

FINAL  
INTERIM RESPONSE STEPS WORK PLAN

OLIN CHEMICAL SUPERFUND SITE  
51 EAMES STREET  
WILMINGTON, MASSACHUSETTS



SDMS DocID 293559

Submitted to:  
United States Environmental Protection Agency  
Region I – New England  
One Congress Street  
Boston, Massachusetts 02114

Superfund Records Center  
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Submitted by:  
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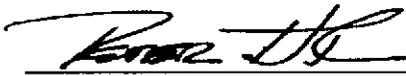
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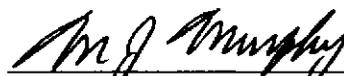


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Project No. 6100080016/02

August 8, 2008

  
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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY  
EPA NEW ENGLAND  
1 Congress Street, Suite 1100  
Boston, MA 02114-2023

**MEMORANDUM**

**DATE:** August 27, 2008

**SUBJ:** **Final Interim Response Steps Work Plan  
Olin Chemical Superfund Site**

**FROM:** Jim DiLorenzo, Remedial Project Manager

**TO:** Addressees

Attached for your file are 2 CD Roms and 1 paper copy of the Final Interim Response Steps Work Plan produced by Olin's consultant, MACTEC.

This work plan addresses ongoing activities at the Site including: (1) slurry wall/cap monitoring, (2) operation and shutdown evaluation for the Plant B remediation system, and (3) design and implementation of a DAPL extraction pilot test.

This document replaces the Draft Interim Response Steps Work Plan dated July 25, 2007, and is the result of numerous interim reviews and meetings. A copy of the Final Work Plan will be placed on EPA's home page for public view at [www.epa.gov/region1](http://www.epa.gov/region1).

Please call me at (617) 918-1247 if you have any questions or concerns.

**Addressees:**

Mike Caira, Town of Wilmington  
Martha Stevenson, WERC  
Joe Coyne, MassDEP (w/o attachments)



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY  
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BOSTON, MA 02114-2023

August 6, 2008

Steven G. Morrow  
Olin Corporation  
3855 North Ocoee Street  
Suite 200  
Cleveland, TN 37312

Subject: Conditional Approval of Draft Interim Response Steps Work Plan  
("IRSWP"), Olin Chemical Superfund Site, Wilmington, Massachusetts

Dear Mr. Morrow:

In accordance with Paragraph 40 of the Administrative Settlement Agreement and Order on Consent ("AOC"), Region I of the United States Environmental Protection Agency ("EPA") has completed review of the Draft IRSWP prepared by MACTEC and dated July 25, 2007. This letters serves to notify Olin that the Draft IRSWP has been approved by EPA, subject to the conditions specified herein.

The Draft IRSWP was prepared under the terms of the AOC to provide a mechanism for EPA to review certain activities previously approved by the Massachusetts Department of Environmental Protection (MassDEP). These activities include:

1. *Slurry wall/Cap* - monitoring of the slurry wall containment system and maintenance of the associated temporary cap;
2. *Plant B* - operation and maintenance of the Plant B groundwater depression and treatment system that was installed for the containment and recovery of light non-aqueous phase liquid (LNAPL); and
3. *DAPL Pilot Test* - submission of plans for the design, installation and operation of an off-property west ditch pilot extraction well for dense aqueous phase liquid ("DAPL").

In accordance with the AOC, these activities have continued during the review process under previous agreements.

The Draft IRSWP has been subject to a comprehensive and iterative EPA and stakeholder review process as follows: In September 2007, EPA requested and Olin provided supplemental information including groundwater contours and cross sections, and

detailed information regarding the operation of Plant B. EPA provided original agency and stakeholder comments to Olin in a letter dated November 2, 2007. Olin responded to EPA's comments in a letter dated December 31, 2007. On January 15, 2008, EPA responded in a memorandum to Olin providing additional comments. Comments were discussed in meetings held on January 17, and March 18, 2008. In response to remaining comments, Olin submitted a comparison of rail versus truck off-loading and a conceptual design of the DAPL pilot layout in electronic mail messages respectively dated April 14 and May 7, 2008, and a revised proposal for the continued operation of Plant B on April 7, 2008. EPA submitted written agency and stakeholder comments on the Plant B proposal to Olin on July 14, 2008. These comments were discussed in a meeting held on July 17, 2008. Olin responded to EPA's comments in a letter dated July 28, 2008.

### *Conditions of Approval*

Within 14 days from the date of this letter, Olin shall submit a Final IRSWP which incorporates the previously agreed upon changes (i.e., changes agreed to by Olin in the correspondence described above), and incorporates the conditions specified herein.

#### *1. Slurry wall/Cap*

- a. Maintenance of the temporary cap shall include replacement of deteriorated sand bags.
- b. EPA reserves the right to request the replacement of the temporary cap should it fail prior to the installation of a final cap.
- c. EPA remains concerned about the long-term integrity of the slurry wall. While the rigorous pre-design materials compatibility testing that was performed has reduced this concern to a level where EPA agrees that intrusive testing of the wall is not necessary at this time, Olin shall propose non-intrusive methods to be incorporated into future monitoring activities. At the July 17<sup>th</sup> meeting, EPA provided information on hydraulic pulse interference testing as an example of such a method.
- d. EPA remains concerned with the potential for seepage between the slurry wall and bedrock interface, as well as seepage of dissolved constituents into bedrock fractures. These concerns shall be addressed by Olin in the pending Remedial Investigation study for Operable Unit 3.

#### *2. Plant B*

- a. Olin shall provide EPA with a minimum of 14 days advanced notice prior to an initial reduction in the current pump rate.
- b. Any subsequent reductions must receive prior EPA approval. Olin shall provide EPA with a minimum of 7 days advanced notice prior to any subsequent requests for a reduction in pump rate.

#### *3. DAPL Pilot Test*

- a. Olin shall off-load the DAPL material using trucks, rather than rail, which

would have required construction of a pipe line and rail spur. This modified approach assumes access can be obtained from the Jewell Drive property owner in a reasonable time frame.

- b. Olin shall submit the draft design report to EPA within 45 days from the date of this letter.

Please call me if you have any questions or want to discuss any of the conditions contained in this letter.

Sincerely,



James M. DiLorenzo  
Remedial Project Manager  
USEPA Region 1 - New England

Cc: Wesley Kelman, EPA  
Rick Sugatt, EPA  
Dick Willey, EPA  
Heather Ford, Nobis  
Joe Coyne, MassDEP  
Michael Caira, Town of Wilmington  
Michael Webster, GeoInsight  
Martha Stevenson, WERC

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## GLOSSARY OF ACRONYMS

AOC	Agreement of Consent
AS/SVE	air sparging/soil vapor extraction
AST	above ground storage tanks
BEHP	bis(2-ethylhexyl)phthalate
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm/s	centimeter per second
DAPL	dense aqueous phase liquid
DI	de-ionized
DOT	Department of Transportation
DQO	Data Quality Objective
EPH	extractable petroleum hydrocarbons
FDR	Field Data Record
FFS	Focused Feasibility Study
FS	Feasibility Study
gpm	gallons per minute
HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
IDW	investigation derived wastes
IRA	Immediate Response Action
IRS	Interim Response Step
IRSWP	Interim Response Steps Work Plan
LNAPL	light non-aqueous phase liquid
MACTEC	MACTEC Engineering and Consulting, Inc.
MADEP	Massachusetts Department of Environmental Protection
MBTA	Massachusetts Bay Transit Authority
MCP	Massachusetts Contingency Plan
MEK	2-Butanone methyl ethyl ketone
μmhos/cm	micro mhos/cm
mg/L	milligrams per liter
ml/min	milliliter per minute
MPE	Multiphase Extraction Well
MSL	mean sea level
NDMA	N-nitrosodimethylamine
NDPA	N-nitrosodiphenylamine

## GLOSSARY OF ACRONYMS - CONTINUED

NIS	Nutrient Injection System
NPDES	National Pollution Discharge Elimination System
NPI	National Polychemicals, Inc.
NPL	National Priority List
NTU	nephelometric turbidity unit
off-PWD	off-Property West Ditch
Olin	Olin Corporation
O&M	Operations and Maintenance
on-PWD	on-Property West Ditch
ORP	oxidation-reduction potential
OU	Operable Unit
PCMP	Post-Construction Monitoring Plan
PVC	polyvinyl chloride
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RAM	Release Abatement Measure
RGP	Remediation General Permit
RI/FS	Remedial Investigation and Feasibility Study
RPM	revolutions per minute
SARA	Superfund Amendments and Reauthorization Act
SGT-HEM	Silica Gel Treated Hexane Extractable Material
Site	The Olin Chemical Superfund Site
SOW	Statement of Work
SPCC	Spill Prevention, Control and Countermeasure Plan
SRM	Substantial Release Migration
SVOC	semi-volatile organic compounds
TSD	treatment/storage/disposal
USEPA	United States Environmental Protection Agency
USGS	U.S. Geologic Survey
VOC	volatile organic compounds
VPH	volatile petroleum hydrocarbons

## **1.0 INTRODUCTION**

This Interim Response Steps Work Plan (IRSWP) has been prepared for the Olin Chemical Superfund Site in Wilmington, Massachusetts on behalf of Olin Corporation (Olin) by MACTEC Engineering and Consulting, Inc. (MACTEC). The IRSWP has been prepared consistent with Section II.B. of the Statement of Work, Remedial Investigation and Feasibility Study (RI/FS), Olin Chemical Superfund Site, prepared by the United States Environmental Protection Agency (USEPA) Region I – New England and dated June, 2007. The IRSWP identifies the scope for continuing certain activities previously approved by the Massachusetts Department of Environmental Protection (MADEP) under the Massachusetts Contingency Plan (MCP). Those activities that will be continued are identified as Interim Response Steps (IRs).

The Olin Chemical Superfund Site (the Site) includes, but is not limited to, the property at 51 Eames Street, Wilmington, MA. The site location is presented in Figure 1-1. The approximately 50-acre property is the site of a former chemical manufacturing plant, which was purchased by Olin in 1980. Figure 1-2 is a site plan that identifies the three areas that are the object of the IRSWP (Slurry Wall/Cap Containment Area, Plant B, and the off-Property West Ditch (off-PWD) area).

The chemical manufacturing facility was constructed in 1953 and was operated by National Polychemicals, Inc. (NPI). From 1953 to 1968 the business conducted by NPI was owned by three different corporations: American Biltrite Rubber Co., Fisons Limited, and Fisons Corporation, now known as NOR-AM Agro LLC. In 1968 Stepan Chemical Company bought the business, and continued to operate the facility until 1980, when the facility was purchased by Olin. Olin closed the facility in 1986. The facility was used to manufacture chemical blowing agents, stabilizers, antioxidants and other specialty chemicals for the rubber and plastics industry.

The Site has been the subject of many years of investigations and remedial actions carried out by Olin and supervised by MADEP under Chapter 21E of the General Laws of Massachusetts and the MCP. The Site has been a Priority site under the MCP since 1993, and a Tier I site since 1994.

The 51 Eames Street property is currently completely fenced and is inactive, with the exception of on-going remedial and monitoring activities.

The Site was listed on the National Priority List (NPL) on April 18, 2006. It is currently in the RI/FS process under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA).

There are three specific IRSs that will be continuing and that are addressed in this IRSWP:

- Slurry Wall/Cap – monitoring of groundwater and surface water in the area surrounding the Slurry Wall and inspection of the temporary cap.
- Plant B – operation, maintenance, and monitoring of the groundwater recovery/treatment system that was designed to remove and control migration of light non-aqueous phase liquid (LNAPL).
- Dense Aqueous Phase Liquid (DAPL) Extraction Pilot Test in the off-PWD Area – continue design efforts and provide a schedule for the submittal to USEPA of the DAPL Extraction Pilot Test Design Report.

Each of these IRSs has specific objectives and each was initiated to address previously completed or planned future remedial actions. General descriptions of each of the IRSs are presented in the following paragraphs.

The Slurry Wall/Cap is a containment structure that was constructed in 2000 as a Release Abatement Measure (RAM) consistent with the MCP. The intent of this source control action was to eliminate, to the extent feasible, the on-Property DAPL source material as a source of dissolved constituents to groundwater. The containment structure is comprised of a perimeter slurry wall keyed into bedrock and a temporary cap to minimize infiltration of precipitation into the containment area. Construction of the slurry wall was preceded by a pre-design boring program to determine the depth to bedrock. The slurry wall contains, to the maximum extent practical, the on-Property DAPL and overlying impacted groundwater that is located within the containment structure. Along the northern, eastern and southern portions of the slurry wall, the DAPL contained within the perimeter of the slurry wall is at an elevation below the point where the slurry wall is keyed into bedrock. On the western, up gradient side of the slurry wall, a gravel equalization window was constructed in the top of the slurry wall to maintain equal hydraulic pressure between groundwater inside and outside of the containment structure. The temporary cap is a scrim reinforced polyethylene sheet cover held in place by sandbags. The physical condition of the temporary cap has been routinely inspected and repaired as necessary to maintain an effective barrier to infiltration of precipitation. Monitoring of water levels inside and outside of the slurry

wall indicate that the containment structure is working per design as a source control measure for on-Property DAPL. Monitoring of groundwater quality within and around the perimeter of the containment structure and monitoring of surface water quality in the adjacent surface water features (South Ditch and off-PWD) has been conducted since construction of the Slurry Wall/Cap to characterize the long-term effect of this source control measure.

The Plant B groundwater recovery/treatment system has been in operation and its performance has been monitored since 1981 with continued operation from 1997 to present as an Immediate Response Action (IRA) under the MCP. The system was installed in response to the seepage of LNAPL into the East Ditch that is located at the eastern perimeter of the former facility property. The LNAPL is a processing oil that contains bis(2-ethylhexyl)phthalate (BEHP), N-nitrosodiphenylamine (NDPA), and trimethylpentenes. The system was designed to create a groundwater cone of depression to prevent migration of the LNAPL and allow for mechanical removal of the material. During its operation, various in-situ technologies have also been applied to enhance removal of LNAPL and dissolved phase constituents, including air sparging/soil vapor extraction (AS/SVE) and bio-stimulation. These additional measures were applied successfully and resulted in a large increase in the rate of contaminant mass removal. The cumulative effect of these remedial measures has been to remove the majority of recoverable LNAPL from the subsurface. As a result, the LNAPL recovery rate has declined and remains low, warranting evaluation of the efficacy of further LNAPL recovery efforts. Groundwater extracted during operation of the system is treated to remove iron and ammonia as well as dissolved organic compounds. The treated groundwater is discharged to surface water on the former facility property in compliance with a Remediation General Permit (RGP). Visual observations of the East Ditch, LNAPL gauging in monitoring and interceptor wells, sampling and analysis of the treatment system influent and effluent and groundwater monitoring have been components of the monitoring program for Plant B.

The DAPL Extraction Pilot Test (Pilot Test) is planned to determine the feasibility of extraction and off-site disposal of DAPL from the area immediately to the west of the Slurry Wall/Cap containment area (in the vicinity of the off-PWD). The DAPL pool in this area is a source of dissolved constituents to groundwater that flows toward and discharges, in part, to the Upper South Ditch located on the former facility property. The Pilot Test will be conducted at the off-PWD area to evaluate the technical feasibility of DAPL extraction. The Pilot Test will include the extraction and off-site disposal of DAPL material and completion of a monitoring program to document

existing groundwater conditions prior to start up, as well as, monitoring of groundwater conditions throughout the Pilot Test. The results of the Pilot Test will be used in the Feasibility Study (FS) to support evaluation of remedial alternatives.

This IRSWP is organized as follows:

Section 1.0 – Introduction

Section 2.0 – Slurry Wall/Cap IRSWP

Section 3.0 – Plant B IRSWP

Section 4.0 – DAPL Extraction Pilot Test IRSWP

Appendix A – Sampling and Analysis Plan

Appendix B – Plant B LNAPL Distribution Figures

## 2.0 SLURRY WALL/CAP INTERIM RESPONSE STEPS WORK PLAN

This IRSWP related to the Slurry Wall/Cap (containment structure including the temporary cap) involves the continuance of the most recent requirements of the Post-Construction Monitoring Plan (PCMP) that has been in place since the completion of construction of the Slurry Wall/Cap in 2000/2001.

This section presents:

- the purpose and scope of the IRSWP for the Slurry Wall/Cap;
- background information and discussion of prior monitoring and inspection activities conducted under the PCMP; and
- the proposed monitoring program and reporting requirements.

### 2.1 WORK PLAN PURPOSE AND SCOPE

This work plan has two specific purposes. First, to present a description of the historical monitoring conducted under the PCMP and general conclusions developed from that work. Second, to present an approach for the continued monitoring and inspection of the containment structure and temporary cap based on the most recent monitoring and reporting activities that were established with the MADEP. This work plan describes both the most recent monitoring program approved by the MADEP and identifies changes proposed for USEPA approval. Monitoring and inspection of the Slurry Wall/Cap will continue in accordance with the requirements of the most recent MADEP approved monitoring program until USEPA approval of this IRSWP. This work plan describes proposed monitoring locations, frequency of monitoring, the analytical program, quality assurance and quality control, data management and data validation requirements. In addition, a process is also proposed for evaluation and optimization of the monitoring program based on future monitoring results.

## 2.2 BACKGROUND

The following section provides background information on the construction and maintenance of the containment structure and historical monitoring and maintenance activities conducted under the PCMP since 2001.

### 2.2.1 Slurry Wall/Cap Description

The installation of a containment structure was first evaluated in a Focused Feasibility Study (FFS) (GEI, 2000), as one of several alternatives to achieve a permanent source control measure for on-Property DAPL, consistent with requirements of the MCP. The FFS concluded that structure would contain approximately 90 percent of the total mass of DAPL and dissolved constituents at the Property, including greater than 90 percent of chromium mass. The remedial objective for the containment structure was eliminating, to the extent feasible, the on-Property DAPL as a source of the dissolved plume that was contributing constituents in the ditches through groundwater discharge (GEI, 2000). The discharge of dissolved constituents results in the formation of a floc in the Upper South Ditch and in increased concentrations of surface water solutes, including ammonia.

The design of the slurry wall was based on a series of perimeter borings to define the bedrock surface. Prior to constructing the slurry wall, a detention basin was constructed to manage surface water run-off. This structure required excavation into shallow bedrock. Excavation was completed first to avoid any subsequent disturbance of the slurry wall. In December 2000, a three foot thick slurry wall was installed to bedrock and keyed into the bedrock surface. The location of the containment area is shown on Figure 1-2. The temporary cap was completed in April 2001 over the entire containment area using 6-mil reinforced polyethylene sheeting. A gravel roadbed was installed around the eastern and southern perimeter of the temporary cap to allow vehicle access to the southwest area of the Site. The 6-mil sheeting was replaced in 2003 with an 8-mil polyethylene sheeting utilizing ultraviolet resistant thread for sewn seams. The new material was ballasted with sandbags on a grid pattern to minimize potential wind damage, and the seams were sewn between sheets to reduce potential leakage. Olin instituted quarterly inspections to monitor the integrity of the temporary cap material, evaluate the need for periodic maintenance and document maintenance activities and repairs.

The containment structure was constructed with an equalization window on its western side to allow movement of shallow groundwater out of the structure, should head buildup occur from leakage of precipitation through the temporary cap. The equalization window is a gravel backfill section within the slurry wall located at an elevation corresponding to the water table. The equalization window is instrumented with two wells that allow measurement of water levels and collection of water quality samples to assess flux of groundwater and solutes through the window.

Prior to construction of the Slurry Wall/Cap, the on-Property DAPL area had been investigated by numerous wells and borings. A majority of the wells within the footprint of the containment structure were decommissioned at the time of construction although specific wells were retained for future monitoring.

### **2.2.2 DAPL and Dissolved Plume Characteristics**

Because of its density, DAPL migrates by gravity rather than hydraulic gradients. The DAPL within the Slurry Wall/Cap is contained in a bedrock depression and is not mobile. The bedrock underlying the on-Property DAPL pool is a medium to coarse grained crystalline gabbro. Olin installed a bedrock borehole adjacent to the DAPL pool at the request of MADEP (then DEQE) to “investigate the potential for vertical migration of groundwater contaminants from the glacial overburden aquifer to any bedrock aquifer that may underlie it”. This borehole (BR-1) was cored fifty feet into bedrock from within a casing that had been grouted several feet into the bedrock surface. Olin transmitted results of this investigation to MEDEP in a letter dated January 13, 1988. The bedrock at this location was relatively unfractured and the borehole did not recharge during the time frame of installation. Within two weeks after installation, water in the boring rose to within 7 feet of ground surface. Groundwater analytical results from this location in 1992 for chloride, ammonia and sulfate were comparable to water quality of shallow groundwater downgradient of this area. The elevation of the DAPL interface within the slurry wall has been monitored through MP-1 and induction logging in GW-35D. Results of these monitoring activities over the last decade have shown the top of DAPL elevation to be stable within measurement sensitivity.

The composition of DAPL and the dissolved constituents in groundwater that result from diffusion, advection and dispersion processes in groundwater overlying DAPL has been studied extensively (Smith, 1997). DAPL is defined by a density threshold (a specific gravity greater than 1.025) that has been statistically correlated to a specific set of indicator parameters and pH. These indicator

parameters include sulfate, sodium, chloride, and ammonia, and can be used to estimate fluid density based on concentrations and statistically derived correlation factors. The potential presence of DAPL-like material is also indicated by specific conductance values greater than 20,600 micro mhos/cm ( $\mu\text{mhos/cm}$ ). The inorganic constituents detected in DAPL in order of decreasing concentration include dissolved sulfate, sodium, chloride, ammonia, chromium, iron, aluminum and manganese. In order of decreasing concentrations, organic compounds detected in DAPL include phenol, acetone, 2-hexanone, bromoform, 2-butanone methyl ethyl ketone, (MEK), BEHP, toluene, trimethylpentenes, 4-bromophenyl-phenylether, naphthalene, benzoic acid, N-nitrosodimethylamine (NDMA) and NDPA.

### **2.2.3 Post Closure Monitoring Plan and Semi-Annual Status Reports**

In 2000, a PCMP was prepared to assess the performance of the subsurface containment structure in encompassing the DAPL and the temporary cap in minimizing the influx of precipitation and storm water into the containment structure. Since 2001, on a semi-annual basis, Olin has prepared a PCMP status report which has documented the post-construction performance monitoring for the containment structure. The most recent semi-annual report submitted to the MADEP covered the period of June 2005 through December 2005 (MACTEC, 2006a).

The PCMP includes two primary monitoring components. First, water level elevation data is collected from areas within, upgradient and down gradient of the containment structure, including vertical gradient data from monitoring well couplets. This information is used to compare the hydraulic conditions within and outside of the containment structure as a measure of groundwater containment. Second, water quality data are collected from groundwater wells and surface water to evaluate long-term changes in groundwater conditions outside of the containment structure, and in changes in surface water quality. Sediment samples have also been collected annually since 2003 from five locations to monitor chromium concentrations in sediment.

In addition to an introduction and summary and conclusions, the semi-annual PCMP status report, has historically included discussion of the following four topics:

- Groundwater elevations and hydraulic gradients;
- Groundwater and surface water quality data;

- Groundwater and solute mass flux through the equalization window; and
- Presentation of data logger measurements to compare groundwater elevations to precipitation.

The groundwater and solute flux out of the equalization window has been calculated from Darcy's Law using local horizontal hydraulic gradients, the known cross-sectional area of the window and an estimated hydraulic conductivity as previously reported by GEI Consultants (GEI, 2001).

The PCMP Status Report has also provided appendices documenting the results of the temporary cap quarterly inspections, and presenting the laboratory analytical data reports including chemical data validation memorandums. On an annual basis, the data have been more fully evaluated to provide recommendations for modification to the PCMP plan, if applicable.

The previous cap inspections were conducted on a quarterly basis and included a walkover to observe and document the condition of the polyethylene sheeting and to report deficiencies or damage requiring repair. The inspection included observation of the cap surface noting:

- Integrity of sewn seams;
- Condition of ballast sand bags;
- Evidence of animal activity;
- Condition of previous repairs;
- Location(s) of areas of pooled or ponded water; and
- Locations of rips or tears in the cover.

The inspectors documented their observations, and to the extent necessary, provided digital photographic documentation of conditions requiring maintenance. Repairs that were determined to be appropriate, if any, were completed by on-site personnel.

The quarterly inspections were followed by a letter report transmitting inspection findings and recommendations to MADEP. These letter reports were appended to the PCMP Semi-Annual Status Report which was also distributed to MADEP.

#### 2.2.4 Post Closure Monitoring Plan General Conclusions

Since construction of the Slurry Wall/Cap in 2001, monitoring of water levels in wells within the containment structure have indicated that the horizontal hydraulic gradient within the structure is essentially flat (<0.002 ft/ft). Vertical gradients within the containment area have also remained essentially neutral since 2001. Although there is some water level response within the containment area to precipitation events, due to a limited amount of leakage through the temporary cap, that response is muted compared to wells outside the structure. Though small, the hydraulic gradient through the equalization window is typically positive indicating outward flow from the containment area. Based on these results, the equalization window is functioning as designed to relieve build up of any hydraulic pressure inside the slurry wall resulting from minor leakage through the temporary cap. The relatively flat internal gradient and lack of vertical gradients within the structure indicate the slurry wall is effectively containing the DAPL and diffuse groundwater above the DAPL from the overburden groundwater outside the containment structure. Thus the containment structure is performing per design as a source control measure.

Construction of the Slurry Wall/Cap was completed to isolate the on-Property DAPL material currently located within the structure. The construction has isolated the identified zone of DAPL and groundwater. Monitoring of groundwater outside the containment structure has shown declining concentration patterns in some wells for some constituents. The completion of the structure has resulted in groundwater flow around the structure generally from the north-northwest to the south-southeast. The containment structure was not intended to control migration of impacted groundwater that was outside the Slurry Wall/Cap at the time of construction. Additional monitoring is required for a more complete assessment of long term groundwater quality trends.

A weir was installed in the Upper South Ditch to increase and control surface water head in the upstream off-PWD. The increased head has reduced groundwater discharge to the off-PWD. Piezometric and stream elevation data collected upstream of the weir within the Upper South Ditch indicate recharging conditions (downward gradients) predominate while data immediately downstream of the weir generally indicate discharging groundwater conditions (upward gradients). The section of the Upper South Ditch immediately down stream of the weir is typically associated with higher solute concentrations in surface water than the area upstream of the weir. The area immediately downstream of the weir is where a chemically stable floc is observed in the water column. The surface water immediately downstream of the weir is also impacted by discharging

groundwater. Solute concentrations in Upper South Ditch surface water tend to be highly variable and additional monitoring is necessary to evaluate longer term trends.

### **2.3 HISTORICAL PCMP MONITORING ACTIVITIES AND MODIFICATIONS**

Over the course of monitoring under the PCMP from 2001 to 2005, several modifications to the PCMP have been proposed by Olin and approved by the MADEP. For example, historically over this time period shallow groundwater elevations have been recorded at least quarterly from up to a total of 47 different locations. The most recent program monitors fewer locations as a consequence of monitoring information gained over the past six years. Since 2001, the sampling program has evolved through recommendations to optimize the sampling strategy, based on prior results. A statistical evaluation of water quality trends in PCMP data was requested by MADEP in a letter to Olin dated June 8, 2004. That statistical evaluation was performed and presented in “Olin Wilmington Technical Series XXXV. Semi-Annual Analysis of PCMP Data, July 2003 – May 2004” (Geomega, 2004c). The proposed reduction in sampling frequency (from quarterly to semiannually) was recommended in the Part 2 Construction-Related Release Abatement Measure Status Report No. 7 (GEI Consultants, 2004). In a letter dated March 29, 2005, MADEP approved the changes to the PCMP program as proposed. These approved changes included reducing the monitoring frequency for 15 wells from quarterly to semi-annually.

Table 2-1 summarizes which monitoring locations have been monitored for specific objectives since 2001 with changes to monitoring program indicated by subscript notations. All historical groundwater sampling locations are shown in Figure 2-1.

Table 2-2 summarizes the monitoring program that resulted from the changes approved by MADEP. This monitoring program is the most current program under agreement with MADEP. Table 2-3 summarizes the PCMP analytical program by media for groundwater, surface water, and sediment. The following paragraphs summarize the monitoring program and intended use of the data.

#### **Groundwater Level Measurements**

Groundwater level measurements have been taken from all PCMP monitoring wells at the time of and prior to groundwater sampling. Data loggers were installed to record daily groundwater elevations along the northern, western, southern exterior areas of the Slurry Wall/Cap, within the

equalization window and interior of the containment system. The following locations were instrumented with data loggers: GW-10S, GW-35S, GW-76S, GW-78S and GW-CA1.

Specific well couplets were used to monitor vertical gradients in the area including: GW-6D/6S, GW-29D/29S, GW-34D/34SR, GW-35D/35S, GW-55D/55S, GW-202D/202S and GW-CA3D/CA3S.

### **Groundwater Quality Monitoring**

The PCMP groundwater monitoring program required analysis of groundwater for several DAPL-related indicator parameters including ammonia, chloride, sulfate, aluminum, chromium, and specific conductivity by methods listed in Table 2-3. Groundwater samples were collected using low stress/low flow procedures. Groundwater samples analyzed for metals were filtered and reported as dissolved metals. The most recent groundwater sampling locations are presented in Figure 2-2. Quarterly groundwater sampling has included monitoring well locations west (GW-25) and south (GW-202S and GW-79S) of the containment structure and three piezometer locations in the Upper South Ditch (PZ-16RR, PZ-17RR, and PZ-18RR). Semi-annual groundwater sampling included additional monitoring wells located north (GW-34D, GW-34SR), west (GW-10S, GW-24, GW-26, GW-42S and GW-43S), south (GW-39, GW-55S, GW-76S, GW-78S, and GW-202D) and east (GW-201S) of the containment structure. Two groundwater wells located within the containment area (GW-35S and GW-CA1) were also sampled semi-annually.

### **Surface Water Quality Monitoring**

Historically, downstream portions of the South Ditch have been shown to be losing or gaining at different times of the year under varying groundwater elevation and recharge (precipitation) conditions. During the summer months, the downstream portions of the South Ditch have gone dry and sampling sometimes is not possible.

Surface water was sampled in accordance with the PCMP at six locations within the South Ditch (ISCO1, ISCO2, PZ-16RR/PZ-16RSW, PZ-17RR, PZ-18R and SD-17) and one location in the East Ditch (ISCO3). These surface water sampling locations are presented in Figure 2-3. Surface water samples have historically been analyzed for aluminum, chromium, sulfate, chloride, sodium, ammonia, nitrate, nitrite, and specific conductance by methods shown in Table 2-3. Both unfiltered and filtered surface water samples were collected and analyzed for metals.

## **Sediment Sampling**

The sediment of the Upper South Ditch was excavated and replaced with clean loam in 2000 as part of the RAM plan. Sediment sampling began in 2003 to monitor for possible recontamination of the imported clean loam from solutes contained in discharging groundwater and floc. Annual sediment sampling was conducted under the PCMP in 2003, 2004 and 2005 at the following five locations: SD-SD1, SD-SD2, SD-SD3, SD-SD4 and SD-SD5. These sediment sampling locations are shown in Figure 2-3. Sediment samples were analyzed for aluminum, chromium, iron and percent solids by methods shown in Table 2-3.

### **2.3.1 Interim PCMP Monitoring Program**

The interim monitoring program described below is the most recent monitoring program as provided in the last Semi-Annual PCMP Status Report (MACTEC, 2006). Olin will continue to monitor the Slurry Wall/Cap according to this interim plan described as follows, until such time as USEPA approves this IRSWP.

#### **Quarterly Sampling**

Surface water (ISCO1, ISCO2, PZ-16RR/PZ-16RSW, PZ-17RR, PZ-18R, SD-17, ISCO3)  
Groundwater (GW-25, GW-202S, GW-79S, PZ-16RR, PZ-17RR, PZ-18RR)

#### **Semi-Annual Sampling**

Groundwater (GW-34D, GW-34SR, GW-35S, GW-10S, GW-24, GW-26, GW-42S, GW-39,  
GW-55S, GW-78S, GW-202D, GW-201S, GW-CA1, PZ-13R)

#### **Annual Sampling**

Sediment (SD-SD1, SD-SD2, SD-SD3, SD-SD4, SD-SD5)

These most recent PCMP sampling locations were identified previously in Figures 2-2 and 2-3. The sampling frequency is identified in Table 2-2, and the analytical methods are shown in Table 2-3. Data loggers will be installed in the five wells shown on Table 2-2. Manual water level measurements will be collected at the other locations at the time of sampling. The temporary cover will be inspected quarterly as described in Section 2.2.3. Appropriate repairs to the temporary cover will be made after Olin review of the inspection reports.

## 2.4 PROPOSED SLURRY WALL/CAP MONITORING PROGRAM

This section presents the proposed Slurry Wall/Cap monitoring program under CERCLA which, upon USEPA approval, would supersede the most recent (Interim) PCMP monitoring program under the MCP. The proposed Slurry Wall/Cap monitoring program is based on the PCMP monitoring approach but proposes the modifications described below. The purpose of these modifications is to optimize the sampling process to meet monitoring objectives more efficiently. This section also describes the data quality objectives (DQOs), the sample locations, frequency of sampling, and analytical methods for the proposed monitoring program. This document contains a Sampling and Analysis Plan Appendix (Appendix A) which describes Quality Assurance Project Plan (QAPP) elements that pertain to this proposed monitoring program. Appendix A describes procedures for sample identification, sample chain of custody, sample preservation, data management and sample tracking, field and laboratory analytical methods, data validation and evaluation, quality control and corrective actions, and field sampling methods. These procedures will be followed for the interim monitoring program and for the proposed monitoring plan when it is approved.

### 2.4.1 Proposed Monitoring Program Modifications

The primary objectives of the proposed Slurry Wall/Cap monitoring program are the same as described in the PCMP monitoring program. In summary, they include:

- to obtain data to demonstrate that the containment system is performing as intended as a source control;
- to document the physical condition of the cap and any repairs; and
- to document groundwater and surface water quality in the vicinity of the Slurry Wall/Cap.

The latter objective is accomplished through collection and analysis of groundwater samples from upgradient and down gradient locations in proximity to the containment area. Some of the locations sampled historically provide duplicative data or are too far removed from the Slurry Wall/Cap to be representative of groundwater quality conditions related to the containment structure, when compared to other wells that are better located to provide data to evaluate the monitoring objectives. It is proposed that these wells be permanently removed from this specific monitoring program, recognizing that these wells will be sampled at some time in the future during

the CERCLA RI/FS process. The upgradient and downgradient wells that would be removed from the monitoring program include GW-55S, GW-55D and GW-39. The rationale for these proposed changes is described in more detail in the following paragraphs.

**GW-55S and GW-55D.** Groundwater downgradient of the containment area flows toward and then along the axis of the South Ditch. GW-55 and GW-55D are a well of a couplet located south of the South Ditch and within the Ephemeral Drainage area and it does not monitor groundwater passing by the containment area. Monitoring of this well will not provide insight to changes in groundwater or surface water quality related to the Slurry Wall/Cap. Removing GW-55S and GW-55D from the sampling and analysis components of the monitoring program will not reduce the program's ability to meet monitoring objectives. This well couplet will require future monitoring under the CERCLA RI/FS program. Water levels would still be collected from this well couplet on a semi-annual frequency.

**GW-39.** This well is located in the general upgradient direction from GW-55S/GW-55D and is neither down gradient nor up gradient of the Slurry Wall/Cap containment area. It is proposed that this well be removed from the sampling and analysis requirements of the monitoring program which will not reduce the programs ability to meet monitoring objectives. Water levels would still be collected from this well on a semi-annual frequency.

Modifications to sampling frequency are also included in the proposed monitoring program. Currently GW-78S which is located south of the containment area near the northern bank of South Ditch is monitored on a semi-annual frequency. It is proposed that this well be increased to a quarterly sampling frequency to match the frequency of monitoring in the nearby stream piezometer PZ-17RR. In addition, it is proposed that GW-25, which is currently monitored on a quarterly frequency, be reduced to a semi-annual frequency to match the other upgradient well monitoring frequencies. Table 2-4 presents the proposed Slurry Wall/Cap monitoring program.

In 2005, Olin installed two piezometers on the south side of the containment structure; one on the interior (PZ-24) and another on the exterior (PZ-25) to measure water levels on both sides of the slurry wall (Figure 2-4). These two piezometers are well located to provide additional information on the groundwater elevation between the containment structure and South Ditch and will be added to the program for quarterly water level measurements.

## **2.4.2 Data Quality Objectives (DQOs)**

As defined by USEPA, the DQOs process is “the process used to establish performance and acceptance criteria, which serve as the basis for designing a plan for collecting data of sufficient quality and quantity to support the goals of the study” (USEPA, 2006). For this work, the DQO process includes establishing criteria for the collection of chemical and hydrogeologic data to assess groundwater and surface water quality, and hydraulic performance of the containment system. This process includes but is not limited to identification of sampling procedures, documentation, analytical methods and detection limit criteria for chemical data, frequency of analyses and quality assurance/quality control (QA/QC) criteria for QC samples, validation and QA/QC criteria for acceptance or qualification of that data.

Chemical data will be used to assess changes in groundwater, surface water, and sediment quality. In the future these data will be used to support contaminant assessments in a remedial investigation report and the risk characterization for media with completed exposure pathways including surface water and sediment. Table 2-5 indicates the analysis methods and reporting limits that are adequate to meet the needs of the risk characterization. Chemical data will be collected, documented, analyzed, and validated in accordance with the requirements established in Appendix A. Data validation procedures described in Appendix A are consistent with requirements of the MCP which provide a level of data quality review comparable to USEPA Region 1 data validation guidelines. When USEPA approves the RI/FS work plan, the data validation procedures specific to USEPA Region 1 requirements will be included in the QAPP and incorporated into this Slurry Wall/Cap monitoring program.

## **2.4.3 Sample Locations, Frequency of Sampling and Rationale**

This section summarizes in text and tabular form the proposed monitoring and inspection program for the Slurry Wall/Cap containment area, subject to USEPA review and approval. On an annual basis, Olin will review the effectiveness of the monitoring program and may propose changes in sampling frequency, locations, and analytical program in the semi-annual reports.

The rationale for groundwater sample locations and monitoring frequency has been discussed previously. Semi-annual sampling is proposed for the previous upgradient groundwater monitoring wells, GW-201S located east of the Slurry Wall/Cap, and GW-CA1 located within the equalization

window. The proposed sampling locations are indicated in Table 2-4 and shown on Figure 2-4. Given the number of prior sampling events, these wells have a sufficient number of data points to evaluate water quality trends, and do not require quarterly monitoring. A quarterly sampling frequency is proposed for groundwater wells located between the containment area and the South Ditch and stream piezometers located along South Ditch.

A quarterly monitoring frequency is also proposed for surface water sampling within the South Ditch. This higher sampling frequency is justified by the need to understand and document seasonality in surface water and groundwater interaction and to determine whether constituent concentrations in surface water, particularly ammonia, are increasing, decreasing, or remain unchanged. Surface water monitoring locations are indicated in Table 2-4 and shown on Figure 2-5.

Sediment sampling will continue on an annual frequency to monitor for chromium, iron, and aluminum recontamination of sediment. Sediment sampling locations are indicated in Table 2-4 and shown on Figure 2-5. The primary mechanism for metals deposition is discharge of lower pH, metal bearing groundwater, groundwater mixing with higher pH surface water, floc precipitation from surface water and incorporation of the floc into the sediment. As discussed previously, the floc is an aluminum-chromium-iron precipitate, and is chemically stable once formed. The South Ditch has a mineral bottom over most of its length with the exception of wetland floodplain areas and where leaf litter has accumulated. Floc trapped within leaf litter and thick wetland vegetation can eventually be incorporated into the sediment on the stream bottom.

The proposed monitoring program is summarized below:

#### **Quarterly Water Quality Sampling and Analysis and Inspections**

- Surface water (ISCO1, ISCO2, PZ-16RR/PZ-16RSW, PZ-17RR, PZ-18R, SD-17, ISCO3)
- Groundwater (GW-202S, GW-202D, GW-78S, GW-79S, PZ-16RR, PZ-17RR, PZ-18RR)
- Inspection Temporary Cap inspection to document cover condition and areas requiring maintenance

#### **Semi-Annual Water Quality Sampling and Analysis**

- Groundwater (GW-34D, GW-34SR, GW-35S, GW-10S, GW-24, GW-25, GW-26, GW-42S (destroyed), GW-43S, GW-76S, GW-201S, GW-CA1)

## **Annual Sediment Sampling and Analysis**

Sediment (SD-SD1, SD-SD2, SD-SD3, SD-SD4, SD-SD5)

### **Continuous Water Levels**

Data loggers and pressure transducers, which collect a continuous record of groundwater levels, will be deployed at GW-10S, GW-35S, GW-76S, GW-78S, and GW-CA1 to continue comparison of water level trends within and outside of the containment area. Data loggers will be checked quarterly and data downloaded. Daily precipitation data will be recorded by Olin personnel during weekdays.

#### **2.4.4 Sample Collection Methods**

Groundwater samples will be collected by the USEPA Region 1 Low Stress (low flow) Purging and Sampling Procedure (USEPA, 1996) using a Geopump™ and flow through cell in accordance with procedures described in Appendix A- Attachment A. Sample documentation will include field notes and a Field Data Record (FDR) as provided in Appendix A- Attachment C. After parameter stabilization, the sample will be collected prior to entry to the flow through cell. Turbidity measurements will be taken from a sample “T” located up stream of the flow through cell. Samples that do not meet sampling turbidity criteria will be field filtered. Samples exceeding a turbidity criterion of 50 nephelometric turbidity units (NTUs) will be field filtered with a 0.45 micron filter. Both the filtered and non-filtered fraction will be submitted for analysis. Samples will be labeled, preserved, and shipped in accordance with procedures in Appendix A.

Surface water samples will be collected by direct dip methods in accordance with procedures described in Appendix A- Attachment A. Sample documentation will include field notes and a FDR as provided in Appendix A- Attachment C. The sampler will approach the sample location from the down stream side to avoid disturbing sediment prior to collection of the water sample. Samples will be labeled, preserved, and shipped in accordance with procedures in Appendix A.

Sediment samples will be collected from 0-6 inches using a clean, stainless steel sediment sampling device in accordance with procedures described in Appendix A- Attachment A. Sample documentation will include field notes and a FDR as provided in Appendix A- Attachment C. The sampler will take care to avoid incorporating visually identifiable floc into the sample. The

sampler will note substrate conditions, presence of organic leaf matter, and floc in the field notes. Samples will be labeled, preserved, and shipped in accordance with procedures in Appendix A.

#### **2.4.5 Summary of Proposed Analytical Program**

Table 2-5 summarizes proposed analytical program by media, analysis, and analytical method. The analytical method specific sample container, sample perseveration, and hold time requirements are discussed along with quality assurance and quality control measures in Appendix A.

Groundwater samples will be analyzed for aluminum, chromium, ammonia, chloride, sulfate and specific conductance. Surface water samples will be analyzed for aluminum, chromium, ammonia, chloride, nitrate, nitrite, sulfate, sodium, and specific conductance. Sediment samples will be analyzed for aluminum, chromium, iron and percent solids.

Off-site analytical samples will be preserved, and shipped under chain of custody as described in Appendix A. The analytical results reported by the laboratory shall be reviewed by a MACTEC chemist and validated, the data managed in accordance with procedures described in Appendix A.

### **2.5 HEALTH AND SAFETY**

Sampling will be conducted in modified level D personal protective equipment using the following equipment: safety glasses, nitrile or latex gloves, and steel-toed safety boots/shoes. All work completed at the site will be performed in accordance with the existing site specific Health and Safety Plan (HASP). All on-site personnel will meet the training and medical monitoring requirements for Hazardous Waste Operations and Emergency Response (HAZWOPER) under 29 CFR 1910.120.

### **2.6 SCHEDULE**

Sampling events will be scheduled on a quarterly and semi-annual basis with the start date within four weeks of the effective date of the Agreement of Consent (AOC).

## 2.7 REPORTING

Olin will submit semi-annual status reports beginning six months after the effective date of the AOC to document monitoring, inspection and maintenance activities described in the IRSWP. Chemical data will be presented in the semi-annual report if the sampling and data receipt schedule has allowed sufficient time for the data to be validated or reviewed by a chemist prior to incorporation into the report.

The report components for the Slurry Wall/Cap will be similar to past semi-annual PCMP status reports and include presentation of groundwater elevation data, groundwater, and surface water quality data. On an annual basis, this assessment will include estimates of mass flux through the equalization window and assessment of sediment analytical data. Groundwater and surface water analytical results for the report period will be presented in tables, and with prior data in time series plots. Appendices will include data validation reports and inspection reports on the temporary cap. A complete and comprehensive assessment of all surface water, groundwater, and sediment data collected in the vicinity of the South Ditch as part of this work plan will be completed and submitted as part of the Operable Unit (OU) 1 remedial investigation report.

Olin will assess the scope of the monitoring program annually, and provide recommendations for further optimization in the semi-annual status reports.

### 3.0 PLANT B INTERIM RESPONSE STEP WORK PLAN

Olin has operated a groundwater containment, recovery and treatment system since 1981 to prevent reoccurrence of LNAPL seepage and related sheen to the East Ditch in the vicinity of Plant B. In July 1997, the MADEP determined that the Plant B system operation constituted an IRA due to the presence of LNAPL in the environment and the presence of a Substantial Release Migration (SRM) condition, consisting of the past discharge of LNAPL to the East Ditch. As an IRA, Plant B System operation was subject to periodic reporting requirements described in the MCP [310 CMR 40.0000].

Since recovery of LNAPL commenced in 1981, the rate and volume of LNAPL recovered has declined and remains low. The existing LNAPL containment and extraction system has undergone several optimization steps to increase mass removal of contaminants. Additionally, the Plant B area contained an area with extractable petroleum hydrocarbons/volatile petroleum hydrocarbons (EPH/VPH) in groundwater and EPH/VPH and trimethylpentenes in soil that was located west (upgradient) of the LNAPL area. The EPH/VPH area has been remediated by an AS/SVE system. The shutdown of the EPH/VPH portion of the AS/SVE system was approved by MADEP in 2005 and that portion of the system has been dismantled. AS/SVE and biostimulation were also implemented at the Plant B LNAPL area as enhancements to the conventional dual phase LNAPL recovery approach implemented earlier at the site. These operations continued through the end of 2006.

Given the success of the treatments implemented at the Plant B area and the current low rate of LNAPL recovery, the system has reached a logical point to test whether systematic adjustments in pumping rate have an affect on LNAPL recovery. Based on some prior operating data, the occurrence of LNAPL and its recoverability was affected historically by the prevailing water table elevation in the LNAPL area. Some of the LNAPL recovery data indicated that initial higher LNAPL recovery rates occurred at a water table elevation higher than is currently maintained. Manipulation of that water level can be accomplished by progressively reducing and controlling groundwater extraction pumping rates. Olin therefore proposes a monitored pumping rate reduction test to evaluate the relationship between water level and LNAPL recovery at the Site. The test would allow for one or several pumping rate reductions depending upon the LNAPL response to changes in water table elevation. After the first pumping rate change, subsequent

changes to pumping rates would be based on assessment of operational monitoring data (e.g., water elevation, LNAPL thickness, LNAPL distribution, and LNAPL recovery rate).

### 3.1 WORKPLAN PURPOSE AND SCOPE

This document has been prepared in accordance with Section 2.II.B of the Statement of Work (SOW) for the RI/FS at the Olin Chemical Superfund Site. This work plan has three specific purposes. First, this work plan presents a description of the current monitoring, operation and maintenance program at Plant B which Olin will continue to conduct until such time as Olin and USEPA agree upon a SOW to conduct a monitored reduction in pumping rates of the system. Second, this work plan presents a summary and evaluation of historical monitoring data for the Plant B system. Third, this work plan proposes an operational approach for a monitored reduction in groundwater extraction pumping rates at the Plant B treatment system. Based on the sporadic nature of LNAPL recovery and limited volumes of LNAPL that have been recovered over the last several years, it is expected that the pumping rates of the system may now be reduced without impact to the East Ditch. The monitored reduction in pumping rates will be used to determine how recovery of remaining LNAPL responds to systematic increases in water table elevation.

The monitoring data collected over the past several years indicates LNAPL recovery is declining and remains low and that the mobility of LNAPL remaining in the subsurface is limited. A monitored reduction of the groundwater extraction pumping rates is appropriate. The approach, steps and actions to be taken during this proposed pumping rate reduction test are presented below. Monitoring during this test will allow contingency actions to be defined and implemented if required.

The general approach will be to reduce the groundwater pumping rates in several steps, allowing water levels to increase and temporarily stabilize at sequentially higher elevations. Groundwater elevation, LNAPL thickness, and LNAPL recovery measurements will occur at each step. Only the first pumping rate reduction step is specified in this work plan. Subsequent pumping rate reductions will occur if warranted by operational data. This work plan describes the pumping rate reduction, the location, type and frequency of monitoring, and possible contingency actions if LNAPL recovery increases or is mobilized toward the East Ditch.

A reduction in pumping rates at the Plant B system has additional potential effects that need to be considered and evaluated with appropriate monitoring strategies. First, the clean treated water from Plant B, when discharged, currently flows to the South Ditch and constitutes a large, but undefined, percentage of the normal flow (base flow) in that reach of the ditch. The permitted discharge flows into the on-Property West Ditch (on-PWD) and into the Upper South Ditch on the downstream side of the weir shown previously in Figure 1-2. This discharge does not affect the water levels, surface water flows, or hydrology of the off-Property West Ditch. The surface water quality in South Ditch is currently monitored on a quarterly frequency as described in the Slurry Wall/Cap IRSWP. The surface water quality monitoring in the South Ditch will be augmented as part of the Plant B IRSWP by adding more frequent sampling of surface water immediately downstream of the weir and conducting on-site laboratory analysis of ammonia for those samples. Olin will separately address, and propose actions to USEPA related to changes in surface water quality based on monitoring results, if warranted.

Second, the Plant B system also captures some component of the dissolved phase constituents associated with the LNAPL impacted soil located below the water table within the saturated zone. As the Plant B pumping rate reduction progresses, the capture of these dissolved constituents in groundwater, which includes ammonia, BEHP and other organic compounds, will be reduced. There are no current users of this groundwater in this industrialized area, and the primary receptor of this groundwater is adjacent East Ditch surface water. The East Ditch is a railway drainage ditch that is periodically maintained by the Massachusetts Bay Transit Authority (MBTA). Maintenance activities include grading of the ballast rock and mechanically clearing vegetation and sediment from the Ditch. Based on prior assessments, the East Ditch offers little if any valuable aquatic habitat. In the eventual absence of a groundwater pumping stress, it is expected that groundwater from the Plant B area will flow east toward the East Ditch, and hence south, parallel to surface water flows in the East Ditch and the railroad. Some groundwater is expected to discharge to water within East Ditch. Olin will include monitoring of groundwater in proximity to the East Ditch and surface water in East Ditch during the pump rate reduction for volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs), VPH, and ammonia. This monitoring will provide additional data to assess changes in groundwater and surface water quality, if any.

The outcomes required for a continued reduction in groundwater extraction pumping rates for Plant B will therefore include:

- No LNAPL migration or associated LNAPL sheen migration to the East Ditch, and
- No observed impact to surface water receptors within the East Ditch from dissolved phase constituents in groundwater.

Evaluation of these outcomes is discussed further in this IRSWP.

## **3.2 BACKGROUND**

The following section describes the location, regulatory and operational history, and current operations and maintenance (O&M) activities at Plant B.

### **3.2.1 Location**

Plant B is located in the northeastern quadrant of the approximate 50 acre 51 Eames Street property (Figures 1-1 and 1-2). The Plant B remedial system includes a larger building which houses the treatment plant and a smaller concrete block building which houses a transfer pump and electrical panels (Figure 3-1). In addition, the system also makes use of three pre-existing insulated above ground storage tanks (ASTs) (Tanks 1, 2 and 7) for storing treated and untreated water. Two other non-insulated ASTs (Tanks 3 and 4) exist but are not used in the treatment system, except for overnight storage / discharge of treated water on Mondays through Fridays.

### **3.2.2 Regulatory and Operational History**

The groundwater containment, recovery, and treatment system has been operated by Olin since 1981 and conducted under an IRA in accordance with the MADEP Conditional Approval since July 3, 1997. The system has been operated to prevent reoccurrence of LNAPL seepage and related sheen to the East Ditch in the vicinity of Plant B.

The LNAPL recovery system has been modified twice since the initial 1981 installation. In 1984, the initial three recovery wells were replaced by an additional five wells. Those wells were subsequently replaced by the existing three-well recovery system in 1988. The LNAPL removal

has been augmented with in-situ biostimulation and air sparging. Implementation of the in-situ remediation system to enhance the cleanup of the Plant B LNAPL area was conditionally approved by MADEP on August 4, 2000, and October 31, 2000. The in-situ enhanced remediation included AS/SVE and biostimulation via nutrient addition. The enhanced remediation has been operating since 2000. In addition, Olin has completed in-situ measures to remediate the area of EPH/VPH.

The Plant B groundwater containment, recovery and treatment system is operated continuously except for maintenance and repair activities. Treated groundwater is discharged to the South Ditch below the weir via the on-PWD (Figure 1-2) under the conditions as set forth in the RGP. Treated groundwater is discharged daily between Monday and Friday. Groundwater extracted on weekends is stored in tanks on the Olin property for treatment and discharge.

Currently, three wells (IW-12, IW-11 and IW-13) are used for groundwater extraction (Figure 3-1). Recovered groundwater is treated for removal of iron by pH adjustment, ammonia by breakpoint chlorination, and organics with activated carbon. Since 2000, the majority of LNAPL has been recovered from two extraction wells (IW-11, and IW-13). LNAPL is collected within a floating skimmer that is periodically retrieved from these wells. In addition, since 2002, a very small quantity of LNAPL has been recovered from the water surface using a peristaltic pump at four other monitoring wells (GW-23, PID, P5 and 12-IN) when measurable LNAPL is observed. In December 2007, a passive skimmer was installed in P5.

As previously stated certain in-situ measures were implemented in the Plant B area. These measures were initially proposed and implemented as a Pilot Study during 2000 - 2001 and consisted of an AS/SVE and Multiphase Extraction Well (MPE) Cluster System. The results of the Pilot Testing were submitted to MADEP for review and approval in August 2001 (Envirogen, 2001). In February 2002, MADEP approved a modification to the remedial system to include a Nutrient Injection System (NIS). In October 2003, a laboratory study to evaluate the progress of biostimulation of BEHP and NDPA in the Plant B LNAPL area was completed as part of the operation and maintenance program associated with the NIS. The analytical and field results collected during September 2003 revealed the presence of the indigenous bacterial population responsible for biodegradation of BEHP and NDPA at the Site. The bacterial population's ability to degrade BEHP and NDPA was limited in nitrogen and oxygen. Based on these preliminary results, it was proposed to the MADEP that the original nutrient mix (mono- and di-potassium phosphate) be replaced with a solution of di-ammonium phosphate to satisfy both the nitrogen and

phosphorous requirements of the BEHP and NDPA degrading bacterial population. In addition, it was proposed that the air sparge rate and frequency be increased to meet the biological oxygen demand. From June 2004 through January 2006, Shaw Environmental (Shaw) operated the NIS on behalf of Olin.

As part of MADEP's December 21, 2004, approval of modifications to the NIS at Plant B, MADEP requested additional monitoring to ensure that the increased AS does not result in vapor migration into indoor air at Plant B. Air monitoring in Plant B was completed on September 8, 2005, and showed no indication of vapor migration due to the AS system.

From 2000 to 2005, Olin operated a second component of the AS/SVE system west of the groundwater extraction and LNAPL recovery system, to treat the EPH/VPH area (Figure 3-1). The principal contaminants in this area were trimethylpentenes. Treatment of the EPH/VPH area was modified in 2002 to include a shutdown test for the AS/SVE system in the EPH/VPH area which was conducted in July and August of 2004. In a letter dated March 21, 2005, the MADEP approved the request to discontinue the operation of the AS/SVE system in the EPH/VPH area, and the system was subsequently shutdown and dismantled in August 2005. The AS/SVE system components in the LNAPL area were not dismantled and continue to operate. Shaw estimated that the total mass (primarily trimethylpentenes) removed by the SVE system to be approximately 2,223 pounds from 2000 through July 2006 as shown in Figure 3-2.

### 3.2.3 Current Monitoring Program

**Groundwater Level Measurements.** Groundwater levels are measured on a monthly frequency in 26 monitoring wells and the three groundwater extraction wells (Table 3-1). The groundwater levels are then computed to groundwater elevation and that data, along with interpreted groundwater surfaces, are presented in a semi-annual Status Report.

**LNAPL Thickness Measurements.** LNAPL thickness is measured on a monthly basis. The number of wells with measurable LNAPL thickness during each sampling event varies as the LNAPL layer is very thin and is sporadically detected in certain individual wells from month to month. The lateral extent of measurable LNAPL is limited, and generally restricted to seven wells, including the three extraction wells (IW-11, IW-12, IW-13) and four monitoring wells (PID, GW-

23, 12-IN, and P5). Typical LNAPL thicknesses measured in monitoring and extraction wells over the last year typically ranged from 0.01 to 0.04 feet (0.12 to 0.48 inches).

**Groundwater Sampling and Analysis.** Groundwater samples are collected and analyzed on a quarterly frequency from one well (GW-16), and an annual frequency from five additional wells (B-03, GW-101, GW-13, IW-10 and IW-6).

The monitoring well groundwater samples are analyzed for trimethylpentenes, NDPA, BEHP, VPH, ammonia, iron, and pH.

**Influent and Effluent Monitoring.** Samples are collected from the treatment plant influent and effluent and analyzed in accordance with the requirements of the RGP. This analysis includes VOCs, SVOCs, total metals (iron), ammonia, total phenols, and residual chlorine. Tables 3-1 and 3-2 summarize the analytical program under the current RGP. The analytical methods are described in Appendix A. Validation procedures are discussed in Appendix A, and include the data validation checklists.

### 3.2.4 Current Operations and Maintenance

**LNAPL Recovery.** LNAPL is recovered from extraction wells IW-11, and IW-13 using a floating LNAPL skimmer with a trap and is checked on a weekly basis. LNAPL is also recovered from the water surface in IW-11, GW-23, PID, 12-IN and P5 using a peristaltic pump or bailer when measurable LNAPL is observed. The LNAPL volume recovered is measured, recorded, and stored in a satellite storage drum. The recovered LNAPL is manifested and shipped as hazardous waste to a licensed treatment/storage/disposal (TSD) facility.

**Water Treatment and Discharge.** The Plant B treatment system uses pH adjustment (iron removal) and break point chlorination to treat ammonia in conjunction with liquid phase granular activated carbon for pretreatment and polishing to remove inorganic and organic compounds. . Extracted groundwater flows to Tanks 1 and 2 for pH adjustment and is then stored in Tank 7 (see Figure 3-1). The pH adjusted water is pretreated through a bag filter and two carbon beds in series, prior to break point chlorination with calcium hypochlorite solution. Treated water is polished through three additional carbon beds in series prior to discharge. Carbon beds are rotated generally

five times a year and back flushed to prevent clogging on a periodic basis. Bag filters are changed out based on pressure differentials through the filter.

Water is treated 24 hours per day during weekdays. Treated water is discharged to the on-PWD wetland and flows into the South Ditch, immediately downstream of the weir, during standard weekday working hours. Overnight, treated water is stored in Tanks 3 and 4. Over the weekend, collected water is stored in Tank 7 for treatment during standard weekday working hours. This water can also be circulated through the other tanks to prevent freezing of lines, pumps and tanks during cold weather months.

**Maintenance.** Maintenance typically includes replacement and adjustment of peristaltic pump drive head hose, maintenance of pump motors on an as needed basis, inspection of valves, pipes and ancillary equipment. In 2006, Storage Tanks 1 through 4, and 7 were tested for wall thickness, the pressure vessel for the air injection system was replaced and the containment area concrete joint seals were refurbished.

### 3.2.5 Historical Data Summary

The following paragraphs provide a summary of LNAPL recovery trends at Plant B and the distribution of certain dissolved phase constituents that are related to the LNAPL and past Plant B operations. These dissolved constituents include trimethylpentenes, BEHP, ammonia and NDPA.

Since June 2000, Olin has been collecting monthly water level, LNAPL thickness, and LNAPL recovery data from 28 wells at the site. To date, over the last seven years, the LNAPL recovery rate has declined significantly, and a total of 101 gallons of LNAPL have been physically recovered.

#### Annual LNAPL Recovery From June 2000 – February 2008

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008
Number of Months	6	12	12	12	12	12	12	12	2
LNAPL Recovered (Gallons)	35.2	34.9	13.1	6.4	3.7	1.8	1.5	3.17	1.14

The cumulative LNAPL recovery curve in Figure 3-3 for Plant B indicates the overall LNAPL recovery rate is declining and remains low.

Figure 3-4 is a plot of monthly water level elevation and LNAPL recovery trends from 2000 to February 2008 for a subset of the Plant B wells that have measurable or recoverable LNAPL. This figure indicates that the historical LNAPL recovery rate was to some extent influenced by groundwater elevations in the extraction wells. For example, during the most productive LNAPL recovery periods in 2000 and 2001, extending into the summer of 2002, water levels in IW-11 ranged between 75.5 and 76.0 feet mean sea level (MSL). Since the summer of 2003, water levels in extraction wells IW-11 and IW-13 have declined (ranging between 75 and 71 feet MSL), with a corresponding decline in LNAPL recovery.

Figure 3-5 is a plot of the water levels and monthly LNAPL recovery of the three most productive recovery wells during the period from 2000 through February 2008. IW-11 and IW-13 account for 98.5% of the LNAPL volume recovered (86.5% and 12.0 % respectively). During the earlier years of system operation (June 2000 through June 2002), the recovery of LNAPL was principally from IW-11 when water elevation in IW-11 ranged between 75.5 and 76.0 feet. In late 2001, LNAPL recovery from IW-11 declined, although it still accounted for most of the LNAPL recovered. LNAPL recovery from IW-13 was most productive in 2002 and 2003 when groundwater elevations in the extraction wells were slightly higher and ranged from 76.4 to 76.8 feet. The water levels where historically LNAPL recovery rates were higher provide water level targets for the proposed pumping rate reduction test. Since August 2005, water levels in IW-11 and IW-12 have progressively increased, (approximately three feet), and this period has also been accompanied by a slight increase in LNAPL recovery. In February 2008, the water level was 73.85 feet MSL in IW-11, 73.71 ft MSL in IW-13 and 76.35 feet MSL in IW-12.

Monitoring data collected by Olin indicates that there is no discernable relationship between LNAPL thickness and LNAPL recovery rates in even the most successful recovery well IW-11 (Figure 3-6). Therefore, based on LNAPL recovery rate data collected from 2000 through 2007, it is reasonable to conclude that the volume of recoverable LNAPL has been substantially depleted around IW-11, and IW-13, and that that the mobility of the limited quantity of LNAPL remaining has been greatly diminished by the combined remedial efforts. Operating decisions related to the proposed changes in pumping strategy will consider several factors including: LNAPL recovery efficiency, water level conditions and the distribution of measurable LNAPL in observation wells.

Groundwater quality in the vicinity of the LNAPL area has historically been monitored in the extraction wells and more recently, monitoring wells including GW-16, B-03, GW-101, GW-13, IW-10, and IW-6. The groundwater samples for the extraction well network are routinely collected from a combined point that provides a composite influent sample to the treatment plant. Groundwater samples collected from the six monitoring wells and the extraction well influent have been analyzed for trimethylpentenes, NDPA, BEHP, VPH, ammonia, iron, and pH. The results of sampling for 2,4,4 trimethyl-1 pentene, BEHP, ammonia and NDPA are summarized below and presented in time series graphs (Figures 3-7 through 3-10). The data for 2,4,4 trimethyl-2 pentene is very similar to 2,4,4 trimethyl-1 pentene and only the 1-pentene isomer data is presented. Figure 3-10 presents each of these compounds in a time series graph for the influent sample location. Figure 3-12 presents the most recent analytical results for these compounds for the six groundwater well locations. Groundwater in the interpreted down gradient region of Plant B, in absence of the Plant B pumping influence, is classified as Non-Zone II and is not used as a potable source of water.

Groundwater flows from west to east across this portion of the Site and groundwater monitored by the well network described above is within capture zone of IW-11, IW-12, and IW-13.

### **Trimethylpentenes**

Figure 3-7 presents a plot of 2,4,4-trimethyl-1-pentene concentrations in groundwater samples with time since 1997 for these six wells. Historically, the trimethylpentenes, which include 2,4,4-trimethyl-1-pentene and 2,4,4-trimethyl-2-pentene, have been detected in all of these six wells. In the most recent sampling event, 2,4,4-trimethyl-1-pentene was only detected in groundwater from three wells (GW-101, GW-16 and IW-6). The influent sample data (Figure 3-11) indicates the range of 2,4,4-trimethyl-1-pentene concentrations in the influent are consistent with, though slightly lower than the highest concentrations detected historically in groundwater. The highest detected concentrations in groundwater located east of the extraction wells have typically been from GW-101 and IW-6. The highest reported concentration of 2,4,4-trimethyl-1-pentene in a groundwater sample was 30 milligrams per liter (mg/L) in December 1997 from GW-101. The most recently reported concentration at that location was 0.073 mg/L in November 2007. For 2,4,4-trimethyl-2-pentene, a similar pattern was observed. It is probable that the highest reported concentrations of the two trimethylpentene compounds were not representative of in situ groundwater, since the reported concentrations are well above any published solubility for these two compounds which are routinely reported to be insoluble in groundwater but soluble in non-

polar substances. Since 1997, the concentration of trimethylpentenes has declined most dramatically in GW-101 and GW-16. The AS/SVE system has effectively removed more than 2,000 pounds of trimethylpentenes from the LNAPL area and the EPH/VPH area (near GW-16) during its operation.

### **BEHP**

Figure 3-8 presents a plot of BEHP concentrations in groundwater samples with time since 1997 for these six wells. BEHP has historically been detected in five of these six wells, as it was not detected in groundwater from B-3. In the most recently sampling event (November 2007), BEHP was only detected in groundwater samples from GW-101 and GW-13. The influent sample data (Figure 3-11) indicates the range of BEHP concentrations in the influent are consistent with concentrations detected in groundwater. East of the extraction wells, the highest concentrations of BEHP detected in groundwater was from GW-101, and to the west, from GW-16. The maximum detected concentration of BEHP in groundwater from GW-101 was 16 mg/L in February 1998, and most recently was reported at a concentration of 0.054 mg/L in November 2007. It is probable that the maximum reported concentration of BEHP was not representative of in situ groundwater, since the reported concentration was well above the water solubility (0.285 mg/L) of BEHP. The concentrations of BEHP in groundwater from GW-101 have declined over the past four years. Since 1997, the concentration of BEHP has remained relatively constant in each of the other four wells. In the most recent sampling round, BEHP was only detected in groundwater samples collected from GW-13 and GW-101.

### **Nitrogen Ammonia**

Figure 3-9 presents a plot of ammonia concentrations detected in groundwater samples with time since 1997 for these six wells. Ammonia has been detected historically in groundwater from each of the six wells monitored. In the most recent sampling event (November 2007), ammonia was detected in groundwater samples from four wells including IW-10, GW-101, IW-6 and GW-16. The influent sample data (Figure 3-11) indicates ammonia concentrations in influent are consistent with a weighted average of concentrations detected in groundwater in the vicinity of the three extraction wells. Based on the distribution of ammonia in groundwater, the majority of ammonia mass in the influent is contributed through IW-13 in the vicinity of IW-10. East of the extraction wells the highest concentration of ammonia has been detected in groundwater from IW-10. The maximum detected concentration of ammonia in groundwater from IW-10 was 62.4 mg/L in July 1997, and most recently was reported at a concentration of 59 mg/L in November 2007. Ammonia

concentrations in B-03 have declined over the last seven years and have remained relatively constant over time in the other wells. Ammonia was not detected in GW-13 during the most recent sampling event (November 2007) and concentrations in other wells were low, ranging between 6.9 and 0.92 mg/L.

### **NDPA**

Figure 3-10 presents a plot of NDPA concentrations in groundwater samples with time since 1997 for these six wells. NDPA has historically been detected in five of these wells. In the most recent sampling event (November 2007), NDPA was detected in groundwater samples from five wells including IW-10, GW-101, IW-6 B-3 and GW-16. NDPA has not been detected in groundwater collected from GW-13, which is the most northern of the monitoring well locations. The influent sample data (Figure 3-11) indicates NDPA concentrations in influent are consistent with the range of concentrations detected in groundwater. The highest concentrations of NDPA detected in groundwater from these wells were from B-03 and GW-101, and have declined from one to two orders of magnitude since 1997. NDPA has also been detected in GW-13, GW-16 and IW-6, but not with sufficient frequency to ascertain changes in concentration over time. The most recent chemical data (November 2007) are presented in Figure 3-12, and indicate that NDPA concentrations in groundwater are highest upgradient of Plant B in GW-16 and to the south in B-3. NDPA concentrations in IW-6, IW-10 and GW-101 are low, ranging from 0.0076 ug/L to an estimated concentration of 0.0014 ug/L.

Groundwater quality monitoring results from IW-10, GW-101 and IW-6 indicates the presence of LNAPL-related compounds in groundwater between the extraction wells and East Ditch. The location of these wells relative to the groundwater pumping induced flow directions indicates LNAPL related compounds are sorbed to soil between the extraction wells and East Ditch. These constituents in groundwater would be expected to migrate easterly toward the East Ditch in the absence of a pumping stress, then south east parallel to the East Ditch. As discussed previously, the East Ditch is a railroad drainage ditch, and offers little valuable aquatic habitat.

### **Distribution of Ammonia, BEHP, NDPA and TMP in On-Property Groundwater**

The distribution of these compounds in on-Property groundwater was presented in the Draft Focused Remedial Investigation Report (MACTEC, October 2007). The highest concentrations of ammonia in groundwater at Plant B are not anomalous when compared to concentrations observed elsewhere at the Property including areas south of Plant B which also border East Ditch. The

distribution of NDPA and TMPs in on-Property groundwater includes the Plant B area, and areas associated with on-Property DAPL within the containment area and former Lake Poly. The distribution of BEHP in on-Property groundwater is restricted to the Plant B area, and deeper groundwater associated with on-Property DAPL within the containment area.

### **3.3 PUMPING RATE REDUCTION MONITORING OBJECTIVES**

The following section describes the general monitoring objectives of the proposed monitored pumping rate reductions of the Plant B system, including monitoring the effects of water level change on LNAPL recovery, evaluating the potential for mobility of any residual LNAPL and measurement of water quality changes in Plant B groundwater and East Ditch surface water. Goals or measurements of success for the reduction in pumping rates of the Plant B system are described in Section 3.5. The Plant B groundwater extraction and treatment system was implemented for LNAPL migration control and was not intended as a remedy or control for dissolved phased groundwater in vicinity of Plant B, or adjacent on-Property areas. The Plant B pumping rate reduction monitoring objectives focus on LNAPL related issues. Olin will evaluate all Site groundwater as part of OU3 in the CERCLA RI/FS program and identification of remedial requirements for groundwater in the Plant B area will occur during that process.

Assessment of further biostimulation is not a monitoring objective of this test. The operation of air sparging will affect water levels upgradient of the extraction wells and will add one more unknown variable into the assessment of effect of water table elevation on LNAPL mobility and recoverability. Therefore during the progression of the pumping rate reductions, the AS/SVE system will not be operated, and consequently, nutrient additions will also not be conducted.

#### **3.3.1 Assessment of Further LNAPL Recovery**

Historical data suggests some relationship may have existed between the water table elevation and the appearance and recovery of LNAPL. Therefore, one of the monitoring objectives of the pumping rate reduction will be to assess if LNAPL recovery rates are affected by manipulation of the water table elevation. Since September 2005, a gradual increase in water levels in extraction wells IW-11 and IW-12 has occurred as in the course of normal system operation. This period of time has also been accompanied with a small but perceptible increase in LNAPL recovery. During the course of this pumping rate reduction test, the water levels will be allowed to increase further.

The drawdown in the pumping wells will be held at specific water table elevations targets for a sufficient time period to observe if LNAPL recovery increases or decreases. The length of that time that constitutes a sufficient period will be based on the results of water level, LNAPL thickness, LNAPL distribution and LNAPL recovery data. Figure 3-13 presents the interpreted distribution of LNAPL from the most recent sampling period. Historical LNAPL distribution figures are presented in Appendix B. If after an adequate monitoring period, (to be determined by field data), there is no indication of increased recovery of LNAPL, Olin will propose further reduction in the extraction well pumping rate. Olin will make proposed modifications with EPA concurrence. The proposed changes may be included in status report submittals or in general correspondence with EPA.

### 3.3.2 Assessment of LNAPL Mobility

Currently the groundwater pumping cone of depression restricts LNAPL and associated sheen migration toward the East Ditch. LNAPL mobility is a function of LNAPL saturation and LNAPL conductivity (a function of LNAPL density, viscosity, and permeability relative to water). The stability of an LNAPL plume refers to the ability of the LNAPL to migrate and is a function of LNAPL mobility and LNAPL gradient which is defined by the elevation change of the air-LNAPL interface over a distance (API, 2004). If the LNAPL is in vertical hydrostatic equilibrium with the groundwater, then the LNAPL gradient is approximately the same as the groundwater gradient. As the groundwater pumping rate is reduced, the groundwater gradient from current residual sources of LNAPL to the recovery wells will decrease and eventually flatten. Current LNAPL measured thicknesses are trace to very low values (0.01 - 0.04 feet), which indicates that the LNAPL gradient is small relative to the hydraulic gradient due to pumping. As this hydraulic gradient is reduced, it is reasonable to expect that remaining LNAPL will become increasingly immobile (i.e., unable to overcome capillary and surface tension forces opposing flow) if a thickening of the LNAPL layer does not occur as the water table rises.

One of the pumping rate reduction monitoring objectives will be to verify that LNAPL is not migrating beyond the capture zone of the extraction wells as pumping rates are reduced. This will be accomplished by monitoring changes in LNAPL thicknesses in the extraction wells, and observing for the presence of sheen or LNAPL in down gradient wells (eight wells located east of the current extraction wells). If sheen or LNAPL is shown to be migrating, or dissolved concentrations are shown to be increasing in area wells in response to a reduced pumping

condition, appropriate actions will be taken. Such actions will include increased frequency of monitoring, and if free or dissolved phase constituents are increasing in wells between Plant B and the East Ditch, will include daily observations (during normal working hours) for sheen in the East Ditch and may include increasing pumping rates. Sheen that can be attributed to LNAPL in the East Ditch shall be contained and removed with absorbents. Pumping rates will be adjusted as necessary to prevent further release of sheen to the East Ditch.

### **3.3.3 Assessment of Dissolved Phase Groundwater on East Ditch Water Quality**

One of the monitoring objectives of the pumping rate reduction test is to monitor East Ditch surface water and groundwater east and south of Plant B for VOCs, SVOCs, VPH and ammonia. The analytical data will be used to evaluate potential for impacts to East Ditch from dissolved phase constituents in groundwater. An additional monitoring objective is to verify groundwater flow directions in the vicinity of Plant B as the pumping rate changes continue by collecting and evaluating several synoptic rounds of water level measurements. Pumping rates will be adjusted as necessary to reduce groundwater discharge to the East Ditch.

### **3.3.4 Assessment of Water Quality Changes in South Ditch**

One of the monitoring objectives is to document ammonia concentrations in South Ditch surface water as the volume of treated groundwater discharge from Plant B into the South Ditch is reduced. These discharge flows would occur during Monday through Friday during normal working hours, with durations dependent on the total pumping rate at Plant B. Over weekends, the water is extracted and stored and is not treated or discharged.

The groundwater which currently discharges to the South Ditch downstream of the weir contains ammonia and other site-related constituents. Depending on the time of the year and the volume of base flow in the South Ditch, the Plant B treated groundwater inflow to South Ditch can contribute a large percentage of the total stream flow. This treated discharge has higher alkalinity and pH and lower concentrations of ammonia, inorganics, and metals than the base flow surface water in the South Ditch. In general, the discharge of the treated groundwater to the South Ditch reduces concentrations of ammonia, inorganics, and metals in South Ditch surface water. The mixing of the treated groundwater with the South Ditch base flow also results in the formation of the floc observed immediately downstream of the weir.

During the pumping rate reductions conditions in South Ditch will be monitored and observed. The monitoring of South Ditch will include collection of surface water samples for on-site analysis of pH and ammonia and measurement of surface water levels at weekly frequency as shown on Table 3-3. These activities will be completed at locations PZ-20 and PZ-17RR, located 25 feet and 150 feet respectively, downstream of the weir in Upper South Ditch. The top of risers on these piezometers have been surveyed for vertical control. The surface water level measurement will include the surface water elevation (measured from the top of riser) and surface water depth at each piezometer. In addition the shallow groundwater level in the piezometer will be measured to allow computation of the vertical gradient between surface water and shallow groundwater. If changes in conditions are observed that merit further communication outside of the Status Reports, Olin will contact USEPA.

### 3.3.5 Data Quality Objectives

The data developed during the monitored reduction in pumping rates will be used to:

- monitor and adjust groundwater pumping rates in response to water level, LNAPL thickness or dissolved concentrations as required;
- evaluate groundwater flow directions prior to, during and after any pumping rate change;
- monitor LNAPL distribution and thickness prior to, during and after any pumping rate change; and
- monitor VOCs, SVOCs, ammonia and other COC concentrations in area groundwater sufficient to determine any impacts after a pumping rate change.

Water level and LNAPL level measurements will be taken with calibrated meters capable of measuring the water table to within 0.01 feet, and LNAPL thickness to within 0.01 feet.

Groundwater pumping rates will be adjusted using a separate variable frequency motor drive dedicated to each pump to maintain consistent, measurable and repeatable pumping rates. Total flows will be measured by recording the volumetric flow over a measured time period and calculating volume per time.

Under the existing RGP for treated water discharge, samples of the Plant B influent and effluent are collected monthly for off-site chemical analysis, as described previously. These monthly influent

and effluent samples will be collected and analyzed during the course of the pumping rate reductions for periods when groundwater is being extracted, treated and discharged. These are quantitative data used for verifying compliance with the RGP. These data will be validated in accordance with procedures in Appendix A. Reporting limits for laboratory analysis are also provided in Appendix A.

Collection, preservation, tracking, validation and reporting of off-site laboratory analysis of groundwater and surface water samples shall be completed in accordance with procedures and QA/QC requirements provided in Appendix A. On-site analysis of ammonia shall also be completed, and this work will be completed in accordance with methods contained in Appendix A. Collectively, this data will be used to assess potential for water quality impacts associated with the Plant B pumping rate reductions.

### **3.4 PROPOSED PUMPING RATE CHANGES AND MONITORING PROGRAM**

This section describes four major aspects of the monitored pumping rate reduction program including:

- modifications to the existing pump controls;
- operational adjustments;
- sample locations and frequency of sampling; and
- summary of analytical program.

#### **3.4.1 Modification to Existing Pump Controls**

The existing Plant B groundwater extraction system was not designed to allow fine adjustment of the pumping rates. The groundwater extraction was designed to maintain a groundwater depression sufficient to contain LNAPL and inhibit LNAPL migration to the East Ditch. The groundwater is pumped with large peristaltic pumps at nearly constant revolution. The water table fluctuates in response to recharge events and surrounding seasonal groundwater conditions superimposed on the extraction system pumping cone of depression.

