane 124481	This material apperas in our treated process water in a range of .5 - 5 ppm. and is a by-product of our bromoxynil process that has been in operation since 1971. Estimated amount produced is 2,729 lbs.
Methylene Chloride 75092	This material was used in the manufacture of MCPA from 1966-76 and MCPB manufacture from 1971-75. Total usage was 8,472,892.
Parathion 56382	This material was used to make insecticides from 1955-1969 in our insecticide manufacturing unit. Records are only available for the years 1965, 66, and 69 showing 1960 lbs used during those years.

Phenol 108952	Was used in the manufacture of DCP for making 2,4-DB and 2,4-D Acid or 2,4-DCP, 2,6-DCP, Thrichlorophenol, and parachloro-phenol. Total usage was 136,041,012 lbs.
Phosphoric Acid 7664382	This material was used to assist in the remedial treatment of Doane Lake prior to 1983. Records do not exist of how much was purchased or used, but from my own experience, it was less than 1000 gallons. Also, used as a catalyst for Ester production 1956-1959.
Potassium Hydroxide 1310532	This material was used in making the insecticide MCPA 334. I have no records indicating how much was used or how much MCPA 334 was produced prior to 1971.
Sodium Bisulfite 7631905	This material is used in the Bromoxynil production process to neutralize any excess bromine prior to pumping the material to the neutsche. In recent years we purchased about 8,000 lbs per year and this amount was less for years prior. Estimated usage since 1971 to 1988 is 50,000 lbs.
Hydrochloric Acid 7647010	This material was a by-product of DCP manufacture and of Bromoxynil Octanoate manufacture. In recent years, 1983 to present, it was purchased as a plant chemical in the amount of 553,556 lbs. HCL produced from the manufacture of DCP from 1956 to 1982 shutdown was 93,412,348 bls. and from B.O. operation from 1971 - present was 1,585,100 lbs. Total approximante quantity handled was 95,551,000 lbs.
Sodium Hydroxide 1310732	This material was used in the making of 2,4-D, MCPA, 2,4-DB, and MCPB as well as for neutralization of our effluent and our odor control systems. Usage from 1956-1988 was 355,990,298 lbs.
Sulfuric Acid 7664939	This material was used in our MCPA process and B.O. process, and MCPB process. Total usage from 1966 - 1982 was 8,334,043 lbs.
Thiram 137268	This material was used to make insecticides in our insecticide manufacturing building. We have no records of amount used or dates of any production.
Toxaphene 8001352	This material was used to make insecticides in our insecticide manufacturing building. Records exist for the years 1965, 66, 68, 69 and 70 showing 191,441 lbs. of this material used.

Xylene	This material was used in our Bromoxynil Process and in the formulation of Buctril and Bronate. In December 1982 we started using a solvent called Tenneco 500/100 in place of Xylene, although this material is approximately 20% Xylene. Total usage from 1967-1988 is 12,148,097 lbs. This material was also used in a few insecticide formulations in relatively small amounts and was in the solvents Socal and Chevron 170-L used in formulating varous insecticides and herbicides.
Triethylamine 121448	This material was used in the formulation of 2,4,5-T Amine 4L from 1952-1970. Estimated usage was 9,000 lbs.
2,4,5-T Acid 93765	This material was produced from 1960-63 in our 2,4-D plant. Quantity produced was 608,000 lbs.
2,4,5-T Esters 2545597	This material was produced in our 2,4-D Ester plant. 2,4,5-T Iso Octyl was produced from 1961-1964 in the quantity of 600,000 lbs. and 2,4,5-T Iso Butyl Ester was produced from 1961-66 in the quantity of 20,000 lbs.
2,4,5-T Formulations	These materials were produced from 1952-75 in a variety of products. Estimated production was over 1,000,000 lbs.
2,4,6-Trichlorophenol 25167822	This material was produced for the merchant market in 1977 in the amount of 2,900 lbs. It also appears as an impurity in the manufacure of 2,4-DCP and may be found in these waste streams at very low levels.
Toluene 108883	This material was used as a laboratory chemical and received in 55-gallon drums. Estimated usage is eight drums per year for 30 years, or 110,000 lbs.

Spies, K.H. 1966. Personal communication (letter to R.F. Gitschlag, Chipman Chemical Company, Portland, OR, dated July 14, 1966, regarding IW 3-0 Chipman Chemical Co.). Oregon State Sanitary Authority, Portland, OR.

TO ~~EK~~ & ~~EAS~~

OREGON STATE SANITARY AUTHORITY
STATE OFFICE BUILDING
1400 S. W. 5TH AVENUE
PORTLAND, OREGON 97201

July 14, 1966

Mr. R. F. Gitschlag
Production Manager
Western Region
Chipman Chemical Company, Inc.
6200 N. W. St. Helens Road
Portland, Oregon 97210

Re: IW 3-0
Chipman Chemical Co.

Dear Mr. Gitschlag:

We have completed our review of the air and water protection facilities planned for your new MCPA/MCPP plant as outlined in your letter of June 10, 1966, to our office.

Approval for the construction of this proposed project is herewith granted subject to the following conditions:

1. Discharge of liquid effluents from your plant to the Willamette River is considered by our office to be temporary until a municipal sewer is available in the area. An agreement should be reached with the city of Portland as soon as possible so that the connection can be made to the city's sewer when it becomes available.

2. It is our understanding that the two effluent holding tanks, each holding eight hours of waste effluent, are working out very well and are of sufficient capacity to enable you to adequately test all effluents before they are discharged. If at any time the capacity of these two tanks becomes insufficient for proper testing and control of effluent discharges, additional tanks shall be provided and required.

3. A considerable quantity of water containing DCP is still contained in Doane Lake. Not only does this present a potential source of material that may, under low flow conditions, produce off-flavors in fish; but it also contributes to the odor problems in the local area. A continued effort must be made toward eliminating this situation.

4. Monitoring for O-cresol and DCM in the plant area shall be done on a continual basis. In addition, monitoring of the proposed incinerator facility and all odor abatement equipment shall be continuously accomplished in order to maintain them in an effective and efficient operating condition.

COPY

It is the statutory responsibility of the State Sanitary Authority to restore and preserve the natural purity of the waters of the State of Oregon. This obligation is constant and continuous and over a period of years, changes in local conditions may occur which cannot be anticipated at the present time. Approval of these plans, therefore, must be and is but tentative and conditional, dependent upon changing conditions; construction of the plant in accordance with the plans submitted; and proper functioning of the plant after it has been placed in operation.

In view of these circumstances, the Sanitary Authority reserves the right to stipulate conditions under which these facilities are operated and to require changes when circumstances so warrant.

Should there be any questions regarding this approval, please feel free to call.

Very truly yours,

Kenneth H. Spies
State Sanitary Engineer

RWJ:ch

cc: City of Portland
Air Quality Control
cc: City of Portland
Dept. of Public Works
cc: Portland District Office
cc: Air Quality Control

Weathersbee, E.J. 1965. Personal communication (letter to R.F. Gitschlag, Chipman Chemical Co., Portland, OR, dated October 26, 1965, regarding IW 3-0 Chipman Chemical Co.). Oregon State Sanitary Authority, Portland, OR.

PC-20

To ~~295~~
Eg

OREGON STATE SANITARY AUTHORITY
STATE OFFICE BUILDING
1400 S. W. 5TH AVENUE
PORTLAND, OREGON 97201

October 26, 1965

Mr. R. F. Gitschlag
Production Manager
Western Region
Chipman Chemical Co., Inc.
6200 N. W. St. Helens Road
Portland, Oregon 97210

Re: IW 3-0
Chipman Chemical Co.

Dear Mr. Gitschlag:

At its regularly scheduled meeting on August 26, 1965, the Sanitary Authority adopted a motion which established March 1, 1966, as a deadline by which the liquid effluents from your Portland, Oregon, plant and Doane Lake must be adequately treated or disposed of in a manner so as not to cause objectionable tastes and odors in fish.

On September 14, 1965, representatives of your company met with representatives of the Sanitary Authority in Mr. Spies' office at which time it was mutually agreed that you would immediately submit a letter outlining in detail your company's proposal for complying with the August 26 action of the Authority. Said letter was specifically to include details of the following items:

1. Construction of new MCPA process (by February 1, 1966).

2. Facilities and procedure for pumping out Doane Lake.

3. Consultant service of Dr. Charlton regarding possible bacterial degradation of phenols in Doane Lake.

4. Agreement with Dr. Warren, Oregon State University, for bio-assays of liquid waste effluents.

5. Program and facilities for adjustment of pH in Doane Lake and plant effluents.

6. Proposed changes in 2-4-D plant to further reduce waste concentrations.

COPY

It was our understanding from your letter of September 13, 1965, and our meeting on September 14 that the greatest improvements in the fish tainting problem were to be achieved through changes in your MCPA plant and process and pumping out or neutralizing the fish tainting effects of the large inventory of waste waters in Doane Lake.

Your letter of October 13, 1965, indicates that you may not construct a new MCPA plant this Fall and in fact will plan to operate the existing plant possibly up to March 1, 1966. Also you have not as yet furnished a detailed program including physical facilities and procedures for pumping out Doane Lake.

In view of the short time left between now and March 1, 1966, it is requested that a definite and complete proposal including time table for meeting the Sanitary Authority requirements be submitted immediately for our review and approval.

Very truly yours,

Ely J. Weathersbee
Deputy State Sanitary Engineer

EJW:ch

cc: Air Quality Control
cc: Portland District Office

Attachment C—Selected Aerial Photographs and Maps

Aerial Photographs

Ackroyd Photography Inc. 1951. Untitled Aerial Photograph.

Environmental Data Resources. 1955. Untitled Aerial Photograph.

INQUIRY #: 2532194.3
YEAR: 1955
= 750'
N

Deland Studios and Aerial Surveys. 1957. Untitled Aerial Photograph.

Ackroyd Photography Inc. 1959. Untitled Aerial Photograph.

AMEC Earth and Environmental. 1961/1967. Untitled Aerial Photograph.

NOTE: Aerials from Oregon Historical Society and University of Oregon Aerial Reference Library

CLIENT	SLLI
AMEC Earth & Environmental	7376 SW Durham Road Portland, OR, U.S.A. 97224
DWN BY:	LM
CHKD BY:	JE/SG
DATUM:	--
PROJECTION:	--
SCALE:	NTS
PROJECT:	RESPONSE TO ARKEMA'S DRAFT CONCEPTUAL SITE MODEL AS PROVIDED TO LOWER WILLAMETTE GROUP
TITLE:	HISTORICAL AERIALS 1961, 1963, 1967, 1971
DATE:	DECEMBER 2006
PROJECT NO.:	
REV. NO.:	1
FIGURE NO.:	2

Environmental Data Resources. 1963. Untitled Aerial Photograph.

INQUIRY #: 2532194.3
YEAR: 1963
= 750'
N

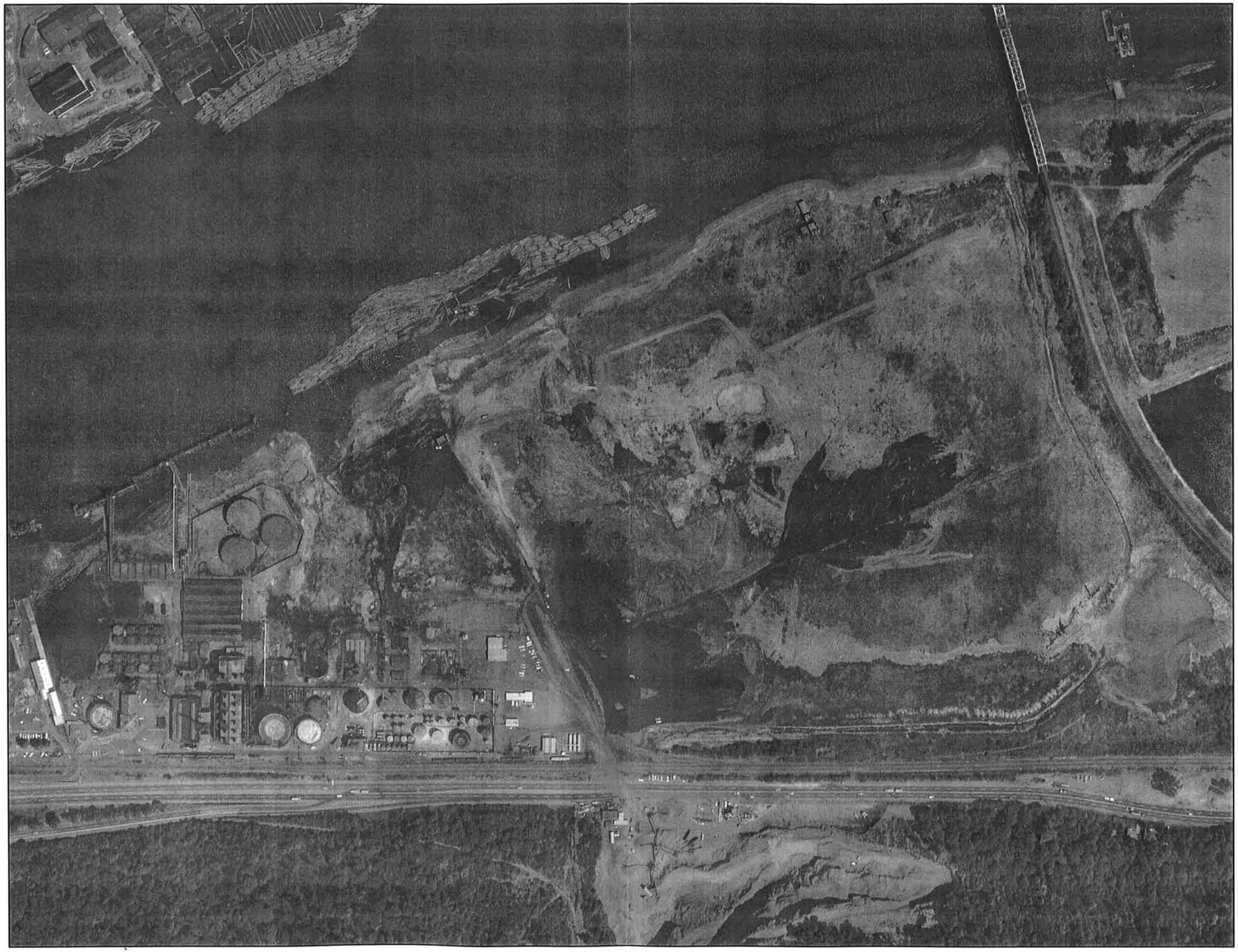
Ackroyd Photography Inc. 1964. Untitled Aerial Photograph.

Source Unknown. September 23, 1964. Untitled Aerial Photograph.

9-23-64

Source Unknown. 1966. Untitled Aerial Photograph.

1966



Source Unknown. 1967. Untitled Aerial Photograph.

N

Source Unknown. August 29, 1968. Untitled Aerial Photograph.

8-29-68

Source Unknown. 1969. Untitled Aerial Photograph.

1969

Environmental Data Resources. 1970. Untitled Aerial Photograph.

INQUIRY #: 2532194.3
YEAR: 1970
= 750'
N

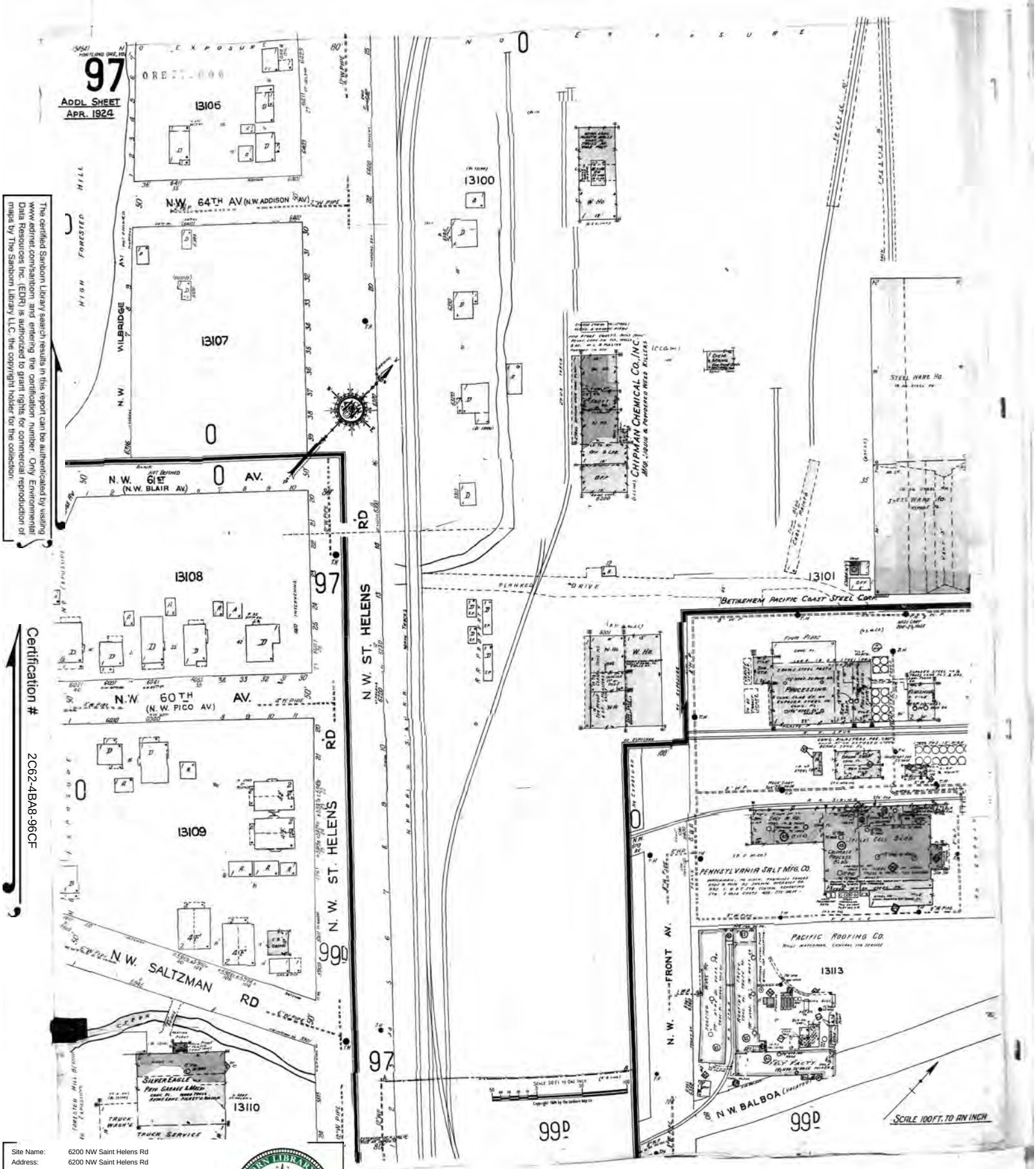
Source Unknown. 1971. Untitled Aerial Photograph.

1971

Sanborn Maps

Sanborn Map Company. 1950. Map of 6200 NW St. Helens Road, Portland, Oregon, 97210. Environmental Data Resources.

1950 Certified Sanborn Map



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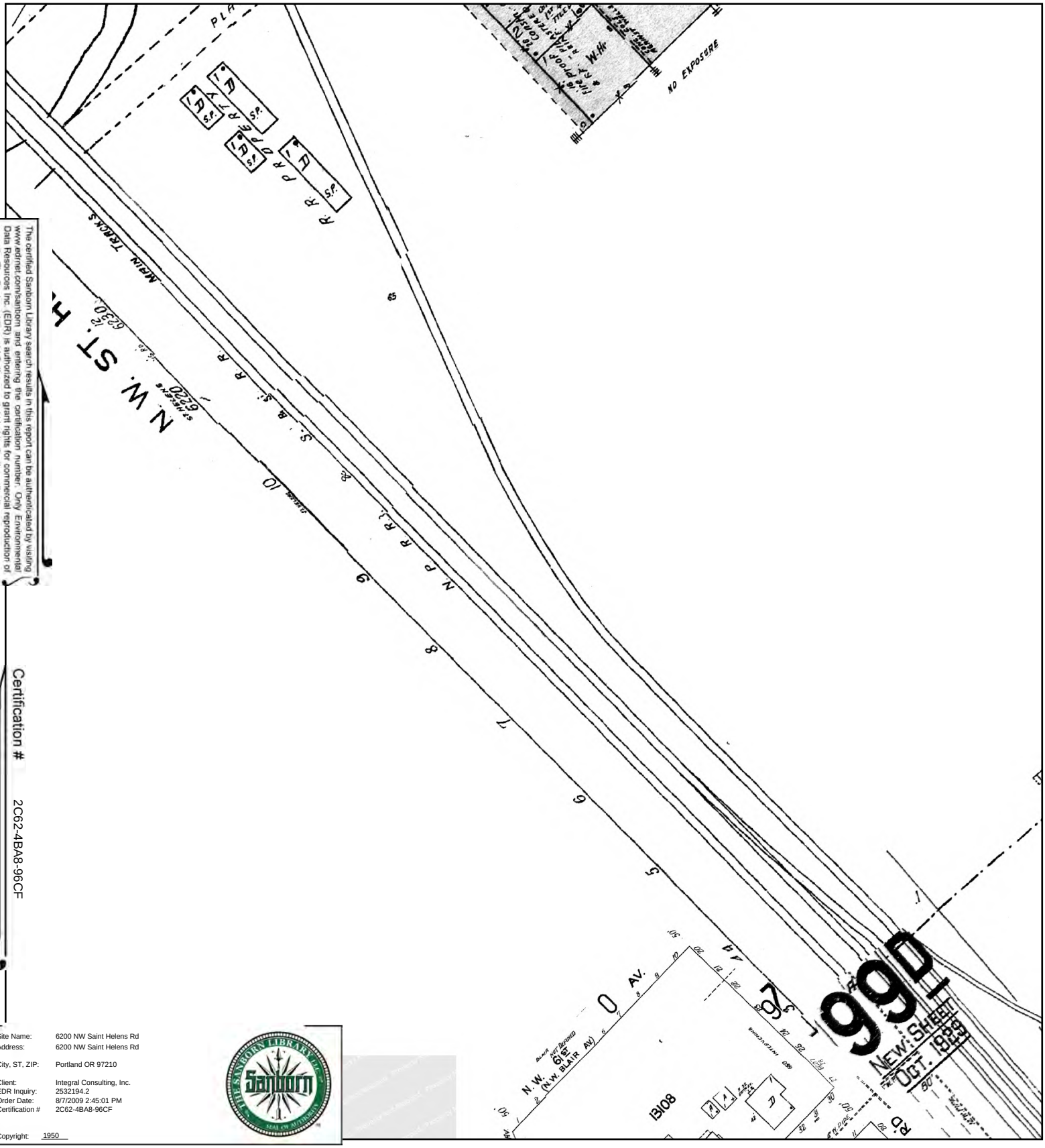
Certification # 2C62-4BA8-96CF

Site Name:	6200 NW Saint Helens Rd
Address:	6200 NW Saint Helens Rd
City, ST, ZIP:	Portland OR 97210
Client:	Integral Consulting, Inc.
EDR Inquiry:	2532194.2
Order Date:	8/7/2009 2:45:01 PM
Certification #	2C62-4BA8-96CF

Copyright: 1950

1950 Certified Sanborn Map



The certified Sanborn Library search results in this report can be authenticated by visiting www.edrnet.com/sanborn and entering the certification number. Only Environmental Data Resources Inc. (EDR) is authorized to grant rights for commercial reproduction of maps by The Sanborn Library LLC, the copyright holder for the collection.

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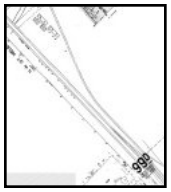
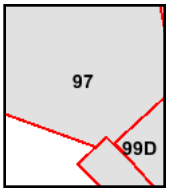
EDR Inquiry:	2532194.2
Order Date:	8/7/2009 2:45:01 PM
Certification #	2C62-4BA8-96CF

Copyright: 1950

This Certified Sanborn Map combines the following sheets (thumbnails on page 3).