The existing peristaltic groundwater extraction pumps have been upgraded with variable frequency drives to allow precise control of motor speed measured in revolutions per minute (RPM). Changes in pumping rates will be roughly proportional to changes in motor RPM.

### **3.4.2 Pumping Rate Changes, Operational Adjustments, and Monitoring**

This subsection describes the general schedule for pumping rate changes and operational adjustments which may be required if an increase in additional recoverable LNAPL is encountered.

#### **3.4.2.1 Pumping Rate Changes**

The system response to initial pumping rate changes will be evaluated. The monitoring and evaluation period will include pumping rate adjustments where the current total system pumping rate of 8.5 gallons per minute (gpm) will be stepped down initially to approximately 5.5 gpm over a four to six week period, by making gradual and incremental pumping rate adjustments. . The exact reduced pumping rate will be based on target water elevations as outlined below. Any further reductions or cycling of the system may be proposed based on the measured response to LNAPL, dissolved constituents and water levels.

The initial target water elevations include 75.5 to 76 feet for IW-11 and IW-12, and 76 to 76.5 feet for IW-13. These elevations replicate general water level conditions that persisted from 2000 to 2002, when LNAPL recovery was most productive. The water level elevation targets for PID, GW-23 and P5 should range from 77 to 77.5 feet during the initial rate adjustment. These target water level elevations are intended for initial adjustment of the pumping rates and maintaining them are not rigid requirements for system operation. It is expected that operational experience will identify ranges around these initial targets that the system can be operated to achieve. The objective will be to stabilize water levels at or near the target elevations over a four to six week period. Once these target elevations are reached and reasonable operational ranges become better understood, pumping rates will need to be adjusted on an as needed basis to respond to water table fluctuations that arise from changes in direct recharge from precipitation events and dry spell periods.

Pumping rate changes will be preceded and followed by a series of monitoring steps. Each of these steps and the frequency of monitoring activities are described in Table 3-3. Subsequent

modifications to pumping rates will be based on evaluation of the data collected during this process.

#### 3.4.2.2 Operational Adjustments

One of the purposes of the monitored pumping rate reduction is to assess the effects of a rising water table elevation on LNAPL mobility. If a gradual increase in the water table elevation is accompanied by a measurable monthly increase in LNAPL recovery, the water table will be held at that level and pumping rate until LNAPL recovery rates again begin to decline.

Olin will evaluate and summarize monitoring data and make recommendations to EPA concerning pumping rate changes. Other operational adjustments will be evaluated based on changes in operating conditions and/or observations of sheen or LNAPL in wells at other locations in the monitoring well network. The appearance of sheen or LNAPL as the water table rises do not necessarily indicate that LNAPL is mobile or recoverable.

#### 3.4.2.3 Monitoring

Current monitoring activities include collection of water levels, LNAPL thickness, LNAPL recovery data and extraction well flow rates. The wells, monitoring activities and monitoring frequencies are shown in Table 3-3. Prior to initiating pumping rate changes, a synoptic water level data set will be collected from a larger number of wells to gain a better understanding of the hydraulic influence of the Plant B groundwater extraction wells. If the water level probe indicates the presence of a LNAPL in the well, a LNAPL level measurement will be made. LNAPL level measurements will be made in all wells that have historically detected LNAPL. The presence of sheens will be checked in the eight downgradient wells on the east side of the Site prior to initiating the initial incremental pumping rate adjustments. The presence of sheen is determined visually by obtaining a groundwater sample at the water table in a clear bailer. If the bailers indicate the presence of sheen in any well between the Plant B extraction wells and the East Ditch, monitoring will include daily observations for sheen in the East Ditch when Olin staff is normally scheduled to be on site during weekdays.

After pumping rate adjustments have achieved the target water levels, LNAPL recovery and flow rate measurements will be collected during weekday operations with daily water level

measurements from the extraction wells. On a weekly basis, additional wells will be checked for LNAPL and LNAPL related sheen and LNAPL (if present) will be recovered. On a monthly basis, a larger set of wells will be measured for water levels as part of Plant B operations and will continue to be monitored during the pumping rate reduction test

### **3.4.3 Summary of Proposed Analytical Program**

During normal operation of the Plant B groundwater extraction and treatment system, monthly influent and effluent sampling and analysis will be conducted in accordance with the RGP. This will include analysis for VOCs including trimethylpentenes, SVOCs, iron, ammonia, pH, total phenols, residual chlorine and silica gel treated hexane extractable material (SGT-HEM) (Tables 3-1 and 3-2). Normal operational monitoring will also include quarterly sampling of GW-16, and semiannual sampling of B-03, GW-101, GW-13, IW-10, and IW-6. Groundwater samples collected from these wells will be analyzed for trimethylpentenes, NDPA, BEHP, EPH, VPH, ammonia, iron, and pH. Samples will be collected and analyzed in accordance with methods and procedures described in Appendix A.

On a monthly frequency, after initial target water levels are achieved, a groundwater sample will be collected by low flow methods from IW-6, GW-101, and IW-10 and analyzed for VOCs, SVOCs, EPH, VPH and ammonia to document groundwater quality immediately down gradient of the Plant B area. On a monthly frequency, two surface water samples will be collected from East Ditch and analyzed for VOCs, SVOCs, EPH, VPH and ammonia in accordance with methods in Table 3-2 and Appendix A. Sampling access to East Ditch is dependent upon obtaining necessary access permits and approval of sampling dates which will require advance notice and approval from Massachusetts Bay Transit Authority (MBTA). If access cannot be obtained for a particular sampling date, that sampling cannot be performed.

On a weekly basis during normal Plant B discharge operations, a surface water sample will be collected from the surface water locations immediately downstream of the weir (PZ-21) and also slightly downstream of the weir (PZ-17RR) and analyzed on-site for ammonia and pH in accordance with methods described for sampling and analysis in Table 3-2 and Appendix A. The water level in the stream will be gauged at the time of sampling, and field parameters of temperature, turbidity and specific conductance will be collected. Surface water samples collected from South Ditch will not be collected for off-site analysis.

### **3.5 MEASUREMENTS OF SUCCESS**

The following bullets identify the criteria that would be considered measures of success for the LNAPL recovery pumping rate modifications. The measurements must be substantially achieved in order for the effort to be deemed successful.

- Increased volume and/or efficiency of recovered LNAPL (i.e., monthly/cumulative volume or LNAPL/water ratio); or
- Achieve and maintain conditions that indicate remaining LNAPL is immobile;
- No LNAPL or LNAPL related sheen observed in East Ditch surface water or bank;
- No adverse impact on surface water quality in the East Ditch (ammonia, VOCs, SVOCs);
- No visually observable adverse impacts to aquatic life in the East Ditch.

### **3.6 SCHEDULE**

A start date for the pumping rate modifications will be negotiated with the USEPA based on comments on this work plan, and completion of training and access agreement to sample East Ditch within the MBTA.

### **3.7 REPORTING**

The results of the pumping rate reductions, groundwater and surface water monitoring will be provided in the semi-annual status report. These reported results will include tabulated LNAPL recovery data, water level data, and LNAPL thickness data. Figures will include monthly and cumulative LNAPL recoveries for individual wells and plots of extraction well water levels. Interpreted groundwater surfaces from the monthly water level measurements will also be provided.

### **3.8 HEALTH AND SAFETY**

The activities related to pumping rate modifications within the Olin Property will be conducted principally by Olin personnel as part of the Plant B O&M. This work will be carried out under Olin's Site HASP.

#### **4.0 DAPL EXTRACTION PILOT TEST DESIGN INTERIM RESPONSE STEP WORK PLAN**

This IRSWP addresses the schedule for the design of the DAPL Extraction Pilot Test for a DAPL extraction remedy at a portion of the Site, referred to as the off-PWD Study Area. The off-PWD Study Area and the DAPL extent within the off-PWD Study Area are shown as Figure 4-1. This IRSWP has been prepared in accordance with Statement of Work for the RI/FS (USEPA, 2007). The IRSWP presents the current proposed site plan which identifies the previously MADEP-approved location for the extraction well and associated monitoring wells (Figure 4-2). In addition, this IRSWP also presents the description of the extraction and monitoring program as it was presented to and approved by the MADEP. Data collection during the IRSWP described herein will document hydrogeologic responses and potential geochemical changes in response to pumping stresses.

Information developed during the DAPL Extraction Pilot Test will be used in the preparation of the off-PWD Study Area component of the FS for groundwater.

#### **4.1 PURPOSE OF DAPL EXTRACTION PILOT TEST**

##### **4.1.1 Purpose of DAPL Extraction Pilot Test**

The DAPL Extraction Pilot Test described below is intended to determine the feasibility of DAPL extraction in the off-PWD Study Area, and to assess the hydrogeologic and geochemical impact of DAPL extraction on groundwater and surface water quality in areas proximate to the extraction operations. Information developed during the DAPL Extraction Pilot Test will be used in the FS for groundwater. The location of the off-PWD Study Area is shown in Figure 4-1.

## 4.2 BACKGROUND

### 4.2.1 Conceptual Site Model Considerations

#### *Hydrogeologic Considerations*

Figure 4-3 presents a cross section to scale through a portion of the off-PWD Study Area. This section (A-A') shows the interpreted bedrock surface and the estimated top of DAPL between well clusters GW43S/43D (A) and GW42S/42D (A'). Multilevel piezometer MP-2, not shown on the section, is adjacent to GW42S/42D. The location of this section is shown on Figure 4-2. The interpreted DAPL/diffuse layer interface was estimated previously by Geomega to be near 60 feet MSL (Geomega, 2003a) based on results of inductance logging and sampling of piezometers and wells around the Study Area.

The DAPL thickness over the deepest portion of the bedrock depression is approximately 22 feet. The upper DAPL surface is approximately 28 feet below ground surface. From surrounding borings, the overburden geology consists of a layered sequence of fine to coarse sand and mixtures of sand, gravel and cobbles. It has been noted in a number of borings that the gravel and cobble content increases with depth, but in borings completed by Geomega to collect samples for column testing, the lower sections of unconsolidated deposits in the bedrock depression are a silty glacial till. Geomega assigned a hydraulic conductivity of 1 foot/day for this material in its implementation of the finite element numerical model for the simulation of remedial alternatives (Geomega, 2003b).

#### *DAPL Geochemical Considerations*

DAPL is an acidic, reduced, hypersaline fluid with both elevated concentrations of inorganics and organics. Inorganics detected in DAPL at high concentrations include dissolved sulfate, sodium, chloride, ammonia, chromium, iron, aluminum and manganese. Organics detected in DAPL include phenol, acetone, 2-hexanone, bromoform, MEK, BEHP, toluene, trimethylpentenes, 4-bromophenyl-phenylether, naphthalene, benzoic acid, NDPA and NDMA. Column flushing studies conducted by Geomega (Geomega, 2004a) have clearly demonstrated the potential for precipitation of inorganic minerals and pore throat clogging (i.e., the blocking of the smaller apertures within the connected inter-granular pore spaces between soil particles) when DAPL is displaced by higher pH groundwater, thus changing Eh and pH conditions within the aquifer. At the lower pH conditions that are characteristic of DAPL, the majority of the dissolved iron is

present as ferrous iron. As pH increases, the mineralization mechanism is initiated by oxidation of soluble ferrous to insoluble ferric iron and precipitation of iron oxides. The iron oxide mineral surfaces form nucleation points for precipitation of an aluminum-chromium sulfate. These mineral phases are not only capable of clogging aquifer pore throats, but presumably also extraction well screens, sand pack, and piping when appropriate conditions are created. One of the extraction test objectives is to remove DAPL in a manner that minimizes intrusion of overlying groundwater and diffuse groundwater into the DAPL, and thereby mitigating undesirable mineralization. As DAPL is drawn down and inward to the extraction point, mineralization would be expected to occur to some extent from disconnected ganglia of DAPL that are retained within dead-end pore throats and constrictions in the till. Since the precipitated minerals will likely slowly dissolve from the aquifer matrix over long periods of time, maximizing the percentage of recoverable DAPL should be a primary remedial objective. This may require a longer term, more gradual DAPL recovery strategy that minimizes the formation and retention of DAPL ganglia in the aquifer.

The DAPL will be extracted from the bottom of the DAPL layer at controlled rates in order to avoid uncontrolled, large scale mixing of DAPL with relatively un-impacted groundwater, which could potentially cause precipitation reactions that could clog the subsurface soil matrix and potentially make further DAPL extraction difficult or impossible.

#### *DAPL Density Flow Considerations*

The movement of the DAPL is governed by density driven flow mechanisms that are dominated by convection. The DAPL within the off-PWD study area has migrated vertically downward to the bedrock surface, which constitutes an essentially impervious boundary. The DAPL is contained within a shallow sloping bedrock depression, which forms a “bowl shaped” sloping aquifer with a central low point, or bottom. Extraction of fluid from the low point of this depression will result in DAPL movement along this sloping boundary toward the central extraction point. For a DAPL removal strategy to be effective, the rate at which the DAPL is pumped should not exceed the density driven flow rate towards the extraction point. Pumping at an excessive rate over an extended period of time could create several general conditions that would favor failure of the extraction strategy. These include:

- Causing the DAPL body to become disconnected and intruded by diffuse and overlying regions of groundwater resulting in mineralization and aquifer clogging;

- Causing excessive DAPL drawdown of the DAPL/diffuse layer interface in vicinity of the pumping wells with similar detrimental effects;
- Causing a disturbance of either the DAPL or the diffuse layer could induce convective flow patterns that may exacerbate the existing conditions (e.g., cause contamination to spread over a broader area, increase concentrations at shallow depths in the aquifer and/or in off-PWD surface water); and
- Causing an expansion of the diffuse layer thickness.

The pumping rate that would cause these types of failures over both short and longer term conditions is not currently known, and investigating that question further is an objective of the DAPL Extraction Pilot Test. Geomega (Geomega, 2004b) has made an initial estimate of the density driven flow rate for the upper DAPL pool in the off-PWD Study Area. This estimate, which ranges from 0.2 to 0.8 gpm, is a function of the DAPL density, bedrock slope, aquifer porosity and hydraulic conductivity. The DAPL pool is known to be density stratified, and density is a variable that will change with time and presumably affect sustainable DAPL pumping rates. Mineralization within the aquifer, discussed previously, could impact aquifer porosity and conductivity. The aquifer properties at the point of extraction will not be known until the extraction and monitoring wells have been installed. Sustainable pumping rates will be evaluated by increasing the pumping rate and monitoring drawdown of the DAPL/diffuse layer interface and any associated chemical changes.

### **4.3 DAPL EXTRACTION PILOT TEST DESIGN**

This section describes the design schedule and the physical components that need to be designed to extract, and to safely manage and transport the extracted DAPL for off-site treatment and disposal at a licensed facility approved for these materials. The DAPL Extraction Pilot Study design also encompasses the monitoring strategy and requirements for operation and maintenance of the system during the pilot test. The general monitoring strategy has been proposed to and has been approved by the MADEP. The principal components of that monitoring approach are summarized in this work plan.

#### **4.3.1 Design Schedule**

The design schedule is presented in Figure 4-4. The design will include extraction and monitoring wells, two dual wall DAPL storage tanks and a truck loading facility, with appropriate leak

detection, and automatic shutdown controls and telemetry, to provide a safe and reliable pilot system. This will require preparation of a Spill Prevention, Control and Countermeasure Plan (SPCC). An O&M Plan will be developed based upon the final design and as built equipment. The design will undergo an extensive safety review by Olin and MACTEC, to ensure protection of site operators and the public.

The pilot DAPL extraction system will be built, operated, and maintained on a property not owned by Olin, and the DAPL will be transported off-site on in truck tanker cars not owned or operated by Olin. Therefore several additional parties will be involved in the process of providing access, and implementation of the DAPL extraction test. These parties include the property owner, the transport and the disposal contractor

#### **4.3.2 Description of Pilot Test**

The Pilot Test will consist of the installation of a DAPL extraction and conveyance system, a phased DAPL extraction program, and the shipment of recovered DAPL over road trucks to an off-site disposal facility. Figure 4-2 is the current proposed site plan showing the approved location of the extraction well, proposed locations of inductance logging wells and multi-level piezometers in the immediate vicinity of the extraction well, and the proposed location of the truck tanker car loading station. During the DAPL Extraction Pilot Test, monitoring will be conducted to assess the impact of the DAPL extraction operation on groundwater and residual DAPL in the off-PWD Study Area.

The DAPL Extraction Pilot Test has several distinct phases including a baseline monitoring period and a DAPL extraction period that entails several stepped periods with increasing rates of pumping. The duration of each step test period will be considerably longer than a typical aquifer pumping test due to the geochemical concerns described above. The purpose of the overall test is to better understand hydraulic properties of the till, DAPL/diffuse layer interface response to pumping, geochemical changes near the extraction well and longer term overall lowering of the height of the DAPL pool. The general approach to the pilot test and key elements of the design are described below.

### 4.3.3 Proposed Extraction Well

The proposed DAPL extraction well and the configuration of the monitoring well network are depicted in plan view in Figure 4-2 and in schematic sectional view in Figure 4-5. The final location of the extraction well may be modified based on third party agreements required for access to the property.

The currently proposed extraction well will be screened in the DAPL and constructed from 6-inch diameter, Schedule 40 polyvinyl chloride (PVC) with a 5-foot long continuous slot (wire wound) well screen, installed to the bottom of the DAPL pool, at the deepest central point in the bedrock depression. This depth is approximately 50 feet below ground surface. The final design of the well screen and sand pack will be based on geologic stratigraphy encountered at the location during installation of the monitoring wells. Samples of the soil will be collected for field or laboratory grain size distribution to verify field classification. The final field well design will consider placing the well screen several feet into bedrock to act as a sump, and will evaluate the screen length and its position relative to the top of till, if present. The sand pack will extend two feet above the top of screen and be sealed with three feet of bentonite chips. The remainder of the well annulus will be grouted to the surface with a cement/bentonite grout. The well head will be secured within a well vault with a small enclosure for a peristaltic pump. The pump drop-pipe will be constructed from PVC.

The extraction well and all nearby monitoring wells and piezometers will be installed by Rotasonic drilling methods. This method is intended to minimize disturbance to the aquifer during drilling.

### 4.3.4 Monitoring Well Network

Short-term changes in groundwater quality in the vicinity of the extraction well will be monitored with two new multilevel piezometers and two induction logging wells on the currently downgradient side of the extraction well, and one induction logging well on the currently upgradient side, as shown schematically in Figure 4-5. All wells will be flush-mounted.

The two downgradient multilevel piezometers will be installed at 7.5 feet and at 15 feet from the extraction well. The two downgradient induction logging wells will be installed at 15 feet and 30 feet from the extraction well. The upgradient induction logging well will be 15 feet from the

extraction well. This well configuration is intended to provide a thorough understanding of upgradient hydraulic and geochemical responses to pumping, and an ability to compare down gradient responses. The well network is not intended to evaluate symmetry of response around the extraction well. Existing wells in the area will also be used to monitor groundwater elevation and water quality. These include GW-42S, which will be instrumented with continuous recording water level transducers, and GW-42D, which will be inductively logged during the test monitoring period. Wells GW-43S/43D were destroyed when the 4-6 Jewel Drive industrial property was developed.

The multilevel piezometers will each have from ten to twelve ports and will span the DAPL/diffuse layer interface, overlying groundwater and underlying DAPL. The diffuse layer is estimated to be 3 to 4 feet thick. The piezometer construction will be the same as other multilevel piezometers on-site (e.g., MP-2), with single tube ports that will be accessed for collection of groundwater samples and physical measurement of the potentiometric surface. The induction logging wells will be two-inch diameter Schedule 40 PVC with a solid cap bottom. These wells will be filled with de-ionized (DI) water as they are constructed and installed down the borehole to help overcome buoyancy. The DI water will remain in the wells for logging.

Depending on the best route for access, the sequence of drilling will be to install the extraction well first, followed by the induction logging wells. After these wells are installed, the three induction wells will be inductively logged to locate the DAPL/diffuse layer interface. Those data will be used to determine the depths of the ports in the multilevel wells. The multilevel wells will be installed last.

#### **4.3.5 Conveyance Pipe**

The location of the truck loading area is shown in Figure 4-2. The area is within the property setbacks to avoid restrictions on the commercial use of the property. The piping will be above ground between the well house, storage tanks and off loading connection. The conveyance pipe from the pump house to the tanks will be a dual wall and heat traced. The tanks will also be heat traced with interstitial monitoring devices and high level alarms. The freezing point of DAPL is only several degrees less than water and all exterior components must be protected from freezing.

#### **4.3.6 Truck Tanker Car Loading Station**

The general area of the tanker loading station is shown on Figure 4-2. The final configuration of this location will be established by the final design. The DAPL will be loaded from the storage tanks the truck tankers using a vacuum pump on the trucks.

The storage tanks (8,700 gallons each) will have a combined capacity of 17,400 gallons. Assuming a 100% on stream time, at a 1 gpm fill rate, the storage tanks will have an approximate 12 day total storage capacity.

The design will include security and safety measures for the safe filling and storage of materials at the loading station. This will include level safety controls, shut offs and alarms. The design will also identify any applicable permits and other requirements.

#### **4.3.7 Electrical Service**

The proposed system will use an electrical power drop at the pump house.

### **4.4 PILOT TEST MONITORING**

The DAPL Extraction Pilot Test includes a pre-pumping baseline monitoring phase and a monitoring program during active extraction of DAPL. These monitoring phases are described in the following subsections. The expected durations of each monitoring phase are provided for context but may be modified based on actual monitoring data.

#### **4.4.1 Baseline Monitoring**

It is anticipated that the process of drilling the extraction and monitoring wells will disturb the density stratification in the DAPL locally. This may result in creation of density convection cells, which could cause short-term instability in the DAPL/diffuse layer interface. Thus after the wells are installed (and prior to pumping), the DAPL/diffuse layer interface will be monitored to establish baseline conditions. Depending on the degree of disturbance, this monitoring might last from one to two months, or less. This baseline monitoring will also establish the range of natural fluctuations in the monitoring parameters and inductance logging responses. This will be useful in

assessing whether differences measured under pumping conditions constitute changes or normal fluctuations.

Baseline monitoring will consist of induction logging of the three induction logging wells and sampling the ten zones in each multilevel well using a flow through cell at low flow pumping rates (<300 milliliter per minute (ml/min)). Induction logging will also be completed in GW-42D and GW-43D. The water from the multilevel wells will be monitored for pH, oxidation-reduction potential (ORP), specific conductance, temperature, turbidity and color. Samples will be collected for on-site analysis of ferrous and ferric iron and sulfate. These parameters will be analyzed using a HACH kit with a portable spectrophotometer. The frequency of monitoring will be determined based upon initial results and changes that are observed in subsequent sampling events.

#### **4.4.2 Monitoring During DAPL Extraction**

The rate of density driven flow to a central well was estimated by Geomega to be 0.2 to 0.8 gpm. The DAPL extraction pilot test is designed to pump first within that range, and then slowly and incrementally increase the pumping rates to test that theoretical range by intentionally exceeding the upper limit. Thus several pumping rates will be tested (0.5 gpm, 1.0 gpm and 2.0 gpm) to see if they are attainable without creating adverse geochemical or hydrologic conditions caused by excessive DAPL drawdown, intrusion of the diffuse layer into the DAPL zone or expansion of the diffuse layer. The durations and pumping rates are provided to add context to the discussion. The actual durations and the pumping rates will be determined from monitoring data as it is collected and assessed.

##### *First Pumping Step: Rate = 0.5 gpm*

The initial pumping rate (0.5 gpm) is the midpoint of the range of DAPL density flow rate to a central well estimated by Geomega (0.2 – 0.8 gpm).

Prior to pumping, a final set of static water levels will be taken and static inductance logging completed. After pumping has been initiated, monitoring will be more frequent, during the first several days and gradually reduced over time. Initial monitoring will include daily collection of water samples from the multilevel piezometers and water level measurements for the first several days. The water from the multilevel wells and the extraction well effluent will be monitored for pH, ORP, specific conductance, temperature, turbidity and color. Samples will be collected for on-

site analysis of ferrous and ferric iron and sulfate using a HACH kit with a portable spectrophotometer. The three inductance logging wells in the vicinity of the extraction well will also be logged.

The first pumping step period is proposed to continue for 90 days but that time period will be assessed based on the monitoring data collected during the test. After the initial start up period, monitoring will occur on a weekly schedule and may gradually be reduced in frequency if data trends are stable. Monitoring will include inductance logging, sampling the multilevel wells for the same parameters and measurement of water levels. Inductance logging will be completed in the three wells near the extraction well and in GW-42D. Well GW-42S will be instrumented with transducers and a data logger.

*Second Pumping Step: Rate = 1.0 gpm*

The monitoring data will be evaluated during progress of the initial pumping step. If adverse DAPL interface drawdown and geochemical conditions are not apparent, the pumping rate will be doubled to 1.0 gpm if this proposed rate is supported by field data. This pumping stress period will last for an estimated 120 days unless modified based on field data. The stress period will be longer due to the higher pumping rate and potentially longer time to reach equilibrium. The first week following the increase in pumping rate, operating parameters will be monitored more frequently, and then gradually reduced depending on trends observed in the data.

*Third Pumping Step: Rate = 2.0 gpm*

The monitoring data will be evaluated during progress of the second pumping step. If adverse DAPL interface drawdown and geochemical conditions are not apparent, the pumping rate will be doubled to 2.0 gpm, if this rate is supported by field data. This pumping stress period will last for an estimated 180 days unless modified based on field data. The monitoring procedures will be the same as the prior pumping step.

*Extended Pumping Period*

If the third pumping step is completed successfully, the test will have operated for approximately one year. At that time, Olin may conduct additional DAPL pumping for an extended period to last an additional six months.

### *Test Termination*

Based on the current understanding of the site hydrogeology, it is expected that pumping rates exceeding or even approaching 2 gpm may not be sustainable either at or near the pumping well or within a connected DAPL pool. If geochemical conditions or logging trends are encountered, during any pumping steps, which warrant a reduction in pumping rate, that data will be shared immediately with the USEPA. Given the potential complexity of chemical reactions and unknown nature of DAPL and diffuse layer response to pumping, establishing a set of definitive, pre-determined termination criteria for the test may not be possible at this time. Clogging of the extraction well would be an obvious criterion for terminating the test. Other potential conditions that would lead to test termination include excessive drawdown or intrusion of diffuse layer and overlying groundwater into the DAPL or expansion of the diffuse layer thickness. The magnitude of change that would be deemed adverse is best determined by actual data collection. Some expansion of the diffuse layer or drawdown of the DAPL/diffuse layer interface may be acceptable. What constitutes an unacceptable change will be subject to interpretation as data are collected.

### **4.4.3 Pilot Test Shut Down**

After completion of the Pilot Test or Test Termination, the truck loading facility and storage tanks with associated piping will be removed from the Jewel Drive property. The well house, pilot test well and associated monitoring wells will remain on site for possible future use after a Feasibility Study is completed and a Record of Decision has been issued for Operable Unit 3 (OU3).

## **4.5 SOIL MANAGEMENT**

Management of investigation derived wastes (IDW) will be in accordance with the USEPA memorandum “Guide to Management of Investigation Derived Wastes”, (USEPA, 1992) Drill cuttings from below the water table will be drummed and labeled in accordance with Department of Transportation (DOT) requirements and transported to the 51 Eames Street property for temporary storage pending laboratory analysis of the soil and a determination for its final disposition. Waters returned from the drill cuttings below the depth of the DAPL/diffuse layer interface will also be contained and drummed. Other drill waters will be allowed to re-infiltrate on site.

Unsaturated soil within the Study Area depicted in Figure 4-1 is not affected by contaminants associated with the 51 Eames Street Site, and therefore the management or disturbance of unsaturated soils is not subject to the soil management requirements described herein.

All soil excavated from depths greater than the estimated maximum seasonal high groundwater elevation at the property, during this IRS, will be temporarily stockpiled adjacent to the excavation on poly sheeting and covered, and returned to the excavation upon completion of subsurface work. Any soil excavated from depth that cannot be returned to the excavation, will be also transported to the 51 Eames Street property, pending laboratory analysis of the soil and a determination as to its final disposition. Excavated soil will not be staged at the property for a period greater than 90 days.

#### **4.6 GROUNDWATER MANAGEMENT**

Wells will not be developed in an effort to minimize disturbance of the DAPL/diffuse layer interface. Aside from drill spoils discussed previously, other groundwater waste requiring management is not expected during well installation. During sampling, a minimal amount of purge water will be generated and will be containerized and transported to 51 Eames Street Property and characterized for disposal.

#### **4.7 HEALTH AND SAFETY**

All field activities related to this IRS will be performed in accordance with a site specific HASP that will be developed commensurate with the features and operation and maintenance requirements of the final designed system. Field activities related to drilling, installing, and sampling of monitoring wells will be in accordance with the existing HASP as amended in 2006 (MACTEC, 2006c).

#### **4.8 PERMITS**

The DAPL Extraction Pilot Test is being conducted as a study in the context of Section XIII of the Settlement Agreement. Based on the specific language of the Settlement Agreement, Olin believes the Pilot Study complies with intention of SEC. 121 [42 U.S.C. 9621] of CERCLA, and that no local, state or federal permits will be required for on-site Pilot Test components. Olin will confer with USEPA to confirm that state and local permits will not be required for on-site Pilot Test components but that the substantive requirements of such permits will be met. Some permits may be subrogated to subcontractors as in the case of permits that may be required for the transportation of the DAPL for off-site treatment.

#### **4.9 REPORTING**

Semi-Annual Status Reports will be submitted to report the progress of the DAPL Extraction Pilot Test and design. The Semi-Annual Status Reports will be prepared as outlined in the Statement of Work (USEPA, 2007). The first and second Semi-Annual Status Reports were submitted six and 12 months respectively after the Effective Date of the AOC.

#### **4.10 SCHEDULE**

A schedule for the implementation of the DAPL extraction Pilot Test will be included with the design. The schedule for the design, which is a required submittal under this IRSWP, has been discussed. The project will require that third party access agreements be negotiated. Olin will make a good faith effort to proceed with and conclude these negotiations in an expeditious manner. When these negotiations have been completed and agreements are signed, the final design approval and construction of the truck loading station and pump house will be initiated. These negotiations are critical path items and have potential to drive the overall project schedule. Failure to obtain access will change the scope of the project.

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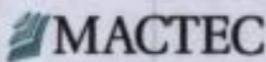
## **FIGURES**



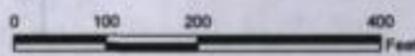


**Legend**

- ~ Railroad
- Slurry Wall
- ~ Water
- ~ Culvert
- Site Boundary



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**Figure 1-2  
Site Plan**

**Final Interim Response Steps Work Plan  
Olin Chemical Superfund Site  
Wilmington, Massachusetts**

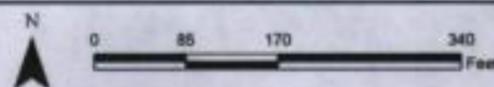
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DWG NO		Checked by MH



**Legend**

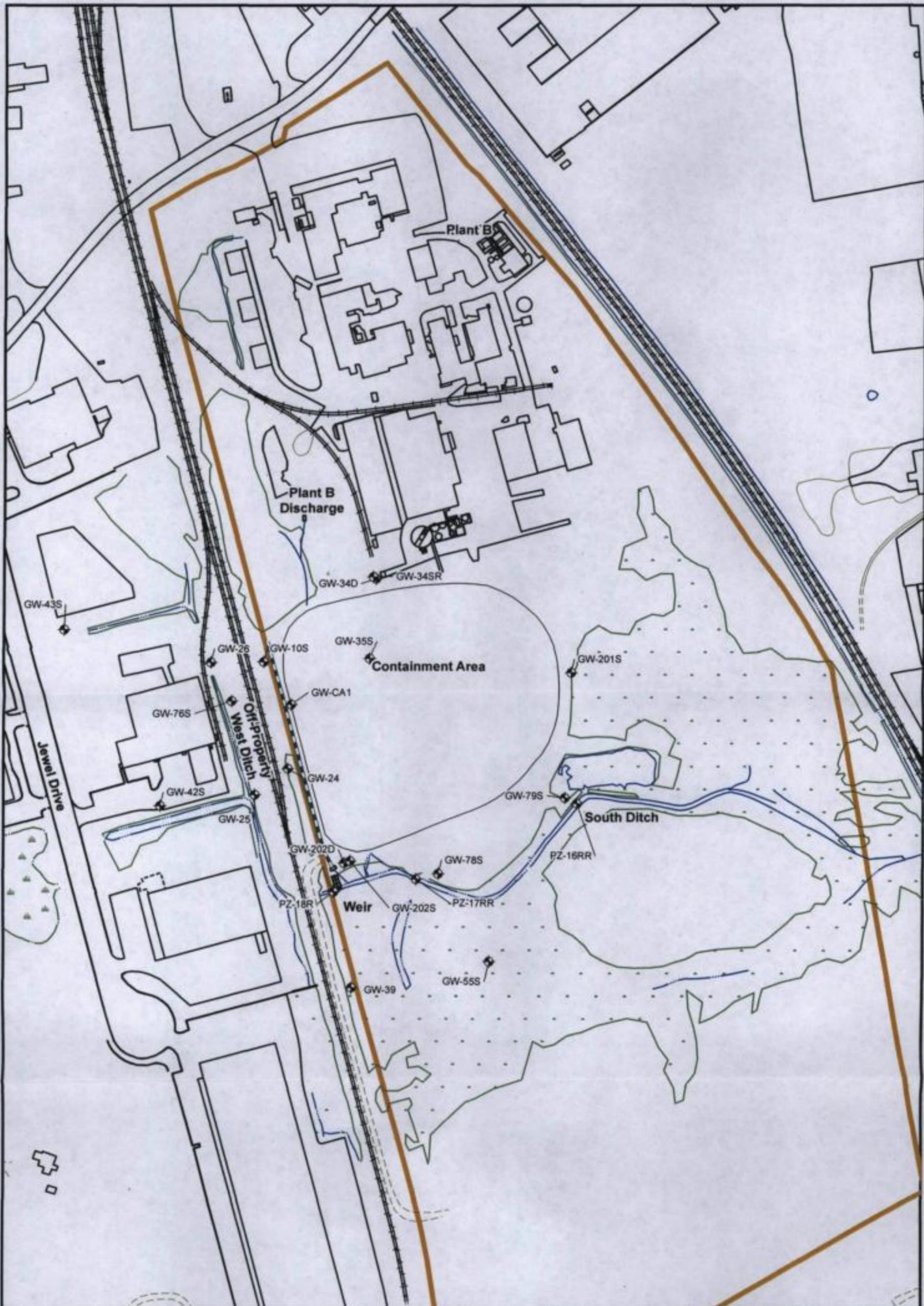
- ◆ Monitoring Well
- Slurry Wall
- ≡ Culvert
- - Trail
- ~ Paved Road
- ~ Unpaved Road
- ~ Railroad
- ~ Structure
- ~ Water
- ~ Wetland Symbol
- ~ Wetland Boundary
- Site Boundary

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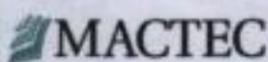
**Figure 2-1**  
 Historical PCMP Groundwater  
 Sampling Locations  
 Final Interim Response Steps Work Plan  
 Olin Chemical Superfund Site  
 Wilmington, Massachusetts

PRJ NO	6100080016 / 02	Prepared by BJR
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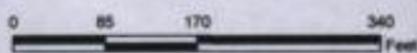


**Legend**

- ◆ Monitoring Well
- Slurry Wall
- ≡ Culvert
- - Trail
- ~ Paved Road
- ~ Unpaved Road
- ~ Railroad
- ~ Structure
- ~ Water
- ~ Wetland Symbol
- ~ Wetland Boundary
- Site Boundary

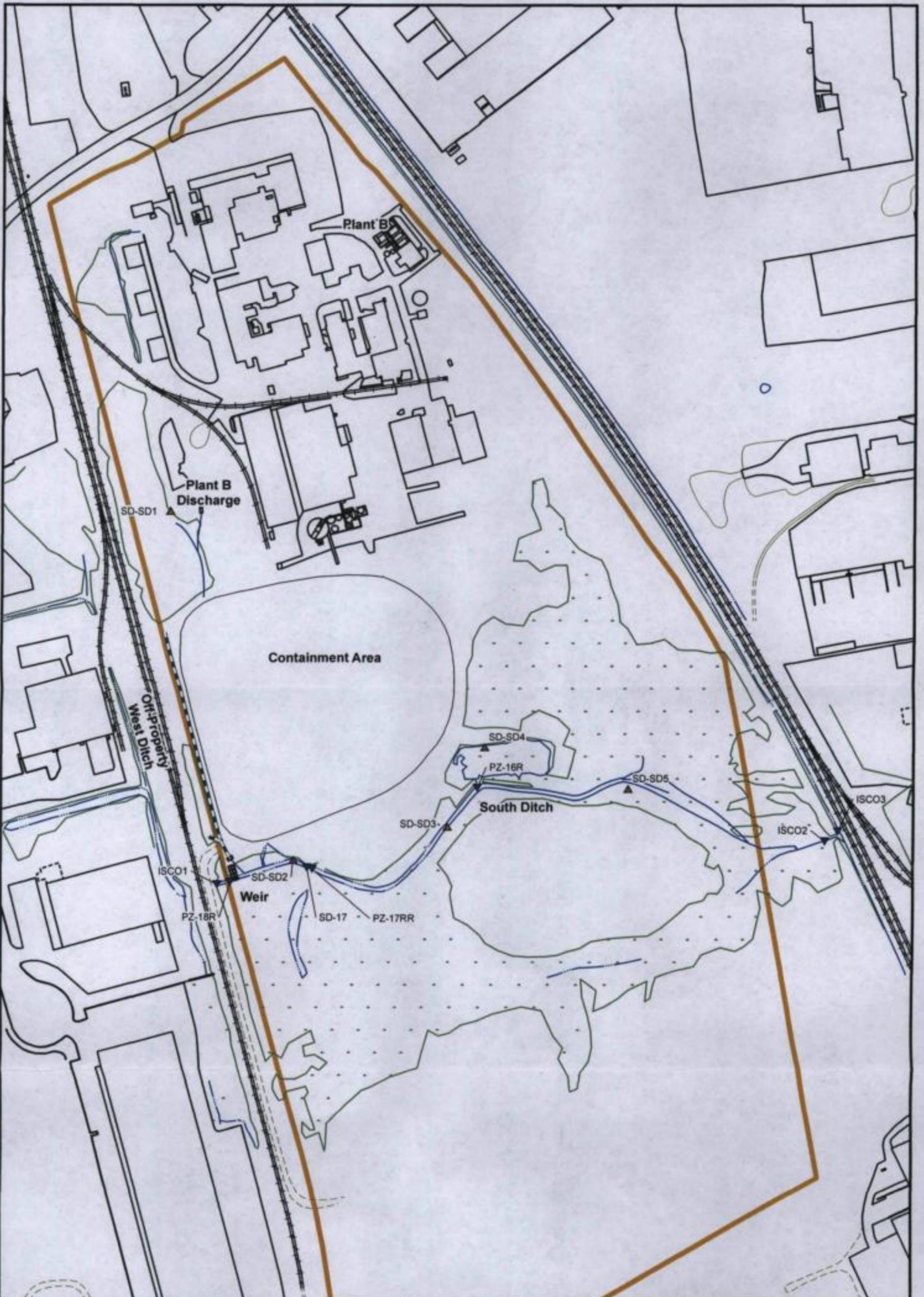


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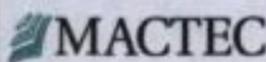
**Figure 2-2**  
Most Recent PCMP Groundwater  
Sampling Locations  
Final Interim Response Steps Work Plan  
Olin Chemical Superfund Site  
Wilmington, Massachusetts

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DWG NO		Checked by MH

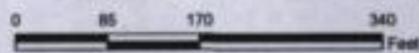


**Legend**

- ▲ Recent PCMP Sediment Location
- ▼ Historical/Recent PCMP Surface Water Location
- ▼ Recent PCMP Surface Water Location
- Slurry Wall
- ⊗ Culvert
- - - Trail
- ~ Paved Road
- ~ Unpaved Road
- ~ Railroad
- ~ Structure
- ~ Water
- ~ Wetland Symbol
- ~ Wetland Boundary
- Site Boundary



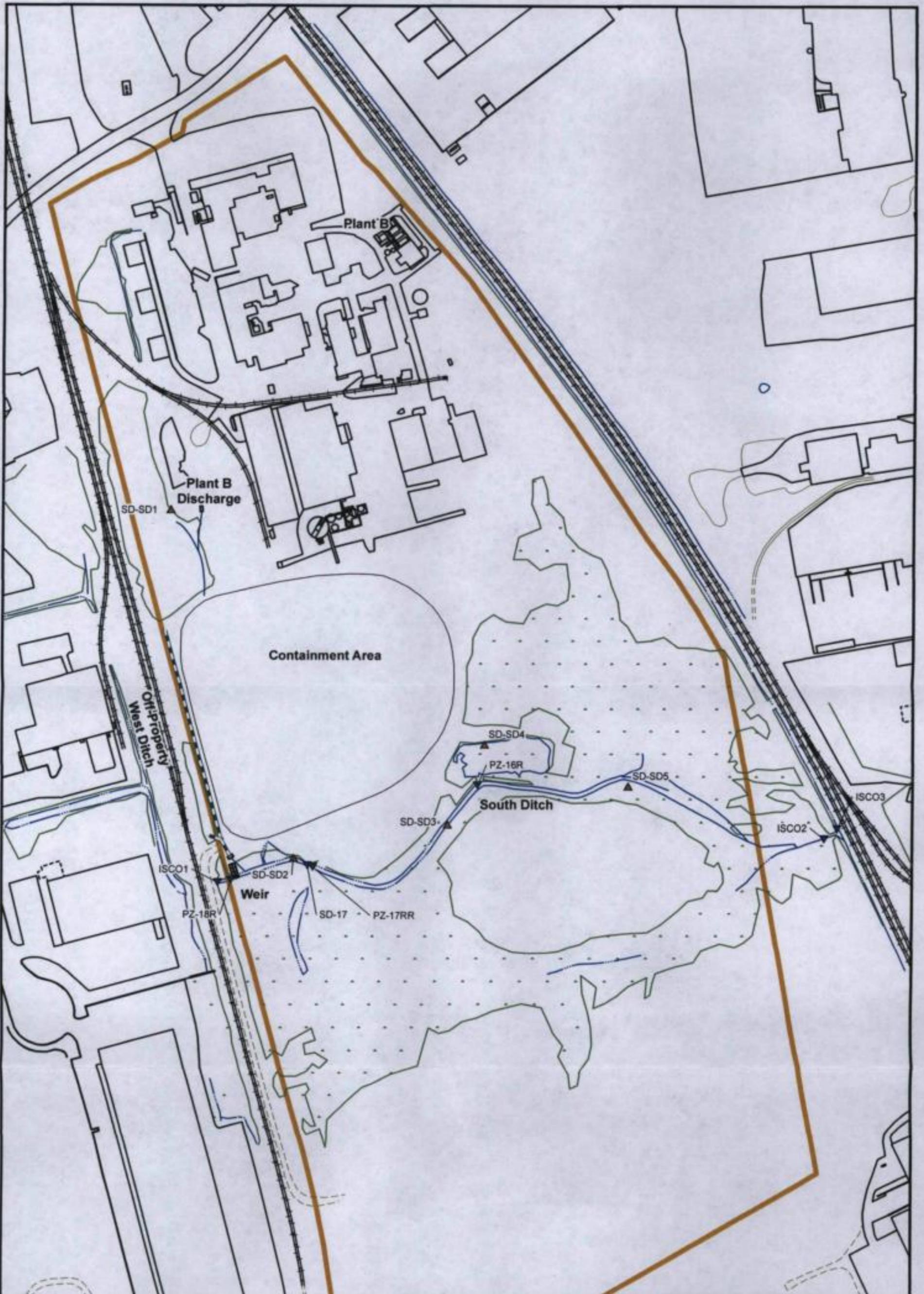
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**Figure 2-3**  
Historical and Most Recent PCMP Surface  
Water and Sediment Sampling Locations  
Final Interim Response Steps Work Plan  
Olin Chemical Superfund Site  
Wilmington, Massachusetts

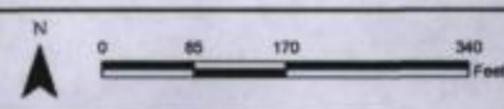
PROJ NO	6100080016 / 02	Prepared by BJR
DWG NO		Checked by MH





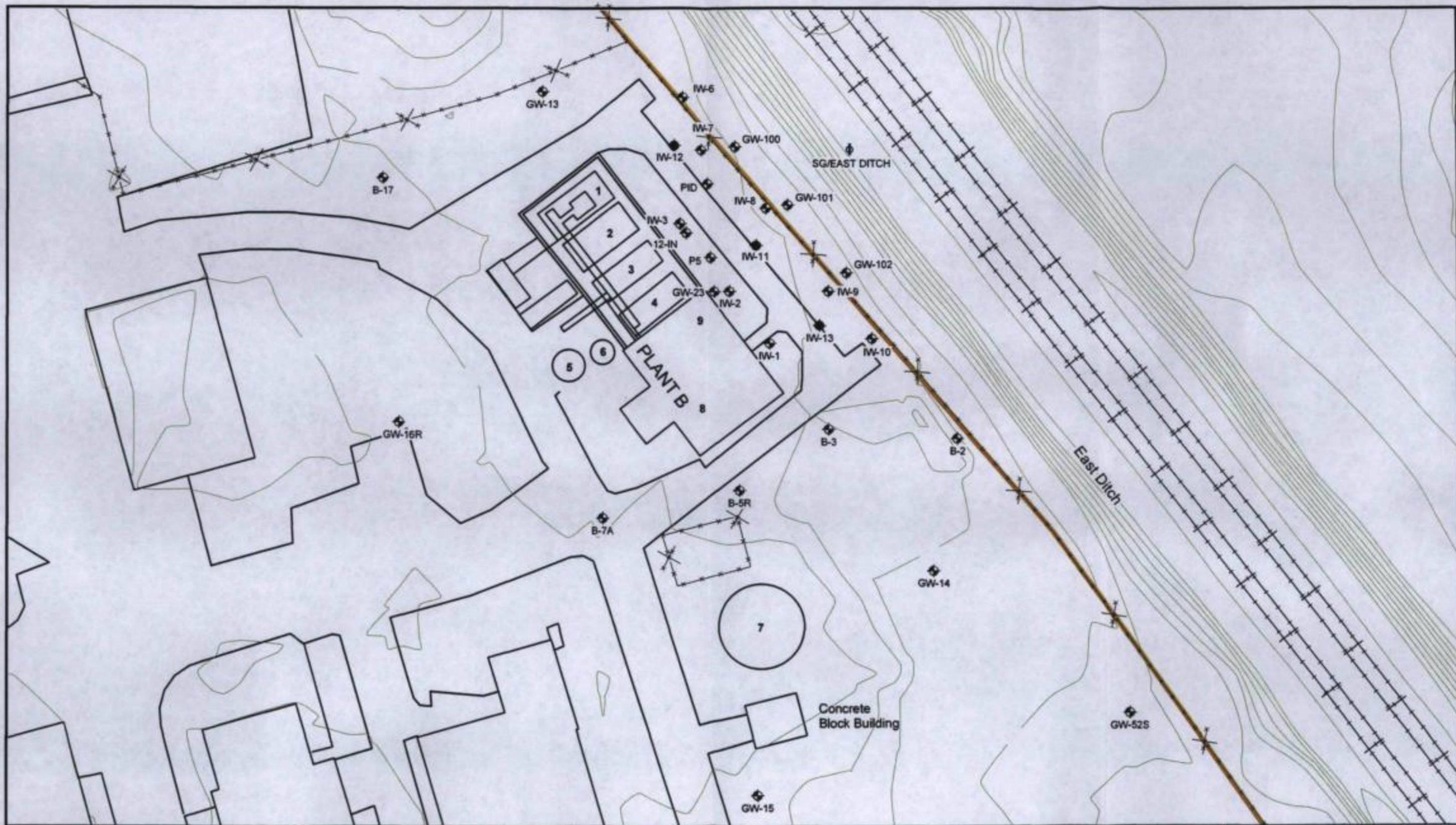
- Legend**
- ▲ Sediment Location
  - ▼ Surface Water Location
  - Slurry Wall
  - ⊕ Culvert
  - - - Trail
  - ~ Paved Road
  - ~ Unpaved Road
  - ~ Railroad
  - ~ Structure
  - ~ Water
  - ~ Wetland Symbol
  - ~ Wetland Boundary
  - Site Boundary

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**Figure 2-5**  
**Proposed Slurry Wall/Cap Monitoring Surface**  
**Water and Sediment Sampling Locations**  
**Final Interim Response Steps Work Plan**  
**Olin Chemical Superfund Site**  
**Wilmington, Massachusetts**

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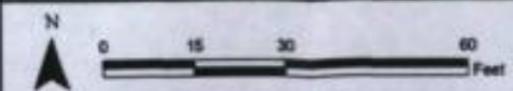


- Tank #1 - Receives gravity overflow from Tank 2 and allows for further settling
- Tank #2 - Caustic addition and initial iron drop-out
- Tank #3 & #4 - Overnight holding tank for treated water
- Tank #5 - Pre-carbon hold tank
- Tank #6 - Residence tank
- Tank #7 - Raw water (pH adjusted)
- Tank #8 - Pre-carbon transfer
- Tank #9 - Day discharge to NPDES Outfall 002

**Legend**

- Monitoring Well
- Recovery Well
- Staff Gauge
- Elevation Contours

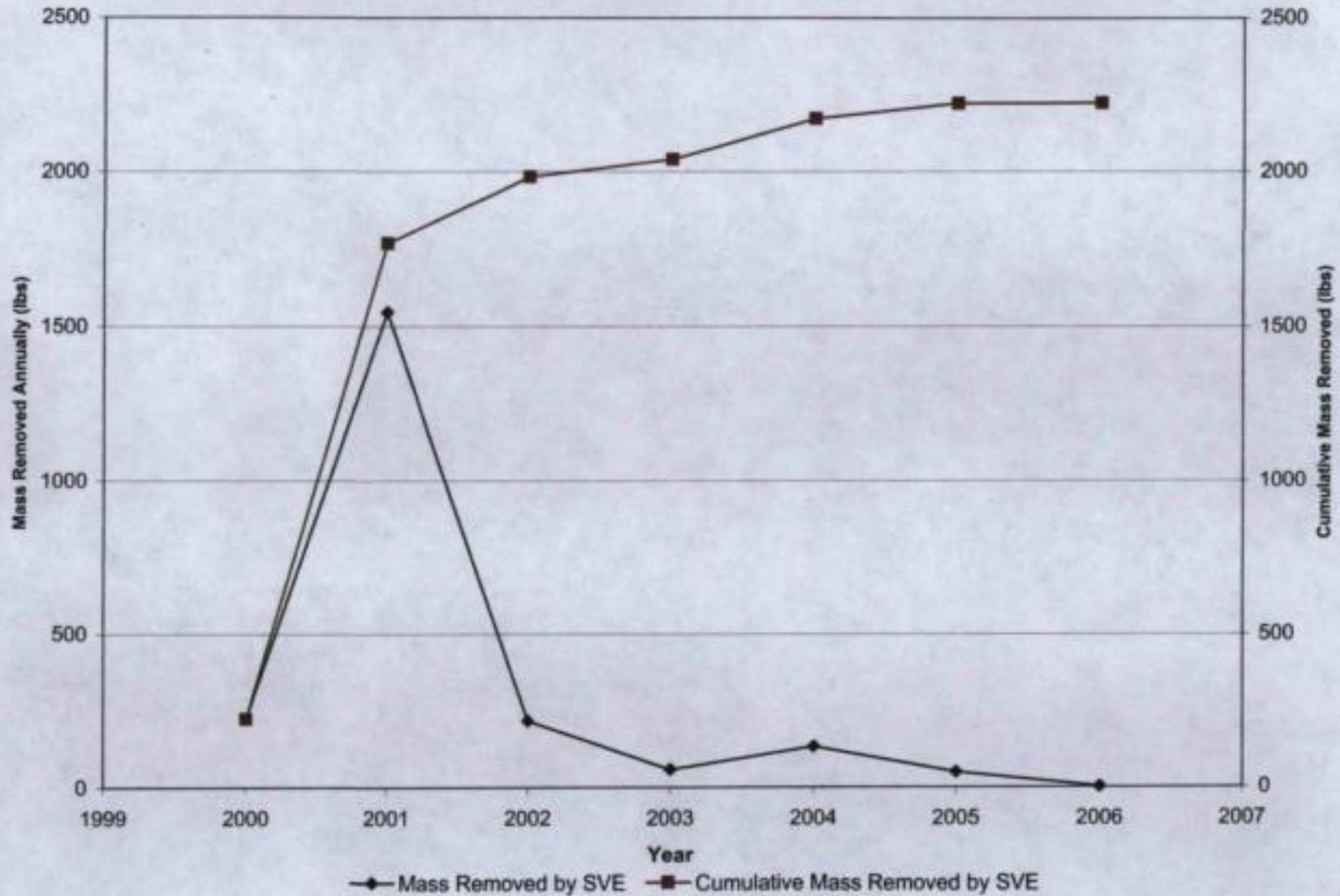
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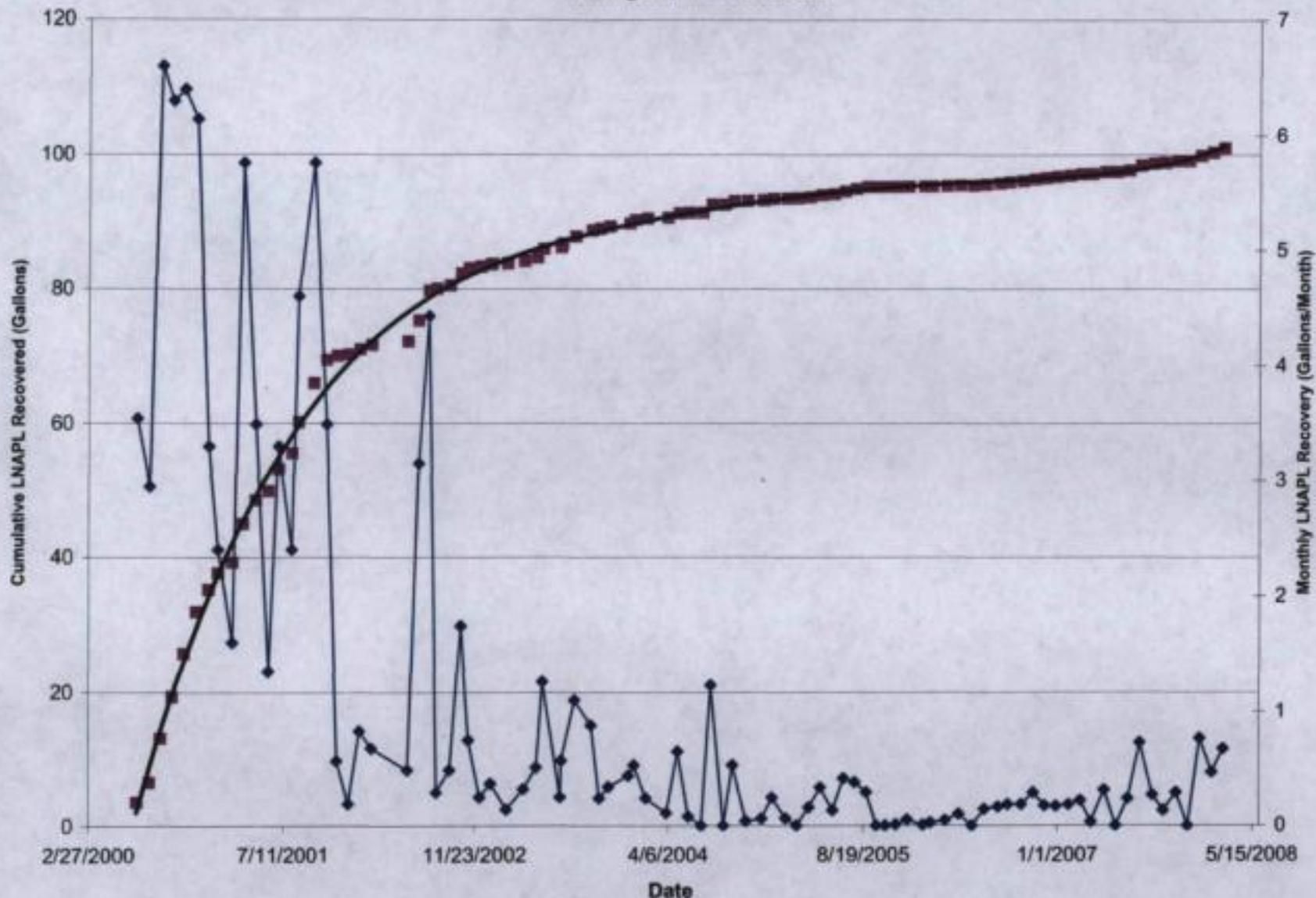
**Figure 3-1**  
**Plant B**  
**Facility and Well Locations**  
 Final Interim Response Steps Work Plan  
 Olin Chemical Superfund Site  
 Wilmington, Massachusetts

Prepared/Date: BJR 08/05/08    Checked/Date: PHT 08/05/08

**Figure 3-2  
Soil Vapor Extraction (SVE) Mass Removal  
Final Interim Response Steps Work Plan  
Olin Chemical Superfund Site  
Wilmington, Massachusetts**



**Figure 3-3  
 Monthly and Cumulative LNAPL Recovery  
 Final Interim Response Steps Work Plan  
 Olin Chemical Superfund Site  
 Wilmington, Massachusetts**

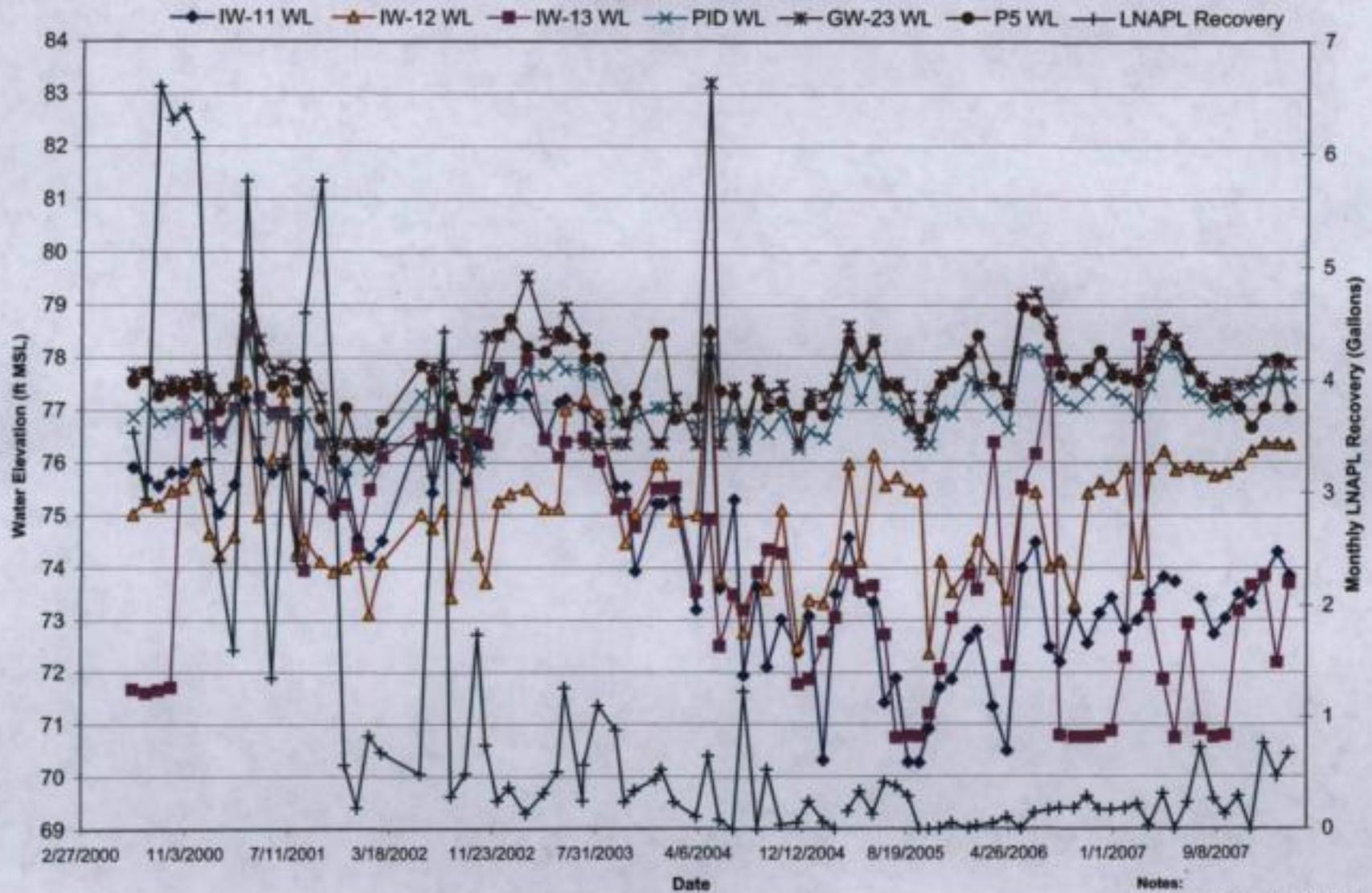


Cumulative LNAPL Recovery    
  Monthly LNAPL Recovery    
  Cumulative LNAPL Recovery Line

**Notes:**  
 LNAPL = Light Non-Aqueous Phase Liquid

Prepared/Dayey: PHT 07/17/07  
 Checked/Date: RAL 07/19/07

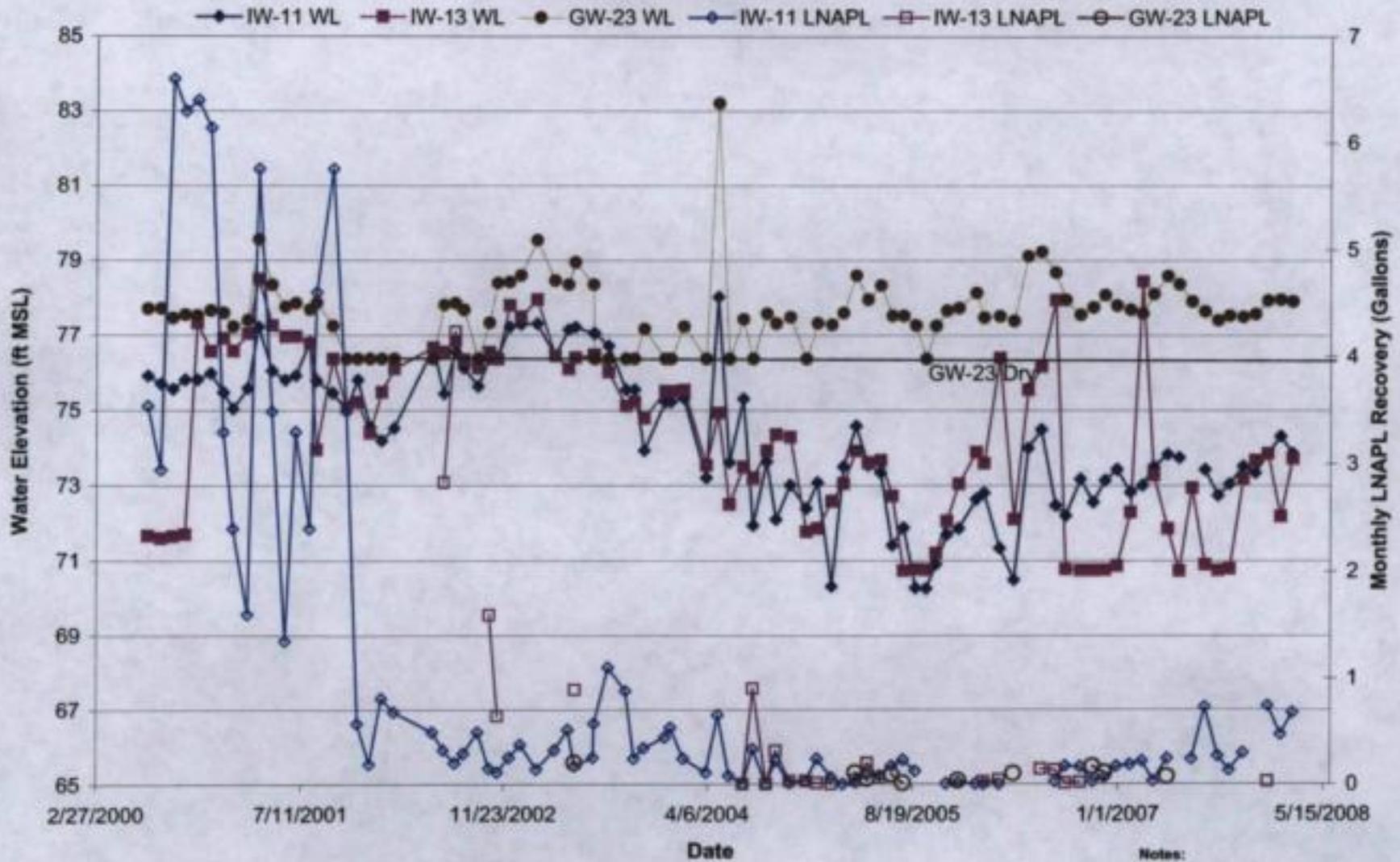
**Figure 3-4**  
**Water Levels (WL) and Monthly LNAPL Recovery**  
**Final Interim Response Steps Work Plan**  
**Olin Chemical Superfund Site**  
**Wilmington, Massachusetts**



Notes:  
 LNAPL = Light Non-Aqueous Phase Liquid

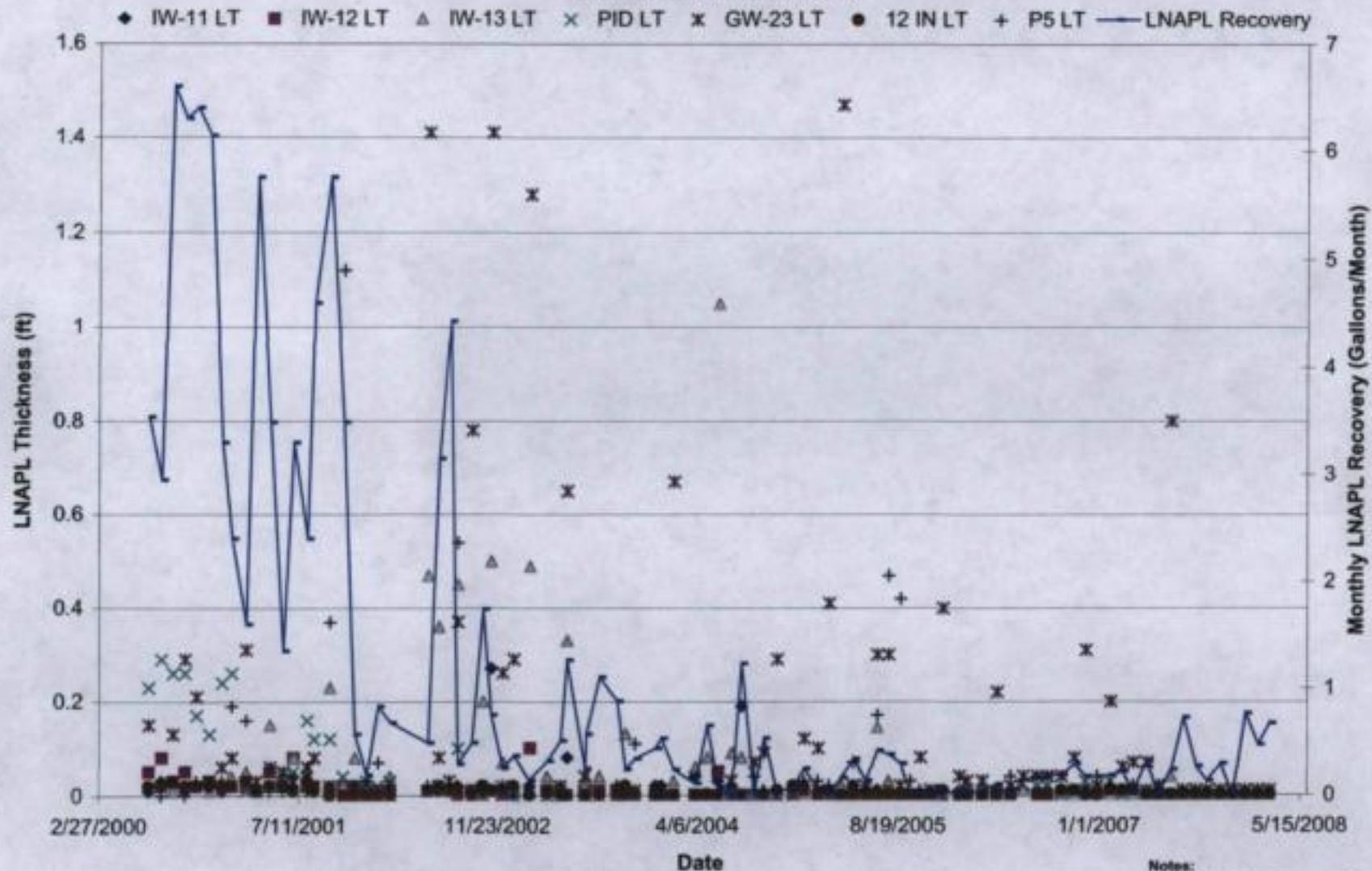
Prepared/Date: PHT 07/17/07  
 Checked/Date: RAL 07/19/07

**Figure 3-5**  
**Water Levels (WL) and Individual Well LNAPL Recovery (LNAPL)**  
**Final Interim Response Steps Work Plan**  
**Olin Chemical Superfund Site**  
**Wilmington, Massachusetts**



Notes:  
 LNAPL = Light Non-Aqueous Phase Liquid

Figure 3-6  
 LNAPL Thickness (LT) and LNAPL Recovery  
 Final Interim Response Steps Work Plan  
 Olin Chemical Superfund Site  
 Wilmington, Massachusetts



**Figure 3-7**  
**Concentrations of 2,4,4-Trimethyl-1-pentene in Plant B Area Groundwater Samples**  
**Final Interim Response Steps Work Plan**  
**Olin Chemical Superfund Site**  
**Wilmington, Massachusetts**

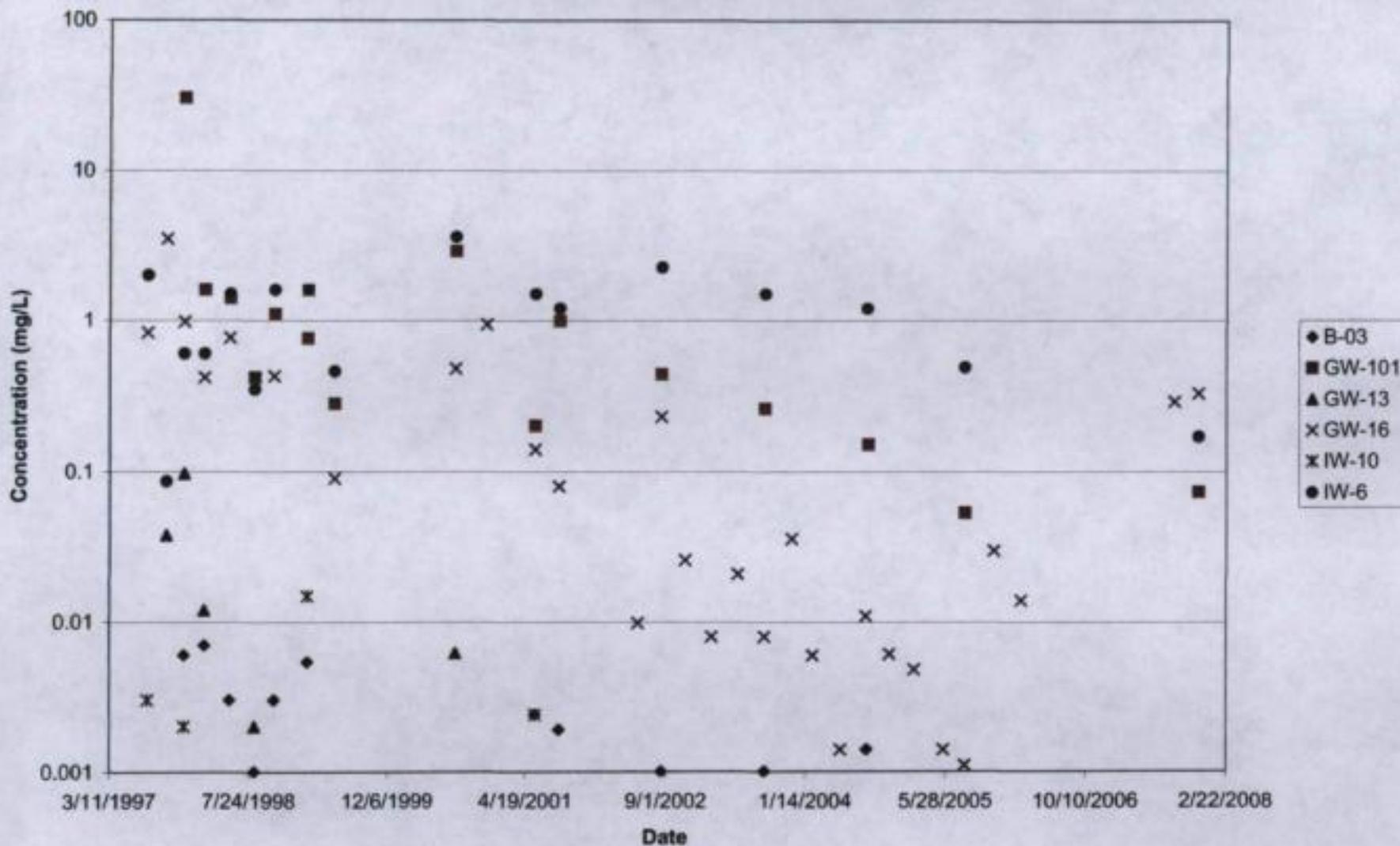
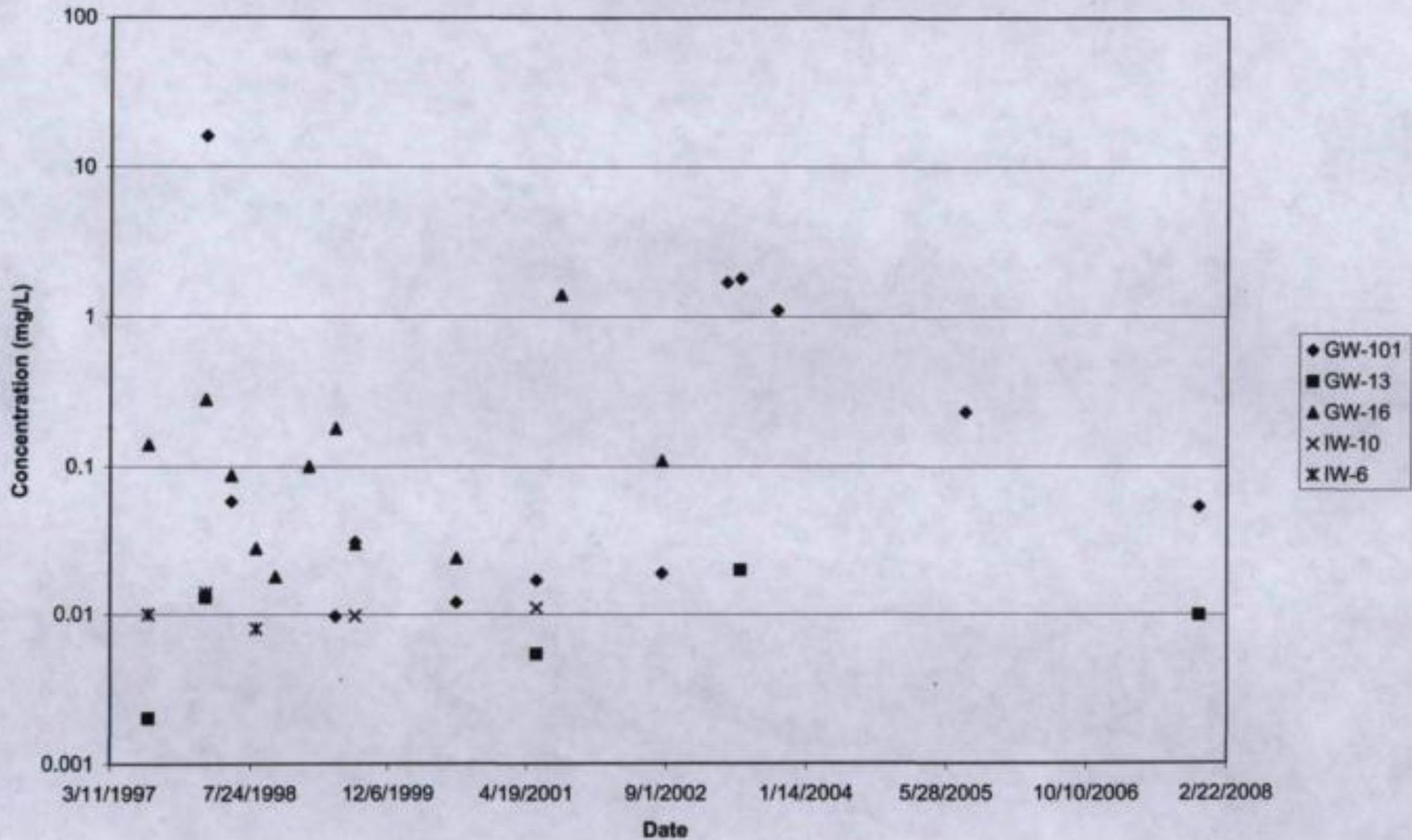
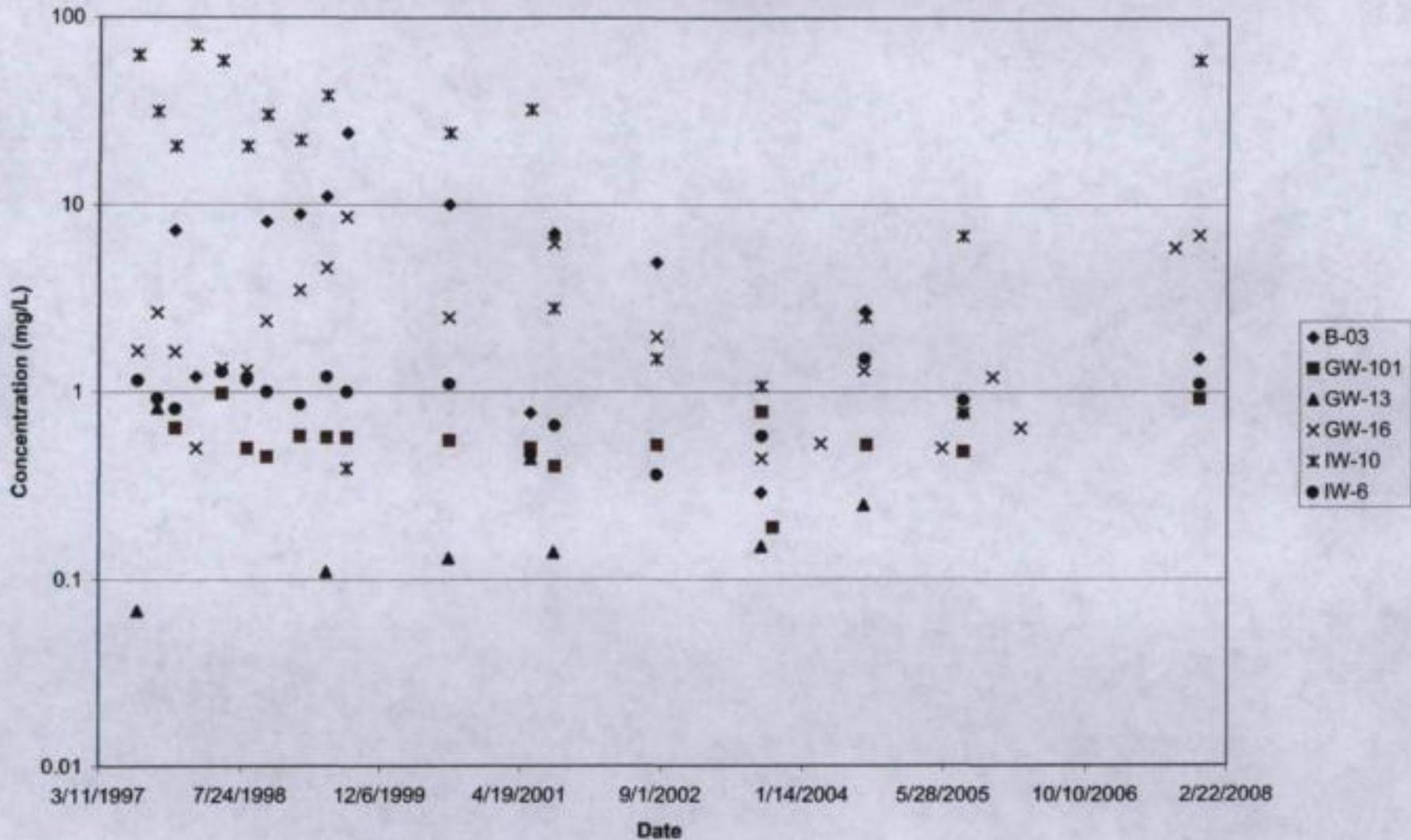


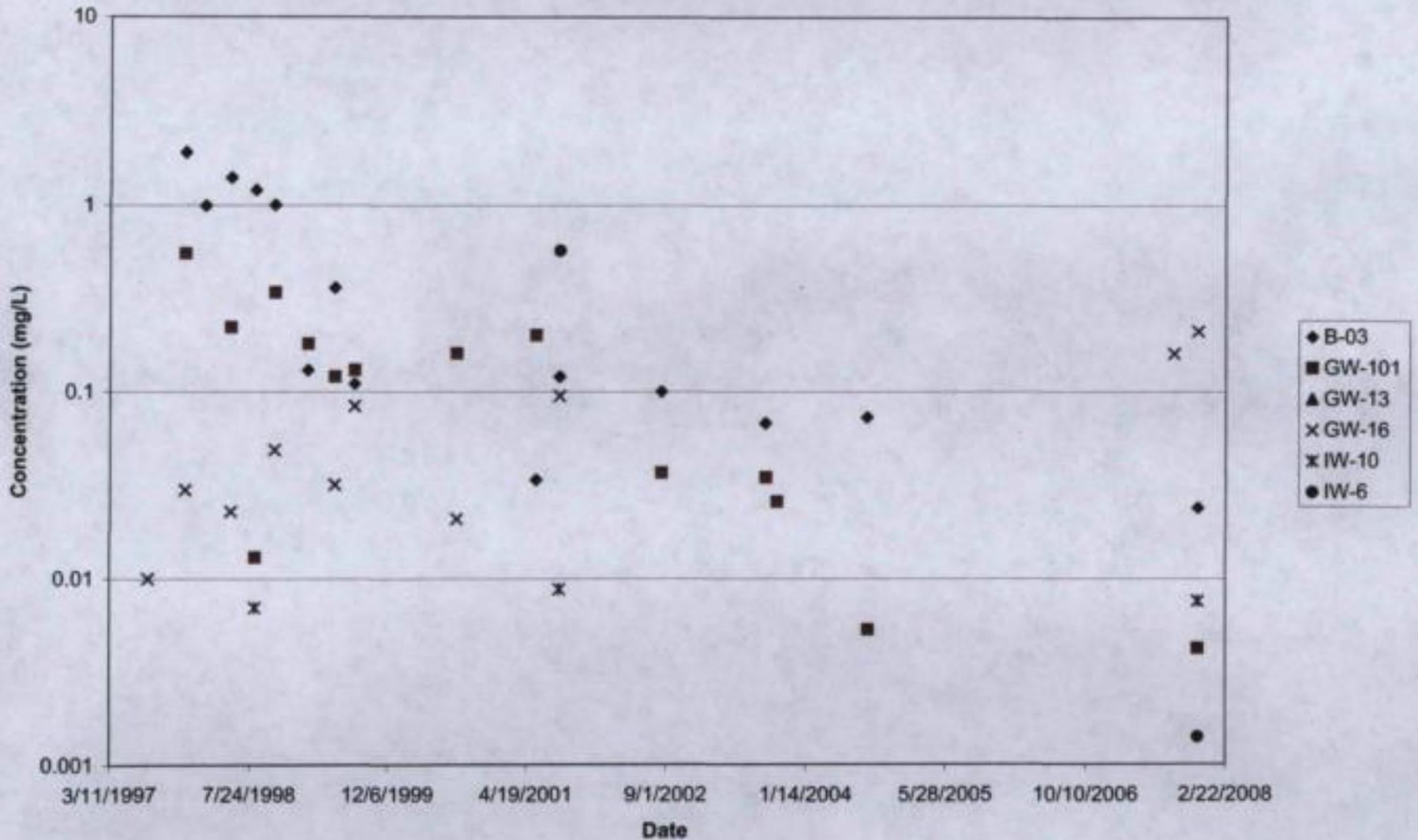
Figure 3-8  
 Concentrations of Bis(2-ethylhexyl)phthalate in Plant B Area Groundwater Samples  
 Final Interim Response Steps Work Plan  
 Olin Chemical Superfund Site  
 Wilmington, Massachusetts



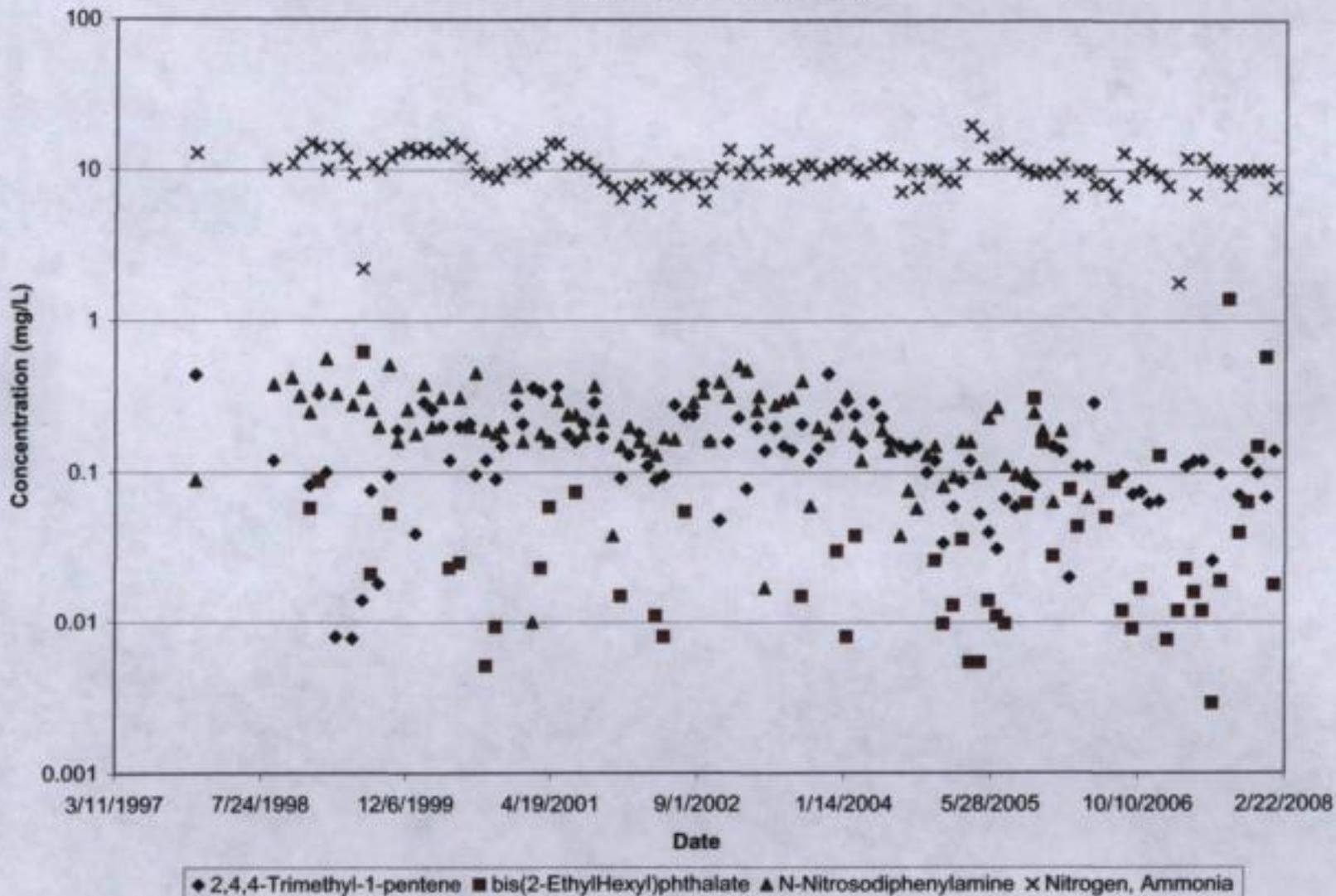
**Figure 3-9**  
**Concentrations of Nitrogen, Ammonia in Plant B Area Groundwater Samples**  
**Final Interim Response Steps Work Plan**  
**Olin Chemical Superfund Site**  
**Wilmington, Massachusetts**

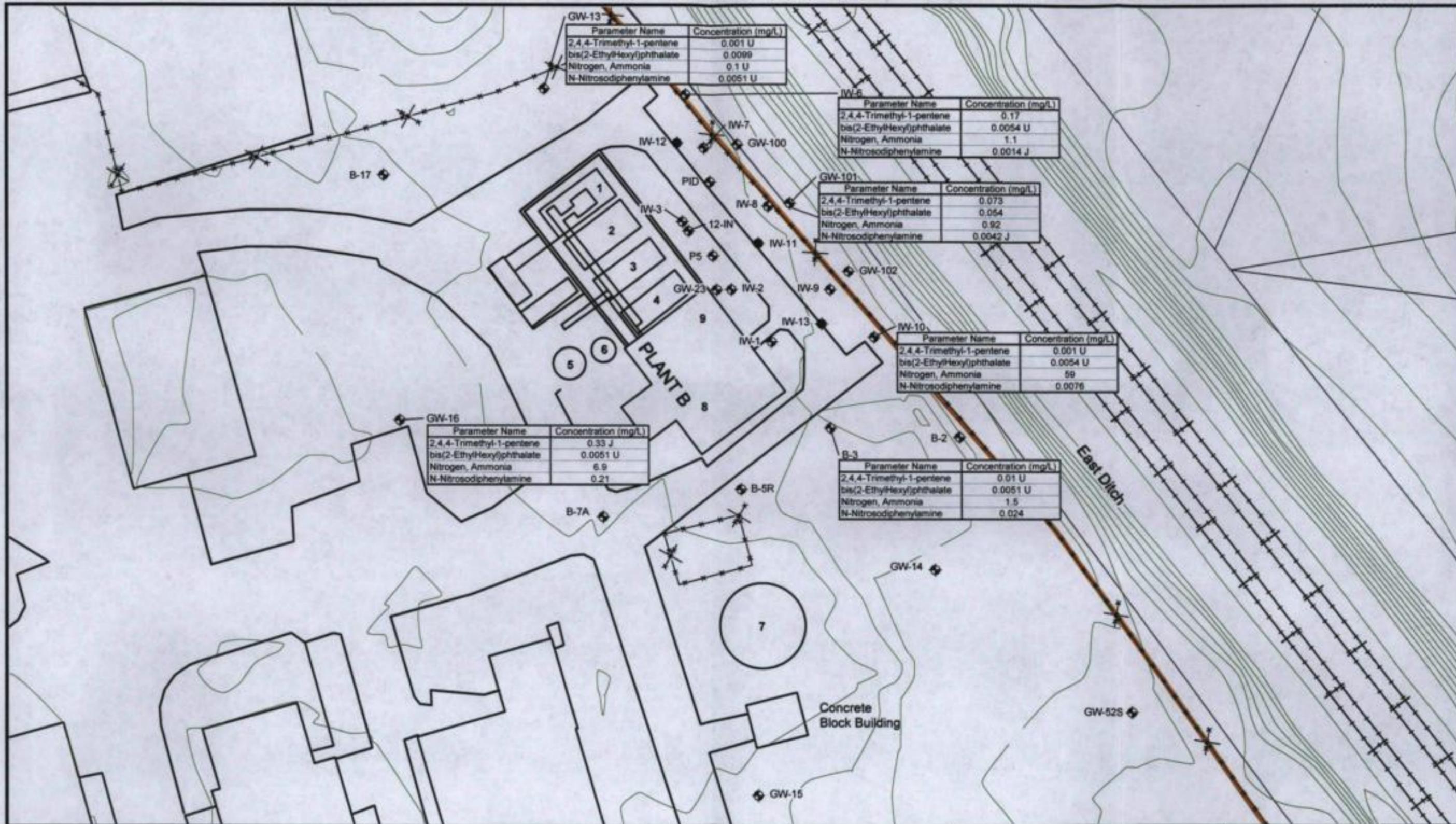


**Figure 3-10**  
**Concentrations of N-Nitrosodiphenylamine in Plant B Area Groundwater Samples**  
**Final Interim Response Steps Work Plan**  
**Olin Chemical Superfund Site**  
**Wilmington, Massachusetts**



**Figure 3-11**  
**Concentrations of 2,4,4-Trimethyl-1-pentene, Bis(2-EthylHexyl)phthalate, N-Nitrosodiphenylamine,**  
**and Nitrogen Ammonia in Plant B Influent Samples**  
**Final Interim Response Steps Work Plan**  
**Olin Chemical Superfund Site**  
**Wilmington, Massachusetts**





Tank #1 - Receives gravity overflow from Tank 2 and allows for further settling  
 Tank #2 - Caustic addition and initial iron drop-out  
 Tank #3 & #4 - Overnight holding tank for treated water  
 Tank #5 - Pre-carbon hold tank  
 Tank #6 - Residence tank  
 Tank #7 - Raw water (pH adjusted)  
 Tank #8 - Pre-carbon transfer  
 Tank #9 - Day discharge to NPDES Outfall 002

**Legend**  
 ◆ Existing Well/Wellpoint  
 ● Existing Recovery Well  
 — Elevation Contours

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N  
 0 15 30 60 Feet

Concentrations shown are from November 15, 2007 sampling event.

**Figure 3-12**  
 Distribution of Ammonia, 2,4,4-Trimethyl-1-pentene, Bis(2-ethylhexyl)phthalate, and N-Nitrosodiphenylamine in Plant B Groundwater  
 Final Interim Response Steps Work Plan  
 Olin Chemical Superfund Site  
 Wilmington, Massachusetts

Prepared/Date: BJR 03/26/08 Checked/Date: PHT 03/26/08



Tank #1 - Receives gravity overflow from Tank 2 and allows for further settling  
 Tank #2 - Caustic addition and initial iron drop-out  
 Tank #3 & #4 - Overnight holding tank for treated water  
 Tank #5 - Pre-carbon hold tank  
 Tank #6 - Residence tank  
 Tank #7 - Raw water (pH adjusted)  
 Tank #8 - Pre-carbon transfer  
 Tank #9 - Day discharge to NPDES Outfall 002

- Legend**
- Interpreted LNAPL Thickness Contour (ft)
  - - - Inferred LNAPL Thickness Contour (ft)
  - Recovery Well
  - ⊕ Monitoring Well
  - - - Ditch
  - Elevation Contours
  - ND Not Detected

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N  
 0 15 30 60  
 Feet

**Figure 3-13**  
**Plant B Interpreted LNAPL Thickness Contours**  
 March 2008

Final Interim Response Steps Work Plan  
 Olin Chemical Superfund Site  
 Wilmington, Massachusetts

Prepared/Date: BJR 05/05/08    Checked/Date: PHT 05/05/08



**Legend**

- ~ DAPL Boundary
- ~ OPWD Study Area
- ⊕ Proposed Extraction Well
- ▭ Slurry Wall
- ~ Bedrock Contour
- ~ Structure
- ▭ Site Boundary
- ~ Wetland Boundary
- ~ Water
- ~ Culvert

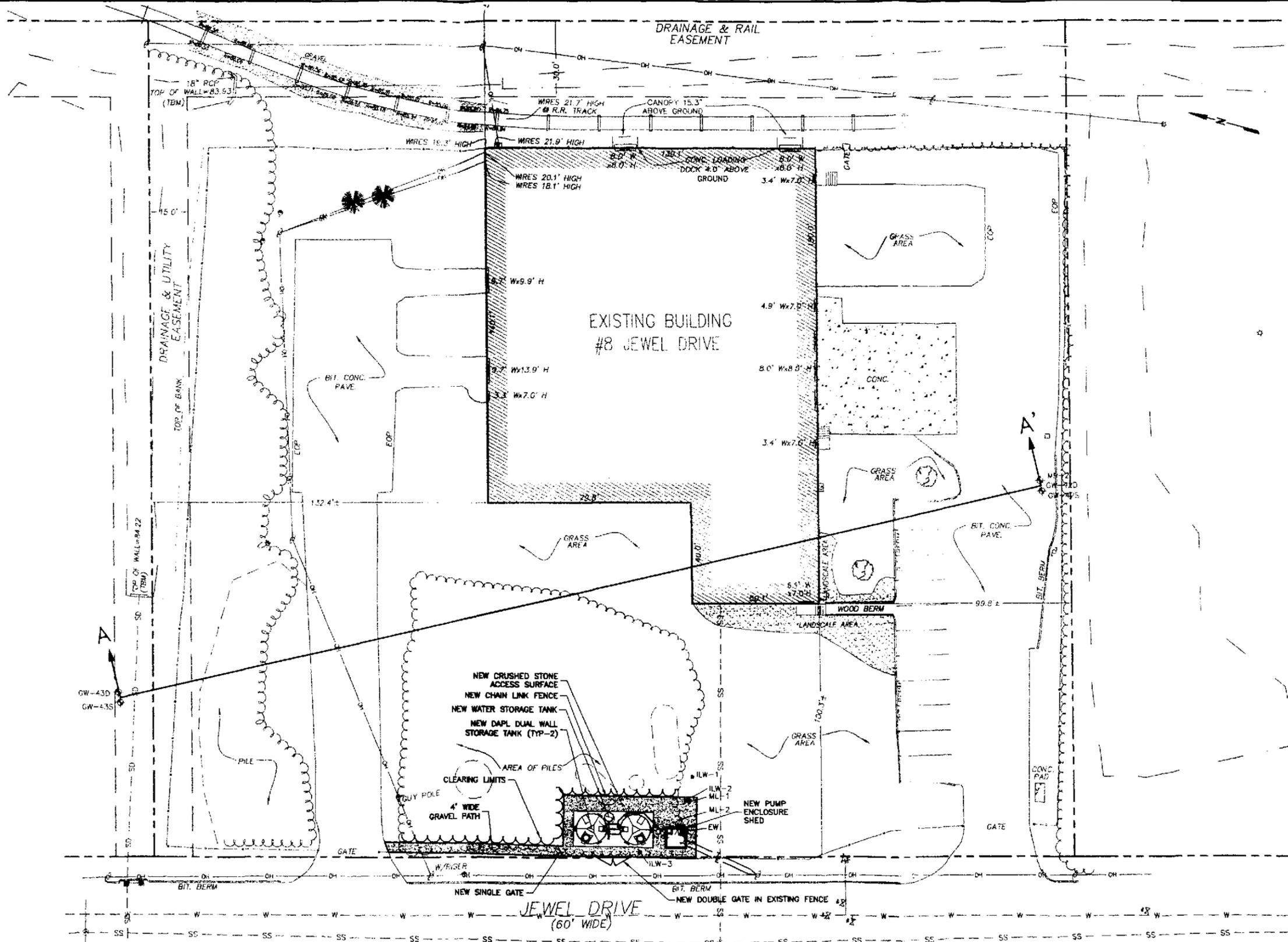


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**Figure 4-1**  
Extent of Dense Aqueous Phase Liquid (DAPL) -  
Off-Property West Ditch (OPWD) Study Area  
Final Interim Response Steps Work Plan  
Olin Chemical Superfund Site  
Wilmington, Massachusetts

PROJ NO	6100080016 / 02	Prepared by BJR
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**LEGEND:**

- W WATER LINE
- SD DRAIN LINE
- SS SEWER LINE
- OH OVERHEAD WIRES
- CL CHAINLINK FENCE
- EW EDGE OF WOODS
- RR RAILROAD TRACKS
- SMH SEWER MANHOLE (SMH)
- DMH DRAIN MANHOLE (DMH)
- CB CATCH BASIN (CB)
- WV WATER VALVE
- HYDRANT
- FAB FIRE ALARM BOX
- LP LIGHT POLE
- UP UTILITY POLE
- GW GUY WIRE
- DUAL WALL CONVEYANCE PIPING
- TELEPHONE LINE OVERHEAD
- POWER CONDUIT OVERHEAD
- POWER CONDUIT UNDERGROUND
- INSTRUMENTATION CONDUIT UNDERGROUND
- PROPOSED CHAINLINK FENCE
- EXTRACTION WELL (BY OTHERS)
- INDUCTANCE LOGGING WELL (BY OTHERS)
- MULTILEVEL PIEZOMETER (BY OTHERS)
- MONITORING WELL

**NOTES:**

1. EXISTING CONDITIONS SHOWN ON THIS PLAN ARE THE RESULT OF AN ON THE GROUND SURVEY PERFORMED BY DANA F. PERKINS, INC. ON JUNE 27 & 29, 2005.
2. THE UNDERGROUND UTILITIES SHOWN HAVE BEEN LOCATED FROM FIELD SURVEY INFORMATION AND EXISTING DRAWINGS. THE SURVEYOR MAKES NO GUARANTEE THAT THE UNDERGROUND UTILITIES SHOWN COMPRISE ALL SUCH UTILITIES IN THE AREA, EITHER IN SERVICE OR ABANDONED. THE SURVEYOR FURTHER DOES NOT WARRANT THAT THE UNDERGROUND UTILITIES SHOWN ARE IN THE EXACT LOCATION INDICATED ALTHOUGH HE DOES STATE THAT THEY ARE LOCATED AS ACCURATELY AS POSSIBLE FROM INFORMATION AVAILABLE. THE SURVEYOR HAS NOT PHYSICALLY LOCATED THE UNDERGROUND UTILITIES.

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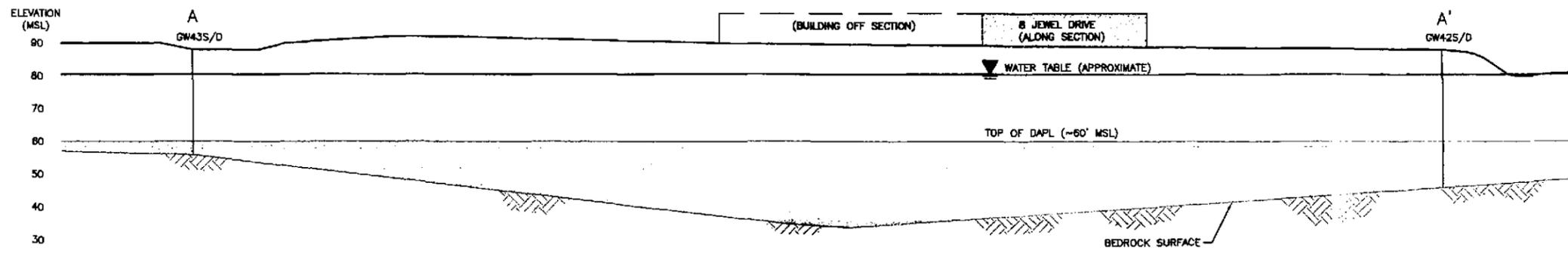
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ENGINEER:	SCALE: 1" = 20'
MAP	APPROVED:
CHECKED: REQ	DATE:

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INTERIM RESPONSE STEPS WORK PLAN  
 OLIN CHEMICAL SUPERFUND SITE  
 WILMINGTON, MASSACHUSETTS

CML  
 FIGURE 4-2  
 PROPOSED SITE PLAN  
 DAPL EXTRACTION PILOT TEST

DRAWING NO:  
 -



NOTE:  
SEE FIGURE 4-2 FOR LOCATION OF SECTION LINE.



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					JUNE 1, 2007	JUNE 1, 2007

DRAWN: MRS  
ENGINEER: MAP  
CHECKED: PHT  
DATE: JUNE 1, 2007

PROJECT NO: 6300-06-0010 41.1  
SCALE: 1" = 20'  
APPROVED: PHT  
DATE: JUNE 1, 2007

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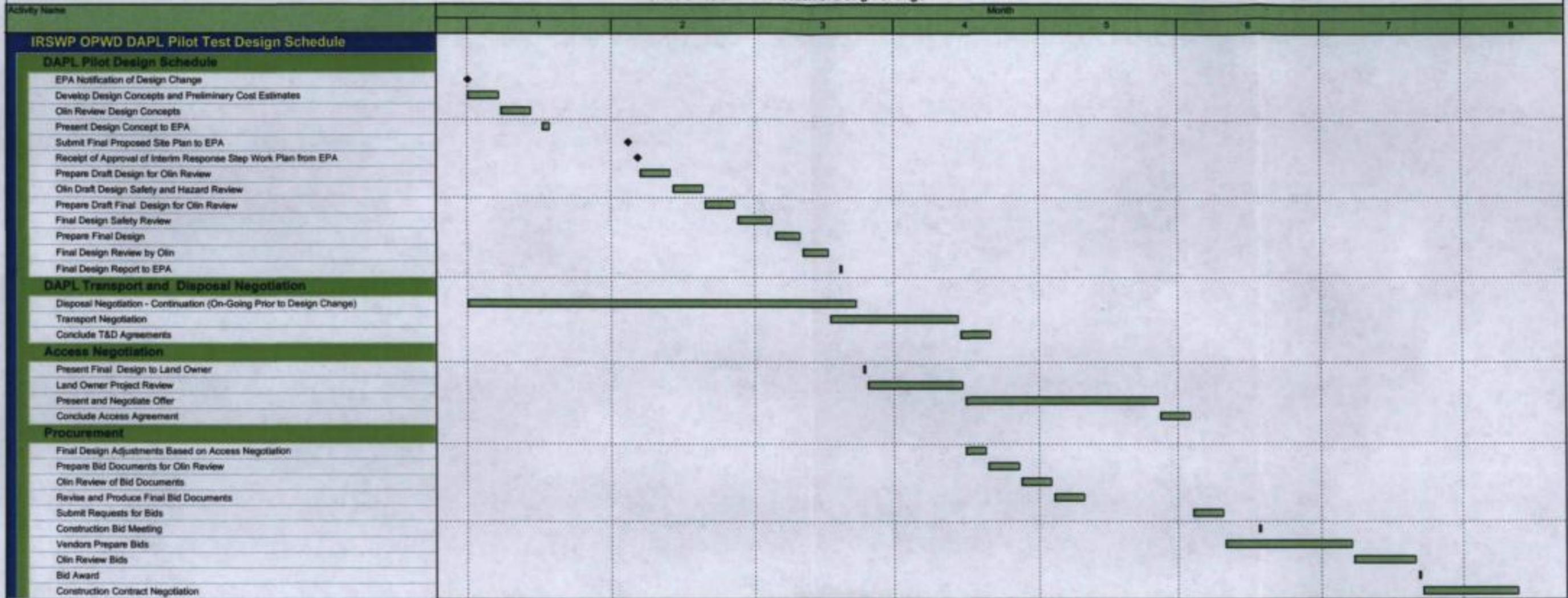
INTERIM RESPONSE STEPS WORK PLAN  
OLIN CHEMICAL SUPERFUND SITE  
WILMINGTON, MASSACHUSETTS

FIGURE 4-3  
SECTION A-A'  
DAPL EXTRACTION PILOT TEST

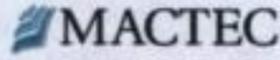
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IRSWP OPWD DAPL Pilot Test Design Schedule

Months Since EPA Notification of Design Change



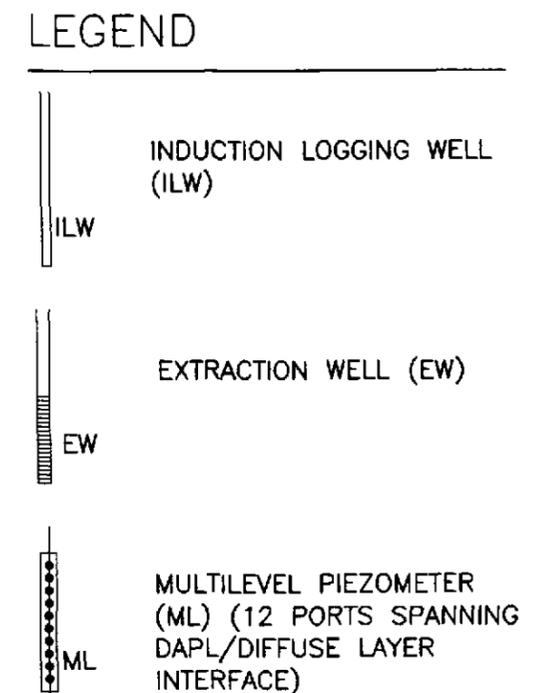
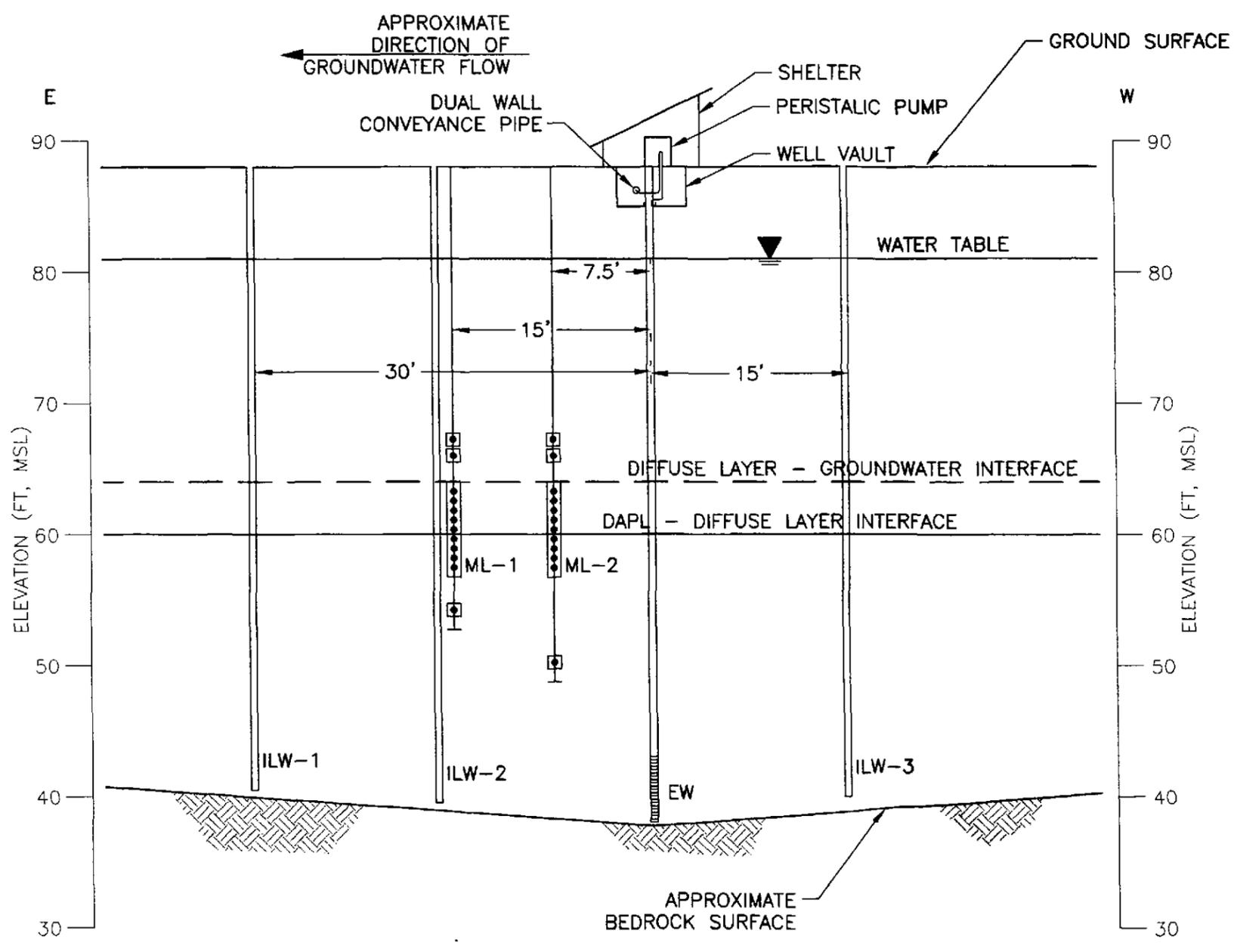
Activity  
Milestone



6100080016/02

Prepared by: Rena Armstrong Date: 8/6/08  
Checked by: Peter Thompson Date: 8/6/08

Figure 4-4  
DAPL Extraction Pilot Test Design Report Schedule  
Final Interim Response Steps Work Plan  
Olin Chemical Superfund Site  
Wilmington, Massachusetts



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NO.	DATE	REVISIONS	BY	CHK	DRAWN: MRS	PROJECT NO: 6300-06-0010 41.1
					ENGINEER: MAP	SCALE: 1" = 20'
					CHECKED: PHT	APPROVED: PHT
					DATE: JUNE 1, 2007	DATE: JUNE 1, 2007

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INTERIM RESPONSE STEPS WORK PLAN  
 OLIN CHEMICAL SUPERFUND SITE  
 WILMINGTON, MASSACHUSETTS

FIGURE 4-5  
 EXTRACTION AND MONITORING WELL  
 CONFIGURATION  
 DAPL EXTRACTION PILOT TEST

DRAWING NO:  
 000



## **TABLES**

**Table 2-1  
Historical Groundwater and Surface Water Sampling Plan  
Final Interim Response Steps Work Plan  
Olin Chemical Superfund Site  
Wilmington, Massachusetts**

Well <sup>1</sup>	Groundwater Elevations and Contours	Vertical Gradients	Groundwater Chemistry	Surface Water Chemistry	Mass Flux Through Window	Equipped with Data Logger
GW-10S	X		X			X <sup>7</sup>
GW-15	X					
GW-17D	X					
GW-17S	X					
GW-201S	X					
GW-202D	X	X				
GW-202S	X	X	X			
GW-24	X		X		X	
GW-25	X		X			
GW-28D	X					
GW-28S	X					
GW-29D	X	X				
GW-29S	X	X				
GW-30DR	X					
GW-32S	X					
GW-34D	X	X	X			
GW-34S		X				
GW-34SR	X	X	X			
GW-35D	X	X				
GW-35S	X	X			X	X
GW-39	X					
GW-42D	X					
GW-42S	X					
GW-43D	X					
GW-43S	X					
GW-50D	X					
GW-50S	X					
GW-54D	X					
GW-54S	X					
GW-55D	X	X				
GW-55S	X	X				
GW-56D	X					
GW-56S	X					
GW-6D	X	X				
GW-6S	X	X				
GW-76S			X <sup>2</sup>		X	X
GW-77S	X					
GW-78S	X		X			X
GW-79S	X		X			
GW-CA1	X		X			X
GW-CA2	X		X <sup>3</sup>		X	
GW-CA3D	X	X				
GW-CA3S	X	X				
GW-CA4S	X					
GW-LPB-11	X					
ISCO1				X		
ISCO2				X		
PW-2	X					
PZ-16R <sup>4</sup>	X					
PZ-16RSW				X <sup>5</sup>		
PZ-17R <sup>6</sup>	X					
PZ-18R	X					
SD-17				X		

**Notes:**

<sup>1</sup>Groundwater well locations shown on Figure 2-1. Surface water sample locations shown on Figure 2-3.

<sup>2</sup>Periodic monitoring of groundwater chemistry ceased at GW-76S after 8/19/03.

<sup>3</sup>Periodic monitoring of groundwater chemistry ceased at GW-CA2 after 8/28/03.

<sup>4</sup>Well location replaced on 8/26/05.

<sup>5</sup>Periodic monitoring of groundwater chemistry ceased at PZ-16RSW after 4/22/02.

<sup>6</sup>Well location replaced in 8/26/05.

<sup>7</sup>Datalogger reinstalled (removed on 4/17/03) in GW-10S in mid-April 2004.

Prepared/Date: MH 07/17/07

Checked/Date: BJR 007/19/07

**Table 2-2  
Most Recent PCMP Monitoring Program  
Final Interim Response Steps Work Plan  
Olin Chemical Superfund Site  
Wilmington, Massachusetts**

Location	Continuous <sup>1</sup>	Sampling Frequency <sup>2</sup>		
	Water Levels	Quarterly	Semi-Annually	Annually
<b>Groundwater</b>				
GW-10S	X		X	
GW-201S			X	
GW-202D			X	
GW-202S		X		
GW-24			X	
GW-25		X		
GW-26			X	
GW-34D			X	
GW-34SR			X	
GW-35S	X		X	
GW-39			X	
GW-42S			X	
GW-43S			X	
GW-55S			X	
GW-76S	X		X	
GW-78S	X		X	
GW-79S		X		
GW-CA1	X		X	
PZ-16RR		X		
PZ-17RR		X		
PZ-18R		X		
<b>Surface Water</b>				
ISCO1		X		
ISCO2		X		
ISCO3		X		
PZ-16RSW		X		
PZ-17RR		X		
PZ-18R		X		
SD-17		X		
<b>Sediment</b>				
SD-SD1				X
SD-SD2				X
SD-SD3				X
SD-SD4				X
SD-SD5				X

**Notes:**

1. Data loggers installed at wells.
2. Analytical program is provided in Table 2-5.

PCMP = Post-Construction Monitoring Plan

Prepared/Date: MH 07/17/07

Checked/Date: BJR 07/19/07

**Table 2-3  
Most Recent PCMP Analytical Program  
Final Interim Response Steps Work Plan  
Olin Chemical Superfund Site  
Wilmington, Massachusetts**

Medium	Most Recent PCMP Analytical Methods			
	Analysis	Analytical Methods	Reporting Limits	Units
Groundwater	Ammonia, as nitrogen	LAC 107061B	0.1	mg/L
	Chloride	EPA300.0 Part A	1	mg/L
	Sulfate	EPA300.0 Part A	2	mg/L
	Specific conductivity	SM18 2510B		µmhos/cm
	Aluminum, dissolved	SW846 6010B	100	µg/L
	Chromium, dissolved	SW846 6010B	5	µg/L
Surface Water	Ammonia, as nitrogen	LAC 107061B	0.1	mg/L
	Chloride	EPA300.0 Part A	1	mg/L
	Nitrate	EPA300.0 Part A	0.05	mg/L
	Nitrite	EPA300.0 Part A	0.01	mg/L
	Sulfate	EPA300.0 Part A	2	mg/L
	Specific conductivity	SM18 2510B	1	µmhos/cm
	Aluminum, dissolved	SW846 6010B	100	µg/L
	Chromium, dissolved	SW846 6010B	5	µg/L
	Sodium, dissolved	SW846 6010B	1000	µg/L
	Aluminum, total	SW846 6010B	100	µg/L
	Chromium, total	SW846 6010B	5	µg/L
Sediment	Aluminum	SW846 6010B	17	mg/kg
	Chromium	SW846 6010B	0.8	mg/kg
	Iron	SW846 6010B	8	mg/kg
	Percent solid	% Solids 160.3M		

**Notes:**

µg/L = micrograms per Liter  
µmhos/cm = micromhos per centimeter  
mg/kg = milligrams per kilogram  
mg/L = milligrams per Liter  
PCMP = Post-Construction Monitoring Plan

Prepared/Date: MH 07/17/07  
Checked/Date: BJR 07/19/07

**Table 2-4**  
**Proposed Slurry Wall/Cap Monitoring Program**  
**Final Interim Response Steps Work Plan**  
**Olin Chemical Superfund Site**  
**Wilmington, Massachusetts**

Location	Manual <sup>1</sup>	Continuous <sup>2</sup>	Sampling Frequency <sup>3</sup>		
	Water Levels	Water Levels	Quarterly	Semi-Annually	Annually
<b>Groundwater</b>					
GW-10S		X		X	
GW-201S	X			X	
GW-202D	X		X		
GW-202S	X		X		
GW-24	X			X	
GW-25	X			X	
GW-26	X			X	
GW-34D	X			X	
GW-34SR	X			X	
GW-35S		X		X	
GW-39	X				
GW-42S	X			DESTROYED	
GW-43S	X			X	
GW-55D	X				
GW-55S	X				
GW-76S		X		X	
GW-78S		X	X		
GW-79S	X		X		
GW-CA1		X		X	
PZ-24	X				
PZ-25	X				
PZ-16RR	X		X		
PZ-17RR	X		X		
PZ-18R	X		X		
<b>Surface Water</b>					
ISCO1			X		
ISCO2			X		
ISCO3			X		
PZ-16RSW			X		
PZ-17RR			X		
PZ-18R			X		
SD-17			X		
<b>Sediment</b>					
SD-SD1					X
SD-SD2					X
SD-SD3					X
SD-SD4					X
SD-SD5					X

**Notes:**

1. Manual water levels collected during semi-annual events as synoptic round.
2. Data loggers installed at wells.
3. Analytical program is provided in Table 2-5.

Prepared/Date: MH 07/17/07  
Checked/Date: BJR 07/19/07

**Table 2-5  
Proposed Slurry Wall/Cap Analytical Plan  
Final Interim Response Steps Work Plan  
Olin Chemical Superfund Site  
Wilmington, Massachusetts**

Medium	Proposed Slurry Wall/Cap Analytical Program			
	Analysis	Analytical Methods	Reporting Limits	Units
Groundwater	Ammonia, as nitrogen	EPA 350.1	0.1	mg/L
	Chloride	EPA 300	1	mg/L
	Sulfate	EPA 300	2	mg/L
	Specific conductivity	SM18 2510B		µmhos/cm
	Aluminum, dissolved	SW846 6010B	100	µg/L
	Chromium, dissolved	SW846 6010B	5	µg/L
Surface Water	Ammonia, as nitrogen	EPA 350.1	0.1	mg/L
	Chloride	EPA 300	1	mg/L
	Nitrate	EPA 300	0.05	mg/L
	Nitrite	EPA300.0 Part A	0.01	mg/L
	Sulfate	EPA 300	2	mg/L
	Specific conductivity	EPA 120.1	1	µmhos/cm
	Aluminum, dissolved	SW846 6010B	100	µg/L
	Chromium, dissolved	SW846 6010B	5	µg/L
	Sodium, dissolved	SW846 6010B	1000	µg/L
	Aluminum, total	SW846 6010B	100	µg/L
	Chromium, total	SW846 6010B	5	µg/L
Sodium, total	SW846 6010B	1000	µg/L	
Sediment	Aluminum	SW846 6010B	17	mg/kg
	Chromium	SW846 6010B	0.8	mg/kg
	Iron	SW846 6010B	8	mg/kg
	Percent solid	% Solids 160.3M		

**Notes:**

µg/L = micrograms per Liter  
µmhos/cm = micromhos per centimeter  
mg/kg = milligrams per kilogram  
mg/L = milligrams per Liter

Prepared/Date: MH 07/17/07  
Checked/Date: BJR 07/19/07

**Table 3-1**  
**Summary of Former and Current Plant B Monitoring Program Sampling Frequency and Analytical Program**  
**Final Interim Response Steps Work Plan**  
**Olin Chemical Superfund Site**  
**Wilmington, Massachusetts**

Location	Water Levels	Sampling Frequency			Media
	Monthly	Monthly	Quarterly	Annually	
12-IN	X				Groundwater
B-02	X				Groundwater
B-03	X			B	Groundwater
B-05-R	X				Groundwater
B-07-A	X				Groundwater
B-17	X				Groundwater
EAST DITCH	X				Groundwater
GW-100	X				Groundwater
GW-101	X			B	Groundwater
GW-102	X				Groundwater
GW-13	X			B	Groundwater
GW-14	X				Groundwater
GW-15	X				Groundwater
GW-16	X		B		Groundwater
GW-23	X				Groundwater
GW-52S	X				Groundwater
IW-1	X				Groundwater
IW-10	X			B	Groundwater
IW-11	X				Groundwater
IW-12	X				Groundwater
IW-13	X				Groundwater
IW-2	X				Groundwater
IW-3	X				Groundwater
IW-6	X			B	Groundwater
IW-7	X				Groundwater
IW-8	X				Groundwater
IW-9	X				Groundwater
P5	X				Groundwater
PID	X				Groundwater
Plant B Effluent		A			Treated Water
Plant B Influent		A			Groundwater

**Notes:**

Analytical methods, reporting limits, sample container and preservation requirements are contained in Appendix A.

**Current Analytical Program**

A - VOCs, SVOCs, iron, SGT-HEM, and general chemistry analysis for ammonia, total recoverable phenolics, pH, residual chlorine in accordance with RGP since 6/21/06

B - VOC (Trimethylpentenes only), SVOCs (NDPA, BEHP only), VPH, ammonia, iron, and pH

LNAPL thickness is measured in wells that show an indication of an LNAPL phase on the water level meter

BEHP = Bis(2-ethylhexyl)phthalate

NDPA = N-nitrosodiphenylamine

PAH = Polycyclic Aromatic Hydrocarbons

RGP = Remediation General Permit

SGT-HEM = Silica Gel Treated n-Hexane Extractable Material (oil and grease)

SVOC = Semi-Volatile Organic Compound

VOC = Volatile Organic Compound

VPH = Volatile Petroleum Hydrocarbon

Prepared/Date: BJR 07/17/07

Checked/Date: KJC 07/19/07

**Table 3-2  
Plant B Summary of Analytical Program  
Final Interim Response Steps Work Plan  
Olin Chemical Superfund Site  
Wilmington, Massachusetts**

Program	Medium	Analytical Methods				
		Analysis	Analytical Methods	Reporting Limits	Units	
Plant B Normal Operations	Plant B Influent/Effluent	VOCs	EPA 8260 B	See Appendix A - Table A-3		
		SVOCs	EPA 8270C	See Appendix A - Table A-3		
		VPH	MADEP VPH	See Appendix A - Table A-3		
		Ammonia, as nitrogen	EPA 350.1	0.1	mg/L	
		Total Recoverable Phenolics	EPA 420.20	0.01	mg/L	
		Iron	EPA 6010B	0.05	mg/L	
		SGT-HEM	EPA 1664A	5.5	mg/L	
		Residual Chlorine	SM18 4500 Cl F	0.05	mg/L	
		pH	EPA 350.1	0.1	pH unts	
	Groundwater (B-03, GW10, GW-13, IW-10, IW-6)	Trimethylpentenes	EPA 8260 B	See Appendix A - Table A-3		
		NDPA, BEHP	EPA 8270C	See Appendix A - Table A-3		
		VPH	MADEP VPH	See Appendix A - Table A-3		
		Ammonia, as nitrogen	EPA 350.1	0.1	mg/L	
		Iron	EPA 6010B	0.05	mg/L	
		pH	EPA 350.1	0.1	pH unts	
	Plant B Shut Down Test (Additional Sampling)	Groundwater (GW-101, IW-10, IW-6)	VOCs	EPA 8260 B	See Appendix A - Table A-3	
			SVOCs	EPA 8270C	See Appendix A - Table A-3	
VPH/EPH			MADEP VPH/EPH	See Appendix A - Table A-3		
Ammonia, as nitrogen			EPA 350.1	0.1	mg/L	
Surface Water East Ditch		VOCs	EPA 8260 B	See Appendix A - Table A-3		
		SVOCs	EPA 8270C	See Appendix A - Table A-3		
		VPH/EPH	MADEP VPH/EPH	See Appendix A - Table A-3		
Surface Water South Ditch		Ammonia, as nitrogen	EPA 350.1	0.1	mg/L	
		Ammonia, as nitrogen	HACH Method 8038	0.1	mg/L	
		pH	Field Measurement		pH unts	

**Notes:**

µg/L - micrograms per Liter  
 µmhos/cm - micromhos per centimeter  
 BEHP = Bis(2-ethylhexyl)phthalate  
 mg/L - milligrams per Liter  
 NDPA = N-nitrosodiphenylamine  
 PAH = Polycyclic Aromatic Hydrocarbons  
 SGT-HEM = Silica Gel Treated n-Hexane Extractable Material (oil and grease)  
 SVOC = Semi-Volatile Organic Compound  
 VOC = Volatile Organic Compound  
 VPH = Volatile Petroleum Hydrocarbon

Prepared/Date: MH 07/17/07  
 Checked/Date: BJR 07/19/07

Table 3-3

**Plant B Groundwater Pumping Rate Reduction Test  
Normal Operational Monitoring Activities  
Final Interim Response Steps Work Plan  
Olin Chemical Superfund Site  
Wilmington, Massachusetts**

Step Number	Purpose	Wells	Activity	Frequency	Data Analysis
1	Initial Synoptic Water Level	GW-31D, GW-31S, GW-32D, GW-32S, GW-301, GW-302, GW-54S, GW-54D, GW-53S, GW-53D, ECS-2, GW-303, GW-52S, GW-52D, GW-16, GW-15, GW-14, GW-13, GW-98, GW-48S, GW-48D, GW-307, GW-23, GW-102, GW-101, GW-100, IW-7, IW-8, IW-9, IW-10, IW-11, IW-12, IW-13, IW-1, IW-2, IW-3, P5, 12 IN, PID	Water Level Measurement	Day prior to initiating pumping rate changes	Compute water table elevation, post elevation values to a map and contour. Check deep and Shallow well pairs for vertical gradients.
2	Initial LNAPL Levels	GW-23, IW-11, IW-12, IW-13, IW-1, IW-2, IW-3, P5, 12 IN, PID	LNAPL Thickness Measurement	Day prior to initiating pumping rate changes	Compute LNAPL thickness values to a map and contour.
3	Initial Sheen Check	GW-102, GW-101, GW-100, IW-6, IW-7, IW-8, IW-9, IW-10	Bail Sample from Water Table	Day prior to initiating pumping rate changes	Pour sample into clean sample jar and observe surface for LNAPL related sheen
4	Flow Measurement and Extraction Well Water Level	IW-11, IW-12, IW-13	Record Extraction Well Flow Rates and Water Levels	Daily	Compare to preceding data for variation
5	Weekly LNAPL Recovery, LNAPL Thickness, and Water Level Measurements	GW-23, IW-11, IW-12, IW-13, P5, 12 IN, PID, IW-1, IW-2, IW-3	Check Traps, Remove and Record LNAPL Volumes, Measure LNAPL and Water Levels	Weekly after start of test	Record Data in spreadsheet and compare to preceding data for changes
6	Weekly Sheen Check	GW-102, GW-101, GW-100, IW-6, IW-7, IW-8, IW-9, IW-10	Bail Sample from Water Table	Weekly after start of test	Compare to preceding data for variation
7	Monthly Synoptic Water Levels	GW-52S, GW-13, GW-14, GW-15, GW-16 GW-98, GW-23, GW-102, GW-101, GW-100, IW-7, IW-8, IW-9, IW-10, IW-11, IW-12, IW-13, IW-1, IW-2, IW-3, P5, 12 IN, PID, B-02, B-03, B-05-R, B-07-A, B-17, East Ditch	Water Level Measurement	Monthly after start of test	Compute water table elevation, post elevation values to a map and contour.

Table 3-3

**Plant B Groundwater Pumping Rate Reduction Test  
Normal Operational Monitoring Activities  
Final Interim Response Steps Work Plan  
Olin Chemical Superfund Site  
Wilmington, Massachusetts**

Step Number	Purpose	Wells	Activity	Frequency	Data Analysis
8	South Ditch Monitoring Ammonia, pH and surface water levels	PZ-20, PZ-17RR	Collect Surface Water Samples. Analyze On-Site for Ammonia and pH. Measure surface water elevation, depth, and shallow groundwater elevation.	Weekly after start of test	Compare to preceding data for changes. Compute vertical groundwater / surface water gradient for each event.
9	East Ditch Monitoring VOCs, SVOCs, VPH, EPH and Ammonia	GW-101, IW-10, IW-6, Surface Water (2 locations)	Collect Surface Water Sample and Groundwater Samples. Analyze Off-Site for VOCs, SVOCs, VPH, EPH, and Ammonia	Monthly after start of test	Compare to preceding data for changes
10	East Ditch Monitoring Daily Sheen Check	Surface Water in East Ditch adjacent to Plant B area	Visual Observation	Daily if during weekly sheen check an LNAPL sheen is detected in wells listed in Step 6	Record observations

**Notes:**

SVOC = Semi-Volatile Organic Compound  
VOC = Volatile Organic Compound  
VPH = Volatile Petroleum Hydrocarbon

Prepared/Date: PHT 07/17/07  
Checked/Date: MJM 07/19/07



**APPENDIX A**  
**SAMPLING AND ANALYSIS PLAN**

## **Final Sampling and Analysis Plan**

**Prepared for:  
Olin Chemical Superfund Site  
Wilmington, Massachusetts**

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## **ATTACHMENTS**

Attachment A	Standard Operating Procedures
Attachment B	Field Laboratory Methods
Attachment C	Field Data Records
Attachment D	Data Validation Checklists

## GLOSSARY OF ACRONYMS AND ABBREVIATIONS

BR	bedrock
COC	chain-of-custody
D	deep
DI	de-ionized
DO	dissolved oxygen
DQI	Data Quality Indicators
EDD	Electronic Data Deliverable
FID	flame ionization detector
FDRs	field data records
IDW	investigation derived waste
IRSWP	Interim Response Steps Work Plan
LCS	laboratory control samples
M	medium
MACTEC	MACTEC Engineering and Consulting, Inc.
MS/MSD	Matrix spike/Matrix spike duplicates
NDMA	N-nitrosodimethylamine
ORP	oxidation-reduction potential
PAH	polynuclear aromatic hydrocarbons
PID	photoionization detector
PQOs	project quality objectives
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act
S	shallow
SAP	Sampling and Analysis Plan
SOP	Standard Operating Procedure
STL	Severn Trent Laboratories
SVOC	semi-volatile organic compounds
TPH	total petroleum hydrocarbons
USEPA	U.S. Environmental Protection Agency
VOCs	volatile organic compounds

## 1.0 INTRODUCTION

### 1.1 PURPOSE

The purpose of this Sampling and Analysis Plan (SAP) Appendix is to provide documented methods and procedures to govern implementation of Interim Response Steps Work Plan (IRSWP) data collection activities, at the Olin Chemical Superfund Site (Site) until such time as a Quality Assurance Project Plan (QAPP) consistent with U.S. Environmental Protection Agency (USEPA) Region 1 guidance is prepared and approved by USEPA. Work conducted in the past has been consistent with the prior Olin QAPP which has evolved over the last decade, and methods and procedures contained herein are generally consistent with those past procedures and methods. This SAP Appendix is focused solely on the activities to be performed under the IRSWP to which it is appended. The purpose of this document is to insure proper Quality Assurance/Quality Control (QA/QC) of data collected under the IRSWP, and to allow an opportunity for USEPA input.

### 1.2 DOCUMENT ORGANIZATION

This document contains two major sections: 2.0 QAPP Components and 3.0 Field Sampling Methods and Procedures. The QAPP components include explanation of the procedures for sample identification, custody, preservation, data validation and data management in the following subsections:

- 2.1 Sample Identification
- 2.2 Sample Chain of Custody Procedures and Shipping
- 2.3 Sample Preservation
- 2.4 Data Management and Sample Tracking
- 2.5 Laboratory Analytical Procedures
- 2.6 Field Analytical Procedures
- 2.7 Data Validation and Evaluation
- 2.8 Quality Control
- 2.9 Corrective Actions

These subsections are supported by tables and validation checklists.

Section 3.0 provides discussion of field sampling plan procedures for:

- 3.1 Groundwater
- 3.2 Surface water and sediment
- 3.3 Equipment Decontamination and Investigation Derived Waste

## 2.0 QAPP COMPONENTS

Section 2.0 of this document contains information to ensure proper QA/QC of data collected at the Site.

### 2.1 SAMPLE IDENTIFICATION

Groundwater, surface water, and sediment sample identifications will be determined using the following criteria:

- Sample identification can be up to 12 digits (e.g., OC-SD-05-001XXX).
- Each group of digits will be separated by a dash.
- The first group of digits, up to two, indicates the Site name (OC=Olin Chemical).
- The next group of digits indicates the location being sampled, where the number will increase sequentially.
- The last group of digits, up to three, indicates the depth the sample was collected from. Depth may not be applicable for all types of media.
- Samples which are collected as duplicates will end with “-DUP”

This format allows sufficient flexibility to accommodate older locations that may be re-sampled which have longer location names.

### 2.2 SAMPLE CHAIN OF CUSTODY PROCEDURES AND SHIPPING

The chain-of-custody (COC) record is used to document sample-handling information (i.e., sample location, sample identification, and number of containers corresponding to each sample number).

The following information is recorded on the COC record:

- Project reference;
- Site identification, sample identification, date of collection, time of collection, number and type of sample containers for each analysis, method of analysis requested, preservation methods, total number of containers for each sample, and sample depth;
- Names of the sampler(s) and the person shipping the samples; and
- Date and time that the samples were delivered for shipping.

The COC is completed in triplicate. One copy accompanies the samples to the laboratory, the second copy is included in the final data report from the lab, and the third copy is given to the database manager for inclusion in project sample tracking and then maintained in the project file.

The majority of off-site laboratory analysis will be performed at Severn Trent Laboratories (STL) located in Westfield, Massachusetts. STL is a direct subcontractor of Olin. Prior to the start of a sampling event, a bottle order request will be sent to STL. Based on this bottle order STL will preprint the COC's with the following information:

- project reference; and
- site identifications, sample identification, number and type of sample containers for each analysis, method of analysis requested, preservation method, and total number of containers for each sample.

If other laboratories are used for chemical analysis, the COC will be completed by the field sampling technician.

Sample COCs and packaging procedures are summarized below. These procedures will ensure that the samples will arrive at the laboratory with the COC intact. The field sampling technician is responsible for the implementation of proper sample custody procedures in the field and up until the samples have been transferred to a courier (FedEx or lab courier). The COC procedures are initiated in the field immediately following sample collection. The procedures consist of: (1) preparing and attaching a unique sample label to each sample collected, (2) completing the COC form, and (3) preparing and packing the samples for shipment.

The field sampler is personally responsible for the care and custody of the samples until they are transferred or dispatched properly. Field procedures have been designed such that as few people as possible will handle the samples.

All bottles will be identified by the use of pre-printed adhesive sample labels with site name and location, sample number, sample locations, date/time of collection, type of preservation, type of analysis, and sampler's initials. The sample numbering system is presented in Section 2.1 of this document. Whenever possible, sample labels will be generated prior to the sampling event.

Sample labels will be completed for each sample using waterproof ink unless prohibited by weather conditions. If waterproof ink cannot be used, a logbook notation would explain that a pencil was used to fill out the sample label because the pen would not function in wet weather. In addition, sample labels will be covered with clear tape to minimize water damage during transit.

Samples will be transported in containers (coolers) which will maintain the refrigeration temperature for those parameters for which refrigeration is required.

Samples will be accompanied by a properly completed COC form for chemical analyses. The sample numbers and locations will be listed on the COC form. When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the record. This record documents the transfer of custody of samples from the sampler to another person, to a mobile laboratory, to the permanent laboratory or to/from a secure storage location.

The field sample technician will follow the Standard Operating Procedures (SOP) for completing the sample COC. This SOP is included in Attachment A of this document. The COC record is initiated by the samplers in the field. The field portion of the custody documentation should include: (1) the project name; (2) signatures of samplers; (3) the sample number, date and time of collection, and whether the sample is grab or composite; (4) signatures of individuals involved in sampling; (5) the designation of field duplicate and equipment blank samples and (6) if applicable, air bill or other shipping number.

All shipments will be accompanied by the COC record identifying the contents of the cooler or shipment container. The original record will accompany the shipment, and copies will be retained by the sampler and placed in the project files.

Samples will be properly packaged for shipment and dispatched to the laboratory for analysis, with a separate signed custody record enclosed in and secured to the inside top of each sample box or cooler. An SOP for packaging and shipping of environmental samples is provided in Attachment A and will be followed during sample collection at the Site. Shipping containers will be secured for shipment to the laboratory. If an authorized laboratory courier does not pickup the samples from the project site, custody seals will be attached to the front right and back left of the cooler and covered with clear plastic tape after being signed by field personnel. Subsequently, the cooler will be strapped shut with strapping tape in at least two locations.

Samples remain in the custody of the sampler until transfer of custody is completed. This consists of delivery of samples to the laboratory sample custodian, and signature of the laboratory sample custodian on the COC or traffic report document as receiving the samples and the signature of sampler as relinquishing samples.

### **2.3 SAMPLE PRESERVATION**

Summaries of sample containers, required sample volumes, preservation and holding time requirements for all samples are presented in Table A-1.

Samples will either be shipped to the laboratory or a courier from the laboratory will pick-up the samples at the Site. Federal Express overnight service will be used for shipping samples to the laboratory. Samples will be shipped within 24 to 48 hours of sample collection. If analytical holding times are 24 to 48 hours from the time of sample collection (e.g., hexavalent chromium), or if samples need to be preserved at the laboratory, samples will be shipped within 24 hours of sample collection using the overnight service. An attempt will be made to collect these samples at the latter part of the day in order to provide the laboratory with adequate time for analysis prior to exceeding the holding time.

### **2.4 DATA MANAGEMENT AND SAMPLE TRACKING**

Prior to data collection, determinations made regarding the data to be gathered in the field and the methodologies to be used are documented in project-specific work plans. Once the data are obtained, they will be reviewed and assessed as to their adequacy. A variety of data records and data reports will be generated during the sample collection, chemical analysis, data review and reporting processes.

#### **2.4.1 Data Management**

The greatest amount of data will be generated through the chemical analysis of field samples. The majority of the analyses will be completed at off-site laboratories, although some chemical data will be analyzed on-site.

Off-site laboratory chemical data will be sent to the data manager as an Electronic Data Deliverable (EDD) via email. The EDD will be in the format provided in Table A-2 to expedite the process of uploading data. After validation is complete, as described in Section 2.7, the EDD will be uploaded to the Microsoft Access Project Database. Any changes which occurred during validation will be incorporated into the upload of the EDD. Once the data are loaded into the project database, a Microsoft Access Report is printed which will be compared to the validated hard copy of the lab report to ensure all data were correctly uploaded to the project database. The validated hard copy lab report will be retained in the MACTEC Engineering and Consulting, Inc. (MACTEC) project files.

Data collected in the field during sample collection activities (e.g., pH, water level data) will be recorded on field data records (FDRs). Upon completion of field activities, the FDRs will be provided to the project data manager to enter data into the Microsoft Access Project Database.

#### **2.4.2 Sample Tracking**

A sample tracking process has been developed to ensure that each sample is accounted for at all times. This process will track the sample from the time it is sampled to the time the sample has been uploaded into the Microsoft Access Project Database. The following steps are taken in this process:

- Upon completion of the field program the field staff will give all COCs to the data manager.
- The data manager will enter into the sample tracking database the following: sampling program, sample identification, date sampled, time sampled, sample type, matrix, laboratory shipped to, date shipped to lab and analyses requested.
- The data manager will enter the date on which the EDD was received from the lab. The data validator will enter the date on which the hard copy report was received from the lab. Olin expects a laboratory turnaround time of 3 weeks.
- The data manager will enter the date the validation memo is received both electronically and in hard copy. It is Olin's expectation that all data validation should be completed within one week of MACTEC's receipt of data from the laboratory.

- The data manager will enter the date the sample is uploaded to the Microsoft Access Project Database. It is Olin's expectation that the project database should be updated within one week of the completion of data validation.
  
- The data manager will enter the date the Microsoft Access Project Database is posted for the use of the project team.

The sample tracking system is used to monitor compliance with the above deadlines.

## **2.5 LABORATORY ANALYTICAL PROCEDURES**

The analytical chemistry program used during sample collection at the Site will include a combination of on-site (field analytical) and off-site (laboratory) analyses. This section provides a description of the off-site laboratory analytical program. The primary laboratory selected to perform off-site analyses is STL located in Westfield, Massachusetts. A description of the field analytical procedures is presented in Section 2.6 of this document.

Analyses will be completed using USEPA methods (USEPA, 1996a; USEPA, 1983) and Standard Methods (APHA, 1998). A listing of analytical methods to be used during sampling activities at the Site is presented in Table A-3 of this document. Analytical methods and reporting limits for surface water and groundwater matrices are described for volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), polynuclear aromatic hydrocarbons (PAHs), N-nitrosodiphenylamine (NDPA), total petroleum hydrocarbons (TPH)/Oil and grease, metals, and wet chemistry parameters (e.g., pH, chloride, nitrate). Analytical lab methods from STL specific to analyzing samples from the Site will not be presented in this document, but will be housed at MACTEC in Portland, Maine. Review of these lab methods will be done by MACTEC prior to submission of environmental samples for analysis.

## **2.6 FIELD ANALYTICAL PROCEDURES**

HACH field test kits and laboratory probes will be used at the Site treatment plant to analyze for the following parameters:

- Ammonia by HACH Method 8038
- pH by Method USEPA 150.1 using the HACH sensION4 pH meter
- Temperature

The HACH DR2000 spectrophotometer will be used at Plant B to analyze ammonia. The HACH sensION4 pH meter will be used at Plant B to analyze pH. The HACH DR2000 spectrophotometer, HACH sensION4 pH meter instrument manual and analytical methods 8038 and 8146 are presented in Attachment B.

A water quality meter (Horiba U-22 meter, or equivalent) will be used by field technicians to measure the following parameters during surface water and groundwater sample collection: pH, temperature, conductivity, dissolved oxygen (DO), salinity, and/or oxidation-reduction potential (ORP). For collection of the water quality parameters during groundwater sampling, an in-line flow-through cell for continuous monitoring will be utilized. A HACH 2100P portable turbidity meter, or equivalent, will be used to determine turbidity in conjunction with the water quality meter.

The instruments calibration will be checked prior to each day's operation using a NIST-traceable reference standard(s). The readings obtained during the instrument calibration check will be recorded on the Field Instrument Calibration FDR (presented in Attachment C). If calibration check readings are outside of acceptable limits printed on the FDR, the meter will be re-calibrated or replaced in accordance with the manufacture's specifications. Calibration data including reference material, dates of reference material preparation and expiration and the true value observed will be recorded in the field logbook and Field Instrument Calibration FDR.

## **2.7 DATA VALIDATION AND EVALUATION**

The purpose of data validation and data quality assessment is to ensure that data generated for the Olin Wilmington project are accurate and consistent with project objectives. Each report for the interim response investigations will include an assessment of data usability.

Data quality assessment will be conducted in three phases.

Phase 1. Prior to data collection, sampling and analysis procedures are evaluated with regard to their ability to generate the appropriate, technically acceptable information required to achieve project objectives. General project objectives are defined in terms of target analytes, analytical methods, required sampling protocols and reporting goals. Specifics for data acquisition (e.g.,

media sampled, explorations locations, quantity of samples, and sampling approach) are documented in IRSWPs.

Phase 2. During data collection, field procedures will be assessed to ensure that data acquisition is completed in accordance with QA procedures and requirements in order to achieve project objectives.

Phase 3. Following the completion of data collection activities, an assessment of the adequacy of the data generated with regard to QC measurement goals and project objectives will be undertaken by the Technical Leaders, QA Supervisor, and Project Manager. A major part of the data review effort includes the assessment of analytical sample results. Data review procedures for analytical data generated at the on-site and off-site laboratories are discussed in the following subsections. Based on these reviews, recommendations on data usability will be developed. In the event that data gaps are identified, the QA Supervisor may recommend the collection of additional raw data to fully support the project's findings and recommendations or qualify data usability.

The following items will be evaluated by MACTEC for the interim response investigations as appropriate:

- method goals and limitations:
  - MDL
  - quantitation limits/reporting limits
  - representativeness
  - accuracy
  - precision
  - comparability
  - completeness
  
- use of data:
  - compliance with standards, regulations, and project objectives
  - presence or absence of chemical constituents
  - quantity and completeness of data

- quality of data:
  - acceptable without qualification
  - acceptable with qualification
  - unacceptable
  -

### **2.7.1 On-Site Data**

Data generated by on-site analysis of samples using HACH™ kits (e.g., ammonia nitrogen) and on-site measurements with instrumentation (e.g., dissolved oxygen) will be subject to a secondary review by the project chemist and/or Olin's on-site QA Supervisor. Results generated by on-site analysis and on-site measurements will be entered into the Olin database (as appropriate) subsequent to the secondary review. The secondary review will include the evaluation of instrument calibration results, a review of the field chemist's log book entries and verification of appropriate significant figures for final results. This secondary review will be completed before results are considered to be final.

### **2.7.2 Off-Site Laboratory Data**

Data generated at the off-site laboratory are reviewed by the project chemist and QA Supervisor prior to finalizing results for use in investigation reports. Data review will include project chemist reviews and formal data validation using the Olin Wilmington Level I Data Quality Evaluation Standard Operating Procedure and Checklists. These data quality evaluation checklists are presented in Attachment D of this document. Through the reviews and validation steps, the Data Quality Indicators (DQIs) for the data set will be completed. This process also includes the qualification of results with qualifiers that identify data usability considerations for the data users.

Assessment of representativeness of sample results will be made by the evaluation of quality control blanks reported with each data set. Sample data will be qualified using the methods outlined in the Olin Wilmington Level I Data Quality Evaluation Standard Operating Procedures and Checklists. Evaluation and possible result qualifications will be made for target analytes detected in a blank from each analytical method for each matrix. Based on trends observed for the entire data set, data interpretations on potential false positive data reporting may be developed for analytes observed in blanks. Potential laboratory or field contaminants will be identified and addressed when presenting results for the interim response investigations.

An assessment of precision and accuracy of analytical data is accomplished via review of field duplicate analyses, and surrogate and/or spike recovery, both in water and soil matrices. Spike sample data include blank spike laboratory control samples (LCS) and Matrix spike/Matrix spike duplicates (MS/MSD) results. Accuracy is expressed as percent recovery. Precision is expressed as the relative percent difference between results for duplicate pairs. Interpretations on data usability and control limits for surrogate recovery, MS recovery, and field duplicates will be based on comparable limits presented in Table A-3 and applicable laboratory generated control limits. Control limits are also documented in the Olin Level I Data Quality Evaluation Checklists (Attachment D).

Results generated for VOCs, SVOCs, PAHs, NDPA, VPH, inorganics (metals and elements), and wet chemistry methods will be validated and evaluated using the Olin Level I Data Quality Evaluation Checklists. The data validation using the Olin Level I Data Quality Evaluation Checklists is similar to performing a Tier II USEPA Region I validation (USEPA, 1996b; USEPA, 1989). The QC limits specified in Table A-4 will be used as project-specific QC goals.

Results will be qualified in accordance with the Olin Level I Data Quality Evaluation Checklists. Edits will be made to preliminary results based on the validation actions and qualifications to generate a final data set. Data quality assessments, data qualifications, and professional judgments will be summarized in the data quality section of each interim response semi-annual report.

The MACTEC QA Supervisor will provide a senior review of all validation reports and data qualifications leading to the production of the final data presented in project reports. During the QA review, the following examinations will be completed:

- Validation procedures used during validation will be compared to procedures scoped for the project to verify that the correct guidelines, QC criteria, and levels of validation were completed;
- Data qualification actions will be reviewed for all data delivery groups to verify that the correct qualifiers are applied and actions meet specifications of the referenced validation guidelines;
- Professional judgment decisions described in validation reports will be reviewed to provide a final review of judgment decisions; and

- Data usability statements for methods, target analytes, or specific samples will be developed for presentation in the project reports.

Each interim response semi-annual report will contain an assessment of data quality and usability. This assessment will be included in the report prior to contamination nature and risk assessments evaluations. The report will include a summary of data qualified during validation due to precision and accuracy measurements, identification of potential lab or field contamination, a review of detection limits, and a review of data completeness, to determine if the quantity and quality of data are adequate to meet project quality objectives (PQOs) established in project-specific work plans. Data usability and data gap considerations will be identified again when results are presented in contamination and risk assessments.

## **2.8 QUALITY CONTROL**

### **2.8.1 Sampling Quality Control**

This section identifies the QC procedures, checks, samples, and acceptance limits that will be used to monitor the analytical data quality generated during sampling events. Collection frequency, acceptance limits, and corrective actions are also documented in this section 2.8. Table A-4 and Table A-5 summarize this information for each matrix, analytical parameter, and sampling method. It should be noted that bottle blanks are not being submitted for analysis during investigation at the Olin Site. All bottles will be certified clean from the manufacturer and the certifications will be stored in the project file. Potential contaminants due to the sample container will also be detected in the equipment blanks, discussed below.

#### **2.8.1.1 Equipment Blanks**

Equipment blanks may be collected to check for sampling process contamination that may cause sample contamination. Equipment blanks will be prepared by routing de-ionized (DI) water through sampling equipment after equipment decontamination and before field sample collection. In general, equipment blanks will be submitted at a frequency of one per twenty samples, per matrix and per parameter. Equipment blanks will not be collected if sample are obtain directly from a tap (treatment system valve), directly from a surface water location using a sample container, or in association with wells that are sampled with dedicated equipment.

#### 2.8.1.2 Cooler Temperature Blanks

Cooler temperature blanks consist of a sample container filled with non-preserved water (potable or distilled) and are included in all coolers which are shipped to the laboratory. The laboratory uses these temperature blanks to measure cooler and samples temperature when they are received at the laboratory. The laboratory records the results of the temperature blanks on the COC or sample login form immediately upon receipt of the samples at the laboratory and prior to inventory and refrigeration.

#### 2.8.1.3 Field Duplicates

In general, field duplicates will be collected at a frequency of five percent (1 duplicate for every 20 samples collected) per matrix and analytical parameter. Field duplicate samples are an additional aliquot of the same sample submitted for the same parameters as the original sample and will be used for aqueous and solid matrices. Field duplicate samples will be collected by alternately filling sample bottles from the source being sampled. Field duplicates will be used to assess the sampling and analytical reproducibility.

#### 2.8.1.4 Trip Blanks

Trip blanks will be shipped with samples collected for VOC analysis. One trip blank is required for every cooler containing VOC samples.

### 2.8.2 Analytical Quality Control

This section identifies the QC procedures, checks and samples, and the associated acceptance limits, that will be used during the project to monitor the quality of various preparatory and analytical steps. Table A-4 summarizes quality control limits for each analytical parameter where QC procedures are required.

#### 2.8.2.1 Field Analytical QC

Instrument blanks are required to be analyzed with the photoionization detector (PID) or the flame-ionization detector (FID) or to evaluate potential contamination resulting from the instrumentation. The analysis of an instrument blank for the PID or FID will consist of attaching a canister of zero

air to the instrument. The PID or FID should read zero when the canister is attached and opened. If the instrument displays a positive reading then re-calibration or replacement of the unit is necessary. Re-calibration of the PID or FID will be performed according to the manufacturer's manual.

#### 2.8.2.2 HACH DR-2000 and sensION4 pH meter Analytical QC

Field analytical QC samples collected for analysis by the HACH DR-2000 and sensION4 pH meter are presented in Table A-5 of this document. A summary of control limits for QC samples analyzed using the HACH DR-2000 and sensION4 pH meter is presented in Table A-4.

#### 2.8.2.3 Fixed Laboratory QC

All required QC checks and QC samples and the associated QC acceptance limits are detailed in USEPA SW-846 or associated USEPA methods.

**Method Blanks.** Method blanks will be performed as part of each analytical batch for each methodology performed. Method blanks are used to evaluate contamination introduced during sample preparation and/or analysis by the laboratory.

**Instrument Blanks.** Instrument blanks are used to evaluate contamination resulting from the analytical reagents and the instrumentation. In addition, instrument blanks are sometimes used to assess potential carryover after the analysis of a highly contaminated sample.

**Matrix Spike Samples.** The MS samples are used to determine laboratory preparation and analysis bias for specific compounds in specific matrices (i.e., sample specific QC). MS samples are typically performed at a frequency of one per twenty investigative samples. MS samples are not required for grain size analyses and metals analyses associated with air samples.

**Matrix Spike Duplicate Samples.** MSDs are used to evaluate laboratory preparation and analysis bias and precision for specific compounds in specific sample matrices (i.e., sample specific QC). MSDs are performed for organic parameters only.

**Surrogate Spikes.** Surrogate spikes are used to evaluate extraction efficiency or analytical bias on a sample by sample basis for organic parameters. Surrogate spikes are added to VOC and SVOC samples.

**Laboratory Control Samples (LCS).** LCSs are used to evaluate almost all parameters for the ability of the laboratory to accurately identify and quantitate target compounds in a reference matrix when spiked at a known concentration using a secondary source standard. LCSs are typically performed as part of each analytical batch for each methodology. LCSs are also a self-check for the laboratory to ensure the method is in compliance.

**Laboratory Duplicate.** Laboratory duplicates are used to evaluate laboratory preparation and analysis precision. These analyses are typically performed for inorganic parameters only. Laboratory duplicates are typically performed at a frequency of one per twenty samples.

## 2.9 CORRECTIVE ACTIONS

### 2.9.1 Field Non-Conformances

Corrective action in the field may be needed when the sample network is changed (i.e., more/less samples, sampling locations other than those specified in the QAPP), or when sampling procedures and/or field analytical procedures require modification, etc. due to unexpected conditions. The field team may identify the need for the corrective action. The Field Sampling Coordinator will approve the corrective action and notify the Project Manager. The MACTEC Project Manager, in consultation with Olin and USEPA, if necessary, will approve the corrective measure. The Field Sampling Coordinator will ensure that the corrective measure is implemented by the field team. Corrective actions will be implemented and documented in the field record book. Documentation will include:

- A description of the circumstances that initiated the corrective action;
- The action taken in response;
- The final resolution; and
- Any necessary approvals.

No staff member will initiate corrective action without prior communication of findings through the proper channels. If necessary, a problem resolution audit will be conducted.

### **2.9.2 Laboratory Non-Conformances**

Corrective action in the laboratory may occur prior to, during, and after initial analyses. A number of conditions such as broken sample containers, omissions or discrepancies with COC documentation, low/high pH readings, and potentially high concentration samples may be identified during sample log-in or just prior to analysis. Following consultation with laboratory analysts and Laboratory Section Leaders, it may be necessary for the Laboratory QA Manager to approve the implementation of the corrective action.