0 Feet 150 300 600



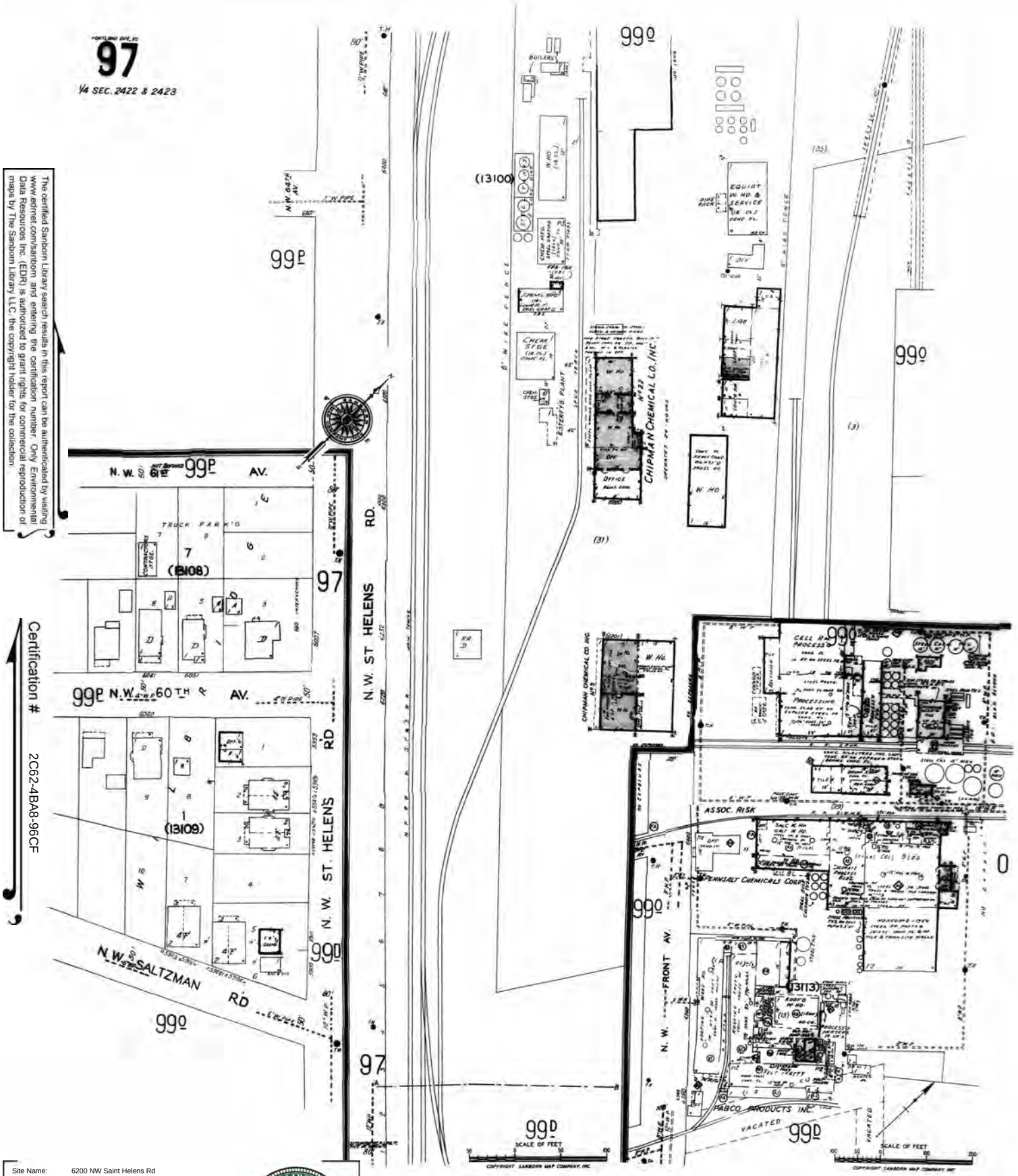


Volume 1, Sheet 99D
Volume 1, Sheet 97

N

Sanborn Map Company. 1969. Map of 6200 NW St. Helens Road, Portland, Oregon, 97210. Environmental Data Resources.

1969 Certified Sanborn Map



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Certification # 2C62-4BA8-96CF

Site Name:	6200 NW Saint Helens Rd
Address:	6200 NW Saint Helens Rd
City, ST, ZIP:	Portland OR 97210
Client:	Integral Consulting, Inc.
EDR Inquiry:	2532194.2
Order Date:	8/7/2009 2:45:01 PM
Certification #	2C62-4BA8-96CF

Copyright: 1969

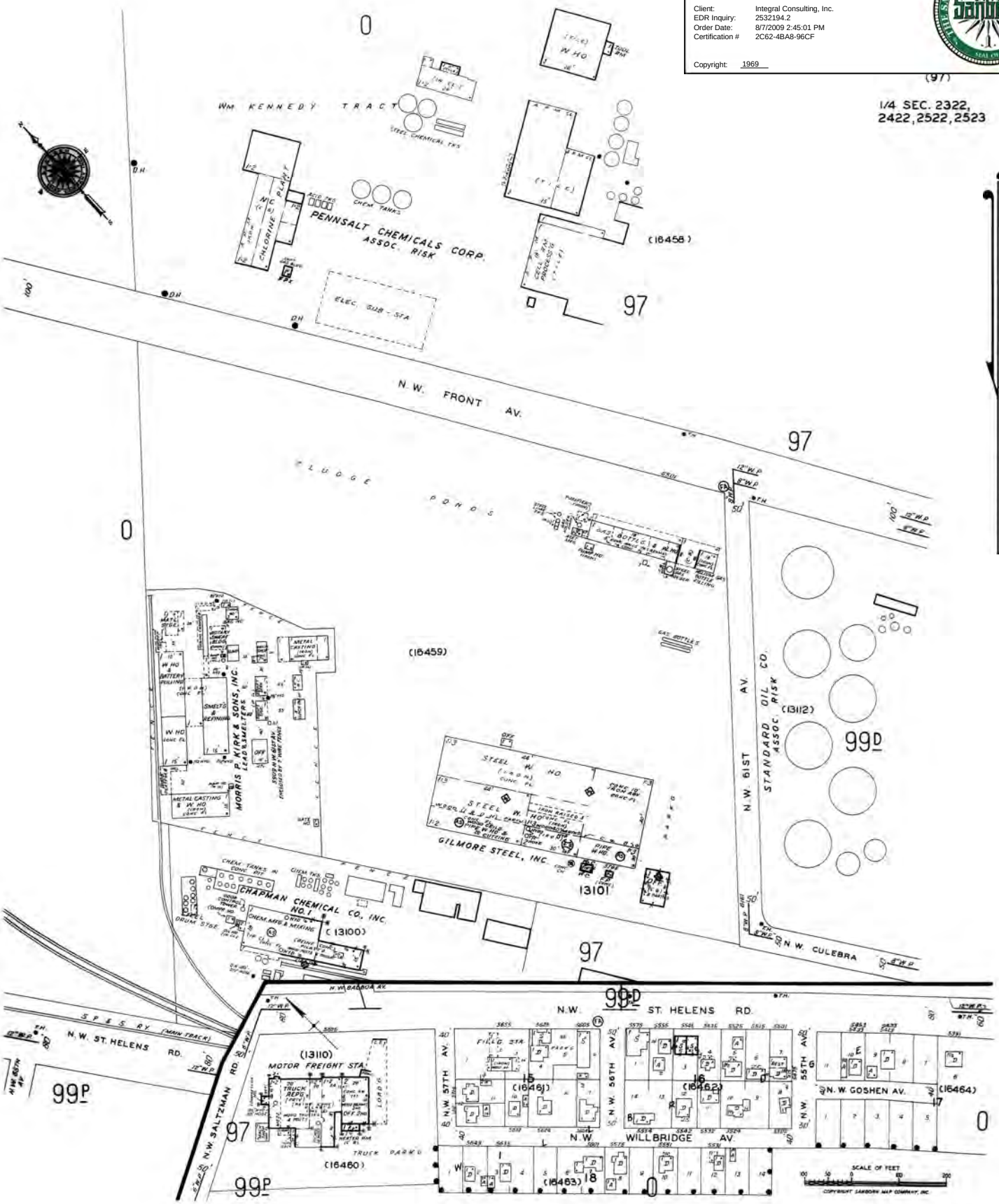
1969 Certified Sanborn Map

Site Name: 6200 NW Saint Helens Rd
Address: 6200 NW Saint Helens Rd

City, ST, ZIP: Portland OR 97210

Client: Integral Consulting, Inc.
EDR Inquiry: 2532194.2
Order Date: 8/7/2009 2:45:01 PM
Certification # 2C62-4BA8-96CF

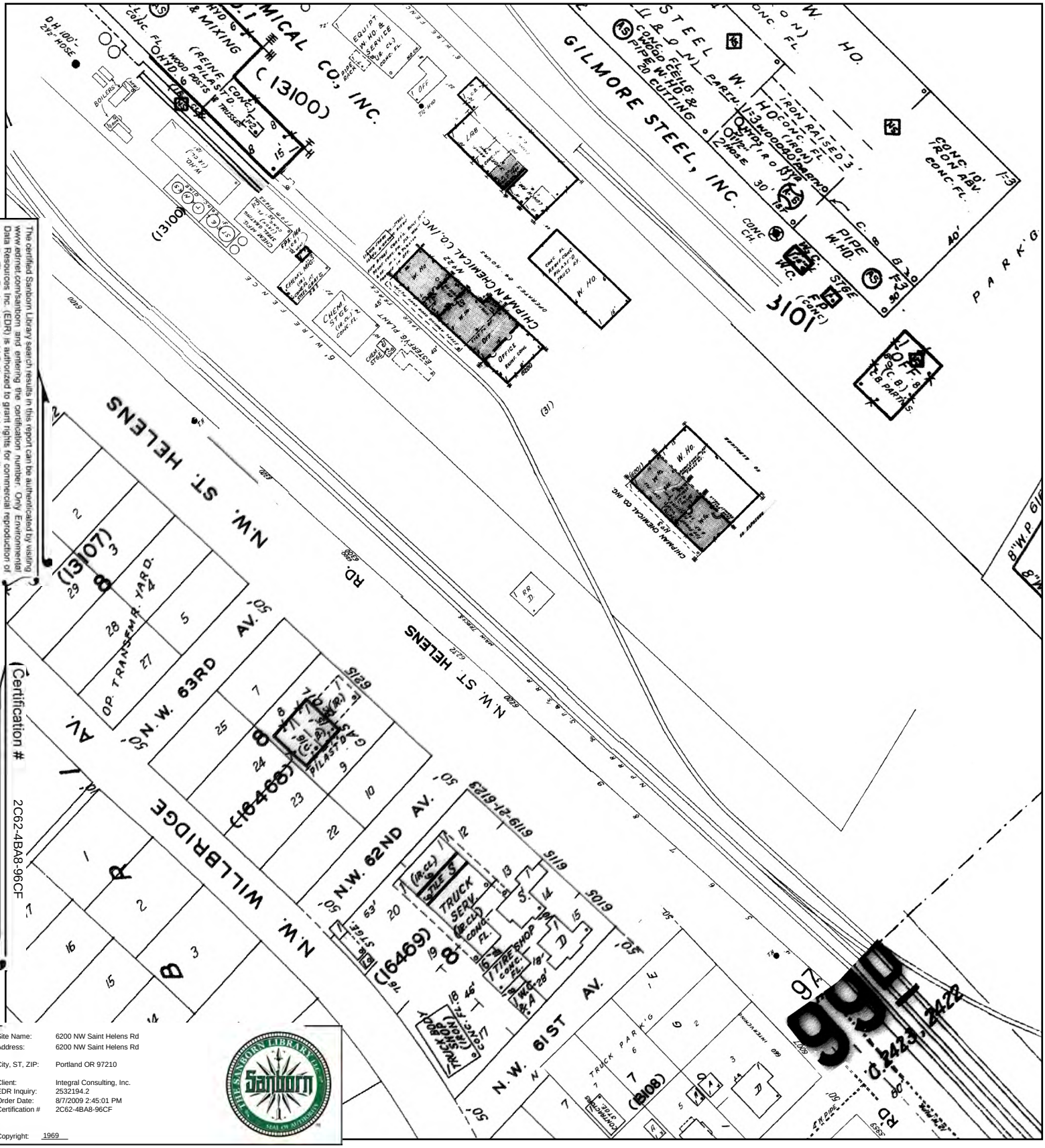
Copyright: 1969



The certified Sanborn Library search results in this report can be authenticated by visiting www.edrnet.com/sanborn and entering the certification number. Only Environmental Data Resources Inc. (EDR) is authorized to grant rights for commercial reproduction of maps by The Sanborn Library LLC, the copyright holder for the collection.

Certification # 2C62-4BA8-96CF

1969 Certified Sanborn Map



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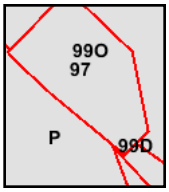
Certification # 2C62-4BA8-96CF

Site Name:	6200 NW Saint Helens Rd
Address:	6200 NW Saint Helens Rd
City, ST, ZIP:	Portland OR 97210
Client:	Integral Consulting, Inc.
EDR Inquiry:	2532194.2
Order Date:	8/7/2009 2:45:01 PM
Certification #	2C62-4BA8-96CF
Copyright:	1969

This Certified Sanborn Map combines the following sheets (thumbnails on page 3).



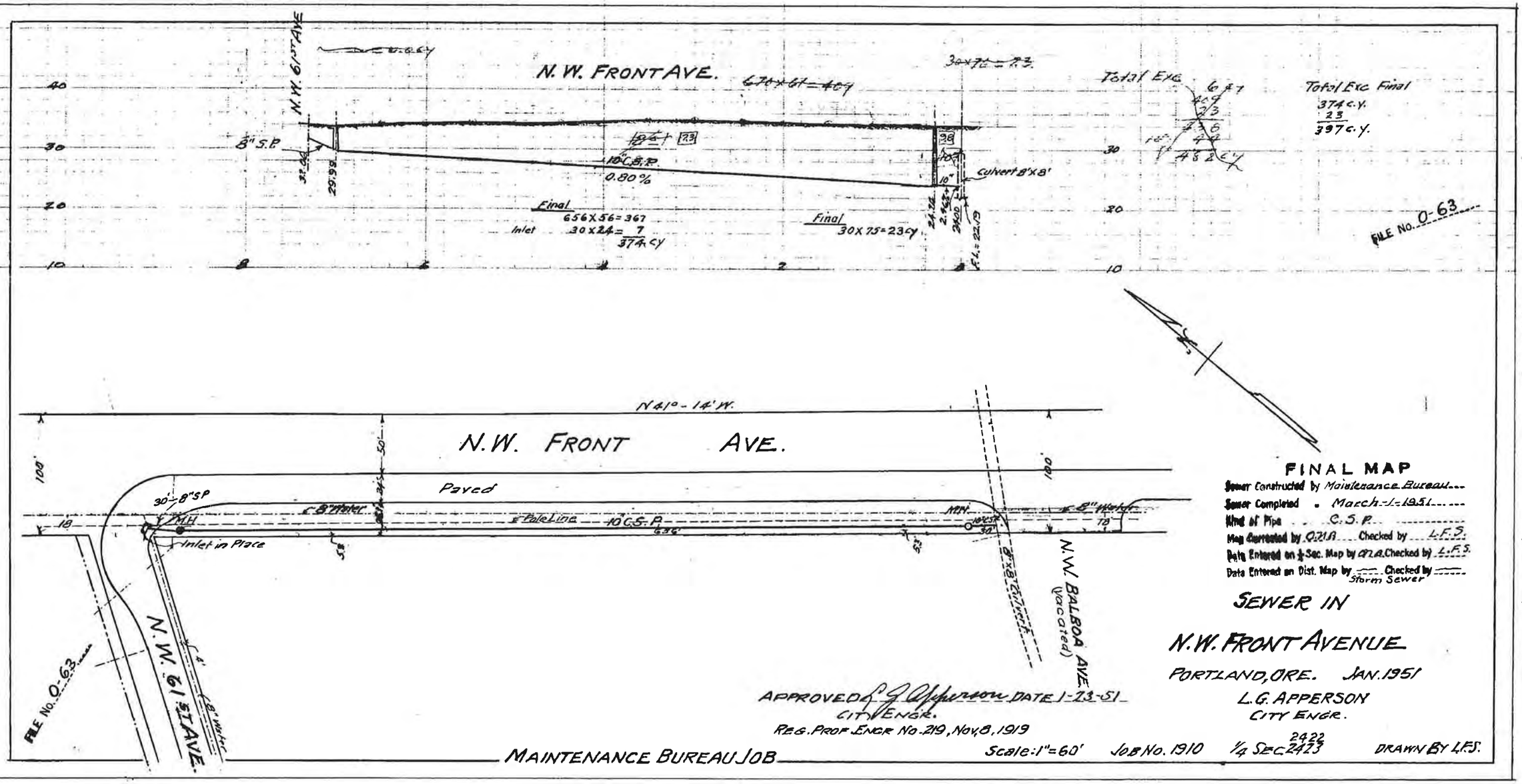
Volume 1, Sheet 97
Volume 1, Sheet P
Volume 1, Sheet 99O
Volume 1, Sheet 99D

0 Feet 150 300 600

N

Sewer Maps

City of Portland. 1951. Map of Sewer in NW Front Avenue, Portland, OR. Job No. 1910. City of Portland, Portland, OR.


N.W. FRONT AVE.
N.W. 61ST AVE
8" S.P.
10" C.S.P.
0.80%
Final
656X56=367
Inlet 30X24= 7
374 cy
Final
30X75=23cy
Culvert 8'X8'
Total Exc.
Total Exc. Final
374 c.y.
23
397 c.y.
FILE No. O-63
N41°-14' W.
N.W. FRONT AVE.
Paved
8" Water
Pole Line
10 C.S.P.
Inlet in Place
N.W. 61ST AVE.
N.W. BALBOA AVE (vacated)
FILE No. O-63
FINAL MAP
Sewer Constructed by Maintenance Bureau
Sewer Completed March 1-1951
Kind of Pipe C.S.P.
Map Corrected by O.J.A. Checked by L.F.S.
Date Entered on ¼ Sec. Map by O.J.A. Checked by L.F.S.
Date Entered on Dist. Map by ---- Checked by ----
Storm Sewer
SEWER IN
N.W. FRONT AVENUE
PORTLAND, ORE. JAN. 1951
L.G. APPERSON
CITY ENGR.
APPROVED L.G. Apperson DATE 1-23-51
CITY ENGR.
REG. PROF. ENGR. No. 219, Nov. 8, 1919
MAINTENANCE BUREAU JOB
Scale: 1" = 60'
JOB No. 1910
¼ SEC 2422 2423
DRAWN BY L.F.S.

City of Portland. 1969. Unit 1, Guilds Lake Interceptor Plan & Profile. As Built dated April 15, 1969. Sheet 1 of 8. City of Portland, Department of Public Works, Portland, OR.

1969

NOTE:
ALL TIMBER BULK HEADS
TO BE 6" MIN THICKNESS
& WATERTIGHT

PUMP STATION SITE

TEST HOLE #6 SEE BORING LOG, SHT. #3

60" STUBOUT TIMBER BULKHEAD

36" STUBOUT & TIMBER BULKHEAD

FILL AREA

D O A N E L A N E

2+40 SMH

7+65 SMH

NW FRONT AVE

NOTE: ALL STATIONING SHOWN ON THIS DRAWING IS VOID.

AS BUILT

FILL PROFILE

VARIES

WATER SURFACE

END ASPHALT

DRILL HOLE #1

12+50 SMH

60" STUBOUT & TIMBER BULK HEAD
36" STUBOUT & TIMBER BULKHEAD

60" S= .00036 L=231.4'

60" S= .00036 L= 513.8'

60" S= .00036 L= 490.8'

I.E. 9.13

I.E.

I.E. 9.58

LEGEND

G	NATURAL GAS LINE
W	WATER LINE
PL	PETROLEUM PRODUCTS PIPELINE
SMH	STANDARD MANHOLE
SDMH	STANDARD DROP MANHOLE
T	BURIED TELEPHONE CONDUIT
S	EXISTING SEWER

CHAIN LINK FENCE

17+75 SMH

2" STEEL PIPE IN 4" STEEL PIPE FOR HYDROGEN TO

BEGINNING TELEPHONE IN IRON PIPE

WATER METER VALVES

23+50 SMH

VALVE

ASPHALT LINE (JACKETED)

SHELL OIL CO. (JACKETED) G LINE

28+8 SMH

END TELEPHONE IRON PIPE

BURIED TELEPHONE CABLE IN IRON PIPE TO BE RELOCATED AT EXPENSE OF UTILITY COMPANY

SEWER W 30" COVER

ASPHALT PAVING

NW FRONT AVE

NW 61st AVE

8 X 8 CONC BOX

NW BALBOA AVE

END BURIED TEL CABLE

2" STEEL PIPE IN 4" STEEL PIPE

4" GAS 6 5/8" GAS

6" GAS

8" WATER 10" WATER

6" STEEL PIPE

3/4" GAS

60" S= .00036 L= 528.5'

60" S= .00036 L= 569'

60" S= .00036 L= 560'

I.E. 2.77

I.E.

I.E.

AS BUILT

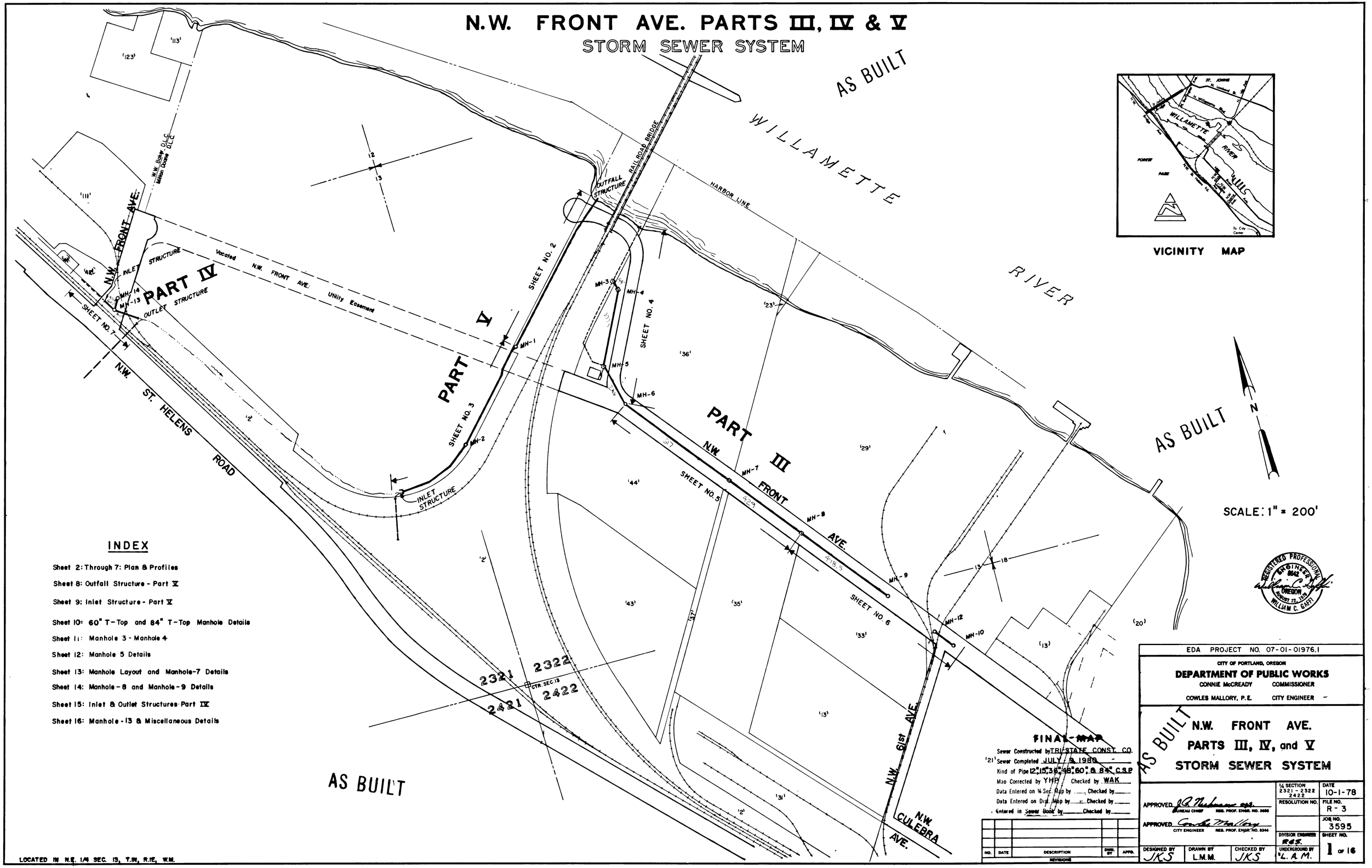
22262

4-15-69	1 AS BUILT	ALE		STEVENS & THOMPSON, INC. PORTLAND OREGON — Consulting Engineers SEATTLE WASHINGTON	PORTLAND, OREGON DEPARTMENT OF PUBLIC WORKS RIVER POLLUTION CONTROL PROJECT	UNIT i GUILDS LAKE INTERCEPTOR PLAN & PROFILE	SHEET 1 / 8

City of Portland. 1980. N.W. Front Ave. Parts I & II Storm Sewer System. As Built dated September 4, 1980. EDA Project No. 07-01-01976.1. Job No. 3595. Sheet 5 of 8. City of Portland, Department of Public Works, Portland, OR.

N.W. FRONT AVE. PARTS III, IV & V

STORM SEWER SYSTEM



INDEX

Sheet 2: Through 7: Plan & Profiles

Sheet 8: Outfall Structure - Part V

Sheet 9: Inlet Structure - Part V

Sheet 10: 60" T-Top and 84" T-Top Manhole Details

Sheet 11: Manhole 3 - Manhole 4

Sheet 12: Manhole 5 Details

Sheet 13: Manhole Layout and Manhole-7 Details

Sheet 14: Manhole - 8 and Manhole - 9 Details

Sheet 15: Inlet & Outlet Structures-Part IV

Sheet 16: Manhole - 13 & Miscellaneous Details

FINAL MAP

Sewer Constructed by TRI-STATE CONST. CO.

Sewer Completed JULY 9, 1980

Kind of Pipe 12", 15", 36", 48", 60" & 84" C.S.P.