The analyst may identify the need for a corrective action. The Laboratory Section Leader, in consultation with the staff, will approve the required corrective action to be implemented by the laboratory staff. The Laboratory QA Manager will ensure implementation and documentation of the corrective action. If the nonconformance causes project objectives not to be achieved, the MACTEC Lead Chemist will be notified. The Lead Chemist will notify the Project Manager, who in turn will communicate with the MACTEC / Olin project team for concurrence with the proposed corrective action.

These corrective actions are performed prior to release of the data from the laboratory. The corrective action will be documented in both the laboratory's corrective action files, and the narrative data report. If the corrective action does not rectify the situation, the laboratory will contact the MACTEC Lead Chemist, who will determine the action to be taken and inform the appropriate personnel. If necessary, a problem resolution audit will be conducted.

### **2.9.3 Data Validation and Data Assessment Non-Conformances**

The need for corrective action may be identified during either data validation or data assessment. Potential types of corrective action may include resampling by the field team or reinjection/reanalysis of samples by the laboratory. These actions are dependent upon the ability to mobilize the field team and whether the data to be collected is necessary to meet the required QA objectives. If the data validator or data assessor identifies a corrective action situation, the MACTEC Project Manager will be responsible for informing the appropriate personnel. All corrective actions of this type will be documented by the MACTEC Project Manager and maintained in the project files.

### 3.0 FIELD SAMPLING PLAN METHODS AND PROCEDURES

The following sections describe the general methods for sample collection and documentation. In general, sample collection information is retained in a bound site logbook completed at the time of sampling. The sampler will note the site name, date, weather conditions, time at which the Site is entered and time at which the Site is departed. The log book will include the time and sample number for samples collected and other pertinent information. Correction to entries will be stricken with a single line, dated and initialed. Each page will be numbered and signed by the field sampler.

Samples will be collected in general conformance with referenced SOPs and sample information transcribed to a FDR.

Attachment A contains SOPs and Attachment C contains the FDRs.

#### 3.1 GROUNDWATER

Groundwater samples will be collected in conformance with the USEPA *Low Stress (low flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells* (USEPA, Revision 2, July 30, 1996). Wells have dedicated sampling tubing installed in them. Groundwater levels are shallow and low flow sampling has in the past been conducted using a Geopump (low flow rate peristaltic pump). The pump head tubing will be replaced with new tubing between samples. The low flow groundwater sampling SOP will be followed and any deviations noted. Low flow sample data will be recorded on the low flow FDR. If a well is hydraulically not suited to low flow sampling due to excessive drawdown, the well will be purged and allowed to recover, with sampling occurring from the recovered groundwater.

Prior to collecting groundwater samples, a water level measurement will be taken from the well in accordance with the attached SOP.

For Plant B, LNAPL level measurements are also taken at specific wells. A LNAPL interface probe is used for this procedure and is used in accordance with the manufacturer's instructions. LNAPL level information is retained in a log book and later transcribed to a summary sheet for entry into the Olin Database.

### **3.2 SURFACE WATER AND SEDIMENT**

Surface water and sediment sample collection for monitoring purposes occurs at marked sample locations. The methods and procedures for sample collection are contained in the attached SOPs. A Surface Water - Sediment FDR will be filed out in the field at the time of sample collection. In general, the surface water sample is collected by a bottle dip method, approaching the location from the downstream location to avoid stirring up sediment or floc. Sediment samples are collected by hand methods using cleaned and decontaminated stainless steel or steel sampling devices.

### **3.3 EQUIPMENT DECONTAMINATION AND INVESTIGATION DERIVED WASTE**

The sampling procedures conducted in this program use dedicated equipment for groundwater and surface water which does not require decontamination between samples. Sediment sampling equipment, consisting of soil augers/tube samplers, stainless steel trowels or spoons, will be decontaminated between sample locations using DI water and, if required, phosphate free soap wash (liquinox™). Decontamination fluids will be containerized and disposed through sanitary sewer.

No other investigation derived waste (IDW) will be generated. Olin manages the accumulated LNAPL at Plant B separately through its Resource Conservation and Recovery Act (RCRA) facility permit.

#### 4.0 REFERENCES

- American Public Health Association (APHA), 1998. "Standard Methods for Examination of Water and Wastewater"; APHA, 1015 Fifteenth St., NW., Washington, D.C. 20005.
- U.S. Environmental Protection Agency (USEPA), 1983. "Methods for the Chemical Analysis of Water and Wastes"; Environmental Monitoring and Support Laboratory; USEPA 600-4-79-020; Cincinnati OH; March 1983.
- U.S. Environmental Protection Agency (USEPA), 1989. "Region 1 Laboratory Data Validation Functional Guidelines For Evaluating Inorganic Analyses"; Hazardous Site Evaluation Division; February 1989.
- U.S. Environmental Protection Agency (USEPA), 1996a. "Test Methods for Evaluating Solid Waste"; Laboratory Manual Physical/Chemical Methods; Office of Solid Waste and Emergency Response; Washington, DC; SW-846; November 1986; Revision 4 -December 1996.
- U.S. Environmental Protection Agency (USEPA), 1996b. "Region 1 EPA-NE Data Validation Guidelines For Evaluating Environmental Analyses"; Quality Assurance Unit Staff; Office of Environmental Measurement and Evaluation; December 1996
- U.S. Environmental Protection Agency (USEPA), 1996c. "Region 1 Low Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples From Monitoring Wells; Revision 2-July 1996.

**TABLES**

**Table A-1**  
**Sampling Volumes, Containers and Hold Times**  
**Sampling and Analysis Plan**  
**Final Interim Response Steps Work Plan**  
**Olin Chemical Superfund Site**  
**Wilmington, Massachusetts**

Medium/ Matrix	Analytical Parameter	Conc. Level	Analytical Method	Sample Volume	Containers (Number, size and type)	Preservation Requirements	Maximum Holding Time (preparation/analysis)
GW	VOCs	Low	SW-846 8260B	3 x 40 mL	3 x 40 mL VOA vials	pH < 2 w/ HCl; No headspace; Cool, 4°C	14 days to analysis
GW	SVOC	Low	SW-846 8270C	2 x 1L	2 x 1L Amber Glass	Cool, 4°C	7 days to extraction; 40 days from extraction to analysis
GW	PAHs	Low	SW-846 8270C Low Level Method	2 x 1L	2 x 1L Amber Glass	Cool, 4°C	7 days to extraction; 40 days from extraction to analysis
GW	VPH	Low	MADEP VPH	3 x 40 mL	3 x 40 mL VOA vials	pH < 2 w/ HCl; No headspace; Cool, 4°C	14 days to analysis
GW	TPH / Oil and Grease	Low	EPA 1664	2 x 1L	2 x 1L Amber Glass	Cool, 4°C, w/ 1:1 HCL	28 days to analysis
SW/GW	Metals (total or dissolved)	Low	SW-846 6010B	1 x 500 mL	1 x 500 mL polyethylene	pH < 2 w/ HNO <sub>3</sub> ; Cool, 4°C	180 days to analysis
SW/GW	Sulfate	Low	USEPA 300	1 x 500 mL	1 x 500 mL polyethylene	Cool, 4°C	28 days to analysis
SW/GW	Chloride	Low	USEPA 300	1 x 500 mL	1 x 500 mL polyethylene	Cool, 4°C	28 days to analysis
SW	Nitrate and Nitrite (as N)	Low	USEPA 300	1 x 250 mL	1 x 250 mL polyethylene	H <sub>2</sub> SO <sub>4</sub> to pH<2, Cool, 4°C	28 days to analysis
SW/GW	Ammonia	Low	SM4500/Lachate	1 x 1L	1 x 1000 mL polyethylene	H <sub>2</sub> SO <sub>4</sub> to pH<2, Cool, 4°C	28 days to analysis
GW	Chlorine	Low	SM 4500-CL-F	1 x 500 mL	1 x 500 mL polyethylene	Cool, 4°C	Immediately upon arrival at the lab
GW	pH	Low	USEPA 150.1	1 x 250 mL	1 x 250 mL polyethylene	Cool, 4°C	Immediately upon arrival at the lab
SW/GW	Specific Conductance	Low	USEPA 120.1	1 x 100 mL	1 x 100 mL polyethylene	Cool, 4°C	28 days to analysis
GW	Phenols (total)	Low	EPA 420.2 - LACHAT 10-210-00-1A	1 x 250 mL	1 x 250 mL amber glass	H <sub>2</sub> SO <sub>4</sub> to pH<2, Cool, 4°C	28 days to analysis
SED	Metals	Low	SW-846 6010B	1 x 4 oz.	Glass	Cool, 4°C	180 days to analysis

**Notes:**

GW = Groundwater  
H<sub>2</sub>SO<sub>4</sub> = Sulfuric acid  
HCL = Hydrochloric acid  
HNO<sub>3</sub> = Nitric Acid  
L = Liters  
mL = milliliters  
N = Nitrogen  
oz. = ounces

PAH = Polycyclic Aromatic Hydrocarbons  
SED = Sediment  
SVOC = Semi-Volatile Organic Compound  
SW = Surface Water  
TPH = Total Petroleum Hydrocarbons  
VOA = Volatile Organic Analysis  
VOC = Volatile Organic Compound  
VPH = Volatile Petroleum Hydrocarbons

Prepared/Date: TLC 07/25/07  
Checked/Date: CSR 07/26/07

**Table A-2**  
**Electronic Data Deliverable (EDD) Format**  
**Sampling and Analysis Plan**  
**Final Interim Response Steps Work Plan**  
**Olin Chemical Superfund Site**  
**Wilmington, Massachusetts**

<b>Field Name</b>	<b>Field Description</b>
Job Number	Sample Delivery Group Number
Client	<b>"Olin Chemical"</b>
Sample Number	Laboratory Sample ID
Client ID	Field Sample ID
Project ID	<b>"B RTP Distribution System"</b>
Sample Matrix	<b>"TG"</b> (treated groundwater)
Date Received	Date sampled received at laboratory
Date Collected	Date samples collected in the field
Parameter	Compound name
CAS Number	Cas Number
Result	Concentration detected in analyte
Quantitation Limit	Sample quantitation limit
Units	Units
Method	Analytical method
Date Analyzed	Date sample analyzed at laboratory

Prepared/Date: TLC 07/25/07  
 Checked/Date: CSR 07/26/07

**Table A-3**  
**Summary of Analytical Methods and Reporting Limits**  
**Sampling and Analysis Plan**  
**Final Interim Response Steps Work Plan**  
**Olin Chemical Superfund Site**  
**Wilmington, Massachusetts**

Parameter Name	Water Reporting Limit	Units	Sediment Reporting Limit	Units
<b>VOCs by SW846 B260B (TCL plus MCP Compounds)</b>				
1,1,1,2-Tetrachloroethane	1.0	µg/L		
1,1,1-Trichloroethane	1.0	µg/L		
1,1,2,2-Tetrachloroethane	0.5	µg/L		
1,1,2-Trichloro-1,2,2-trifluoroethane	1.0	µg/L		
1,1,2-Trichloroethane	1.0	µg/L		
1,1-Dichloroethane	1.0	µg/L		
1,1-Dichloroethene	1.0	µg/L		
1,1-Dichloropropane	1.0	µg/L		
1,2,3-Trichlorobenzene	1.0	µg/L		
1,2,3-Trichloropropane	1.0	µg/L		
1,2,4-Trichlorobenzene	1.0	µg/L		
1,2,4-Trimethylbenzene	1.0	µg/L		
1,2-Dibromo-3-Chloropropane	5.0	µg/L		
1,2-Dichlorobenzene	1.0	µg/L		
1,2-Dichloroethane	1.0	µg/L		
1,2-Dichloropropane	1.0	µg/L		
1,3,5-Trimethylbenzene	1.0	µg/L		
1,3-Dichlorobenzene	1.0	µg/L		
1,3-Dichloropropane	1.0	µg/L		
1,4-Dichlorobenzene	1.0	µg/L		
1,4-Dioxane	50	µg/L		
2,2-Dichloropropane	1.0	µg/L		
2,4,4-Trimethyl-1-pentene	1.0	µg/L		
2,4,4-Trimethyl-2-pentene	1.0	µg/L		
2-Chlorotoluene	1.0	µg/L		
2-Hexanone	10	µg/L		
4-Bromofluorobenzene	1.0	µg/L		
4-Chlorotoluene	1.0	µg/L		
4-Isopropyltoluene	1.0	µg/L		
Acetone	50	µg/L		
Benzene	1.0	µg/L		
Bromobenzene	1.0	µg/L		
Bromoform	1.0	µg/L		
Bromomethane	2.0	µg/L		
Carbon disulfide	10	µg/L		
Carbon tetrachloride	1.0	µg/L		
Chlorobenzene	1.0	µg/L		
Chlorobromomethane	1.0	µg/L		
Chlorodibromomethane	0.5	µg/L		
Chloroethane	2.0	µg/L		
Chloroform	1.0	µg/L		
Chloromethane	2.0	µg/L		
cis-1,2-Dichloroethene	1.0	µg/L		
cis-1,3-Dichloropropene	0.5	µg/L		
Cyclohexane	1.0	µg/L		
Dibromofluoromethane	1.0	µg/L		
Dibromomethane	1.0	µg/L		
Dichlorobromomethane	1.0	µg/L		
Dichlorodifluoromethane	1.0	µg/L		
Ethylbenzene	1.0	µg/L		
Ethylene Dibromide	1.0	µg/L		
Ethyl ether	10.0	µg/L		

Table A-3  
 Summary of Analytical Methods and Reporting Limits  
 Sampling and Analysis Plan  
 Final Interim Response Steps Work Plan  
 Olin Chemical Superfund Site  
 Wilmington, Massachusetts

Parameter Name	Water Reporting Limit	Units	Sediment Reporting Limit	Units
Fluorobenzene	1.0	µg/L		
Hexachlorobutadiene	1.0	µg/L		
Isopropyl ether	10	µg/L		
Isopropylbenzene	1.0	µg/L		
Methyl acetate	10.0	µg/L		
Methylene Chloride	2.0	µg/L		
Methyl Ethyl Ketone	10	µg/L		
methyl isobutyl ketone	10	µg/L		
Methyl tert-butyl ether	1.0	µg/L		
Methylcyclohexane	1.0	µg/L		
m-Xylene & p-Xylene	2.0	µg/L		
Naphthalene	5.0	µg/L		
n-Butylbenzene	1.0	µg/L		
N-Propylbenzene	1.0	µg/L		
o-Xylene	1.0	µg/L		
sec-Butylbenzene	1.0	µg/L		
Styrene	1.0	µg/L		
Tert-amyl methyl ether	5.0	µg/L		
Tert-butyl ethyl ether	5.0	µg/L		
tert-Butylbenzene	1.0	µg/L		
Tetrachloroethene	1.0	µg/L		
Tetrahydrofuran	10	µg/L		
Toluene	1.0	µg/L		
trans-1,2-Dichloroethene	1.0	µg/L		
trans-1,3-Dichloropropene	0.5	µg/L		
Trichloroethene	1.0	µg/L		
Trichlorofluoromethane	1.0	µg/L		
Vinyl chloride	1.0	µg/L		
<b>VOCs by SW846 8260B (Short List for RGP)</b>				
1,1,1-Trichloroethane (TCA)	1	µg/L		
1,1-Dichloroethane	1	µg/L		
2,4,4-Trimethyl-1-pentene	1	µg/L		
2,4,4-Trimethyl-2-pentene	1	µg/L		
Acetone	50	µg/L		
Benzene	1	µg/L		
cis-1,2-Dichloroethene	1	µg/L		
Ethylbenzene	1	µg/L		
m,p-Xylene	2	µg/L		
o-Xylene	1	µg/L		
Toluene	1	µg/L		
Trichloroethene (TCE)	1	µg/L		
<b>SVOC by SW846 Low Level 8270C (TCL plus MCP Compounds)</b>				
1,1-Biphenyl	10	µg/L		
1,2,4,5-Tetrachlorobenzene	10	µg/L		
1,2,4-Trichlorobenzene	10	µg/L		
1,2-Dichlorobenzene	10	µg/L		
1,3-Dichlorobenzene	10	µg/L		
1,4-Dichlorobenzene	10	µg/L		
bis (2-Chloroisopropyl) ether	10	µg/L		
2,4,5-Trichlorophenol	10	µg/L		
2,4,6-Trichlorophenol	10	µg/L		
2,4-Dichlorophenol	10	µg/L		
2,4-Dimethylphenol	10	µg/L		

Table A-3  
**Summary of Analytical Methods and Reporting Limits**  
**Sampling and Analysis Plan**  
**Final Interim Response Steps Work Plan**  
**Olin Chemical Superfund Site**  
**Wilmington, Massachusetts**

Parameter Name	Water Reporting Limit	Units	Sediment Reporting Limit	Units
2,4-Dinitrophenol	10	µg/L		
2,4-Dinitrotoluene	10	µg/L		
2,6-Dinitrotoluene	10	µg/L		
2-Chloronaphthalene	10	µg/L		
2-Chlorophenol	10	µg/L		
2-Methylnaphthalene	5	µg/L		
2-Methylphenol	10	µg/L		
2-Nitroaniline	50	µg/L		
2-Nitrophenol	10	µg/L		
3 & 4 Methylphenol	10	µg/L		
3,3'-Dichlorobenzidine	20	µg/L		
3-Nitroaniline	50	µg/L		
4,6-Dinitro-2-methylphenol	50	µg/L		
4-Bromophenyl phenyl ether	10	µg/L		
4-Chloro-3-methylphenol	20	µg/L		
4-Chloroaniline	20	µg/L		
4-Chlorophenyl phenyl ether	10	µg/L		
4-Nitroaniline	50	µg/L		
4-Nitrophenol	50	µg/L		
Acenaphthene	5	µg/L		
Acenaphthylene	5	µg/L		
Acetophenone	10	µg/L		
Aniline	50	µg/L		
Anthracene	5	µg/L		
Atrazine	10	µg/L		
Azobenzene	10	µg/L		
Benzaldehyde	10	µg/L		
Benzo[a]anthracene	5	µg/L		
Benzo[a]pyrene	5	µg/L		
Benzo[b]fluoranthene	5	µg/L		
Benzo[g,h,i]perylene	5	µg/L		
Benzo[k]fluoranthene	5	µg/L		
Bis(2-chloroethoxy)methane	10	µg/L		
Bis(2-chloroethyl)ether	10	µg/L		
Bis(2-ethylhexyl) phthalate	10	µg/L		
Butyl benzyl phthalate	10	µg/L		
Caprolactam	10	µg/L		
Carbazole	10	µg/L		
Chrysene	5	µg/L		
Dibenz(a,h)anthracene	5	µg/L		
Dibenzofuran	10	µg/L		
Diethyl phthalate	10	µg/L		
Dimethyl phthalate	10	µg/L		
Di-n-butyl phthalate	10	µg/L		
Di-n-octyl phthalate	10	µg/L		
Fluoranthene	5	µg/L		
Fluorene	5	µg/L		
Hexachlorobenzene	10	µg/L		
Hexachlorobutadiene	10	µg/L		
Hexachlorocyclopentadiene	10	µg/L		
Hexachloroethane	10	µg/L		
Indeno[1,2,3-cd]pyrene	5	µg/L		
Isophorone	10	µg/L		

Table A-3  
 Summary of Analytical Methods and Reporting Limits  
 Sampling and Analysis Plan  
 Final Interim Response Steps Work Plan  
 Olin Chemical Superfund Site  
 Wilmington, Massachusetts

Parameter Name	Water Reporting Limit	Units	Sediment Reporting Limit	Units
Naphthalene	5	µg/L		
Nitrobenzene	10	µg/L		
N-Nitrosodimethylamine (NDMA)	10	µg/L		
N-Nitrosodi-n-propylamine	10	µg/L		
N-Nitrosodiphenylamine	10	µg/L		
Pentachlorophenol	50	µg/L		
Phenanthrene	5	µg/L		
Phenol	10	µg/L		
Pyrene	5	µg/L		
<b>SVOC/PAHs by SW846 Low-Level 8270C (Short List for RGP)</b>				
2,4,5-Trichlorophenol	5	µg/L		
2,4,6-Trichlorophenol	5	µg/L		
2,4-Dichlorophenol	5	µg/L		
2,4-Dimethylphenol	5	µg/L		
2,4-Dinitrophenol	5	µg/L		
2-Chlorophenol	5	µg/L		
2-Methylphenol (o-Cresol)	5	µg/L		
2-Nitrophenol	5	µg/L		
3- & 4-Methylphenol	5	µg/L		
4,6-Dinitro-2-methylphenol	5	µg/L		
4-Chloro-3-methylphenol	5	µg/L		
4-Nitrophenol	5	µg/L		
Acenaphthene	1	µg/L		
Acenaphthylene	0.31	µg/L		
Anthracene	1	µg/L		
Benzo(a)anthracene	0.31	µg/L		
Benzo(a)pyrene	0.21	µg/L		
Benzo(b)fluoranthene	0.31	µg/L		
Benzo(g,h,i)perylene	0.52	µg/L		
Benzo(k)fluoranthene	0.31	µg/L		
bis(2-EthylHexyl)phthalate	6	µg/L		
Butylbenzylphthalate	5	µg/L		
Chrysene	1	µg/L		
Dibenzo(a,h)anthracene	0.52	µg/L		
Diethylphthalate	5	µg/L		
Dimethylphthalate	5	µg/L		
Di-n-butylphthalate	5	µg/L		
Di-n-octylphthalate	5	µg/L		
Fluoranthene	1	µg/L		
Fluorene	1	µg/L		
Indeno (1,2,3-cd) pyrene	0.52	µg/L		
Naphthalene	1	µg/L		
N-Nitrosodiphenylamine	10	µg/L		
Pentachlorophenol	5	µg/L		
Phenanthrene	0.21	µg/L		
Phenol	5	µg/L		
Pyrene	5	µg/L		
<b>Volatile Petroleum Hydrocarbons - VPH</b>				
Benzene	5	µg/L		
Ethylbenzene	5	µg/L		
m- & p-Xylene	5	µg/L		
Methyl tert-butyl ether	5	µg/L		
Naphthalene	10	µg/L		

Table A-3  
**Summary of Analytical Methods and Reporting Limits**  
**Sampling and Analysis Plan**  
**Final Interim Response Steps Work Plan**  
**Olin Chemical Superfund Site**  
**Wilmington, Massachusetts**

<i>Parameter Name</i>	<i>Water Reporting Limit</i>	<i>Units</i>	<i>Sediment Reporting Limit</i>	<i>Units</i>
o-Xylene	5	µg/L		
Toluene	5	µg/L		
C5-C8 Aliphatics (adjusted)	5	µg/L		
C5-C8 Aliphatics (unadjusted)	5	µg/L		
C9-C10 Aromatics	5	µg/L		
C9-C12 Aliphatics (adjusted)	5	µg/L		
Total VPH	5	µg/L		
<b>Oil &amp; Grease by 1664A</b>				
Oil & Grease-Gravimetric	5.5	mg/L		
<b>Phenolics by EPA 420.2</b>				
Phenolics, Total Recoverable	0.01	mg/L		
<b>Wet Chemistry</b>				
Chloride by EPA 300	1	mg/L		
Sulfate as SO <sub>4</sub> by EPA 300	2	mg/L		
Nitrogen, Ammonia by EPA 350.1	0.1	mg/L		
Specific Conductance by EPA 120.1	1	µmhos/cm		
Nitrate as N by EPA 300	0.05	mg/L		
Nitrite as N by EPA 300 or EPA 353.2	0.01	mg/L		
Residual Chlorine by SM18 4500 Cl F	0.05	mg/L		
<b>Metals by 6010B Total and Dissolved</b>				
Aluminum	100	µg/L	17	mg/Kg
Calcium	200	µg/L		
Chromium	5	µg/L	0.8	mg/Kg
Iron	50	µg/L	8	mg/Kg
Sodium	1000	µg/L		

**Notes:**

mg/L = milligrams per liter (parts per million)  
µg/L = micrograms per liter (parts per billion)  
µmhos/cm - micromhos per centimeter  
mg/Kg = milligrams per kilogram  
N = Nitrogen  
PAH = Polycyclic Aromatic Hydrocarbon  
SVOC = Semi-Volatile Organic Compound  
VOC = Volatile Organic Compound

Prepared/Date: KJC 07/25/07  
Checked/Date: TLC 07/26/07

**Table A-4**  
**Summary of Quality Control Limits for Surrogates, Spikes and Duplicates**  
**Sampling and Analysis Plan**  
**Final Interim Response Steps Work Plan**  
**Olin Chemical Superfund Site**  
**Wilmington, MA**

Parameter	QC Test	Analyte	Water % Recovery	Water RPD Limit	Soil % Recovery	Soil RPD Limit
<b>OFF-SITE LABORATORY QC SAMPLES</b>						
Volatiles	Surrogate	All Surrogates	70 - 130			
	LCS	All Target Compounds	70 - 130			
	MS/MSD	All Target Compounds	70 - 130	30		
	Field Duplicate	All Target Compounds		30		
Semivolatiles and PAHs	Surogate	Phenol-d6	15 - 110			
		2-Fluorophenol	15 - 110			
		2,4,6-tribromophenol	15 - 110			
		nitrobenzene-d5	30 - 130			
		2-fluorophenyl	30 - 130			
		terphenyl-d14	30 - 130			
Volatile Petroleum Hydrocarbons (VPH)	Surrogate	All Surrogates	70 -130	70 -130		
	LCS	All Target Compounds	70 -130	70 -130		
	MS/MSD	All Target Compounds	70 -130	70 -130		
Inorganics	LCS	All Target Compounds	80 - 120		80 - 120	
	MS/MSD	All Target Compounds	75 -125	20	75 -125	35
	Lab Duplicate	All Target Compounds		20		35
	Field Duplicate	All Target Compounds		30		35
TPH and Oil and Grease	LCS	All Target Compounds	70 -130			
	MS/MSD	All Target Compounds	70 -130	50		
	Field Duplicate	All Target Compounds		30		
Wet Chemistry	LCS	All Target Compounds	80 - 120			
	MS/MSD	All Target Compounds	75 -125	20		
	Lab Duplicate	All Target Compounds		20		
	Field Duplicate	All Target Compounds		30		
<b>ON-SITE LABORATORY QC SAMPLES</b>						
Ferrous Iron (by HACH 8146)	Lab Duplicate	Fe <sup>2+</sup>		20		
	Field Duplicate	Fe <sup>2+</sup>		30		
	Accuracy Check	Fe <sup>2+</sup>	80 - 120			
pH (by sensION4)	Lab Duplicate	pH		20		
Ammonia (by HACH 8038)	Lab Duplicate	Nitrogen, Ammonia		20		
	Field Duplicate	Nitrogen, Ammonia		30		
	Accuracy Check	Nitrogen, Ammonia	80 - 120			

**Notes:**

LCS = Laboratory Control Sample  
 MS/MSD = Matrix Spike/ Matrix Spike Duplicate  
 QC = Quality Control

RPD = Relative Percent Difference  
 TPH = Total Petroleum Hydrocarbon

Prepared/Date: TLC 07/25/07  
 Checked/Date: CSR 07/26/07

**Table A-5**  
**Field Quality Control Sample Summary Table**  
**Sampling and Analysis Plan**  
**Final Interim Response Steps Work Plan**  
**Olin Chemical Superfund Site**  
**Wilmington, Massachusetts**

Medium/Matrix	Analytical Parameter	Conc. Level	Analytical Method	No. of Sampling Locations	Field Duplicate Pairs (1)	MS/MSD (2)		Trip Blanks	Equip. Blanks (3)	Total No. of Samples
						MS	MSD			
GW	VOCs	Low/Medium	SW-846 8260B	TBD	5% of field samples	5% of field samples	5% of field samples	1 per cooler shipment	5% of field samples	TBD
GW	SVOCs	Low/Medium	SW-846 8270C	TBD	5% of field samples	5% of field samples	5% of field samples	NA	5% of field samples	TBD
GW	PAHs	Low	SW-846 8270C – Low level PAH Method	TBD	5% of field samples	5% of field samples	5% of field samples	NA	5% of field samples	TBD
GW	VPH	Low	MADEP	TBD	5% of field samples	5% of field samples	5% of field samples	1 per cooler shipment	5% of field samples	TBD
GW	Oil and Grease / TPH	Low	1664	TBD	5% of field samples	5% of field samples	5% of field samples	NA	5% of field samples	TBD
SW/GW	Metals	Low/Medium	SW-846 6010B (ICP)	TBD	5% of field samples	5% of field samples	NA	NA	5% of field samples	TBD
SW/GW	Sulfate	Low	EPA 300	TBD	5% of field samples	5% of field samples	NA	NA	5% of field samples	TBD
SW/GW	Chloride	Low	EPA 300	TBD	5% of field samples	5% of field samples	NA	NA	5% of field samples	TBD
GW	Chlorine	Low	SM 4500-CL-F	TBD	5% of field samples	5% of field samples	NA	NA	5% of field samples	TBD
SW	Nitrate and Nitrite (as N)	Low	USEPA 300 or 353.2	TBD	5% of field samples	5% of field samples	NA	NA	5% of field samples	TBD
SW/GW	Ammonia	Low	EPA 350.1	TBD	5% of field samples	5% of field samples	NA	NA	5% of field samples	TBD
GW	pH	NA	EPA 150.1	TBD	5% of field samples	NA	NA	NA	5% of field samples	TBD
SW/GW	Specific Conductance	NA	EPA 120.1	TBD	5% of field samples	NA	NA	NA	5% of field samples	TBD
GW	Phenols	Low	EPA 420.2 - LACHAT 10-210-00-1A	TBD	5% of field samples	5% of field samples	5% of field samples	NA	5% of field samples	TBD
Sediment	Metals	Low/Medium	SW-846 6010 B	TBD	5% of field samples	5% of field samples	NA	NA	5% of field samples	TBD

**Notes:**

- 1 = Field duplicate samples will not be collected during Plant B influent/effluent sampling. One field duplicate annually for Plant B groundwater.
- 2 = MS/MSD will not be collected during Plant B influent/effluent sampling. One MS/MSD annually for Plant B groundwater.
- 3 = Equipment rinse blanks will not be collected in association with groundwater samples collected with dedicated equipment or surface water samples collected directly into sample containers.

GW = Groundwater  
MS = Matrix Spike  
MSD = Matrix Spike Duplicate  
N = Nitrogen  
NA = Not Applicable  
PAH = Polycyclic Aromatic Hydrocarbons

SVOC = Semi-Volatile Organic Compound  
SW = Surface Water  
TBD = To Be Determined  
TPH = Total Petroleum Hydrocarbons  
VOC = Volatile Organic Compound  
VPH = Volatile Petroleum Hydrocarbons

Prepared/Date: TLC 07/25/07  
Checked/Date: CSR 07/26/07

**ATTACHMENT A**  
**Standard Operating Procedures**

**MACTEC  
STANDARD OPERATING PROCEDURE**

**DECONTAMINATION OF FIELD EQUIPMENT**

## DECONTAMINATION OF FIELD EQUIPMENT

### 1.0 GENERAL APPLICABILITY

This Standard Operating Procedure describes the methods to be used for the decontamination of all field equipment which becomes potentially contaminated during a sample collection task. The equipment may include split-spoons, bailers, trowels, shovels, hand-augers, or any other type of equipment used during field activities.

Decontamination is performed as a quality assurance measure and a safety precaution. It prevents cross-contamination between samples and also helps to maintain a clean working environment for the safety of all field personnel.

Decontamination is mainly achieved by rinsing with liquids which may include: soap and/or detergent solutions, tap-water, deionized water, acid solutions, and methanol. Equipment will be allowed to air dry after being cleaned or may be wiped dry with clean cloths or paper towels if immediate re-use is needed.

The frequency of equipment use dictates that most decontamination be accomplished at each sampling site, between collection points. Waste products produced by the decontamination procedures, such as waste liquids, solids, rags, gloves, etc. must be collected and disposed of properly. All decontamination materials and wastes should be stored in a central location so as to maintain control over the quantity of materials used and/or produced throughout the study.

### 2.0 RESPONSIBILITIES

*It is the primary responsibility of the project geologist to assure that the proper decontamination procedures are followed and that all waste materials produced by decontamination are properly stored and disposed of.*

It is the responsibility of the project safety officer to draft and enforce safety measures which provide the best protection for all persons involved directly with sampling and/or decontamination.

It is the responsibility of any subcontractors (i.e., drilling contractors) to follow the proper designated decontamination procedures that are stated in their contracts and outlined in the Project Health and Safety Plan.

It is the responsibility of all personnel involved with sample collection or decontamination to maintain a clean working environment and to ensure that any contaminants are not negligently introduced to the environment.

### 3.0 EQUIPMENT DESCRIPTIONS

#### 3.1 Cleaning Liquids:

Tap (potable) water, deionized water, and other liquids/solutions as needed such as; Soap and/or detergent solutions, nitric acid solutions, methanol

3.2 Personal safety gear

(Defined in Project Health and Safety Plan)

3.3 Paper towels

3.4 Disposable gloves

3.5 Waste storage containers:

Drums, boxes, plastic bags

3.6 Cleaning containers:

Plastic buckets, galvanized steel pail

3.7 Cleaning Brushes

**4.0 PROCEDURES**

4.1 General

4.1.1

The extent of known contamination will determine to what extent the equipment needs to be decontaminated. If the extent of contamination cannot be readily determined, cleaning should be done according to the assumption that the equipment is highly contaminated until enough data is available to allow assessments of the actual level of contamination.

4.1.2

Adequate supplies of all materials must be kept on hand. This includes all rinsing liquids and other materials listed in Section 3.0.

4.1.3

The standard procedures listed in the following section can be considered the procedure for full field decontamination. If different or more elaborate procedures are required for a specific task, they will be spelled out in the project work plan. Such variations in decontamination may include following all, just part, or an expanded scope of the decontamination procedure stated herein.

4.2 Detailed

4.2.1

Remove any solid particles from the equipment or material by brushing and then rinsing with available tap-water. This initial step is performed to remove gross contamination.

4.2.2

Wash equipment with a soap or detergent solution and brush.

4.2.3

Rinse with tap-water.

4.2.4

Rinse with deionized water.

4.2.5

Repeat entire procedure or any parts of the procedure if necessary.

4.2.6

If sampling equipment is to be used immediately at another location, wrap the equipment in aluminum foil and store in a safe place.

4.3 Submersible Pump Decontamination Procedures

4.3.1

Applicability

This procedure will be used to decontaminate submersible pumps (if used) between groundwater sample collection points and at the end of each day of use.

4.3.2

Materials

4.3.2.1

Plastic-nalgene or PVC upright cylinder

4.3.2.2

5-10 gallon plastic water storage containers

4.3.2.3

Deionized water and dispenser bottle

4.3.2.4

Paper towels

4.3.3

Procedure

4.3.3.1

During decontamination the submersible pump will be placed on a clean surface (sheet of plastic) or held away from ground.

4.3.3.2

Clean the upright plastic-nalgene/PVC cylinder as described above in Section 4.2.

4.3.3.3

Decontaminate the outer surface of the submersible pump as using a potable water rinse followed by a deionized water rinse.

4.3.3.4

Place the submersible pump upright in the cylinder and fill the cylinder with potable water.

4.3.3.5

Activate the pump in the forward mode withdrawing water from the cylinder.

4.3.3.6

Continue pumping until the water in the cylinder is pumped down and air is drawn through the pump. At this time air pockets will be observed in the discharge line. Shut off the pump immediately.

4.3.3.7

Using the water remaining in the cylinder, rinse the sealed portion of the power cord and discharge tube by pouring the water carefully over the coiled lines.

4.3.3.8

Repeat steps 4.3.3.4 through 4.3.3.7 using deionized water.

4.3.3.9

When reaching the next monitoring well place the pump in the well casing and wipe dry both the power and discharge lines with a clean paper towel as the pump is lowered.

**5.0 REFERENCES**

Chapter 10, Decontamination, of the "Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities" developed by NIOSH/OSHA/USCG/EPA. October 1985.

U.S. Environmental Protection Agency. "Decontamination Techniques for Mobile Response Equipment Used at Waste Sites (State-of-the-Art Survey)." EPA/600/52-85/105. January 1986.

U.S. Environmental Protection Agency. "Guide for Decontaminating Buildings, Structures, and Equipment at Superfund Sites." EPA/600/2 85/028. March 1985.

U.S. Environmental Protection Agency. "Field Standard Operating Procedures #7 Decontamination of Response Personnel." January 1985.

U.S. Environmental Protection Agency. "Standard Operating Safety Guides." November 1984.

**MACTEC  
STANDARD OPERATING PROCEDURE**

**SAMPLE CHAIN OF CUSTODY PROCEDURE**

## **SAMPLE CHAIN OF CUSTODY PROCEDURE**

### **1) INTRODUCTION**

This SOP describes chain of custody procedures to be followed whenever collecting environmental samples. This SOP is referenced in all SOPs for environmental sample collection.

### **2) CROSS-REFERENCES**

ASTM D4840-95: Guide for Sampling Chain-of-Custody Procedures  
U.S. EPA Region 4 "Environmental Investigations Standard Operating Procedures and Quality Assurance Manual," May 1996 Including 1997 Revisions  
Site-specific Health and Safety Plan

### **3) MATERIALS**

- a) DOCUMENTATION
  - i) Surface water FDR, Groundwater FDR, Work Plan
  - ii) Chain-of-custody forms
  - iii) Sample labels
  - iv) Field book (and data recording sheets, if used)
  - v) Permanent marker
  - vi) Lab contact information
  - vii) Avery labels # 5260
  
- b) CHAIN-OF-CUSTODY FORM

### **4) PREPARATION**

Review Work Plan to identify samples to be collected, analyses to be performed, laboratory performing the analyses, etc.

### **5) SAMPLE LABELING**

Enter in the log book and label each sample container with the following information:

- a) Olin project number
- b) Date and time of collection
- c) Sample location
- d) Sample number
- e) Analysis to be performed
- f) Sampler's initials
- g) Preservative

If using field sample tracking system labels will be generated and printed by the field sample coordinator.

### **6) CHAIN OF CUSTODY**

- a) DEFINITION

EPA provides the following definition of chain-of-custody:

"A sample is considered to be in your custody if any of the following criteria are met:

- The sample is in your possession or is in your view after being in your possession;
- The sample was in your possession and then locked up or sealed to prevent tampering; or
- You have placed the sample in a secured area."

b) PURPOSE

"The chain-of-custody form is functionally similar to a packing slip that accompanies a shipment of goods. The chain-of-custody form includes a chain-of-custody record located at the bottom of the form. The form is used as physical evidence of sample custody. EPA guidelines specify that official custody of samples must be maintained and documented from the time of collection until the time the samples are introduced as evidence in the event of litigation. The sampler is responsible for the care and custody of the sample until sample shipment."

c) DOCUMENTATION

- i) After samples are collected and labeled, fill out the chain-of-custody form. An example of the COC form to be used presented in Attachment A of this SOP. The sampler becomes the initial sample custodian.
- ii) Chain-of-custody forms must be completed for every shipment of samples to an analytical laboratory.
- iii) Use indelible ink only, no pencil (a ball point pen is best). Make corrections by drawing a line through and initialing and dating the error, then enter the correct information. Erasures are not allowed.
- iv) A separate chain-of-custody form must accompany each cooler for each shipment. Place the original COC form in a zipper-type plastic bag in the cooler with the samples. The chain-of-custody forms must address all samples in that sample shipment. If multiple coolers are shipped a copy of the COC should accompany each cooler. This practice maintains the chain-of-custody for all samples in case of mis-shipment.

d) TRANSFER OF CUSTODY

- i) When transferring the possession of samples, the individuals relinquishing and receiving custody will sign, date, and note the time on the record. Persons receiving the custody of a sample group are responsible for confirming the accuracy of the COC with regard to the number and type of sample containers for which they are accepting responsibility.
- ii) When samples are to be shipped to an analytical facility by commercial delivery service, the samples will be relinquished to the courier in sealed containers, and, if practicable, the shipment number will be noted on the COC form. When samples are transferred by commercial delivery service, a copy of the shipping documentation will serve as the COC record for the delivery service's role in the chain of custody.
- iii) The sample custodian relinquishing custody to a facility or agency will request the signature of a representative of the appropriate party acknowledging receipt of the samples. If a representative is unavailable or refuses to sign, this will be noted in the "Received by" space on the COC. When appropriate, the custody record will contain a statement that the samples were delivered to the designated location at the designated time.

7) DECONTAMINATION N/A

**Attachment A**  
**Example of Olin Chain of Custody**



**MACTEC  
STANDARD OPERATING PROCEDURE  
SAMPLE PACKAGING AND SHIPMENT**

## **SAMPLE PACKAGING AND SHIPMENT**

### **1.0 Scope and Application**

This Standard Operating Procedure (SOP) establishes methodologies for shipping samples collected during environmental field investigation/remediation activities. This SOP applies to all environmental samples including drinking water, most groundwater and surface water samples, soil and sediment samples, treated industrial wastewater samples, biological specimens, or any samples not expected to be contaminated with hazardous levels of contaminants. Samples collected from process wastewater streams, drums, bulk storage tanks, or soil, sediment, or water samples collected from areas suspected of being highly-contaminated *may* require shipment as dangerous goods.

### **2.0 Definitions**

Shipper's Declaration – A paper document describing the contents of a shipment.

### **3.0 Health and Safety Warnings**

Shippers of dangerous goods should take all precautions to eliminate any hazards associated with the goods being shipped. The shipper should consult the most-recent version of the International Air Transportation Association (IATA) regulations regarding shipment of dangerous goods.

### **4.0 Personnel Qualifications**

Any person designated as a shipper of dangerous goods shall be trained in the U.S. Department of Transportation Hazardous Materials Regulations, which must be renewed every two years.

Shipment of environmental samples does not require specialized training; however, a familiarity with the regulations and the materials being shipped is considered beneficial.

### **5.0 Equipment and Supplies**

Consult the most-recent version of the IATA regulations for a listing of proper shipping materials.

- Cooler
- Samples
- Labels
- Ink pen
- Packing materials (bubble wrap, Styrofoam, vermiculite, or similar) to prevent breakage, absorb leakage, and insulate samples.
- Polyethylene zip-type baggies large enough to contain the largest sample bottles
- Custody seals

- Large plastic trash bag to act as containment for the packing materials.

## **6.0 Procedures**

- 1) Be certain that all containers are sufficiently tight, preserved, and labeled correctly. Sediment samples should be allowed to settle for a minimum of 2 hrs prior to shipping to the laboratory. The sample manger should look closely at all sediment samples to see if a clear water layer forms above the sediment. Any water layer should be decanted from the sample jar prior to shipping to the laboratory.
- 2) Clean the exterior of each sample container such that no gross contamination remains.
- 3) Wrap sample containers in bubble wrap. Zip-type plastic baggies may be used as additional containment.
- 4) Line the cooler with the trash bag and add a layer of packing material. If the cooler has a drain, close and seal to prevent leakage of water from melting ice.
- 5) Place sample containers into the cooler, and pack them sufficiently to prevent them from shifting during shipment.
- 6) Place ice-filled zip-type bags on samples such that all samples are contacted by the ice. Place sufficient ice to retain the sample temperature between 2 and 6 degrees C. Place a temperature blank in with the samples.
- 7) Fill the remaining space in the cooler with packing material and close and secure the top of the trash bag.
- 8) On the chain of custody, sign in the relinquished by box and add in the subsequent received by box the name of the courier/carrier and the airbill No. (if applicable).
- 9) Place the COC into a plastic bag and tape it to the inside top of the cooler.
- 10) Close the cooler and tape the cooler shut with strapping tape or similar high-strength shipping tape.
- 11) If more than one cooler is being shipped under the same COC, copies of the COC should be placed into each additional cooler in the same manner as the original COC.
- 12) Apply custody seals to the cooler such that the seals must be broken in order to open the cooler.
- 13) Apply "UP Arrows" in the appropriate direction on at least opposing sides of the cooler exterior, or indicate on top "this side up".
- 14) Add the appropriate shipping address labels to the cooler along with a return address to the cooler. If more than one cooler is being shipped, add "one of \_\_\_\_" to the label so that the recipient is aware that more than one cooler should be received.

## **7.0 Data and Records Management**

A copy of the COC shall be retained by the shipper until the completed laboratory data package is received. In addition, a copy of the airbill shall also be retained for validation/custody purposes and also for payment.

## **8.0 References**

MACTEC Engineering and Consulting, Inc. Standard Operating Procedure for  
Chain of Custody  
Code of Federal Regulations 40 CFR Part 261.4(d) Samples.  
Dangerous Goods Regulations, IATA, Most-Current Version.

**MACTEC  
STANDARD OPERATING PROCEDURE  
SURFACE WATER AND SEDIMENT SAMPLING**

## **SURFACE WATER AND SEDIMENT SAMPLING**

### **1.0 PURPOSE:**

To establish clear, uniform procedures for surface water and sediment sampling that will ensure consistency and quality of samples.

### **2.0 SCOPE:**

This procedure applies to all surface water and sediment sampling activities for laboratory analysis, in compliance with MACTEC Engineering and Consulting, Inc. Quality Assurance Project Plan (QAPP) and U.S. Environmental Protection Agency (USEPA) Region IV Standard Operating Procedures Quality Assurance Manual. This procedure is a guideline that must be flexible to accommodate site-specific situations without sacrificing data quality objectives.

### **3.0 REQUIREMENTS:**

A working knowledge of the sampling equipment to be used is a basic requirement for understanding surface water and sediment sampling procedures.

Familiarity with the environmental regulations of the USEPA and the state in which work is taking place is also required.

Familiarity with the site-specific work plan and health and safety plan (HASP) is required prior to conducting surface water and sediment sampling procedures.

### **4.0 EQUIPMENT:**

Equipment requirements and specifications for surface water and sediment sampling are as follows.

For Surface Water:

Any equipment used to collect surface water samples is acceptable as long as it does not violate the integrity of the sample and it provides a representative surface water sample. Actual site-specific conditions and the physical sample location will determine the appropriate equipment required for sample collection. The following list includes several types of equipment typically used for the collection of surface water samples:

- waders (chest-high or waist-high);
- a small boat, raft, or canoe;
- glass beakers or sample bottles;
- glass or stainless-steel (SS) bucket;
- temperature, specific conductivity, and pH meter;

- personal protective equipment (PPE) as specified in the site-specific HASP;
- appropriate sample containers (from a certified lab) w/ labels and a preservation kit with the appropriate preservatives;
- hard cover field log book, indelible pen, coolers, ice in sealable plastic bags, wide transparent tape, reinforced strapping tape, and chain-of-custody (COC) forms and seals;
- dissolved oxygen (DO) meter;
- filtration kits;

**For Sediment:**

Any equipment used to collect sediment samples is acceptable as long as it does not violate the integrity of the sample and it provides a representative sediment sample.

Actual site-specific conditions and the physical sample location will determine the appropriate equipment required for sample collection. The following list includes several types of equipment typically used for the collection of sediment samples appropriate for the Olin Site:

- SS Shelby or similar push tubes;
- SS spoons, scoops, or trowels;
- SS or S hand augers with extensions;
- glass/pyrex mixing bowls;
- PPE as specified in the site-specific HASP;
- appropriate sample containers (from a certified lab) with labels; and a preservation kit with the appropriate preservatives; and
- hard cover field log book, indelible pen, coolers, ice in sealable plastic bags, wide transparent tape, reinforced strapping tape, and chain of custody papers and seals.

**PROCEDURE FOR SURFACE WATER AND SEDIMENT SAMPLING:**

**6.0 BASIC REQUIREMENTS**

Surface water and sediment samples are occasionally taken at the same time to help define the partitioning of contamination between water and sediment. If both water and sediment are to be collected at a given sample point, the water sample should be collected first. Sample locations are often determined in the field at the time of sampling and should be noted in the field log book.

All sampling equipment must be decontaminated prior to sample collection. During prolonged field events, a designated decontamination area should be set up on site to facilitate repetitive decontamination as required.

During sediment sampling the field sampler will take time to allow all surface water to run off the sampling device and sample prior to preparing laboratory samples. This will be done to reduce the water content of the sediment sample prior to homogenization and preparation of samples.

## 7.0 SURFACE WATER SAMPLING

The physical location of the sample and site conditions will dictate the type of sampling equipment selected. Several common sampling methods and the corresponding equipment to be used are presented as follows. The appropriate method will be specified in the site-specific sampling and analysis plan (SAP).

### Direct Dipping Method

Because of simplicity, when sampling surface water, direct dipping of the sample container into the surface water body is desirable. Steps to follow in using the direct dipping method include:

1. Acquire a small boat or waders. If wading is required always approach the sample location from downstream. Wading may cause bottom deposits to rise and bias the sample and is acceptable only if a current is noticeable.
2. Arrange sample containers in the preferred order of sampling (see Attachment I).
3. Using a small beaker or the sample port of the pH/specific conductivity meter, collect a small water sample and record the temperature, pH, and specific conductivity readings in the field log book.
4. Dip containers such that the top or opening is pointed upstream allowing the sample to be collected directly into the container.
5. Take special care to avoid completely submersing pre-preserved sample containers so that these chemical are not lost and released into the water.
6. Repeat as necessary filling all required sample containers.
7. Preserve sample containers as necessary.
8. As the sample containers are filled place them in a cooler supplied with ice for packing and shipment.
9. Secure all containers in coolers with adequate bubble wrap and ice so as to maintain a temperature of 4°C during shipment.
10. Complete all required COC and analysis request forms and release samples for shipment.

## 8.0 SEDIMENT SAMPLING

The physical location of the sample may dictate the type of equipment used. The following outlines several sampling methods and the corresponding equipment to be used. A project specific method may be specified in the site-specific SAP. During sediment sampling the field sampler will take time to allow all surface water to run off the sampling device and sample prior to preparing laboratory samples. This will be done to reduce the water content of the sediment sample prior to homogenization and preparation of samples.

When collecting sediment samples using any of the following sample collection techniques the following steps need to be taken to reduce the moisture content of the samples.

Remove the sampling device and sediment sample from the water and allow water to run off the sample. Transfer the sediment to the mixing bowl trying to avoid adding any surface water to the sample.

If sediment samples are scheduled for VOC analysis, this parameter will be collected first. For off-site VOC soils, both low concentration samples and methanol preserved samples will be collected as described in Method 5035. Low concentration samples will be collected (with 5 grams of sample) in vials containing stirrer bars and sodium bisulfate. High concentration samples are collected (with 10 grams of sample) in vials preserved with methanol. Off-site VOC samples will consist of two vials for low concentration analysis and one vial (methanol preserved) for high concentration analysis. The soil sample will be transferred to the vial using a plastic syringe designed to reduce the exposure of the soil sample to air. The syringe will be advanced directly into the sediment in the stainless steel bowl. An additional soil jar will be collected for percent solids determination to be used only for the VOC sample. The jar should be labeled "VOC percent solid" with the same sample information as the original sample. If a field duplicate sample is scheduled at the location, the sampler will first remove the VOC sample segments for both the field sample and duplicate sample using the procedure described above.

After the VOC sample has been collected (if required by work plan), the soil within the stainless steel bowl will be homogenized (mixed) with a stainless steel spoon so that each sample aliquot is representative of the whole. Care should be taken to ensure that sufficient soil is present in the stainless steel bowl to fill all of the associated sample fractions (containers) and duplicate fractions, if necessary. The sampler will collect the remaining sample fractions (e.g., SVOCs, pesticide/PCBs, and inorganics) using a stainless steel spoon to transfer the soil into the sample containers.

#### Direct Push Core or Augers

Shelby tubes and most other push tubes commonly use Teflon™, Lucite™, or polyethylene liners in various lengths (1 to 3 feet) and diameters (2 to 4 inches). They can be used together or as a stand alone sampling device. Other sampling equipment includes hand driven split spoon samplers and soil augers with an extension handle.

1. Acquire a small boat or waders. If wading is required always approach the sample location from downstream. Wading may cause bottom deposits to rise and bias the sample and is acceptable only if a current is noticeable, or if boat access is not possible.
2. Arrange sample containers in the preferred order of sampling (see Attachment I).
3. Place corer tube assembly, or split spoon sampler, or auger head in proper location and drive or auger to desired depth in the sediment using steady hand pressure.
4. Work the tube or device to loosen the sample by twisting, if possible, to shear off the sediment at the base.
5. Carefully pull the tube or device upward and immediately cap the bottom or contain the bottom to prevent loss of sample. If using a sampling tube, or a tube and liner, a Teflon-lined cap should be used to seal the bottom.
6. If using a Shelby or direct push tube, wipe off the tube walls and rinse with mild Liquinox detergent or similar to remove excess sediment sticking on the tube. If using a split spoon samplers or auger device, transfer sample to a clean SS bowl, obtain samples for VOC

analysis (if required) as previously described, homogenize and then transfer remaining sample aliquots to appropriate sample containers as required.

7. Drain off any excess standing water in the sample tube or sample bottles.
8. Cap the top of the tube with a Teflon-lined cap and tape both ends of the tube as necessary.
9. Label the tube or sample bottles with the proper sample ID, site, length of sample, date, and time.
10. Place the tube or sample bottles in a cooler supplied with ice for packing and shipping.
11. Repeat Steps 3 through 10 for all required analyses.
12. Secure all containers in coolers with adequate bubble wrap and ice so as to maintain a temperature of 4°C during shipment.
13. Complete all required COC and analysis request forms and release samples for shipment.

REFERENCES: ABB Environmental Services, Inc., 1993, Comprehensive Quality Assurance Plan.

U.S. Environmental Protection Agency, Region IV, 1991, Standard Operating Procedures and Quality Assurance Manual.

State of Florida Department of Environmental Regulation, 1990, Guidelines for Preparing Quality Assurance Plans.

ATTACHMENTS:

Attachment I Preferred Order of Sampling

GLOSSARY:

QAPP: The Quality Assurance Project Plan is a guidance document which provides MACTEC Employees) approved procedures and techniques for field activities to be completed at the site.

COC: Chain of Custody.

DO: dissolved oxygen.

HASP: Health and Safety Plan. A site-specific HASP is prepared for each MACTEC site. All personnel onsite are required to be familiar with this document.

PPE: personal protection equipment.

SAP: A Sampling and Analysis Plan is generally prepared along with the workplan. The SAP specifies equipment to be used and summarizes the type, frequency, and location of sampling to be accomplished in accordance with the workplan. It is mandatory that all field personnel be familiar with this document.

SS: stainless steel.

SVOC: semi volatile organic compound

USEPA: United States Environmental Protection Agency.

VOC: volatile organic compound.

Workplan: A workplan is prepared for all MACTEC sites. The work plan summarizes the investigations which will be accomplished and provides guidelines for all aspects of an environmental assessment. It is mandatory that all field personnel be familiar with this document.

**ATTACHMENT i**  
**PREFERRED ORDER OF SAMPLING**

### **PREFERRED ORDER OF SAMPLING**

1. Volatile organic compounds (VOC)
2. POX
3. Total organic halides (TOX)
4. Total organic carbon (TOC)
5. Extractable organics (including TRPH, O&G)
6. Total metals
7. Dissolved metals
8. Microbiological
9. Phenols
10. Cyanide
11. Inorganic
12. Turbidity
13. Radionuclides

**MACTEC  
STANDARD OPERATING PROCEDURE  
PROCEDURES FOR MEASURING GROUNDWATER LEVELS**

## STANDARD OPERATING PROCEDURE

### PROCEDURES FOR MEASURING GROUNDWATER LEVEL

#### 1) INTRODUCTION

Procedure to measure groundwater levels in monitoring wells or piezometers. In general, water levels will be measured prior to purging wells and collecting groundwater samples. Water level data acquired may be used to assess hydraulic gradients, perform drawdown tests, etc.

#### 2) CROSS-REFERENCES

ASTM D4750-87(93): Test Method For Determining Subsurface Liquid Levels In A Borehole Or Monitoring Well (Observation Well)  
Site-specific Health and Safety Plan

#### 3) MATERIALS

##### a) MEASUREMENT

- i) Electronic water level meter (e.g. Solinst™)
- ii) Well keys and wrenches (include an extension for keys and wrenches to apply extra leverage), screwdriver, hammer
- iii) Photoionization detector (PID), or other monitoring equipment (as required by Health and Safety Plan)
- iv) Metal detector (project-specific)

##### b) DOCUMENTATION

- i) Well installation logs, boring logs
- ii) Field book (and data recording sheets, if used)
- iii) Permanent marker

##### c) DECONTAMINATION

Tap or spring water, Alconox™ (or equivalent), distilled/deionized water, brush, paper towels

##### d) HEALTH AND SAFETY EQUIPMENT PER WORK PLAN

#### 4) PREPARATION

Inspect the meter's probe to ensure that it is clean and has been decontaminated after previous uses. Test the probe to verify that it is functioning.

#### 5) PROCEDURES

##### a) WELL CONDITION

Check the condition of the standpipe or roadbox and protective seal, if any. Observe and record any abnormalities with the well such as a missing cap, run-on, evidence of tampering, missing/rusted/open lock, damaged roadbox or standpipe, etc. Record observations in the log book or, if used, a sampling form.

b) HEALTH AND SAFETY MONITORING

Depending upon the requirements of the site-specific Health and Safety Plan, screen the wellhead during removal of the cap with a PID or other monitoring equipment (as required by the Health and Safety Plan). Follow requirements for use of personal protective equipment.

c) GROUNDWATER ELEVATION REFERENCE POINT

- i) Record the type of measurement reference point used (i.e., roadbox, standpipe, mark on PVC).
- ii) If not already done, mark the measurement reference point either by etching or with indelible ink at the top of the PVC riser pipe or steel casing. The measurement reference point will generally be the highest point of the PVC riser or casing. Mark well number on the outside of well if not otherwise permanently marked.

d) LNAPL (Project-specific/not anticipated at this site)

- i) Check for the presence and measure the thickness of light or dense non-aqueous phase liquid using a transparent bailer, product-water interface probe, or water-sensitive paste (LNAPL). If LNAPL is observed, do not immerse the electronic water level meter unless specifically required by the Work Plan. Measure and record thickness of NAPL.
- ii) To use a bailer to measure NAPL, lower it slowly into the water column using a polypropylene or nylon line. For LNAPL, hold the bailer so that the bottom check valve and approximately half the bailer's length are submerged; for DNAPL, lower the bailer to the bottom of the well. Hold the bailer at the appropriate level for about 10 to 30 seconds to allow NAPL to enter the bailer.
- iii) If the well is known to contain LNAPL, an interface probe should be used to give a more accurate measurement of the product thickness. Lower the probe down the well, similarly to the water level meter. The probe sounds differently when it has detected LNAPL and when it has detected water. The difference between the two tones indicates the product thickness.

e) WELL DEPTH

Sound well depth and record to the nearest 0.01 feet. Compare to installed depth of well.

f) WATER LEVEL MEASUREMENT

- i) Slowly lower the water level meter's probe into the well until the auditory signal indicates that water is reached.
- ii) Raise the probe above water level and slowly lower it again until the exact position of the water is indicated on the tape gauge.
- iii) Hold the cable or tape against the side of the PVC riser or steel casing at the reference point designated for water level measurements and record the measured depth to the nearest 0.01 feet.
- iv) If no additional work is to be performed, lock or secure the wellhead.

6) DECONTAMINATION

- Inspect meter and tape for the presence of free product. If present, decontaminate accordingly.
- If contaminants are suspected, perform a gross decon by wiping the tape with a paper towel as it is retrieved from the well.
- Rinse with tap or bottled water.
- *Rinse with distilled/deionized water.*
- Containerize and handle decontamination wastes and wastewater in accordance with applicable Federal, State, and local regulation, and as specified in the sampling plan.

**MACTEC  
STANDARD OPERATING PROCEDURE  
LOW-FLOW/LOW-STRESS GROUNDWATER SAMPLING**

## LOW-FLOW/LOW-STRESS GROUNDWATER SAMPLING

### 1.0 Scope and Application

This Standard Operating Procedure (SOP) establishes methodologies for low-flow/low-stress groundwater sampling and calibration of the field instruments utilized. This procedure includes the minimum required steps and quality checks that employees and subcontractors are to follow when sampling groundwater using this technique. This SOP addresses technical requirements and required documentation to be completed during low-flow groundwater sampling and equipment calibration.

MACTEC Engineering and Consulting, Inc. follows the EPA Region I Low Stress (low flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells, Revision 2, June 30, 1996.

### 2.0 Summary of Method

This method of groundwater sample collection involves minimal disturbance of the groundwater aquifer to obtain a "representative" sample of groundwater. The method requires pumping of groundwater at a slow rate to minimally influence the water level, all the while monitoring groundwater quality parameters including dissolved oxygen, redox potential, conductivity/specific conductance, temperature, pH, and turbidity. These parameters will dictate the point at which the aquifer water entering the well is considered representative of the ambient groundwater surrounding the well.

### 3.0 Definitions

Not applicable

### 4.0 Health and Safety Warnings

Collecting groundwater samples using this method is not particularly hazardous physically. Care should be taken to minimize slip/trip/fall hazards due to the presence of a large amount of equipment in a fairly small area. Additionally, sample preservatives commonly include strong acids and bases. Care should be taken to prevent human contact with the acids and bases, and in addition, particular care should be taken to store each separate from the other. For chemical hazards, the monitoring well to be sampled should have a headspace reading collected from it immediately upon opening the well riser. Refer to the site safety plan for details regarding action levels and response actions.

### 5.0 Cautions

See section 4.0.

### 6.0 Interferences

Minimizing turbidity in the sample is the core reason for utilizing this method of sampling. If turbidity is encountered in excessive amounts, the analytical results can be skewed to the higher end, and not provide a "representative" groundwater sample.

### 7.0 Personnel Qualifications

The sample collection personnel should be familiar with the sample collection method as well as being familiar with the particular pumps to be used. Familiarity with the pumping system will allow the field personnel to troubleshoot a problem more efficiently.

## 8.0 Equipment and Supplies

- Pump (bladder pumps and centrifugal pumps are preferred) constructed of stainless-steel. Peristaltic pumps may be utilized with caution.
- Tubing, (Teflon or Teflon lined is preferred); however polyethylene tubing and silicone tubing may also be used.
- Water level meter
- 0.45µm cellulose-based membrane filter for dissolved sample fraction collection
- Power source (generator, compressed gas)
- Flow-through cell with multi-probes
- Decontamination supplies
- Logbooks
- Sample bottles
- Labels
- Preservatives
- Well keys
- PID/FID

## 9.0 Procedures

### 9.1 Equipment Calibration

- Equipment including the flow-through cell and water quality probes, turbidity meter, and pump flow (as necessary) will be calibrated as per the manufacturer's specifications. Manufacturer's literature for each piece of equipment will be included in planning documents and will be made available to the field staff.

### 9.2 Sample Collection

- Record condition of the well at the surface
- Remove the well cap and immediately record monitoring well headspace using a calibrated PID/FID.
- Measure and record the initial depth to water
- Install the pump in such a manner so as not to disturb the well. The intake should be set at the midpoint of the interval to be sampled.
- Connect all tubing such that the flow-through cell is connected in-line with the sample system.
- Start the purge of the well using the lowest setting on the pump, and gradually increase the speed until discharge occurs. Recheck the water level to verify that not more than 0.3 feet of head change is noted. Attaining this criterion is not always possible particularly in tight formations. If excessive drawdown occurs, record water level measurements and compare discharge and drawdown to well storage to determine inflow volume of water through well screen
- Continue purging until monitoring parameters stabilize. Readings should be taken at least every five minutes. Stabilization is considered to be achieved after three consecutive readings are within the following limits:

Turbidity - +/- 10% for values greater than 1 NTU; if turbidity is greater than 5 and well is not stable, continue purging well for up to two hours, collect sample and document on field data record and in log book (collection of a filtered sample for metals analysis is necessary if turbidity is greater than 5 NTU).

Dissolved Oxygen - +/- 10%

Specific Conductance - +/- 3%

Temperature - +/- 3%

PH - +/- 0.1 standard units

ORP - +/- 10 mV

- After the monitoring parameters have stabilized according to the above criteria, the sample may be collected by removing the in-flow tubing from the flow-through cell and inserting it into the sample container. Do not turn the pump off at any point during the purging or sample collection procedures. Otherwise, reinitializing the system may require additional stabilization time.
- If turbidity value of final parameter measurement is greater than 5 NTU, an additional filtered fraction will be collected for metals analysis using a 0.45µm cellulose-based membrane filter.
- After the sample has been collected, remove the pump from the well and disconnect all tubing and other connections.
- The tubing may be dedicated to the well or disposed of.
- The pump (excluding peristaltic pumps) must be decontaminated prior to use in a subsequent well. New bladders in bladder pumps must be installed (after the unit has been decontaminated). The decontamination procedure is as follows:
  - Flush the unit with portable water
  - Flush the unit with a non-phosphate detergent solution
  - Flush the unit with distilled/deionized water
  - Flush the unit with methanol. This step may be skipped if previous blank samples show no or insignificant levels of organic contamination
  - Flush the unite with distilled/deionized water

#### **10.0 Data and Records Management**

Field data should be recorded on the data sheet (See Appendix C of the Field Sampling Plan), or on a similar replacement. These reports along with any analytical data will be provided in some form or investigation or completion report.

#### **11.0 Quality Control/Quality Assurance**

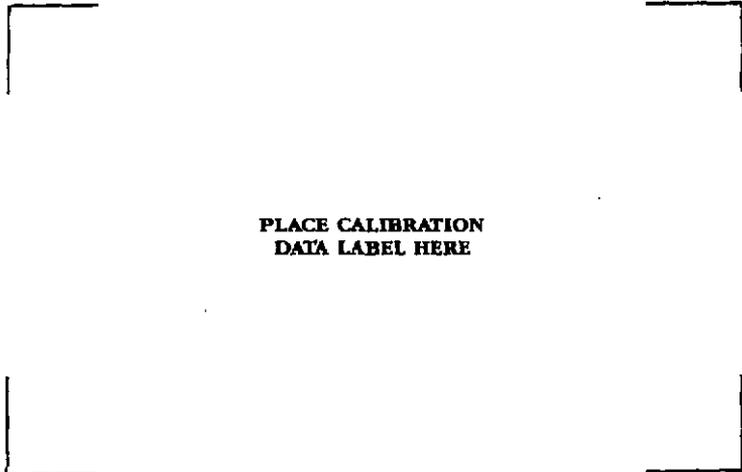
Quality control for this groundwater sampling method involves the collection of field quality control samples including field duplicated, matrix spike/matrix spike duplicate samples, trip blank samples, equipment blank samples, and temperature blank samples.

#### **12.0 References**

EPA Region I Low Stress (low flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells, Revision 2, June 30, 1996.

**Attachment B**  
**Field Laboratory Methods**

# DR/2000 SPECTROPHOTOMETER INSTRUMENT MANUAL



PLACE CALIBRATION  
DATA LABEL HERE

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## **SAFETY PRECAUTIONS**

Before attempting to unpack, set up or operate this instrument, please read this entire manual. Pay particular attention to all warnings, cautions and notes. Failure to do so could result in serious injury to the operator or damage to the equipment.

### **Use of Warnings, Cautions and Notes**

Warnings, cautions and notes used in this manual have the following significance:

#### **WARNING**

Failure to observe this information can result in personal injury or loss of life.

#### **CAUTION**

Failure to observe this information can result in damage to equipment.

## **NOTE**

Information that requires special emphasis.

### **Precautionary Labels**

Please pay particular attention to labels and tags attached to the instrument. Personal injury or damage to the instrument could occur if not observed.

## **CERTIFICATION**

Hach Company certifies this instrument was tested thoroughly, inspected and found to meet its published specifications when it was shipped from the factory.

---

## **INSTRUMENT SPECIFICATIONS**

(Specifications subject to change without notice)

**Wavelength Range** 400–900 nm

**Bandwidth** 12 ± 2 nm @ 600 nm

**Wavelength Accuracy** ±2 nm from 400-700 nm;  
±3 nm from 700-900 nm

**Wavelength Resolution** 1 nm

**Monochromator Design** Littrow Prism, Aspheric Optics

**Wavelength Selection** Manual

**Wavelength Readout** 3-digit LCD, 0.5-cm Character Height

**Photometric Linearity** ±0.002 A (0-1 A, 500 nm—constant on mode)

**Photometric Reproducibility** ±0.005 A (0-1 A—constant on mode)

**Source Lamp** Gas-filled Tungsten

**Detector** Silicon Photodiode, UV enhanced

**Data Readout** 4-digit LCD, 1.5-cm Character Height

**Message Display** 16 character LCD dot-matrix, 0.6-cm Character Height

**Operation Modes** Momentary, Constant-On

**Readout Modes** Transmittance, Absorbance, Concentration

**Decimal Location** Hach Program—Automatic, User Program—Selected

**Readout Languages** Selectable by menu: English, French, Italian, Spanish, Portuguese, German, Dutch, Norwegian, Swedish, Danish, Finnish, Turkish, Greek, Japanese

**External Outputs** RS-232 Serial, (printer optional)  
0-1 V Analog

**Line Power** Selectable 110/220 V 50/60 Hz

**Battery Power (optional)** Rechargeable 8 V sealed or 6-battery "D" Cell Pack

**Dimensions** 22 x 24 x 11 cm (8.75 x 9.5 x 4.375 in)

**Weight** 2 kg (4.4 lb)

**Dynamic Range** 0-2 A (100:1)

**Stray Light** < 1.00% at 400 nm

**Bulb Life** 2,000 hours, >1,000,000 measurement cycles

**Battery Life** 1000 measurement cycles (rechargeable). Charger included.

**Battery Weight (optional rechargeable)** 1.7 kg (3.75 lb) (rechargeable)

**Temperature Range** 0-40°C operating range

# SECTION 1 GENERAL DESCRIPTION

## 1.1 Instrument Description

The Hach Model DR/2000 Spectrophotometer shown in Figure 1 is a microprocessor-controlled, single-beam instrument suitable for the laboratory or the field. The current instrument is precalibrated for over 120 different colorimetric measurements and has RAM capacity sufficient for up to 50 more operator-generated calibrations. Additional memory for future Hach updates has been incorporated.

Test results can be displayed in percent transmittance, absorbance or concentration of the appropriate units of measure. The LCD dot-matrix digital display offers automatic ranging in the pre-programmed parameters, operator-selected languages (a choice of 14), full prompting during testing and error messages for procedural or instrument troubleshooting. A built-in timer helps the operator observe specific reaction times called for in the test procedures. RS-232 interface capability allows an external printer to be driven by the spectrophotometer, and a 0 to 1-volt analog output is provided for a recorder.

The spectrophotometer can operate on battery power or ac line power using the battery eliminator/charger unit supplied with the accessories. The battery holder supplied holds six D-size dry cells that will power the instrument for

approximately 100 tests. An optional rechargeable battery is available, and it can be recharged with the battery eliminator/charger supplied with the instrument. The eliminator/charger can not be used to charge rechargeable D-size batteries, however.

## 1.2 Accessories

Accessories supplied with the DR/2000 Spectrophotometer include:

- Matched Sample Cells (2)
- Battery Eliminator/Charger
- Battery Holder (for 6 D-size batteries)
- AccuVac Vial Adapter
- AccuVac Zeroing Vial
- Spare Lamp
- Manual Set
- COD Vial Adapter
- 13-mm Test Tube Adapter

In addition to these accessories, several optional accessories are available from Hach Company. Refer to Section 6.



Figure 1

DR/2000 Spectrophotometer With Accessories

## SECTION 2 PREPARATION FOR USE

### 2.1 Unpacking

Remove the instrument and accessories from the shipping container and inspect each item for any damage that may have occurred because of rough handling or extreme weather conditions during shipment. Verify that the items listed in paragraph 1.2 are included. If any items are missing or damaged, please contact Hach Customer Service, Loveland, Colorado for instructions. The toll-free number is 800-227-4224.

### 2.2 Supplying Operating Power

#### 2.2.1 Battery Eliminator/Charger

If line power is to be used, connect the battery eliminator/charger cable plug to the POWER jack on the back of the instrument. When the battery eliminator/charger is connected and operating, the instrument will operate on line power only and the battery can not power the instrument. If the optional rechargeable battery is installed, the instrument can be operated and the battery charged in this configuration. To operate on D-cell battery power, the eliminator/charger must be disconnected from the instrument. If the eliminator/charger is connected to the instrument but not plugged into a line power receptacle, the instrument will not operate.

#### CAUTION

The battery eliminator/charger unit is switchable for 115V or 230 V operation. Be sure the voltage selector switch on the underside of the battery eliminator/charger is set to the appropriate position before plugging in the unit. Improper setting can result in serious damage to the instrument and the eliminator/charger when power is applied.

#### 2.2.2 Battery Installation

The battery compartment is accessible from the underside of the instrument. Lay the instrument upside down on a padded surface and install batteries as follows:

1. Remove the compartment cover as shown in Figure 2.
2. *D-Cells*—Install six D-cells in the battery holder as shown in the battery holder detail in Figure 2. Polarity marks on the holder also show how the cells should be installed for the proper configuration. Place the holder into the battery compartment.

#### WARNING

Use care when installing the D-cells in the battery holder to be sure that the proper

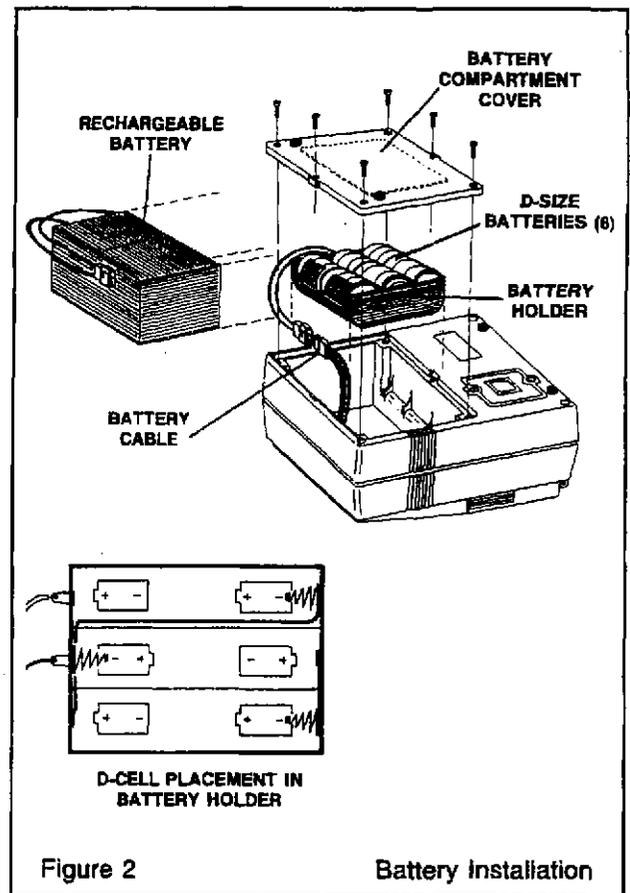


Figure 2

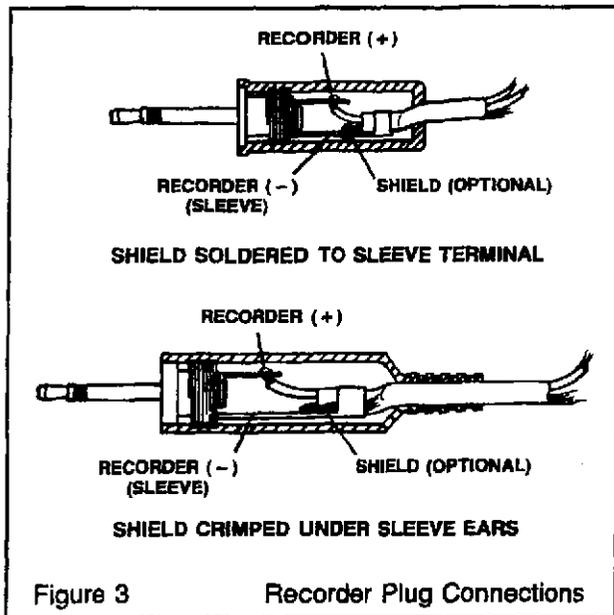
Battery Installation

polarities are observed. Improper installation could cause damage to the instrument or injury to the operator.

3. Connect the battery cable from the instrument to the battery holder cable connector or the rechargeable battery connector.
4. *Rechargeable Battery*—Place the battery into the battery compartment as shown in the drawing and route the wires along the side of the battery.
5. Replace the battery compartment cover and return the instrument to the upright position.
6. If the rechargeable lead-acid battery is being used, top-charge the battery for 18 to 20 hours before placing it in operation

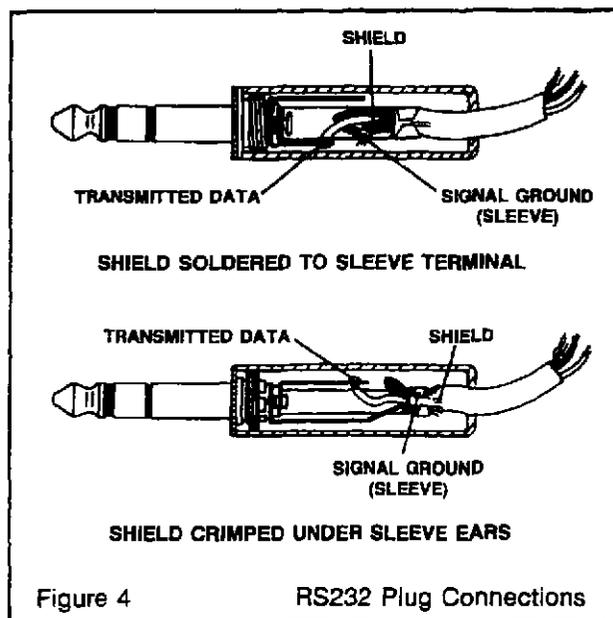
### 2.3 Recorder Connection

The recorder output jack (REC) on the back panel takes a sub-miniature phone plug wired as shown in Figure 3. A suitable plug is listed in the list of optional accessories in Section 6. Hach recommends a twisted-pair, shielded cable be used for the recorder input cable and the load impedance be greater than 10k ohms. The shield connection may be optional in some cases.



### 2.4 RS-232 Connection

The RS-232 jack on the back panel mates with a three-conductor, 1/4" phone plug wired as shown in Figure 4. A suitable plug is listed in the List of Accessories in Section 6. The RS-232C interface output is an eight-bit data word plus one stop bit and no parity with a baud rate of 1200. It can be used to link to either a serial printer or a serial input port on a computer. If the RS-232 feature is to be used for a serial printer, a printer cable assembly terminated with a standard 25-pin D connector is available as an optional accessory. Refer to Section 6. With the use of a serial-to-parallel converter, the data string transmitted from the DR/2000 Spectrophotometer can be printed on any Epson-

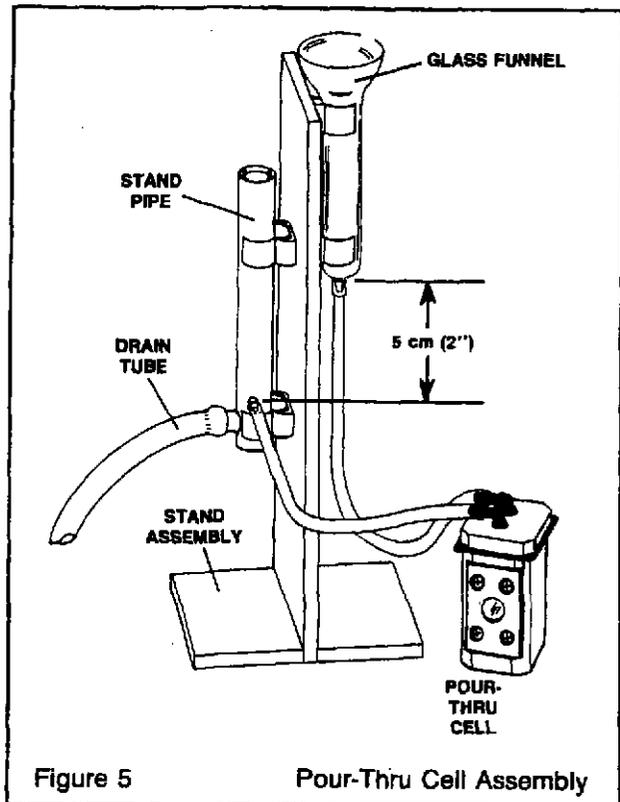


compatible parallel printer of the type normally used with IBM-compatible applications.