Map Corrected by YHP Checked by WAK

Data Entered on ¼ Sec. Map by ____ Checked by ____

Data Entered on Dist. Map by ____ Checked by ____

Entered in Sewer Book by ____ Checked by ____

NO.	DATE	DESCRIPTION	DWN. BY	APPD.
		REVISIONS		

EDA PROJECT NO. 07-01-01976.1

CITY OF PORTLAND, OREGON

DEPARTMENT OF PUBLIC WORKS

CONNIE McCREADY COMMISSIONER

COWLES MALLORY, P.E. CITY ENGINEER

AS BUILT

N.W. FRONT AVE. PARTS III, IV, and V STORM SEWER SYSTEM

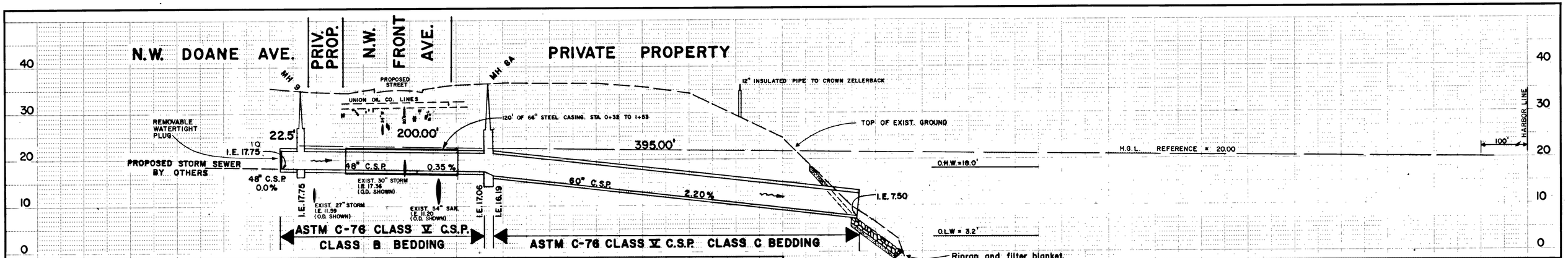
APPROVED J. C. Nelmes BUREAU CHIEF REG. PROF. ENGR. NO. 3686

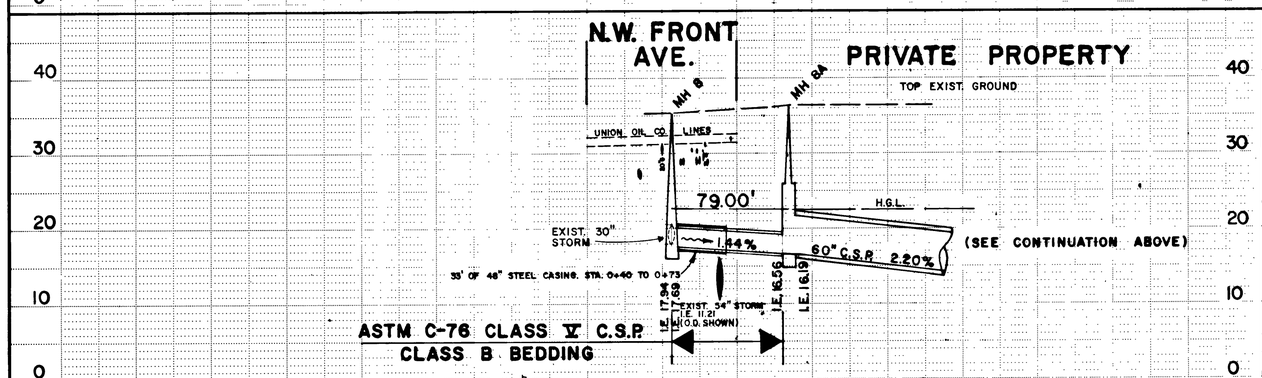
APPROVED Cowles Mallory CITY ENGINEER REG. PROF. ENGR. NO. 8344

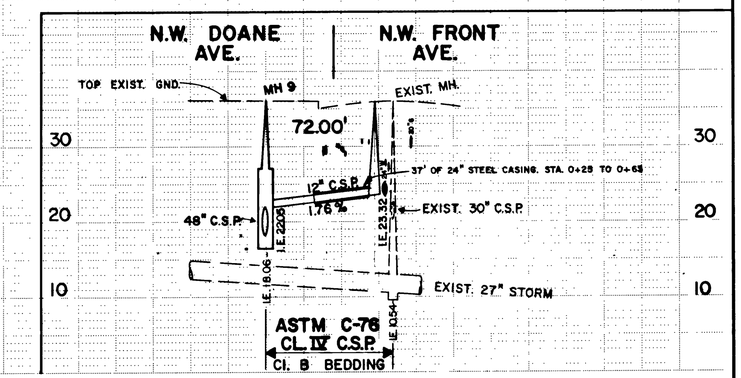
¼ SECTION 2321 - 2322 2422	DATE 10-1-78	
RESOLUTION NO.	FILE NO. R - 3	
	JOB NO. 3595	
DIVISION ENGINEER R.G.S.	SHEET NO. 1 OF 16	

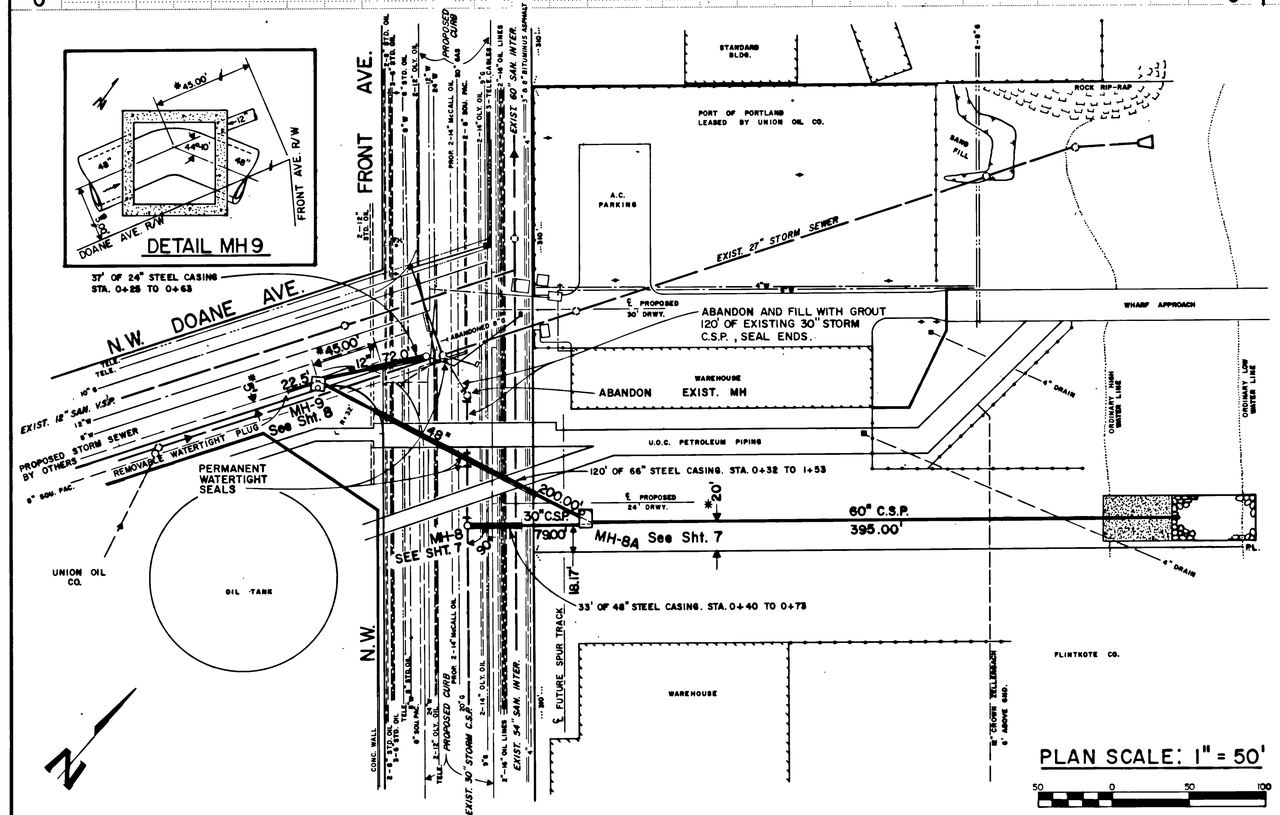
DESIGNED BY	DRAWN BY	CHECKED BY	UNDERGROUND BY
JKS	L.M.M.	JKS	L.A.M.

LOCATED IN N.E. 1/4 SEC. 13, T.1N, R.1E, W.M.



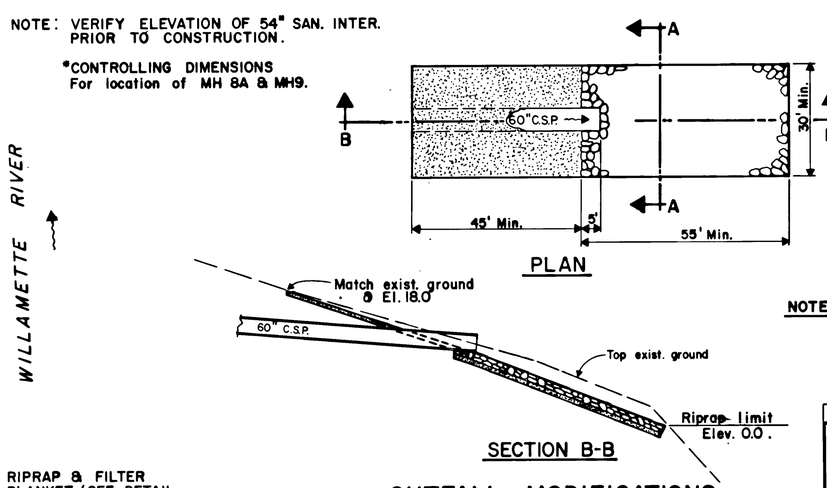


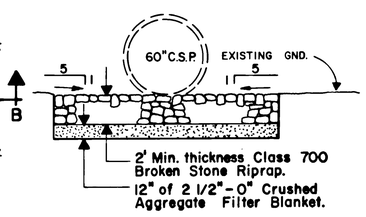




NOTE: VERIFY ELEVATION OF 54" SAN. INTER. PRIOR TO CONSTRUCTION.

*CONTROLLING DIMENSIONS For location of MH 8A & MH9.

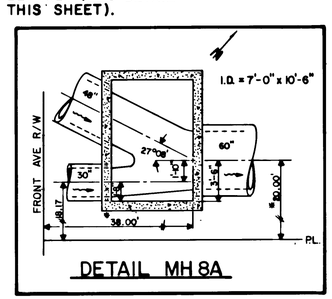




TYPICAL SECTION A-A

NOTE: Riprap and filter blanket materials and placement shall conform to section 610 of the Standard Construction Specifications, and any Special Specifications.

RIPRAP & FILTER BLANKET (SEE DETAIL THIS SHEET).



OUTFALL MODIFICATIONS
RIPRAP & FILTER BLANKET DETAIL

N.T.S.

FINAL MAP

Sewer Constructed by TRI-STATE CONSTRUCTION CO.
Sewer Completed SEPT. 4, 1980
Kind of Pipe 12" & 30" C.S.P.
Map Corrected by YHP Checked by WAK
Data Entered on ¼ Sec. Map by ____ Checked by ____
Data Entered on Dist. Map by ____ Checked by ____
Entered in Sewer Book by ____ Checked by ____

REGISTERED PROFESSIONAL ENGINEER 8642 OREGON AUGUST 23, 1979 WILLIAM C. GARTI

NO.	DATE	DESCRIPTION	DWN. BY	APPD.

REVISIONS

EDA PROJECT NO. 07-01-01976.1

CITY OF PORTLAND, OREGON
DEPARTMENT OF PUBLIC WORKS
CONNIE McCREADY COMMISSIONER
COWLES MALLORY, P.E. CITY ENGINEER

AS BUILT

N.W. FRONT AVE.
PARTS I & II
STORM SEWER SYSTEM

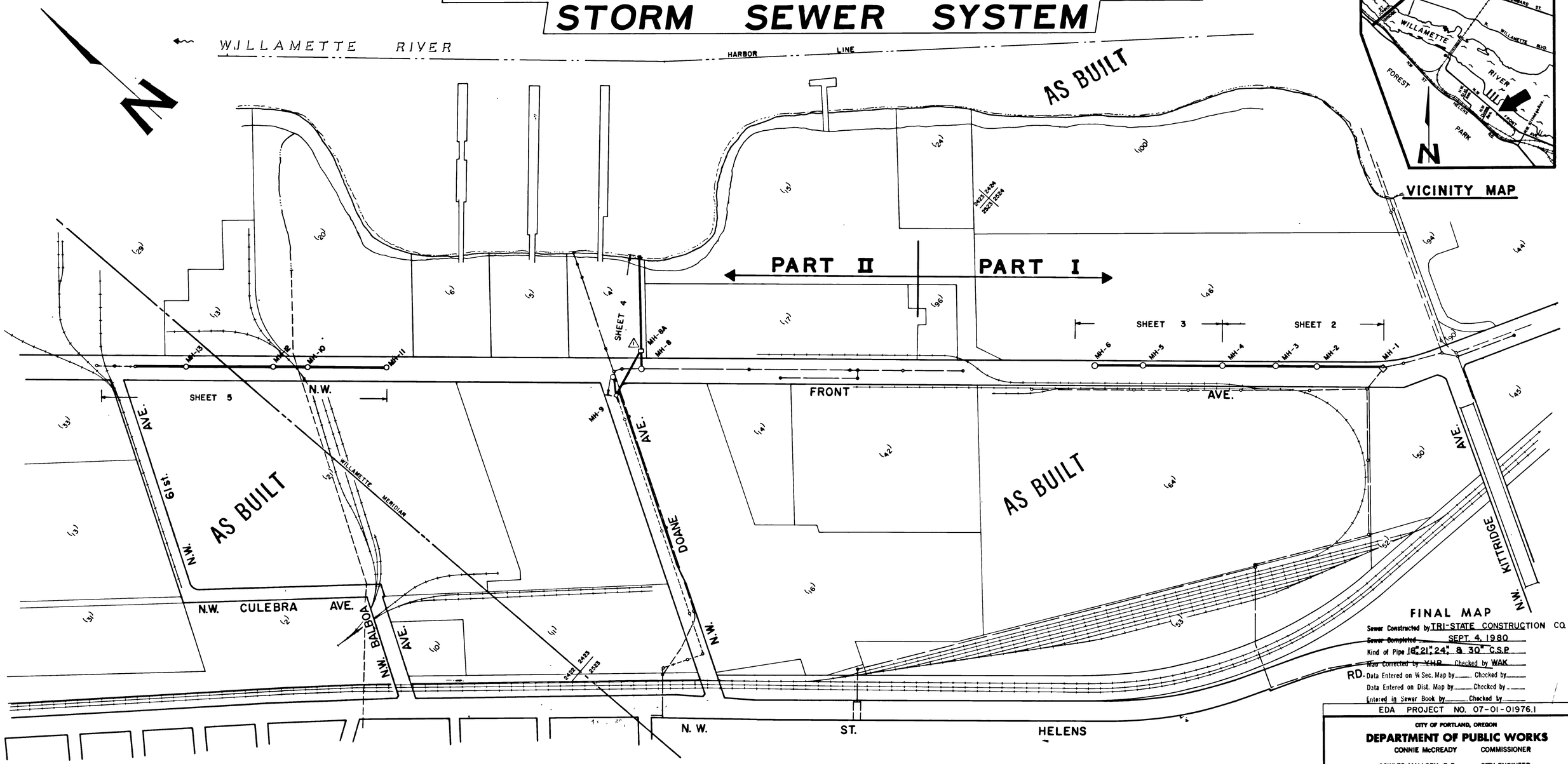
APPROVED BUREAU CHIEF REG. PROF. ENGR. NO. 3656
APPROVED CITY ENGINEER REG. PROF. ENGR. NO. 5344

¼ SECTION	DATE
2423	2-12-79
RESOLUTION NO.	FILE NO.
	R-2
	JOB NO.
	3595
DIVISION ENGINEER	SHEET NO.
	4 OF 8

DESIGNED BY	DRAWN BY	CHECKED BY	UNDERGROUND BY
JKS		W.C.G.	M.A.B.

MICROFILMED

N.W. FRONT AVE - PARTS I & II
STORM SEWER SYSTEM



LEGEND

- EXISTING STORM SEWER
- PROPOSED STORM SEWER
- PROPOSED STORM SEWER TO BE CONSTRUCTED BY OTHERS

SCALE: 1" = 200'

200 0 200 400

AS BUILT

REGISTERED PROFESSIONAL ENGINEER 9642 OREGON AUGUST 22, 1978 WILLIAM C. GARTY

NO.	DATE	DESCRIPTION	DWN. BY	APPD.
1	2-12-79	OUTFALL REALIGNED		W.C.G.

REVISIONS

FINAL MAP

Sewer Constructed by TRI-STATE CONSTRUCTION CO.
Sewer Completed SEPT. 4, 1980
Kind of Pipe 18", 21", 24" & 30" C.S.P.
Map Corrected by YHR Checked by WAK
RD. Data Entered on ¼ Sec. Map by ____ Checked by ____
Data Entered on Dist. Map by ____ Checked by ____
Entered in Sewer Book by ____ Checked by ____

EDA PROJECT NO. 07-01-01976.1

CITY OF PORTLAND, OREGON
DEPARTMENT OF PUBLIC WORKS
CONNIE McCREADY COMMISSIONER
COWLES MALLORY, P.E. CITY ENGINEER

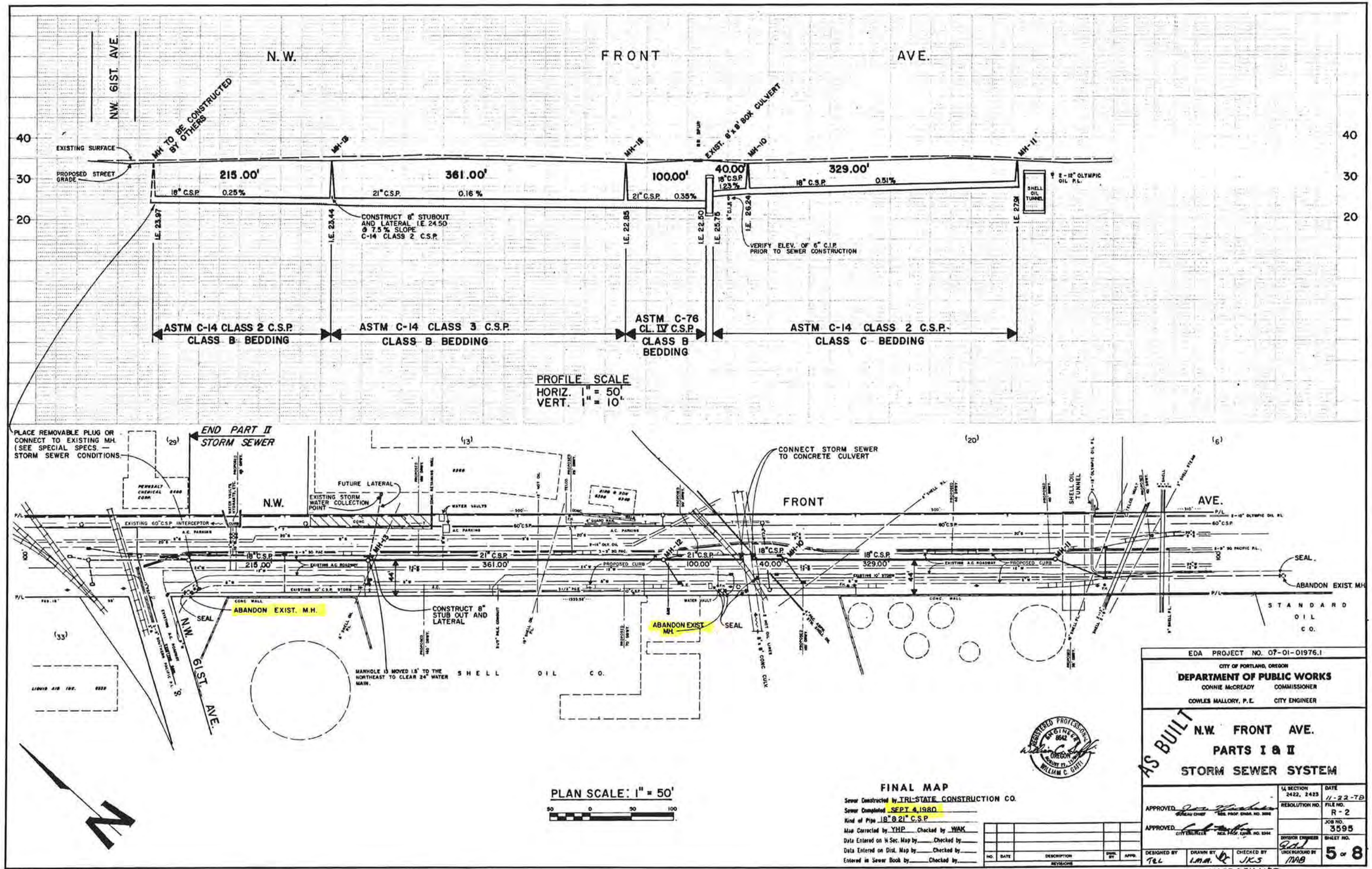
AS BUILT

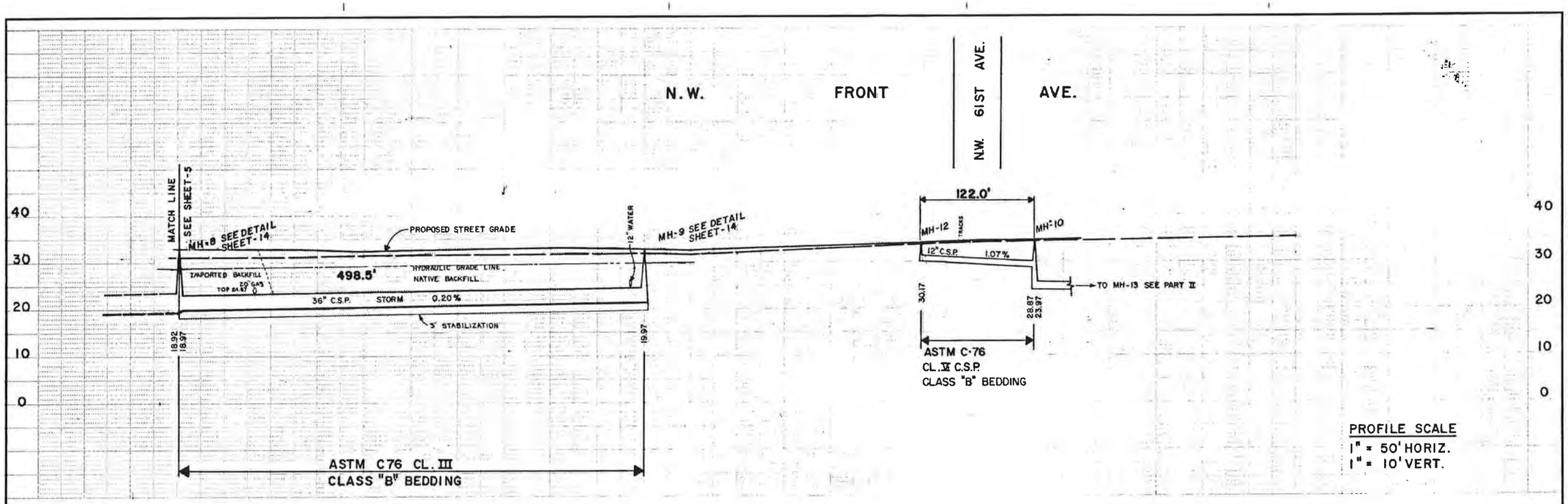
N.W. FRONT AVE.
PARTS I & II
STORM SEWER SYSTEM

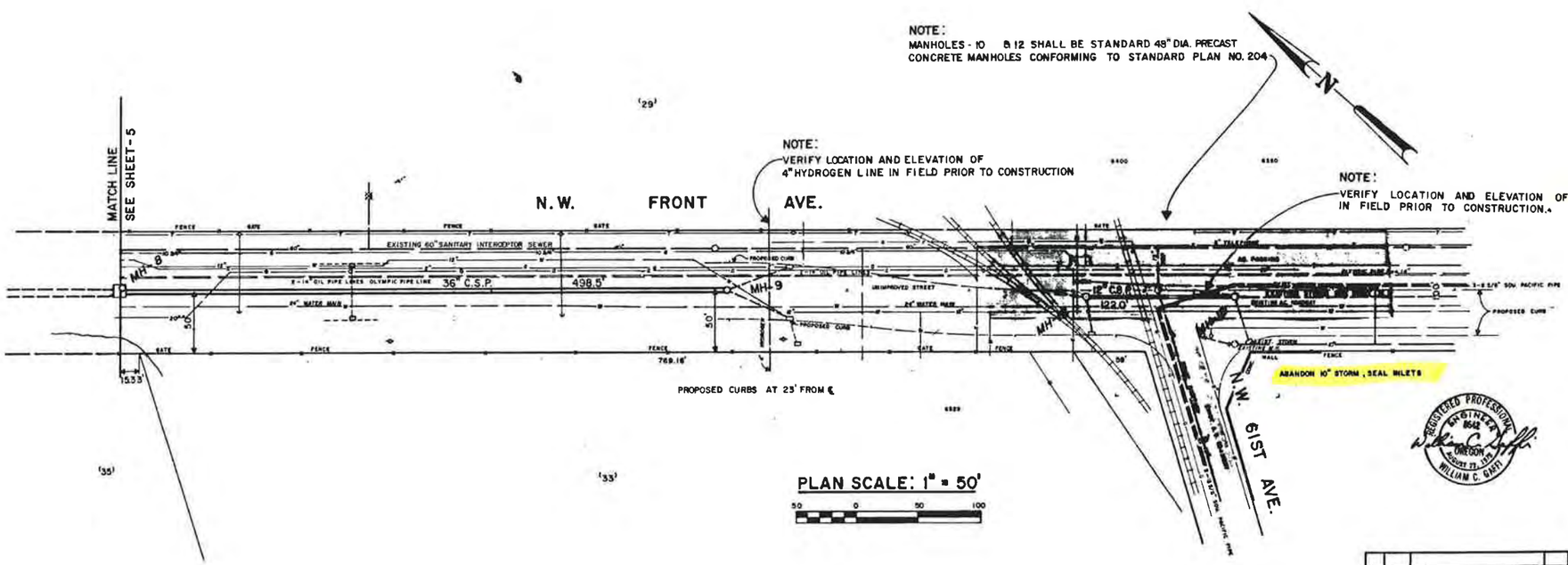
APPROVED [signature] BUREAU CHIEF REG. PROF. ENGR. NO. 3686
APPROVED [signature] CITY ENGINEER REG. PROF. ENGR. NO. 8344

¼ SECTION	2422, 2423, 2523, 2524
RESOLUTION NO.	
DATE	11-22-78
FILE NO.	R-2
JOB NO.	3595
DIVISION ENGINEER	[signature]
UNDERGROUND BY	
SHEET NO.	1 OF 8

DESIGNED BY	DRAWN BY	CHECKED BY
TBC JKS	JX	W.C.G.


N.W. FRONT AVE.
NW. 61ST. AVE.
MH TO BE CONSTRUCTED BY OTHERS
EXISTING SURFACE
PROPOSED STREET GRADE
MH-13
MH-12
MH-10
MH-11
EXIST. 8'x8' BOX CULVERT
215.00'
361.00'
100.00'
40.00'
329.00'
18" C.S.P. 0.25%
21" C.S.P. 0.16 %
21" C.S.P. 0.35%
18" C.S.P. 1.23 %
18" C.S.P. 0.51%
I.E. 23.97
I.E. 23.44
I.E. 22.85
I.E. 22.50
I.E. 25.75
I.E. 26.24
I.E. 27.24
CONSTRUCT 8" STUBOUT AND LATERAL I.E. 24.50 @ 7.5 % SLOPE C-14 CLASS 2 C.S.P.
VERIFY ELEV. OF 6" C.I.P. PRIOR TO SEWER CONSTRUCTION
SHELL OIL TUNNEL
ASTM C-14 CLASS 2 C.S.P. CLASS B BEDDING
ASTM C-14 CLASS 3 C.S.P. CLASS B BEDDING
ASTM C-76 CL. IV C.S.P. CLASS B BEDDING
ASTM C-14 CLASS 2 C.S.P. CLASS C BEDDING
PROFILE SCALE
HORIZ. 1" = 50'
VERT. 1" = 10'
PLACE REMOVABLE PLUG OR CONNECT TO EXISTING MH. (SEE SPECIAL SPECS. — STORM SEWER CONDITIONS.
END PART II STORM SEWER
FUTURE LATERAL
EXISTING STORM WATER COLLECTION POINT
CONNECT STORM SEWER TO CONCRETE CULVERT
EXISTING 60" C.S.P. INTERCEPTOR
ABANDON EXIST. M.H.
SEAL
CONSTRUCT 8" STUB OUT AND LATERAL
MANHOLE IS MOVED 1.8' TO THE NORTHEAST TO CLEAR 24" WATER MAIN.
ABANDON EXIST MH.
SHELL OIL CO.
STANDARD OIL CO.
SHELL OIL TUNNEL
N.W. 61ST. AVE.
PLAN SCALE: 1" = 50'
FINAL MAP
Sewer Constructed by TRI-STATE CONSTRUCTION CO.
Sewer Completed SEPT 4, 1980
Kind of Pipe 18" & 21" C.S.P
Map Corrected by YHP Checked by WAK
Date Entered on ¼ Sec. Map by ____ Checked by ____
Data Entered on Dist. Map by ____ Checked by ____
Entered in Sewer Book by ____ Checked by ____
REGISTERED PROFESSIONAL ENGINEER 8642 OREGON AUGUST 17, 1976 WILLIAM C. GAFFI
AS BUILT
EDA PROJECT NO. 07-01-01976.1
CITY OF PORTLAND, OREGON
DEPARTMENT OF PUBLIC WORKS
CONNIE McCREADY COMMISSIONER
COWLES MALLORY, P.E. CITY ENGINEER
N.W. FRONT AVE.
PARTS I & II
STORM SEWER SYSTEM
¼ SECTION 2422, 2423
DATE 11-22-78
RESOLUTION NO.
FILE NO. R-2
JOB NO. 3595
SHEET NO. 5 OF 8
APPROVED BUREAU CHIEF
APPROVED CITY ENGINEER
DIVISION ENGINEER
UNDERGROUND BY MAB
DESIGNED BY TEL
DRAWN BY L.M.M.
CHECKED BY JKS
NO. DATE DESCRIPTION REVISIONS
MICROFILMED





FINAL MAP

Sewer Constructed by TRI-STATE CONSTRUCTION CO.
Sewer Completed JULY 9, 1980
Kind of Pipe 12" & 36" C.S.P.
Map Corrected by YHP Checked by WAK
Data Entered on ¼ Sec. Map by ____ Checked by ____
Date Entered on Dist. Map by ____ Checked by ____
Entered in Sewer Book by ____ Checked by ____

EDA PROJECT NO. 07-01-01976.1

CITY OF PORTLAND, OREGON
DEPARTMENT OF PUBLIC WORKS
CONNIE McCREADY COMMISSIONER
COWLES MALLORY, P.E. CITY ENGINEER

AS BUILT

N.W. FRONT AVE.
PARTS III, IV, and V
STORM SEWER SYSTEM

APPROVED (Bureau Chief) Reg. Prof. Engr. No. 3088		¼ SECTION 2322-2323	DATE 10-1-78
APPROVED (City Engineer) Reg. Prof. Engr. No. 6946		RESOLUTION NO.	FILE NO. R-3
			JOB NO. 3595
DESIGNED BY JBS	DRAWN BY T.A.R.	CHECKED BY JBS	DIVISION ENGINEER / UNDERGROUND BY L.A.R.	SHEET NO. 6 of 16

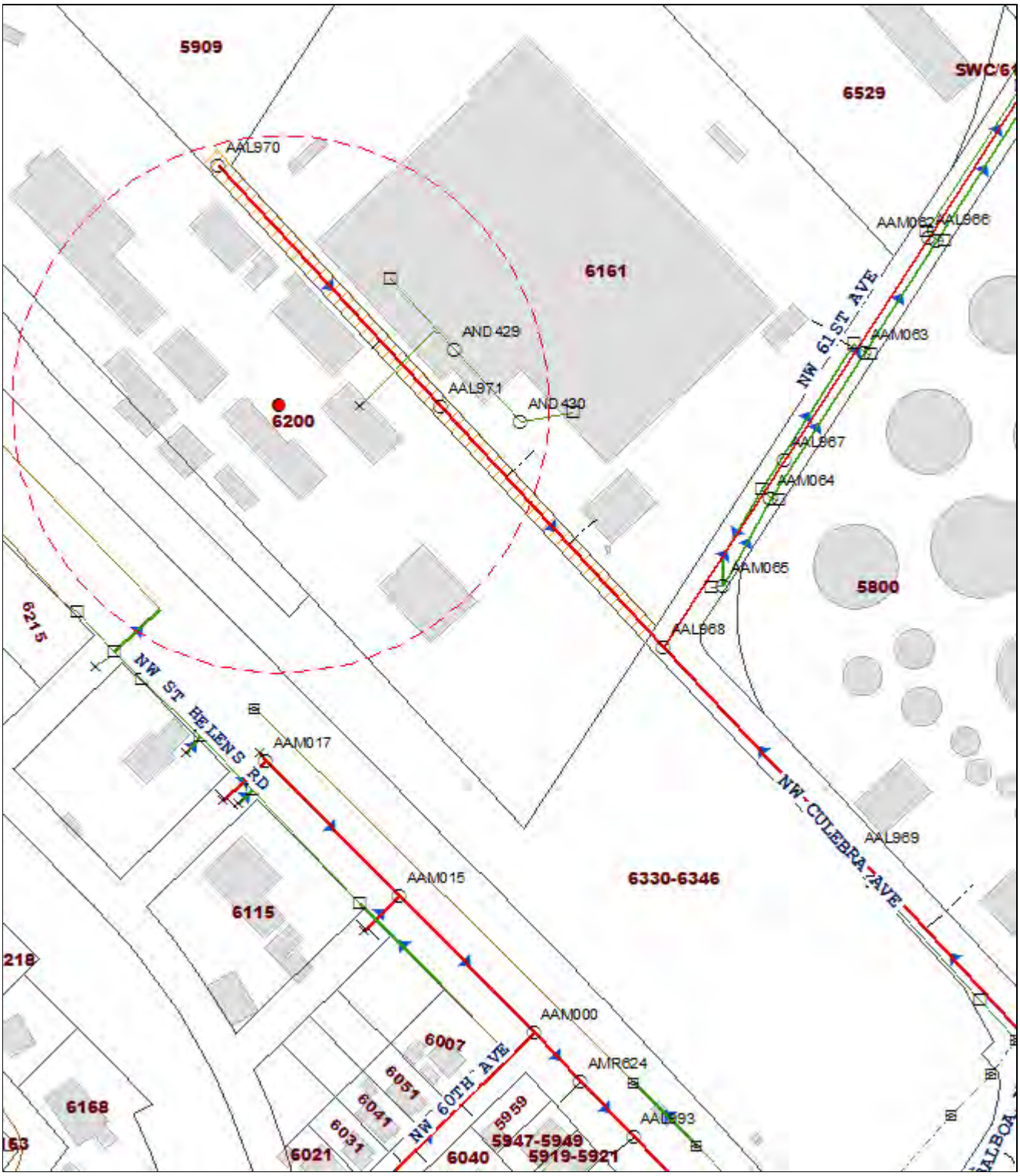
NO.	DATE	DESCRIPTION	DWN. BY	APPR.
4	2-21-79	CHANGE DEPTH MH 10, 11, 12	J.D.C.	W.C.G.

REVISIONS

REGISTERED PROFESSIONAL ENGINEER 8542 OREGON JANUARY 22, 1979 WILLIAM C. GRAFF

MICROFILMED

City of Portland. 2009. Sewer Map. Available at: www.portlandmaps.com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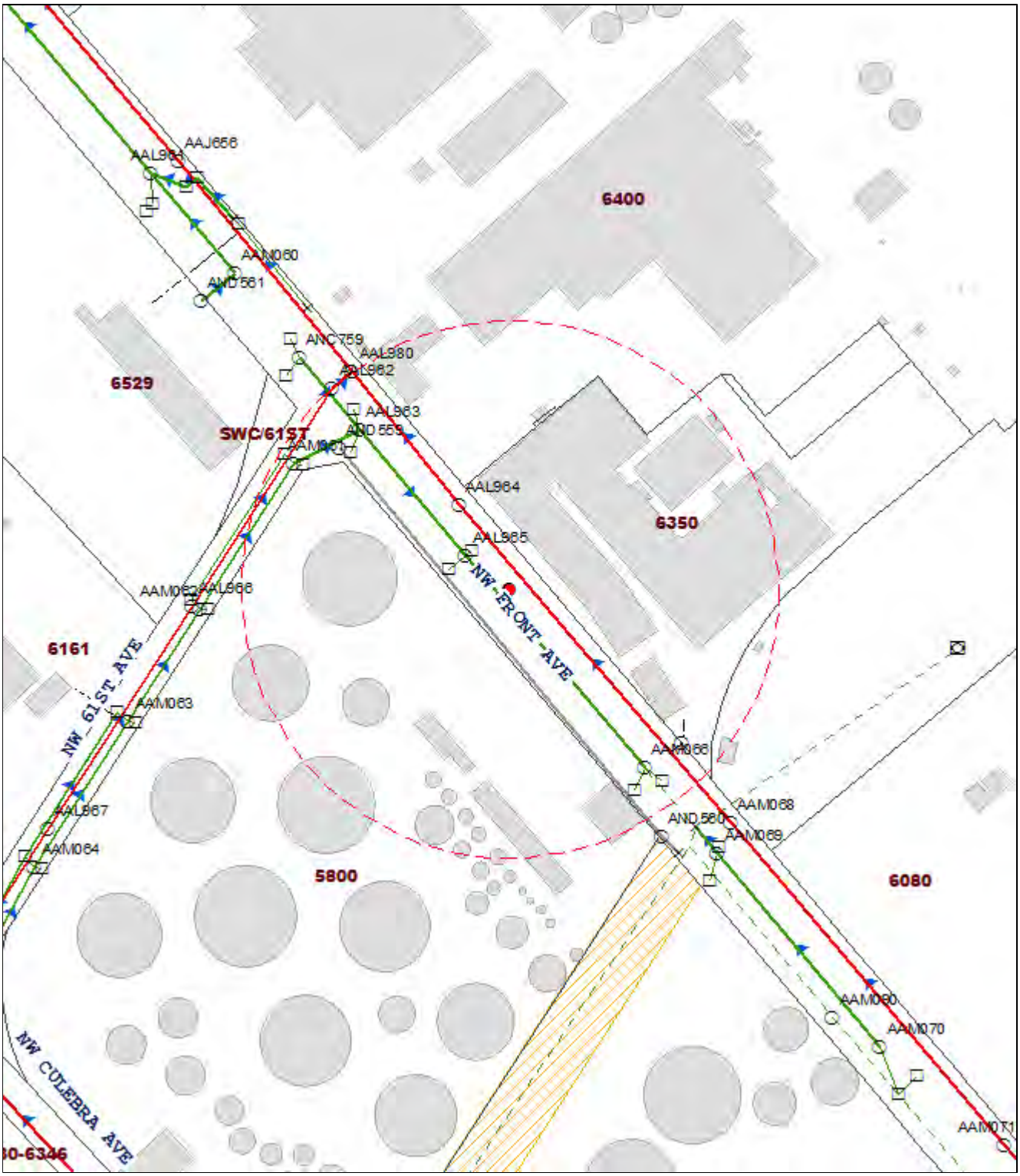
6529
SWC/61
AAL970
6161
AAM062
AAL966
NW 61ST AVE
AND 429
AAM063
AAL971
AND 430
6200
AAL967
AAM064
AAM065
5800
6215
AAL968
NW ST HELENS RD
AAM017
NW CULEBRA AVE
AAL969
AAM015
6330-6346
6115
218
AAM000
6007
AMR624
6051
6041
NW 60TH AVE
5959
6168
AAL993
6031
5947-5949
63
6021
6040
5919-5921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AND561
ANC759
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AND559
SWC/61ST
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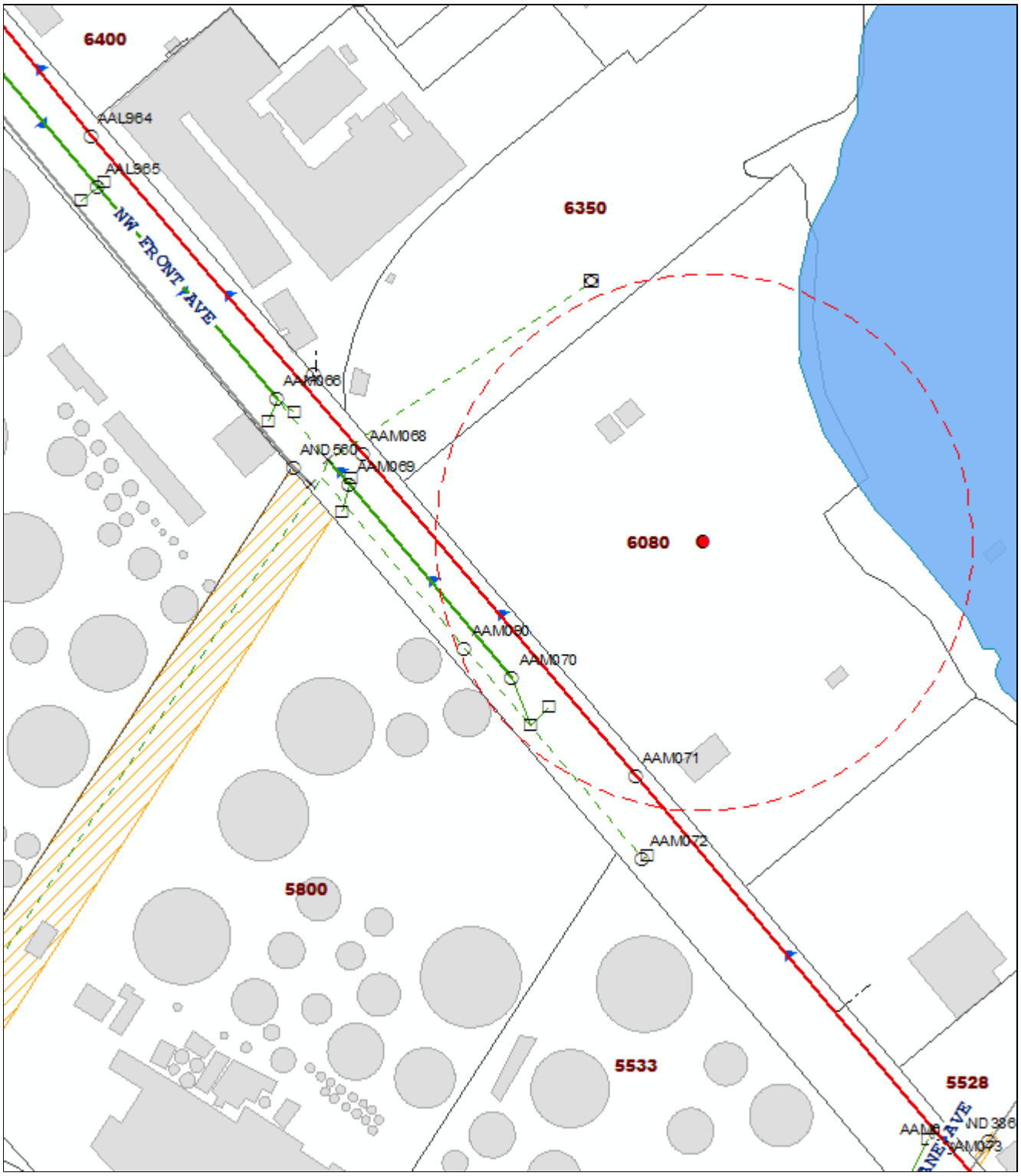
AAL965
AAM062
AAL966
AAM063
AAL967
AAM064
AAM066
AAM068
AND560
AAM069
AAM070
AAM071
6400
6529
6350
6161
5800
6080
NW 61ST AVE
NW FRONT AVE
NW CULEBRA AVE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AND 386
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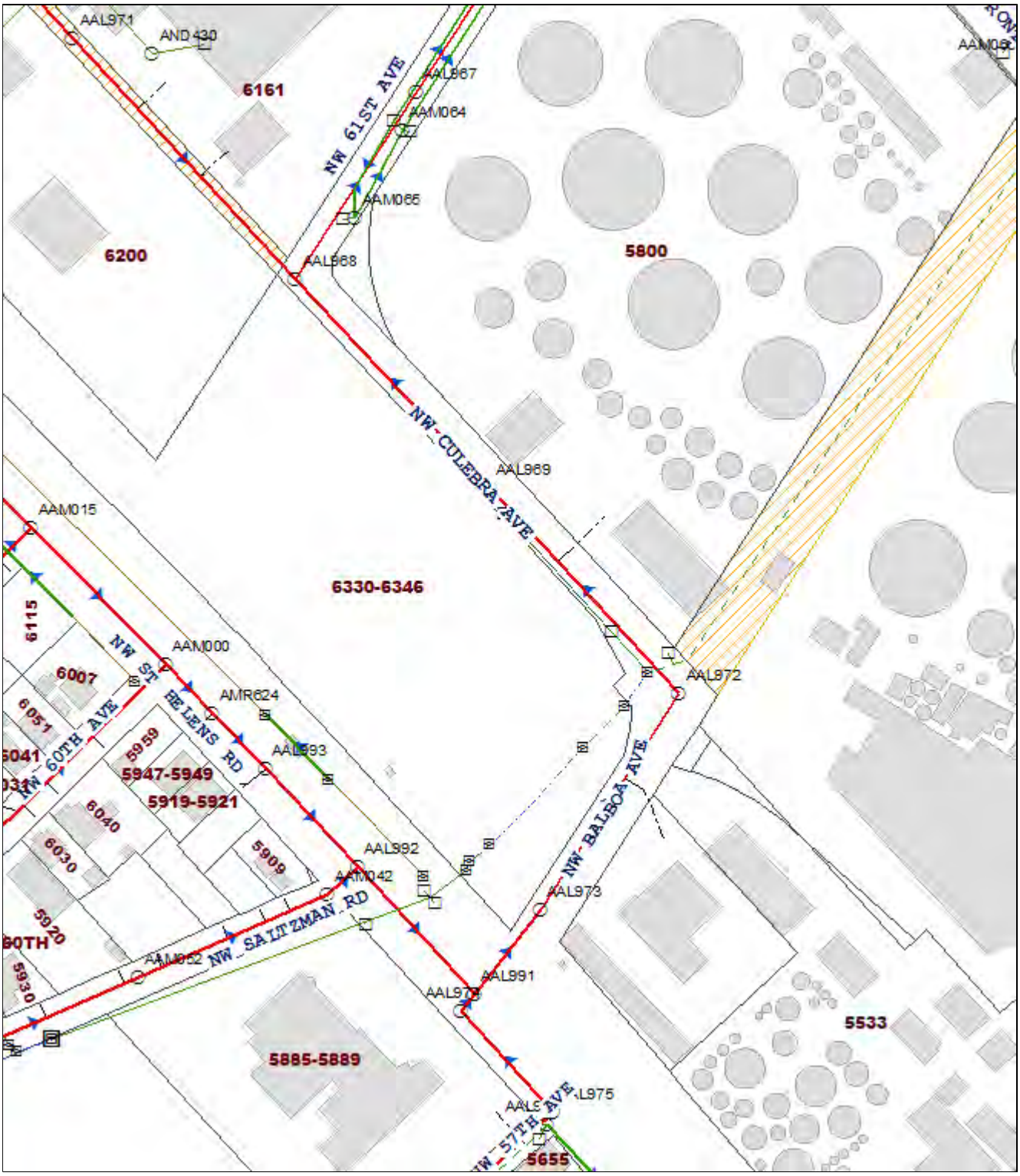
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NW CULEBRA AVE
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AAM015
6330-6346
6115
NW ST HELENS RD
AAM000
6007
AAL972
AMR624
6051
NW 60TH AVE
5959
AAL993
5947-5949
5919-5921
6040
6030
5909
AAL992
AAM042
NW BALBOA AVE
AAL973
NW SAUTZMAN RD
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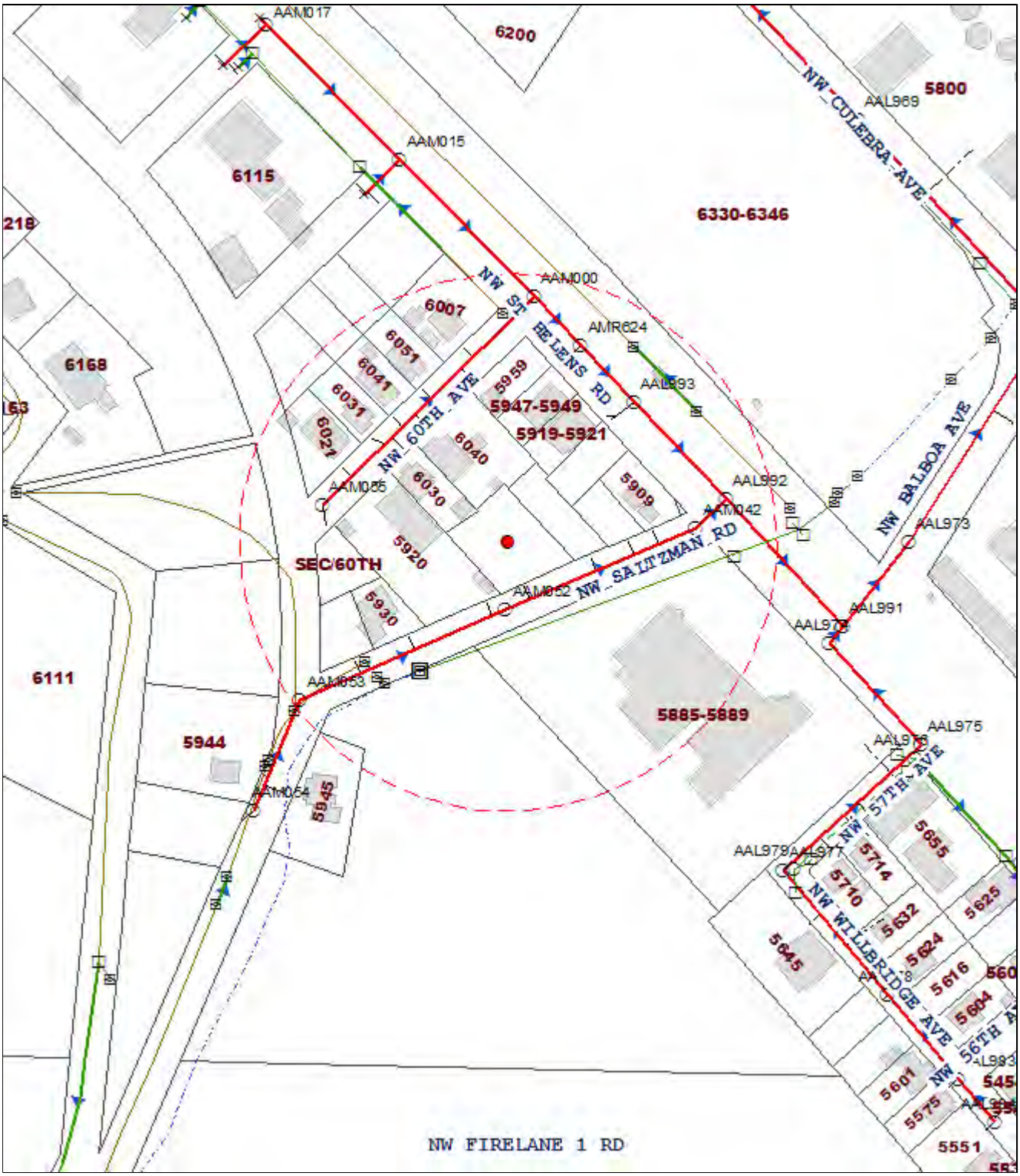
60TH
AAM052
5930
AAL991
AAL970
5533
5885-5889
AAL975
NW 57TH AVE
5655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6200
NW CULEBRA AVE
AAL969
5800
AAM015
6115
6330-6346
218
AAM000
NW ST HELENS RD
6007
AMR624
6051
6041
6031
6021
6168
5959
5947-5949
5919-5921
AAL993
NW 60TH AVE
6040
6030
AAM065
5909
AAL992
AAM042
NW BALBOA AVE
AAL973
5920
SEC/60TH
AAM052
NW SALTZMAN RD
5930
AAL991
AAL970
6111
AAM053
5885-5889
AAL975
5944
AAL976
AAM054
5945
NW 57TH AVE
AAL979
AAL977
5714
5655
5710
NW WILLBRIDGE AVE
5632
5625
5645
5624
5616
5604
NW 56TH AVE
5601
5575
5551
NW FIRELANE 1 RD