Data is transmitted to the printer as a 26-character string plus the line feed and carriage return.

### 2.5 Pour-Thru Cell Setup

The optional Pour-Thru Cell must be assembled before use. Figure 5 illustrates the assembled unit.



The kit includes:

- Pour-Thru Cell
- Stand Assembly
- Glass Funnel
- Stand Pipe
- 1/8" ID plastic tubing (6 ft)
- 1/4" ID rubber tubing (12 ft)
- Instruction Sheet

#### CAUTION

Do not use the pour-thru cell in tests that call for the use of organic solvents such as toluene, chloroform, trichloroethane or cyclohexanone.

### 2.6 Sample Cell Adapter Installation

The light path is oriented on a course from right to left as you view from the front of the instrument. When placing one of the adapters into the cell holder, have the light path ports in the adapters with the same orientation. All of the adapters can be rotated 180 degrees with no effect on the optics. For a list of the available adapters, refer to *Replacement Parts and Accessories* in Section 6.

## SECTION 3 OPERATION

### 3.1 Description of Operating Controls

Figure 6 shows the spectrophotometer controls, indicators and connections. Their functional descriptions are given in Table 1.

Table 1. Operating Controls, Indicators and Connections

Item No.	Name	Description
1	Cell Compartment Cover	Light shield for sample cell compartment. Contains list of stored program numbers on underside
2	Wavelength Control	Used to select wavelength in nanometers appropriate for test parameter
3	Display	LCD display window divided into three function areas: wavelength, numeric output and alphanumeric message. Indicates wavelength, prompts and gives measurement results in operational modes. Displays menu options when scrolling through menu with arrow keys. Provides error messages when invalid entries are made.
4	TIMER/7 key	Initiates timer function when used with shift key. Has numeric key function when shift key is not used.
5	-/8 key	Minus sign for entering negative superscript sign. Used with shift key. Has numeric key function when shift key is not used.
6	+/9 key	Plus sign for entering positive superscript sign. Used with shift key. Has numeric key function when shift key is not used.
7	CONC/6 key	Initiates concentration readout mode when used with shift key. Has numeric key function when shift key is not used.
8	ABS/5 key	Initiates absorbance readout mode when used with shift key. Has numeric key function when shift key is not used.
9	%T/4 key	Initiates percent transmittance readout mode when used with shift key. Has numeric key function when shift key is not used.
10	PROG/3 key	Used to initiate operator-stored calibrations when used with shift key and METH key. Also used with SHIFT and TIMER keys to initiate timer. Has numeric key function when shift key is not used.
11	EDIT/2 key	Used to review or alter operator-stored calibrations when used with the shift key. Has numeric key function when shift key is not used.
12	BATT/1 key	Used to check condition of battery when used with shift key. Current battery voltage and battery-life bar graph will be displayed. Has numeric key function when shift key is not used.
13	CLEAR/ZERO key	Used with the shift key to correct a wrong keystroke in the display before the value has been entered. Without shift key, used to zero the instrument with the blank solution in the cell holder prior to measuring the test sample.
14	./0 key	Decimal point used in Lamp Out diagnostics only. Without shift key, has numeric function.
15	CONFIG/METH key	Used with shift key to call up configure menu for selection of language and momentary or constant-on operation. Without shift key, used to call up method menu. Also used to exit a method and return to method prompt without shift key.
16	READ/ENTER key	Initializes function selections that have been keyed in or scrolled to. Can be used to over-ride a programmed wavelength to substitute an alternate.

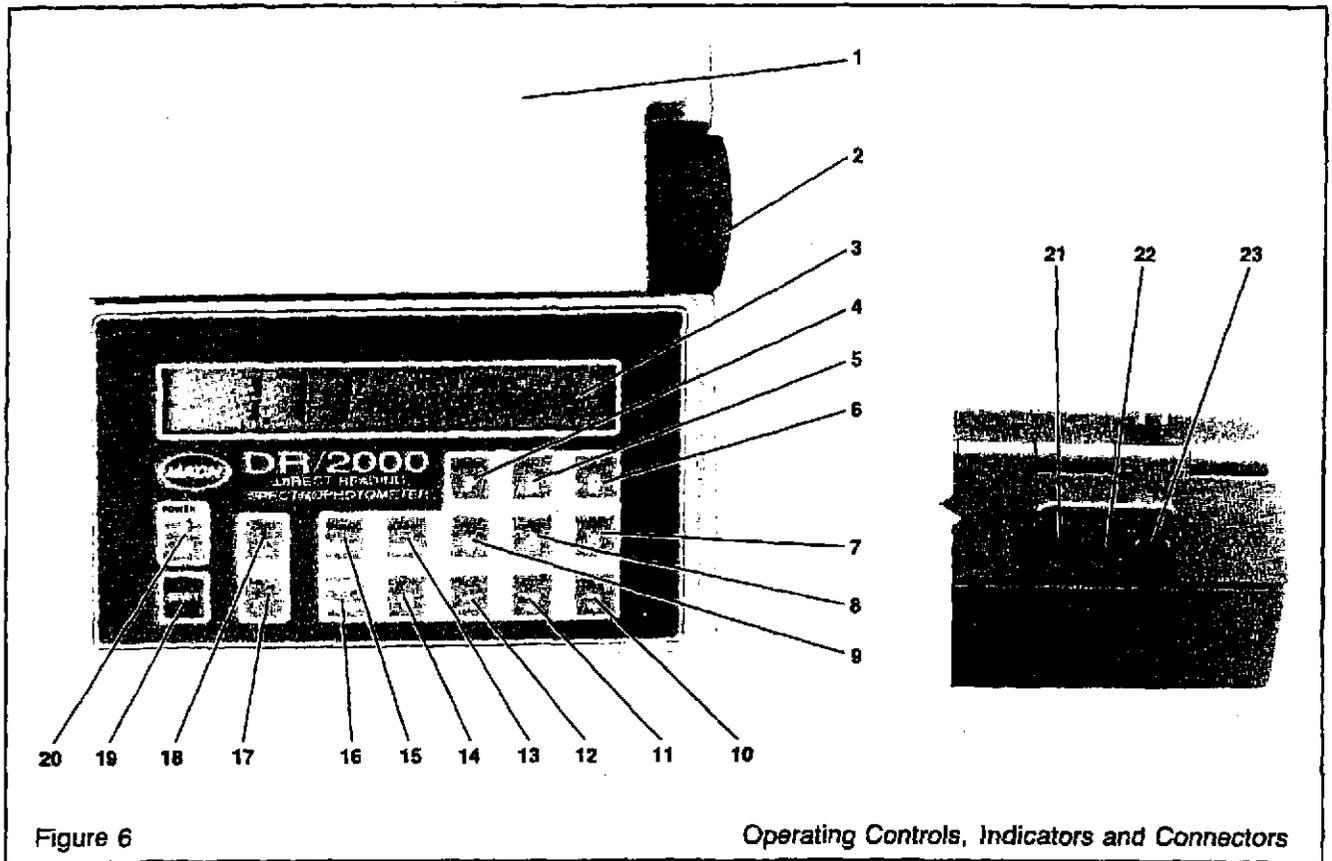


Figure 6

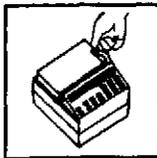
Operating Controls, Indicators and Connectors

Item No.	Name	Description
17	Right Arrow/Down Arrow key	Right arrow key used to move the cursor to the right (one digit at a time) when changing a displayed value. Down arrow used to scroll in forward direction through selected menu. Shift key is not used for these functions.
18	Left Arrow/Up Arrow key	Left arrow used to move the cursor to the left (one digit at a time) for editing a displayed value. Up arrow used to scroll in backward direction through selected menu. Shift key is not used for these functions. Left arrow used with shift key to erase and backspace to allow wrongly keyed characters to be corrected.
19	SHIFT key	Used to select the top (blue) function of the dual-function keys. Also used to toggle the tone generator on and off. (See 3.7.4.) When on, audible beep will sound each time a key is pressed, indicating the keystroke has been accepted by the instrument.
20	POWER key	Toggles operating power on and off. If the instrument is to be operated in the Constant-On mode, allow 5 minutes for warm-up.
21	REC Jack	Connection for 0 to 1 V analog output.
22	POWER Jack	Connection for battery eliminator/charger unit.
23	RS-232 Jack	Serial port for printer or computer interface.

### 3.2 Testing With Factory-Programmed Methods

The graphic presentation here is a summarized example that is typical of most preprogrammed test methods. A more detailed discussion follows. Once

the operator is familiar with DR/2000 Spectrophotometer operation, this summary can be used as a quick reference source when needed.

Step	Action/Keystroke(s)	Display
1. Turn on Power		METHOD #?
2. Select Stored Program	2 2 5	METHOD ? 225
3. Set Wavelength	READ ENTER	DIAL nm TO 522
		522 nm DIAL nm to 522
	READ ENTER	. mg/l CaCO <sub>3</sub> Mg
4. Insert Blank and Set Zero	CLEAR ZERO	. WAIT
		0.00 mg/l CaCO <sub>3</sub> Mg
5. Place Prepared Sample into Cell Holder	READ ENTER	WAIT
		1.00 mg/l

Colorimetric testing with Hach's dedicated, pre-programmed calibrations can be divided into four general phases: instrument setup, sample preparation, standardizing the instrument and taking the reading. In the following paragraphs, the scope of each phase is described in detail.

### 3.2.1 Spectrophotometer Setup

Instrument setup in this test situation is limited to selecting the method or program number assigned to the desired calibration and selecting the wavelength. Prompting messages will appear in the display at the appropriate times to guide the operator through the procedure. The first prompt appears when the instrument is turned on. The message will read:



The method or program number can be entered with the numeric keys or it can be scrolled to, using the up or down arrow keys. Holding the arrow key down allows rapid scrolling. A list of the tests with their numbers is affixed to the underside of the cell compartment cover. To enter the number with the numeric keys, key in the two or three digit number and press the READ/ENTER key. If the number is not valid, the display will read:



After three seconds, the display will return to the prompt for the method number. Reenter the proper method number, or use the following procedure to locate the desired test.

Instead of selecting the method by number, you can use the up or down arrow keys to scroll through the method list and select from the displayed methods. During scrolling, the method number is displayed in the large digits and the unit of measure and symbol for the test subject are displayed in the text area; for example,



Once the proper method appears in the display, accept by pressing the READ/ENTER key. Upon entry, either by selecting by number or scrolling, the display next prompts you to set the wavelength value; for example,



Adjust the wavelength control as shown in Figure 7 until the nanometer readout displayed matches the prompted value. When the values are equal, press the READ/ENTER key to proceed. You may, however, perform the test with an alternate wavelength by pressing the READ/ENTER key when the alternate value is in the display



Figure 7

Selecting Wavelength

### 3.2.2 Sample Preparation

The next task in the colorimetric test is the preparation of the sample. If the zero sample or blank to be used requires some special treatment, it too is prepared at this time. Generally, sample preparation consists of adding the contents of a pre-measured reagent powder pillow to 25 mL of the sample (Figure 8) and allowing time for a color reaction to take place. It is important to observe the waiting period specified in the particular test procedure to be certain that the color (due to the reaction of the reagent with the substance being measured) develops fully. Many procedures also give a maximum time limit after which the color may begin to fade. The DR/2000 Spectrophotometer has color development times programmed into the method software, and the operator is notified with a series of short beeps when the time has elapsed. At

this time the instrument is ready to be zeroed. The timer must be initiated, however, by pressing SHIFT TIMER at the time the countdown should begin. Up to four separate time periods can be incorporated in a test procedure.

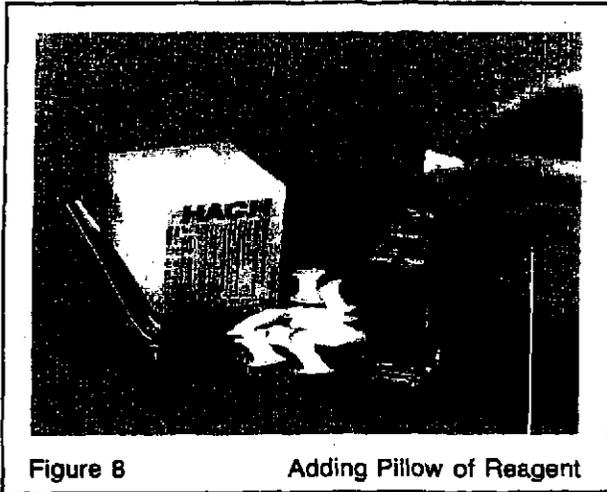


Figure 8 Adding Pillow of Reagent

### 3.2.3 Zeroing the Spectrophotometer

The instrument must be standardized for each determination. This establishes a zero reference for the measurement and is done by placing a blank solution in the cell holder and setting the instrument to zero concentration units. The display indicating readiness for this function appears as:



Place the zero solution (blank) in the instrument (with the 25-ml mark to the left or right) and press the ZERO key. See Figure 9. If this step is forgotten and you attempt to read a sample, the instrument will remind you that a zero is required with the message:



While the instrument is zero calibrating (which may take up to eight seconds), the display will read:

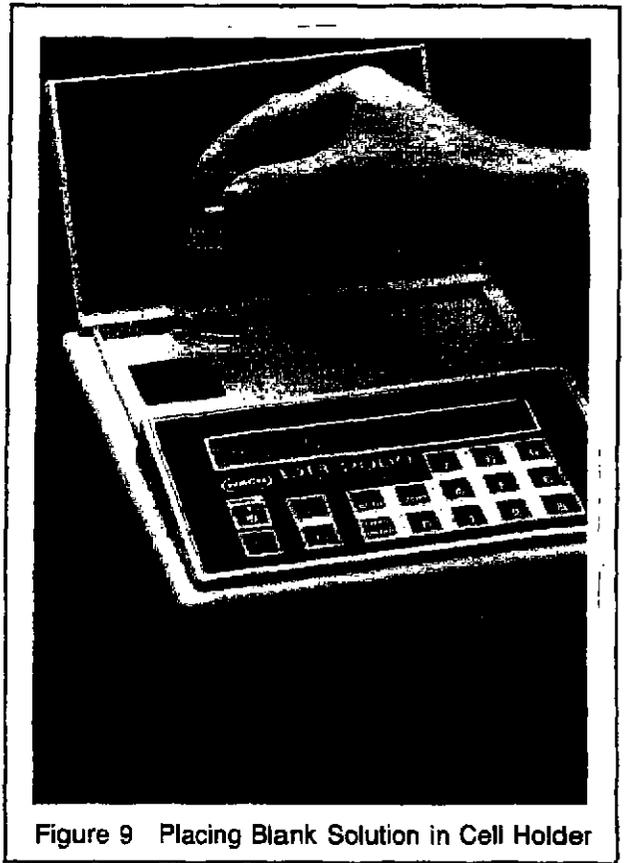


Figure 9 Placing Blank Solution in Cell Holder

When the zero calibration is completed, the display will show a zero result:



You are now ready to measure the sample.

### 3.2.4 Taking The Reading

Place the prepared sample into the cell compartment with the 25-ml mark to the left or right as shown in Figure 10, close the compartment cover and press the READ/ENTER key. The display will read:



In about six seconds, the test result will appear; for example:



More samples can be measured at this point merely by placing the new sample into the cell holder and pressing the READ/ENTER key. Also, the instrument can be zeroed at any time by placing the zero solution (blank) in the instrument and pressing the ZERO key. To change test parameters, press the METH key. The instrument will revert to the prompt message calling for the method number.

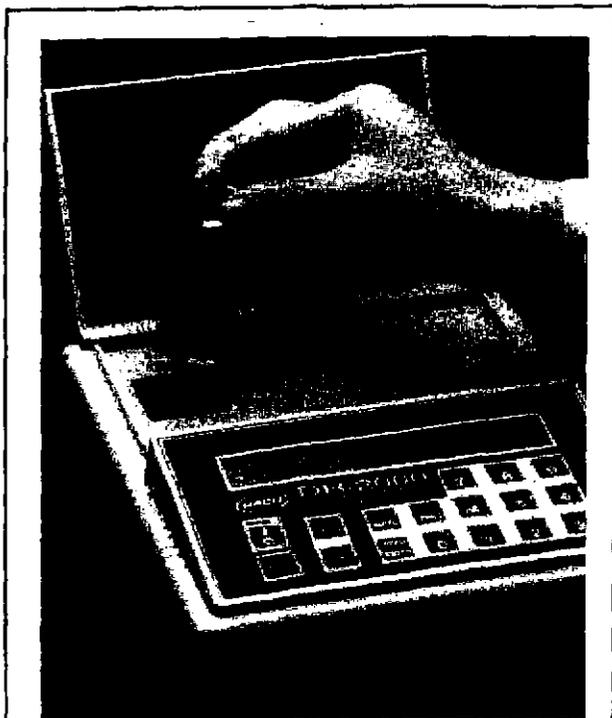


Figure 10 Placing Prepared Sample in Cell Holder

**NOTE**

The procedure above is applicable when operating in the momentary mode. When operating in the Constant-On mode, it is not necessary to press the READ/ENTER key to get the reading and the WAIT prompt will not appear.

Test results can be displayed in three forms: concentration, percent transmittance and absorbance. Concentration is shown in the example above. A concentration value can be converted to percent transmittance or absorbance by pressing SHIFT %T or SHIFT ABS, respectively. Pressing SHIFT CONC will return the display to concentration.

**3.3 Testing With Operator-Programmed Calibrations**

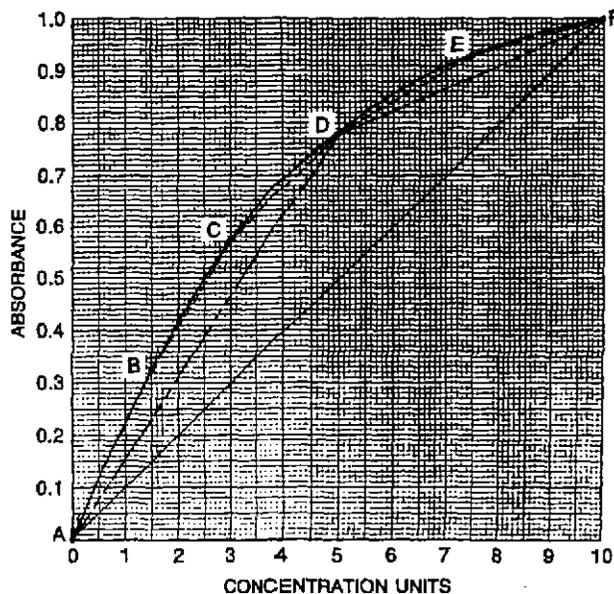
The DR/2000 Spectrophotometer can store positive-slope, user-developed test methods. Accurate results may be obtained for test samples up to two standard

absorbance units. Once a user-generated method has been entered, it can be accessed and run just as the factory-programmed methods. Both timed and untimed methods can be defined. User-entered methods are stored as method numbers 950 through 999, allowing up to 50 additional methods. A method can have up to 16 data points to describe the absorbance-concentration curve, but there is a total limit of 290 data points available. Thus to enter 50 additional methods, calibrations would have to average approximately six data points per method.

To run a user-entered method, select the method either by entering the number or scrolling to the method. The display will scroll to the user-entered area directly following the Hach-stored methods.

**3.3.1 Entering A Calibration**

Prior to entering a calibration, the operator should prepare a calibration curve of concentration versus absorbance. If the curve is linear, only a few concentration data points are needed to form a good calibration curve. For example, a zero, a standard of approximately 0.5 absorbance and a standard between 0.85 and 0.95 would be appropriate. However, if the calibration is nonlinear, additional data points are needed to achieve good accuracy. Up to sixteen data points can be entered for a single calibration curve. The graph below illustrates why the additional points are necessary. If only points A



and F were entered, the instrument would base its calculations on a straight line (A-F) and the result would be grossly in error. By adding data point D, the curve is greatly improved with the two straight lines A-D and D-F, but in some regions of the curve, measurements still may not be accurate enough.

Further improvement is gained when data points B, C and E are entered, giving straight lines A-B, B-C, C-D, D-E and E-F.

In general, the calibration data may be entered in up to sixteen data points of a minimum of 0.063 absorbance units for calibrations not exceeding one absorbance unit. If the calibration curve exceeds one absorbance unit, the minimum absorbance between data points may not be less than 0.125. Therefore, if a nonlinear relationship between absorbance and concentration is found, the calibration should not extend above one absorbance unit to achieve the best accuracy.

Entering a new test method requires that the operator utilize the numerous characters in the menu to construct an alpha-numeric description of the test parameter. The list of characters below shows what is included and in what sequence they appear. By holding the up or down arrow keys down, you can scroll through the menu rapidly until you are close to the character being sought and then proceed slowly in steps until the desired character appears in the display. A list of the characters available in the order of their sequence in the menu is given below.

— abcdefghijklmnopqrstuvwxyz

### Entering a User Stored Program

At the end of this exercise, the operator will be able to select the user stored calibration by method number or by scrolling, the same as selecting a factory-programmed method. A sample worksheet for documenting calibrations is provided following page 30. Fill in a copy of the form to record the calibration data for future reference.

#### CAUTION

Once a user entered calibration procedure has been started, do not terminate the procedure or turn the instrument off before two data points have been entered and the prompt "#2 STANDARD" is displayed. Ending the calibration too soon could cause the loss of all user entered methods and possibly factory monochromator calibration. If an improper entry is made, continue with the procedure and make the necessary corrections later using the Re-Using Operator Stored Method Number, *paragraph 3.5*, or Reviewing and Changing Operator-Programmed Methods, *paragraph 3.4*.

When entering a calibration point value during a user entered calibration, do not attempt to enter a decimal point using SHIFT 0 keys. The decimal point will already be entered via the decimal point selection, and pressing SHIFT 0 (used only as a diagnostic tool during servicing) could erase all user entered memory.

Step	Action/Keystroke(s)	Display
1. Turn on Power		
2. Select User Stored Program Mode	  	

Following the z, a series of special characters appear.

ΑΑΑ5QIN0008ΦΔΑΠΩΓΞμ<sup>0</sup>

Except for the symbols  $\delta\mu^0$  only four different special characters may be used in a single display.

() / 0123456789+-

Numbers that appear during scrolling are full size. Subscript and superscript numbers are entered from the keyboard and are shown below.

2<sub>2</sub>3<sub>3</sub>4<sub>4</sub>5<sub>5</sub>6<sub>6</sub>7<sub>7</sub>8<sup>+</sup>

In the graphics summary below, the three-column presentation provides a brief procedural step, the appropriate keystrokes and the resulting display. It provides a quick reference when performing an operator-programmed test method calibration and intended for use after the operator has become familiar with the instrument operation. A more detailed discussion for first-time user calibrations follows the summary.

3. Set Wavelength Control to 560 and also key in the wavelength to program the instrument



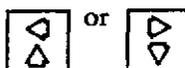
ABS 5 CONC 6 . 0

READ  
ENTER

950 ENTER nm 560

950 DECIMAL? 00.00

4. Set Decimal

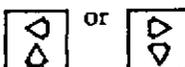


READ  
ENTER

950 DECIMAL? 0.000

950 UNITS?

5. Select Units

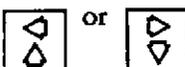


READ  
ENTER

950 mg/l

950 SYMBOL?

6. Construct Symbol (e.g. Cu<sup>2+</sup>)



SHIFT

READ  
ENTER

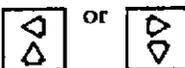
950 mg/l c

950 mg/l C

950 mg/l C\_

Shift to capitalize C

Scroll to Letter u



READ  
ENTER

950 mg/l Cu

950 mg/l Cu\_

Select No. 2

EDIT  
2

950 mg/l Cu2

Shift for Superscript

SHIFT

950 mg/l Cu2

READ  
ENTER

950 mg/l Cu2\_

Select +

SHIFT +  
9

950 mg/l Cu2+

READ  
ENTER

950 mg/l Cu<sup>2+</sup> \_

READ  
ENTER

950 TIMER?

**7. Set Time to 1:00**

SHIFT TIMER  
7

950 MM:SS TIME 1?

Select 01:00

0 BATT 1 0 0

950 01:00 TIME 1?

READ  
ENTER

950 MM:SS TIME 2?

READ  
ENTER

950 ZERO SAMPLE

**8. Set Zero On Blank**

CLEAR  
ZERO

950 WAIT

READ  
ENTER

0.000 #0 STANDARD

0.000 #0 0.000 mg/l

**9. Place Zero Concentration Standard In Cell**

READ  
ENTER

0.000 WAIT

x.xxx Abs 0.000 mg/L

READ  
ENTER

x.xxx #1 STANDARD

**10. Place 0.2 mg/l Standard In Cell**

READ  
ENTER

x.xxx #1 0.000 mg/l

0 EDIT 2

x.xxx #1 0.200 mg/l

READ  
ENTER

x.xxx WAIT

y.yyy Abs 0.200 mg/l

Key In Value 0.2  
CAUTION: Do not enter the decimal point (SHIFT 0). Position of decimal was set in Step 4. "SHIFT 0" is only used as a diagnostic entry by service personnel and could erase user-entered memory.

**11.** Place 0.4 mg/l Standard In Cell

Key In Value 0.4 Do not enter decimal point (SHIFT 0).

READ  
ENTER

y.yyy #2 STANDARD

READ  
ENTER

y.yyy #2 0.000 mg/l

0 WT 4

y.yyy #2 0.400 mg/l

READ  
ENTER

y.yyy WAIT

z.zzz Abs 0.400 mg/l

READ  
ENTER

z.zzz #3 STANDARD

**12.** Place 0.8 mg/l Standard In Cell

Key In Value 0.8 Do not enter decimal point (SHIFT 0).

READ  
ENTER

z.zzz #3 0.000 mg/l

0 8

z.zzz #3 0.800 mg/l

READ  
ENTER

z.zzz WAIT

a.aaa Abs 0.800 mg/l

READ  
ENTER

a.aaa #4 STANDARD

**13.** No Other Standards. End Data Entry and Store Method.

SHIFT READ  
ENTER

METHOD #?

To create a new method, answer the method prompt by calling up the user program mode; press: SHIFT PROG METH keys. The instrument determines the next available method number (for instance 954) and the display changes to:



Record the method number displayed for future reference when using the method.

Enter the wavelength of the test you wish to perform using the numeric keys. As the numbers are keyed in, the wavelength digits are forced in from the right, and the displays will progress as follows:

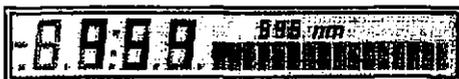


If you make an error entering the wavelength value, press SHIFT CLEAR and re-enter the number correctly. When the proper number is displayed, enter the value by pressing the READ/ENTER key.

The display will now ask you to position the decimal point with the prompt:



Using the cursor keys (left and right arrows), position the decimal point properly and press the READ/ENTER key. The display will now prompt:



Using the scroll keys (up and down arrows), scroll through the available units of measure. Note that the first display in the menu will be blank (no units).

mg/l    μg/l    g/l    ppm    Lbs/Ac    kg/ha    %  
g/kg    mg/kg    mg/100g    mg%    UNITS    FTU  
Mol/l    mMol/l    meq/l    Oz/gal

These units will appear sequentially in the display. When the appropriate choice is in the display, press the READ/ENTER key. If the unit you need is not available (for example, GRAINS/GAL or g/m<sup>3</sup>), select the blank units field (blank precedes mg/l), press READ/ENTER, and construct your own unit using the individual characters as described below in constructing your symbol.

The display now changes to:



To construct the desired symbol, begin by scrolling for the symbol characters. The display will change to show the unit of measure selected and the cursor positioned to begin the symbol. Resume scrolling and continue until the first character of the symbol is in the display. For example, to construct a display for a low-range test of SO<sub>4</sub><sup>2-</sup>, scroll to obtain the letter s in the display. Holding the arrow key down provides rapid scrolling through the alphabet. The letter will be lower case and must be changed to an upper case S by using the shift key. Accept the S with the READ/ENTER key and move to the next space. Scroll for the letter o, capitalize the letter to O and accept it with the READ/ENTER key. Move to the next space. Enter a 4 from the keyboard. It will appear as a subscript number, and since a subscript is desired, press the READ/ENTER key to accept. Press 2 on the keyboard. The 2 will also appear as a subscript and must be changed to a superscript by pressing the SHIFT key. Press READ/ENTER. Key in a minus sign and press the READ/ENTER key. The keyboard-entered minus and plus signs display only as superscripts, so they do not need to be shifted. Subscripts available are 2 through 8, and superscripts available are 2 through 6, + and -. There is a limit of four different custom symbols per message.

To distinguish this low range sulfate method from the sulfate method already in memory, you can add LR at the end of the symbol field in the display. Scroll to the blank space character. During scrolling, the blank appears between the underline and the letter "a." Accept it with the enter key. You can enter up to four blank spaces and then enter the L and R. After examining the display to see that everything is correct, press the READ/ENTER key a second time to accept and store the entire display. The display will now change to:



If this is to be a timed procedure, press SHIFT TIMER. The next prompt will be:



The interval for the first timed period is now entered, one digit at a time, using the number keys. The numbers will appear in place of MM:SS. When the correct minutes and seconds are shown in the display, press the READ/ENTER key to store the interval in memory. At this point, the display will prompt:



If more timed intervals are needed, repeat the above procedure. Up to four time intervals can be stored. When all interval entries are complete, store the entire sequence by pressing READ/ENTER once if all four intervals are used or two times if less than four are entered. The timer sequences can be bypassed entirely when the timer is not needed by pressing READ/ENTER in response to the timer prompt. In either case, the next prompt message will be:



Place the zero solution in the cell holder, close the cover and press the ZERO key. The instrument will perform a zero calibration, and while doing so will display:



followed by a display prompting:



With the blank sample still in the instrument, press the READ/ENTER key. The display will change to read:



Accept the displayed zero concentration value by pressing READ/ENTER. The display will change to:



while the instrument performs a zero absorbance calibration. On completion, the display will change to:



Accept the zero point for the calibration curve by pressing READ/ENTER. The next prompt will ask for the next standard; that is:



Insert the first or weakest standard in the cell holder and press READ/ENTER. The display will change to:



Key in the desired concentration;

for example:



All four digits must be entered, including any leading zeroes to the left of the decimal. The decimal point is already positioned according to your earlier choice. A wrong keystroke can be corrected by using the shift, left arrow key to backspace over an incorrect entry. Accept the correct entry with the READ/ENTER key. The display will first read:



and then show the absorbance value for the measured standard in addition to the concentration; that is:



Press READ/ENTER. The data pair (concentration and absorbance) will be stored in memory as calibration data point number 1. The display will now prompt you for the next standard:



Repeat the above procedure for entering standard 1 for all calibration standards. When all calibration data points have been entered, conclude the calibration by pressing SHIFT, READ/ENTER. The display will now prompt:

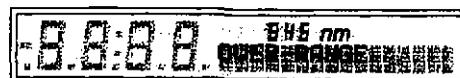


If only one calibration standard is measured, a straight line between that point and the origin (0, Abs, 0 Conc) is calculated, and measurements will be linearly interpolated along that line. If two or more data points (up to a maximum of 16) are entered, the DR/2000 Spectrophotometer constructs a point-to-point straight line approximation of the curve, beginning at zero-zero and ending at a point which is the next 0.125 absorbance interval above the highest input value.

The procedure is stored, program mode terminated and instrument returned to regular operation with

the completed user-method selected. For future use of the user-stored method, either scroll to the method or enter the number with the keypad. The example above would, for instance, be recalled by keying in 954 in response to the method prompt.

For all calibrations, any measured absorbances greater than approximately 10 percent above the highest entered calibration absorbance will result in the message:



If the memory is filled during entering a new method, the display will blink off and on, indicating there is no more memory available and the method can not be completed. Exit this condition by turning the instrument off.

It will be necessary to evaluate the user-entered methods and determine if something can be eliminated to make room for the new method. Refer to 3.5 Re-Using Operator-Stored Method Number. It will be beneficial to maintain a log of the operator-stored methods both as a record of what is in memory in case of accidental loss or a ROM update and as a review document to evaluate for changing test requirements. Figure 11 provides a sample record form that would meet these needs.

FIGURE 11. sample

USER-ENTERED CALIBRATIONS WORKSHEET

Test Name: VANADIUM Pentavalent Test Method: PAR Date: 2-29-88 By: Example

**METHOD #?** BEGIN USER PROGRAM MODE  
Press SHIFT PROG METH.  
Record the number displayed by the DR/2000: 0954

**ENTER W** ENTER THE WAVELENGTH  
Key in the desired wavelength value and record it here: 550  
Make corrections by pressing SHIFT CLEAR and re-entering the wavelength.  
When you have correctly keyed the wavelength, press READ/ENTER.

**DECIMAL? ↓ 00.00** POSITION THE DECIMAL POINT  
Use the arrow keys to position the decimal point; record it here: 0.000  
Press READ/ENTER to accept the decimal position.

**UNITS? ↓** SELECT THE UNIT OF MEASUREMENT  
Use the arrow keys to select the desired unit, record it here: mg/l  
To construct a unit of measure - accept blank field; go to next step.  
Press READ/ENTER to accept the unit or blank selection.

**SYMBOL? ↓** CONSTRUCT THE CHEMICAL SYMBOL  
Use the arrow keys to select the characters.  
Press READ/ENTER to accept each character.  
Make corrections with SHIFT LEFTARROW or SHIFT CLEAR.  
When completed, record both unit and symbol here: → mg / L V5+  
Press READ/ENTER to record the entire construction.

**TIMER?** SET THE TIMERS (OPTIONAL)  
To bypass entry of the optional timers, press READ/ENTER at the timer prompt.  
If you wish to set timers, press SHIFT TIMER.  
Record each timer you have set in the spaces below:  
Enter all four digits including leading zeros.

MM:SS TIMER 1 ? 30:00 MM:SS TIMER 3 ?             
MM:SS TIMER 2 ?            MM:SS TIMER 4 ?           

Press READ/ENTER when you have completed entering timer values.

**ZERO SAMPLE** PERFORM A ZERO CALIBRATION  
Insert a prepared blank sample and press READ/ENTER.

**# 0 STANDARD** SET THE ZERO CONCENTRATION POINT  
Leave the blank sample in the well and press READ/ENTER.  
Begin calculation of the concentration - absorbance zero point by pressing READ/ENTER.

ENTER THE ABSORBANCE - CONCENTRATION DATA PAIRS.  
Enter the concentration values of your prepared samples in the table below.  
Follow the steps outlined for entry and calculation of each point.

	Press	Enter & record Concentration	Press	Record Displayed Absorbance	Press
# 1 STANDARD	READ/ENTER	<u>.200</u>	READ/ENTER	<u>0.339</u> ( <u>0.200</u> )	READ/ENTER
# 2 STANDARD	READ/ENTER	<u>.400</u>	READ/ENTER	<u>0.678</u> ( <u>0.400</u> )	READ/ENTER
# 3 STANDARD	READ/ENTER	<u>.600</u>	READ/ENTER	<u>1.017</u> ( <u>0.600</u> )	READ/ENTER
# 4 STANDARD	READ/ENTER		READ/ENTER		READ/ENTER
# 5 STANDARD	READ/ENTER		READ/ENTER		READ/ENTER
# 6 STANDARD	READ/ENTER		READ/ENTER		READ/ENTER
# 7 STANDARD	READ/ENTER		READ/ENTER		READ/ENTER
# 8 STANDARD	READ/ENTER		READ/ENTER		READ/ENTER
# 9 STANDARD	READ/ENTER		READ/ENTER		READ/ENTER
# 10 STANDARD	READ/ENTER		READ/ENTER		READ/ENTER
# 11 STANDARD	READ/ENTER		READ/ENTER		READ/ENTER
# 12 STANDARD	READ/ENTER		READ/ENTER		READ/ENTER
# 13 STANDARD	READ/ENTER		READ/ENTER		READ/ENTER
# 14 STANDARD	READ/ENTER		READ/ENTER		READ/ENTER
# 15 STANDARD	READ/ENTER		READ/ENTER		READ/ENTER
# 16 STANDARD	READ/ENTER		READ/ENTER		READ/ENTER

**METHOD #?** END USER PROGRAM MODE  
When you have entered at least one point but not more than sixteen points conclude the entry of data pairs by pressing SHIFT READ/ENTER

SELECT A METHOD  
At the method prompt you may now select your new method and perform a test.

Figure 11

Sample User-Entered Calibrations Worksheet

### 3.3.2 Completing the Test

Once the user-generated calibration is accepted with the SHIFT, READ/ENTER keystrokes, the instrument is ready to measure an unknown sample, beginning with selecting the new method number. Now select the wavelength and zero the meter with a blank sample. Then the sample is placed into the cell holder, the cover closed and the READ/ENTER key pressed. The display will read:



followed in about six seconds with the test result, such as:



A new sample can be inserted and tested. At any time, the instrument can be re-zeroed by inserting the blank sample and pressing the ZERO key.

### 3.3.3 Alternate Method For Entering A Calibration

Another method for entering new calibrations prescribes using a single standard for all calibration points to enter a flat curve (that is, all calibration points have the same absorbance), and later using the edit procedure as described in paragraph 3.4 to manually correct the absorbance values to establish the proper curve.

If you use this alternate method, you must enter the proper number of calibration points because you cannot add a calibration point in the editing procedure. After entering a flat calibration, pressing SHIFT ENTER to return to the method prompt will cause the instrument to lock up where it fails to respond to any further keystrokes. Turn the instrument off and back on again. The flat calibration will now be stored and it can be edited to establish the correct curve. Refer to *Reviewing and Changing Operator-Programmed Methods*, paragraph 3.4.

### 3.4 Reviewing and Changing Operator-Programmed Methods

Data pair information stored previously by the operator can be reviewed and changed to correct or modify bad data points. If you wish to change other components of the user method (i.e., the display) or increase the number of data points, you must reenter the method from the beginning. To select an operator-entered method for review or modification, enter the method number as usual followed by pressing SHIFT,EDIT. The method number will be

displayed in the large digits and the data pairs in the alpha-numeric field as:



The previous example shows the display for the zero point for the method 954 example. To accept the zero point and proceed to review the data pairs, press READ/ENTER. The display will show the next data pair, for example:



The cursor is positioned under the first digit of the absorbance value. You can move from digit to digit with the arrow keys, changing any numbers you wish to correct. For instance to change the concentration in the above example to 00.15, press the right arrow key six times to position the cursor under the 2 and key in the new number (1). The new number will replace the old and the cursor will advance to the next digit as:



Then either press the right arrow key one more time to advance past the last number, or press READ/ENTER. Either action will accept the modified pair and go on to the next point:



Repeat this procedure for each data point, either accepting the values as they are, or making any modifications required. When the data from the last data point has been reviewed and accepted by pressing READ/ENTER, the set will be stored and the display will return to method prompt:



You can now reenter the number of the modified method and perform the test.

With the review and edit process, it is not possible to add or subtract data points to a method. You may, if necessary, replace a bad data point in a curve by interpolating a new value for the point based on the preceding and following points.

### 3.5 Re-Using Operator-Stored Method Number

It may be desirable to obsolete a user stored calibration in favor of a new one if memory capacity becomes filled. This can be accomplished by calling up the method number to be re-used and then proceeding with the normal procedure for entering a user method. For example, to use user-method number 951 for a new calibration, proceed as follows:

1. Using the numeric keys, key in 951 in response to the method prompt when the instrument is first turned on.
2. Press SHIFT, PROG, METH. The display will show the number and request the wavelength. From this point on, follow the procedure described in paragraph 3.3.1, *Entering A Calibration, beginning with entering the wavelength.*

### 3.6 Erasing All Operator-Stored Methods

Provision is made to allow the operator to erase the entire group of operator-stored methods. They can not be erased individually. If you wish to clear this part of the memory, proceed as follows:

Press the SHIFT, CONFIG keys. The display will show:



Enter the number 888 and press the READ/ENTER key. Within two seconds, enter the number 951. All user-entered methods that have been stored will be cleared from memory.

### 3.7 Configure Programming

For most operations, the DR/2000 Spectrophotometer is ready to use as shipped. There are options, however, to adapt the instrument for specific purposes. These include choosing a language other than English for prompts and messages, selecting one of two lamp modes, selecting the printer output interval and choosing the presence or absence of an audible tone when keys are pressed. Programming selections for language and lamp mode can be made by entering the number or by scrolling through the configure menu. Programming options that are currently selected are flagged by a darkened rectangle at the right of the display. Selecting these options in the most efficient way would set the language first, then the lamp option (momentary or constant on) and finally the printer frequency. The tone option is independent of the configure menu

and can be selected at any time. Details of the configure programming are described in the following paragraphs.

#### 3.7.1 Language Selection

Thirteen languages in addition to English are available with this spectrophotometer. They can be selected by number or by scrolling through the configure menu and then accepting the choice by pressing the READ/ENTER key. Once selected, the language will be retained when the instrument is turned off. The menu entries, number and name, appear as follows:

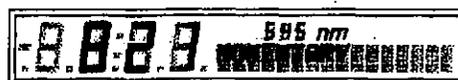
801	ENGLISH (English)
802	FRANCAIS (French)
803	ITALIANO (Italian)
804	ESPAÑOL (Spanish)
805	PORTUGUES (Portuguese)
806	DEUTSCH (German)
807	NEDERLANDS (Dutch)
808	NORSK (Norwegian)
809	SVENSKA (Swedish)
810	DANSK (Danish)
811	SUOMI (Finnish)
812	TURKÇE (Turkish)
813	ΕΛΛΗΝΙΚΑ (Greek)
814	日本語 (Japanese)

Proceed as follows:

1. Press SHIFT, CONFIG. The display will read:



2. Key in the number of the language or scroll with the down arrow until the language is displayed and press READ/ENTER. The display will read:



If a language other than English has been selected and you wish to return to English, press the SHIFT and CONFIG keys followed by the READ/ENTER key. English is the default language.

#### 3.7.2 Choosing the Lamp Mode

All configure options are selected through the configure menu which is called up by pressing the SHIFT CONFIG keys. The display will read:



You can select a configure mode by keying in the number or by using the up or down arrow key to scroll through the configure menu until the display indicates:



OR



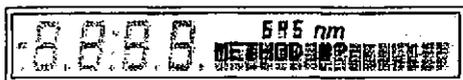
whichever mode is desired. (Momentary is the default mode.) With the desired mode in the display, press the READ/ENTER key. If the momentary mode was selected, the lamp will light only long enough to take the measurement after the ZERO or READ key is pressed. The instrument automatically turns off, to save battery power five minutes after the last key stroke. In the constant-on mode, the lamp and display stay on at all times the instrument is turned on. Hach recommends the constant-on mode only when working in the laboratory on battery eliminator/charger power.

### 3.7.3 Choosing Printer Output Frequency

Printer output selection is the third function in the configure menu, following language selection and lamp mode selection. After the lamp mode (momentary or constant on) is selected with the READ/ENTER key, the prompt for the print frequency will be displayed:



Use the numeric keys to select the print interval in seconds (5-99) and enter with the READ/ENTER key. The display will return to the method prompt.



If the instrument is set in the momentary mode, printer data will be transmitted automatically at the end of each test. In the Constant On mode, printer data will be transmitted at the interval selected. The instrument can be programmed to print "on demand only" in the Constant On mode by selecting 0 seconds. A printout is then initiated by pressing the READ/ENTER key.

### 3.7.4 Tone Generator

The tone generator is toggled on and off by holding the SHIFT key down until a beep is heard. When

on, the beep will sound each time a key is pressed, indicating that the keystroke has been accepted by the instrument. Without the tone, more care is called for when using the keyboard. Watch the display to see that the keystroke has been accepted.

## 3.8 Using the Pour-Thru Cell

The Pour-Thru Cell is an optional accessory that improves accuracy and convenience. It is particularly advantageous for measurements of very low concentrations. Because the same optical characteristics exist for both standardizing and measuring or when comparing measurements of different samples, any error that would result from optical differences between individual sample cells is eliminated. Assembly of the Pour-Thru Cell is described in Section 2. Install the Pour-Thru Cell in the spectrophotometer as follows:

1. Examine the glass windows in the Pour-Thru Cell. If either is dirty or smudged, clean with a soft, lint-free cloth or optical tissue.
2. Insert the Pour-Thru Cell into the instrument cell holder with the windows aligned with the windows in the cell holder. See Figure 12. Be sure the Pour-Thru Cell is fully inserted to prevent any light leak around the gasket. The cell compartment cover can remain open when using this accessory.

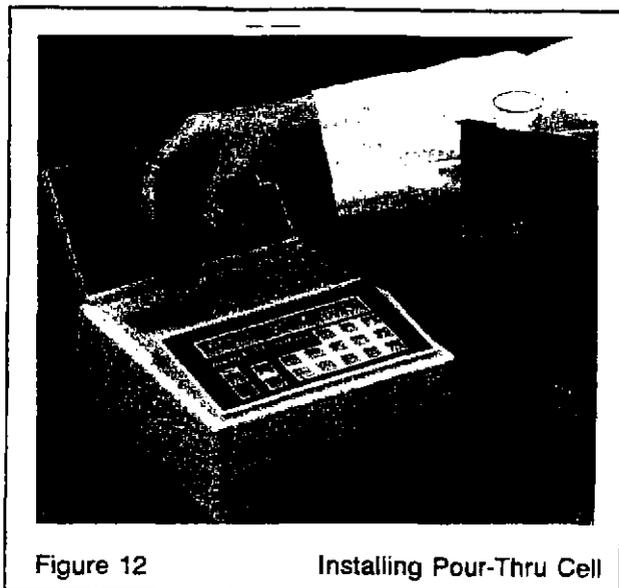


Figure 12 Installing Pour-Thru Cell

3. Adjust the relative heights of the stand pipe and funnel to ensure proper drainage for the funnel. The funnel should drain completely with the final level of liquid in the tube about 5 cm (2 inches) below the tip of the funnel. Initially, adjust the stand pipe so that the inlet is 5 cm below the tip of the funnel. See Figure 5.

4. Pour 25 to 50 mL of deionized water into the funnel and allow the funnel to drain. If necessary, move the stand pipe up or down to achieve the proper liquid level. When properly adjusted, the funnel will drain smoothly and stop draining at the correct level.

The drain tube attached to the stand pipe must be allowed to drain freely. It should always remain below the outlet of the stand pipe and should not run horizontally any more than necessary. Preferably, the tube should be as short as possible with the outlet end inserted into a drain (or suitable collecting vessel if treatment is necessary before discharge).

### 3.9 Using the AccuVac Vial Adapter

Hach Company's line of AccuVac Ampul reagents can be used in the DR/2000 Spectrophotometer with the aid of the adapter provided in the accessories. Test procedures for the AccuVac reagents are designated as such both in the procedure manual and in the list of methods on the underside of the cell compartment cover. Reagents are contained in sealed, evacuated vials and are mixed with the water sample by partially immersing the ampul and breaking off the tip to allow sample to be drawn in. Reacted sample can be measured in the ampul once the adapter is installed in the instrument. Proper orientation of the adapter in the sample cell compartment places the grip tab of the adapter toward the back of the compartment. See Figure 13.

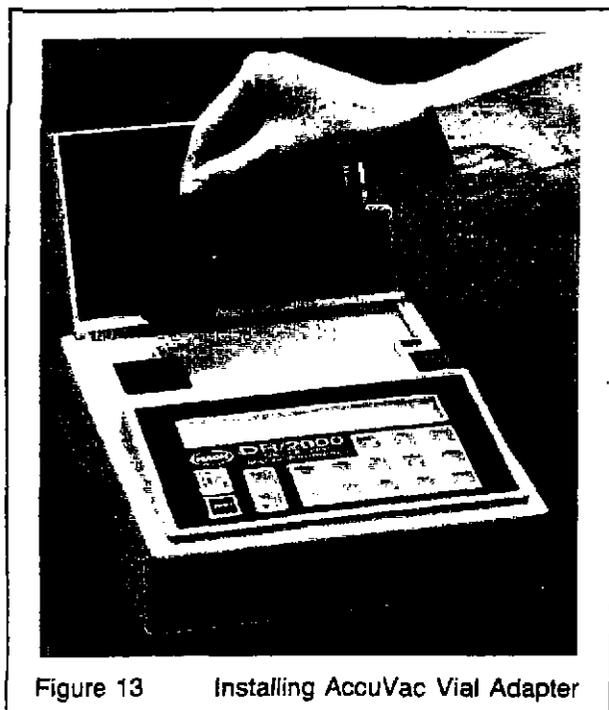


Figure 13 Installing AccuVac Vial Adapter

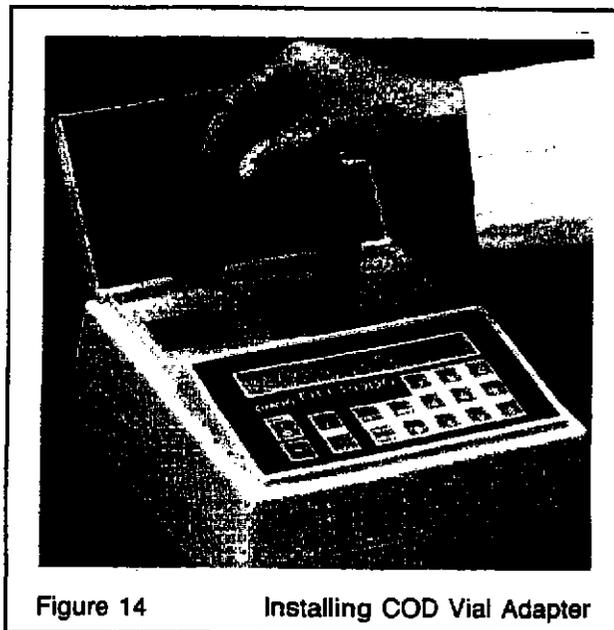


Figure 14 Installing COD Vial Adapter

### 3.10 Using the COD Vial Adapter

One of the methods for chemical oxygen demand (COD) determinations included in the DR/2000 Procedures Manual uses a COD Reactor and premixed reagent vials for both the digestion process in the reactor and for making the colorimetric measurement. With the COD Vial Adapter installed in the spectrophotometer sample cell compartment, reagent vials can be placed in the instrument for measurement. The COD Vial Adapter also can be used to hold a standard 16-mm test tube.

The COD vial adapter can be placed in the instrument's sample cell compartment with the orientation mark either toward the left or right. See Figure 14. A light shield cover is included with the adapter and must be in place when taking the COD measurement. The cell compartment cover will remain open.

### 3.11 Using the 1-cm Cell Adapter

Standard 1-cm square cuvettes can be used with the DR/2000 Spectrophotometer when Hach's 1-cm adapter is installed in the cell holder. One-centimeter cuvettes are not supplied with the instrument but are available as optional accessories either individually or in matched pairs.

The adapter is placed in the instrument cell compartment with the handling tab to the rear. See Figure 15. This position will orient the adapter correctly in the light path. When using glass cuvettes, place them in the adapter with the clear sides in the left-to-right optical path. The cell compartment cover must be closed while taking readings.



Figure 15 Installing 1-cm Cell Adapter

### 3.12 Using the 13-mm Test Tube Adapter

This test tube adapter is placed in the instrument cell holder with the orientation mark either to the right or left. See Figure 16. Proper placement is necessary to match the left-to-right light path. Because of the height of the test tube, the adapter comes with its own light shield which must be in place when readings are taken. The cell compartment cover will remain open.

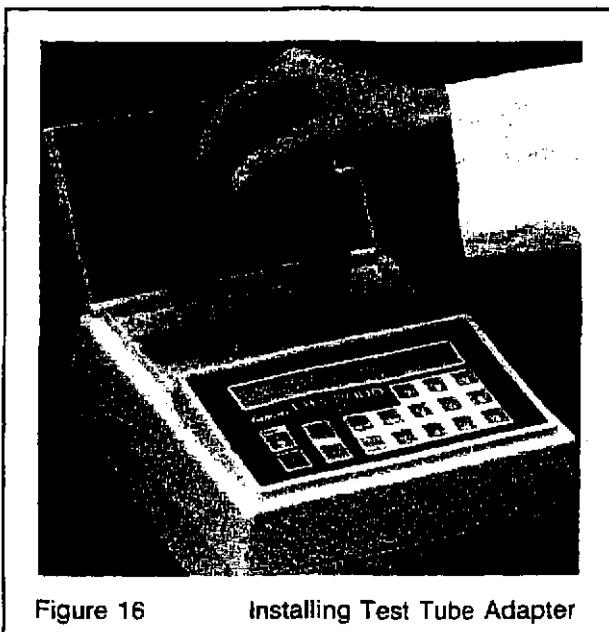


Figure 16 Installing Test Tube Adapter

### 3.13 Using a Printer

A permanent record of test results can be obtained by using the RS-232 serial output to drive a printer. Figure 17 provides a sample printout from the forty-column personal printer listed in the optional accessories in Section 6. When operating in the momentary mode, a data string will be transmitted to the printer at the end of a test cycle after the READ/ENTER key is pressed to obtain the sample measurement. Operation in the constant-on mode provides a printout according to the frequency selected and does not require the READ/ENTER keystroke. Refer to paragraph 3.7.3 Choosing Printer Output Frequency.

Because the spectrophotometer programming for printer operation provides for a carriage return and line feed, printers with carriage returns (CR) must be configured to avoid the carriage return. In the case of the Citizen printer listed as an optional accessory in Section 6, it means setting jumpers 1 through 5 of Preset Jumper 1. Refer to "Setting the Preset Jumper" in the Citizen Printer manual. The five jumpers of Preset Jumper 1 should be set as follows: jumpers 1, 2 and 4 open, jumpers 3 and 5 closed.

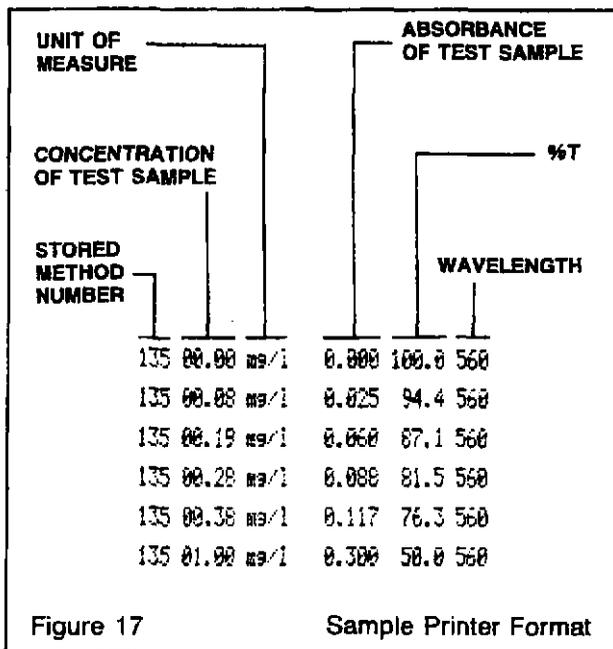


Figure 17 Sample Printer Format

### 3.14 Using a Recorder

The recorder output provided is 0 to 1 V and linear from 0 to 100 %T and 0 to 2 ABS units. It also is linear with concentration measurements. For the factory programmed calibrations, the full-scale limits are predetermined for each stored program. Refer to Table 2 for these settings when setting up the recorder. In user-entered calibrations, the recorder full scale is equal to the concentration of the last data point entered. The recorder output is in steps of 5 mV from 0 to 1 volt.

When using the DR/2000 Spectrophotometer with an analog recorder, the 100 percent output level at the recorder is set to a predetermined value for each stored program. Those values are shown below under "limit."

**Table 2. Full-Scale Limits**

#	limit	units	chemistry
009	.250	mg/l	aluminum (ECR)
010	1.00	mg/l	aluminum
020	125.	mg/l	barium
025	125.	mg/l	barium (AV)
030	20.0	mg/l	benzotriazole
040	15.0	mg/l	boron
050	5.00	mg/l	bromine
055	5.00	mg/l	bromine (AV)
060	200.	µg/l	cadmium
070	25.0	mg/l	chloride
072	1.25	mg/l	chlorine dioxide, (low range)
075	700.	mg/l	chlorine dioxide, (high range)
080	2.50	mg/l	chlorine, free & total
085	2.50	mg/l	chlorine, free & total (AV)
090	1.00	mg/l	chromium, hexavalent
095	1.00	mg/l	chromium, hexavalent (AV)
100	1.00	mg/l	chromium, total
105	25.0	g/l	chromium, trivalent
110	2.50	mg/l	cobalt
120	600.	units	color
130	15.0	ppm	copper in soil
135	6.00	mg/l	copper, Bicinch.
140	6.00	mg/l	copper, Bicinch. (AV)
145	250.	µg/l	copper, Porph.
160	.250	mg/l	cyanide
170	75.0	mg/l	cyanuric acid
180	500.	µg/l	diethylhydroxylamine
190	2.50	mg/l	fluoride
195	2.50	mg/l	fluoride, ampules
200	500.	µg/l	formaldehyde, (low range)
220	5.00	mg/l	hardness, calcium as CaCO <sub>3</sub>
221	2.00	mg/l	hardness, calcium
225	5.00	mg/l	hardness, magnesium as CaCO <sub>3</sub>
226	600.	mg/l	hardness, magnesium
230	600.	µg/l	hydrazine
240	7.50	mg/l	iodine
242	7.50	mg/l	iodine (AV)
250	75.0	ppm	iron in soil
255	3.50	mg/l	iron, ferrous
257	3.50	mg/l	iron, ferrous (AV)
260	1.50	mg/l	iron, total (FerroZine)
265	3.50	mg/l	iron, total (FerroVer)
267	3.50	mg/l	iron, total (FerroVer) (AV)
270	2.00	mg/l	iron, total (TPTZ)
272	2.00	mg/l	iron, total (TPTZ) (AV)
280	200.	µg/l	lead
283	200.	µg/l	lead, fast column extraction
286	75.0	µg/l	lead, anion exchange
290	.750	mg/l	manganese (low range)
295	25.0	mg/l	manganese (high range)
300	250.	ppm	manganese in soil
315	35.0	mg/l	molybdenum (low range)
320	40.0	mg/l	molybdate (high range)
330	8.00	g/l	nickel, autocatalytic
335	2.00	mg/l	nickel, heptoxime
340	1.20	mg/l	nickel, PAN
351	.500	mg/l	nitrate (low range)
353	5.00	mg/l	nitrate (medium range)
355	35.0	mg/l	nitrate (high range)
358	5.0	mg/l	nitrate (medium range) (AV)
360	35.0	mg/l	nitrate (high range) (AV)
363	2.00	%	nitrogen (nitrate) in plants, NV-V
366	75.0	ppm	nitrogen (nitrate) in soil
367	300.	Lbs/Ac	nitrogen (nitrate) in soil
368	350.	kg/ha	nitrogen (nitrate) in soil
371	.400	mg/l	nitrite (low range)
373	200.	mg/l	nitrite (high range)
375	.350	mg/l	nitrite (low range) (AV)
380	3.00	mg/l	nitrogen (ammonium) Nessler
385	.750	mg/l	nitrogen (ammonium) Sal Sea
391	500.	ppm	nitrogen (ammonium) in soil, A/F
392	1000.	Lbs/Ac	nitrogen (ammonium) in soil, A/F
393	1000.	kg/ha	nitrogen (ammonium) in soil, A/F
399	200.	mg/l	nitrogen, total Kjeldahl
410	100.	ppm	oil in water
420	6.00	%	organic matter in soil
430	200.	mg/l	oxygen demand, chemical, react.
435	2000.	mg/l	oxygen demand, chemical, react.
440	1000.	mg/l	oxygen demand, chemical, reflux
445	15.0	mg/l	oxygen, dissolved (high range)
446	1000.	µg/l	oxygen, dissolved (low range)
448	50.0	mg/l	oxygen, dissolved (s high range)
450	1.50	mg/l	ozone, DPD
452	1.50	mg/l	ozone, DPD (AV)
454	1.00	mg/l	ozone (indigo) (low range) (AV)
455	1.00	mg/l	ozone (indigo) (mid range) (AV)
456	2.00	mg/l	ozone (indigo) (high range) (AV)
460	300.	mg/l	palladium
470	.250	mg/l	phenols
480	50.0	mg/l	phosphate, reactive (molybd.)
481	20.0	mg/l	phosphorus, reactive (molybd.)
485	35.0	mg/l	phosphate, reactive (amino acid)
486	10.0	mg/l	phosphorus, reactive (amino acid)
490	3.00	mg/l	phosphate, reactive (PhosVer)
491	1.00	mg/l	phosphorus, reactive (PhosVer)
492	3.00	mg/l	phosphate, reactive (PhosVer) (AV)
493	1.00	mg/l	phosphorus, reactive (PhosVer) (AV)
500	30.0	mg/l	phosphonates
510	.500	%	phosphorus in plant tissue
521	1000.	ppm	phosphorus in soil PhosVer 3
522	500.	Lbs/Ac	phosphorus in soil PhosVer 3
523	600.	kg/ha	phosphorus in soil PhosVer 3
531	100.	ppm	phosphorus in soil PhosVer 4
532	200.	Lbs/Ac	phosphorus in soil PhosVer 4
533	200.	kg/ha	phosphorus in soil PhosVer 4
550	25.0	mg/l	polyacrylic acid LMW-10
555	25.0	mg/l	polyacrylic acid LMW-20
560	25.0	mg/l	polyacrylic acid LMW-45
630	800.	mg/l	residue, nonfilterable
640	1.50	mg/l	selenium
650	2.000	mg/l	silica (low range)
655	120.0	mg/l	silica (high range)
660	.75	mg/l	silver
670	1500.	mg/l	sodium chromate
680	75.0	mg/l	sulfate
685	75.0	mg/l	sulfate (AV)
690	.750	mg/l	sulfide
700	.500	%	sulfur (sulfate) in plant tissue
705	50.0	ppm	sulfur (sulfate) in soil
710	.300	mg/l	surfactant, anionic
720	10.0	mg/l	tannin & lignin
730	25.0	mg/l	tolyltriazole
750	500.	FTU	turbidity
770	3500.	mg/l	volatile acid
780	2.50	mg/l	zinc
790	25.0	ppm	zinc in soil

## SECTION 4 MAINTENANCE

### 4.1 Cleaning

#### 4.1.1 Spectrophotometer

The spectrophotometer and sample cells should be kept clean at all times and spills should be wiped up promptly. The photocell window, located on the left-hand side of the cell holder, can be wiped with lens tissue or a soft, lint-free cloth that will not leave an oil film.

#### 4.1.2 Sample Cells

Sample cells should be cleaned with detergent, rinsed several times with tap water and then rinsed thoroughly with deionized water. Sample cells used with organic solvents (chloroform, benzene, toluene, etc.) should be rinsed with acetone before the detergent wash and again as a final rinse before drying. If other special cleaning procedures are needed for a particular test, they are detailed in the test procedure.

#### 4.1.3 Pour-Thru Sample Cell

Remove the pour-thru cell occasionally to check for accumulation of film on the windows. If the windows appear dirty or hazy, soak in a detergent bath and then rinse thoroughly with deionized water. Always rinse thoroughly with deionized water between tests. Do not use solvents (e.g., acetone) to clean the pour-thru cell. The pour-thru cell can be disassembled for cleaning if necessary.

### 4.2 Replacement Instructions

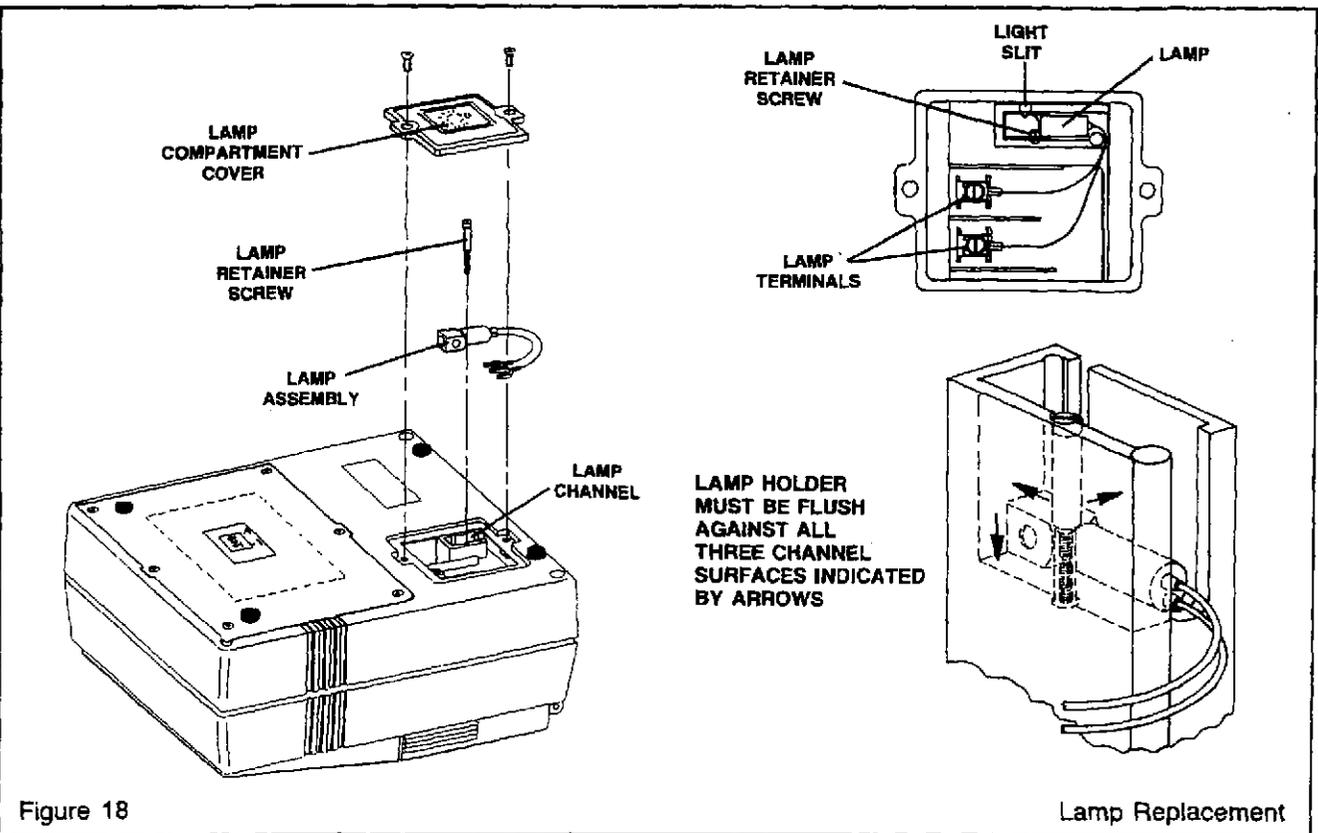
#### 4.2.1 Battery Replacement

The battery power source must be replaced or recharged whenever a LOW BATTERY message appears in the display. If D-size dry cell batteries are being used, all six should be replaced, and if a rechargeable battery is installed, recharge as soon as possible. Generally, 18 to 24 hours is adequate to return the battery to full charge. Refer to paragraph 2.2.2 for battery installation instructions for D-cell replacement.

#### 4.2.2 Lamp Replacement

If the monochromator lamp fails and must be replaced as determined by information in paragraph 5.2.4 LAMP OUT Display, proceed as follows.

1. Disconnect power to the instrument and empty the cell holder. Place the instrument upside down on a padded surface.
2. Remove the two screws securing the lamp compartment cover and remove the cover. See Figure 18.
3. Remove the lamp retainer screw and metal sleeve from the lamp channel. The sleeve is tapered at the bottom end and, because of its snug fit,



probably will need to be loosened with a tool (needle-nose pliers recommended) for removal. Remove the lamp. Loosen the two terminal screws to free the lamp leads.

4. Place the lamp in the lamp channel with the lamp light slit toward the light slit in the lamp channel. Push the lamp to the bottom of the lamp channel, install and firmly tighten the lamp retainer screw and sleeve in the channel to secure the lamp. The lamp must be held tightly in the proper position, flush against the bottom, end, and light slit side of the lamp channel. See Figure 18. Connect the lamp leads of the new lamp assembly at the lamp terminals (lead orientation does not matter). Do not overtighten.
5. Install the lamp compartment cover. Return the instrument to the upright position and restore power.

#### 4.3 Wavelength Accuracy Check

A wavelength accuracy check can be performed using a holmium based test solution. A premeasured volume of holmium trichloride powder, appropriate for 25 mL of the test solution, is available in powder pillow form for this test. This test is only a secondary check of the wavelength accuracy and does not indicate the absolute nanometer value.

1. Fill a clean sample cell with 25 mL of demineralized water. Add the contents of one Holmium Trichloride Powder Pillow and swirl to dissolve.
2. Call up the configure menu by pressing SHIFT CONFIG. When the display shows



use the edit keys to scroll for a display of:



3. Press READ/ENTER to accept the constant on mode and return to the method prompt:



4. Turn the Wavelength Control for a reading of 460 nm. Press READ/ENTER to enter the absorbance mode.
5. With the cell holder empty and the cell compartment cover closed, perform a zero calibration by pressing ZERO.
6. Insert the sample cell containing the Holmium Solution into the cell holder and close the cell compartment cover.
7. Slowly turn the Wavelength Control counterclockwise in 1-nm increments, pausing between increments and watching the display for a peak reading. Note the approximate nanometer value at the peak. Return to a somewhat higher wavelength and repeat the process until you can stop the control with the highest absorbance value displayed. Always approach the peak value from the high wavelength side (turning counterclockwise). Without moving the control from its peak setting, read the wavelength setting. If the wavelength at the peak is  $451 \pm 5$  nm, the instrument wavelength is accurately adjusted.

#### NOTE

This test is only a "secondary" check of the wavelength accuracy and does not necessarily indicate the absolute value for the DR/2000 Spectrophotometer which is factory set at  $\pm 2$  nm or better.

# SECTION 5 TROUBLESHOOTING

## 5.1 Introduction

Correcting problem conditions with the DR/2000 Spectrophotometer in the field is limited to responding to the error messages presented in the display. Any other problems must be handled by a Hach technician at a service center. Refer to Section 7, Repair Service. Do not attempt any servicing other than battery and lamp replacement. There are no other field-serviceable parts. Opening the instrument case will void the warranty.

## 5.2 Error Messages

### 5.2.1 INCORRECT # Display

When the instrument displays:



it indicates that the reference number keyed in is not available for the operation expected. If a method number is being keyed in and the incorrect number message appears, it may be caused by a mis-keyed number or from attempting to enter a number in the configure series (800—900). When the instrument is in the configure mode, only numbers for configure options may be keyed in. Refer to paragraph 3.4. User-entered method numbers must range from 950 to 999. Entering a number outside the appropriate range for these procedures will result in the incorrect number message. When this error message is displayed, re-enter the proper number or scroll to the desired method or option.

### 5.2.2 OVER-RANGE Display

The display:



indicates that the displayed absorbance or concentration value exceeds the range of valid results. To indicate an erroneous negative result, the numeric display will show all zeros with a negative sign. Make sure the test procedure is followed correctly and rerun the test. Each Hach test has an upper absorbance value beyond which results are unreliable. If the test results exceed that limit by more than one-eighth of an absorbance unit, the over-range message appears and the test should be repeated.

### 5.2.3 LOW BATTERY Display

The instrument performs a battery test continuously. If the battery voltage of the rechargeable lead-acid battery falls to a level indicating less than ten percent battery life remaining, it will automatically warn the operator every five minutes by beeping once, displaying the message



for two seconds, beeping once again and then returning the display to normal. The warning will be repeated every five minutes. When the battery voltage falls below 7.2 volts, the instrument will switch to the momentary mode if it was not already in that mode. Then when the voltage drops below 7.0 volts, the instrument will turn on, display "Low Battery" and turn off. The batteries should be replaced, or if a rechargeable battery is installed, recharged as soon as possible to avoid losing test results or obtaining results that are not accurate. Refer to paragraph 2.2.2 for battery installation instructions.

The condition of the battery power source can be checked manually at any time by pressing SHIFT BATT. The battery voltage will be displayed in the large digits and a bar graph indication of the battery life will be displayed in the text section of the display. For example:



indicates a battery voltage of 8.0 volts and a battery life bar running half the width of the 16-character section for 50-percent life still remaining. The battery life indication, however, applies only to a lead-acid rechargeable battery. To cancel the battery condition display and return the instrument to its previous condition, press READ/ENTER.

### 5.2.4 LAMP OUT Display

If the monochromator lamp burns out or does not supply adequate light to provide a measurement, the display will read:



indicating that the lamp may need to be replaced. If the lamp will not light, it must be replaced. However, if the lamp is lit when the LAMP OUT ? message

appears, there are three possible conditions that could cause this message.

First, light reaching the photodetector is not adequate to make the measurement. The sample being measured may have too high an absorbance. This would be most likely to occur when operating at the low end of the wavelength range. Or, if a cell adapter is being used, it may be positioned in the cell holder improperly. Empty the cell compartment and determine if the message remains. If the absorbance was too high, sample dilution may be appropriate. Again the problem could be a deteriorating lamp that should be replaced.

Second, the lamp may be blackened to the extent that it will no longer supply sufficient light. Replacement of the lamp as described in paragraph 4.2.2 will correct the problem.

Third, the problem could be low lamp voltage. If a new lamp has been installed and the message remains in the display, this condition is likely. Because there is no gain adjustment the operator can make, contact a Hach service center for assistance.

### 5.2.5 MEMORY ERROR Display

When the display shows:



it indicates a probable condition where there is low supply voltage or an electrostatic discharge has occurred that interfered with operation of the instrument memory. The first step in determining the trouble is to disconnect power to the instrument. This means disconnecting the battery eliminator/charger cable from the POWER jack and, if a battery pack is installed, the battery cable inside the battery compartment must be disconnected. Now reconnect power, both the eliminator/charger cable and the battery cable if batteries are installed. If the memory error message is no longer displayed, the problem was transient and no permanent damage has occurred. The instrument will now operate properly.

If the message is displayed again after power is restored, additional investigation is necessary. If the instrument was operating on battery power only when the error message appeared, install fresh, fully charged batteries or use the battery eliminator/charger unit and perform the reset as described in paragraph 5.2.6, Restoring Factory Settings. The instrument should now return to normal operation.

If the instrument was operating on the battery eliminator/charger when the memory error message appeared, disconnect that unit and install batteries. If the instrument returns to normal operation, the

problem is due to low line voltage or the battery eliminator/charger unit malfunctioned.

If the memory error message occurs even with the batteries installed, perform the reset procedure in paragraph 5.2.6. If the instrument returns to normal operation after the reset, reconnect the battery eliminator/charger to recheck that unit. If the error message appears again, the problem is due to low line voltage or a faulty battery eliminator/charger.

A memory error display with a W requires attention by a trained service representative. Please contact the Hach service center or distributor serving you.

### 5.2.6 Restoring Factory Settings

This procedure allows the operator to erase all user-entered settings and calibrations to return to the original factory settings. It only applies to the three latest software configurations of the DR/2000 Spectrophotometer, v1.270, v2.0 and v2.2.

#### CAUTION

**DO NOT perform this procedure if your software configuration number is v1.261. Monochromator calibration will be lost, requiring the instrument to be returned to the factory for recalibration.**

To determine which software version you have, proceed as follows:

1. Press the POWER key to turn the instrument on.
2. Press the SHIFT and CONFIG keys.
3. Enter 888 and then press the READ/ENTER key. After three seconds, the software configuration number will appear in the display.

To perform the reset for v1.270, v2.0 and v2.2 software configurations, proceed as follows. **Be aware that all user-stored calibrations and settings will be lost.**

1. Press the POWER key to turn on the instrument.
2. Press the SHIFT and CONFIG keys.
3. Enter 888 and then press the READ/ENTER key. After three seconds, the software configuration number will be displayed.

#### CAUTION

**If your software number is v1.261, do not continue.**

4. Press the SHIFT and CONFIG keys again.
5. Enter 888 and then press READ/ENTER. Within two seconds, enter 357.
6. Turn the instrument off and back on. The factory settings will be restored and all user-entered methods and options will be erased.

## **SECTION 6      REPLACEMENT PARTS AND ACCESSORIES**

<b>Cat. No.</b>	<b>Description</b>	<b>Unit</b>
43784-00	Adapter, AccuVac Vial	each
44799-00	Adapter Kit, COD Vial	each
44798-00	Adapter Kit, test tube, 13-mm	each
45168-00	Battery Eliminator/Charger	each
44866-00	Battery Holder, for 6 D cells	each
23432-67	Holmium Trichloride Powder Pillows	10
45218-00	Lamp Assembly Kit, includes Holmium Trichloride Powder Pillow	each
44800-88	Manual Set, includes: Instrument Manual Procedures Manual Three-Ring Binder	each
20950-00	Sample Cells, 1-inch, matched pair	each
21228-00	Zeroing Vial, AccuVac, w/cap	each

### **OPTIONAL ACCESSORIES**

44895-00	Adapter, 1-cm cuvette	each
11494-54	Batteries, D size, pkg of 4	each
45185-00	Battery, rechargeable, 8 V	each
45193-00	Cable Assembly, printer	each
45215-00	Pour-Thru Sample Cell	each
45194-00	Recorder Output Phone Plug	each
16084-00	RS-232 Interface Phone Plug	each
45192-00	Printer, 115 V	each
13537-02	Sample Cell, 1-inch, unmatched pair	each
20951-00	Sample Cells, 1-cm, matched pair	each
24102-12	Sample Cells, Disposable, 1-inch Polystyrene, with caps	pkg/12
272-17	Water, deionized	3.78 L

## **SECTION 7 REPAIR SERVICE**

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For service assistance on your instrument, please contact the Hach Factory Service Center in Ames, Iowa, first for arrangements. Call toll-free **800-227-4224** and request Instrument Repair. If you are located in Canada, contact instead the Hach Sales & Service Canada Ltd., Winnipeg, Manitoba, for arrangements. The toll-free number is **800-665-7635**.

### **Hach Factory Service Center**

Hach Company  
100 Dayton Ave.  
P.O. Box 907  
Ames, Iowa 50010  
(515)232-2533  
FAX: (515)232-1276

### **Hach Canada Service Centre**

Hach Sales & Service Canada Ltd.  
1313 Border Street, Unit 34  
Winnipeg, Manitoba  
R3H 0X4  
(204)632-5598  
FAX: (204)694-5134

In Latin America, the Caribbean, the Far East or the Pacific Basin, please contact Hach Company, World Headquarters, P.O. Box 389, Loveland, Colorado 80539 U.S.A. Telephone (303)669-3050, Telex 160840, FAX (303)669-2932. Customers located in Europe, the Middle East or Near East, or in Africa, please contact Hach Europe, S.A./N.V., B.P. 229, B5000 Namur 1, Belgium. Telephone (32)(81)44.53.81, Telex (846)59027, FAX (32)(81)44.13.00.