TREATMENT PLANTS
PUMP STATIONS
CLEANOUTS
MANHOLES
DISCHARGE POINTS
DIVERSIONS
INLETS
OUTFALL
SEDIMENTATION MANHOLES
STORAGE
SUMPS
TRASH RACK
WATERWAY FEATURES
FLOW CONTROL
NO ACCESS POINTS

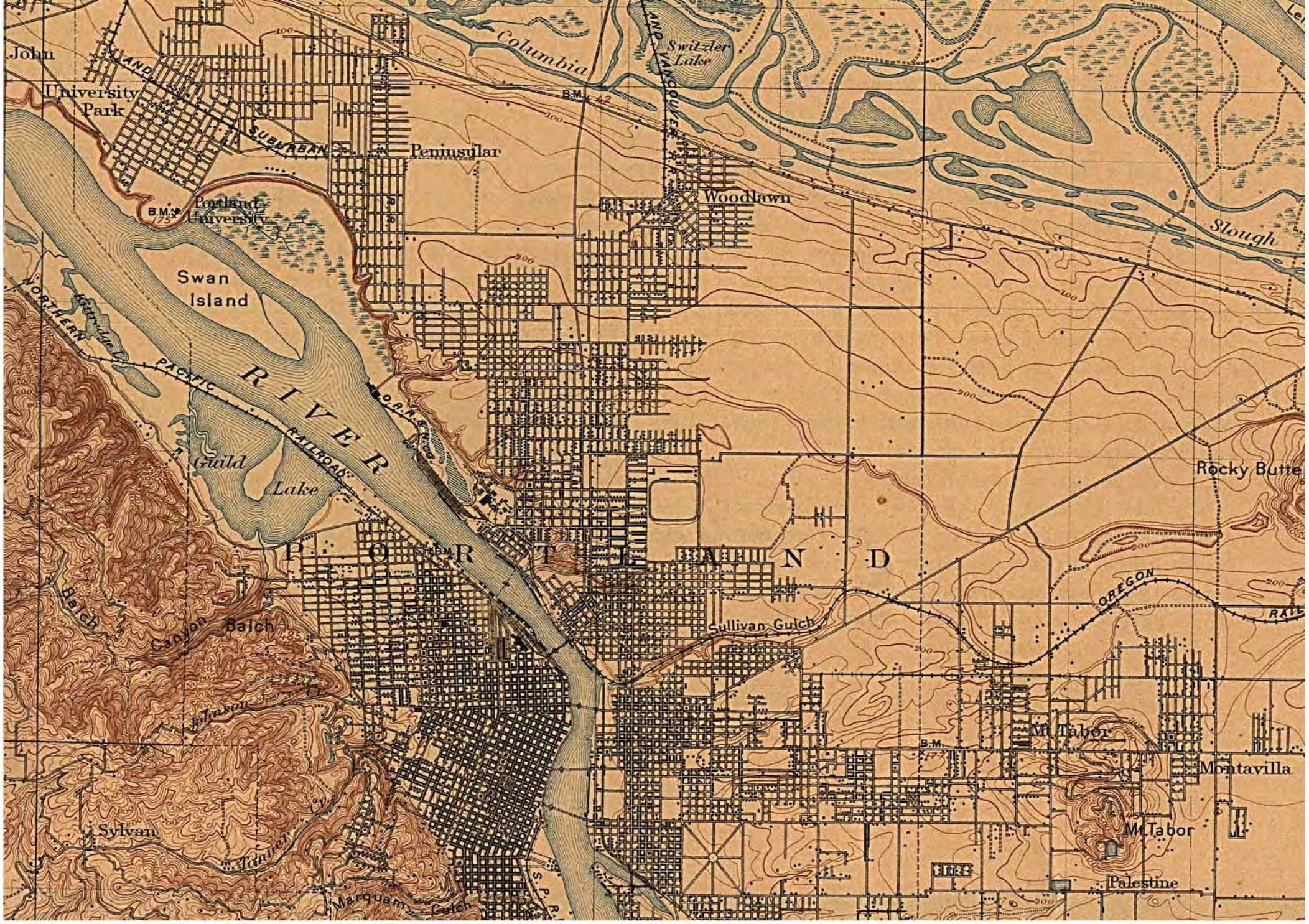
SANITARY GRAVITY MAIN
COMBINED GRAVITY MAIN
STORM GRAVITY MAIN
SANITARY PRESSURE MAIN
COMBINED PRESSURE MAIN
STORM PRESSURE MAIN
INLETS
INLET LEADS
CULVERT
CONSTRUCTED CHANNEL
FRENCH DRAIN
DITCH
NATURAL CHANNEL
POLLUTION REDUCTION FAC.
CONNECTION
LATERALS
ABANDONED MAIN

* Note - All pipes which have this yellow undertone are under construction and not as-built

EASEMENTS

Topographic Maps

US Geological Survey. 1897. Topographic Map. Available at: www.lib.utexas.edu/maps/historical/portland_or_1897.jpg

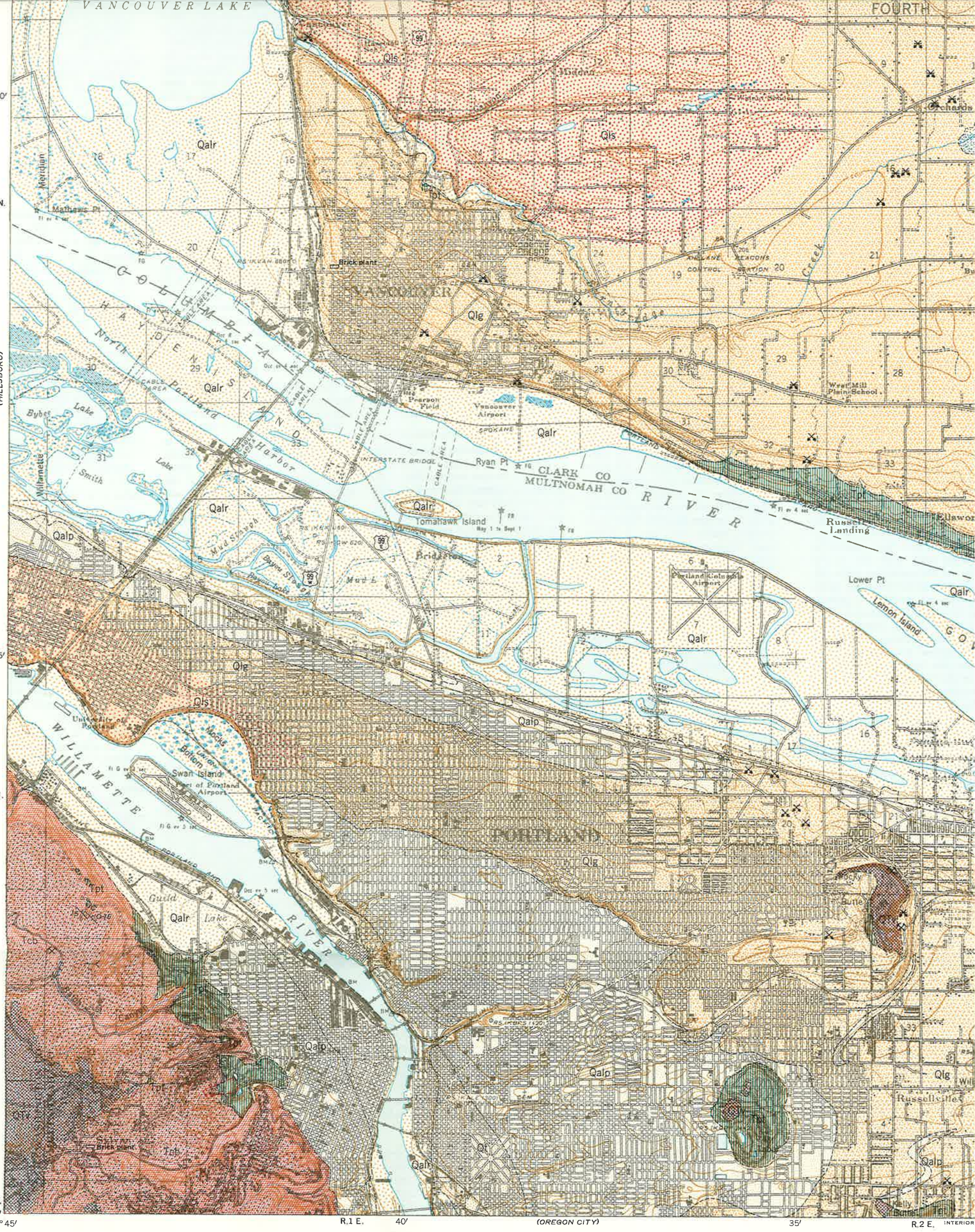


Scale $\frac{1}{62500}$

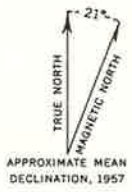
1 ½ 0 1 2 3 4 Miles

1 ½ 0 1 2 3 4 5 Kilometers

US Army Corps of Engineers. 1940. Topographic Map.



Base map by Corps of Engineers
U. S. Army, 1940



GEOLOGIC MAP
OF THE
PORTLAND QUADRANGLE, OREGON–WASHINGTON

By

Donald E. Trimble

Scale 1: 62500

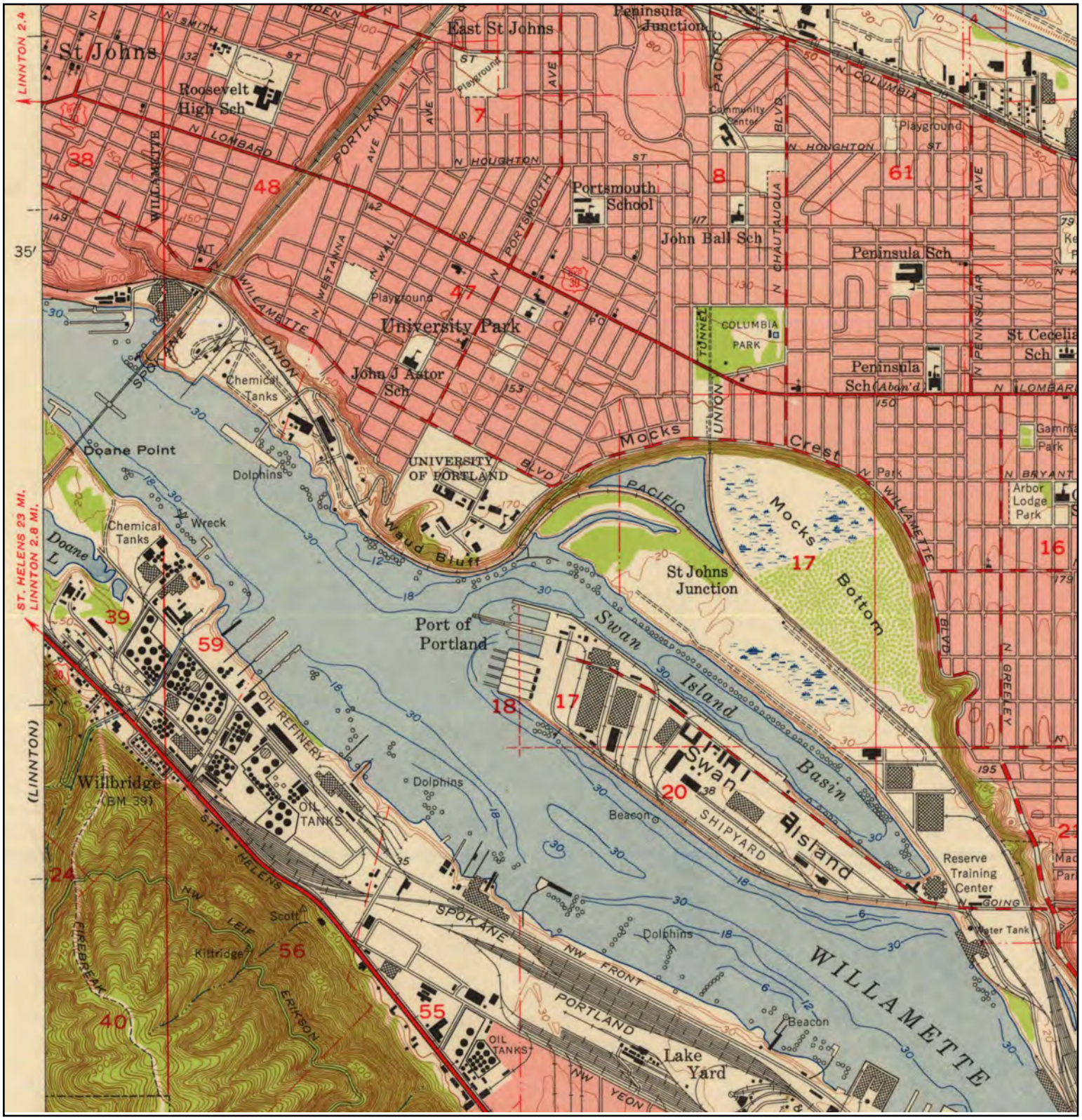
1 ½ 0 1 2 3 Miles

Contour interval 25 feet
Datum is mean sea level

1957

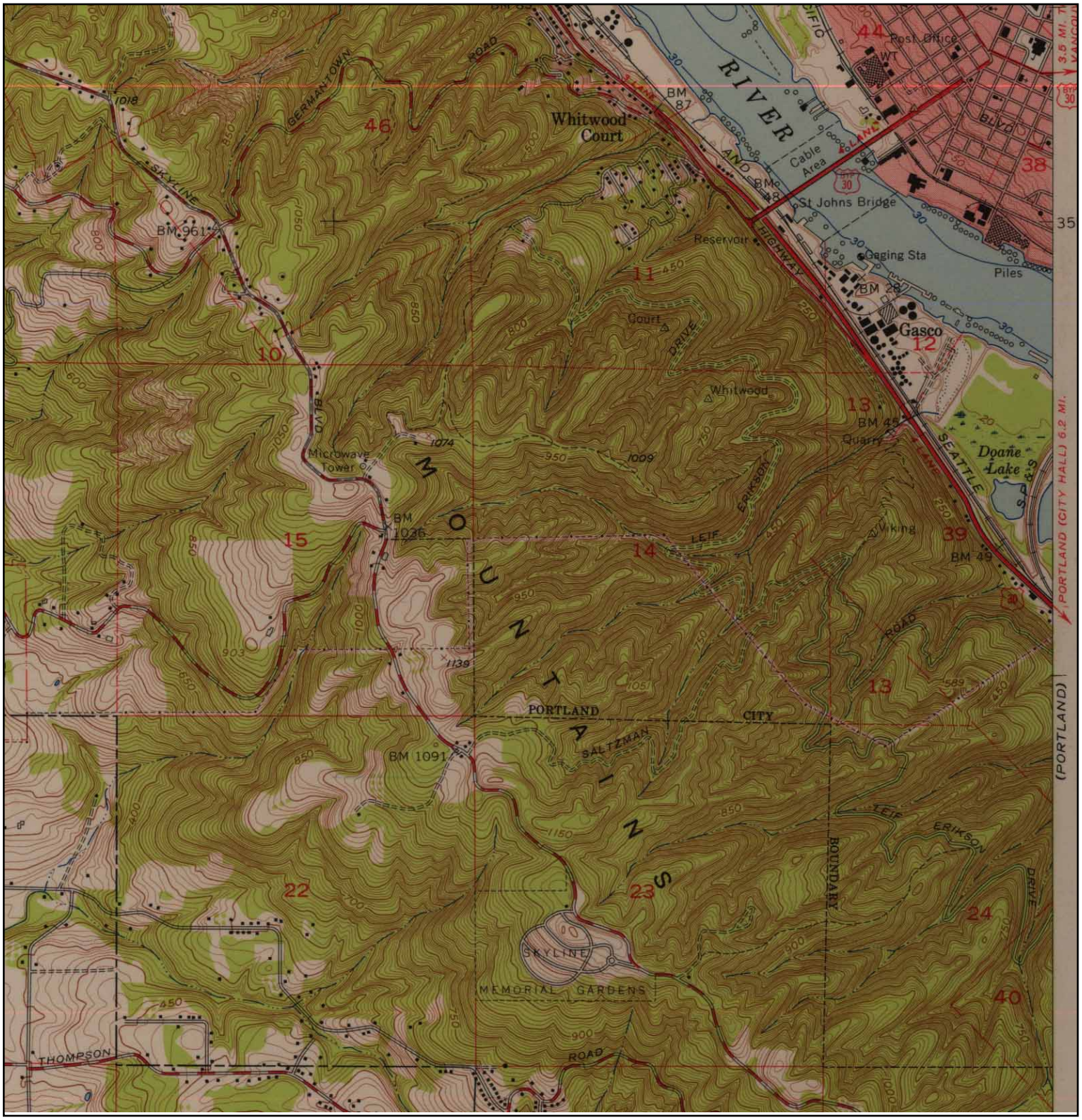
US Geological Survey. 1954. Topographic Map. Environmental Data Resources.

Historical Topographic Map



N	TARGET QUAD NAME: Portland, OR MAP YEAR: 1954 SERIES: 7.5 SCALE: 1:24,000	SITE NAME: 6200 NW Saint Helens Rd ADDRESS: 6200 NW Saint Helens Rd Portland, OR 97210 LAT/LONG: 45.5664 / 122.749	CLIENT: Integral Consulting, Inc. CONTACT: Manon Tanner INQUIRY#: 2532194.1 RESEARCH DATE: 07/07/2009

Historical Topographic Map



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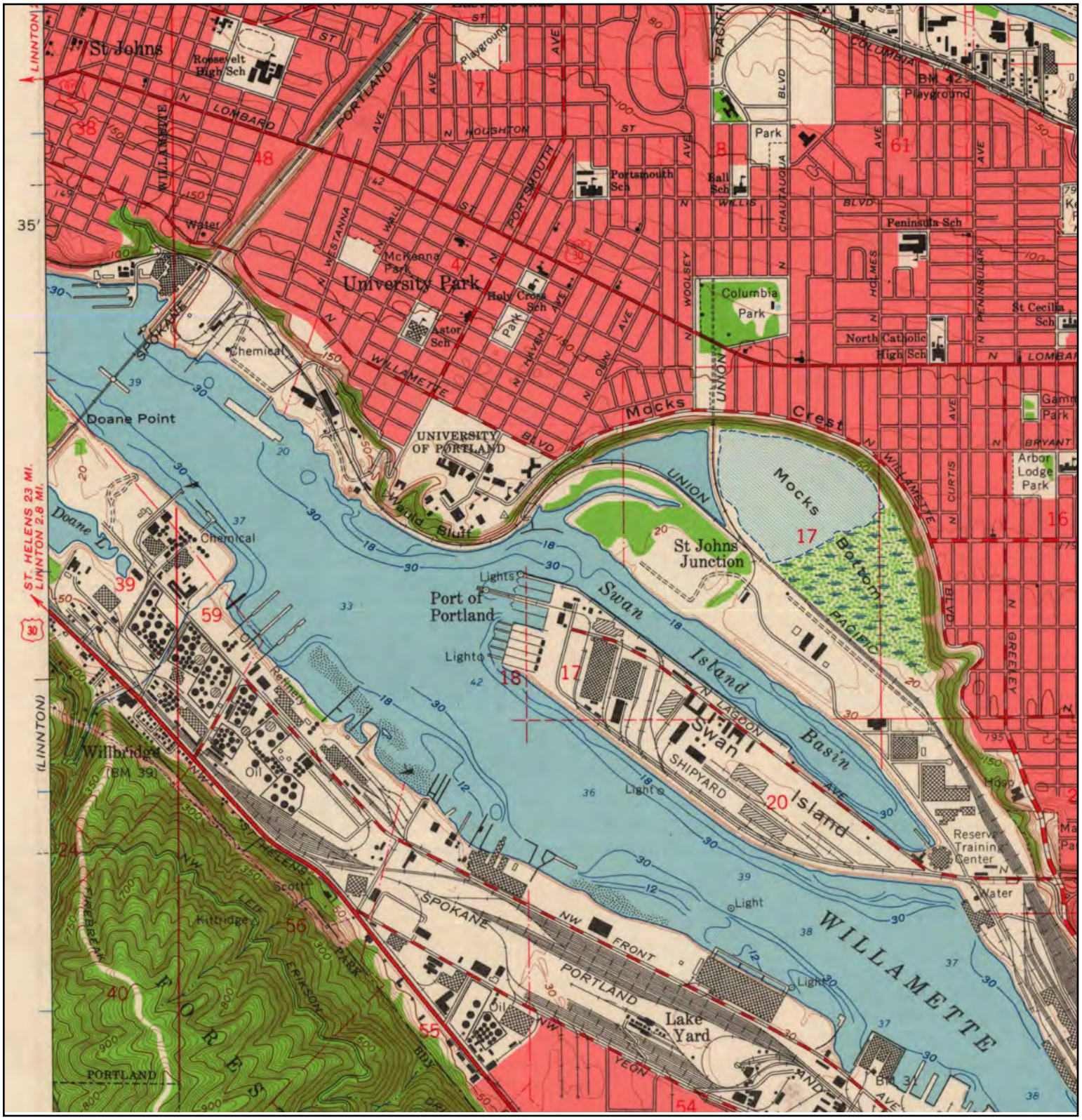
US Geological Survey. 1961. Topographic Map. Environmental Data Resources.

Historical Topographic Map



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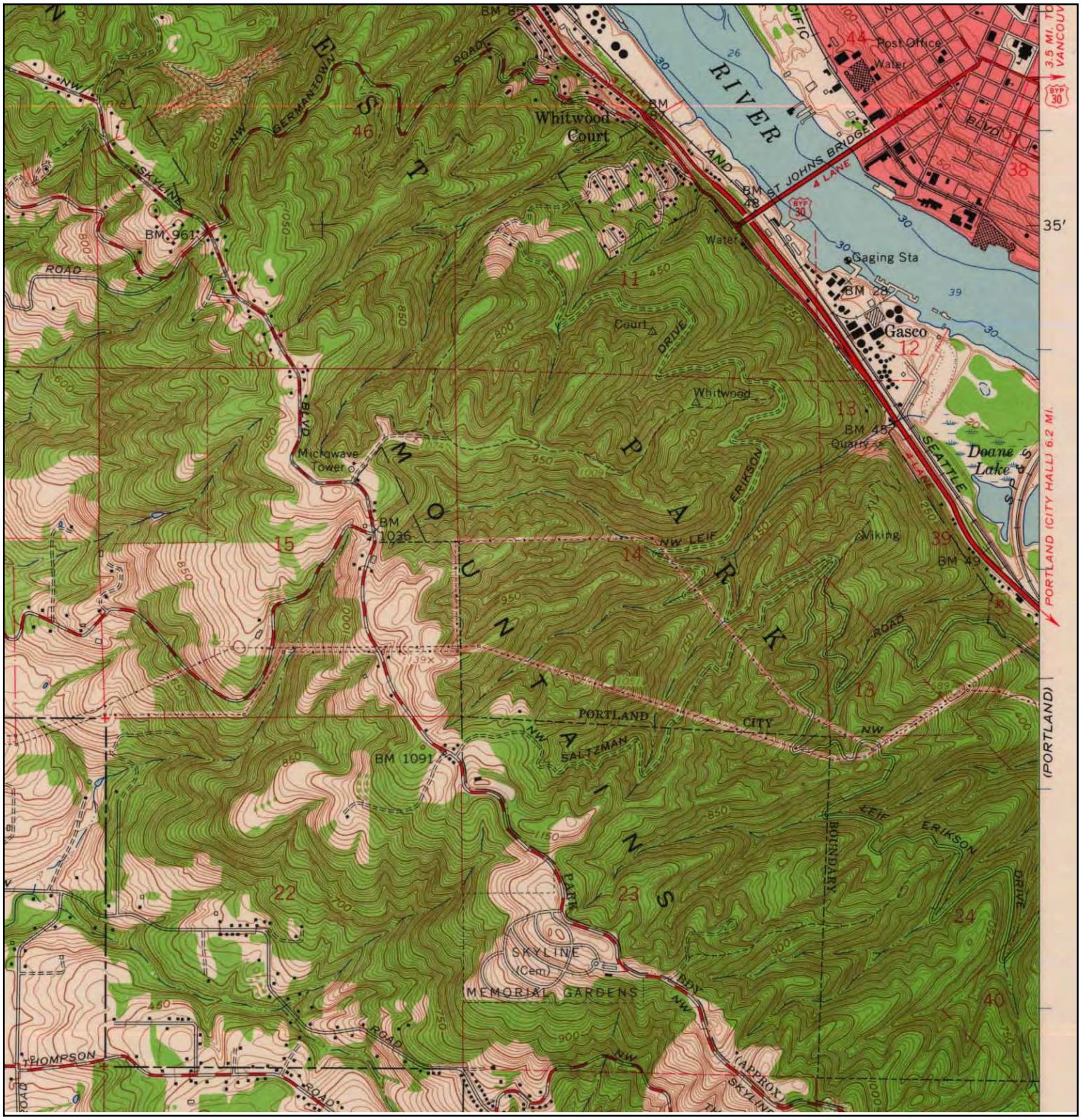
Historical Topographic Map



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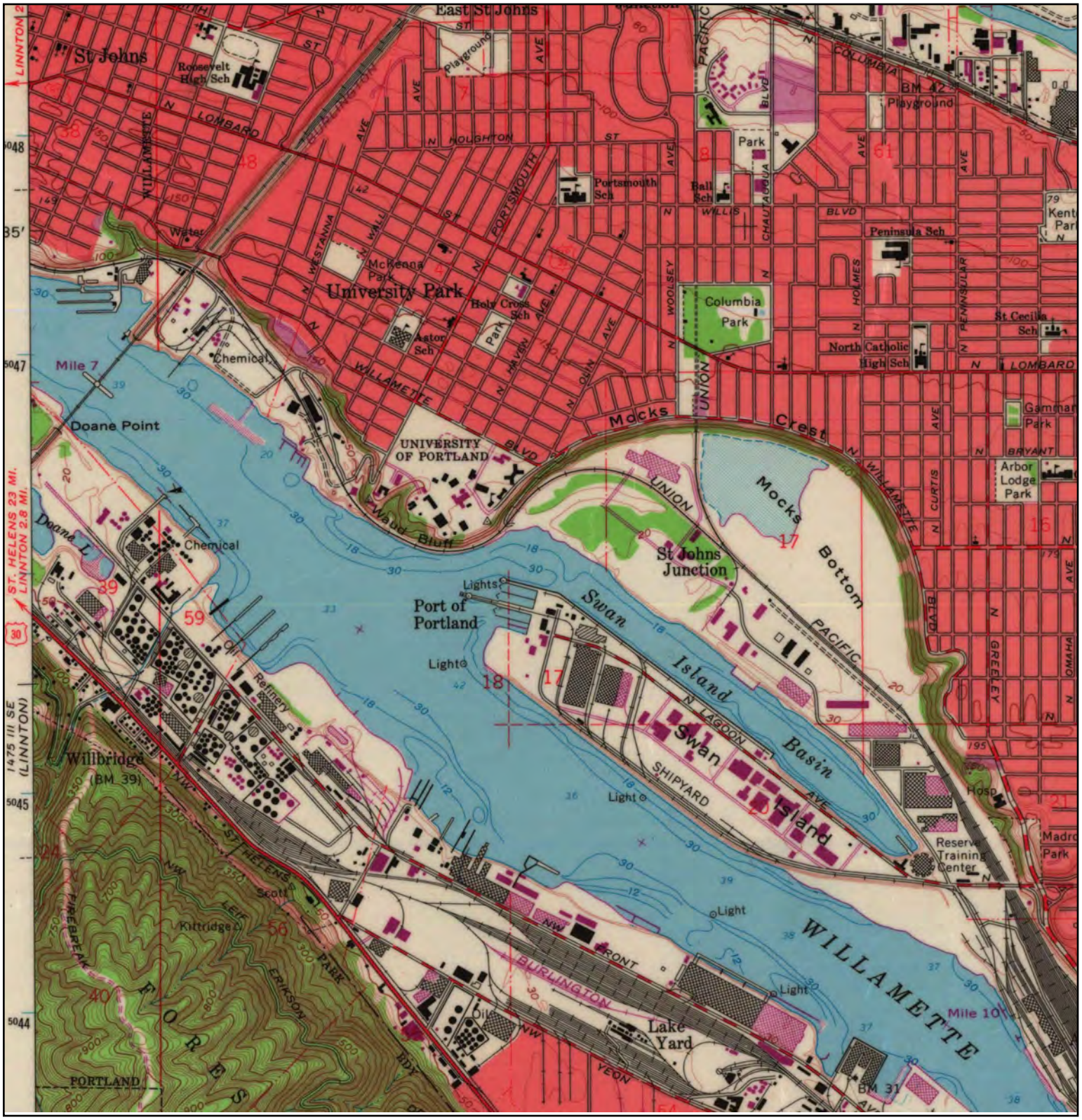
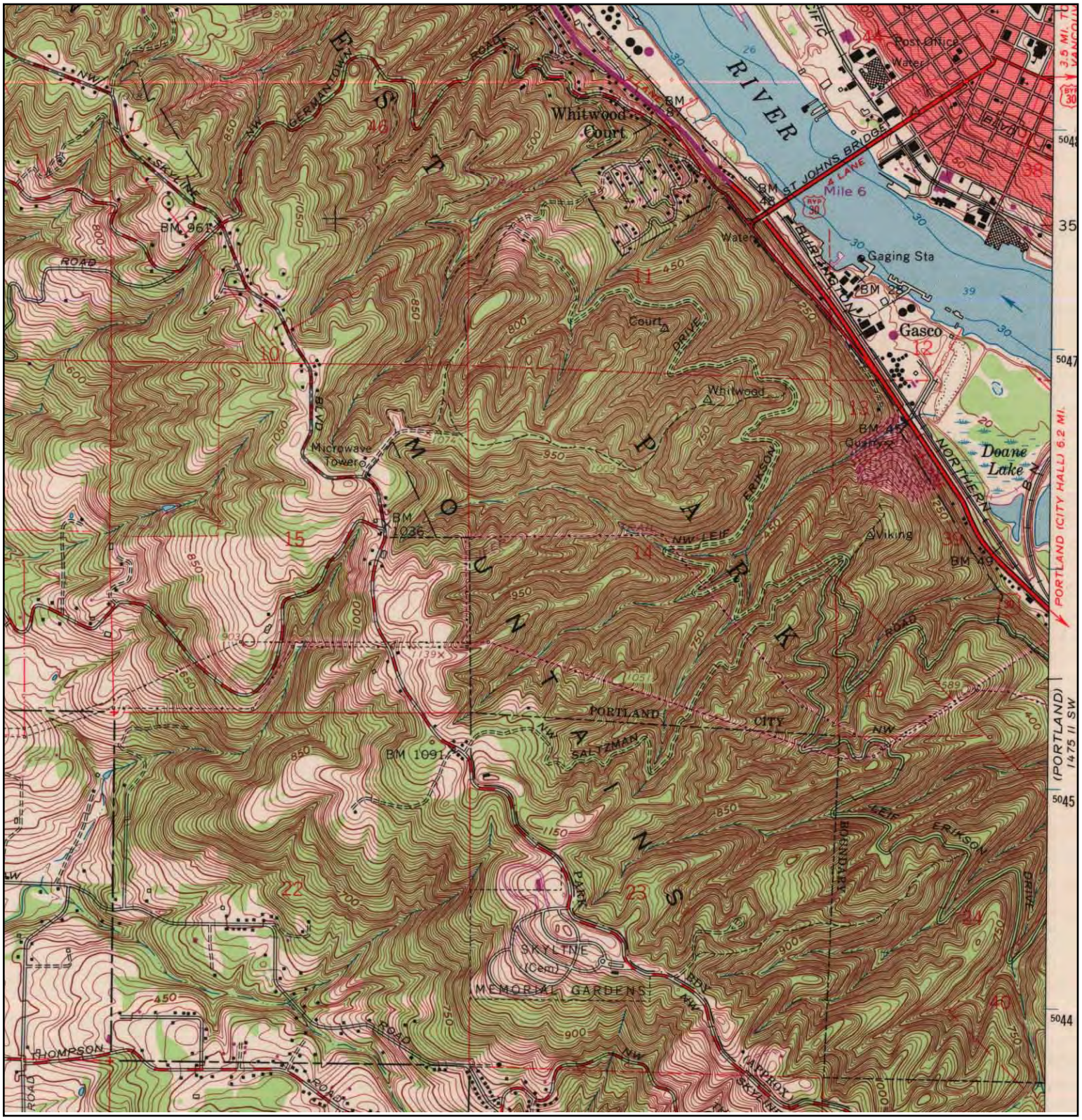
US Geological Survey. 1970. Topographic Map. Environmental Data Resources.

Historical Topographic Map



N	TARGET QUAD NAME: Portland, OR MAP YEAR: 1970 PHOTOREVISED FROM:1961 SERIES: 7.5 SCALE: 1:24,000	SITE NAME: 6200 NW Saint Helens Rd ADDRESS: 6200 NW Saint Helens Rd Portland, OR 97210 LAT/LONG: 45.5664 / 122.749	CLIENT: Integral Consulting, Inc. CONTACT: Manon Tanner INQUIRY#: 2532194.1 RESEARCH DATE: 07/07/2009

Historical Topographic Map



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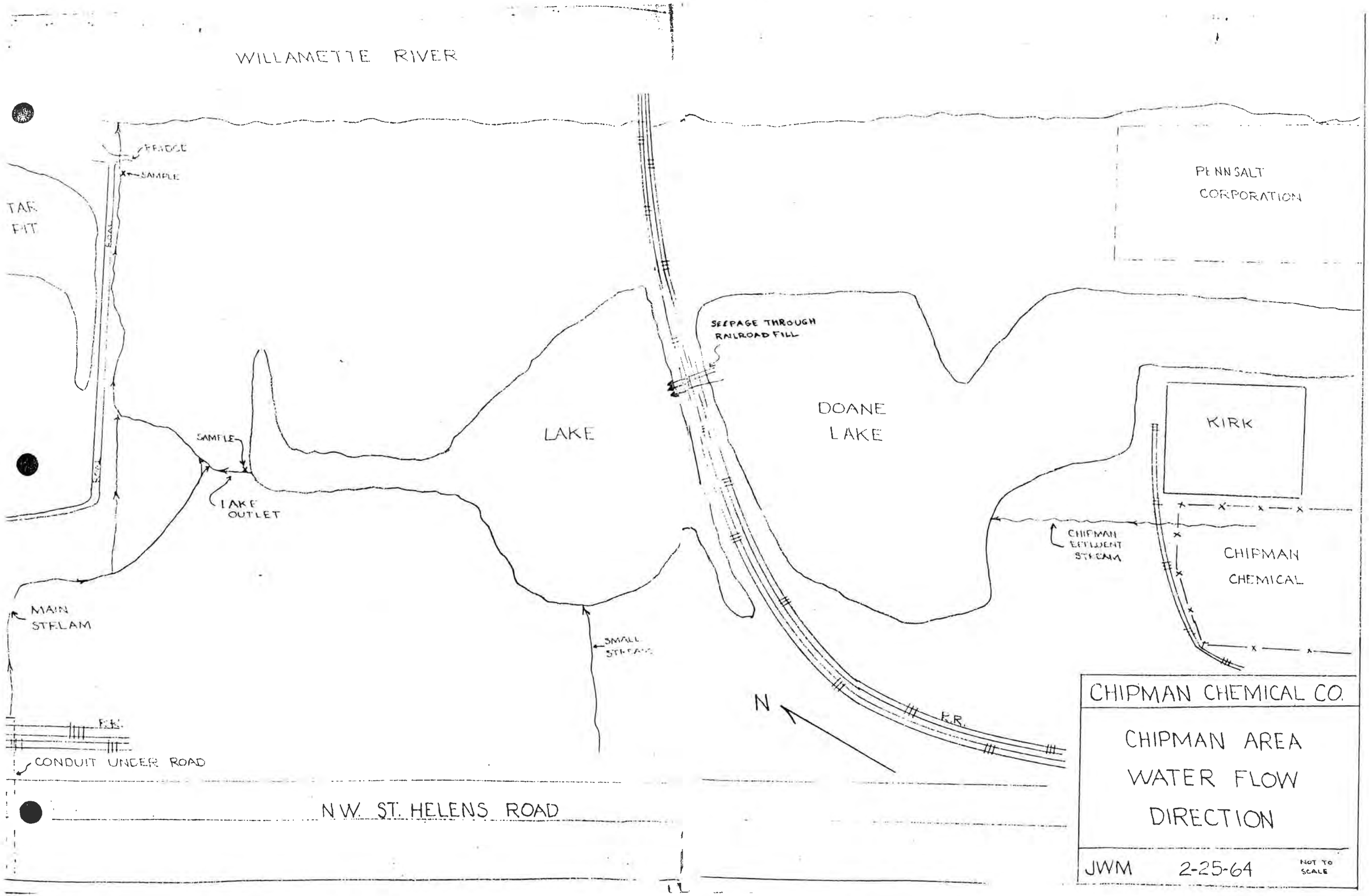
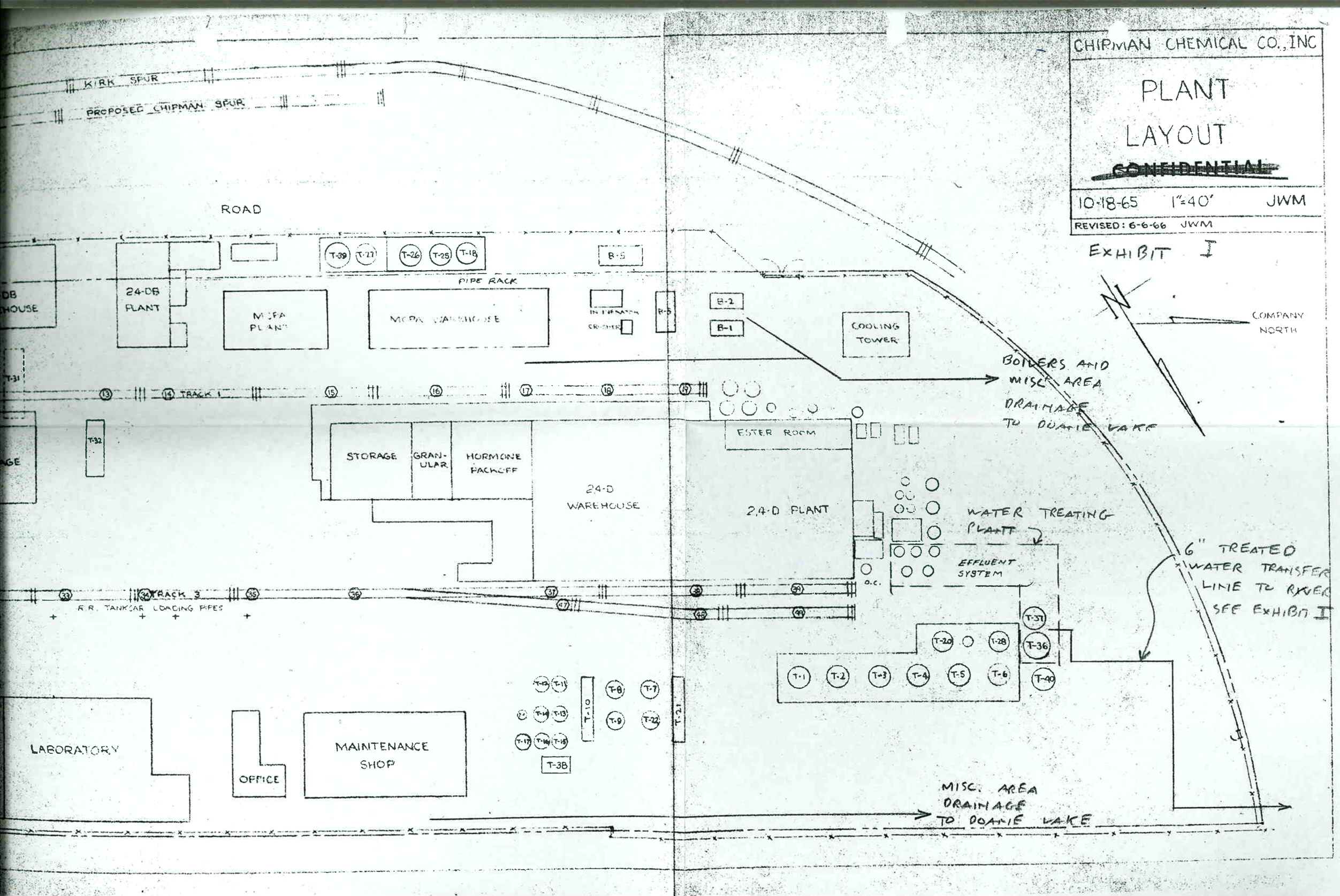
Other Maps

Oregon DEQ. 1964. Doane Lake Drainage Map.

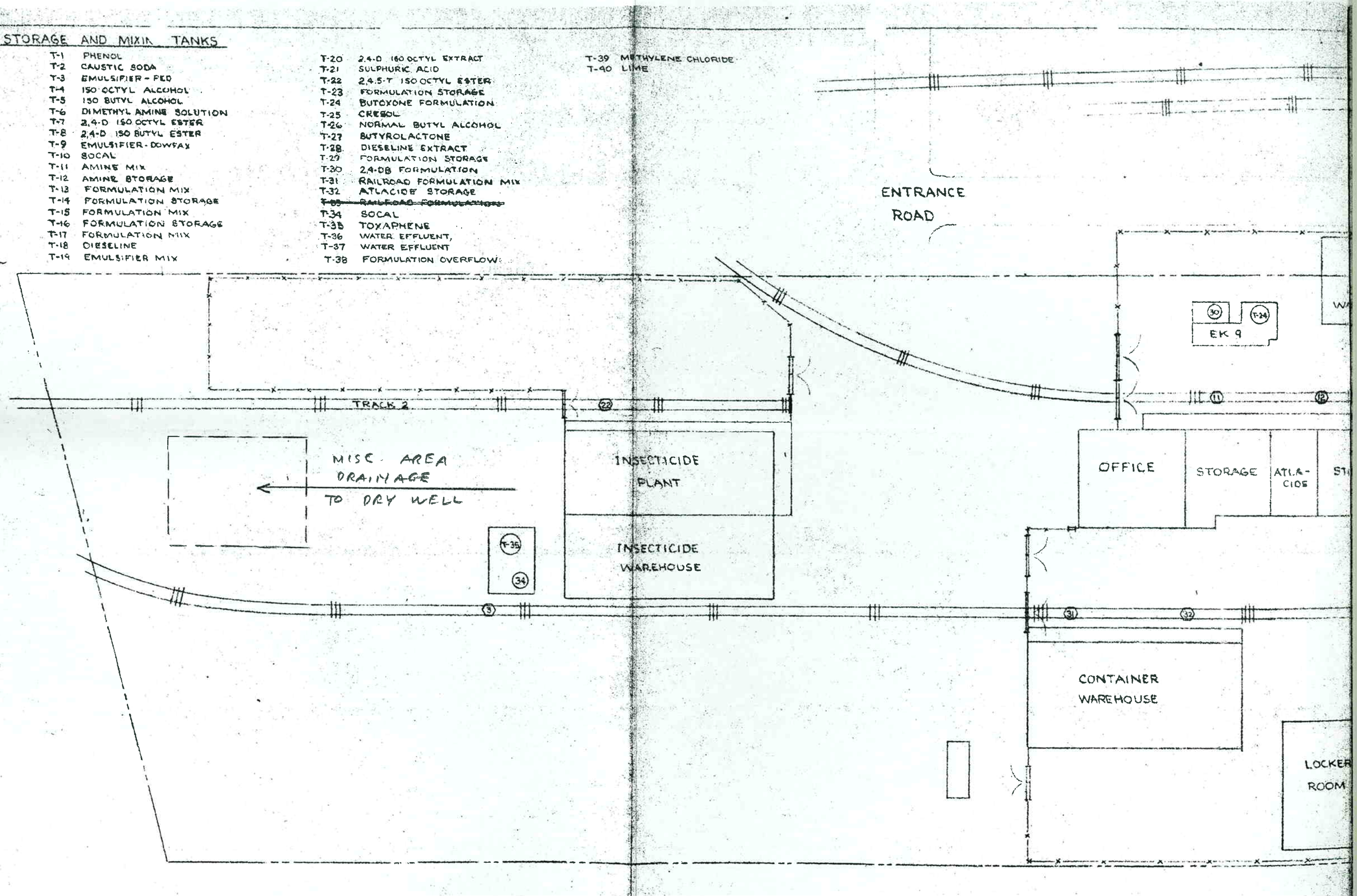

WILLAMETTE RIVER
BRIDGE
SAMPLE
TAR PIT
PENNSALT CORPORATION
SEEPAGE THROUGH RAILROAD FILL
DOANE LAKE
LAKE
KIRK
SAMPLE
LAKE OUTLET
CHIPMAN EFFLUENT STREAM
CHIPMAN CHEMICAL
MAIN STREAM
SMALL STREAMS
N
R.R.
CONDUIT UNDER ROAD
N.W. ST. HELENS ROAD
CHIPMAN CHEMICAL CO.
CHIPMAN AREA WATER FLOW DIRECTION
JWM 2-25-64
NOT TO SCALE

Oregon DEQ. 1965. Rhone Poulenc Plant Layout Map.