## **SECTION 8                      WARRANTY**

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Seller warrants equipment of its manufacture against defective materials or workmanship for a period of one year from date of shipment.

The liability of Seller under this warranty is limited, at Seller's option, solely to (1) repair, (2) replacement with equivalent Hach products, or (3) an appropriate credit adjustment not to exceed the original sales price of products returned to the Seller, provided that:

- a. Buyer promptly notifies Seller in writing on discovery of the defects, stating where applicable, the product type and serial numbers and fully describing the circumstances giving rise to the claim. Seller must receive such notification within the applicable warranty period in order for this warranty to apply.
- b. On receipt of written instructions from Seller, Buyer returns the equipment as instructed with transportation charges prepaid by the Buyer; and
- c. Seller's examination of such equipment discloses to its satisfaction that the defects have not resulted from any negligence, misuse, improper installation, accident or unauthorized repair or alteration by the Buyer. Seller's determination of the cause and nature of the failure of the equipment shall be final.

This warranty does not include limited life electrical components which deteriorate with age such as

batteries, lamps, photocells, electrodes, etc. In the case of equipment and accessories not manufactured by the Seller, but which are furnished with equipment of Seller's manufacture, Seller's liability is limited to whatever warranty is extended by the manufacturers thereof and transferable to the Buyer. **This warranty is applicable to the original Buyer only and shall be in lieu of and exclude all other warranties, expressed or implied, including, but not limited to, any implied warranty of merchantability or fitness. The foregoing shall constitute the sole and exclusive remedy of Buyer and the sole and exclusive liability of Seller, whether Buyer's claims shall be for breach of warranty or negligence. Seller neither assumes nor authorizes any person to assume for it any other obligation or liability in connection with the sale of the equipment. In no event shall Seller be liable for special, incidental or consequential damages.**

In no event shall Seller be liable for any damage resulting from improper handling or storage by Buyer.

If Seller finds that Buyer has returned the equipment without cause, Seller shall notify Buyer and return the equipment at Buyer's expense; in addition, Seller may, at its sole discretion, impose a charge for testing and examination of any equipment so returned.

# USER-ENTERED CALIBRATIONS WORKSHEET

Test Name: \_\_\_\_\_ Test Method: \_\_\_\_\_ Date: \_\_\_\_\_ By: \_\_\_\_\_

METHOD #?

**BEGIN USER PROGRAM MODE**

Press SHIFT PROG METH.

Record the number displayed by the DR/2000: →



ENTER nm

**ENTER THE WAVELENGTH**

Key in the desired wavelength value and record it here: →

Make corrections by pressing SHIFT CLEAR and re-entering the wavelength.

When you have correctly keyed the wavelength, press READ/ENTER.



DECIMAL? 00.00

**POSITION THE DECIMAL POINT**

Use the arrow keys to position the decimal point; record it here: →

Press READ/ENTER to accept the decimal position.



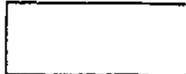
UNITS? ↓

**SELECT THE UNIT OF MEASUREMENT**

Use the arrow keys to select the desired unit, record it here: →

To construct a unit of measure - accept blank field; go to next step.

Press READ/ENTER to accept the unit or blank selection.



SYMBOL? ↓

**CONSTRUCT THE CHEMICAL SYMBOL**

Use the arrow keys to select the characters.

Press READ/ENTER to accept each character.

Make corrections with SHIFT LEFTARROW or SHIFT CLEAR.

When completed, record both unit and symbol here: →

Press READ/ENTER to record the entire construction.



TIMER?

**SET THE TIMERS (OPTIONAL)**

To bypass entry of the optional timers, press READ/ENTER at the timer prompt.

If you wish to set timers, press SHIFT TIMER.

Record each timer you have set in the spaces below:

Enter all four digits including leading zeroes.

MM:SS TIMER 1 ?		MM:SS TIMER 3 ?	
MM:SS TIMER 2 ?		MM:SS TIMER 4 ?	

Press READ/ENTER when you have completed entering timer values.

ZERO SAMPLE

**PERFORM A ZERO CALIBRATION**

Insert a prepared blank sample and press ZERO.

# 0 STANDARD

**SET THE ZERO CONCENTRATION POINT**

Leave the blank sample in the well and press READ/ENTER.

Begin calculation of the concentration - absorbance zero point by pressing READ/ENTER.

Accept the zero point by pressing READ/ENTER

**ENTER THE ABSORBANCE - CONCENTRATION DATA PAIRS.**

Enter the concentration values of your prepared samples in the table below.

Follow the steps outlined for entry and calculation of each point.

To reject a calculated point - re-enter the concentration value.

	Press to begin point	Enter & record Concentration	Press	Record Displayed Absorbance	Press to accept point
# 1 STANDARD	READ/ENTER		READ/ENTER		READ/ENTER
# 2 STANDARD	READ/ENTER		READ/ENTER		READ/ENTER
# 3 STANDARD	READ/ENTER		READ/ENTER		READ/ENTER
# 4 STANDARD	READ/ENTER		READ/ENTER		READ/ENTER
# 5 STANDARD	READ/ENTER		READ/ENTER		READ/ENTER
# 6 STANDARD	READ/ENTER		READ/ENTER		READ/ENTER
# 7 STANDARD	READ/ENTER		READ/ENTER		READ/ENTER
# 8 STANDARD	READ/ENTER		READ/ENTER		READ/ENTER
# 9 STANDARD	READ/ENTER		READ/ENTER		READ/ENTER
# 10 STANDARD	READ/ENTER		READ/ENTER		READ/ENTER
# 11 STANDARD	READ/ENTER		READ/ENTER		READ/ENTER
# 12 STANDARD	READ/ENTER		READ/ENTER		READ/ENTER
# 13 STANDARD	READ/ENTER		READ/ENTER		READ/ENTER
# 14 STANDARD	READ/ENTER		READ/ENTER		READ/ENTER
# 15 STANDARD	READ/ENTER		READ/ENTER		READ/ENTER
# 16 STANDARD	READ/ENTER		READ/ENTER		READ/ENTER

**END USER PROGRAM MODE**

When you have entered at least one point but not more than sixteen points

conclude the entry of data pairs by pressing SHIFT READ/ENTER

METHOD #?

**SELECT A METHOD**

At the method prompt you may now select your new method and perform a test.

# SYSTEMS FOR ANALYSIS

## AUTOMATIC ANALYZERS FOR

ALKALINITY  
CALCIUM IN BRINE  
CHELANT  
CHLORINE  
CHLORINE DIOXIDE  
CONDUCTIVITY  
COPPER  
HARDNESS  
HEXAVALENT CHROMIUM  
HYDRAZINE  
IRON  
MANGANESE<sup>+7</sup>  
OZONE  
pH  
PHOSPHATE  
POTASSIUM PERMANGANATE  
SILICA

## TURBIDIMETERS

## pH AND CONDUCTIVITY METERS

## PORTABLE INSTRUMENTS

## PORTABLE TEST KITS

## LABORATORY APPARATUS

## REAGENTS



*The Analytical Methods Company*

**HACH COMPANY WORLD HEADQUARTERS**  
P.O. Box 389  
Loveland, CO 80539 USA  
Phone: (303) 669-3050  
Telex: 160840  
FAX: (303) 669-2932

**HACH COMPANY**  
P.O. Box 907  
Ames, Iowa 50010 U.S.A.  
Phone: (515) 232-2533  
FAX: (515) 232-1276

**HACH EUROPE S.A./N.V.**  
B.P. 229, B5000 Namur 1  
Belgium  
Phone: (32)(81)44.53.81  
Telex: 846-59027  
FAX: (32)(81)44.13.00

*International distributors and sales agents in principal cities worldwide*

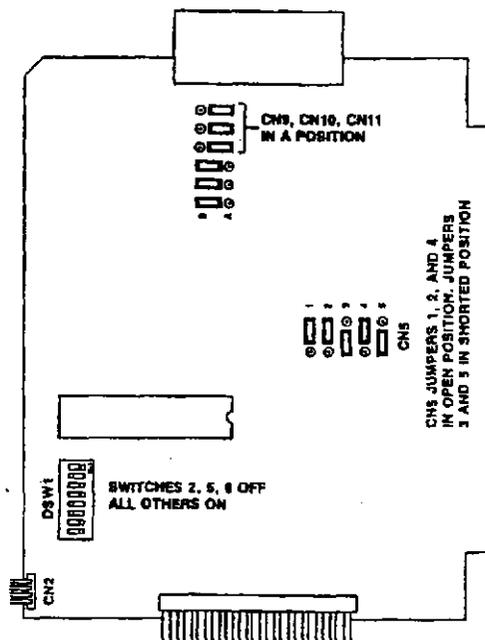
## MANUAL CHANGE NOTICE

Changes made to the optional Citizen Printer offered by Hach affect the instructions given in *paragraph 3.13 Using a Printer* in the DR/2000 Spectrophotometer Instrument Manual. Paragraph 3.13 (on page 22) should now read as follows. The change bar in the right hand margin indicates where the copy was changed.

## 3.13 Using a Printer

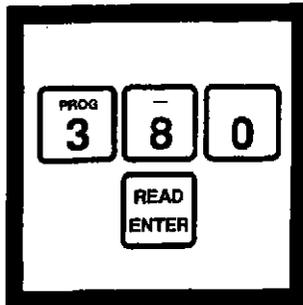
A permanent record of test results can be obtained by using the RS232 serial output to drive a printer. Figure 17 provides a sample printout from the forty-column personal printer listed in the optional accessories in Section 6. When operating in the Momentary mode, a data string will be transmitted to the printer at the end of a test cycle after the READ-ENTER key is pressed to obtain the sample measurement. Operation in the Constant On mode provides a printout according to the frequency selected and does not require the READ-ENTER keystroke. Refer to paragraph 3.7.3 *Choosing Printer Output Frequency*.

Because the spectrophotometer programming for printer operation provides for a carriage return and line feed, printers with carriage returns (CR) must be configured to avoid the carriage return. In the case of the Citizen printer listed as an optional accessory in Section 6, it means setting switch and jumper positions on the Citizen 560RSL II printer board as follows. Set CN5 jumpers 1, 2 and 4 to open (to the right as viewed when reading CN5) and CN5 jumpers 3 and 5 to the shorted position (left). Set jumpers CN9, CN10 and CN11 to position "A". CN6, CN7 and CN8 should remain in position "B". Set all DSW1 switches **except** #2, #5 and #6 to ON. Refer to the drawing below and to "Setting of Preset Jumper" in the Citizen Printer manual.



# NITROGEN, AMMONIA (0 to 2.50 mg/L NH<sub>3</sub>-N) For water, wastewater\* and seawater\*

Nessler Method\*\*, USEPA accepted for reporting wastewater analysis (distillation is required)\*\*\*



1. Enter the stored program number for ammonia nitrogen (NH<sub>3</sub>-N).

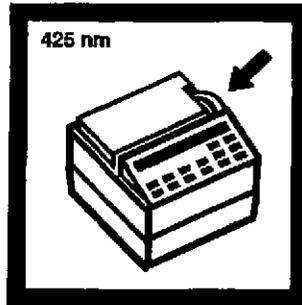
Press: **3 8 0 READ/ENTER**

The display will show:  
**DIAL nm TO 425**

*Note:* DR/2000s with software versions 3.0 and greater will display "P" and the program number.

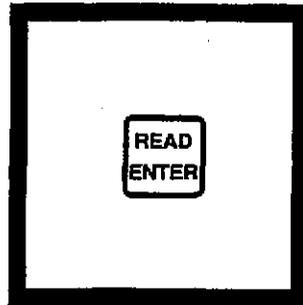
*Note:* Instruments with software versions 3.0 and greater will not display "DIAL nm TO" message if the wavelength is already set correctly. The display will show the message in Step 3. Proceed with Step 4.

*Note:* If samples cannot be analyzed immediately, see Sampling and Storage following these steps. Adjust pH of stored samples before analysis.



2. Rotate the wavelength dial until the small display shows:  
**425 nm**

*Note:* This test is sensitive to the wavelength setting. To assure accuracy, run the test using a 1.0 mg/L standard solution and demineralized water blank. Repeat Steps 9 to 12 at slightly different wavelengths, setting the dial from higher to lower values, until the correct result is obtained. The wavelength should be 425 ±2 nm. Always set this wavelength by approaching from high to low values.



3. Press: **READ/ENTER**

The display will show:  
**mg/l N NH<sub>3</sub> Ness**



4. Fill a 25-mL graduated mixing cylinder to the 25-mL mark with sample (the prepared sample).

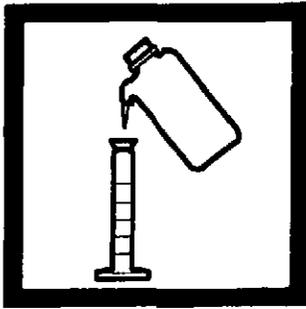
*Note:* For proof of accuracy, use a 1.0-mg/L Nitrogen Ammonia Standard Solution (listed under Optional Reagents) in place of the sample.

\*Requires distillation

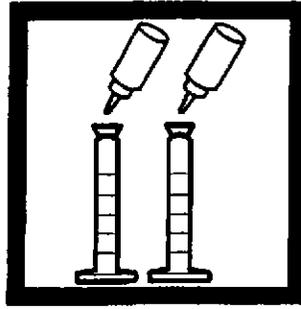
\*\* Adapted from *Standard Methods for the Examination of Water and Wastewater*.

\*\*\*Procedure is equivalent to USEPA method 350.2 and Standard Method 4500-NH<sub>3</sub> B and C for wastewater.

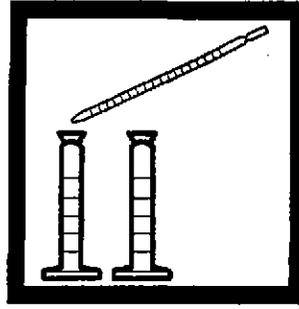
# NITROGEN, AMMONIA, continued



**5.** Fill another 25-mL mixing graduated cylinder with demineralized water (the blank).



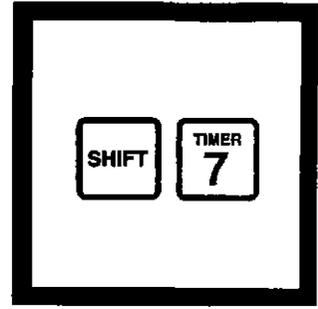
**6.** Add three drops of Mineral Stabilizer to each cylinder. Invert several times to mix. Add three drops of Polyvinyl Alcohol Dispersing Agent to each cylinder (hold the dropping bottle exactly vertical). Invert several times to mix.



**7.** Pipet 1.0 mL of Nessler Reagent into each cylinder. Stopper. Invert several times to mix.

*Note: Nessler Reagent is toxic and corrosive. Pipet carefully and use a pipet filler.*

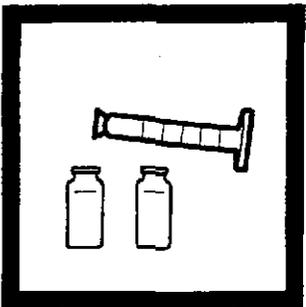
*Note: A yellow color will develop if ammonia is present. (The reagent will cause a faint yellow color in the blank.)*



**8.** Press: **SHIFT TIMER**

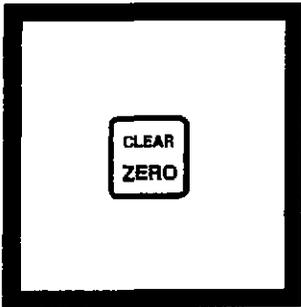
A 1-minute reaction period will begin.

*Note: Continue with Step 9 while timer is running.*



**9.** Pour each solution into respective blank and prepared sample cells.

*Note: The Pour-Thru Cell can be used with this procedure. If the Pour-Thru Cell Assembly Kit is used, periodically clean the cell by pouring a few sodium thiosulfate pentahydrate crystals into the cell funnel. Flush it through the funnel and cell with enough demineralized water to dissolve. Rinse out the crystals.*

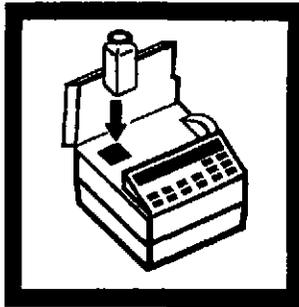


**10.** When the timer beeps, the display will show:  
**mg/l N NH<sub>3</sub> Ness**  
Place the blank into the cell holder. Close the light shield.

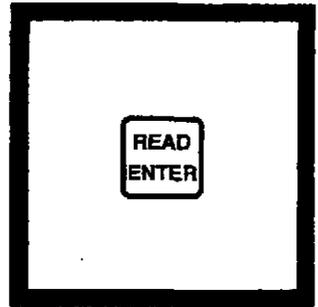
Press: **ZERO**

The display will show:  
**WAIT**

then:  
**0.00 mg/l N NH<sub>3</sub> Ness**



**11.** Place the prepared sample into the cell holder. Close the light shield.



**12.** Press: **READ/ENTER**

The display will show:  
**WAIT**  
then the result in mg/L ammonia expressed as nitrogen (NH<sub>3</sub>-N) will be displayed.

*Note: Do not wait more than five minutes after reagent addition (Step 7) before performing Step 12.*

*Note: The results may be expressed as mg/L ammonia (NH<sub>3</sub>) or mg/L ammonium (NH<sub>4</sub><sup>+</sup>) by multiplying the result by 1.22 or 1.29 respectively.*

*Note: In the constant-on mode, pressing READ/ENTER is not required. WAIT will not appear. When the display stabilizes, read the result.*

# NITROGEN, AMMONIA, continued

## SAMPLING AND STORAGE

Collect samples in clean glass or plastic bottles. If chlorine is present, add one drop of 0.1 N sodium thiosulfate for each 0.3 mg/L  $\text{Cl}_2$  in a 1-liter sample. Preserve the sample by reducing the pH to 2 or less with sulfuric acid (at least 2 mL). Store at 4 °C (39 °F) or less. Preserved samples may be stored up to 28 days. Before analysis, warm samples to room temperature and neutralize with 5 N sodium hydroxide. Correct the test result for volume additions (see *Correction for Volume Additions in Section I*).

## ACCURACY CHECK

### Standard Additions Method

- a) Snap the neck off a Nitrogen Ammonia Voluette Ampule Standard Solution, 50 mg/L  $\text{NH}_3\text{-N}$ .
- b) Use the TenSette Pipet to add 0.1, 0.2 and 0.3 mL of standard to three 25-mL samples. Mix each thoroughly.
- c) Analyze each sample as described above. The nitrogen concentration should increase 0.20 mg/L for each 0.1 mL of standard added.
- d) If these increases do not occur, see *Standard Additions in Section I* for more information.

### Standard Solution Method

To check accuracy, use a 1.0-mg/L  $\text{NH}_3\text{-N}$  Nitrogen Ammonia Standard Solution listed under *Optional Reagents*. Or, this can be prepared by diluting 1.00 mL of solution from a Voluette Ampule Standard For Nitrogen Ammonia to 50.0 mL with demineralized water.

## PRECISION

In a single laboratory, using standard solutions of 1.00 mg/L ammonia nitrogen ( $\text{NH}_3\text{-N}$ ) and two representative lots of reagent with the DR/2000, a single operator obtained a standard deviation of  $\pm 0.015$  mg/L.

## INTERFERENCES

A solution containing a mixture of 500 mg/L  $\text{CaCO}_3$  and 500 mg/L Mg as  $\text{CaCO}_3$  does not interfere. If the hardness concentration exceeds these concentrations, extra Mineral Stabilizer should be added.

Iron and sulfide interfere by causing a turbidity with Nessler Reagent.

Residual chlorine must be removed by addition of sodium arsenite solution. Use two drops to remove each mg/L Cl from a 250-mL sample. Sodium thiosulfate can be used in place of sodium arsenite. See *Sampling and Storage* section.

Less common interferences, such as glycine, various aliphatic and aromatic amines, organic chloramines, acetone, aldehydes and alcohols may cause greenish or other off colors or turbidity. It may be necessary to distill the sample if these compounds are present.

Seawater samples may be analyzed by addition of 1.0 mL (27 drops) of Mineral Stabilizer to the sample before analysis. This will complex the high magnesium concentrations found in sea water, but the sensitivity of the test will be reduced by 30 percent due to the high chloride concentration. For best results, perform a calibration, using standards spiked to the equivalent chloride concentration, or distill the sample as described below.

## DISTILLATION

- a) Measure 250 mL of sample into a 250-mL graduated cylinder and pour into a 400-mL beaker. Destroy chlorine, if necessary, by adding 2 drops of Sodium Arsenite Solution per mg/L  $\text{Cl}_2$ .
- b) Add 25 mL of Borate Buffer Solution and mix. Adjust the pH to about 9.5 with 1.0 N Sodium Hydroxide Standard Solution. Use a pH meter.
- c) Set up the general purpose distillation apparatus as shown in the *Hach Distillation Apparatus Manual*. Pour the solution into the distillation flask. Add a stir bar.
- d) Use a graduated cylinder to measure 25 mL of demineralized water into a 250-mL erlenmeyer flask. Add the contents of one Boric Acid Powder Pillow. Mix thoroughly. Place the flask under the still drip tube. Elevate so the end of the tube is immersed in the solution.
- e) Turn on the heater power switch. Set the stir control to 5 and the heat control to 10. Turn on the water and adjust to maintain a constant flow through the condenser.
- f) Turn off the heater after collecting 150 mL of distillate. Immediately remove the collection flask to avoid sucking solution into the still. Measure the distillate to assure 150 mL was collected (total volume 175 mL).
- g) Adjust the pH of the distillate to about 7 with 1.0 N Sodium Hydroxide Standard Solution. Use a pH meter.
- h) Pour the distillate into a 250-mL volumetric flask. Rinse the erlenmeyer with several small volumes of demineralized water and add the rinsings to the volumetric flask.

# NITROGEN, AMMONIA, continued

i) Dilute to the mark with ammonia-free demineralized water. Stopper. Mix thoroughly. Analyze as described above.

## SUMMARY OF METHOD

The Mineral Stabilizer complexes hardness in the sample. The Polyvinyl Alcohol Dispersing Agent aids the color formation in the reaction of Nessler Reagent with ammonium ions. A yellow color is formed proportional to the ammonia concentration.

## REQUIRED REAGENTS

Description	Quantity Required Per Test	Units	Cat. No.
Nessler Reagent	2 mL	500 mL	21194-49
Mineral Stabilizer	6 drops	59 mL* SCDB	23766-26
Polyvinyl Alcohol Dispersing Agent	6 drops	59 mL* SCDB	23765-26
Water, demineralized	25 mL	4 L	272-56

## REQUIRED APPARATUS

Cylinder, graduated, mixing, tall form, 25 mL	2	each	21190-40
Pipet, serological, 1 mL	2	each	532-35
Pipet Filler, safety bulb	1	each	14651-00

## OPTIONAL REAGENTS

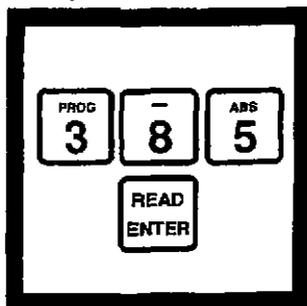
Borate Buffer Solution		1000 mL	14709-53
Boric Acid Powder Pillows		50/pkg	14817-66
Nitrogen, Ammonia Standard Solution, 1 mg/L NH <sub>3</sub> -N		500 mL	1891-49
Nitrogen, Ammonia Standard Solution, Voluette Ampule, 50 mg/L NH <sub>3</sub> -N		16/pkg	14791-10
Sodium Arsenite Solution, 5 g/L		100 mL MDB	1047-32
Sodium Hydroxide Standard Solution, 5.0 N		100 mL* MDB	2450-32
Sodium Hydroxide Standard Solution, 1.0 N		100 mL* MDB	1045-32
Sodium Thiosulfate Solution, 0.1 N		100 mL* MDB	323-32
Sulfuric Acid, ACS		500 mL*	979-49

## OPTIONAL APPARATUS

Ampule Breaker Kit		each	21968-00
Beaker, 400 mL		each	500-48
Cylinder, graduated, 25 mL		each	508-40
Cylinder, graduated, 250 mL		each	508-46
Distillation apparatus general purpose accessories		each	22653-00
Distillation heater and support apparatus set, 115 V		each	22744-00
Distillation heater and support apparatus set, 230 V		each	22744-02
Dropper, plastic, 0.5 and 1.0-mL marks		10/pkg	21247-10
Flask, erlenmeyer, 250-mL		each	505-46
Flask, volumetric, 50 mL		each	547-41
Flask, volumetric, 250 mL		each	547-46
pH Meter, EC10, portable		each	50050-00
Pipet, serological, 2 mL		each	532-36
Pipet, TenSette, 0.1 to 1.0 mL		each	19700-01
Pipet Tips, for 19700-01 TenSette Pipet		50/pkg	21856-96
Pipet, volumetric, Class A, 1 mL		each	14515-35
Pour-Thru Cell Assembly Kit		each	45215-00
Thermometer, -20 to 105 °C		each	1877-01

For additional ordering information, see final section.  
In the U.S.A. call 800-227-4224 to place an order.

\*Contact Hach for larger sizes.

**NITROGEN, AMMONIA** (0 to 0.50 mg/L  $\text{NH}_3\text{-N}$ ) For water, wastewater and seawater**Salicylate Method\***

1. Enter the stored program number for ammonia nitrogen ( $\text{NH}_3\text{-N}$ ), salicylate method.

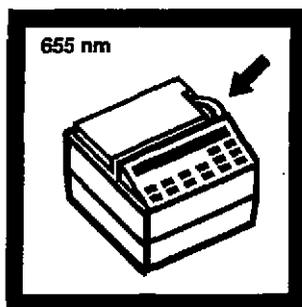
Press: **3 8 5 READ/ENTER**

The display will show:  
**DIAL nm TO 655**

*Note: DR/2000s with software versions 3.0 and greater will display "P" and the program number.*

*Note: Instruments with software versions 3.0 and greater will not display "DIAL nm TO" message if the wavelength is already set correctly. The display will show the message in Step 3. Proceed with Step 4.*

*Note: If samples cannot be analyzed immediately, see Sampling and Storage following these steps. Adjust pH of stored samples before analysis.*



2. Rotate the wavelength dial until the small display shows:  
**655 nm**



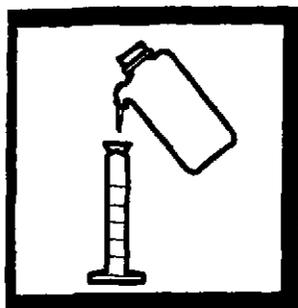
3. Press: **READ/ENTER**  
The display will show:  
**mg/l N  $\text{NH}_3$  Salic**



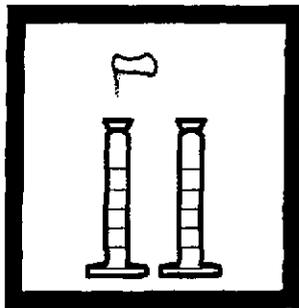
4. Pour 25 mL of sample into a 25-mL graduated mixing cylinder (the prepared sample).

*Note: For proof of accuracy, use a 0.20 mg/L  $\text{NH}_3\text{-N}$  solution (preparation given in the Accuracy Check) in place of the sample.*

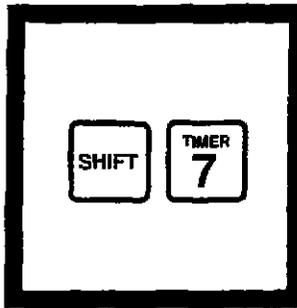
## NITROGEN, AMMONIA, continued



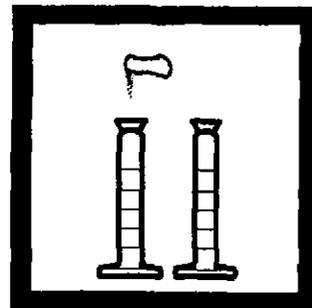
5. Add 25 mL of demineralized water into a second cylinder (the blank).



6. Add the contents of one Ammonia Salicylate Reagent Powder Pillow to each cylinder. Stopper. Shake to dissolve.

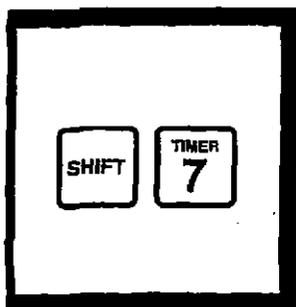


7. Press: **SHIFT TIMER**  
A 3-minute reaction period will begin.

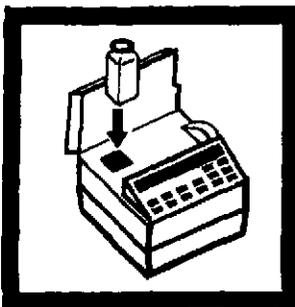


8. When the timer beeps, add the contents of one Ammonia Cyanurate Reagent Powder Pillow to each cylinder. Stopper. Shake to dissolve.

*Note: A green color will develop if ammonia nitrogen is present.*



9. Press: **SHIFT TIMER**  
A 15-minute reaction period will begin.

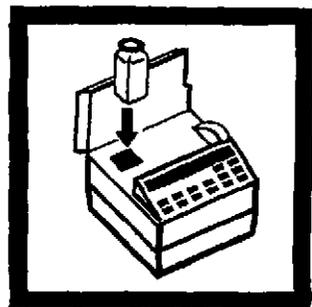


10. When the timer beeps, pour the blank into a sample cell. Place the cell into the cell holder. Close the light shield.

*Note: The Pour-Thru Cell can be used with this procedure.*



11. Press: **ZERO**  
The display will show:  
**WAIT**  
then:  
**0.00 mg/l N NH<sub>3</sub> Salic**



12. Fill a second cell with the prepared sample. Place the cell into the cell holder. Close the light shield.

## NITROGEN, AMMONIA, continued

---



### 13. Press: **READ/ENTER**

The display will show:

**WAIT**

then the result in mg/L ammonia as nitrogen ( $\text{NH}_3\text{-N}$ ) will be displayed.

*Note: Results may be expressed as mg/L ammonia ( $\text{NH}_3$ ) or mg/L ammonium ( $\text{NH}_4^+$ ) by multiplying the above result by 1.22 or by 1.29, respectively.*

*Note: In the constant-on mode, pressing READ/ENTER is not required. WAIT will not appear. When the display stabilizes, read the result.*

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### SAMPLING AND STORAGE

Collect samples in clean plastic or glass bottles. Most reliable results are obtained when samples are analyzed as soon as possible after collection.

If chlorine is known to be present, the sample must be treated immediately with sodium thiosulfate. Add one drop of 0.1 N Sodium Thiosulfate Standard Solution for each 0.3 mg of chlorine present in a one liter sample.

To preserve samples, adjust the pH to 2 or less with concentrated sulfuric acid (about 2 mL per liter). Store samples at 4 °C or less. Samples preserved in this manner can be stored up to 28 days. Just before testing the stored sample, warm to room temperature and neutralize with 5.0 N Sodium Hydroxide Standard Solution. Correct the test result for volume additions (see *Correction for Volume Additions in Section I*).

### ACCURACY CHECK

#### Standard Additions Method

- Measure 25 mL of sample into three 25-mL mixing cylinders.
- Use the TenSette Pipet to add 0.2, 0.4 and 0.6 mL of Ammonium Nitrogen Standard, 10 mg/L as  $\text{NH}_3\text{-N}$  to the three samples. Mix well.
- Analyze each sample as described above. The ammonia nitrogen concentration should increase 0.08 mg/L for each 0.2 mL of standard added.
- If these increases do not occur, see *Standard Additions in Section I* for more information.

#### Standard Solution Method

Prepare a 0.20 mg/L ammonia nitrogen standard by diluting 2.00 mL of the Nitrogen Ammonia Standard Solution, 10 mg/L, to 100 mL with demineralized water. Or, using the TenSette Pipet, prepare a 0.20 mg/L ammonia nitrogen standard by diluting 0.4 mL of a Nitrogen Ammonia Voluette Standard Solution, 50 mg/L as  $\text{NH}_3\text{-N}$ , to 100 mL with demineralized water.

# NITROGEN, AMMONIA, continued

## PRECISION

In a single laboratory, using a standard solution of 0.20 mg/L ammonia nitrogen ( $\text{NH}_3\text{-N}$ ) and two representative lots of reagent with the DR/2000, a single operator obtained a standard deviation of  $\pm 0.015$  mg/L ammonia nitrogen.

## INTERFERENCES

The following ions may interfere when present in concentrations exceeding those listed below:

Calcium	1000 mg/L as $\text{CaCO}_3$
Magnesium	6000 mg/L as $\text{CaCO}_3$
Nitrite	12 mg/L as $\text{NO}_2^-\text{-N}$
Nitrate	100 mg/L as $\text{NO}_3^-\text{-N}$
Orthophosphate	100 mg/L as $\text{PO}_4^{3-}\text{-P}$
Sulfate	300 mg/L as $\text{SO}_4^{2-}$

Sulfide will intensify the color. Eliminate sulfide interference as follows:

- Measure about 350 mL of sample in a 500-mL erlenmeyer flask.
- Add the contents of one Sulfide Inhibitor Reagent Powder Pillow. Swirl to mix.
- Filter the sample through a folded filter paper.
- Use the filtered solution in Step 4.

Iron interferes with the test. Eliminate iron interference as follows:

- Determine the amount of iron present in the sample following one of the Total Iron procedures.
- Add the same iron concentration to the demineralized water blank in Step 5.

The interference from iron in the sample will then be successfully blanked out in Step 11.

Adjust extremely acidic or alkaline samples to approximately pH 7. Use 1.0 N Sodium Hydroxide Standard Solution for acidic samples or 1.0 N Sulfuric Acid Standard Solution for basic samples.

Less common interferences such as hydrazine and glycine will cause intensified colors in the prepared sample. Turbidity and sample color will give erroneous high values. Samples with severe interferences require distillation. Albuminoid nitrogen samples also require distillation. Hach recommends the distillation procedure using the Hach General Purpose Distillation Set (*see Optional Apparatus listing*). The distillation procedure is detailed in the Nitrogen, Ammonia—Nessler Method.

## SUMMARY OF METHOD

Ammonia compounds combine with chlorine to form monochloramine. Monochloramine reacts with salicylate to form 5-aminosalicylate. The 5-aminosalicylate is oxidized in the presence of a sodium nitroprusside catalyst to form a blue-colored compound. The blue color is masked by the yellow color from the excess reagent present to give a final green-colored solution.

## REQUIRED REAGENTS

Nitrogen Ammonia Reagent Set (100 Tests) . . . . .			<b>Cat. No.</b>
Includes: (8) 23955-68, (8) 23953-68			22437-00
<b>Description</b>	<b>Quantity Required</b>	<b>Units</b>	<b>Cat. No.</b>
Ammonia Cyanurate Reagent Powder Pillows . . . . .	2 pillows . . . . .	25/pkg . . . . .	23995-68
Ammonia Salicylate Reagent Powder Pillows . . . . .	2 pillows . . . . .	25/pkg . . . . .	23953-68

## REQUIRED APPARATUS

Clippers, large . . . . .	1 . . . . .	each . . . . .	968-00
Cylinder, graduated, mixing, 25 mL . . . . .	2 . . . . .	each . . . . .	20886-40

## NITROGEN, AMMONIA, continued

### OPTIONAL REAGENTS

Nitrogen Ammonia Standard Solution, 10 mg/L as (NH <sub>3</sub> -N)	500 mL	153-49
Nitrogen Ammonia Voluette Ampule, 50 mg/L as (NH <sub>3</sub> -N), 10 mL	16/pkg	14791-10
Sodium Hydroxide Standard Solution, 1.0 N	100 mL MDB	1045-32
Sodium Hydroxide Standard Solution, 5.0 N	59 mL	2450-26
Sodium Thiosulfate Standard Solution, 0.1 N	100 mL MDB	323-32
Sulfide Inhibitor Reagent Powder Pillows	100/pkg	2418-99
Sulfuric Acid, concentrated, ACS	500 mL	979-49
Sulfuric Acid Standard Solution, 1.0 N	100 mL MDB	1270-32
Water, demineralized	4 L	272-56

### OPTIONAL APPARATUS

Ampule Breaker Kit	each	21968-00
Cylinder, graduated, polypropylene, 500 mL	each	1081-49
Distillation Heater and Support Apparatus, 115 V	each	22744-00
Distillation Heater and Support Apparatus, 230 V	each	22744-02
Distillation Set, General Purpose	each	22653-00
Filter Paper, folded, 12.5 cm	100	1894-57
Flask, erlenmeyer, polypropylene, 500 mL	each	1082-49
Flask, volumetric, Class A, 100 mL	each	14574-42
Funnel, poly, 65 mm	each	1083-67
pH Meter, EC10, portable	each	50050-00
Pipet Filler, safety bulb	each	14651-00
Pipet, TenSette, 0.1 to 1.0 ml	each	19700-01
Pipet Tips, for 19700-01 TenSette Pipet	50/pkg	21856-96
Pipet, volumetric, Class A, 2.0 mL	each	14515-36
Pour-Thru Cell Assembly Kit	each	45215-00
Thermometer, -20 to 105 °C	each	1877-01

For additional ordering information, see final section.  
In the U.S.A. call 800-227-4224 to place an order.



*sensio*<sup>TM</sup>**n4** Laboratory  
**pH/ISE Meter**  
**Instruction Manual**

# TRADEMARKS OF HACH COMPANY

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AccuGrow®	H <sub>2</sub> O University™	Pond In Pillow™
AccuVac®	H <sub>2</sub> OU™	PourRite®
AccuVer™	Hach Logo®	PrepTab™
AccuVial™	Hach One®	ProNetic™
Add-A-Test™	Hach Oval®	Pump Colorimeter™
AgriTrak™	Hach.com™	QuanTab®
AluVer®	HachLink™	Rapid Liquid™
AmVer™	Hawkeye The Hach Guy™	RapidSilver™
APA 6000™	HexaVer®	Ratio™
AquaChek™	HgEx™	RoVer®
AquaTrend®	HydraVer®	<i>sension</i> ™
BariVer®	ICE-PIC™	Simply Accurate <sup>SM</sup>
BODTrak™	IncuTrol®	SINGLET™
BoroTrace™	Just Add Water™	SofChek™
BoroVer®	LeadTrak®	SoilSYS™
C. Moore Green™	M-ColiBlue24®	SP 510™
CA 610™	ManVer®	SpecV™
CalVer®	MolyVer®	StablCal®
ChromaVer®	Mug-O-Meter®	StannaVer®
ColorQuik®	NetSketcher™	SteriChek™
CoolTrak®	NitraVer®	StillVer®
CuVer®	NitriVer®	SulfaVer®
CyaniVer®	NTrak®	Surface Scatter®
Digesdahl®	OASIS™	TanniVer®
DithiVer®	On Site Analysis. Results You Can Trust <sup>SM</sup>	TenSette®
Dr. F. Fluent™	OptiQuant™	Test 'N Tube™
Dr. H. Tueau™	OriFlow™	TestYES! <sup>SM</sup>
DR/Check™	OxyVer™	TitraStir®
EC 310™	PathoScreen™	TitraVer®
FerroMo®	PbEx®	ToxTrak™
FerroVer®	PermaChem®	UniVer®
FerroZine®	PhosVer®	VIScreen™
FilterTrak™ 660	Pocket Colorimeter™	Voluette®
Formula 2533™	Pocket Pal™	WasteAway™
Formula 2589™	Pocket Turbidimeter™	ZincoVer®
Gelex®		

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# CERTIFICATION

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Hach Company certifies this instrument was tested thoroughly, inspected and found to meet its published specifications when it was shipped from the factory.

The *sensioN*<sup>TM4</sup> Laboratory pH/ISE Meter has been tested and is certified as indicated to the following instrumentation standards:

## Product Safety:

External Power Supplies Only:

115 VAC Supply: UL listed and CSA certified or

230 VAC Supply: CE marked per 73/23/EEC, VDE listed

## EMI Immunity:

Instrument tested with external 230V, 50 Hz power supply.

Per **89/336/EEC EMC: EN 61326:1998** (Electrical Equipment for measurement, control, and laboratory use— EMC requirements) Supporting test records by Hach Company, certified compliance by Hach Company.

### Standards include:

IEC 1000-4-2: 1995 (EN 61000-4-2:1995) Electro-Static Discharge Immunity (Criteria B)

IEC 1000-4-3: 1995 (EN 61000-4-3:1996) Radiated RF Electro-Magnetic Fields (Criteria B)

IEC 1000-4-4: 1995 (EN 61000-4-4:1995) Electrical Fast Transients/Burst (Criteria B)

IEC 1000-4-5: 1995 (EN 61000-4-5:1995) Surge (Criteria B)

IEC 1000-4-6: 1996 (EN 61000-4-6:1996) Conducted Disturbance Induced by RF Fields (Criteria A)

IEC 1000-4-11: 1994 (EN 61000-4-11:1994) Voltage Dips, Interruptions and Variations (Criteria B)

ENV 50204:1996 Radiated Electro-Magnetic Field from Digital Telephones (Criteria B)

## **CERTIFICATION, continued**

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### **Emissions:**

Instrument tested with external 230V, 50 Hz power supply.

Per **89/336/EEC EMC: EN 61326:1998** (Electrical Equipment for measurement, control, and laboratory use— EMC requirements). Class B emission limits. Supporting test records by Hewlett Packard Hardware Test Center, Ft. Collins, CO (A2LA #0905-01), certified compliance by Hach Company.

#### **Standards include:**

EN 61000-3-2 Harmonic Disturbances Caused by Electrical Equipment

EN 61000-3-3 Voltage Fluctuations (Flicker) Disturbances Caused by Electrical Equipment

#### **Additional Standards include:**

EN 55011 (CISPR 11) Emissions, Class B Limits

### **Additional Emissions Standard/s include:**

#### **CANADIAN INTERFERENCE-CAUSING EQUIPMENT REGULATION, IECS-003:** Class A emission limits.

Supporting test records by Hewlett Packard Hardware Test Center, Ft. Collins, CO (A2LA #0905-01), certified compliance by Hach Company.

This Class A digital apparatus meets all requirements of the Canadian Interference-Causing Equipment Regulations.

Cet appareil numérique de la classe A respecte toutes les exigences du Règlement sur le matériel brouilleur du Canada.

### **FCC PART 15, Class "A" Limits:**

Supporting test records by Hewlett Packard Hardware Test Center, Ft. Collins, CO (A2LA #0905-01), certified compliance by Hach Company.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

## CERTIFICATION, continued

---

(1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications to this unit not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference, in which case the user will be required to correct the interference at his own expense. The following techniques of reducing the interference problems are applied easily.

1. Disconnect the external power supply from *sensio4* Laboratory pH meter to verify that the meter is not the source of interference.
2. Move the meter away from the device receiving the interference.
3. Reposition the receiving antenna for the device receiving the interference.
4. Try combinations of the above.



# SAFETY PRECAUTIONS

---

Please read this entire manual before unpacking, setting up, or operating this instrument. Pay particular attention to all danger and caution statements. Failure to do so could result in serious injury to the operator or damage to the equipment.

To ensure the protection provided by this equipment is not impaired, do not use or install this equipment in any manner other than that which is specified in this manual.

## Use of Hazard Information

If multiple hazards exist, this manual will use the signal word (Danger, Caution, Note) corresponding to the greatest hazard.

### **DANGER**

*Indicates a potentially or imminently hazardous situation which, if not avoided, could result in death or serious injury.*

### **CAUTION**

*Indicates a potentially hazardous situation that may result in minor or moderate injury.*

### **NOTE**

*Information that requires special emphasis.*

## Precautionary Labels

Read all labels and tags attached to the instrument. Personal injury or damage to the instrument could occur if not observed.

 This symbol, if noted on the instrument, references the instruction manual for operational and/or safety information.

 **Section 2.2 on page 21**

 **Section 2.3 on page 21**

 **Section 2.4 on page 23**

 **Section 5.1 on page 45**



# SPECIFICATIONS

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Specification subject to change without notice.

## **pH mode**

Range	-2.00 to 19.99
Resolution	0.001/0.01/0.1 (selectable)
Slope range	45 to 65 mV/decade at 25 °C

## **ISE mode**

Range	0.000 to 19900
Resolution	Auto-ranging

## **Millivolt mode**

Range	-2000 to 2000 mV
Resolution	0.1 mV
Accuracy	±0.2 mV or ±0.05% of reading, whichever is greater

## **Temperature mode**

Range	-10.0 to 110 °C (can also display °F)
Resolution	0.1 °C
Accuracy	±0.3 °C from 0–70 °C ±1.0 °C from 70–110 °C

**Display:** Custom LCD

**Inputs:** 2 BNC; two 5-pin Hach pH/temperature or Hach temperature probe; 2 pin-tip; (one combination input type for each of the two channels or two half-cells per channel).

**Outputs:** Two-way RS232

**Power Requirements:** 6–9 VDC provided by 120 V 50/60 Hz or 230 V, 50 Hz external power supply or a customer-provided supply with 50 mA output, 5.5-mm power plug with a 2.5 mm center post opening.

**Installation Category:** II (for external power supplies)

**Input Impedance:** >10<sup>12</sup> ohms

**Instrument Drift:** <40 µV/°C

**Input Bias Current:** <±1 picoamp at 25 °C; <±4 picoamp over full range

## **SPECIFICATIONS, continued**

---

**Environmental Requirements:** 0 to 50 °C at 85% non-condensing relative humidity. Enclosure is water resistant, chemical resistant, dust proof.

**Dimensions:** 25.4 x 15 x 8.37 (10.15 x 6 x 3.35 in.)



## OPERATION

### **DANGER**

*Handling chemical samples, standards, and reagents can be dangerous. Review the necessary Material Safety Data Sheets and become familiar with all safety procedures before handling any chemicals.*

### **DANGER**

*La manipulation des échantillons chimiques, étalons et réactifs peut être dangereuse. Lire les Fiches de Données de Sécurité des Produits (FDSP) et se familiariser avec toutes les procédures de sécurité avant de manipuler tous les produits chimiques.*

### **PELIGRO**

*La manipulación de muestras químicas, estándares y reactivos puede ser peligrosa. Revise las fichas de seguridad de materiales y familiarícese con los procedimientos de seguridad antes de manipular productos químicos.*

### **GEFAHR**

*Das Arbeiten mit chemischen Proben, Standards und Reagenzien ist mit Gefahren verbunden. Es wird dem Benutzer dieser Produkte empfohlen, sich vor der Arbeit mit sicheren Verfahrensweisen und dem richtigen Gebrauch der Chemikalien vertraut zu machen und alle entsprechenden Material Sicherheitsdatenblätter aufmerksam zu lesen.*

### **PERIGO**

*A manipulação de amostras, padrões e reagentes químicos pode ser perigosa. Reveja a folha dos dados de segurança do material e familiarize-se com todos os procedimentos de segurança antes de manipular quaisquer produtos químicos.*



Hach provides pH and ISE meters for applications from pH measurements to accurate Ion Selective Electrode work. This manual describes the operation and use of the Hach *sension™4* Portable pH/ISE/mV/Temperature Meter (see *Figure 1*).

This meter features a custom digital LCD display which simultaneously displays temperature and measurement results. This meter has all the features of a simple pH/ISE meter plus:

- two measurement channels
- a millivolt mode
- standard additions program
- automatic buffer recognition when in the pH mode
- pH averaging
- calibration review
- datalogging
- bi-directional RS232 communication for printing results to a computer or printer, or controlling the meter from a PC.

The meter is designed to be maintenance-free. If the meter gets dirty, wipe the surface with a damp cloth. Use a cotton-tipped applicator to clean or dry the connectors if they get wet.

### 1.1 Unpacking the Instrument

Remove the instrument and accessories from the shipping container and inspect each item for any damage that may have occurred during shipping. Verify that all items listed on the packing slip are included. If any items are missing or damaged, contact Hach Customer Service, Loveland, Colorado for instructions. Hach's toll free phone number for customers within the United States is 800-227-4224. For customers outside the United States, contact the Hach office or distributor serving you.

### 1.2 Standard Accessories

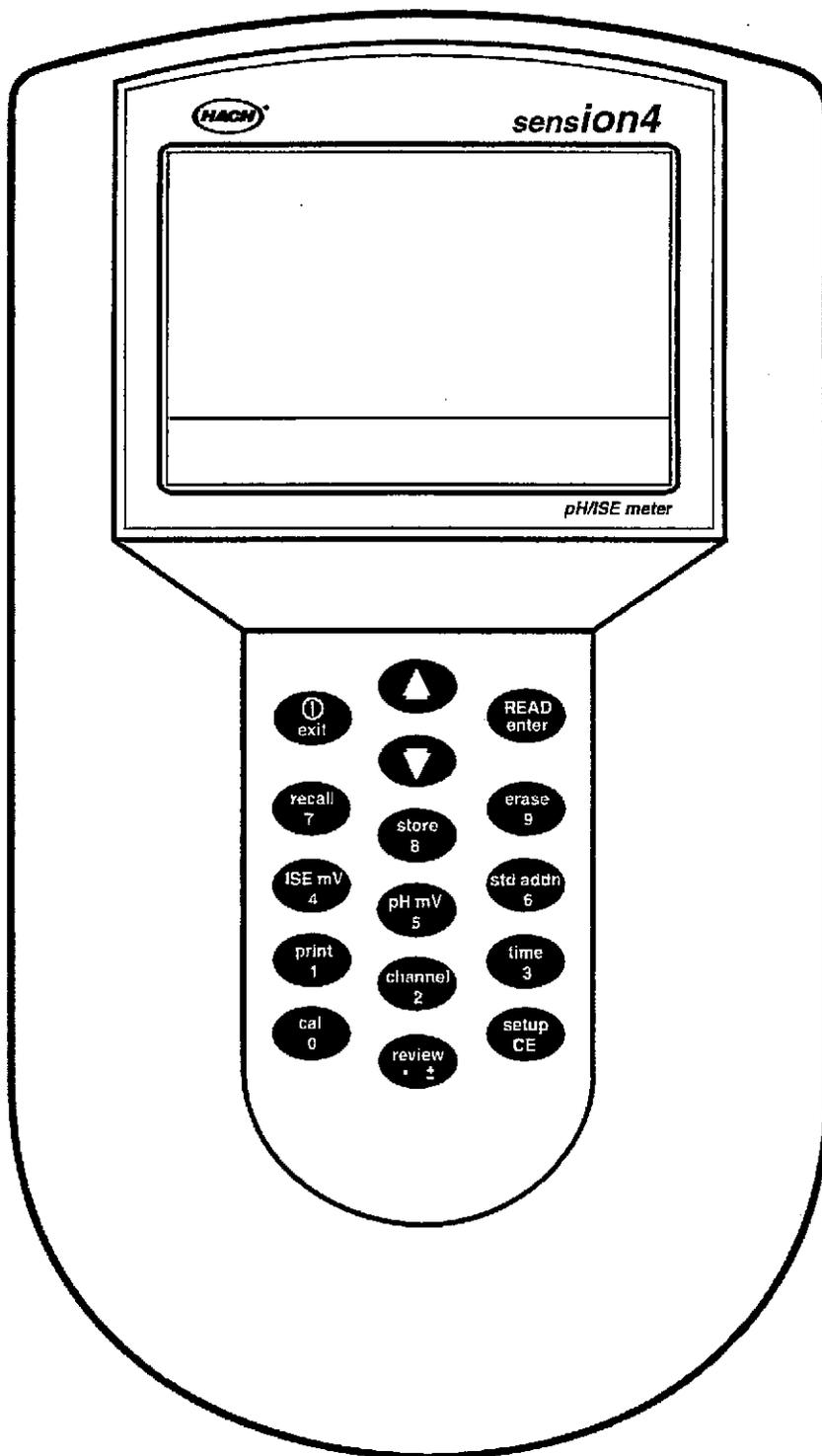
- AC to DC wall adapter
- Instrument Manual
- Include electrode and related accessories (covered in the electrode manual).

## SECTION 1, continued

### 1.3 Keypad Description

Figure 1 illustrates the meter's keypad. The description and function of each key are given in Table 1.

Figure 1 Hach *sensioN4* Meter



## SECTION 1, continued

**Table 1 Keys and Description**

<b>Key</b>	<b>Description</b>
Exit/Power On-Off	Turns the instrument on; turns it off from a Reading mode. Acts as a NO or Cancel key when the question mark icon is flashing. In Setup mode, backs up one step toward the Reading mode. Performs the following and returns to the most recent Reading mode: <ul style="list-style-type: none"> <li>• Exits the Store or Recall mode</li> <li>• Aborts a calibration</li> <li>• Exits a calibration review</li> </ul>
Arrow Keys	Scrolls between options in Setup mode. Scrolls through data points in Store and Recall modes. Scrolls between the option to print or erase one data point and all data points. Changes the default temperature when a temperature probe is not in use.
READ/ENTER Key	Accepts numerical input. Acts as a "YES" answer when the question mark is flashing. Allows user to edit a setup when the setup number is flashing. Accepts the current Setup option when that option is flashing. Initiates a new measurement when the meter has stabilized in the Display Lock Enabled mode.
Recall Key	Recalls stored sample data (from Reading mode only).
Store Key	Stores the current (displayed) measurement (from Reading mode only).
Erase Key	Erases recalled data points.
ISE/mV Key	Toggles between ISE concentration value and mV in Reading, Calibration, and Cal Review modes.
pH/mV Key	Toggles between pH value and mV value in Reading, Calibration, and Cal Review modes.
Std Addn	Moves meter into program to use for standard additions.
Print Key	Sends current or recalled data to a printer or a computer via the RS232 port.
Channel	Toggles between channel 1 and 2. Will not toggle in Calibration, Cal Review, and Recall modes.
Time Key	In Reading mode, allows user to view the current time and date. In Recall Data mode, it toggles between the time and date of the stored measurement.
Cal Key	Enters Calibration mode (from Reading mode only)
Review Key	Enters Calibration Review mode (from Reading mode only)
Setup/CE Key	Enters Setup mode (from Reading mode only) or clears a numeric entry when the keypad icon is displayed.

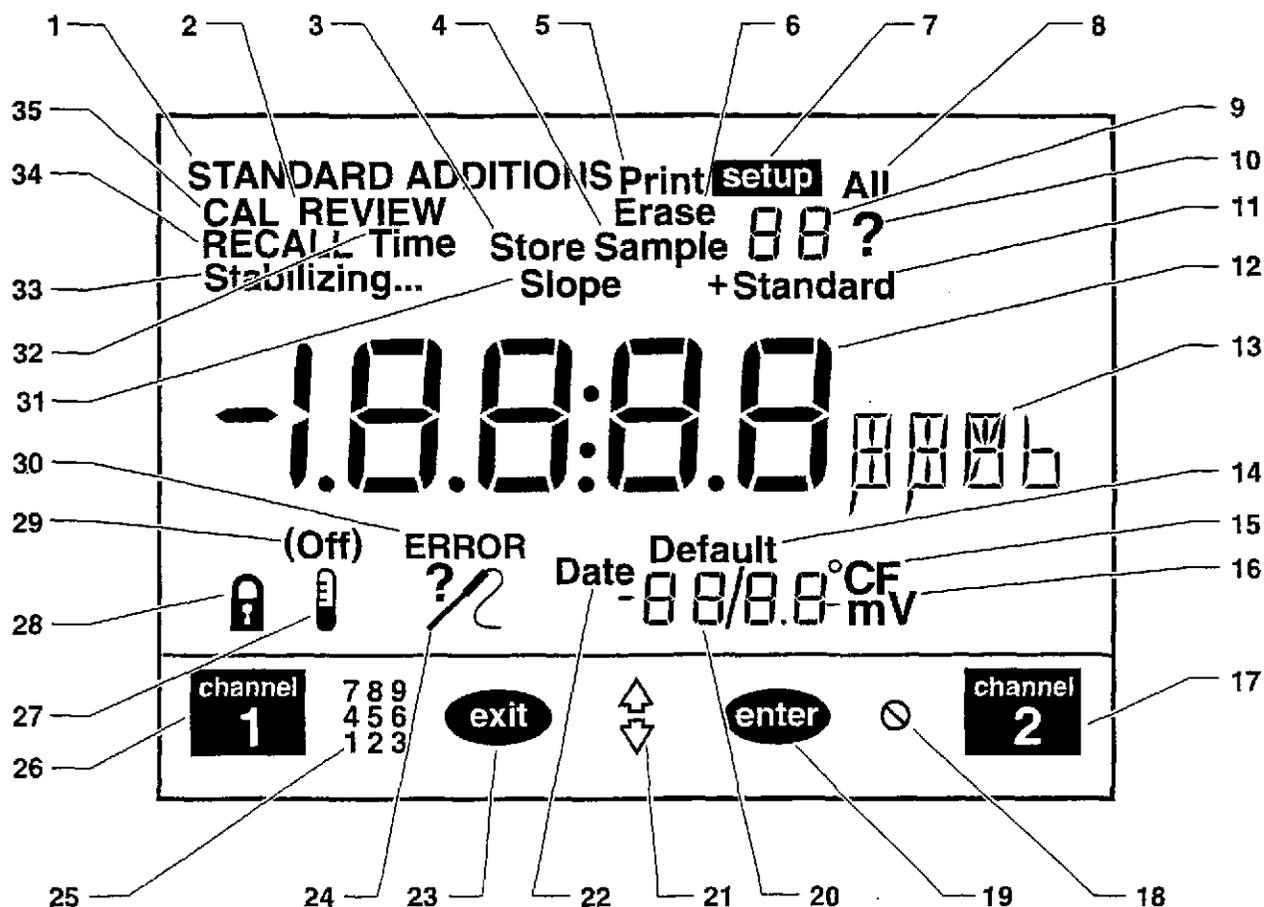
## SECTION 1, continued

### 1.4 Display Fields and Icons

The display has two screens. The upper screen displays measurements or standard values, operation mode, slope, sample/default temperature, pH or mV units, error codes, and indicates if the meter reading is stable. The lower screen displays keys that are active.

Figure 2 shows the icons and screens displayed by the meter and Table 2 describes each element. All icons on the display will be displayed if the power key is held down for several seconds.

Figure 2 *sensION4* Display



## SECTION 1, continued

Table 2 Main Display Elements

Item No.	Description
1	Indicates meter is in Standard Addition mode.
2 (Cal Review)	Indicates meter is in Calibration Review mode.
3	Used with ? to ask if user wants to store calibration, standard value, or sample value
4	Indicates the meter is measuring/reviewing a sample (sample # is displayed to the right).
5	Indicates data is being sent to a printer/computer.
6	Indicates recalled data that is currently displayed is being erased.
7	Indicates meter is in Setup mode.
8	Indicates all data points are being printed or erased.
9	Numerical field that displays Setup, Sample, and Standard numbers when those words are displayed with the number. If <b>Standard</b> and 1 are displayed, the meter is measuring Standard 1.
10	Flashing ? and CAL indicate calibration is necessary. Also a prompt to press the <b>ENTER</b> or <b>EXIT</b> key.
11	Indicates the meter is measuring/reviewing a standard (standard # is displayed above).
12	Numerical field that displays the values of standards and samples, slope, pH or mV.
13	Indicates measurement units (pH, mV, mg/L, µg/L, ppm, ppb, M).
14	When <b>Default</b> is displayed, the meter is using the default temperature value to calculate the temperature correction for the pH value.
15	Temperature units (choice of °C or °F).
16	Indicates value displayed in small numerical field (item 20) is in millivolts.
17	Indicates channel 2 is in use.
18	Indicates an inactive key has been pressed and that function is not allowed.
19	Indicates <b>ENTER</b> key is active.
20	Numerical field that displays temperature value.
21	Indicates arrow keys are active.
22	Indicates the date is being set or displayed.
23	Indicates <b>EXIT</b> key is active.
24	Faulty probe connection or incorrect probe attached. Usually displayed with an error code.
25	Indicates numeric part of the keys is active.
26	Indicates channel 1 is in use.
27	NA
28	Display Lock icon. Indicates reading is locked after stability is achieved.
29	In setup mode, indicates whether Display Lock setting is On or Off.
30	Indicates a meter function problem.

## SECTION 1, continued

Table 2 Main Display Elements (Continued)

Item No.	Description
31	Indicates the displayed number is the electrode slope.
32	Indicates Time is being set or displayed.
33	When on or flashing, <b>Stabilizing...</b> indicates signal from sample is not yet stable. When it disappears, the reading is stable.
34	Indicates meter is in recall mode and the data displayed is stored data.
35 (CAL)	Indicates meter is in Calibration mode. If the ? is flashing, calibration is necessary.

### 1.5 Audible Signals

The meter will beep under certain conditions:

- a non-functional key press is made (one beep)
- when display lock is enabled and measurement stability is reached during reading mode (three beeps)
- any time measurement stability is reached during calibration mode, regardless of the Display Lock setting
- to signal an error condition (two beeps)
- if the number entry and a press of the **ENTER** key causes two beeps, the meter will automatically return to the beginning of number entry.

## SECTION 2      INSTRUMENT SETUP

---

### 2.1 Instrument Description

This *sension*<sup>TM4</sup> Laboratory pH/ISE/mV meter is designed for laboratory use and operates on 115/230 VAC power. Two channels are available for electrode connection.

The meter measures from -2.0 to 19.99 pH units and the sample temperature. Displayed pH values are temperature corrected using the measured sample temperature or a default temperature setting. To display mV and pH values, press the **pH/mV** key to toggle between the units.

In the ISE mode, the meter measures from 0 to 19900 with the highest resolution as ten thousandths (0.0001). To display mV and concentration values, press the **ISE/mV** key to toggle between the units.

### 2.2 Power Connections

A 115 or 230 AC to DC converter is required to power the meter. Plug the power jack of the adapter into the meter power connector (see *Figure 3*). Then plug the adapter into the wall.

### 2.3 pH/ISE and Temperature Probe Connections

#### 2.3.1 pH/ISE Probe Connections

Electrodes may be simultaneously attached to the 5-pin and BNC connectors of the same channel as long as they are not in contact with the same solution. To select either of the connectors for measurement, go to **Setup 1** and choose one.

#### **Five-pin Connectors**

Attach pH electrodes with 5-pin connectors to the meter input by lining the pins up with the holes in the meter port (see *Figure 3*). Push towards the instrument.

#### **BNC Connectors**

For pH or ISE probes with BNC connectors, slide the connector into the input. Push towards the instrument and turn the metal sleeve clockwise to lock into position. Do not use a pH probe with temperature sensor to measure temperature while using an ISE probe.

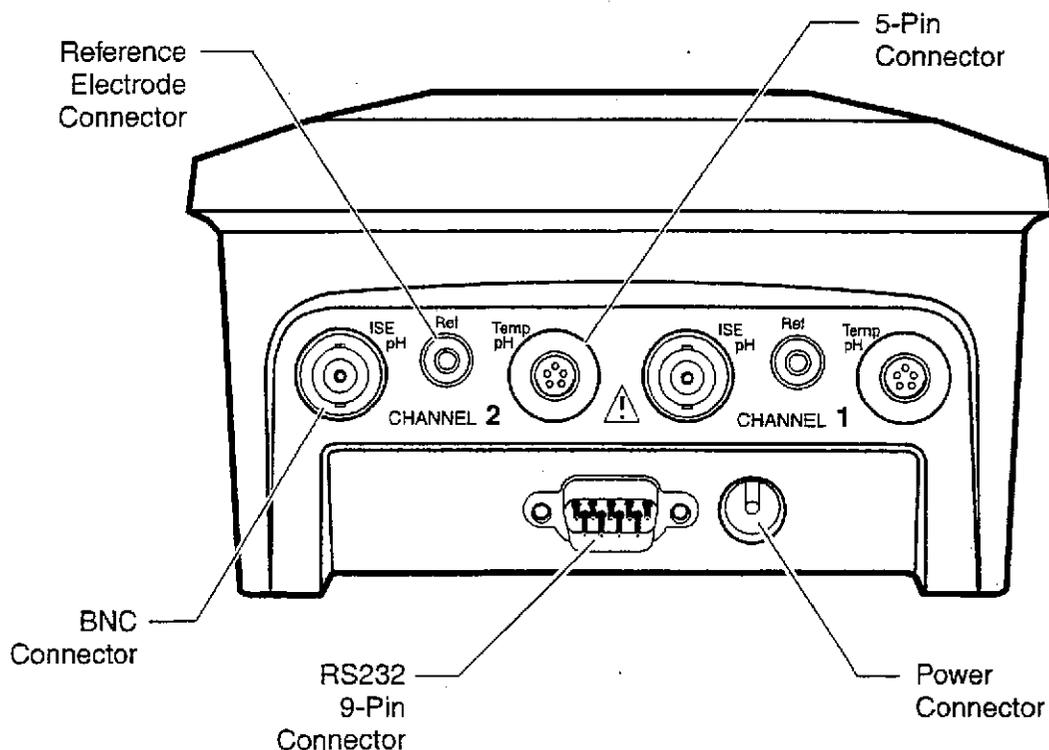
## SECTION 2, continued

### Pin-type Connectors

When using half-cells, connect reference electrodes with pin tip connectors by pushing the connector straight into the center reference input.

**Note:** If using a combination electrode with a BNC or 5-pin connector, the reference pin-tip jack is not used.

Figure 3 *sensION4* Power, RS232, and Probe Connections



### 2.3.2 Temperature Probe Connection

Hach pH electrodes with the 5-pin connector have the temperature sensing unit included in the electrode probe and require only the 5-pin connector. If using a pH electrode with BNC connector, connect the Hach Temperature Probe (Cat. No. 51980-00) to the 5-pin connector on the meter (see *Figure 3*). The user can also measure the temperature manually and enter the value as the default temperature on the meter (see *Section 2.6* on page 23). Do not use a pH probe with temperature sensor to measure temperature while using an ISE probe.

### 2.4 Printer and Computer Connections

The meter can send data to a computer or printer via the 9-pin serial port on the meter (see *Figure 3*). **The printer cable and computer cable are different.** The printer cable is a 9-pin to 25-pin cable and the computer cable is a 9-pin to 9-pin cable. Be sure to use the correct cable.

The meter can print to serial printers without an adapter. For parallel printers, a converter and cable adapter are required. The Citizen PN60 printer (Cat. No. 26687-00) requires a special Citizen adapter (supplied with the printer). Pressing the **PRINT** key will send the currently displayed data to the printer or the user can enable the autoprint function (see *3.1.10* on page 30). The data may be either a current measurement or recalled data.

To communicate with a computer, connect the 9-pin serial port on the meter to a 9-pin serial port of the computer using a 9-pin to 9-pin cable. Pressing the **PRINT** key will send the currently displayed data to the computer. The data may be either a current measurement or recalled data. To send commands from a computer, see the *Table 6* on page 51.

### 2.5 Turning the Meter On

After plugging the correct power adapter into the wall, turn the instrument on using the **I/O/EXIT** key (located on the upper left side of the keypad). Press the key once to power the instrument up. The display will show the software version number, then move to the Reading mode.

### 2.6 Temperature Measurement

The meter displays temperature in the range of -10.0 to +110 °C simultaneously with sample results. If a temperature probe is properly connected, actual temperature measurements are displayed in the temperature/mV field.

The meter requires a temperature to calculate temperature-corrected pH readings. The meter uses temperature data from one of three sources:

- The temperature sensor in the sample
- The factory default setting (20 °C)
- A user-entered default setting

## SECTION 2, continued

---

If a temperature probe is connected properly, the meter will display the current sample temperature and will not allow the temperature to be manually set.

### **To manually set the temperature**

When a temperature probe is not used to supply the temperature for pH temperature compensation, the default temperature (20 °C) will be used. In either case, **Default** will be displayed above the temperature.

To change the default temperature, first put the meter in Reading or Calibration mode. Press the arrow keys to increase or decrease the displayed default temperature value to the desired temperature. The value adjusts in 0.1 °C (0.1 to 0.2 °F) increments. To scroll rapidly, hold the arrow key down.

*Note: Acceptable temperatures range from -10 to 110 °C.*

To change the units of temperature measurement, see Section 3.1.3 on page 26.

## 2.7 Millivolt Measurements

The meter can be used to measure absolute millivolts (mV). To display a current millivolt reading, press the **pH/mV** or **ISE/mV** key. The mV value is displayed with **mV** in the units field. Press the key again to return to pH or ISE measurement units.

Absolute millivolts are displayed with 0.1 mV resolution in the range of -2000.0 to +2000.0. The millivolt mode is useful when measuring oxidation-reduction potential, performing potentiometric titrations, or preparing calibration curves. Detailed instructions for any Hach electrode are given in the electrode instruction manual. Titration instructions are included in the Hach ORP Electrode Instruction Manual, or in standard analytical chemistry texts.

### 3.1 Setup Menu

The *sensION*<sup>TM4</sup> Laboratory pH/ISE meter has a setup menu for each channel which allows the analyst to choose options for connector choice, display lock, temperature units, display resolution, automatic buffer recognition, time, date and others (see *Table 3*). Each channel can have separate setup options except date and time.

To access the Setup menu, press the **SETUP** key. The arrow icons will be displayed, indicating that additional options are available within the menu. Press the up or down arrow key to scroll to the desired option, then press **ENTER**. To exit the setup menus, press **EXIT** until the meter returns to Reading mode.

When using the Setup menu, the screen will display a number in the upper right numerical field, indicating which option is being changed. *Table 3* describes these options.

**Table 3 *sensION4* Setup Options**

Setup Number	Setup Description
1	Use BNC or 5-pin connector
2	Display lock (On or Off)
3	Temperature units (°C or °F)
4	pH measurement resolution (0.0, 0.00, or 0.000)
5	Buffer auto recognition (6.86 or 7.00)
6	Stability criteria
7	Time of day (24-hour clock)
8	Date (mm/dd)
9	Year (4 digits)
10	Print interval settings

#### 3.1.1 Choosing the Probe Connector

This setup ensures the potential from the appropriate electrode is detected by the meter. Do not use both a pH electrode and an ISE electrode from the same channel in the same solution. Both can be connected if they are in separate solutions, but only the electrode on the selected connector (BNC or 5-pin) will be active.

## SECTION 3, continued

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1. From the reading mode, press **SETUP**.
2. The **Setup** icon and the number **1** (flashing) will be displayed. Change the connector choice by pressing **ENTER**; this toggles the selection between **BNC** and **5 pin**.
3. When the desired option is selected, press **EXIT** to return to the reading mode.

### 3.1.2 Turning Display Lock Off and On

Setup 2 is the Display Lock option. This feature stops measurement reading fluctuation on the display once a stable reading is reached. The default setting is Off.

When this feature is not used, the measurement value may continue to fluctuate.

1. From the reading mode, press **SETUP**.
2. The **Setup** icon and the number **1** (flashing) will be displayed. Press the up arrow once so the Setup number is **2**.
3. Change the Display Lock status by pressing **ENTER**; this toggles the Display Lock between off and on. When the Display Lock is disabled, the Display Lock icon and **Off** are displayed. When this feature is enabled, the Display Lock icon is displayed when the stabilization criteria are met.
4. When the desired option is selected, press **EXIT** to return to the reading mode.

### 3.1.3 Selecting Temperature Units

1. From the reading mode, press **SETUP**.
2. The **Setup** icon and the number **1** (flashing) will be displayed. Press the up arrow twice so the Setup number is **3**.
3. Change the temperature unit by pressing **ENTER**; this key toggles the temperature units between °C and °F. The default is °C.
4. When the desired option is selected, press **EXIT** to return to the reading mode.

## SECTION 3, continued

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### 3.1.4 Selecting Measurement Resolution

The meter can display pH measurement values to tenths (0.0), hundredths (0.00) or thousandths (0.000). The default is hundredths. The choice of resolution affects the stability criteria.

1. From the reading mode, press **SETUP**.
2. The **Setup** icon and the number **1** (flashing) will be displayed. Press the up arrow until the Setup number is **4**.
3. Change the resolution by pressing **ENTER**; this toggles between the three resolution options.
4. When the desired option is selected, press **EXIT** to return to the reading mode.

### 3.1.5 Selecting Auto Buffer Recognition

The *sensION4* Meter is designed to auto-recognize and calibrate on 1.68, 4.01, 6.86 or 7.00, 10.01, and 12.45 pH buffers.

The only selection option for pH buffer auto recognition is choosing 6.86 or 7.00. The default is pH 7.00. To change this option:

1. From the reading mode, press **SETUP**.
2. The **Setup** icon and the number **1** (flashing) will be displayed. Press the up arrow until the Setup number is **5**.
3. Change the buffer value by pressing **ENTER**; this toggles the between the choices 6.86 and 7.00.
4. When the desired option is selected, press **EXIT** to return to the reading mode.

### 3.1.6 Selecting Stability Criteria

The meter is designed to recognize a stable ISE reading based on the rate of drift in mV/min (criteria are automatically selected for pH measurement based on resolution). If the electrode voltage is drifting slower than the chosen mV stability criteria, the display will show a stabilized reading. If the electrode voltage is drifting faster than the chosen mV stability criteria, the display will continue to display **Stabilizing...** and measurement values will fluctuate.

## SECTION 3, continued

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The default stability drift rate is 0.500 mV/min. Lower stability criteria (i.e., 0.300 mV/min) will require longer stabilization times, but the measurement will be more precise. Higher stability criteria will require shorter stabilization times, but measurements may be less precise.

To change this option:

1. From the reading mode, press **SETUP**.
2. The **Setup** icon and the number 1 (flashing) will be displayed. Press the up arrow until the Setup number is 6.
3. Change the stability criteria by pressing **ENTER**. The display will show \_\_\_\_\_. The numbered keypad will become active.
4. Enter the desired mV value using the keypad. Press **ENTER** when entry is complete.
5. If a number entry error occurs, start over by pressing **SETUP/CE**.
6. When the desired value has been accepted, press **EXIT** to return to the Reading mode.

### 3.1.7 Setting the Time

1. From the reading mode, press **SETUP**.
2. The **Setup** icon and the number 1 (flashing) will be displayed. Press the up arrow until the Setup number is 7.
3. Change the time by pressing **ENTER**. The main display will change to \_\_:\_\_, with the left place holder flashing. The numerical keypad will become active.
4. Press the desired number key for the left most digit. The meter uses a 24-hour military clock (12 a.m. = 00:00; 1 p.m. = 13:00). All four digit places must have a number. If the left-most digit(s) is not necessary, use zero for the value (i.e., 08:15 for 8:15 a.m. or 00:30 for 12:30 a.m.).

## SECTION 3, continued

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5. Once a number key is pressed, the next digit place holder will flash. Continue to enter the desired numbers until all four places have a value. Press **ENTER**.
6. If a number entry error occurs, start over by pressing **SETUP/CE**.
7. When the desired value has been accepted, press **EXIT** to return to the Reading mode.

### 3.1.8 Setting the Month and Day

1. From the reading mode, press **SETUP**.
2. The **Setup** icon and the number **1** (flashing) will be displayed. Press the up arrow until the Setup number is **8**. The display will show **Date** and a date near the bottom of the display.
3. Change the date by pressing **ENTER**. The numeric display will change to **\_\_/\_\_**, with the left place holder flashing. The date format has two places for the month on the left side of the slash and two places for the day of the month on the right side of the slash.
4. The numerical keypad will become active. Press the desired number key for the left most digit. All four digit places must have a number. If the left-most digit is not necessary, use zero for the value (i.e., 02/06 is February 6).
5. Once a number key is pressed, the next digit place holder will flash. Continue to enter the desired numbers until all four places have a value. Press **ENTER**.
6. If an number entry error occurs, start over by pressing **SETUP/CE**.
7. When the desired value has been accepted, press **EXIT** to return to the Reading mode.

## SECTION 3, continued

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### 3.1.9 Setting the Year

1. From the reading mode, press **SETUP**.
2. The **Setup** icon and the number **1** (flashing) will be displayed. Press the up arrow until the Setup number is **9**. The display will show **Date** and a year in the main display.
3. Change the year by pressing **ENTER**. The main display will change to **\_\_\_\_**, with the left place holder flashing. The numerical keypad will become active.
4. Press the desired number key for the left most digit. Once a number key is pressed, the next digit place holder will flash. Continue to enter the desired numbers until all four places have a value. Press **ENTER** to accept the value.
5. If a number entry error occurs, start over by pressing **SETUP/CE**.
6. When the desired value has been accepted, press **EXIT** to return to the Reading mode.

### 3.1.10 Setting the Print Interval

The default for this option is Off. To transfer data when this option is disabled, press the **PRINT** key. When this option is enabled, the meter will automatically send data at the selected interval to a computer or printer via the RS232 port.

1. From the reading mode, press **SETUP**.
2. The **Setup** icon and the number **1** (flashing) will be displayed. Press the up arrow until the Setup number is **10**. The display will show the current setting.
3. To change the print interval, press **ENTER**.
4. Use the arrow keys to scroll through the options:  
**Off**  
**30 sec**  
**0:01 min (1 minute), 0:05 min., 0:20 min.**  
**1:00 hr, 2:00 hr, 6:00 hr**
5. Press **ENTER** to select the desired option. Press **EXIT** to leave the setup.

## SECTION 3, continued

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### 3.2 Calibrating the Meter

The *sension4* Meter is designed to auto-recognize and calibrate on 1.68, 4.01, 6.86 or 7.00, 10.00, and 12.45 pH buffers. Calibrating with buffers that have pH values other than these requires a modified procedure. Each channel requires independent calibration.

Hach recommends a daily two-point calibration using buffers that bracket the sample pH. This will verify the electrode is working properly and allow the slope value to be stored.

#### 3.2.1 Performing a Calibration Using pH 1.68, 4, 6.86, 7, 10, and 12.45 Buffers

1. Select the desired channel. If using a probe without a temperature sensor, see *Sections 2.3.2* on page 22 and 2.6 on page 23 for information about obtaining and using a default temperature.
2. Prepare pH buffers that bracket the sample pH according to the electrode instruction manual. The meter can be calibrated with two to five autorecognized buffers.

**Note:** Use a 6.86 or 7.0 pH buffer for the mid-range buffer. To view or change the setting for the mid-range buffer see Section 3.1.5.

**Note:** The pH values for the buffers are given for 25 °C. If the sample temperature is not 25 °C, the pH values displayed for the buffers will reflect the correct pH value for the sample temperature.

3. Press **I/O/EXIT** to turn the instrument on. Select the desired channel. If necessary, press the **pH/mV** key to get into the pH reading mode (**pH** will be displayed).
4. From the pH reading mode, press **CAL**. **CAL** and **?** will appear in the upper display area, along with **Standard** and 1.
5. Place the pH electrode in one of the buffers.
6. Press **READ/ENTER**. The temperature and pH values will be updated until a stable reading is reached.

**Note:** If the meter is measuring in pH mode, it automatically moves to the next calibration step when stabilization is reached (indicated by three beeps). If measuring in mV mode, the three beeps will still sound when the stabilization occurs, but you must press **ENTER** to

## SECTION 3, continued

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*accept the reading. This lets the operator control the acceptance point of the buffer.*

7. When the reading has been accepted, the standard number will change to 2.
8. Remove the probe from the first buffer and rinse with deionized water. Place the probe in the second buffer.
9. Press **READ/ENTER**. The temperature and pH values will be updated until a stable reading is reached.
10. When the reading has been accepted, the standard number will change to 3.
11. Repeat *steps 8 and 9* for the third, fourth, or fifth buffer or press **EXIT**. The slope value and the **Store** and **?** icons will appear. Verify the slope value is within the ranges specified in the electrode manual.
12. To save the calibration and return to the reading mode, press **ENTER**. To exit the calibration without saving it and return to the reading mode, press **EXIT**.

### 3.2.2 Calibrating With Other Buffers

1. Select the desired channel. If using a probe without a temperature sensor, see *Sections 2.3.2* on page 22 and 2.6 on page 23 for information about obtaining and using a default temperature.
2. Prepare two pH buffers that bracket the sample according to the electrode instruction manual.
3. Turn the instrument on. Select the desired channel. If necessary, press the **pH/mV** key to get into the pH reading mode (**pH** will be displayed).
4. From the reading mode, press **CAL**. Functional keys will appear in the lower left part of the display. **CAL** and **?** will appear in the upper display area, along with **Standard** and 1. The numeric keypad will become active.

## SECTION 3, continued

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5. Place the pH electrode in a buffer (starting with the lowest pH makes it easy to keep track).
6. Enter the pH value of the buffer using the number keys and press **ENTER**. A flashing underscore (      ) indicates where the next number will be placed. It is not necessary that all four places have a number entered in them.
7. The temperature and pH value will be updated until a stable reading is reached.
8. When the reading has stabilized, the standard number will change to 2. If measuring in the mV mode, press **ENTER** to continue.
9. Rinse the electrode and place it in the next buffer.
10. Enter the pH value of the buffer using the number keys as described above. Press **ENTER**.
11. When the reading has stabilized, the standard number will change to 3. Repeat *steps 9–10* for other calibration buffers.
12. Press **EXIT**. The slope value and the **Store** and **?** icons will appear. Verify the slope value is within the ranges specified in the electrode manual.
13. To save the calibration and return to the reading mode, press **ENTER**. To exit the calibration without saving it and return to the reading mode, press **EXIT**.

### 3.2.3 One-Point Calibration

The one-point calibration is used to adjust the calibration offset and cannot be done unless a prior calibration using at least two points is being used for measurements.

1. From the reading mode, press **CAL**. **Cal, 1, ?, and Standard** will be displayed.
2. Place the electrode in a pH calibration buffer.
3. Press **READ/ENTER**. The temperature and pH values will be continuously updated until a stable reading is reached.

## SECTION 3, continued

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4. When the reading has stabilized, the standard number will change to 2.
5. Press **EXIT**. The adjusted offset value, the slope, and the **Store** and **?** icons will appear. Verify the offset value (isopotential point) is within the range specified in the electrode manual.
6. To save the adjusted calibration and return to the reading mode, press **ENTER**. To exit the calibration without saving it and return to the reading mode, press **EXIT**.

### 3.3 ISE Calibration

Calculation for ISE values does not require temperature compensation, so a temperature probe is not necessary for ISE testing. However, a temperature probe will still function properly and display the correct sample temperature. Use the 5-pin temperature probe available from Hach, Cat No. 51980-00.

1. Prepare standards according to the electrode instruction manual or the instructions for the standard. Use two to five standards for calibration. Pour 25 mL of each standard into a 50-mL beaker.
2. Turn the instrument on. Select the desired channel and the BNC connector (Setup 1). If necessary, press the **ISE/mV** key to get into the ISE reading mode (the last concentration units entered will be displayed).
3. Press **CAL**. Functional keys will appear in the lower left part of the display. **CAL**, **?**, and flashing units will appear.
4. To change the units, use the arrow keys to scroll to the desired choice (g/L, mg/L,  $\mu$ g/L, ppm, ppb, M). Press **ENTER**.
5. Add ionic strength adjustor to 25 mL of the least concentrated standard.
6. **Standard**, and **1** will appear in the upper display. If the meter has been calibrated, the last value for standard 1 will appear. The numeric keypad will become active.
7. Place the ISE electrode in the standard with the lowest value. While measuring, stir the solution slowly and steadily.

## SECTION 3, continued

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8. To enter or change the standard's concentration value, use the number keys, then press **ENTER**. A flashing underscore (      ) indicates where the next number will be placed. It is not necessary that all four places have a number entered in them.

To retain the standard concentration value, just press **ENTER**.

*Note: Once a new value is entered, the meter will assume the calibration values have changed and will no longer display values for other standards from the previous calibration.*

9. The concentration value selected will be displayed until a stable reading is reached. mV values may be observed during calibration by pressing the **ISE/mV** key.

*Note: If the meter is measuring in ISE mode, it automatically moves to the next calibration step when stabilization is reached (indicated by three beeps). If measuring in mV mode, the three beeps will still sound when the stabilization occurs, but you must press **ENTER** to accept the reading. This lets the operator control the acceptance point of the standard.*

10. When the reading has stabilized, the standard number will change to **2**. The previous value for standard **2** will be displayed if a new value for Standard **1** has not been entered.

11. Add ISA to 25 mL of the standard with the next highest concentration.

12. Rinse the electrode and place it in the standard with the next highest concentration. While measuring, stir the solution slowly and steadily.

13. Enter or change the standard's concentration value using the number keys as described above. Press **ENTER**.

14. To retain the standard concentration value, just press **ENTER**.

15. When the reading has stabilized, the standard number will change to **3**. Repeat *steps 10–12* for each standard. The meter will accept up to seven ISE calibration points and five pH calibration points.

16. After the last standard is measured, press **EXIT**. The **Store** and **?** icons will appear.

## SECTION 3, continued

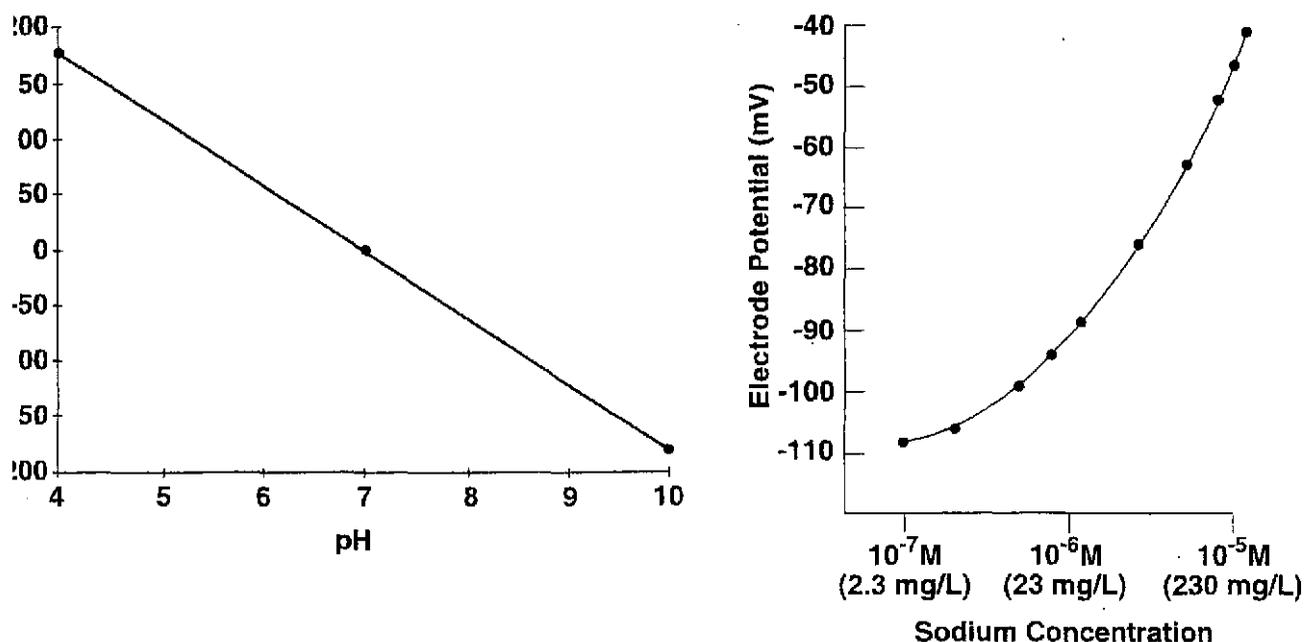
17. To save the calibration and return to the reading mode, press **ENTER**. To exit the calibration without saving it and return to the reading mode, press **EXIT**.
18. After the calibration is stored, the meter is immediately ready to begin measuring samples. See *Section 3.6* on page 38.

### 3.4 Reviewing Calibrations

pH calibrations result in a linear calibration curve, so only one slope value and its correlation coefficient ( $r^2$ ) are displayed in Cal Review mode. ISE calibration result in a linear, piecewise calibration for each pair of standards (see *Figure 4*). Therefore, the meter will display a slope for each “calibration” between each pair of standards. The first slope displayed is for Standards 1 and 2. The second slope displayed is for standards 2 and 3, and so forth. Use the arrow keys to scroll to these values.

The mV values for the standards can be viewed by pressing the **ISE/mV** or **pH/mV** key. This toggles between concentration and mV values.

Figure 4 pH and ISE Calibration Curves



## SECTION 3, continued

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1. Select the desired channel. From the pH or ISE reading mode, press the **REVIEW** key. To review the pH calibration, be sure the meter is in pH mode. To review the ISE calibration, be sure the meter is in ISE reading mode. View mV values by pressing the **pH/mV** or **ISE/mV** key.
2. The meter will display the time the calibration was stored. Press the up arrow key once.
3. The display will show the standard number, standard concentration and temperature. Press the up arrow once.
4. The meter will continue to scroll through the standard information with each press of the up arrow key. When all the standards have been displayed, press the up arrow key again.
5. For pH calibrations, The meter will display the slope and offset of the calibration curve. Press the up arrow again to see the  $r^2$  value for the curve. Skip to *step 8* if reviewing a pH calibration.

For ISE calibrations, the meter will display the slope value of the curve between standards 1 and 2. Press the up arrow once.

6. The meter will display the slope value for the curve between standards 2 and 3.
7. Each press of the up arrow will display the remaining slope values until all the slope values have been displayed.
8. To exit Cal Review mode, press **EXIT**. To review any standard or slope information again, press the down arrow.

## SECTION 3, continued

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### 3.5 Measuring Sample pH

See instructions in the electrode manual for more information and specific steps for using the electrode.

1. Place the electrode in the sample. Press **READ/ENTER**. **Stabilizing...** will be displayed, along with the sample temperature and the pH or mV reading. These values may fluctuate until the system is stable.
2. When the reading is stable, **Stabilizing...** will disappear. If the Display Lock is enabled, the display will “lock in” on the pH or mV and sample temperature. If the Display Lock is off, **Stabilizing...** will still disappear, but the display will show the current reading and temperature and the values may fluctuate.
3. Record or store the pH or mV value. See *SECTION 4* on page 41 to store or recall data.
4. Remove the electrode from the sample, rinse with deionized water and place the electrode in the next sample. Repeat *steps 1–3* for each sample.
5. When measurements are complete, press the **I/O/EXIT** key to turn the meter off. Rinse the electrode with deionized water and blot dry. Replace the protective cap on the electrode. For proper electrode storage, see the electrode manual for specific instructions.

### 3.6 Measuring Samples Using ISEs

This is a general guide for ISE measurements. Most measurements require reagent addition. See instructions in the electrode manual for more information and specific steps.

1. After calibration, rinse the electrode and blot dry. If necessary, add ISA to 25 mL of sample. Place the electrode(s) into the sample.
2. When the reading is stable **Stabilizing...** will disappear. If the Display Lock is enabled, the display will show the concentration or mV and sample temperature when a stable reading is reached. If Display Lock is off, **Stabilizing...** will disappear, but the current readings may fluctuate.

## SECTION 3, continued

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3. Record or store the concentration or mV value. See *SECTION 4* on page 41 to store or recall data.
4. Remove the electrode from the sample, rinse with deionized water, and blot dry. Place the electrode in the next prepared sample. Repeat *steps 1–3* for each sample.
5. When measurements are complete, press the **I/O/EXIT** key to turn the meter off. Rinse the electrode with deionized water and blot dry. Replace the protective cap on the electrode. For proper electrode storage, see the electrode manual for specific instructions.

### 3.7 Measuring Samples Using Standard Additions

This method should only be used within the linear range of the sensing electrode (see the electrode manual). In this mode, the user may also set the stabilization criteria for the channel used. The slope of the electrode being used must be known.

1. If necessary, add ISA to the sample. Rinse the electrode and blot dry. Place the electrode in the sample.
2. Select the desired channel. From the Reading mode, press **STD ADDN**.
3. The display will show **STANDARD ADDITIONS**, and the units will be flashing. Use the arrow keys to scroll to the desired units, then press **ENTER**.
4. The display will show the slope that was used for the last standard addition measurement. If desired, enter another value using the numerical keypad. To enter a negative slope, enter the number first, then press the **REVIEW/ ±** key. The – sign should appear in front of the slope. Press **ENTER**.
5. The display will show **Sample, mL**, a flashing **?**, and a value for the sample volume.
6. To change the sample volume, use the numerical keypad. When entry is complete or no change is needed, press **ENTER**.
7. The meter will measure the sample for a baseline voltage. **Stabilizing...** will appear until the mV reading is stable.

## SECTION 3, continued

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8. After stabilizing, the display will show **Standard**, a flashing **?**, **mL**, and a value for the standard volume.
9. To change the standard volume, use the numerical keypad. When entry is complete or no change is needed, press **ENTER**.
10. The display will show **Standard**, a flashing **?**, units, and a value for the standard concentration.
11. To change the standard concentration, use the numerical keypad. Immediately add the selected volume of the selected standard to the sample. Press **ENTER**. Do not press **ENTER** until the standard has been added to the sample.
12. The meter will return to Reading mode. The **+** icon in front of **Standard** indicates that standard has been added to the sample.
13. During measurement the meter will display a mV value. After stabilization, the meter will calculate and display the value of the original sample.
14. If desired, press **STORE** to store this data. When this data is recalled **STANDARD ADDITIONS** will appear in the display.

### 4.1 Storing pH/ISE Measurements

The *sension*<sup>TM4</sup> meter can store up to 99 measurement readings. Data must be stored to recall it later for review, downloading, or printing. Although the meter display will only show the temperature, data location, and pH/ISE value, the following information is stored (and can be downloaded or printed) for each sample:

- storage location
- software version
- date
- time
- channel
- mV reading
- sample temperature
- pH or ISE value
- instrument model and serial number

The new data is saved in the next available memory location, numbered from 1 to 99. If no memory locations higher than the current one are available, the meter will “wrap around” and choose the next available location. The user also has the option of choosing the storage location.

#### To store data:

1. Press **STORE**. The display will prompt **Store Sample #?** (# is the next available location). The question mark will be flashing.
2. Press **ENTER** to store the measurement reading in that location number. To store the data in another location, use the arrow keys to scroll to another location or enter a location using the number keys. Press **ENTER**.

***Note:** If all memory locations are full, the meter will prompt to overwrite a data point by displaying **Erase Sample ##?** Press **ENTER** to replace the data in that location with the current data. Press **EXIT** to return to the previous screen without replacing the data.*

3. The meter will store the reading and return to Reading mode.

### 4.2 Recalling Stored Data

1. To recall stored data, press the **RECALL** key while in the Reading mode. The screen will display the most recently saved or recalled measurement data.
2. Use the arrow keys to scroll to the desired storage location. Press **RECALL** again to allow number entry of a storage location. The question mark will flash. Enter the number of the desired storage location. Press **ENTER** to accept the storage location or **EXIT** to escape.
3. To display the mV value of the reading, press the **pH/mV** or **ISE/mV** key.
4. To review the time of the calibration, press **TIME** once. To review the date of the calibration, press **TIME** twice. Press **EXIT** to return the reading value.
5. When recalling is complete, press **EXIT** to return to the Reading mode.

### 4.3 Erasing Data

#### 4.3.1 Erasing Single Data Points

1. To erase data, it must be recalled first. Press the **RECALL** key while in the Reading mode. See *Section 4.2* for more information.
2. When the desired data point is displayed, press **ERASE**.
3. The meter will display **Erase Sample #** and a flashing **?**. Press **ENTER** to erase the data. The data will disappear.
4. The meter will recall the most recently stored or recalled. There are three options at this point:
  - Press **ERASE**, then **ENTER**, to erase the displayed data.
  - Press **EXIT** to exit Recall mode.
  - Press an arrow key to scroll to other data points.
5. Repeat *steps 2-3* for each data point that needs to be deleted.

## SECTION 4, continued

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### 4.3.2 Erasing All Data Points

1. To erase data, it must be recalled first. Press the **RECALL** key while in the Reading mode. See *Section 4.2* for more information.
2. When the data point is displayed, press **ERASE**.
3. Press the up arrow. The instrument will show **Erase and All** with the ? (flashing). At this point the options are:
  - Press **EXIT** to return to Recall mode without erasing.
  - Press the down arrow to return to the single point erase prompt.
  - Press **ENTER** to erase all data and return to Reading mode.
4. After all the data is erased, the meter will return to the Reading mode.



## 5.1 Connecting to Printers/Computers

### 5.1.1 Connecting with the RS232 Cable

The standard 9-pin RS232 connector on the meter connects with a 9-pin D-sub connector. A suitable cable is listed under *Optional Apparatus* page 57.

The RS232 interface output is an 8-bit data word plus one stop bit and no parity with a baud rate of 1200. It can communicate with a serial printer or a serial port on a computer.

### 5.1.2 Connecting to a Printer

Connecting a serial printer to the meter requires a 9-pin to 25-pin RS232 cable. See *Figure 5*. The cable provides a direct link between the instrument and the 25-pin connector used for the serial port on most serial printers. *Table 4* shows the proper pin connections for 25-pin printer cables. Using cables that do not match the pin information in the table may cause undesirable operation.

Parallel printers require a serial-to-parallel adapter. This allows use of printers that are normally used for IBM-compatible applications.

The Citizen PN60 printer requires a special cable to fit into the printer. This cable is shipped with the printer when ordered from Hach Company.

**Table 4 Standard 9-pin to 25-pin Printer Cable**

9-pin D Connector Socket		Serial Printer 25-pin D Connector, plug	
Pin	Signal Name	Pin	Signal Name
2	RXD	no connection	
3	TXD	3	RXD
4	DTR	no connection	
5	GND	7	GND
6	DSR	20	DTR
7	RTS	no connection	
8	CTS	20	DTR

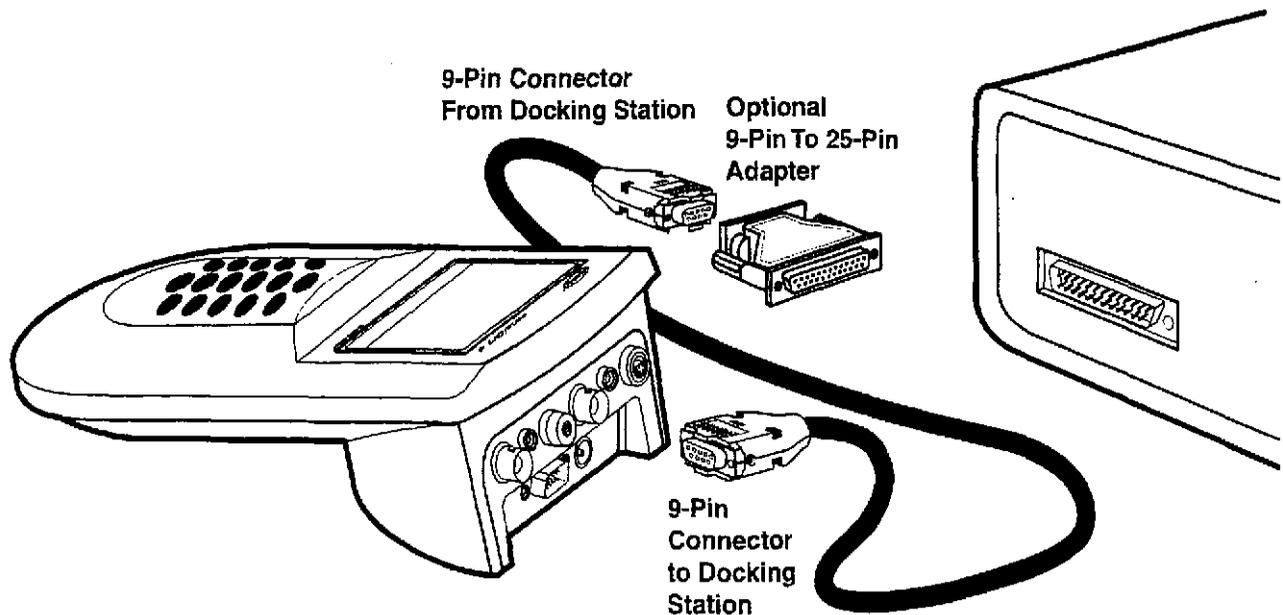
## SECTION 5, continued

Connect the RS232 cable to the meter by lining up the holes in the cable connector with the pins of the meter serial port. Gently and firmly push the cable into the meter. Then secure the connection by screwing in the screws on either side of the cable port. Connect the cable to the printer in the same manner. Once the communication link is established, press **PRINT** to send data to the computer.

**Note:** For optimum performance and ESD protection, use a five-conductor shielded cable. Use a metal shell for the printer or computer terminal connector, and connect the shield of the cable to the metal shell and the sleeve (signal ground) of the RS232 plug.

**Follow the printer manufacturer's instructions to configure the printer for compatibility with the meter.**

Figure 5 RS232 Cable Connector



### 5.1.3 Connecting to a Personal Computer

Connect the meter to a personal computer (PC) with the computer interface cable (Cat. No. 48129-00) listed under *Optional Accessories* page 57. The cable provides a direct link between the meter and the 9-pin D connector used for the serial port on most personal computers. If your computer has a 25-pin D connector, use a 9-pin to 25-pin adapter (available at most computer supply stores).

## SECTION 5, continued

Table 5 shows the proper pin connections for 9-pin computer cables. Using cables that do not match the pin information in the table may cause undesirable operation.

Table 5 Standard 9-pin to 9-pin Computer Cable

9-pin D Connector Socket		Computer 9-pin D Connector, plug	
Pin	Signal Name	Pin	Signal Name
2	RXD	3	TXD
3	TXD	2	RXD
4	DTR	no connection	---
5	GND	5	GND
6	DSR	no connection	---
7	RTS	8	CTS
8	CTS	7	RTS

Connect the RS232 cable to the meter by lining up the holes in the cable connector with the pins of the meter serial port. Gently and firmly push the cable into the meter. Then secure the connection by screwing in the screws on either side of the cable port (see *Figure 5*). Connect the cable to the computer in the same manner.

To transfer data, the communication parameters (baud rate, data bits and parity) of the meter and the computer must match. Once the communication link is established, press **PRINT** to send data to the computer.

Use a communications software, such as HachLink™ (Cat. No. 49665-00) to collect data from the instrument. HachLink is a Windows-based application that allows a personal computer to capture data from several Hach instruments, including the *sension* electrochemical meters. The captured data can be stored in a text file as a spread-sheet compatible format or a free-format text. Data captured in the spreadsheet format is easily transferred into most spreadsheet programs (i.e., MS® Excel, Microsoft® Works, Lotus 123) for graphing and reporting.

To install and run HachLink™ Data Capture, the computer and software must meet the following minimum requirements:

## SECTION 5, continued

---

- IBM PC/AT or compatible with a 386SX processor (16 MHz or better)
- 4 megabytes of RAM
- Hard disk drive with 2 megabytes or more of free space
- 3-1/2 inch, 1.44 megabyte floppy disk drive
- VGA graphics with 640 x 480 or higher resolution, 16 or more colors
- Mouse or other pointing device
- A 9-pin serial port (or 25-pin serial port with 9-pin adapter)
- Windows 3.1 or later
- DOS 3.3 or later

## 5.2 Sending Data to Printers/Computers

### 5.2.1 Printing Data at Intervals

The last option in the Setup menu lets the user choose a print interval. When this option is enabled, the meter will automatically send data to a printer or computer at the selected time interval. See Section 3.1.10 on page 30 for more information on enabling this option

### 5.2.2 Sending Currently Displayed Data

To print or transfer a current reading:

1. Wait until the display is stable. Press **PRINT**.

*Note: Data can be printed before the reading is stable. An asterisk will be printed with the measurement data to indicate the stability criteria were not met.*

2. The word **PRINT** will be briefly displayed, then the meter will return to Reading mode.
3. The printout for data that is printed without being stored will not have a storage location number.

## SECTION 5, continued

---

### 5.2.3 Sending Recalled Data Points

1. To transfer data, it must be recalled first. Press the **RECALL** key while in the Reading mode. See *Section 4.2* on page 42 for more information.
2. When the desired sample data is displayed, press **PRINT**.
3. The word **PRINT** will be briefly displayed, then the meter will return to Reading mode.

### 5.2.4 Sending All Stored Data and the Average pH Value

1. To transfer all data, it must be recalled first. Press the **RECALL** key while in the Reading mode. See *Section 4.2* on page 42 for more information.
2. When a data point is displayed, press **PRINT**. The display will show **Print Sample # ?**.
3. Press the up arrow. The instrument will show **Print, Sample** and **All** with the flashing **?**. At this point the options are:
  - Press **EXIT** to return to Reading mode without printing.
  - Press the down arrow to return to the prompt for printing single data points.
  - Press **ENTER** to print all data and the average pH of the stored data (data that is printed but not stored will not be included). The word **PRINT** will be displayed until all the data has been printed. Then the meter will return to the most recently stored sample data. Press **EXIT** to return to Reading mode or an arrow key to scroll to another data point.

## SECTION 5, continued

---

### 5.2.4.1 Printed Data Format

Printed data will have the following format:

Storage Location	Channel Number	Reading	Temperature	mV Reading	Date	Time	Meter Model	Serial Number	Software Version	
# 1	<1>	7.53 pH	22.7 C	-30.0 mV	10/03/99	08:30	senslon4	12344577	PX.X	
# 2	<1>	6.13 pH	13.6 C	50.0 mV	10/04/99	09:11	senslon4	12344577	PX.X.	
# 3	<2>	7.01 pH	20.1 C	-0.0 mV	10/10/99	12:44	senslon4	12344577	PX.X	
*Average: 6.54				pH						

\* This line will not be included unless **Print All** is chosen. This calculation is included for some reporting regulations, but is not just an average of the pH readings. The calculation for the pH average is:

$$\text{pH}_{\text{AVG}} = -\log_{10} \left( \frac{\sum_{i=1}^n (10^{(-\text{pH}_i)})}{n} \right)$$

### 5.2.5 PC Control of the Meter through the RS232 Interface

The meter can be controlled remotely using a PC. The communication protocols are 1200 baud rate, 8-bit word, 1-stop bit, no parity. A summary of the commands is shown in *Table 6*.

## SECTION 5, continued

Table 6 sensioN4 RS232 Commands

Key	Command (upper or lower case)	Returns
Instrument ID	IID	sensioN4 xxxx (serialized part of serial number)
Exit Key	EXT	OK
Up Arrow	UPA	OK
Down Arrow	DOW	OK
Enter	ENT	OK
Recall	REC	OK
Store	STO	OK
Erase	ERA	OK
ISE/mV	ISE	OK
pH/mV	PHM	OK
Std Addn	STD	OK
Print	PRI	OK
Channel	CHA	OK
Time/Date	TIM	OK
Cal	CAL	OK
Review	REV	OK
Setup	SET	OK
Calibrate Offset (current channel and connector)	CRD	OK



## SECTION 6 TROUBLESHOOTING

---

### 6.1 Introduction

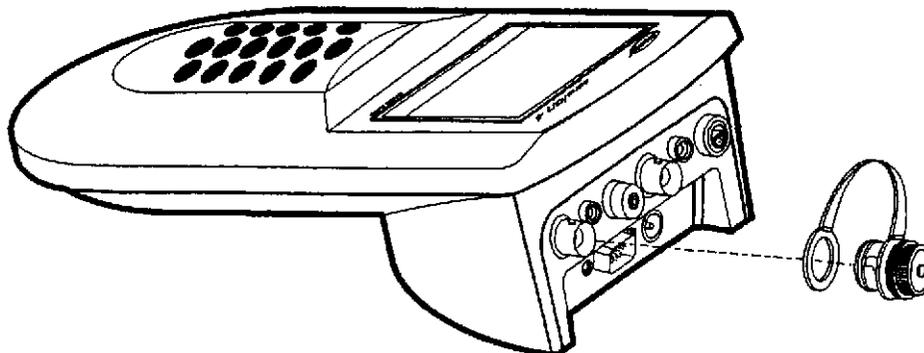
Correcting problem conditions with the *sension* electrochemical meters is limited to responding to the error message displayed. Other problems must be handled by a Hach technician at a service center. Refer to Repair Service. **Do not** attempt to service the meter as there are no field-serviceable parts. Opening the meter case will void the warranty.

### 6.2 Shorting Test

This test detects the meter offset

1. Turn the meter on. Connect the shorting cap to the BNC connector (see *Figure 6*). Make sure the channel with the shorting cap is selected. Select BNC from **Setup 1** choices.
2. Change the output to display in mV (press the **ISE/mV** or **pH/mV** key to toggle between mV and concentration). After the meter has stabilized, simultaneously press **CAL** and **ENTER**. The display should show **0.0 mV**. If it does not, contact Hach Service. Repeat for the other channel.

Figure 6 Attaching Shorting Caps to the BNC Connector



## SECTION 6, continued

---

### 6.3 Error Codes And Errors

Errors and error codes indicate a functional problem with the meter and/or the electrode. Error codes numbers will appear in the temperature field along with other icons. *Table 7* describes the possible error codes, errors, and some possible solutions to eliminate the cause.

**Table 7 Error Codes**

Error Code	Error Name & Display Icons	Description
E2	Cal slope error. <b>ERROR</b> and <b>SLOPE</b> will be displayed.	Calibration slope is too high or low. Ensure correct pH buffers are used. Be sure a pH probe is connected to the meter. Disconnect any probe connected to the BNC connector.
E3	Cal Std Error. <b>ERROR, CAL</b> and <b>Standard</b> will be displayed.	The value read will not work in the calibration algorithm. Repeat calibration with new buffers or standards.
E9	Corrupt data	Recalled data had a bad checksum. Call Hach Service.

### 6.4 Meter Service Request Questionnaire

1. What is the complete lot code of the meter and electrode?
2. On what date was the meter purchased?
3. How long has the meter been in use?
4. What types of samples are being tested?
5. What is the temperature of the samples being tested?
6. How often is the meter being used?
7. How is the meter being stored between uses?
8. If the meter has been in use for a while, what maintenance has been performed?
9. Describe the suspected problem or failure of the meter.
10. Please have your meter, electrode, buffers/standards, and this completed questionnaire near the phone before calling technical support.



## GENERAL INFORMATION

**At Hach Company, customer service is an important part of every product we make.**

**With that in mind, we have compiled the following information for your convenience.**



# REPLACEMENT PARTS

## REPLACEMENT REAGENTS

Description	Quantity Required		Cat. No.
	Per Test	Unit	
<b>Buffer Powder Pillows:</b>			
pH 4.01, color-coded red.....	1.....	50/pkg.....	22269-66
pH 7.00, color-coded yellow.....	1.....	50/pkg.....	22270-66
pH 6.86 (NIST).....	1.....	15/pkg.....	14098-95
pH 10.00, color-coded blue.....	1.....	50/pkg.....	22271-66
<b>Buffer Solutions:</b>			
pH 4.00, color-coded red, NIST.....	25 mL.....	500 mL.....	22834-49
pH 7.00, color-coded yellow, NIST.....	25 mL.....	500 mL.....	22835-49
pH 10.00, color-coded blue, NIST.....	25 mL.....	500 mL.....	22836-49
pH Electrode Storage Powder Pillows.....	1.....	20/pkg.....	26573-64
pH Electrode Storage Solution.....	50 mL.....	475 mL.....	50301-49

Standards and reagents for ISE testing are listed in the specific electrode manuals

## REPLACEMENT APPARATUS

Beaker, poly, 50 mL.....	1.....	each.....	1080-41
<i>sensio</i> <sup>™</sup> 4 Benchtop pH/ISE Meter, 115 V.....	1.....	each.....	51775-10
<i>sensio</i> <sup>™</sup> 4 Benchtop pH/ISE Meter, 230 V.....	1.....	each.....	51775-11
Shorting Cap, BNC.....	1.....	each.....	51895-00
Temperature Probe, 5-pin.....	1.....	each.....	51980-00

## OPTIONAL APPARATUS

Ammonia Combination Electrode, BNC.....	each.....	50250-00
Calcium Half-cell.....	each.....	50240-00
Chloride Combination Electrode, BNC.....	each.....	50225-00
Computer Interface Cable, 9-pin to 9-pin D-sub.....	each.....	48129-00
Cyanide/Iodide Electrode.....	each.....	50260-00
Demineralizer Bottle, 177 mL.....	each.....	14299-00
Electrode Stand.....	each.....	45300-00
Electrode Stand with Electromagnetic Stirrer, 115 Vac.....	each.....	45300-01
Electrode Stand with Electromagnetic Stirrer, 230 Vac.....	each.....	45300-02
Fluoride Combination Electrode.....	each.....	50265-00
Fluoride Half-cell.....	each.....	44500-71
HachLink <sup>™</sup> Data Capture software.....	each.....	49665-00
Low Ionic strength Chamber.....	each.....	51899-00
Nitrate Combination Electrode, Platinum Series, BNC.....	each.....	51920-00
ORP Combination Electrode, BNC.....	each.....	50230-00

## REPLACEMENT PARTS, continued

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### OPTIONAL APPARATUS (continued)

Description	Unit	Cat. No.
Platinum Series pH Flat Combination Electrode, 5-pin connector.....	each	51915-00
Platinum Series pH Combination Electrode, w/temp., 5-pin connector..	each	51910-00
pH Gel-filled Electrode, w/temp., 5-pin connector .....	each	51935-00
Potassium Half-cell.....	each	50245-00
Printer Interface Cable, 9-pin to 25-pin.....	each	49503-00
Printer, Citizen PN60I, 115 V, North American Style Plug.....	each	26687-00
Power Cord, for Citizen PN60I, Continental European Style Plug.....	each	46836-00
Reference Electrode, double junction.....	each	50225-00
Reference Electrode, single junction .....	each	50220-00
<i>sensio</i> <sup>™</sup> <b>1</b> Portable pH Meter.....	each	51700-00
<i>sensio</i> <sup>™</sup> <b>2</b> Portable pH/ISE Meter.....	each	51725-00
<i>sensio</i> <sup>™</sup> <b>3</b> Benchtop pH Meter, 115 V, No. American style plug.....	each	51750-00
<i>sensio</i> <sup>™</sup> <b>3</b> Benchtop pH Meter, 230 V, European style plug .....	each	51750-01
Sodium Combination Electrode, Platinum Series, BNC .....	each	51925-00
Stir Bar, 7/16 x 3/16.....	each	45315-00
Temperature Probe, 5-pin .....	each	51980-00
Thermometer, mercury, -20 to 110 °C .....	each	20959-11

## HOW TO ORDER

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**By Telephone:**

6:30 a.m. to 5:00 p.m. MST  
Monday through Friday  
(800) 227-HACH  
(800-227-4224)

**By FAX:**

(970) 669-2932

**By Mail:**

Hach Company  
P.O. Box 389  
Loveland, Colorado 80539-0389  
U.S.A.

**Ordering information by E-mail:**

orders@hach.com

### Information Required

- Hach account number (if available)
- Your name and phone number
- Purchase order number
- Brief description or model number
- Billing address
- Shipping address
- Catalog number
- Quantity

### Technical and Customer Service (U.S.A. only)

Hach Technical and Customer Service Department personnel are eager to answer questions about our products and their use. Specialists in analytical methods, they are happy to put their talents to work for you. Call **1-800-227-4224** or E-mail **techhelp@hach.com**.

### International Customers

Hach maintains a worldwide network of dealers and distributors. To locate the representative nearest you, send E-mail to **intl@hach.com** or call (970) 669-3050.

**In Canada:**

Hach Sales & Service Canada Ltd.; Manitoba, Canada  
Telephone: (204) 632-5598; FAX: (204) 694-5134

## REPAIR SERVICE

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Authorization must be obtained from Hach Company before sending any items for repair. Please contact the Hach Service Center serving your location.

### **In the United States:**

Hach Company  
100 Dayton Ave.  
Ames, Iowa 50010  
(800) 227-4224 (U.S.A. only)  
Telephone: (515) 232-2533  
FAX: (515) 232-1276

### **In Canada:**

Hach Sales & Service Canada Ltd.  
1313 Border Street, Unit 34  
Winnipeg, Manitoba  
R3H 0X4  
(800) 665-7635 (Canada only)  
Telephone: (204) 632-5598  
FAX: (204) 694-5134  
E-mail: [canada@hach.com](mailto:canada@hach.com)

### **Other locations:**

Hach Company World Headquarters,  
P.O. Box 389  
Loveland, Colorado 80539-0389 U.S.A.  
Telephone: (970) 669-3050  
FAX: (970) 669-2932

# WARRANTY

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Hach warrants most products against defective materials or workmanship for at least one year from the date of shipment; longer warranties may apply to some items.

**HACH WARRANTS TO THE ORIGINAL BUYER THAT HACH PRODUCTS WILL CONFORM TO ANY EXPRESS WRITTEN WARRANTY GIVEN BY HACH TO THE BUYER. EXCEPT AS EXPRESSLY SET FORTH IN THE PRECEDING SENTENCE, HACH MAKES NO WARRANTY OF ANY KIND WHATSOEVER WITH RESPECT TO ANY PRODUCTS. HACH EXPRESSLY DISCLAIMS ANY WARRANTIES IMPLIED BY LAW, INCLUDING BUT NOT BINDING TO ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.**

**LIMITATION OF REMEDIES:** Hach shall, at its option, replace or repair nonconforming products or refund all amounts paid by the buyer. **THIS IS THE EXCLUSIVE REMEDY FOR ANY BREACH OF WARRANTY.**

**LIMITATION OF DAMAGES:** IN NO EVENT SHALL HACH BE LIABLE FOR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES OF ANY KIND FOR BREACH OF ANY WARRANTY, NEGLIGENCE, ON THE BASIS OF STRICT LIABILITY, OR OTHERWISE.

This warranty applies only to Hach products purchased and delivered in the United States.

Catalog descriptions, pictures and specifications, although accurate to the best of our knowledge, are not a guarantee or warranty.

For a complete description of Hach Company's warranty policy, request a copy of our Terms and Conditions of Sale for U.S. Sales from our Customer Service Department.

Hach warrants the meter against defective materials or workmanship three years from the date of shipment. The Docking Station is warranted for one year after the date of shipment.



**HACH COMPANY**  
**WORLD HEADQUARTERS**  
P.O. Box 389  
Loveland, Colorado 80539-0389  
Telephone: (970) 669-3050  
FAX: (970) 669-2932

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**FOR TECHNICAL ASSISTANCE, PRICE INFORMATION AND ORDERING:**

In the U.S.A. - **Call toll-free 800-227-4224**

Outside the U.S.A. - **Contact the HACH office or distributor serving you.**

On the Worldwide Web - **[www.hach.com](http://www.hach.com); E-mail - [techhelp@hach.com](mailto:techhelp@hach.com)**

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**Attachment C**  
**Field Data Records**

# FIELD INSTRUMENTATION CALIBRATION RECORD

MACTEC Engineering and Consulting

PROJECT  DATE

CREW ID OR TASK ID  JOB NUMBER

SAMPLER SIGNATURE \_\_\_\_\_

## EQUIPMENT CALIBRATION

### CALIBRATION INFORMATION

### ACCEPTANCE

	STANDARD VALUE		METER VALUE		CRITERIA **
HORIBA MODEL NO. _____	pH _____	units	pH _____	units	+/- 10% of standard
UNIT ID NO. _____	Sp. Conductivity _____	mS/cm	Sp. Conductivity _____	mS/cm	+/- 10% of standard
	Redox _____	mV	Redox _____	mV	see note 1
	DO _____	mg/L *	DO _____	mg/L	+/- 10% of standard
	Thermometer Temperature _____	deg. C	Temperature _____	deg. C	+/- 2.0 deg. C

TURBIDITY METER TYPE _____	_____ NTU (low)	_____ NTU	within 0.3 NTU of the standard
MODEL NO. _____			
UNIT ID NO. _____	_____ NTU (high)	_____ NTU	+/- 10% of standard

### PHOTOIONIZATION

METER TYPE _____	Background _____ ppmv	Zero Air _____ ppmv	Meter _____ ppmv	within 5 ppmv of Zero
MODEL NO. _____	Span Gas _____ ppmv		Meter _____ ppmv	+/- 10% of standard
UNIT ID NO. _____				

OTHER METER TYPE _____				see note 2
MODEL NO. _____				see note 2
UNIT ID NO. _____				see note 2

OTHER METER TYPE _____				see note 2
MODEL NO. _____				see note 2
UNIT ID NO. _____				see note 2

## MATERIALS RECORD

### Lot Number

### Calibration Fluids/

Deionized Water Source: _____	_____	Standard Source: _____
Trip Blank Water Source: _____	_____	Lot Numbers pH _____
Sample Preservatives Source: _____	_____	mV _____
Disposable Filter Type: _____	_____	Sp. Cond. _____
Other _____	_____	Turb. _____

## NOTES:

\* = Indicate in notes section what was used as the DO standard (i.e., based on saturation at room temperature)

\*\* = If the meter reading is not within acceptance criteria, clean or replace probe and re-calibrate, or use a different meter if available. If project requirements

necessitate use of the instrument, clearly document on all data sheets and log book entries that the specified parameter was not calibrated to the acceptance criteria.

1 = meter must read within specified range of the Zobell solution (usually 231 +/- 10 mv @ 25 deg C).

2 = specify acceptance criteria in the Notes section

# FIELD DATA RECORD - LOW FLOW GROUNDWATER SAMPLING

PROJECT  SAMPLE I.D. NUMBER  ROUND NO.

EXPLORATION ID:  SITE TYPE  DATE

TIME  START  END  JOB NUMBER  FILE TYPE

WATER LEVEL / PUMP SETTINGS		MEASUREMENT POINT		PROTECTIVE CASING STICKUP (FROM GROUND)		PROTECTIVE CASING / WELL DIFFERENCE	
INITIAL DEPTH TO WATER	<input type="text"/> FT	<input type="checkbox"/> TOP OF WELL RISER		<input type="text"/>	FT	<input type="text"/>	FT
FINAL DEPTH TO WATER	<input type="text"/> FT	<input type="checkbox"/> TOP OF PROTECTIVE CASING					
DRAWDOWN VOLUME (initial - final x 0.16 (2-inch) or x 0.65 (4-inch))	<input type="text"/> GAL	<input type="checkbox"/> OTHER					
TOTAL VOL. PURGED	<input type="text"/> GAL	WELL DEPTH (TOR)	<input type="text"/> FT	PID AMBIENT AIR	<input type="text"/> PPM	WELL DIAMETER	<input type="text"/> IN
		SCREEN LENGTH	<input type="text"/> FT	PID WELL MOUTH	<input type="text"/> PPM	WELL INTEGRITY: CAP	YES NO N/A
		RATIO OF DRAWDOWN VOLUME TO TOTAL VOLUME PURGED	<input type="text"/>	PRESSURE TO PUMP	<input type="text"/> PSI	CASING LOCKED	---
				REFILL TIMER SETTING	<input type="text"/>	COLLAR	---
						DISCHARGE TIMER SETTING	<input type="text"/>

PURGE DATA		SPECIFIC						PUMP		COMMENTS
TIME	DEPTH TO WATER (ft)	PURGE RATE (ml/m)	TEMP. (deg. c)	CONDUCTANCE (ms/cm)	pH (units)	DISS. O2 (mg/L)	TURBIDITY (ntu)	REDOX (mv)	INTAKE DEPTH (ft)	

TYPE OF PUMP	TYPE OF TUBING	TYPE OF PUMP MATERIAL	TYPE OF BLADDER MATERIAL
<input type="checkbox"/> QED BLADDER	<input type="checkbox"/> TEFLON OR TEFLON LINED	<input type="checkbox"/> POLYVINYL CHLORIDE	<input type="checkbox"/> TEFLON
<input type="checkbox"/> SIMCO BLADDER	<input type="checkbox"/> HIGH DENSITY POLYETHYLENE	<input type="checkbox"/> STAINLESS STEEL	<input type="checkbox"/> OTHER _____
<input type="checkbox"/> GEOPUMP	<input type="checkbox"/> OTHER _____	<input type="checkbox"/> OTHER _____	

ANALYTICAL PARAMETERS		METHOD NUMBER	PRESERVATION METHOD	VOLUME REQUIRED	SAMPLE COLLECTED
To Be Collected			Specify QAPP	Specify QAPP	<input type="checkbox"/> Check if collected
<input type="checkbox"/> Check if requested for collection					
<input type="checkbox"/> VOC		8260B	HCL / 4 DEG. C	3 X 40 mL	<input type="checkbox"/> VOC
<input type="checkbox"/> SVOC		8270	4 DEG. C	2 X 1 L AG	<input type="checkbox"/> SVOC
<input type="checkbox"/> INORGANICS		8010	4 DEG. C		<input type="checkbox"/> INORGANICS
<input type="checkbox"/> Other _____					<input type="checkbox"/> Other _____
<input type="checkbox"/> Other _____					<input type="checkbox"/> Other _____
<input type="checkbox"/> Other _____					<input type="checkbox"/> Other _____
<input type="checkbox"/> Other _____					<input type="checkbox"/> Other _____
<input type="checkbox"/> Other _____					<input type="checkbox"/> Other _____
<input type="checkbox"/> Other _____					<input type="checkbox"/> Other _____
<input type="checkbox"/> Other _____					<input type="checkbox"/> Other _____
<input type="checkbox"/> Other _____					<input type="checkbox"/> Other _____
<input type="checkbox"/> Other _____					<input type="checkbox"/> Other _____
<input type="checkbox"/> Other _____					<input type="checkbox"/> Other _____

**PURGE OBSERVATIONS**

PURGE WATER CONTAINERIZED YES NO NUMBER OF GALLONS GENERATED \_\_\_\_\_

**NOTES**

SIGNATURE: \_\_\_\_\_

**LOCATION SKETCH**



**FIELD DATA RECORD - SURFACE WATER/ SEDIMENT SAMPLING**

PROJECT  JOB NUMBER  DATE   
 FIELD SAMPLE NUMBER  ACTIVITY TIME START  END  BOTTLE TIME   
 QC SAMPLES COLLECTED

**SURFACE WATER DATA**

WATER DEPTH AT LOCATION  FT SPEC. COND  EQUIPMENT USED:  BEAKER  STREAM/ RIVER DECON FLUIDS USED:  
 DEPTH OF SAMPLE FROM SURFACE  FT D.O.  PPM  PACS BOMB  LAKE/ POND  DI WATER N2 PURGE  
 TEMPERATURE  DEG C SALINITY  PPM  PERISTALTIC PUMP  SEEP  POTABLE WATER  
 TURBIDITY  NTUS ORP  mV  FILTER/ NUMBER \_\_\_\_\_  MARSH  \_\_\_\_\_  
 PH  UNITS ASSOCIATED TRIP BLANK  RINSATE BLANK   OTHER- \_\_\_\_\_  OTHER \_\_\_\_\_

**SEDIMENT DATA**

DEPTH OF SEDIMENT  TYPE OF SEDIMENT:  ORGANIC  SAND  GRAVEL  CLAY  OTHER \_\_\_\_\_  
 TYPE OF SAMPLE  DISCRETE  COMPOSITE EQUIPMENT FOR COLLECTION:  HAND CORER  S.S. SPOON  ALUMINIUM PAN  DREDGE  OTHER \_\_\_\_\_  
 SAMPLE OBSERVATIONS: ODOR \_\_\_\_\_ COLOR \_\_\_\_\_ DECON FLUIDS USED:  DI WATER N2 PURGE  POTABLE WATER  LIQUINOX  OTHER \_\_\_\_\_

**ANALYTICAL PARAMETERS WATER**

	METHOD NUMBER	FILTERED	PRESERVATION METHOD	VOLUME REQUIRED	SAMPLE COLLECTED
<input type="checkbox"/>	_____	_____	_____	_____	<input type="checkbox"/>
<input type="checkbox"/>	_____	_____	_____	_____	<input type="checkbox"/>
<input type="checkbox"/>	_____	_____	_____	_____	<input type="checkbox"/>
<input type="checkbox"/>	_____	_____	_____	_____	<input type="checkbox"/>
<input type="checkbox"/>	_____	_____	_____	_____	<input type="checkbox"/>
<input type="checkbox"/>	_____	_____	_____	_____	<input type="checkbox"/>
<input type="checkbox"/>	_____	_____	_____	_____	<input type="checkbox"/>
<input type="checkbox"/>	_____	_____	_____	_____	<input type="checkbox"/>

**ANALYTICAL PARAMETERS SOIL**

	METHOD NUMBER	PRESERVATION METHOD	VOLUME REQUIRED	SAMPLE COLLECTED
<input type="checkbox"/>	_____	_____	_____	<input type="checkbox"/>
<input type="checkbox"/>	_____	_____	_____	<input type="checkbox"/>
<input type="checkbox"/>	_____	_____	_____	<input type="checkbox"/>
<input type="checkbox"/>	_____	_____	_____	<input type="checkbox"/>
<input type="checkbox"/>	_____	_____	_____	<input type="checkbox"/>
<input type="checkbox"/>	_____	_____	_____	<input type="checkbox"/>
<input type="checkbox"/>	_____	_____	_____	<input type="checkbox"/>

NOTES

SIGNATURE: \_\_\_\_\_  
 RECEIVED BY: \_\_\_\_\_

**Attachment D**  
**Data Validation Checklists**

**ATTACHMENT D**  
**LEVEL I DATA QUALITY EVALUATION STANDARD**  
**OPERATING PROCEDURE AND CHECKLISTS**  
**ANALYTICAL DATA QUALITY SUMMARY**  
**OLIN CHEMICAL SUPERFUND SITE**  
**WILMINGTON, MASSACHUSETTS**

- ICP Metals by Method 6010B/200.7
- Volatile Organic Compounds by Method 8260B/624
- Semivolatile Organics by Method 8270C/625
- Wet Chemistry Parameters (General Chemistry) by Various Methods
- Volatile Petroleum Hydrocarbons by MADEP
- Chemist Review Checklist

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STANDARD OPERATING PROCEDURE AND CHECKLIST  
ICP METALS BY METHOD 6010B/200.7

Reviewer/Date \_\_\_\_\_  
Sr. Review/Date \_\_\_\_\_  
Lab Report # \_\_\_\_\_  
Project # \_\_\_\_\_

**1.0 Laboratory Deliverable Requirements**

**1.1 Laboratory Information:** Was all of the following provided in the laboratory report? Yes  No  N/A  Comments:  
Check items received.

Name of Laboratory     Address     Project ID     Phone #     Sample identification – Field and Laboratory

Client Information:     Name     Address     Client Contact    (IDs must be cross-referenced)

**ACTION:** If no, contact lab for submission of missing or illegible information.

**1.2 Laboratory Report Certification Statement**

Yes  No  N/A  Comments:

Does the laboratory report include a completed Analytical Report Certification in the required format?

**ACTION:** If no, contact lab for submission of missing certification or certification with correct format.

**1.3 Laboratory Case Narrative:**

Yes  No  N/A  Comments:

Narrative serves as an exception report for the project and method QA/QC performance.     Narrative includes an explanation of each discrepancy on the

Certification Statement.

**ACTION:** If no, contact lab for submission of missing or illegible information.

**1.4 Chain of Custody (COC) copy present with all documentation completed**

Yes  No  N/A  Comments:

**NOTE:** Olin receives and maintains the *original* COC.

**ACTION:** If no, contact lab for submission of copy of completed COC.

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**1.5 Sample Receipt Information (Cooler Receipt Form present?):**

Yes  No  N/A  Comments:

Were each of the following tasks completed and recorded upon receipt of the sample(s) into the laboratory?

Sample temperature confirmed: must be 1° – 10° C. (If samples were sent by courier and delivered on the same day as collection, temperature requirement does not apply).

Container type noted  sample condition observed  pH verified (where applicable)  Field and lab IDs cross referenced

**ACTION:** If no, contact lab for submission of missing or incomplete documentation.

**1.5.1** Were all samples delivered to the laboratory without breakage?

Yes  No  N/A  Comments:

**1.5.2** Does the *Cooler Receipt Form* or Lab Narrative indicate other problems with sample receipt, condition of the samples, analytical problems or special circumstances affecting the quality of the data?

Yes  No  N/A  Comments:

**1.6 Sample Results Section:** Was each of the following requirements supplied in the laboratory report for each sample?

Yes  No  N/A  Comments:

- Field ID and Lab ID       Date and time collected       Analyst Initials       Dilution Factor       % moisture or solids       Reporting limits  
 Clean-up method       Analysis method       Preparation method       Date of preparation/extraction/digestion clean-up and analysis, where applicable        
Matrix       Target analytes and concentrations       Units (soils must be reported in dry weight)

**ACTION:** If no, contact lab for submission of missing or incomplete information.

**1.7 QA/QC Information:** Was each of the following information supplied in the laboratory report for each sample batch?

Yes  No  N/A  Comments:

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Method blank results     LCS recoveries     MS/MSD recoveries and RPDs     Laboratory duplicate results (where applicable)

**ACTION:** If no, contact lab for submission of missing or incomplete information.

**2.0 Holding Times**

Have any technical holding times, determined from date of collection to date of analysis, been exceeded? Holding time for metals is 180 days from sample collection to analysis for both water and soil.    Yes     No     N/A     Comments:

**NOTE:** List samples that exceed hold time with # of days exceeded on checklist

**ACTION:** If technical holding times are exceeded, qualify all positive results (J) and non-detects (UJ). If grossly exceeded (2X holding time) reject (R) all non-detect results.

**3.0 Laboratory Method**

**3.1**    Was the correct laboratory method used?    Yes     No     N/A     Comments:

Water Digestion	3005A or 3010A or 3020A
Soil Digestion	3050B
Metals	6010B or 200.7

**ACTION:** If no, contact laboratory to provide justification for method change compared to the requested method. Contact senior chemist to inform Client of change and to request variance.

**3.2**    Are the practical quantitation limits the same as those specified by the    Yes     No     N/A     Comments:  
           SOW     QAPP     Lab     MADEP

**NOTE:** Verify that the reported metals match the target list specified on the COC.

**ACTION:** If no, evaluate variation with respect to sample matrix, preparation, dilution,

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moisture, etc. If sample PQL is indeterminate, contact lab for explanation.

3.3 Are results present for each sample in the SDG? Yes  No  N/A  Comments:

**ACTION:** If no, check Request for Analysis to verify if method was ordered and COC to verify that it was sent, and contact lab for resubmission of the missing data

3.4 If dilutions were required, were dilution factors reported? Yes  No  N/A  Comments:

**ACTION:** If no, contact the lab for submission.

**4.0 Method Blanks**

4.1 Is the Method Blank Summary present? Yes  No  N/A  Comments:

**ACTION:** If no, call the laboratory for submission of missing data.

4.2 Frequency of Analysis: Was a method blank analyzed for each digestion batch of < 20 field samples? Yes  No  N/A  Comments:

**ACTION:** If no, contact laboratory for justification. Consult senior chemist for action needed. Narrate non-compliance.

4.3 Is the method blank less than the PQLs for all target elements? Yes  No  N/A  Comments:

**NOTE:** MADEP requires the method blank to be matrix matched and digested with the samples

4.4 Do any method blanks have positive results for metals? Qualify data according to the following: Yes  No  N/A  Comments:

If the sample concentration is  $< 5 \times$  blank value, flag sample result non-detect "U" at the PQL or the concentration reported if greater than the PQL.

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If the sample concentration is  $> 5 \times$  blank value, no qualification is needed.

**ACTION:** For any blank with positive results, list all contaminants for each method blank including the concentration detected and the flagging level (flagging level = 5x the blank value) and the associated samples and qualifiers.

**5.0 Laboratory Control Standard**

5.1 Was a laboratory control standard run with each analytical batch of 20 samples or less? Yes  No  N/A  Comments:

**NOTE:** A *full target, second source LCS* is required by MADEP.

**ACTION:** Call laboratory for LCS form submittal. If data are not available, use professional judgement to evaluate data accuracy associated with that batch.

5.2 Is a LCS Summary Form present? Yes  No  N/A  Comments:

**ACTION:** If no, contact lab for resubmission of missing data.

5.3 Is the recovery of any analyte outside of MADEP control limits? Yes  No  N/A  Comments:

<u>Sample Type</u>	<u>MADEP % Rec</u>
Water	80-120
Soil	within Lab generated limits

**ACTION:** If recovery is above the upper limit, qualify all positive sample results within the batch as (J). If recovery is below the lower limit, qualify all positive and non-detects results within the batch as (J). If LCS recovery is  $< 30\%$ , positive and non-detect results are rejected (R).

Comments:

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**6.0 Matrix Spikes**

Matrix spikes may be collected at different frequencies based on monthly, quarterly, or task specific schedules. Confirm spike requirements for each set with the senior chemist.

6.1 Were project-specific MS/MSDs collected? List project samples that were spiked. Yes  No  N/A  Comments:

**ACTION:** If no, contact senior chemist to see if any were specified.

6.2 Is the Matrix Spike/Matrix Spike Duplicate Recovery Form present? Yes  No  N/A  Comments:

**NOTE:** A full target, second source MS/MSD is required by MADEP.

**ACTION:** If any matrix spike data are missing, call lab for resubmission.

6.3 Were matrix spikes analyzed as indicated on the COC and project schedule? Yes  No  N/A  Comments:

**ACTION:** If any matrix spike data are missing, call lab for resubmission. If none, no qualification is needed. Narrate non-compliance.

6.4 Are any metal spike recoveries outside of the QC limits? Yes  No  N/A  Comments:

Sample Type	MADEP	QAPP	Method
	% Rec	% Rec	
Water	75-125	N/A	6010B
Water	N/A	70-130	200.7
Soil	75-125	75-125	6010B

**NOTE:**  $\%R = \frac{(SSR-SR)}{SA} \times 100\%$  Where: SSR = Spiked sample result  
SR = Sample result  
SA = Spike added

**NOTE:** If dilutions are required due to high sample concentrations (> 4X spike), the data are evaluated, but no flags are applied.

**NOTE:** If only one of the recoveries for an MS/MSD pair is outside of the control

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limits, no qualification is necessary. Use professional judgment for the MS/MSD flags.

**ACTION:** MS/MSD flags only apply to the sample spiked. If the recoveries of the MS and MSD exceed the upper control limit, qualify positive results as estimated (J). If the recoveries of the MS and MSD are lower than the lower control limit, qualify positive results and non-detects (J).

6.5 Are any RPDs for MS/MSD recoveries outside of the QC limits? Yes  No  N/A  Comments:

**NOTE:**  $RPD = \frac{S-D}{(S+D)/2} \times 100\%$  Where: S = MS sample result  
D = MSD sample result

**NOTE:** If dilutions are required due to high sample concentrations, the data are evaluated, but no flags are applied.

**ACTION:** If the RPD exceeds the control limit, qualify positive results and non-detects (J).

7.0 **Laboratory Duplicate**

7.1 Was a laboratory duplicate sample analyzed? If so, is the Laboratory Duplicate Sample Form present? Yes  No  N/A  Comments:

**NOTE:** MADEP refers to this sample as a "matrix duplicate".

**ACTION:** If not analyzed, qualification is not needed. If data is missing, contact laboratory for resubmission of report. Narrate non-compliance.

7.2 Is the RPD between the result for the laboratory duplicate sample and the result for the parent sample outside of the QA/QC limits? Yes  No  N/A  Comments:

MADEP Laboratory Duplicate Sample RPD Criteria:                      QAPP RPD

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For aqueous results > 5×RL, RPD must be ± 20%	20
For aqueous results < 5×RL, RPD must be ≤ RL	20
For soil/sediment results > 5×RL, RPD must be ± 35%	20
For soil/sediment results < 5×RL, RPD must be ≤ 2×RL	20

**ACTION:** If the RPD exceeds the limits, qualify both positive results and non-detects as estimated and flag them J. Narrate non-compliance

**8.0 Sampling Accuracy**

The majority of ground water samples are collected directly from a tap, process stream, or with dedicated tubing. Rinse blanks will not be collected.

**8.1** Were rinsate blanks collected? Prior to evaluating rinsate blanks, obtain a list of the associated samples from the senior chemist. Yes  No  N/A  Comments:

**8.2** Do any rinsate blanks have positive results? Yes  No  N/A  Comments:

**NOTE:** MADEP does not require the collection of rinsate blanks.

**ACTION:** Evaluate rinsate results against blank results to determine if contaminant may be laboratory-derived. If results are not lab-related, qualify according to below.

If the sample concentration is < 5 × blank value, flag sample result non-detect "U" at the PQL or the concentration reported if greater than the PQL.

If the sample concentration is > 5 × blank value, no qualification is needed.

**9.0 Field Duplicates**

**9.1** Were field duplicate samples collected? Obtain a list of samples and their associated field duplicates. Yes  No  N/A  Comments:

**9.2** Were field duplicates collected per the required frequency? Yes  No  N/A  Comments:

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SOW  QAPP (1 per 10)  MADEP Option 1 (1 per 20)  MADEP Option 3 (1 per 10)

9.3 Was the RPD  $\leq$  50% for soils or waters? Calculate the RPD for all results and Yes  No  N/A  Comments:  
attach to this review.

**ACTION:** RPD must be  $\leq$ 50% for soil and water. Qualify data (J) for both sample results if the RPD exceeds 50%.

10.0 Special QA/QC

10.1 Were both total and dissolved metals analysis performed? If so, the dissolved metal concentration should not exceed that of the total metal. Yes  No  N/A  Comments:

**ACTION:** If results for both total and dissolved are  $\geq$  5x the PQL **and** the dissolved concentration is 10% higher than the total, flag both results as estimated (J). If total and dissolved concentrations are less than 5x the PQL **and** the **difference** exceeds 2x the PQL, flag both results as estimated (J)

10.0 Application of Validation Qualifiers

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Was any of the data qualified?

Yes  No  N/A  Comments:

If so, apply data qualifiers directly to the DQE copy of laboratory report and **flag pages** for entry in database.

**REFERENCES**

- LAW, 1999, "Final Quality Assurance Project Plan, Olin Wilmington Property, 51 Eames Street, Wilmington, MA", LAW Engineering and Environmental Services, Kennesaw, GA 30144. August 1999
- U.S. Environmental Protection Agency (USEPA), 1989. "Region 1 Laboratory Data Validation Functional Guidelines For Evaluating Inorganic Analyses"; Hazardous Site Evaluation Division; February 1989.
- MADEP, 2001. Massachusetts Department of Environmental Protection Bureau of Waste Site Cleanup, "Massachusetts Quality Assurance and Quality Control (QA/QC) Requirements." BWSC-CAM, Interim Final Draft, Revision No. 2, 5 October 2001.
- MADEP, 2001. Massachusetts Department of Environmental Protection Bureau of Waste Site Cleanup, "Quality Assurance and Quality Control Guidelines for Sampling, Data Evaluation and Reporting Activities," BWSC-CAM, Section VII, Public Comment Draft, Revision No. 0, 21 December 2001.

STANDARD OPERATING PROCEDURE AND CHECKLIST

Lab Report # \_\_\_\_\_

VOLATILE ORGANICS BY METHOD SW8260B/624

Project # \_\_\_\_\_

**Note:** The following analyses will be evaluated according to the "MADEP QA/QC Guidelines for Sampling, Data Evaluation and Reporting Activities." MADEP, however, may not list QA/QC criteria for every chemical analysis. Where not defined by MADEP, criteria will default to values stipulated in the QAPP. Where the QAPP does not define criteria, QA/QC requirements will default to limits employed by the laboratory.

**1.0 Laboratory Deliverable Requirements**

**1.1 Laboratory Information:** Was all of the following provided in the laboratory report? Yes  No  N/A  Comments:  
Check items received.

- Name of Laboratory
- Address
- Project ID
- Phone #
- Sample identification – Field and Laboratory

Client Information:  Name  Address  Client Contact (IDs must be cross-referenced)

**ACTION:** If no, contact lab for submission of missing or illegible information.

**1.2 Laboratory Report Certification Statement** Yes  No  N/A  Comments:

Does the laboratory report include a completed Analytical Report Certification in the required format?

**ACTION:** If no, contact lab for submission of missing certification or certification with correct format.

**1.3 Laboratory Case Narrative:** Yes  No  N/A  Comments:

- Narrative serves as an exception report for the project and method QA/QC performance.
- Narrative includes an explanation of each discrepancy on the Certification Statement.

**ACTION:** If no, contact lab for submission of missing or illegible information.

**1.4 Chain of Custody (COC) copy present with all documentation completed?** Yes  No  N/A  Comments:

Does the laboratory report include completed Chain of Custody forms containing all samples in this SDG?

**NOTE:** Olin receives and maintains the *original* COC.

**ACTION:** If no, contact lab for submission of copy of completed COC.

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VOLATILE ORGANICS BY METHOD SW8260B/624

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**1.5 Sample Receipt Information (Cooler Receipt Form present?):**

Yes  No  N/A  Comments:

Were each of the following tasks completed and recorded upon receipt of the sample(s) into the laboratory?

- Sample temperature confirmed: must be 1° – 10° C. (If samples were sent by courier and delivered on the same day as collection, temperature requirement does not apply).  
 Container type noted     Condition observed     Field and lab IDs cross referenced

**ACTION:** If no, contact lab for submission of missing or incomplete documentation.

**1.5.1 Were the correct bottles and preservatives used?**

Yes  No  N/A  Comments:

Water - 40 mL VOA vial/HCL to pH<2, cool to 4°C  
Soil - 5 gram Encore™/cool to 4°C or 40 mL VOA vial with field preservation of sodium bisulfate (low-level) or methanol (high-level) or field preservation in water if soils are reactive to sodium bisulfate (i.e. alkaline conditions, excessive humic acid content, etc.)

**ACTION:** If no, inform senior chemist. Document justification for change in container/volume (if applicable); qualify both positive data and non-detect data (J) if cooler temperature exceeds 10°C. Rejection of data requires professional judgment

**ACTION:** If each VOA vial for a sample contains air bubbles or the VOA vial analyzed contained air bubbles, flag positives (J) and reject nondetects (R).

**1.5.2 Were all samples delivered to the laboratory without breakage?**

Yes  No  N/A  Comments:

**1.5.3 Does the Cooler Receipt Form or Lab Narrative indicate other problems with sample receipt, condition of the samples, analytical problems or special circumstances affecting the quality of the data?**

Yes  No  N/A  Comments:

**1.6 Sample Results Section: Was the following information supplied in the laboratory report for each sample?**

Yes  No  N/A  Comments:

- |  |   |   |   |   |   |
|--|---|---|---|---|---|
| <input type="checkbox"/> Field ID and Lab ID | <input type="checkbox"/> Date and time collected            | <input type="checkbox"/> Analyst Initials                             | <input type="checkbox"/> Dilution Factor  | <input type="checkbox"/> % moisture or solids | <input type="checkbox"/> Reporting limits |
| <input type="checkbox"/> Clean-up method     | <input type="checkbox"/> Analysis method                    | <input type="checkbox"/> Preparation method                           | <input type="checkbox"/> Date of preparation/extraction/digestion clean-up and analysis, where applicable |   |   |
| <input type="checkbox"/> Matrix              | <input type="checkbox"/> Target analytes and concentrations | <input type="checkbox"/> Units (soils must be reported in dry weight) |   |   |   |

**ACTION:** If no, contact lab for submission of missing or incomplete information.

**1.7 QA/QC Information: Was the following information provided in the laboratory report for each sample batch?**

Yes  No  N/A  Comments:

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Method blank results     LCS recoveries     MS/MSD recoveries and RPDs     Surrogate recoveries

**ACTION:** If no, contact lab for submission of missing or incomplete information.

**2.0    Holding Times**

Have any technical holding times, determined from date of collection to date of analysis, been exceeded?

Yes     No     N/A     Comments:

For water samples, the holding time is 7 days (aromatics) from sampling for unpreserved samples and 14 days for preserved samples.

For soil samples, the holding time is 14 days from sampling if field preserved with sodium bisulfate/methanol/or water. If an Encore™ sampler was used, the lab must *preserve* the sample within 48 hours. Analytical holding time from time of preservation is 14 days.

**NOTE:** List samples that exceed hold time with # of days exceeded on checklist

**ACTION:** If technical holding times are exceeded, qualify all positive results (J) and non-detects (UJ). For water samples that are grossly exceeded (>2X hold time) reject (R) all non-detect results. For soil samples professional judgement will be used to determine if rejection is necessary.

**3.0    Laboratory Method**

3.1 Was the correct laboratory method used?

Purge and Trap            Water: 5030B    Soil: 5035  
Volatile Organics        8260B

Yes     No     N/A     Comments:

**ACTION:** If no, contact lab to provide justification for method change compared to the requested method. Contact senior chemist to inform Client of change or to request variance.

3.2 Are the practical quantitation limits the same as those specified by the  
 SOW     QAPP     Lab     MADEP

Yes     No     N/A     Comments:

Evaluate PQLs with respect to sample matrix, preparation, dilution, moisture, etc. If sample PQL is indeterminate, contact lab for explanation. Provide a listing of all samples with PQLs that are elevated due to dilution, sample matrix, or preparation factors.

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3.3 Are the appropriate parameter results present for each sample in the SDG? Yes  No  N/A  Comments:

**NOTE:** The MADEP QA/QC Guidelines requires a minimum compound reporting list for volatile organic compounds. Determine target compound requirement and verify reporting list.

3.4 Were Tentatively Identified Compounds (TICs) reported? Yes  No  N/A  Comments:

**NOTE:** TICs are only required for samples with full MADEP target list. Determine if TICs are required. MADEP requires that all TICs be reported to the LCS. Per the MADEP guidance, TICs, which are identified as aliphatic hydrocarbons, do not have to be reported as TICs. However, these compounds must be evaluated as part of the health-based risk assessment approach (VPH/EPH).

**ACTION:** Qualify reported TIC results as estimated and flag (NJ).

3.5 If dilutions were required, were dilution factors reported? Yes  No  N/A  Comments:

**NOTE:** MADEP guidance states that if a diluted and an undiluted analysis is performed, the laboratory should report results for the lowest dilution within the valid calibration range for each analyte.

**ACTION:** If no, contact the lab for submission.

**4.0 Method Blanks**

4.1 Are the Method Blank Summaries present? Yes  No  N/A  Comments:

**ACTION:** If no, call the laboratory for submission of missing data.

4.2 Was a method blank analyzed for each analytical batch of 20 samples or less? Yes  No  N/A  Comments:

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**ACTION:** If no, document discrepancy in case narrative and contact lab for justification. Consult senior chemist for action needed.

4.3 Is the method blank less than the PQL? (See attached table for PQLs). Yes  No  N/A  Comments:

**NOTE:** MADEP allows common laboratory contaminants (acetone, methylene chloride and 2-butanone) to be present at concentrations < 5x the PQL.

4.4 Do any method blanks have positive results for VOC parameters? Qualify data according to the following: Yes  No  N/A  Comments:

For the common contaminants (methylene chloride, acetone, toluene, and 2-butanone):

If the sample concentration is < 10 × blank value, flag sample result non-detect "U" at the PQL or the concentration reported if greater than the PQL.

If the sample concentration is > 10 × blank value, no qualification is needed.

For other VOC contaminants:

If the sample concentration is < 5 × blank value, flag sample result non-detect "U" at the PQL or the concentration reported if greater than the PQL.

If the sample concentration is > 5 × blank value, no qualification is needed.

**ACTION:** If any blank has positive results, list all the concentrations detected and flagging level (flagging level = 10x or 5 × blank value) on the checklist. List all affected samples and their qualifiers.

**5.0 Laboratory Control Standards**

5.1 Was a laboratory control standard (LCS) run with each analytical batch of 20 samples or less? Yes  No  N/A  Comments:

**ACTION:** If no, call laboratory for LCS form submittal. If data is not available, use professional judgment to determine qualification actions for data associated with that batch.

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5.2 Is a LCS Summary Form present? Yes  No  N/A  Comments:

**ACTION:** If no, contact lab for resubmission of missing data.

5.2 Is the recovery of any analyte outside of control limits? Yes  No  N/A  Comments:

**NOTE:** A full target, second source LCS is required by MADEP.

**NOTE:** Use MADEP guidelines list LCS recovery limits of 70-130.

**ACTION:** If recovery is above the upper limit, qualify all positive sample results within the batch as (J). If recovery is below the lower limit but > 10%, qualify all positive and no-detect results within the batch as (J). If LCS recovery is <10%, non-detect results are rejected (R). Document qualified compounds and percent recoveries in the validation report.

5.4 Are 80% of LCS recoveries within laboratory control limits? Yes  No  N/A  Comments:

**ACTION:** If 80% of LCS recoveries are not within limits, use professional judgment and consult Senior Chemist.

#### 6.0 Matrix Spikes

Matrix spikes may be collected at different frequencies based on monthly, quarterly, or task specific schedules. Confirm spike requirements for each set with the senior chemist.

6.1 Were project-specific MS/MSDs collected? List project samples that were spiked.

**ACTION:** If no, contact senior chemist to see if any were specified.

Yes  No  N/A  Comments:

6.2 Is the MS/MSD Recovery Form present?

**ACTION:** If no, contact lab for resubmission of missing data.

Yes  No  N/A  Comments:

6.3 Were matrix spikes analyzed at the required frequency of 1 per 20 samples per matrix?

Yes  No  N/A  Comments:

**ACTION:** If any matrix spike data is missing, call lab for resubmission.

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6.4 Are any VOC spike recoveries outside of the QC limits?

Yes  No  N/A  Comments:

NOTE: 
$$\%R = \frac{(SSR-SR)}{SA} \times 100\%$$

Where: SSR = Spiked sample result  
 SR = Sample result

SA = Spike added

NOTE: A full target, second source MS/MSD is required by MADEP.

NOTE: MADEP guidelines list MS/MSD recovery limits as 70-130.

NOTES: 1) If only one of the recoveries for an MS/MSD pair is outside of the control limits, no qualification is necessary. Use professional judgment for the MS/MSD flags.  
 2) If the MS/MSD was performed by the laboratory on a non-project sample, no qualification is required.

**ACTION:** MS/MSD flags only apply to the sample spiked. If the recoveries of the MS and MSD exceed the upper control limit, qualify positive results as estimated (J). If the recoveries of the MS and MSD are lower than the lower control limit, qualify both positive results and non-detects (J). If recovery is < 10%, reject non-detects (R).

6.5 Are any RPDs for MS/MSD recoveries outside of the QA/QC limits?

NOTE: 
$$RPD = \frac{S-D}{(S+D)/2} \times 100\%$$
 Where S = MS result  
 D = MSD result

Yes  No  N/A  Comments:

NOTE: MADEP guidelines list MS/MSD RPD limits for both water and soils as  $\leq 20$ .

**ACTION:** If the RPD exceeds the control limit, qualify positive results and non-detects (J).

7.0 Surrogate Recoveries

Were one or more VOC surrogate recoveries outside of laboratory limits for any Yes  No  N/A  Comments:

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sample or method blank? If yes, were samples re-analyzed?

**NOTE:** %R =  $QD \times 100\%$     Where:    S        =    MS    sample    result  
  D = MSD sample result

**NOTE:** No qualification is required if two of the surrogates are within acceptable QC limits. If surrogate recoveries fail due to dilution, results are not flagged. Document on checklist and in the case narrative.

**NOTE:** MADEP guidelines list surrogate limits for both water and soils as 70-130%. Surrogate recovery limits greater than ± 30% are allowed for difficult matrices (wastes, sludges, etc.) with appropriate analytical documentation.

**ACTION:** If recoveries are >10%, but fail to meet quality control criteria: (1) For recoveries below the QC limit but >10%, qualify nondetects and positives (J), and (2) For recoveries above the QC limit, qualify only positives (J). If any surrogate recovery is <10% (unless the QC limits are below 10%, in which case, results are flagged as stated above), flag positives (J) and reject nondetects (R).

**8.0    Sampling Accuracy**

8.1 Were trip blanks shipped with VOC samples and analyzed?

Yes     No     N/A     Comments:

**NOTE:** MADEP requires trip blanks per the following frequency:

	<u>Soil/Sediment</u>	<u>Aqueous</u>	<u>Drinking Water</u>
Option 1	Not Required	Not Required	1 per cooler VOAs/VPH
Option 3	1 per 10 samples	1 per 10 samples	1 per 10 samples

8.2 Do any trip blanks have positive results?

Yes     No     N/A     Comments:

**ACTION:** Prepare a list of samples shipped in the same cooler as a contaminated blank.

If the sample concentration is < 5 × blank value, flag sample result non-detect "U" at the PQL or the concentration reported if greater than the PQL.

If the sample concentration is > 5 × blank value, no qualification is needed.

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The majority of ground water samples are collected directly from a tap, process stream, or with dedicated tubing. Rinse blanks will not be collected. Yes  No  N/A  Comments:

8.3 Were rinsate blanks collected? Prior to evaluating rinsate blanks, obtain a list of the associated samples from the senior chemist.

**NOTE:** MADEP does not specify the collection of rinsate blanks.

8.4 Do any rinsate blanks have positive results? Yes  No  N/A  Comments:

**ACTION:** Evaluate rinsate results against blank results to determine if contaminant may be laboratory-, ambient-, or shipment-derived. If results are not lab-, ambient-, or shipment-related, qualify according to the table above (8.2).

**9.0 Field Duplicates**

9.1 Were field duplicate samples collected? Obtain a list of samples and their associated field duplicates. Yes  No  N/A  Comments:

9.2 Were field duplicates collected per the required frequency? Yes  No  N/A  Comments:

SOW  QAPP (1 per 10)  MADEP Option 1 (1 per 20)

MADEP Option 3 (1 per 10)

9.3 Was the RPD  $\leq$  50% for soils or 30% for waters? Calculate the RPD for all results and attach to this review. Yes  No  N/A  Comments:

**ACTION:** Qualify data (J) for both sample results if the RPD goal is exceeded.

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**10.0 Application of Validation Qualifiers**

Was any of the data qualified?

Yes  No  N/A  Comments:

If so, apply data qualifiers directly to the DQE copy of laboratory report and **flag pages** for entry in database.

**REFERENCES**

LAW, 1999, "Final Quality Assurance Project Plan, Olin Wilmington Property, 51 Eames Street, Wilmington, MA", LAW Engineering and Environmental Services, Kennesaw, GA 30144. August 1999.

STL-Westfield, 2002. "Olin – General Chemistry Control Limits (Soil & Water)," Severn Trent Laboratories, Inc., 53 Southampton Road, Westfield, MA, 01085.

U.S. Environmental Protection Agency (USEPA), 1996. "Region 1 EPA-NE Data Validation Guidelines For Evaluating Environmental Analyses"; Quality Assurance Unit Staff; Office of Environmental Measurement and Evaluation; December 1996.

MADEP, 2001. Massachusetts Department of Environmental Protection Bureau of Waste Site Cleanup, "Massachusetts Quality Assurance / Quality Control (QA / QC Requirements)," BWSC-CAM, Interim Final Draft, Revision No. 2, 5 October 2001.