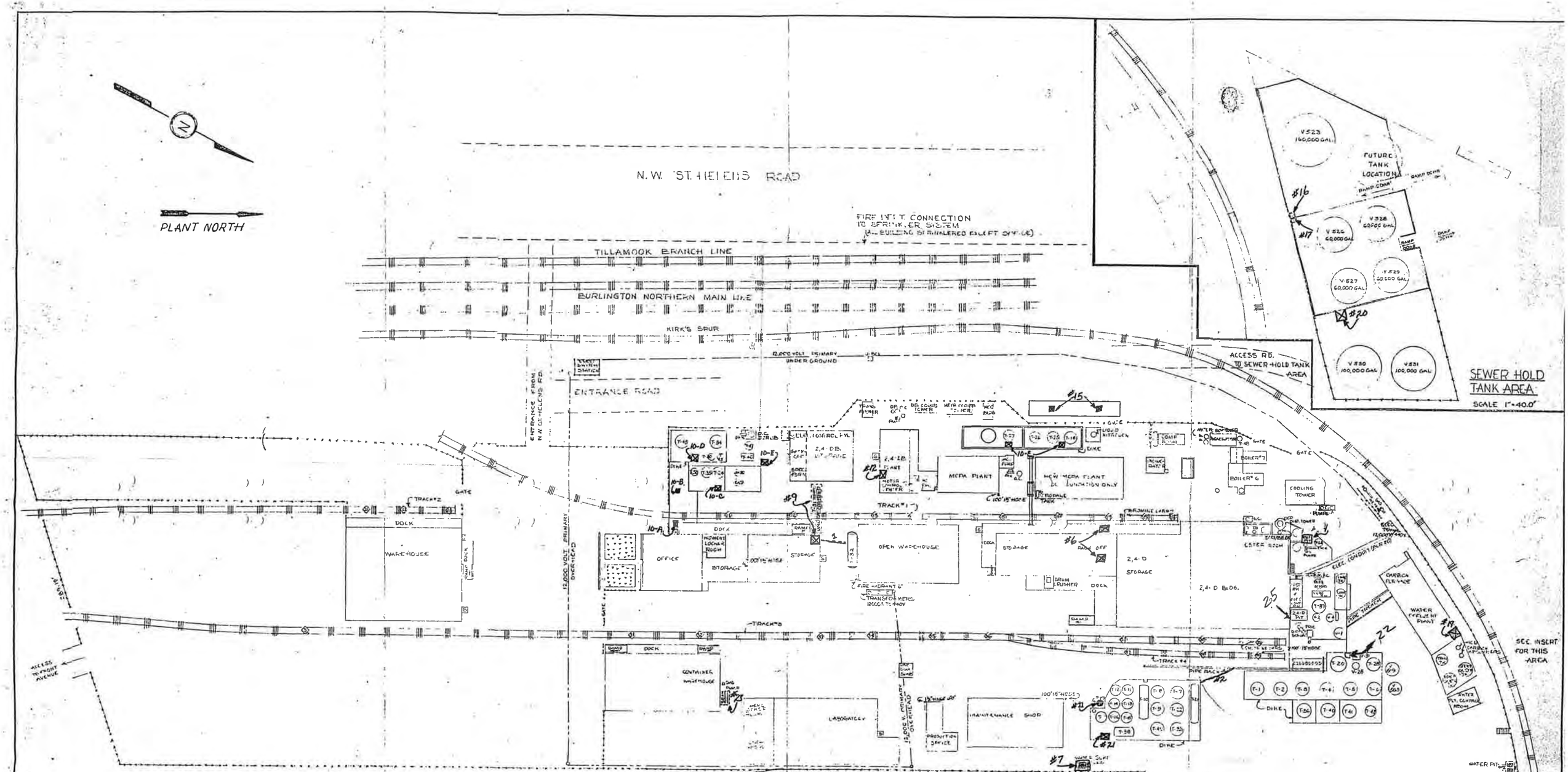

CHIPMAN CHEMICAL CO., INC
PLANT
LAYOUT
CONFIDENTIAL
10-18-65 1"=40' JWM
REVISED: 6-6-66 JWM
EXHIBIT I
KIRK SPUR
PROPOSED CHIPMAN SPUR
ROAD
24-DB PLANT
MCPA PLANT
MCPA WAREHOUSE
PIPE RACK
T-39
T-27
T-26
T-25
T-18
B-5
B-2
B-1
COOLING TOWER
COMPANY NORTH
BOILERS AND MISC. AREA DRAINAGE TO DOANE LAKE
TRACK 1
STORAGE
GRAN-ULAR
HORMONE PACKOFF
24-D WAREHOUSE
ESTER ROOM
2,4-D PLANT
WATER TREATING PLANT
EFFLUENT SYSTEM
6" TREATED WATER TRANSFER LINE TO RIVER SEE EXHIBIT I
TRACK 3
R.R. TANKCAR LOADING PIPES
T-31
T-32
T-37
T-36
T-40
T-20
T-28
T-1
T-2
T-3
T-4
T-5
T-6
T-10
T-21
T-8
T-7
T-9
T-22
T-38
LABORATORY
OFFICE
MAINTENANCE SHOP
MISC. AREA DRAINAGE TO DOANE LAKE

STORAGE AND MIXIN TANKS

T-1 PHENOL
T-2 CAUSTIC SODA
T-3 EMULSIFIER - FED
T-4 150 OCTYL ALCOHOL
T-5 150 BUTYL ALCOHOL
T-6 DIMETHYL AMINE SOLUTION
T-7 2,4-D 150 OCTYL ESTER
T-8 2,4-D 150 BUTYL ESTER
T-9 EMULSIFIER - DOWFAX
T-10 SOCAL
T-11 AMINE MIX
T-12 AMINE STORAGE
T-13 FORMULATION MIX
T-14 FORMULATION STORAGE
T-15 FORMULATION MIX
T-16 FORMULATION STORAGE
T-17 FORMULATION MIX
T-18 DIESELINE
T-19 EMULSIFIER MIX
T-20 2,4-D 160 OCTYL EXTRACT
T-21 SULPHURIC ACID
T-22 2,4,5-T 150 OCTYL ESTER
T-23 FORMULATION STORAGE
T-24 BUTOXONE FORMULATION
T-25 CRESOL
T-26 NORMAL BUTYL ALCOHOL
T-27 BUTYROLACTONE
T-28 DIESELINE EXTRACT
T-29 FORMULATION STORAGE
T-30 2,4-DB FORMULATION
T-31 RAILROAD FORMULATION MIX
T-32 ATLACIDE STORAGE
~~T-33 RAILROAD FORMULATION~~
T-34 SOCAL
T-35 TOXAPHENE
T-36 WATER EFFLUENT,
T-37 WATER EFFLUENT
T-38 FORMULATION OVERFLOW
T-39 METHYLENE CHLORIDE
T-40 LIME



Oregon DEQ. 1979. Rhone Poulenc Plant Layout Map.



LEGEND:
O.C. - ODOR CONTROL
S - SPRINKLER SYSTEM CONTROL STATION

STORAGE & MIXING TANKS

T-1	PHENOL STORAGE	24,670 GAL	T21 DCP STORAGE	20,000	T41 ISO-OCTYL ESTER EXTRACT 29,825
T-2	CAUSTIC STORAGE	20,160	T22 2,4-D ISO OCTYL ESTER (HI GRADE)	2,500	T42 MINERAL SPIRITS 12,000
T-3	2,4-D ISO-OCTYL ESTER	11,670	T23 PACK OFF STORAGE	600	T43 BROMOXYNIL OCTANOATE 20,000
T-4	ISO OCTYL ALCOHOL	11,670	T24 SPECIALITY FORMULATION	3,000	T44 MCPA ESTER STORAGE 1,500
T-5	ISO-BUTYL ALCOHOL	25,000	T25 CRESOL STORAGE	12,000	
T-6	DIMETHYL AMINE	12,520	T26 BLO STORAGE	6,000	T46 SPECIALITY FORM. 1,500
T-7	2,4-D ISO OCTYL EXT.	25,600	T27 IOA STORAGE	12,000	T47 SPECIALITY FORM. 1,500
T-8	2,4-D ISO-BUTYL ESTER	21,800	T28 IOA EXTRACT	20,150	T48 BOILER COLD START 500
T-9	EMULSIFIER	12,000	T29 INSIDE FORMULATION	590	T49 IOA STORAGE 25,000
T-10	EMICOL	8,000	T30 MCPA IOE STG.	1,500	T50 BROMOXYNIL OCTANOATE 2,000
T-11	AMINE MIX	5,000	T31 R.R. FORM. MIX	31,000	T51 2,6 DCP STORAGE 10,000
T-12	AMINE STORAGE	5,000	T32 AMINE STORAGE	10,000	EK9 1,000
T-13	FORMULATION MIX	5,000	T33 2,4-D IOET STG. (HI GRADE)	12,000	EK10 1,000
T-14	FORMULATION STORAGE	5,000	T34 XYLENE STG.	12,000	
T-15	FORMULATION MIX	5,000	T35 SPEC. FORMULATIONS	3,000	
T-16	FORMULATION STORAGE	5,000	T36 ORTOCHLORO PHENOL	12,600	
T-17	FORMULATION MIX	5,000	T37 PARACHLORO PHENOL	28,800	
T-18	FUEL OIL STORAGE (HEAVY OIL)	11,760	T38 FORM. OVERFLOW	5,000	
T-19	EMULSIFIER MIX	600	T39 DCM STORAGE	11,916	
T-20	EMUL. FORM. MIX	27,600	T40 HCL STORAGE	12,375	

SCHEDULE C, Condition 2

The underground testing of product storage tanks, underground lines, tank farms, sumps, and pits shall be carried out as follows:

A. The following items will be tested statically, measured, and re-measured 24 hours later.

	Item
1. Gasoline storage tank	23
2. T-31 and Atlacide pit	9
3. DB pit	12
4. EK-9, pits A, B, C, D, E, and F	10
5. Tank truck pad pit by N_2 tank	15
6. V-523 sump	16
7. City sewer sump	17
8. Effluent sump by HCl adsorbers	19
9. Rainwater sump	20
10. Formulation sump	21
11. 2,4-D tank farm sump	22
12. T-19 sump	11
13. Packoff sumps [2]	6
14. Lab sump by maintenance shop	7
15. Ester pit sump	24
16. 2,4-D pit	25

B. The following lines will be tested by using 75 psig air pressure for thirty (30) minutes.

1. Two-inch [2] transfer line from T-31 to T-32.
2. Two-inch [2] DMA transfer lines from formulation tank farm to pipe rack.

State of Oregon
DEPARTMENT OF ENVIRONMENTAL QUALITY
RECEIVED
NOV 12 1982
WATER QUALITY CONTROL

NO.	REVISION	DATE	BY	APP
1	[illegible]	[illegible]	[illegible]	
2	[illegible]	[illegible]	[illegible]	
3	[illegible]	[illegible]	[illegible]	
4	[illegible]	5-28-79	[illegible]	
5	[illegible]	4-29-79	[illegible]	
6	ADDED SEWER HOLD TANK AREA INSET	6-27-79	[illegible]	

NOV. 1982

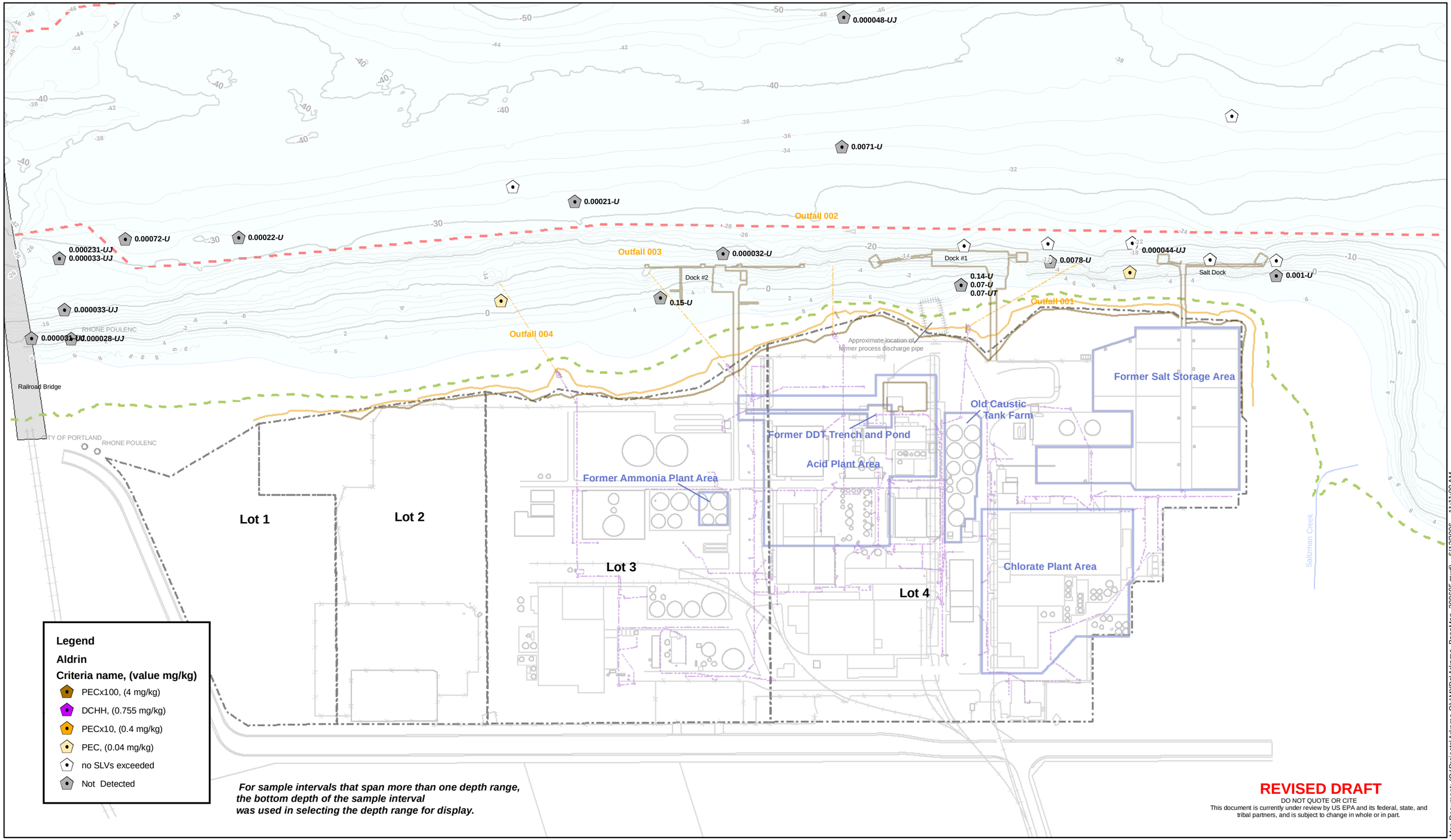
RHONE-POULENC INC.
PORTLAND, OREGON

DR GHD | CH | APP. [illegible] | DATE 4/3/79
SCALE 1" = 40' | W.O. | PROJ.

PLANT LAYOUT

LOCATION PORTLAND | DWG. NO. PL-3-0

2006 Arkema EECA Maps



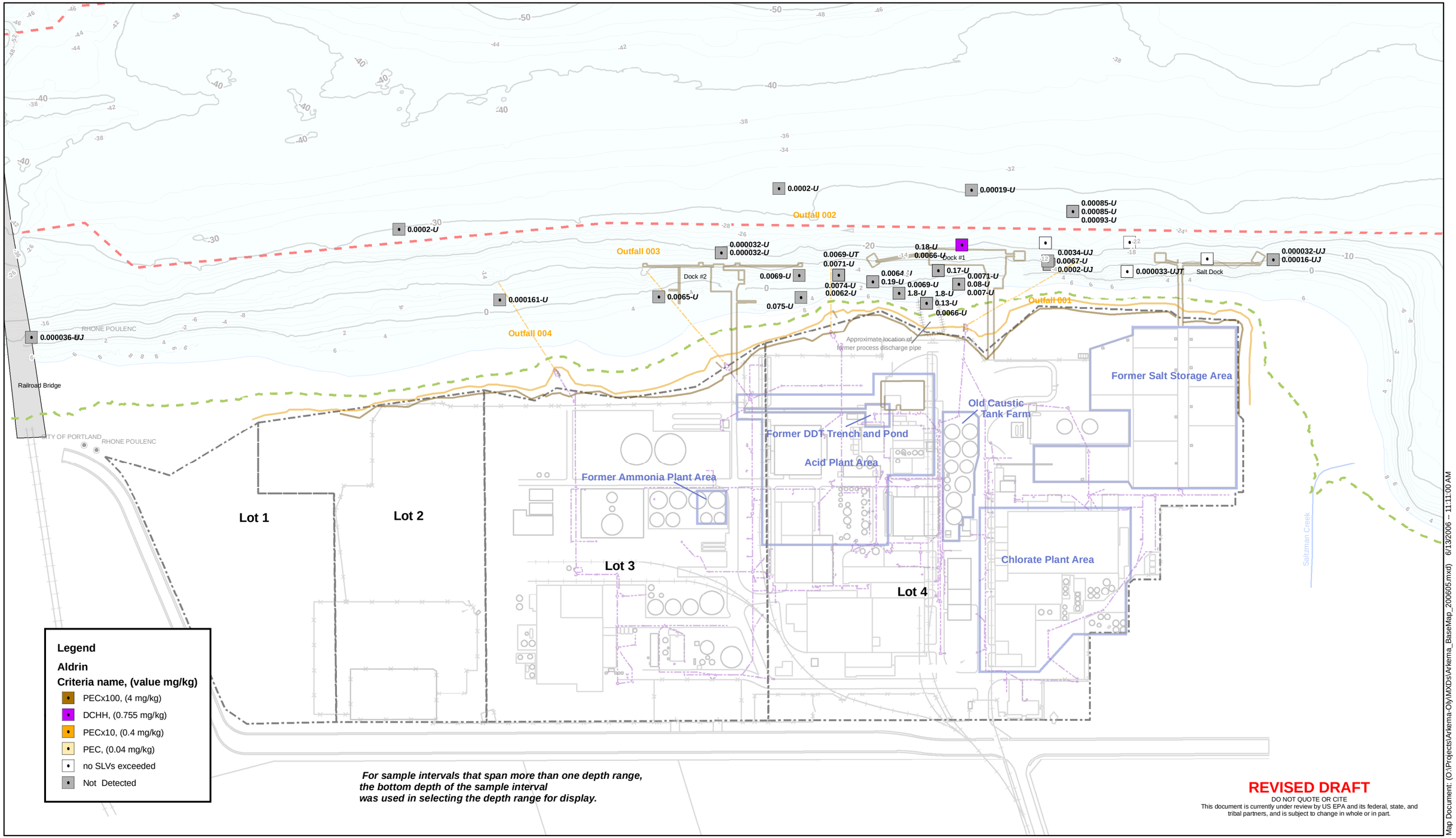
integral consulting inc.

200 100 0 200 Feet

FEATURE SOURCES:
Bathymetric Information: Multibeam bathymetric survey conducted by David Evans and Associates, Inc. from February 6 - March 6, 2004.
Contours were derived from a Digital Terrain Model (DTM) based on a three-foot grid of multibeam data.
Vertical Datum: North American Vertical Datum of 1988(NAVD88).
Horizontal Datum: North American Datum of 1983 - 91 adjusted (NAD83/91), State Plane Coordinate System (SPCS), Oregon North Zone.
Units: International Feet.
Basemap: Basemap features updated in 2006 by David Evans and Associates. Ordinary high water line, top of bank, and other site features surveyed in April 2006.
Most buildings and structures on the Arkema site have been demolished or removed.
OHW and Top of Slope lines were created from the April 2006 DEA survey, the +12ft contour line was derived from the combined lidar/bathymetry grid.
Lot Lines: Created by importing pdf file from ERM, georeferencing to CAD lines (RMS error = 2.3042) and heads-up digitizing the lot lines.

Ordinary High Water
Top of Bank
E-Sewer-L
Storm Drain
12ft_Contour
Bridges
Property Lines
Navigation Channel
River
Outfalls

Map-214
Arkema Site
Surface & Sub-Surface Sediment Samples
Depth Range: Intermediate Subsurface (4-8 ft)
Aldrin



integral consulting inc.

200 100 0 200 Feet

FEATURE SOURCES:
Bathymetric Information: Multibeam bathymetric survey conducted by David Evans and Associates, Inc. from February 6 - March 6, 2004.
Contours were derived from a Digital Terrain Model (DTM) based on a three-foot grid of multibeam data.
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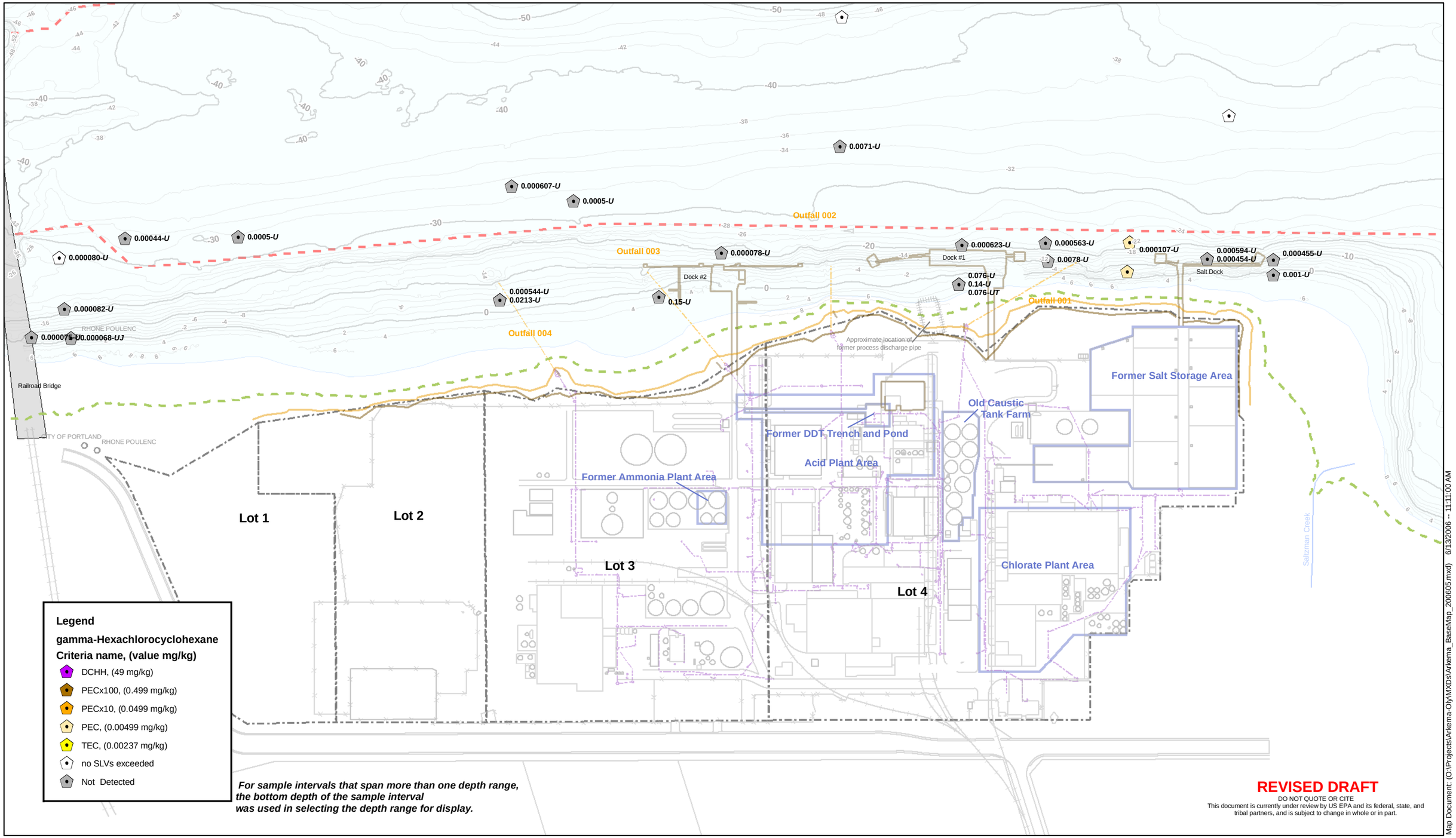
Ordinary High Water
Top of Bank
E-Sewer-L
Storm Drain
12ft_Contour
Bridges
Property Lines
Navigation Channel
River
Outfalls

Map-215
Arkema Site
Surface & Sub-Surface Sediment Samples
Depth Range: Deep Subsurface (> 8 ft)
Aldrin



integral consulting inc.

200 100 0 200 Feet

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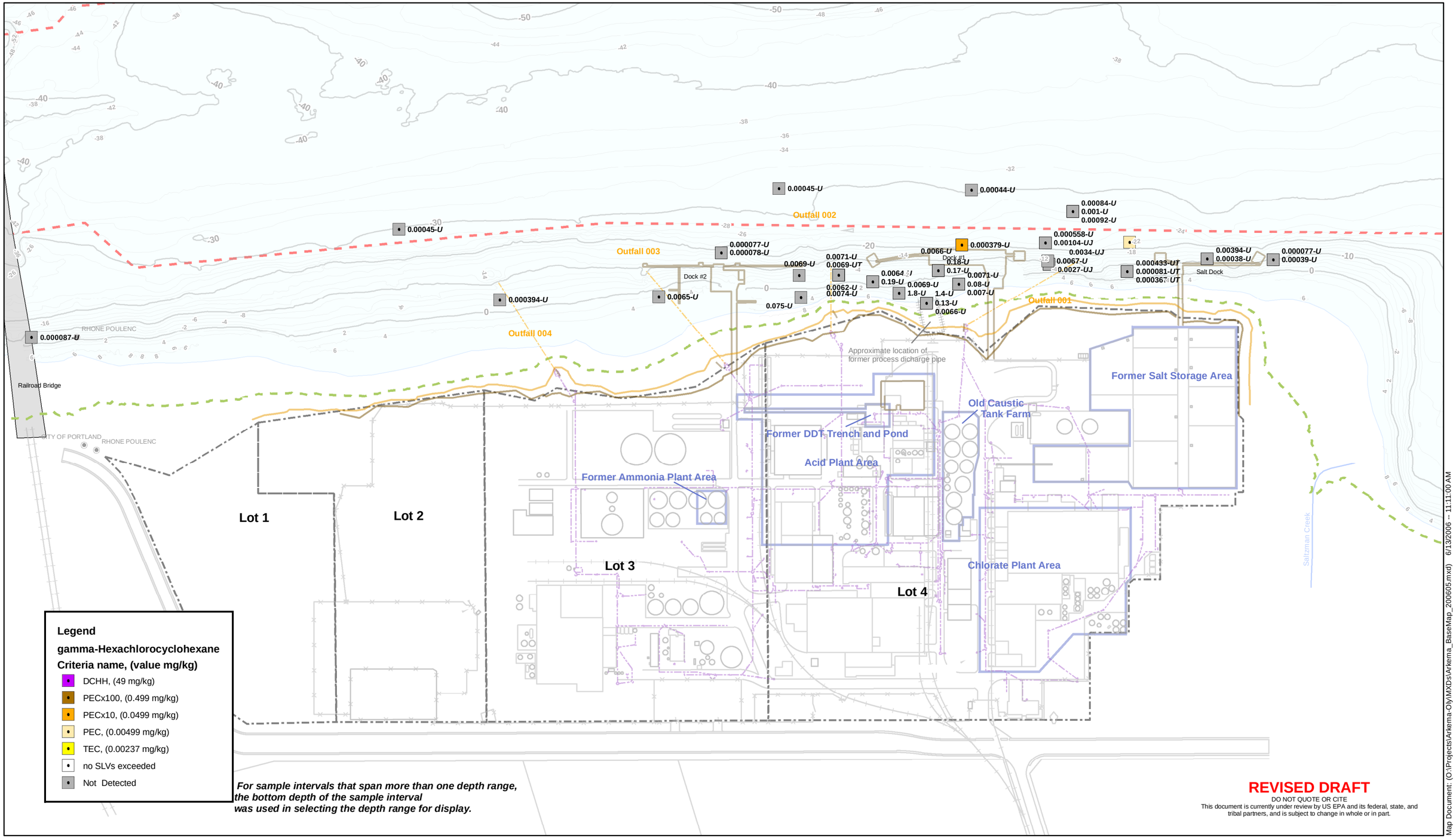
Ordinary High Water
Top of Bank
E-Sewer-L
Storm Drain
12ft_Contour
Bridges
Property Lines
Navigation Channel
River
Outfalls

Map-249
Arkema Site
Surface & Sub-Surface Sediment Samples
Depth Range: Intermediate Subsurface (4-8 ft)
gamma-Hexachlorocyclohexane



integral consulting inc.

200 100 0 200 Feet

FEATURE SOURCES:
Bathymetric Information: Multibeam bathymetric survey conducted by David Evans and Associates, Inc. from February 6 - March 6, 2004.
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Ordinary High Water
Top of Bank
E-Sewer-L
Storm Drain
12ft_Contour
Bridges
Property Lines
Navigation Channel
River
Outfalls

Map-250
Arkema Site
Surface & Sub-Surface Sediment Samples
Depth Range: Deep Subsurface (> 8 ft)
gamma-Hexachlorocyclohexane

City of Portland, Bureau of Planning and Sustainability
Site WR8 Map 1: Doane Lake
October 16, 2009

City of Portland
Bureau of Planning
and Sustainability
October 16, 2009

DRAFT

Site WR8 - Map 1: Doane Lake

2007 Aerial Photography

- Stream/Drainage
- Culvert or Piped
- Site Boundary
- City Boundary
- Urban Services Boundary

INFORMATION SOURCES:

Aerial Orthophotographs:
Natural color and color infrared ortho-rectified digital imagery from flight in June of 2006. Photography has been rectified to adjust for curvature of the earth. Not registered to taxlot base map.

All data compiled from source materials at different scales. For more detail, please refer to the source materials or City of Portland, Bureau of Planning & Sustainability.

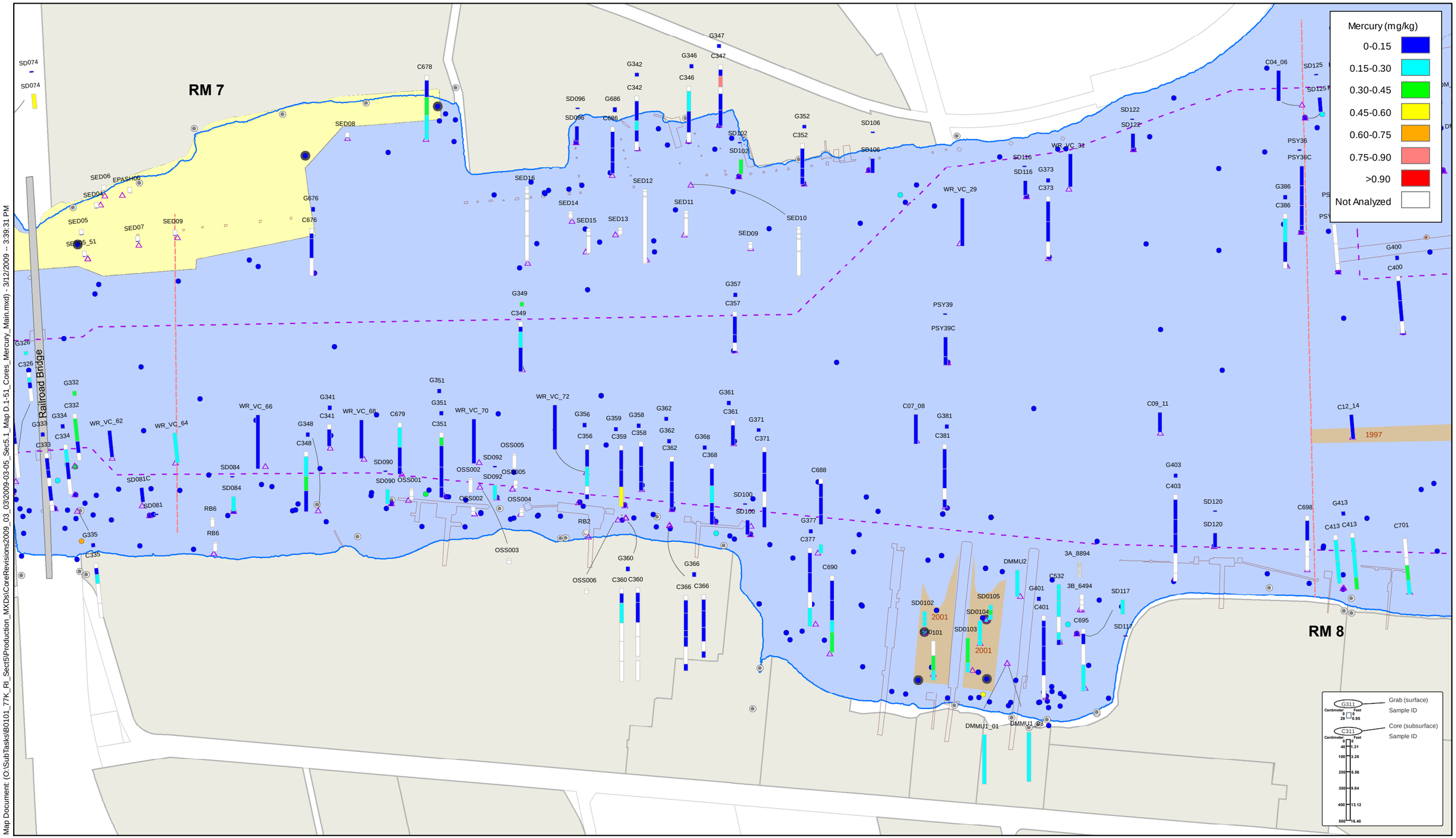
Scale: 1" = 800'

0' 400' 800' 1200'

N

City of Portland Bureau of
Planning & Sustainability
Sam Adams, Mayor | Susan Anderson, Director

Integral, Windward, Kennedy/Jenks, and Anchor QEA. 2009. Portland Harbor RI/FS Remedial Investigation Report. Draft. IC09-0003. Prepared for the Lower Willamette Group, Portland, OR. Integral Consulting Inc., Portland, OR; Windward Environmental LLC, Inc., Seattle, WA; Kennedy/Jenks Consultants, Portland, OR; and Anchor QEA LLC, Seattle, WA. Map D1.1-50h.



Map Document: (O:\SubTasks\B0101_77K_RI_Sect5\Production_MXDs\CoreRevisions2009_03_03\2009-03-05_Sec5.1_Map D.1-51_Cores_Mercury_Main.mxd) - 3/12/2009 -- 3:39:31 PM

integral consulting inc.

LWG Lower Willamette Group

N

FEATURE SOURCES:
Transportation, Property, or Boundaries: Metro RLIS .
Channel & River miles: US Army Corps of Engineers.
Bathymetric Information: David Evans and Associates, Inc.
NOTE: Bottom of cores are generally placed at core sample station, if not possible a tag line indicates the sample location.

0 150 300 450 600 750 Feet

Map Features

- River Miles
- Bridges
- Docks and Structures
- Navigation Channel
- River Edge +13 ft NAVD

Outfalls

- Outfall
- Dock Drain
- Roof Drain

- Surface Chemistry
- Core Locations
- Capping Areas
- Dredging Areas
- Surface Dredge/Cap Locations

- Upland ECSI Sites (2008)
- Waterfront Taxlots

DRAFT

DO NOT QUOTE OR CITE
This document is currently under review by US EPA and its federal, state, and tribal partners, and is subject to change in whole or in part.

Map D1.1- 50 h
Portland Harbor RI/FS
Draft Remedial Investigation Report
Subsurface Sediment Chemistry
Mercury (mg/kg)

River Mile 07 to 08

APPENDIX H

RECONTAMINATION ASSESSMENT

RECONTAMINATION ASSESSMENT

INTRODUCTION

A recontamination evaluation of the dredging, capping, and monitored natural recovery/enhanced natural recovery (MNR/ENR) alternatives was performed to support the Arkema Engineering Evaluation and Cost Analysis (EE/CA). Remedial Alternatives 2(i), 2(r), 3(i), 3(r), 4(i), 4(r), and 5 include various proportions of dredging, capping, and/or MNR/ENR over selected areas within the Arkema removal action area (RAA). Recontamination modeling was performed with a simplified fate and transport model and applicable site-specific data to assess the effects of recontamination on the sediment surface that would be left after implementing each of these above alternatives.

Ongoing sources of constituents of interest (COIs) to the RAA include both upland and upstream activities. Regulation and remediation of upland sources is being performed by Arkema/LSS pursuant to Arkema's Administrative Order on Consent with the Oregon Department of Environmental Quality (DEQ). Potential upland and onsite sources of COIs to the Arkema RAA include groundwater plumes, riverbank erosion, and stormwater discharge. A brief discussion of these onsite sources and proposed source control measures (SCMs) is presented in Section 1.4 of the EE/CA report and offsite uplands sources are presented in Section 4.2 of the EE/CA report. Upland and onsite pathways of other Portland Harbor sites upstream of the Arkema RAA have been identified as potential ongoing sources of COIs (Appendix Q, Anchor QEA et al. 2012). Per the draft Portland Harbor feasibility study (FS), Portland Harbor upland onsite and offsite sources are assumed to be controlled under the DEQ program prior to the commencement of a sediment remedy (Anchor QEA et al. 2012). This assumption was applied for the Arkema screening-level recontamination analysis, and modeled conditions reflect control of onsite sources prior to implementation of sediment removal and capping.

Tributaries to the Willamette River may adversely affect COI concentrations in the Arkema RAA following sediment remediation. DEQ placed Johnson Creek, which enters the Willamette River at river mile (RM) 18.9, on Oregon's 303(d) list of impaired waters due to exceedances of water quality standards for DDT, PCBs, and other COIs (Portland Bureau of Environmental Services 2005). Historical agricultural use of pesticides has likely been the primary source of DDT for Johnson Creek. As a result of these historical sources, DEQ has established a total maximum daily load and waste load allocation in an attempt to control DDT inputs to Johnson Creek and the downstream watershed. The Arkema recontamination analysis examines the impact of potential ongoing upstream sources of COIs, such as those from tributaries, as well as potential future conditions in which these sources are controlled.

RECONTAMINATION MODELING

A mathematical mass balance model, SEDCAM (Jacobs et al. 1988), was applied to evaluate potential recontamination. SEDCAM predicts surficial sediment contaminant concentrations over time. The model assumes that the source inputs of sediments are fully mixed within the surficial layer over the area of potential recontamination. Model inputs include sediment concentrations of incoming (upstream) sediments, sediment load and concentration in the stormwater discharge from the site, initial surficial sediment concentration over the area of potential recontamination, and sedimentation rate. Model input parameters were developed from available site data. Where parameters were uncertain, a range of values was evaluated to provide a bounding estimate of potential sediment concentrations.

The model was set up to evaluate DDD, DDE, and DDT. The evaluation assumed the completion of the onsite stormwater and groundwater SCMs, and evaluated the existing conditions in Portland Harbor as well as the future remediated conditions. The recontamination analysis includes both existing upstream loads and reduced upstream loads, representative of a possible future condition following potential upstream source control activities.

Modeling Approach

The SEDCAM model was developed to estimate natural recovery of contaminated sediments due to burial by cleaner sediments. SEDCAM has frequently been applied to evaluate recontamination following dredging or capping remedial activities. The model provides conservative estimates of surficial sediment concentrations in a mixed layer as a function of incoming loads and initial contaminant concentrations. The SEDCAM mass balance equation is:

$$C_{COI}(t) = \frac{1}{1 + kT_s} * \ C_{COI,DEP} * \left(1 - e^{\frac{-(1+kT_s)t}{T_s}}\right) + \ C_{COI}(0) * e^{\frac{-(1+kT_s)t}{T_s}}$$

Where:

$C_{COI}(t)$ = COI concentration in mixed layer sediment at time t (COI mass/sediment mass)

$C_{COI,DEP}$ = weighted average of COI concentration in sediment deposited over cap area (COI mass/sediment mass)

$C_{COI}(0)$ = initial COI concentration in cap (COI mass/sediment mass)

k = combined first-order decay and diffusion rate constant for COI loss (year^{-1})

t = time (years)

$T_s = ML / R_s$

ML = mixed layer thickness (cm)

R_s = net sedimentation rate (cm/year)

Model inputs (e.g., upstream COI loadings) are assumed constant over time. The model results are predictions of the fully mixed sediment contaminant concentrations in the mixed layer over time.

Model Inputs

Stormwater Loads

Stormwater loads from the Arkema site were calculated from regional information (e.g., average annual rainfall), site-specific data (e.g., drainage area), and target treatment concentrations. Modeled conditions assumed onsite stormwater conveyances, detention ponds, and other SCMs were in place and discharged stormwater concentrations were meeting the target treatment level of 0.05 µg/L for each DDx analyte. A complete description of the estimation of the stormwater loads can in found in Integral (2011).

Upstream Loads

Incoming sediment to the Portland Harbor Site and resuspension of upstream sediments will contribute to the depositional load within the Arkema RAA. Three upstream sediment load scenarios (Table 1) were considered in the evaluation:

1. Existing conditions: Sediment trap data collected in 2007 immediately upstream of the Arkema site (RM 7.7) during the Portland Harbor FS were averaged to characterize existing upstream sediment concentrations for DDD, DDE, and DDT (Anchor QEA et al. 2012).
2. Potential future conditions – complete Portland Harbor sediment remediation, no upstream source control: Sediment trap data collected in 2007 near the upstream end of the Portland Harbor Site (between RM 11 and 12) during the Portland Harbor FS were averaged to characterize existing upstream sediment concentrations for DDD, DDE, and DDT (Anchor QEA et al. 2012).
3. Potential future conditions – complete Portland Harbor sediment remediation, upstream source control: Implementation of future source control actions were assumed to result in a 50 percent reduction of the loads calculated from data collected upstream of the Portland Harbor Site (data used in scenario 2).

Table 1. Model Scenarios: Upstream Sediment Concentrations

COI	1. Existing Upstream Sediment Concentration (µg/kg)	2. Potential Future Upstream Sediment Concentration: Remediated Sediments, No Upstream Source Control (µg/kg)	3. Potential Future Upstream Sediment Concentration: Remediated Sediments, Upstream Source Control (µg/kg)
DDT	7.8	2.7	1.33
DDE	2.9	1.9	0.93
DDD	4.0	0.90	0.45

Estimates of the upstream sediment deposition load are calculated from the difference of the net sedimentation load and the mass loading from the Arkema site's stormwater solids:

Net Sedimentation Load = Upstream Sedimentation Load + Arkema Site Stormwater Load

where the net sedimentation load is estimated as the net sedimentation rate multiplied by the depositional area (the Arkema RAA, 5.4 acres). A conservative assumption inherent in the SEDCAM model is that all solids associated with the Arkema stormwater discharge deposit over the specified depositional area. It is likely that some portion of the stormwater solids load may be entrained in the water column.

SEDCAM Model Parameters

SEDCAM Model parameters include the mixed layer depth, net sedimentation rate, initial surficial sediment concentration and sediment density. These parameters are described below.

Mixed Layer – Bioturbation, anthropogenic activity, and natural forces contribute to the mixing of surficial sediments. To account for the Willamette River's high amount of ship traffic and relatively fast currents, the thickness of the surficial sediment's mixed layer was assumed to be 10 cm, consistent with the mixing layer assumed in the FS.

Net Sedimentation Rate – The net sedimentation rate was estimated by evaluation of depth differences between sequential bathymetric surveys. The bathymetric data collected in 2002 and 2009 were evaluated to characterize net deposition rates over the nearshore sediments adjacent to the Arkema site (note that the bathymetry data does not cover the full nearshore extent of the site). The depth difference map indicates net sedimentation rates over the proposed early action area ranging from 0 to approximately 30 cm/yr in local areas.

Sediment cores collected within the proposed early action area were quantitatively analyzed to better understand local sedimentation patterns (Integral 2011). In all of these

cores the peak DDx concentrations, which are assumed to correspond to DDT manufacturing operations at the site between approximately 1947 and 1954, were buried with depth in the sediment, located at depths ranging from approximately 2 to 10 ft below the sediment-water interface. These data indicate a long-term net depositional environment and suggest an average local net deposition rate of 3.3 cm/year in the early action area (Integral 2011).

The available data generally suggest a depositional environment, although the ongoing net depositional rate varies over the nearshore areas. To evaluate potential recontamination, a low (1 cm/yr) and a high (5 cm/yr) net sedimentation rate were evaluated.

Initial Surficial Sediment Concentrations – The initial surficial sediment concentration in the depositional area was conservatively assumed to be 0, representing a remediated (e.g., capped) scenario.

Sediment Density – The average dry bulk density of sediment was measured to be 0.92 g/cm^3 from samples collected within the preliminary RAA boundary at the Arkema site.

Model Results

Model predictions were compared to remedial action levels (RALs) developed for the Arkema RAA (RM 7-8 RAL) and the Portland Harbor sediment preliminary remediation goals (PRGs) (Table 3.5-2, Anchor QEA et al. 2012; Table 2-1 of the EE/CA report). An RAL was not developed for total DDD as the spatially weighted average concentration of this COI within RM 7 to 8 has met the PRG and no action is required. The RALs, PRGs, and the fully mixed, steady state, predicted surficial sediment concentrations are summarized in Table 2. Predicted surficial sediment concentrations for each of the three model scenarios are below the RM 7-8 RALs and Portland Harbor PRGs. These results were also compared with the RALs developed for the Portland Harbor draft FS, and are more conservative than those developed for the Arkema EE/CA (Table 7.0-1, Anchor QEA et al. 2012). With the exception of DDE at the existing upstream sediment concentrations and a low net sedimentation rate, all modeled conditions meet the Portland Harbor's most conservative RAL, which corresponds with Portland Harbor remedial Alternative F. RALs for all other draft Portland Harbor remedial alternatives were met.

Table 2. Comparison of Model-Predicted Fully Mixed Sediment Concentrations with Portland Harbor Sediment PRGs and RALs

			Existing Upstream Sediment Concentrations (µg/kg)		Remediation of PH Sediments, No Upstream Source Control (µg/kg)		Remediation of PH Sediments, Upstream Source Control (µg/kg)	
Analyte	PH Draft PRG (µg/kg)	RM 7-8 RAL (µg/kg)	Low Net Sedimen-tation Rate	High Net Sedimen-tation Rate	Low Net Sedimen-tation Rate	High Net Sedimen-tation Rate	Low Net Sedimen-tation Rate	High Net Sedimen-tation Rate
Total DDT	62.9	6,000	25.7	11.4	20.5	6.2	19.2	4.9
Total DDE	31.3	400	20.8	6.5	19.7	5.4	18.8	4.5
Total DDD	28	NA	21.8	7.5	18.8	4.5	18.3	4.0

PH = Portland Harbor

Model results for all analytes indicate some recontamination following remediation from upstream loads. Predictions are presented as a function of time, where the initial surficial sediment concentration in the depositional area is assumed to be zero at time=0 (Figure 1). The high and low net sedimentation rates provide bounds on the expected results, and a typical rate in between these values would result in model predictions falling between those presented for each condition. An estimated sedimentation rate of 3.3 cm/yr would result in predicted surficial concentrations below all RALs and PRGs for the three DDx isomers—total DDT, total DDD, and total DDE. The model results suggest that the extent of the recontamination and the achievement of the remedial goals will depend on the upstream sediment COI concentrations, ongoing net sedimentation rate in the RAA, and the implementation of upstream SCMs.

References

Anchor QEA, Windward, Kennedy/Jenks, and Integral. 2012. Portland Harbor RI/FS draft feasibility study. AQ11-12. Prepared for The Lower Willamette Group, Portland, OR. Anchor QEA, LLC, Seattle, WA; Windward Environmental LLC, Seattle, WA; Kennedy/Jenks Consultants, Portland, OR; and Integral Consulting Inc., Portland, OR. March 30. 2012.

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Jacobs, L., R. Barrick, and T. Ginn. 1988. Application of a mathematical model (SEDCAM) to evaluate the effects of source control on sediment contamination in Commencement Bay. pp. 677-684. In: Proceedings: First Annual Meeting on Puget Sound Research, Puget Sound Water Quality Authority, Seattle, WA.

Attachments

Figure 1. Predicted DDE Surficial Sediment Concentrations, High and Low Net Sediment Deposition Rates

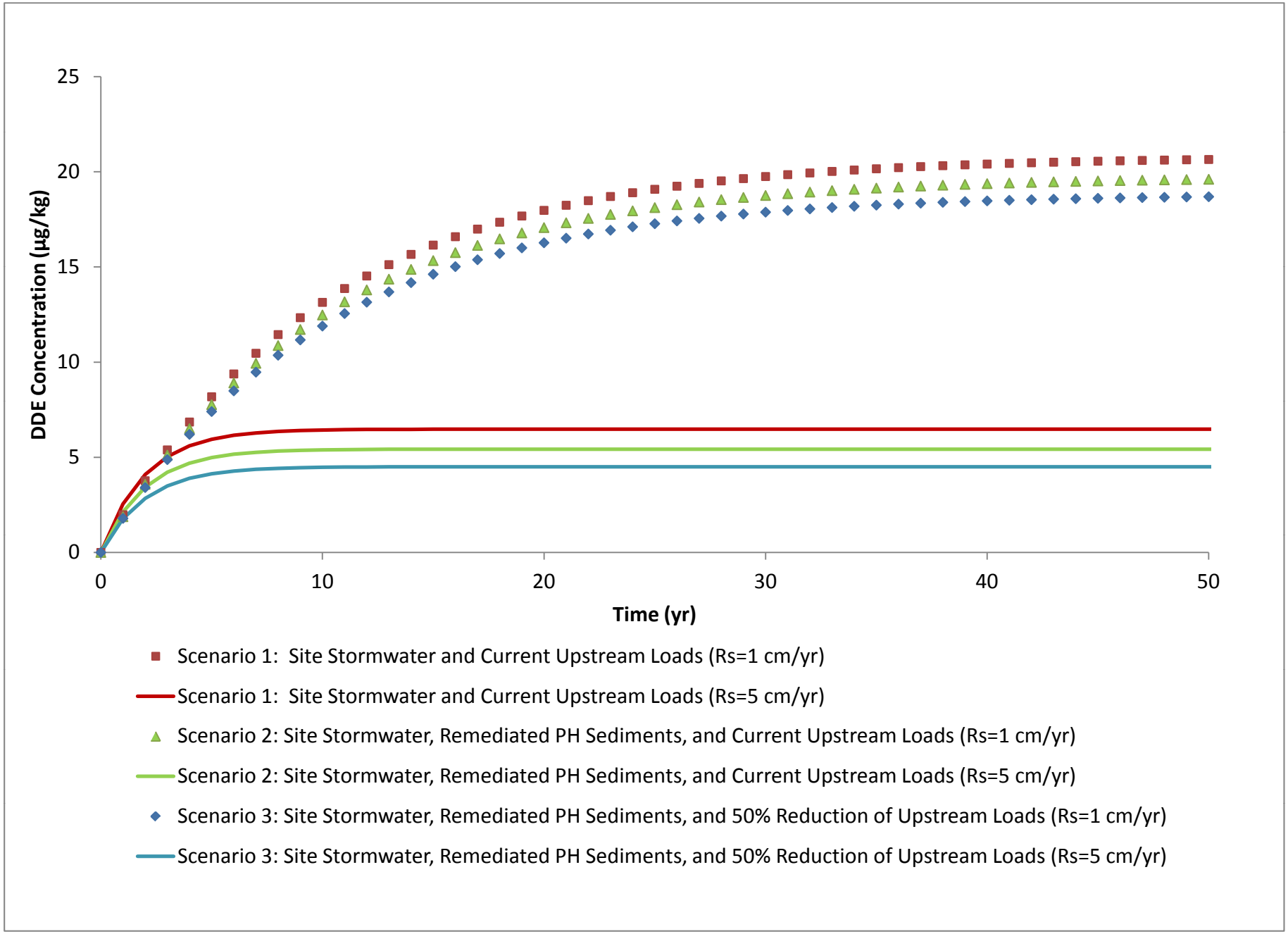

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Figure 1.
Predicted DDE Surficial Sediment Concentrations, High and Low Net Sediment Deposition Rates