MADEP, 2001. Massachusetts Department of Environmental Protection Bureau of Waste Site Cleanup, "Quality Assurance / Quality Control Guidelines for Sampling, Data Evaluation and reporting Activities," BWSC-CAM, Section VII, Public Comment Draft, Revision No. 0, 21 December 2001.

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Sr. Review/Date \_\_\_\_\_  
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Project # \_\_\_\_\_

**1.0 Laboratory Deliverable Requirements**

**1.1 Laboratory Information:** Was all of the following provided in the laboratory report? Yes  No  N/A  Comments:  
Check items received.

- Name of Laboratory
  - Address
  - Project ID
  - Phone #
  - Sample identification – Field and Laboratory
- Client Information:     Name                       Address             Client Contact            (IDs must be cross-referenced)

**ACTION:** If no, contact lab for submission of missing or illegible information.

**1.2 Laboratory Report Certification Statement**

Yes  No  N/A  Comments:

Does the laboratory report include a completed Analytical Report Certification in the required format?

**ACTION:** If no, contact lab for submission of missing certification or certification with correct format.

**1.3 Laboratory Case Narrative:**

Yes  No  N/A  Comments:

- Narrative serves as an exception report for the project and method QA/QC performance.
- Narrative includes an explanation of each discrepancy on the Certification Statement.

**ACTION:** If no, contact lab for submission of missing or illegible information.

**1.4 Chain of Custody (COC) copy present of completed COC?**

Yes  No  N/A  Comments:

Does the laboratory report include a copy of the completed Chain of Custody forms containing all samples in this SDG?

**NOTE:** Olin receives and maintains the *original* COC.

**ACTION:** If no, contact lab for submission of missing completed COC.

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**1.5 Sample Receipt Information (Cooler Receipt Form):** Were each of the following tasks completed and recorded upon receipt of the sample(s) into the laboratory?    Yes     No     N/A     Comments:

Sample temperature confirmed: must be 1° – 10° C. (If samples were sent by courier and delivered on the same day as collection, temperature requirement does not apply).

Container type noted     Condition observed     pH verified (where applicable)     Field and lab IDs cross referenced

**ACTION:** If no, contact lab for submission of missing or incomplete documentation.

**1.5.1**    Were the correct bottles and preservatives used?    Yes     No     N/A     Comments:

Water - 1 Liter amber bottle/cool to 4°C

Soil - 8 oz soil jar/cool to 4°C

**ACTION:** If no, inform senior chemist. Document justification for change in container/volume (if applicable), qualify positive and non-detect data (J) if cooler temperature exceeds 10°C. Rejection of data requires professional judgment.

**1.5.2**    Were all samples delivered to the laboratory without breakage?    Yes     No     N/A     Comments:

**1.5.3**    Does the *Cooler Receipt Form* or Lab Narrative indicate other problems with sample receipt, condition of the samples, analytical problems or special circumstances affecting the quality of the data?    Yes     No     N/A     Comments:

**1.6 Sample Results Section:** Was the following information supplied in the laboratory report for each sample?    Yes     No     N/A     Comments:

Field ID and Lab ID     Date and time collected     Analyst Initials     Dilution Factor     % moisture or solids     Reporting limits  
 Clean-up method     Analysis method     Preparation method     Date of preparation/extraction/digestion clean-up and analysis, where applicable      
Matrix     Target analytes and concentrations     Units (soils must be reported in dry weight)

**ACTION:** If no, contact lab for submission of missing or incomplete information.

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**1.7 QA/QC Information:** Was the following information provided in the laboratory report for each sample batch? Yes  No  N/A  Comments:

Method blank results    LCS recoveries    MS/MSD recoveries and RPDs    Surrogate recoveries

**ACTION:** If no, contact lab for submission of missing or incomplete information.

**2.0 Holding Times**

Yes  No  N/A  Comments:

Have any technical holding times, determined from date of collection to date of analysis, been exceeded?

**NOTE:** For water samples, the holding time is 7 days from sampling to extraction and 40 days from extraction to analysis. For soil samples, the holding time is 14 days from sampling to extraction and 40 days from extraction to analysis.

**ACTION:** If technical holding times are exceeded, qualify all positive results (J) and non-detects (UJ). For water samples that are grossly exceeded (>2X hold time) reject (R) all non-detect results. For soil samples professional judgement will be used to determine if rejection is necessary.

**3.0 Laboratory Method**

Yes  No  N/A  Comments:

**3.1** Was the correct laboratory method used?

Water Extraction      3510C or 3520C  
Soil Extraction        3540C or 3550B  
Semi-volatile Organics 8270C

**ACTION:** If no, contact project manager to inform Client of change; request variance from Client; contact laboratory to provide justification for method change compared to the requested method.

**3.2** Are the practical quantitation limits the same as those specified by the  
 SOW    QAPP    Lab?

Yes  No  N/A  Comments:

**NOTE:** The QAPP and MADEP QA/QC Guidelines provides PQLs for semi-volatile organic compounds. Verify proper PQLs were used for each data set.

**ACTION:** If no, evaluate change with respect to sample matrix, preparation, dilution, moisture, etc. If sample PQL is indeterminate, contact lab for explanation.

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3.3 Are the appropriate parameter results present for each sample in the SDG? Yes  No  N/A  Comments:

**ACTION:** If no, check Request for Analysis to verify if method was ordered and COC to verify that it was sent, and contact lab for resubmission of the missing data

3.4 Were Tentatively Identified Compounds (TICs) reported? Yes  No  N/A  Comments:

*NOTE TICs are only required for samples with full MADEP target list. Determine if TICs are required. MADEP requires that all TICs be reported to the LCS. Per the MADEP guidance, TICs, which are identified as aliphatic hydrocarbons, do not have to be reported as TICs. However, these compounds must be evaluated as part of the health-based risk assessment approach (VPH/EPH).*

**ACTION:** Qualify reported TIC results as estimated and flag (NJ).

3.5 If dilutions were required, were dilution factors reported? Yes  No  N/A  Comments:

**ACTION:** If no, contact the lab for submission.

4.0 **Method Blanks**

4.1 Is the Method Blank Summary present? Yes  No  N/A  Comments:

**ACTION:** If no, call the laboratory for submission of missing data.

4.2 For the analysis of SVOCs, has a method blank been analyzed for each analysis batch of field samples of 20 or less? Yes  No  N/A  Comments:

**ACTION:** If no, document discrepancy in case narrative and contact lab for justification. Consult senior chemist for action needed.

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4.3 Is the method blank less than the PQL?

Yes  No  N/A  Comments:

**NOTE:** MADEP allows common laboratory contaminants (such as phthalates) to be present at concentrations < 5x the PQL

4.4 Do any method blanks have positive results for SVOC parameters? Qualify data according to the following:

Yes  No  N/A  Comments:

For the common contaminants (phthalates):

If the sample concentration is < 10 × blank value, flag sample result non-detect "U" at the PQL or the concentration reported if greater than the PQL.

If the sample concentration is > 10 × blank value, no qualification is needed.

For other SVOC contaminants:

If the sample concentration is < 5 × blank value, flag sample result non-detect "U" at the PQL or the concentration reported if greater than the PQL.

If the sample concentration is > 5 × blank value, no qualification is needed.

**ACTION:** For any blank with positive results, list all contaminants for each method blank, including the concentration detected and the flagging level (flagging level = 5x or 10x the blank value) and the associated samples and qualifiers.

**5.0 Laboratory Control Standard**

5.1 Was a laboratory control standard run with each analytical batch of 20 samples or less?

Yes  No  N/A  Comments:

**ACTION:** Call laboratory for LCS form submittal. If data are not available, use professional judgment to determine the usability of sample results associated with that batch.

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5.2 Is a LCS Summary Form present?

Yes  No  N/A  Comments:

**ACTION:** If no, contact lab for resubmission of missing data.

5.3 Is the recovery of any analyte outside of control limits?

Yes  No  N/A  Comments:

**NOTE:** A full target, second source LCS is required by MADEP.

**NOTE:** MADEP guidelines list LCS recovery limits as 40-140 for base-neutral compounds and 30-130 for the acid compounds. The laboratory must identify analytes that routinely exceed these limits.

**ACTION:** If recovery is above the upper limit, qualify all positive sample results within the batch as (J). If recovery is below the lower limit but > 10%, qualify all positive and no-detect results within the batch as (J). If LCS recovery is <10%, non-detect results are rejected (R).

5.4 Are 80% of LCS recoveries within laboratory control limits?

Yes  No  N/A  Comments:

**ACTION:** If 80% of LCS recoveries are not within limits, use professional judgment and consult Senior Chemist.

## 6.0 Matrix Spikes

Matrix spikes may be collected at different frequencies based on monthly, quarterly, or task specific schedules. Confirm spike requirements for each set with the senior chemist.

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6.1 Were project specified MS/MSDs collected? List project samples that were spiked. Yes  No  N/A  Comments:

**ACTION:** If no, contact senior chemist to see if any were specified.

6.2 Is the MS/MSD recovery form present? Yes  No  N/A  Comments:

**ACTION:** If no, contact lab for resubmission of missing data.

6.3 Were matrix spikes analyzed at the required frequency of 1 per 20 samples per matrix? Yes  No  N/A  Comments:

**ACTION:** If any matrix spike data are missing, call lab for resubmission.

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6.4 Are any SVOC spike recoveries outside of the QC limits?

Yes  No  N/A  Comments:

**NOTE:**  $\%R = \frac{(SSR-SR)}{SA} \times 100\%$

Where: SSR = Spiked sample result  
SR = Sample result  
SA = Spike added

**NOTE:** A full target, second source MS/MSD is required by MADEP.

**NOTE:** MADEP guidelines list MS/MSD recovery limits as 40-140 for base-neutral compounds and 30-130 for acid compounds.

**NOTES:** 1) If only one of the recoveries for an MS/MSD pair is outside of the control limits, no qualification is necessary. Use professional judgment for the MS/MSD flags.

2) If the MS/MSD was performed by the laboratory on a non-project sample, no qualification is required.

**ACTION:** MS/MSD flags only apply to the sample spiked. If the recoveries of the MS and MSD exceed the upper control limit, qualify positive results as estimated (J). If the recoveries of the MS and MSD are lower than the lower control limit, qualify both positive results and non-detects (J). If LCS recovery is <10%, non-detect results are rejected (R).

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**6.5** Are any RPDs for MS/MSD recoveries outside of the QC limits? Yes  No  N/A  Comments:

**NOTE:**  $RPD = \frac{S-D}{(S+D)/2} \times 100\%$       Where: S = MS sample result  
D = MSD sample result

**NOTE:** MADEP guidelines list MS/MSD RPD limits for water as  $\leq 20$  and soils as  $\leq 30$ .

**NOTE:** Laboratory control limits apply when spiked sample results fall within the normal calibration range. If dilutions are required due to high sample concentrations, the data are evaluated, but no flags are applied.

**ACTION:** If the RPD exceeds the control limit, qualify positive results and non-detects (J).

**7.0** Surrogate Recoveries

Were one or more SVOC surrogate recoveries outside of laboratory limits for any sample or method blank? If yes, were samples re-analyzed? Yes  No  N/A  Comments:

**NOTE:**  $\%R = QD \times 100\%$       Where: S = MS sample result  
D = MSD sample result

**NOTE:** MADEP guidelines list surrogate limits for soils as 30-130% for all surrogates, and for water as 30-130% for base-neutrals and 15-110% for acid surrogates.

**NOTE:** Qualify BNE results based upon BNE surrogates and AE results based upon AE surrogates.

**ACTION:** If recoveries are >10%, but 2 or more from any one fraction (acid or base-neutral) fail to meet QC criteria: (1) For recoveries below the QC limit, qualify non-detects and positives (J), and (2) For recoveries above the QC limit, qualify only positives (J). If any surrogate recovery is <10% (unless the lab QC limits are below 10%, in which case, results are flagged as stated above), flag positives (J) and reject non-

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detects (R).

**8.0 Sampling Accuracy**

The majority of ground water samples are collected directly from a tap, process stream, or with dedicated tubing. Rinse blanks will not be collected.

**8.1** Were rinsate blanks collected? Prior to evaluating rinsate blanks, obtain a list of the associated samples from the project chemist.

Yes  No  N/A  Comments:

**NOTE:** MADEP does not specify the collection of rinsate blanks.

**8.2** Do any rinsate blanks have positive results?

Yes  No  N/A  Comments:

**NOTE:** For the common contaminants (phthalates), qualification is applied as indicated above using a 10x blank value in lieu of a 5x blank value.

If the sample concentration is  $< 5 \times$  blank value, flag sample result non-detect "U" at the PQL or the concentration reported if greater than the PQL.

If the sample concentration is  $> 5 \times$  blank value, no qualification is needed.

**9.0 Field Duplicates**

**9.1** Were field duplicate samples collected? Obtain a list of the samples and their associated field duplicates.

Yes  No  N/A  Comments:

**9.2** Were field duplicates collected per the required frequency?

Yes  No  N/A  Comments:

SOW    QAPP    MADEP Option 1 (1 per 20)    MADEP Option 3 (1 per 10)

**9.3** Was the RPD  $\leq 50\%$  for soils or waters? Calculate the RPD for all results and attach to this review.

Yes  No  N/A  Comments:

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**ACTION:** RPD must be  $\leq 50\%$  for soil and water. Qualify data (J) for both sample results if the RPD exceeds 50%.

**10.0 Application of Validation Qualifiers**

Was any of the data qualified?

Yes  No  N/A  Comments:

If so, apply data qualifiers directly to the DQE copy of laboratory report and **flag pages** for entry in database.

**REFERENCES**

- LAW, 1999, "Final Quality Assurance Project Plan, Olin Wilmington Property, 51 Eames Street, Wilmington, MA", LAW Engineering and Environmental Services, Kennesaw, GA 30144. August 1999.
- STL-Westfield, 2002. "Olin – General Chemistry Control Limits (Soil & Water)," Severn Trent Laboratories, Inc., 53 Southampton Road, Westfield, MA, 01085.
- U.S. Environmental Protection Agency (USEPA), 1996. "Region I EPA-NE Data Validation Guidelines For Evaluating Environmental Analyses"; Quality Assurance Unit Staff; Office of Environmental Measurement and Evaluation; December 1996
- MADEP, 2001. Massachusetts Department of Environmental Protection Bureau of Waste Site Cleanup, "Massachusetts Quality Assurance / Quality Control (QA / QC Requirements)," BWSC-CAM, Interim Final Draft, Revision No. 2, 5 October 2001.
- MADEP, 2001. Massachusetts Department of Environmental Protection Bureau of Waste Site Cleanup, "Quality Assurance / Quality Control Guidelines for Sampling, Data Evaluation and reporting Activities," BWSC-CAM, Section VII, Public Comment Draft, Revision No. 0, 21 December 2001.

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LEVEL I DATA QUALITY EVALUATION

Reviewer/Date \_\_\_\_\_  
Sr. \_\_\_\_\_

Review/Date \_\_\_\_\_

STANDARD OPERATING PROCEDURE AND CHECKLIST  
WET CHEMISTRY PARAMETERS BY VARIOUS METHODS

Lab Report # \_\_\_\_\_  
Project # \_\_\_\_\_

**Note:** The following analyses will be evaluated according to the "MADEP QA/QC Guidelines for Sampling, Data Evaluation and Reporting Activities." MADEP, however, may not list QA/QC criteria for every chemical analysis. Where not defined by MADEP, criteria will default to values stipulated in the QAPP. Where the QAPP does not define criteria, QA/QC requirements will default to limits employed by the laboratory.

**1.0 Laboratory Deliverable Requirements**

**1.1 Laboratory Information:** Was all of the following provided in the laboratory report? Yes  No  N/A  Comments:  
Check items received.

- Name of Laboratory
- Address
- Project ID
- Phone #
- Sample identification – Field and Laboratory
- Client Information:  Name
- Address
- Client Contact
- (IDs must be cross-referenced)

**ACTION:** If no, contact lab for submission of missing or illegible information.

**1.2 Laboratory Report Certification Statement** Yes  No  N/A  Comments:

Does the laboratory report include a completed Analytical Report Certification in the required format?

**ACTION:** If no, contact lab for submission of missing certification or certification with correct format.

**1.3 Laboratory Case Narrative:** Yes  No  N/A  Comments:

- Narrative serves as an exception report for the project and method QA/QC performance.
- Narrative includes an explanation of each discrepancy on the Certification Statement.

**ACTION:** If no, contact lab for submission of missing or illegible information.

**1.4 Chain of Custody (COC) copy present with all documentation completed?** Yes  No  N/A  Comments:

Does the laboratory report include copies of Chain of Custody forms containing all samples in this SDG?

**NOTE:** Olin receives and maintains the *original* COC.

**ACTION:** If no, contact lab for submission of copy of missing completed COC.

**1.5 Sample Receipt Information (Cooler Receipt Form):** Were each of the following tasks completed and recorded upon receipt of the sample(s) into the laboratory?

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Yes  No  N/A  Comments:

Sample temperature confirmed: must be 1° – 10° C. (If samples were sent by courier and delivered on the same day as collection, temperature requirement does not apply).

Container type noted  Condition observed  pH verified (where applicable)  Field and lab IDs cross referenced

**ACTION:** If no, contact lab for submission of missing or incomplete documentation.

1.5.1 Were the correct bottles and preservatives used?

Ammonia, – 1 Liter polyethylene/H<sub>2</sub>SO<sub>4</sub> to pH<2, cool to 4°C

Yes  No  N/A  Comments:

Oil & Grease – 1 Liter glass/HCL to pH<2, cool to 4°C

Alkalinity – 1 Liter polyethylene/cool to 4°C

Chemical Oxygen Demand – 50 mL polyethylene/H<sub>2</sub>SO<sub>4</sub> to pH<2, cool to 4°C

Chloride, pH, sulfate - 50 mL polyethylene/cool to 4°C

Organic Carbon – 500 mL amber glass bottle/HCl or H<sub>2</sub>SO<sub>4</sub> to pH<2, cool to 4°C

Sulfide – 50 mL polyethylene/ZnAcetate + NaOH to pH>9, cool to 4°C

Specific conductance, TDS, TSS – 100 mL polyethylene/cool to 4°C

**ACTION:** If no, inform senior chemist. Document justification for change in container/volume (if applicable), qualify positive and non-detect data (J) data if cooler temperature exceeds 10°C. Rejection of data requires professional judgment

1.5.2 Were all samples delivered to the laboratory without breakage?

Yes  No  N/A  Comments:

1.5.3 Does the *Cooler Receipt Form* or Lab Narrative indicate other problems with sample receipt, condition of the samples, analytical problems or special circumstances affecting the quality of the data?

Yes  No  N/A  Comments:

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**1.6 Sample Results Section:** Was the following information supplied in the laboratory report for each sample?

Yes  No  N/A  Comments:

- |  |   |   |   |   |   |
|--|---|---|---|---|---|
| <input type="checkbox"/> Field ID and Lab ID | <input type="checkbox"/> Date and time collected            | <input type="checkbox"/> Analyst Initials                             | <input type="checkbox"/> Dilution Factor  | <input type="checkbox"/> % moisture or solids | <input type="checkbox"/> Reporting limits |
| <input type="checkbox"/> Clean-up method     | <input type="checkbox"/> Analysis method                    | <input type="checkbox"/> Preparation method                           | <input type="checkbox"/> Date of preparation/extraction/digestion clean-up and analysis, where applicable |   |   |
| <input type="checkbox"/> Matrix              | <input type="checkbox"/> Target analytes and concentrations | <input type="checkbox"/> Units (soils must be reported in dry weight) |   |   |   |

**ACTION:** If no, contact lab for submission of missing or incomplete information.

**1.7 QA/QC Information:** Was the following information provided in the laboratory report for each sample batch?

Yes  No  N/A  Comments:

- Method blank results     LCS recoveries     MS/MSD recoveries and RPDs     Laboratory duplicate results (where applicable)

**ACTION:** If no, contact lab for submission of missing or incomplete information.

**2.0 Holding Times**

Yes  No  N/A  Comments:

Have any technical holding times, determined from date of collection to date of analysis, been exceeded? The holding times are as follows:

28 days = ammonia, chemical oxygen demand, chloride, organic carbon, oil & grease, specific conductance, total organic carbon and sulfate

Alkalinity = 14 days                      Sulfide, TDS, TSS = 7 days                      pH = analyze immediately                      Nitrate nitrogen as N = 48 hrs

Nitrite nitrogen as N = 48 hrs                      Nitrate + Nitrite as N = 28 days

**NOTE:** List samples that exceed hold time with # of days exceeded on checklist

**ACTION:** If technical holding times are exceeded qualify results (J). For water samples that are grossly exceeded (>2X hold time) reject (R) all non-detect results. Professional judgment used to qualify soils.

**3.0 Laboratory Method**

Yes  No  N/A  Comments:

3.1 Was the correct laboratory method used?

**ACTION:** If no, contact lab to provide justification for method change compared to the requested method. Contact senior chemist to inform Client of change or to request variance.

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3.2 Are the practical quantitation limits the same as those specified by the  SOW  QAPP  Lab? Yes  No  N/A  Comments:

*Note: The MADEP QA/QC Guidelines do not yet list PQLs for wet chemistry analyses, therefore all criteria will default to values stipulated in the QAPP\*. Where the QAPP does not define criteria, QA/QC requirements default to limits employed by the lab\*\*. Other criteria may also apply.*

Ammonia* <input type="checkbox"/> = 0.1 mg/L	Alkalinity** <input type="checkbox"/> = 1 mg/L	Bicarbonate Alkalinity** <input type="checkbox"/> = 1 mg/L	Carbonate Alkalinity** <input type="checkbox"/> = 1 mg/L
Nitrate Nitrogen as N* <input type="checkbox"/> = .05 mg/L	Nitrite Nitrogen as N* <input type="checkbox"/> = .01 mg/L	Chloride* <input type="checkbox"/> = 1 mg/L	Hardness * <input type="checkbox"/> = 2 mg/L
Spec. Cond.** <input type="checkbox"/> 3 umhos/cm	Total Organic Carbon** <input type="checkbox"/> = 1 mg/L	Oil & Grease* <input type="checkbox"/> = 3 mg/L	Sulfate (EPA 300.0)* <input type="checkbox"/> = 2 mg/L
COD:* Low - 20 mg/L	COD* High - 50 mg/L <input type="checkbox"/>	TDS* <input type="checkbox"/> = 10 mg/L	TSS* <input type="checkbox"/> = 5 mg/L
pH* <input type="checkbox"/> < 2 to > 12			
Other parameter(list) _____	PQL = _____	<input type="checkbox"/> Source of PQL = _____	
Other parameter(list) _____	PQL = _____	<input type="checkbox"/> Source of PQL = _____	

**ACTION:** If no, evaluate change with respect to sample matrix, preparation, dilution, moisture, etc. If sample PQL is indeterminate, contact lab for explanation.

3.3 Are the appropriate parameter results present for each sample in the SDG? Yes  No  N/A  Comments:

**ACTION:** If no, check Request for Analysis to verify if method was ordered and COC to verify that it was sent, and contact lab for resubmission of the missing data

3.4 If dilutions were required, were dilution factors reported? Yes  No  N/A  Comments:

**ACTION:** If no, contact the lab for submission.

4.0 **Method Blanks** Yes  No  N/A  Comments:

4.1 Are the Method Blank Summaries present?

**ACTION:** If no, call the laboratory for submission of missing data.

4.2 Was a method blank analyzed for each analysis batch of wet chemistry field samples of 20 or less? Yes  No  N/A  Comments:

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**ACTION:** If no, document discrepancy in case narrative and contact lab for justification. Consult senior chemist for action needed.

4.3 Is the method blank less than the PQL? (See Section 3.2 for PQLs). Yes  No  N/A  Comments:

4.4 Do any method blanks have positive results for wet chemistry parameters? Qualify data according to the following: Yes  No  N/A  Comments:

If the sample concentration is  $< 5 \times$  blank value, flag sample result non-detect "U" at the PQL or the concentration reported if greater than the PQL.

If the sample concentration is  $> 5 \times$  blank value, no qualification is needed.

**ACTION:** If any blank has positive results, list all the concentrations detected and flagging level (flagging level =  $5 \times$  blank value) on the checklist. List all affected samples and their qualifiers.

**5.0 Laboratory Control Standards**

5.1 Was a laboratory control standard (LCS) run with each analytical batch of 20 samples or less? Yes  No  N/A  Comments:

**ACTION:** If no, call laboratory for LCS form submittal. If data is not available, use professional judgment to determine qualification actions for data associated with the batch.

5.2 Is a LCS Summary Form present? Yes  No  N/A  Comments:

**ACTION:** If no, contact lab for resubmission of missing data.

5.3 Is any wet chemistry analyte LCS recovery outside the control limits? Yes  No  N/A  Comments:

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**LCS Limits:**

Alkalinity** <input type="checkbox"/> = 80-120%	Bicarbonate Alkalinity** <input type="checkbox"/> = 80-120%	Carbonate Alkalinity** <input type="checkbox"/> = 80-120%	Specific Conductivity * <input type="checkbox"/> = 80-120%
Total Organic Carbon** <input type="checkbox"/> = 80-120%	TDS** <input type="checkbox"/> = 80-120%	Oil & Grease* <input type="checkbox"/> = 80-120%	Ammonia Nitrogen as N* <input type="checkbox"/> = 80-120%
COD Low* <input type="checkbox"/> = 80-120%	COD High* <input type="checkbox"/> = 80-120%	Nitrate Nitrogen as N** <input type="checkbox"/> = 85-115%	Nitrite Nitrogen as N** <input type="checkbox"/> = 75-120%
Hardness* <input type="checkbox"/> = 85-115%	Chloride* <input type="checkbox"/> = 80-120%	Sulfate (EPA 300.0)* <input type="checkbox"/> = 75-125%	pH* <input type="checkbox"/> = 98-102%      TSS* NA

Other parameter(list) \_\_\_\_\_ %R = \_\_\_\_\_  Rec Limits= \_\_\_\_\_

Other parameter(list) \_\_\_\_\_ %R = \_\_\_\_\_  Rec Limits= \_\_\_\_\_

*(MADEP has not yet defined LCS recovery limits for wet chemistry analyses.)*

**ACTION:** If recovery is above the upper limit, qualify all positive sample results within the batch as (J). If recovery is below the lower limit, qualify all positive and no-detect results within the batch as (J). If LCS recovery is <10%, non-detect results are rejected (R).

**6.0 Matrix Spikes**

Matrix spikes may be collected at different frequencies based on monthly, quarterly, or task specific schedules. Confirm spike requirements for each set with the senior chemist.

6.1 Were project-specific MS/MSDs analyzed? List project samples that were spiked.

**ACTION:** If no, contact senior chemist to see if any were specified.

Yes  No  N/A  Comments:

6.2 Is the MS/MSD Recovery Form present?

**ACTION:** If no, contact lab for resubmission of missing data.

Yes  No  N/A  Comments:

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6.3 Were matrix spikes analyzed at the required frequency of 1 per 20 samples per matrix? Yes  No  N/A  Comments:

**ACTION:** If any matrix spike data is missing, call lab for resubmission.

6.4 Are any wet chemistry analyte spike recoveries outside of the QC limits? Yes  No  N/A  Comments:

NOTE: 
$$\%R = \frac{(SSR-SR)}{SA} \times 100\%$$
  
SA = Spike added

Where: SSR = Spiked sample result  
SR = Sample result

**MS/MSD Recovery Limits:**

Alkalinity* = NA	Bicarbonate Alkalinity* = NA	Carbonate alkalinity* = NA	Ammonia* (LACHAT) <input type="checkbox"/> = 74-125%
Chloride*(SM 4500 Cl) <input type="checkbox"/> = 77-116%	Specific Conductivity * = NA	Total Organic Carbon* = NA	TDS** = NA
Oil & Grease* = NA	COD Low* <input type="checkbox"/> = 61-142%	COD High* <input type="checkbox"/> = 92-109%	Nitrate Nitrogen as N** <input type="checkbox"/> = 75-119%
Nitrite Nitrogen as N** <input type="checkbox"/> = 68-136%	Hardness* <input type="checkbox"/> = 70-130%	Sulfate (EPA 300.0)* <input type="checkbox"/> = 75-125%	pH* = NA      TSS* = NA
Other parameter(list) _____	% R = _____	<input type="checkbox"/> Rec Limits = _____	

\* = Laboratory Limits      \*\* = Olin QAPP Limits (MADEP has not yet defined LCS recovery limits for wet chemistry analyses.)

**NOTES:** 1) If only one of the recoveries for an MS/MSD pair is outside of the control limits, no qualification is necessary. Use professional judgment for the MS/MSD flags.  
2) If the MS/MSD was performed by the laboratory on a non-project sample, no qualification is required.

**ACTION:** MS/MSD flags only apply to the sample spiked. Do not evaluate if sample concentration is > 4X spike. If the recoveries of the MS and MSD exceed the upper control limit, qualify positive results as estimated (J). If the recoveries of the MS and MSD are lower than the lower control limit but > 30%, qualify both positive results and non-detects (J). If the MS/MSD recovery is < 30% and the sample is non-detect, the results are considered unusable and flagged (R).

**ACTION:** Laboratory control limits apply when spiked sample results fall within the normal calibration range. If dilutions are required due to high sample concentrations, the data is evaluated, but no flags are applied.

6.5 Are any RPDs for MS/MSD recoveries outside of the QA/QC limits? Yes  No  N/A  Comments:

NOTE: 
$$RPD = \frac{S-D}{(S+D)/2} \times 100\%$$
 Where S = MS result  
D = MSD result

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**MS/MSD RPD Limits:**

Alkalinity* = NA	Bicarbonate Alkalinity* = NA	Carbonate alkalinity* = NA	Ammonia** (LACHAT) <input type="checkbox"/> = 8%
Chloride** (SM 4500 Cl) <input type="checkbox"/> = 15%	Specific Conductivity * = NA	Total Organic Carbon* = NA	TDS** = NA Total Organic Carbon* = NA
COD Low** <input type="checkbox"/> = 14%	COD High** <input type="checkbox"/> = 16%	Nitrate Nitrogen as N** <input type="checkbox"/> = 16%	Nitrite Nitrogen as N** <input type="checkbox"/> = 16%
Oil & Grease* = NA	Hardness* = NA	Sulfate (EPA 300.0)* <input type="checkbox"/> = 10%	pH* = NA TSS* = NA
Other parameter(list) _____	RPD = _____	<input type="checkbox"/> RPD limit = _____	
Other parameter(list) _____	RPD = _____	<input type="checkbox"/> RPD limit = _____	

\* = Laboratory Limits                      \*\* = Olin QAPP Limits

(MADEP has not yet defined LCS recovery limits for wet chemistry analyses.)

**7.0 Laboratory Duplicate**

Are the RPDs for the laboratory duplicates <20% unless otherwise specified below?    Yes     No     N/A     Comments:

**ACTION:** If the RPD is greater than specified limits, qualify all results for that analyte as estimated (J).

Alkalinity* = 4%	Bicarbonate Alkalinity* = 4%	Carbonate alkalinity* = 4%	Oil & Grease* <input type="checkbox"/> = 20%
pH* <input type="checkbox"/> = 3%	Specific Conductivity * <input type="checkbox"/> = 5%	TSS** <input type="checkbox"/> = 6%	TDS** <input type="checkbox"/> = 6%

**8.0 Sampling Accuracy**

The majority of ground water samples are collected directly from a tap, process stream, or with dedicated tubing. Rinse blanks will not be collected.

8.1 Were rinsate blanks collected? Prior to evaluating rinsate blanks, obtain a list of the associated samples from the senior chemist.    Yes     No     N/A     Comments:

8.2 Do any rinsate blanks have positive results?    Yes     No     N/A     Comments:

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**ACTION:** Evaluate rinsate results vs. blank results to determine if contaminant may be laboratory-derived. If not lab-related, qualify according to the table below.

If the sample concentration is  $< 5 \times$  blank value, flag sample result non-detect "U" at the PQL or the concentration reported if greater than the PQL.

If the sample concentration is  $> 5 \times$  blank value, no qualification is needed.

**NOTE:** MADEP does not require the collection of rinsate blanks.

**9.0 Field Duplicates**

9.1 Were field duplicate samples collected? Obtain a list of samples and their associated field duplicates. Yes  No  N/A  Comments:

9.2 Were field duplicates collected per the required frequency? Yes  No  N/A  Comments:

SOW  QAPP  MADEP Option 1(1 per 20)  MADEP Option 3 (1 per 10)

9.3 Was the RPD  $\leq 50\%$  for soils or waters? Calculate the RPD for all results and attach to this review. Yes  No  N/A  Comments:

**ACTION:** RPD must be  $\leq 50\%$  for soil and water. Qualify data (J) for both sample results if the RPD exceeds 50%.

Was any of the data qualified? Yes  No  N/A  Comments:

If so, apply data qualifiers directly to the DQE copy of laboratory report and **flag pages** for entry in database.

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**REFERENCES**

LAW, 1999, "Final Quality Assurance Project Plan, Olin Wilmington Property, 51 Eames Street, Wilmington, MA", LAW Engineering and Environmental Services, Kennesaw, GA 30144. August 1999.

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Reviewer/Date \_\_\_\_\_  
Sr. Review/Date \_\_\_\_\_  
Lab Report # \_\_\_\_\_  
Project # \_\_\_\_\_

**1.0 Laboratory Deliverable Requirements**

**1.1 Laboratory Information:** Was all of the following provided in the laboratory report? Yes  No  N/A  Comments:  
Check items received.

- Name of Laboratory
- Certification ID #
- Address
- Project ID
- Phone #
- Sample identification – Field and Laboratory

**Client Information:**  Name  Address  Client Contact (IDs must be cross-referenced)

**ACTION:** If no, contact lab for submission of missing or illegible information.

**1.2 Laboratory Report Certification Statement**

Yes  No  N/A  Comments:

Does the laboratory report include a completed Analytical Report Certification in the required format?

**ACTION:** If no, contact lab for submission of missing certification or certification with correct format.

**1.3 Laboratory Case Narrative:**

Yes  No  N/A  Comments:

- Narrative serves as an exception report for the project and method QA/QC performance.
- Narrative includes an explanation of each discrepancy on the Certification Statement.

**ACTION:** If no, contact lab for submission of missing or illegible information.

**1.4 Chain of Custody (COC)**

Yes  No  N/A  Comments:

Does the laboratory report include a copy of the completed Chain of Custody forms containing all samples in this SDG?

**NOTE:** Olin receives and maintains the *original* COC.

**ACTION:** If no, contact lab for submission of completed COC.

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**1.5 Sample Receipt Information (Cooler Receipt Form):** Were each of the following tasks completed and recorded upon receipt of the sample(s) into the laboratory? Yes  No  N/A  Comments:

Sample temperature confirmed: must be 1° – 10° C. (If samples were sent by courier and delivered on the same day as collection, temperature requirement does not apply).

Container type noted    Condition observed    Field and lab IDs cross referenced

**ACTION:** If no, contact lab for submission of missing or incomplete documentation.

**1.5.1** Were the correct bottles and preservatives used?

Water - 40 mL VOA vial/HCL to pH<2, cool to 4°C  
Soil - 5 gram Encore™/cool to 4°C or 40 mL VOA vial with field preservation of sodium bisulfate (low-level) or methanol (high-level) or field preservation in water if soils are reactive to sodium bisulfate (i.e. alkaline conditions, excessive humic acid content, etc.)

Yes  No  N/A  Comments:

**ACTION:** If no, inform senior chemist. Document justification for change in container/volume (if applicable); qualify both positive data and non-detect data (J) if cooler temperature exceeds 10°C. Rejection of data requires professional judgment

**ACTION:** If each VOA vial for a sample contains air bubbles or the VOA vial analyzed contained air bubbles, flag positives (J) and reject nondetects (R).

**1.5.2** Were all samples delivered to the laboratory without breakage?

Yes  No  N/A  Comments:

**1.5.3** Does the *Cooler Receipt Form* or Lab Narrative indicate other problems with sample receipt, condition of the samples, analytical problems or special circumstances affecting the quality of the data?

Yes  No  N/A  Comments:

**1.6 Sample Results Section:** Was the following information supplied in the laboratory report for each sample?

Yes  No  N/A  Comments:

- Field ID and Lab ID    Date and time collected    Analyst Initials    Dilution Factor    % moisture or solids    Reporting limits  
 Analysis method concentrations    Preparation method    Date of preparation/extraction/digestion clean-up and analysis, where applicable    Matrix    Target analytes and  
 Units (soils must be reported in dry weight)

**ACTION:** If no, contact lab for submission of missing or incomplete information.

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**1.7 QA/QC Information:** Was the following information provided in the laboratory report for each sample batch?    Yes     No     N/A     Comments:

Method blank results     LCS recoveries     MS/MSD recoveries and RPDs     Surrogate recoveries

**ACTION:** If no, contact lab for submission of missing or incomplete information.

**2.0    Holding Times**

Have any technical holding times, determined from date of collection to date of analysis, been exceeded?

Yes     No     N/A     Comments:

For water samples, the holding time is 7 days from sampling for unpreserved samples and 14 days for preserved samples.

For soil samples, methanol preservation required with a holding time of 14 days. If an Encore™ sampler was used, the lab must *preserve* the sample within 48 hours. Analytical holding time from time of preservation is 14 days.

**NOTE:** List samples that exceed hold time with # of days exceeded on checklist

**ACTION:** If technical holding times are exceeded, qualify all positive results (J). Use professional judgment to reject (R) data for grossly exceeded.

**3.0    Laboratory Method**

**3.1** Was the correct laboratory method used?    Yes     No     N/A     Comments:

Purge and Trap                  Water: 5030B    Soil: 5035  
Volatile Petroleum Hydrocarbons                  MADEP VPH 98-1

**ACTION:** If no, contact lab to provide justification for method change compared to the requested method. Contact senior chemist to inform Client of change or to request variance.

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3.2 Are the practical quantitation limits the same as those specified by the Yes  No  N/A  Comments:  
 SOW     QAPP     Lab     MADEP

*NOTE: The MADEP QA/QC Guidelines provides PQLs for volatile petroleum hydrocarbons.  
See MADEP PQLs vs. the PQLs listed in the QAPP.*

**ACTION:** If no, evaluate change with respect to sample matrix, preparation, dilution, moisture, etc. If sample PQL is indeterminate, contact lab for explanation.

3.3 Are the appropriate parameter results present for each sample in the SDG? Yes  No  N/A  Comments:

*NOTE: The MADEP QA/QC Guidelines requires a minimum compound reporting list for volatile organic compounds.*

3.4 If dilutions were required, were dilution factors reported? Yes  No  N/A  Comments:

*NOTE: MADEP guidance states that if a diluted and an undiluted analysis is performed, the laboratory should report results for the lowest dilution within the valid calibration range for each analyte.*

**ACTION:** If no, contact the lab for submission.

**4.0 Method Blanks**

4.1 Are the Method Blank Summaries present? Yes  No  N/A  Comments:

**ACTION:** If no, call the laboratory for submission of missing data.

4.2 Was a method blank analyzed for each analytical batch of 20 samples or less? Yes  No  N/A  Comments:

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**ACTION:** If no, document discrepancy in case narrative and contact lab for justification. Consult senior chemist for action needed.

4.3 Is the method blank less than the PQL? (See attached table for PQLs). Yes  No  N/A  Comments:

4.4 Do any method blanks have positive results for VPH parameters? Qualify data according to the following: Yes  No  N/A  Comments:

For VPH contaminants:

Review blank and sample chromatograms to evaluate the nature of the detection in the blank and associated samples. Use professional judgment. The following actions may be applied:

If the sample concentration is  $< 5 \times$  blank value, flag sample result non-detect "U" at the PQL or the concentration reported if greater than the PQL.

If the sample concentration is  $> 5 \times$  blank value, no qualification is needed..

**ACTION:** If any blank has positive results, list all the concentrations detected and flagging level (flagging level =  $10x$  or  $5 \times$  blank value) on the checklist. List all affected samples and their qualifiers.

**5.0 Laboratory Control Standard**

5.1 Was a laboratory control standard (LCS) run with each analytical batch of 20 samples or less? Yes  No  N/A  Comments:

**ACTION:** Call laboratory for LCS form submittal. If data are not available, reject (R) data associated with that batch.

5.2 Is a LCS Summary Form present? Yes  No  N/A  Comments:

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**ACTION:** If no, contact lab for resubmission of missing data.

**5.3** Is the recovery of any analyte outside of control limits? Yes  No  N/A  Comments:

**NOTE:** A full target, second source LCS is required by MADEP.

**NOTE:** MADEP guidelines list LCS recovery limits as 70-130 except for naphthalene. The laboratory must identify any other analytes that routinely exceed 70-130 percent.

**ACTION:** If recovery is above the upper limit, qualify all positive sample results within the batch as (J). If recovery is below the lower limit but > 10%, qualify all positive and no-detect results within the batch as (J). If LCS recovery is <10%, positive and non-detect results are rejected (R) unless the QC limit for that compound is below 10% (flag as above).

**5.4** Are 80% of LCS recoveries within laboratory control limits? Yes  No  N/A  Comments:

**ACTION:** If 80% of LCS recoveries are not within limits, use professional judgment and consult Senior Chemist. If more than half of the recoveries are above control limits, qualify all positive results as (J). If more than half of the recoveries are below control limits, batch may require rejection and reanalysis

**6.0** Matrix Spikes

**6.1** Were project-specific MS/MSDs collected? List project samples that were spiked.

**ACTION:** If no, contact senior chemist to see if any were specified. Yes  No  N/A  Comments:

**6.2** Is the MS/MSD Recovery Form present?

**ACTION:** If no, contact lab for resubmission of missing data. Yes  No  N/A  Comments:

**6.3** Were matrix spikes analyzed at the required frequency of 1 per 20 samples per matrix? Yes  No  N/A  Comments:

**ACTION:** If any matrix spike data are missing, call lab for resubmission.

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6.4 Are any VPH spike recoveries outside of the QC limits? Yes  No  N/A  Comments:

NOTE:  $\%R = \frac{(SSR - SR)}{SA} \times 100\%$  Where: SSR = Spiked sample result  
SR = Sample result  
SA = Spike added

NOTE: A full target, second source MS/MSD is required by MADEP.

NOTE: MADEP guidelines list MS/MSD recovery limits as 70-130 except for naphthalene.

NOTES: 1) If only one of the recoveries for an MS/MSD pair is outside of the control limits, no qualification is necessary. Use professional judgment for the MS/MSD flags.  
2) If the MS/MSD was performed by the laboratory on a non-project sample, no qualification is required.

ACTION: MS/MSD flags only apply to the sample spiked. If the recoveries of the MS and MSD exceed the upper control limit, qualify positive results as estimated (J). If the recoveries of the MS and MSD are lower than the lower control limit but > 30%, qualify both positive results and non-detects (J). If the MS/MSD recovery is < 30% and the sample is non-detect, the results are considered unusable and flagged (R).

ACTION: Laboratory control limits apply when spiked sample results fall within the normal calibration range. If dilutions are required due to high sample concentrations, the data is evaluated, but no flags are applied.

6.5 Are any RPDs for MS/MSD recoveries outside of the QC limits? Yes  No  N/A  Comments:

NOTE:  $RPD = \frac{S - D}{(S + D)/2} \times 100\%$  Where: S = MS sample result  
D = MSD sample result

NOTE: MADEP guidelines list MS/MSD RPD limits for both water and soils as  $\leq 50$ .

ACTION: If the RPD exceeds the control limit, qualify positive results and non-detects (J).

ACTION: Laboratory control limits apply when spiked sample results fall within the normal calibration range. If dilutions are required due to high sample concentrations, the data are evaluated, but no flags are applied.

7.0 Surrogate Recoveries

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Were VPH surrogate recoveries outside of laboratory limits for any sample or method blank? If yes, were samples re-analyzed? Yes  No  N/A  Comments:

**NOTE:** %R = QD x 100%      Where: S = MS sample result  
D = MSD sample result

**NOTE:** MADEP guidelines list surrogate limits for both water and soils as 70-130% for both detectors.

**ACTION:** If recoveries are >10%, but fail to meet QC criteria: (1) For recoveries below the QC limit, qualify non-detects and positives (J), and (2) For recoveries above the QC limit, qualify only positives (J). If any surrogate recovery is <10% (unless the QC limits are below 10%, in which case, results are flagged as stated above), flag positives (J) and reject nondetects (R).

**NOTE:** If surrogate recoveries fail due to dilution, results are not flagged. Document on checklist and in the case narrative.

**8.0 Sampling Accuracy**

8.1 Were trip blanks shipped with VOC samples and analyzed?

Yes  No  N/A  Comments:

**NOTE:** MADEP requires trip blanks per the following frequency:

	<u>Soil/Sediment</u>	<u>Aqueous</u>	<u>Drinking Water</u>
Option 1	Not Required	Not Required	1 per cooler VOAs/VPH
Option 3	1 per 10 samples	1 per 10 samples	1 per 10 samples

8.2 Do any trip blanks have positive results?

Yes  No  N/A  Comments:

**ACTION:** Prepare a list of samples shipped in the same cooler as the contaminated blank.

**ACTION:** Evaluate trip blank results against method blank results to determine if

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contaminant may be laboratory-derived. If results are not lab-related, qualify according to the table below.

If the sample concentration is  $< 5 \times$  blank value, flag sample result non-detect "U" at the PQL or the concentration reported if greater than the PQL.

If the sample concentration is  $> 5 \times$  blank value, no qualification is needed.

8.3 Were ambient blanks shipped with VPH samples and analyzed?

Yes  No  N/A  Comments:

NOTE: MADEP requires ambient (field) blanks per the following frequency:

	<u>Soil/Sediment</u>	<u>Aqueous</u>	<u>Drinking Water</u>
Option 1	Not Required	Not Required	Not Required
Option 3	1 per 10 samples	1 per 10 samples	1 per 10 samples

8.4 Do any ambient blanks have positive results?

Yes  No  N/A  Comments:

**ACTION:** Prepare a list of samples associated with the contaminated blank (all collected from the site on that day).

**ACTION:** Evaluate ambient blank results against method and trip blank results to determine if contaminant may be laboratory- and/or shipment-derived. If results are not lab- and/or shipment-related, qualify according to the table above (8.2).

8.5 Were rinsate blanks collected? Prior to evaluating rinsate blanks, obtain a list of the associated samples from the senior chemist.

Yes  No  N/A  Comments:

NOTE: MADEP does not specify the collection of rinsate blanks.

8.6 Do any rinsate blanks have positive results?

Yes  No  N/A  Comments:

**ACTION:** Evaluate rinsate results against blank results to determine if contaminant may be laboratory-, ambient-, or shipment-derived. If results are not lab-, ambient-, or shipment-related, qualify according to the table above (8.2).

9.0 **Field Duplicates**

**OLIN CORPORATION  
LEVEL I DATA QUALITY EVALUATION  
STANDARD OPERATING PROCEDURE AND CHECKLIST  
VOLATILE PETROLEUM HYDROCARBONS BY METHOD MADEP**

---

9.1 Were field duplicate samples collected? Obtain a list of samples and their associated field duplicates. Yes  No  N/A  Comments:

9.2 Were field duplicates collected per the required frequency? Yes  No  N/A  Comments:

SOW    QAPP    MADEP Option 1 (1 per 20)    MADEP Option 3 (1 per 10)

9.3 Was the RPD  $\leq$  50% for soils or waters? Calculate the RPD for all results and attach to this review. Yes  No  N/A  Comments:

**ACTION:** RPD must be  $\leq$ 50% for soil and water. Qualify data (J) for both sample results if the RPD exceeds 50%.

**10.0 Application of Validation Qualifiers**

Was any of the data qualified? Yes  No  N/A  Comments:

If so, apply data qualifiers directly to the DQE copy of laboratory report and **flag pages** for entry in database.

**REFERENCES**

LAW, 1999, "Final Quality Assurance Project Plan, Olin Wilmington Property, 51 Eames Street, Wilmington, MA", LAW Engineering and Environmental Services, Kennesaw, GA 30144. August 1999.

Massachusetts Department of Environmental Protection (MADEP), 1998. "Method for the Determination of Volatile Petroleum Hydrocarbons (VPH)"; Division of Environmental Analysis; Office of Research and Standards; Bureau of Waste Site Cleanup; January 1998.

**PROJECT CHEMIST REVIEW RECORD**

**Method :** \_\_\_\_\_

**Laboratory and Lot :** \_\_\_\_\_

**Date:** \_\_\_\_\_

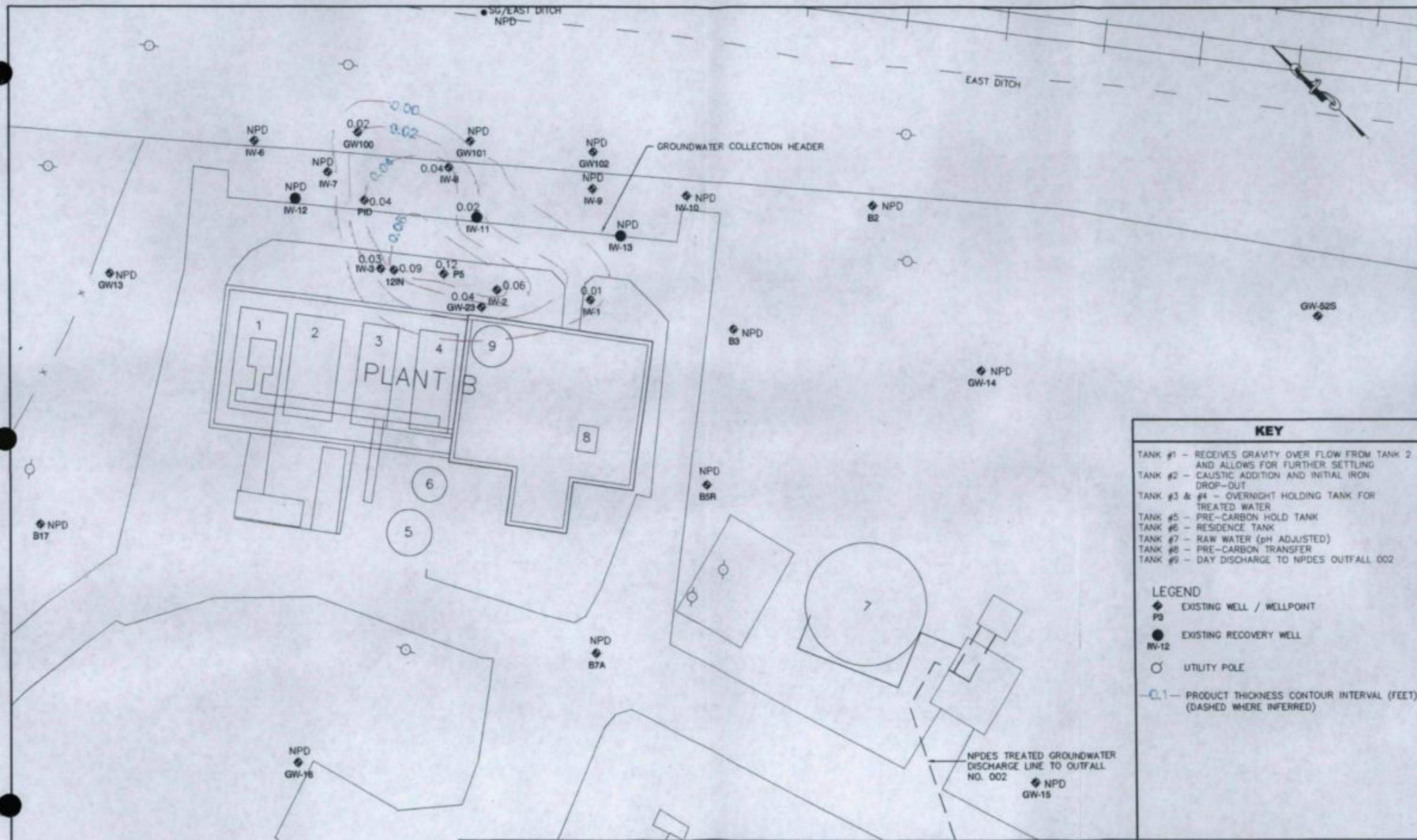
**Reviewer:** \_\_\_\_\_

1. Case Narrative
  
2. Holding time and Sample Collection
  
3. QC Blanks
  
4. Laboratory Control Sample Results
  
5. Surrogate (if applicable)
  
6. Field Duplicate Precision
  
7. Matrix Spike Results (if applicable)
  
8. Reporting Limits and Data Completeness



## **APPENDIX B**

### **PLANT B LNAPL DISTRIBUTION FIGURES**



KEY	
TANK #1	- RECEIVES GRAVITY OVER FLOW FROM TANK 2 AND ALLOWS FOR FURTHER SETTLING
TANK #2	- CAUSTIC ADDITION AND INITIAL IRON DROP-OUT
TANK #3 & #4	- OVERNIGHT HOLDING TANK FOR TREATED WATER
TANK #5	- PRE-CARBON HOLD TANK
TANK #6	- RESIDENCE TANK
TANK #7	- RAW WATER (pH ADJUSTED)
TANK #8	- PRE-CARBON TRANSFER
TANK #9	- DAY DISCHARGE TO NPDES OUTFALL 002

LEGEND	
◆	EXISTING WELL / WELLPOINT
PS	
●	EXISTING RECOVERY WELL
○	UTILITY POLE
○.1	PRODUCT THICKNESS CONTOUR INTERVAL (FEET) (DASHED WHERE INFERRED)

SOURCE: CADD DRAWING FILES TITLED: 7074-030, 7040-61, 7040-62 AND OLIN-NEW BY SMITH TECHNOLOGIES CORP.

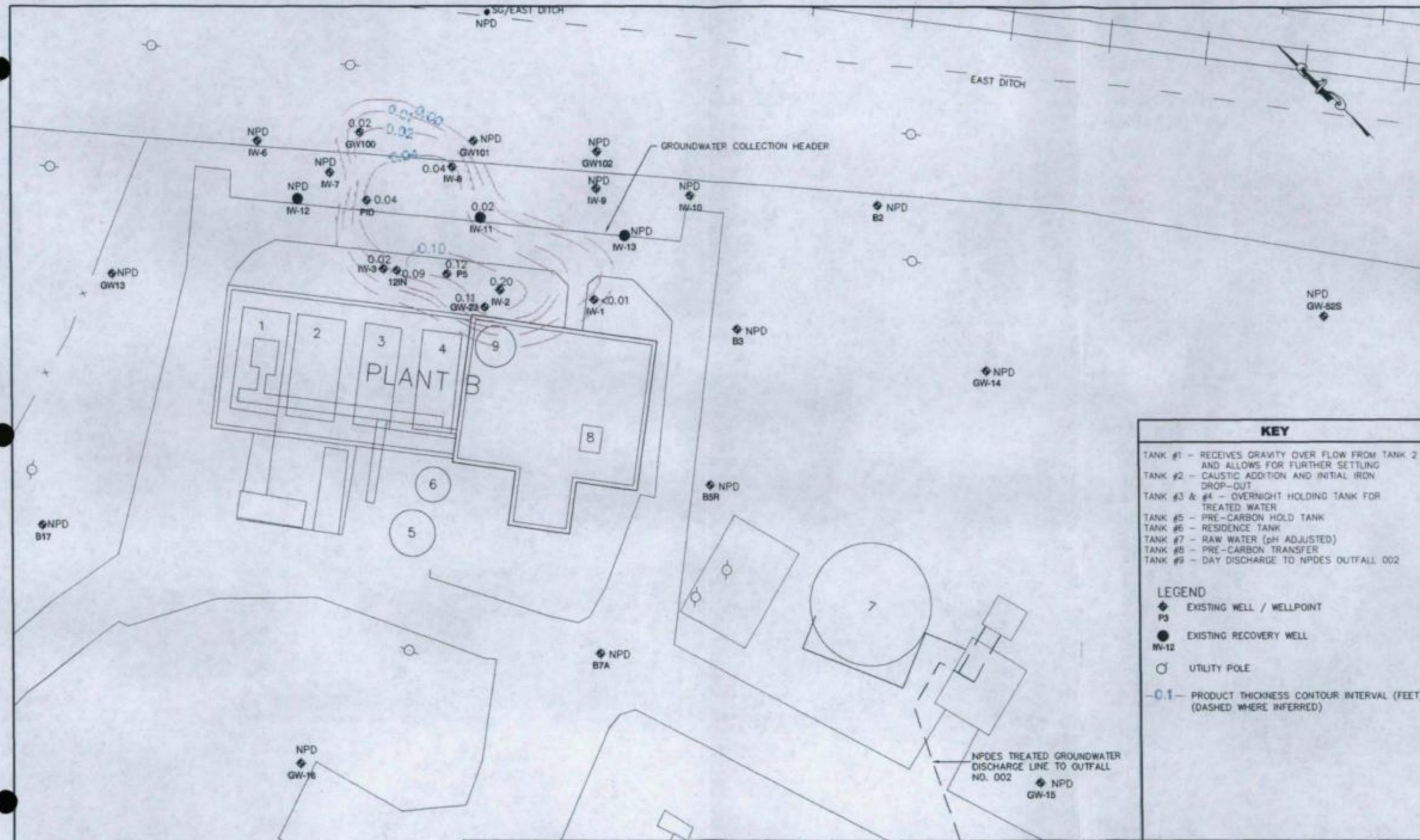


**olim**  
51 Eames Street  
Wilmington, Massachusetts

PREPARED BY: JAH 12/06/99  
DRAWN BY: JAH 12/21/99  
CHECKED BY: MWP 12/15/99  
DATE: 12/21/99

**LAW**  
ENVIRONMENTAL CONSULTANTS, INC.

PLANT B  
PRODUCT THICKNESS  
JUNE 29, 1999



**KEY**

- TANK #1 - RECEIVES GRAVITY OVER FLOW FROM TANK 2 AND ALLOWS FOR FURTHER SETTLING
- TANK #2 - CAUSTIC ADDITION AND INITIAL IRON DROP-OUT
- TANK #3 & #4 - OVERNIGHT HOLDING TANK FOR TREATED WATER
- TANK #5 - PRE-CARBON HOLD TANK
- TANK #6 - RESIDENCE TANK
- TANK #7 - RAW WATER (pH ADJUSTED)
- TANK #8 - PRE-CARBON TRANSFER
- TANK #9 - DAY DISCHARGE TO NPDES OUTFALL 002

**LEGEND**

- ◆ EXISTING WELL / WELLPOINT
- P3
- EXISTING RECOVERY WELL
- UTILITY POLE
- 0.1 - PRODUCT THICKNESS CONTOUR INTERVAL (FEET) (DASHED WHERE INFERRED)

SOURCE: CADD DRAWING FILES TITLED: 7074-030, 7040-61, 7040-62 AND OUN-NEW BY SMITH TECHNOLOGIES CORP.

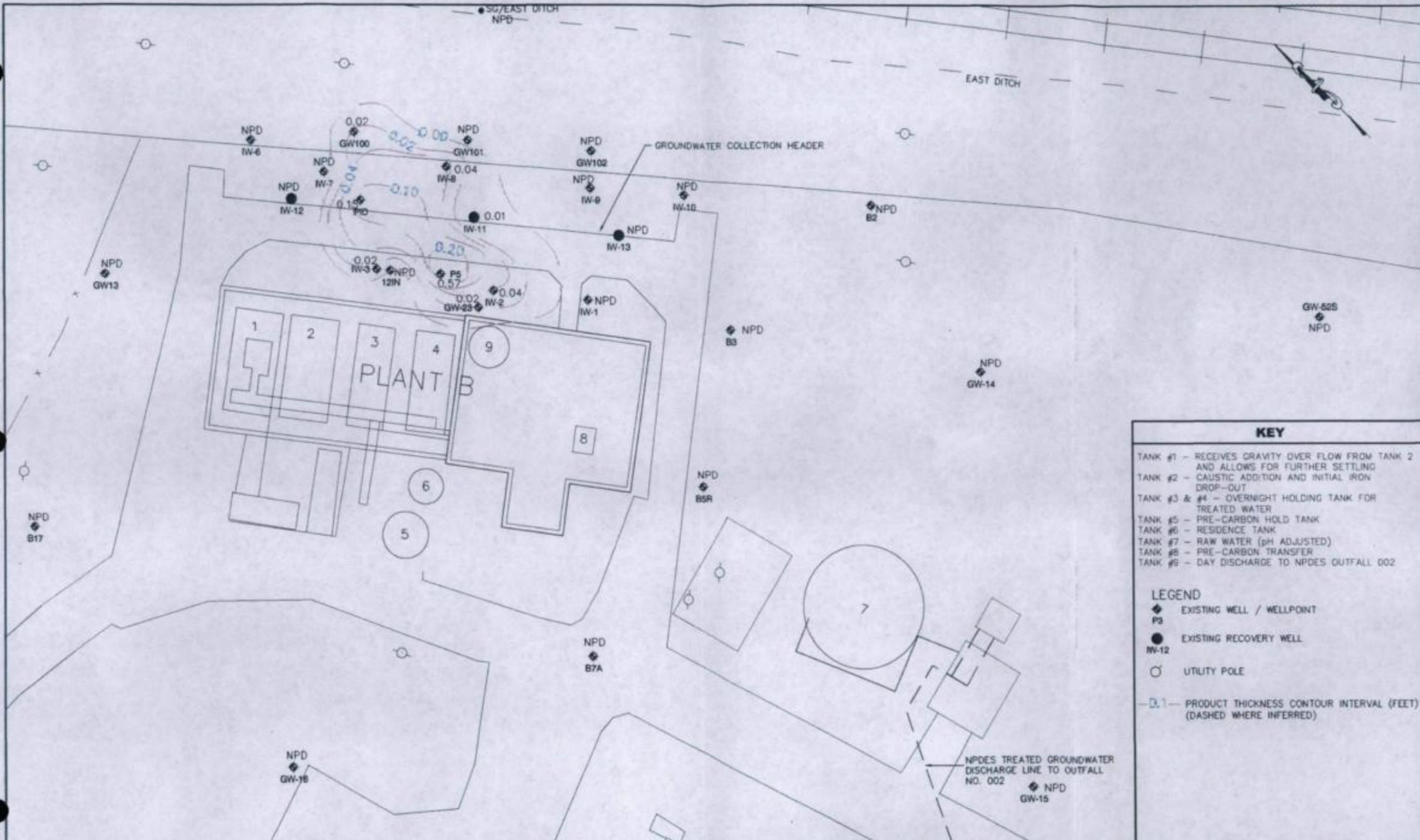


**lin**  
51 Eames Street  
Wilmington, Massachusetts

PREPARED BY: KJM 12/08/99  
DRAWN BY: KJM 12/01/99  
CHECKED BY: WMP 12/11/99  
DATE: 12/21/99

**LAW**  
ENVIRONMENTAL CONSULTANTS, INC.

PLANT B  
PRODUCT THICKNESS  
JULY 28, 1999



**KEY**

- TANK #1 - RECEIVES GRAVITY OVER FLOW FROM TANK 2 AND ALLOWS FOR FURTHER SETTLING
- TANK #2 - CAUSTIC ADDITION AND INITIAL IRON DROP-OUT
- TANK #3 & #4 - OVERNIGHT HOLDING TANK FOR TREATED WATER
- TANK #5 - PRE-CARBON HOLD TANK
- TANK #6 - RESIDENCE TANK
- TANK #7 - RAW WATER (pH ADJUSTED)
- TANK #8 - PRE-CARBON TRANSFER
- TANK #9 - DAY DISCHARGE TO NPDES OUTFALL 002

**LEGEND**

- ◆ EXISTING WELL / WELLPOINT
- PS EXISTING RECOVERY WELL
- EXISTING RECOVERY WELL
- UTILITY POLE
- 0.1 - PRODUCT THICKNESS CONTOUR INTERVAL (FEET) (DASHED WHERE INFERRED)

SOURCE: CADD DRAWING FILES TITLED: 7074-030, 7040-61, 7040-62 AND OLIN-NEW BY SMITH TECHNOLOGIES CORP.

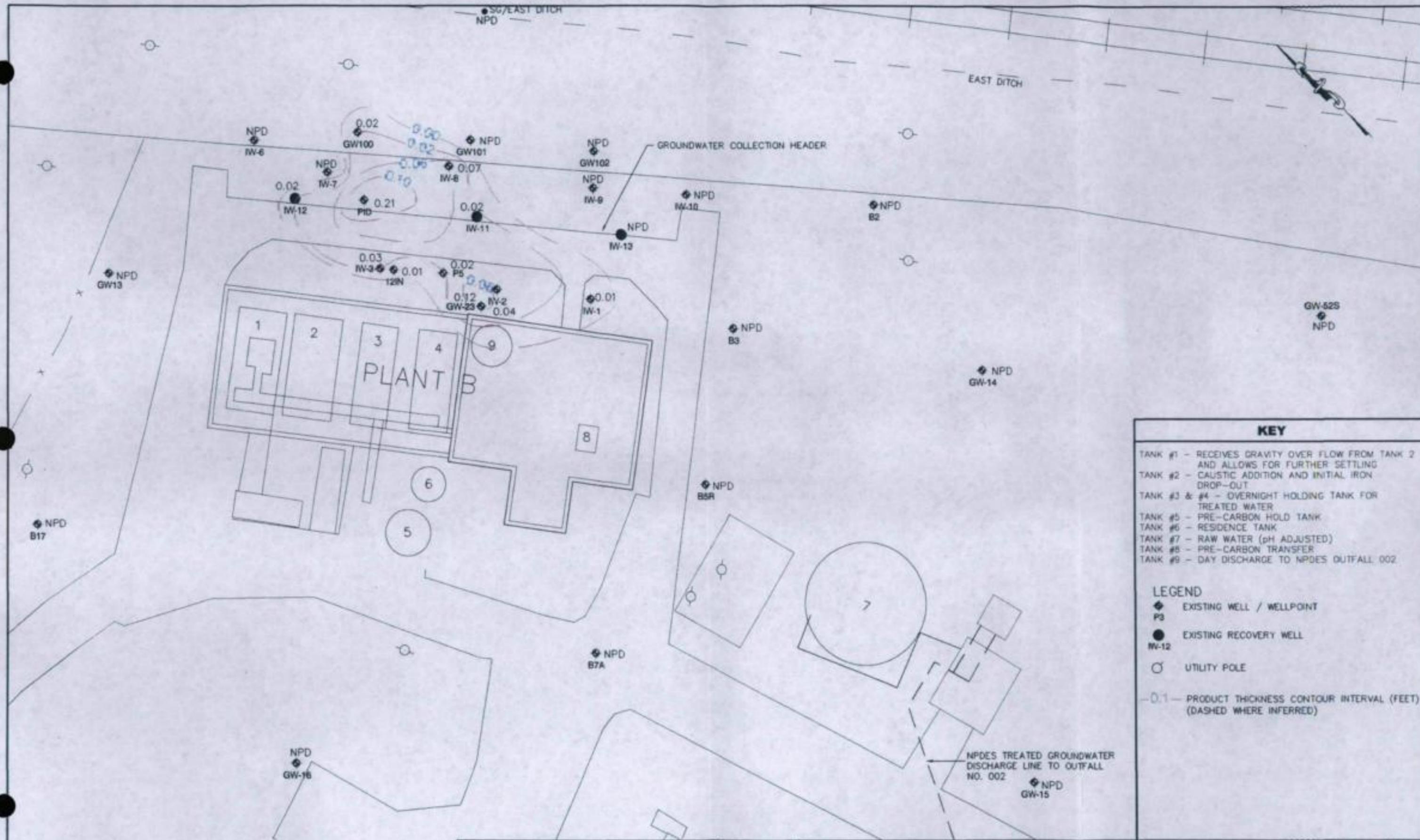


**olin**  
51 Eames Street  
Wilmington, Massachusetts

PREPARED BY: KAH 12/28/99  
DRAWN BY: KAH 12/31/99  
CHECKED BY: WWP 12/15/99  
DATE: 12/31/99

**LAW**  
ENVIRONMENTAL CONSULTANTS, INC.

PLANT B  
PRODUCT THICKNESS  
AUGUST 31, 1999



KEY	
TANK #1	- RECEIVES GRAVITY OVER FLOW FROM TANK 2 AND ALLOWS FOR FURTHER SETTLING
TANK #2	- CAUSTIC ADDITION AND INITIAL IRON DROP-OUT
TANK #3 & #4	- OVERNIGHT HOLDING TANK FOR TREATED WATER
TANK #5	- PRE-CARBON HOLD TANK
TANK #6	- RESIDENCE TANK
TANK #7	- RAW WATER (pH ADJUSTED)
TANK #8	- PRE-CARBON TRANSFER
TANK #9	- DAY DISCHARGE TO NPDES OUTFALL 002

LEGEND	
◆	EXISTING WELL / WELLPOINT
P5	EXISTING RECOVERY WELL
●	UTILITY POLE
○	PRODUCT THICKNESS CONTOUR INTERVAL (FEET) (DASHED WHERE INFERRED)

SOURCE: CADD DRAWING FILES TITLED: 7074-030, 7040-61, 7040-62 AND OLIN-NEW BY SMITH TECHNOLOGIES CORP.



**lim**  
51 Eames Street  
Wilmington, Massachusetts

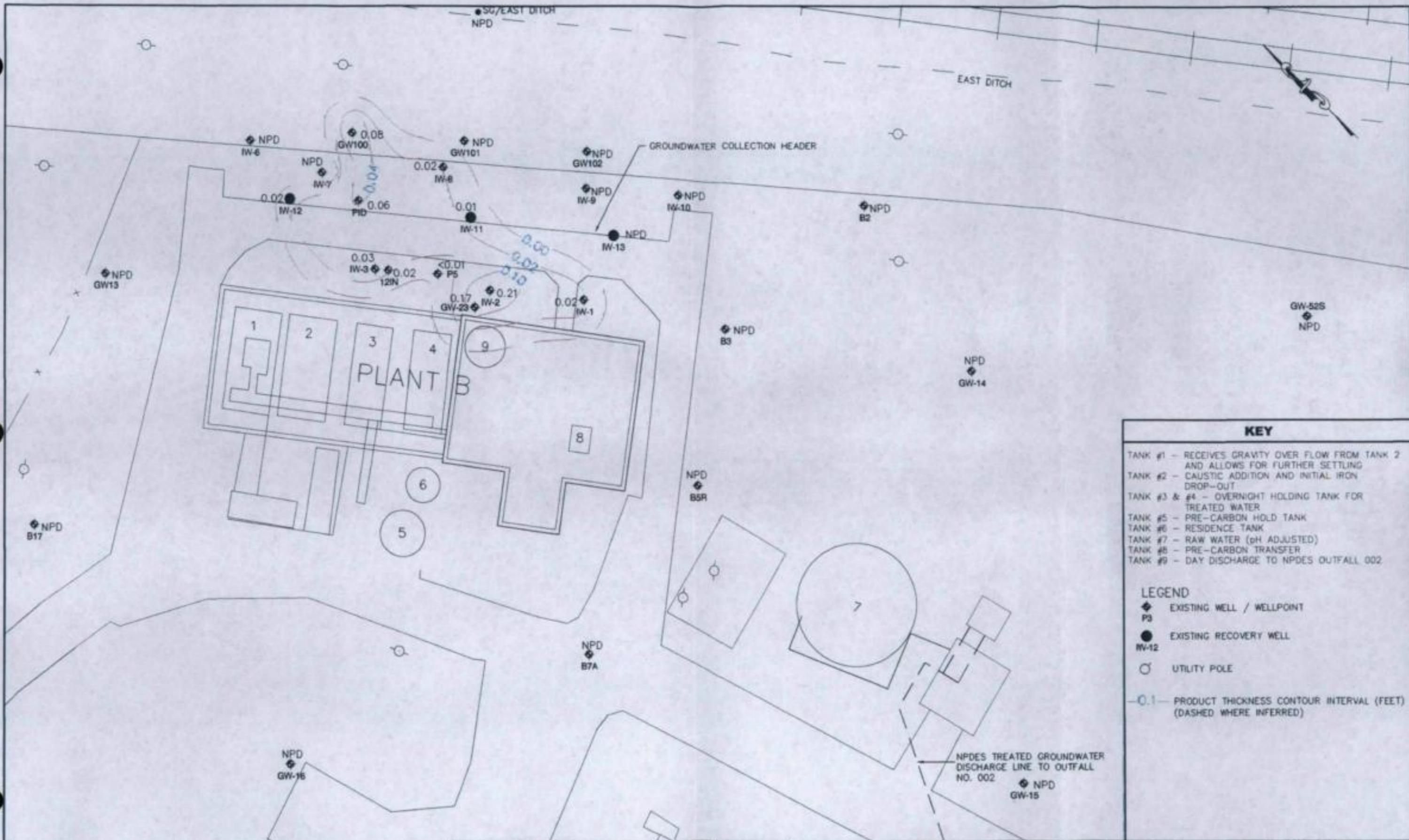
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DRAWN BY: KJM 12/01/99  
CHECKED BY: WMP 12/13/99  
DATE: 12/01/99

**LAW**  
ENVIRONMENTAL CONSULTANTS, INC.

PLANT B  
PRODUCT THICKNESS  
SEPTEMBER 27, 1999

PLATE 17 OF 17

DO NOT SCALE DRAWING FOR DIMENSIONS. SEE DIMENSIONS ON ORIGINAL DRAWING.



**KEY**

- TANK #1 - RECEIVES GRAVITY OVER FLOW FROM TANK 2 AND ALLOWS FOR FURTHER SETTLING
- TANK #2 - CAUSTIC ADDITION AND INITIAL IRON DROP-OUT
- TANK #3 & #4 - OVERNIGHT HOLDING TANK FOR TREATED WATER
- TANK #5 - PRE-CARBON HOLD TANK
- TANK #6 - RESIDENCE TANK
- TANK #7 - RAW WATER (pH ADJUSTED)
- TANK #8 - PRE-CARBON TRANSFER
- TANK #9 - DAY DISCHARGE TO NPDES OUTFALL 002

**LEGEND**

- ◆ EXISTING WELL / WELLPOINT
- PS EXISTING RECOVERY WELL
- EXISTING RECOVERY WELL
- UTILITY POLE
- 0.1- PRODUCT THICKNESS CONTOUR INTERVAL (FEET) (DASHED WHERE INFERRED)

SOURCE: CADD DRAWING FILES TITLED: 7074-030, 7040-61, 7040-62 AND OLIN-NEW BY SMITH TECHNOLOGIES CORP.



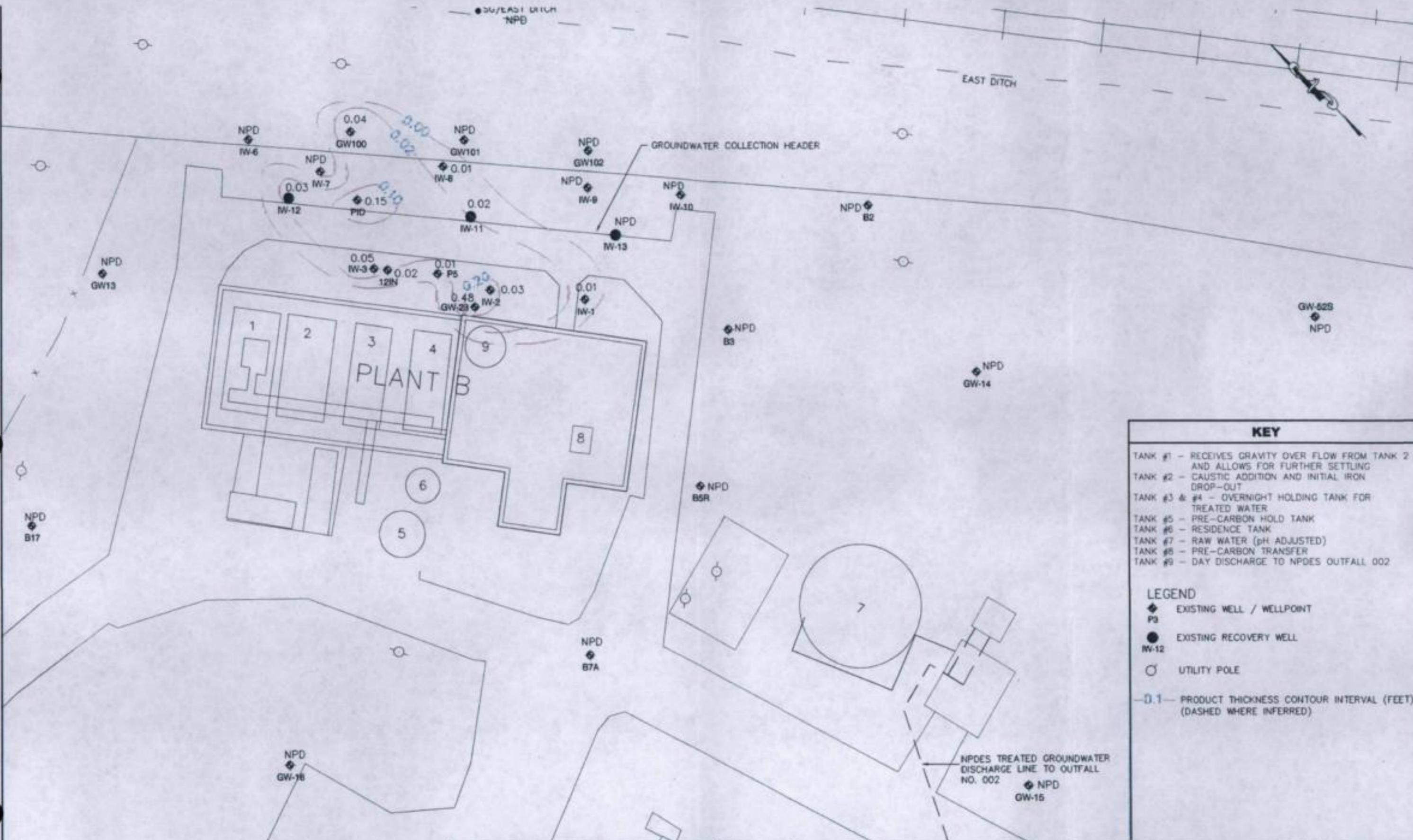
51 Eames Street

PREPARED BY: KJM 12/06/99  
 DRAWN BY: KJM 12/01/99  
 CHECKED BY: KJM 12/12/99  
 DATE: 12/01/99



**LAW**  
 ENVIRONMENTAL CONSULTANTS, INC.

PLANT B  
 PRODUCT THICKNESS  
 OCTOBER 26, 1999



**KEY**

- TANK #1 - RECEIVES GRAVITY OVER FLOW FROM TANK 2 AND ALLOWS FOR FURTHER SETTLING
- TANK #2 - CAUSTIC ADDITION AND INITIAL IRON DROP-OUT
- TANK #3 & #4 - OVERNIGHT HOLDING TANK FOR TREATED WATER
- TANK #5 - PRE-CARBON HOLD TANK
- TANK #6 - RESIDENCE TANK
- TANK #7 - RAW WATER (pH ADJUSTED)
- TANK #8 - PRE-CARBON TRANSFER
- TANK #9 - DAY DISCHARGE TO NPDES OUTFALL 002

**LEGEND**

- ◆ EXISTING WELL / WELLPOINT
- P3
- EXISTING RECOVERY WELL
- IW-12
- UTILITY POLE
- 0.1- PRODUCT THICKNESS CONTOUR INTERVAL (FEET) (DASHED WHERE INFERRED)

SOURCE: CADD DRAWING FILES TITLED: 7074-030, 7040-61, 7040-62 AND OLIN-NEW BY SMITH TECHNOLOGIES CORP.

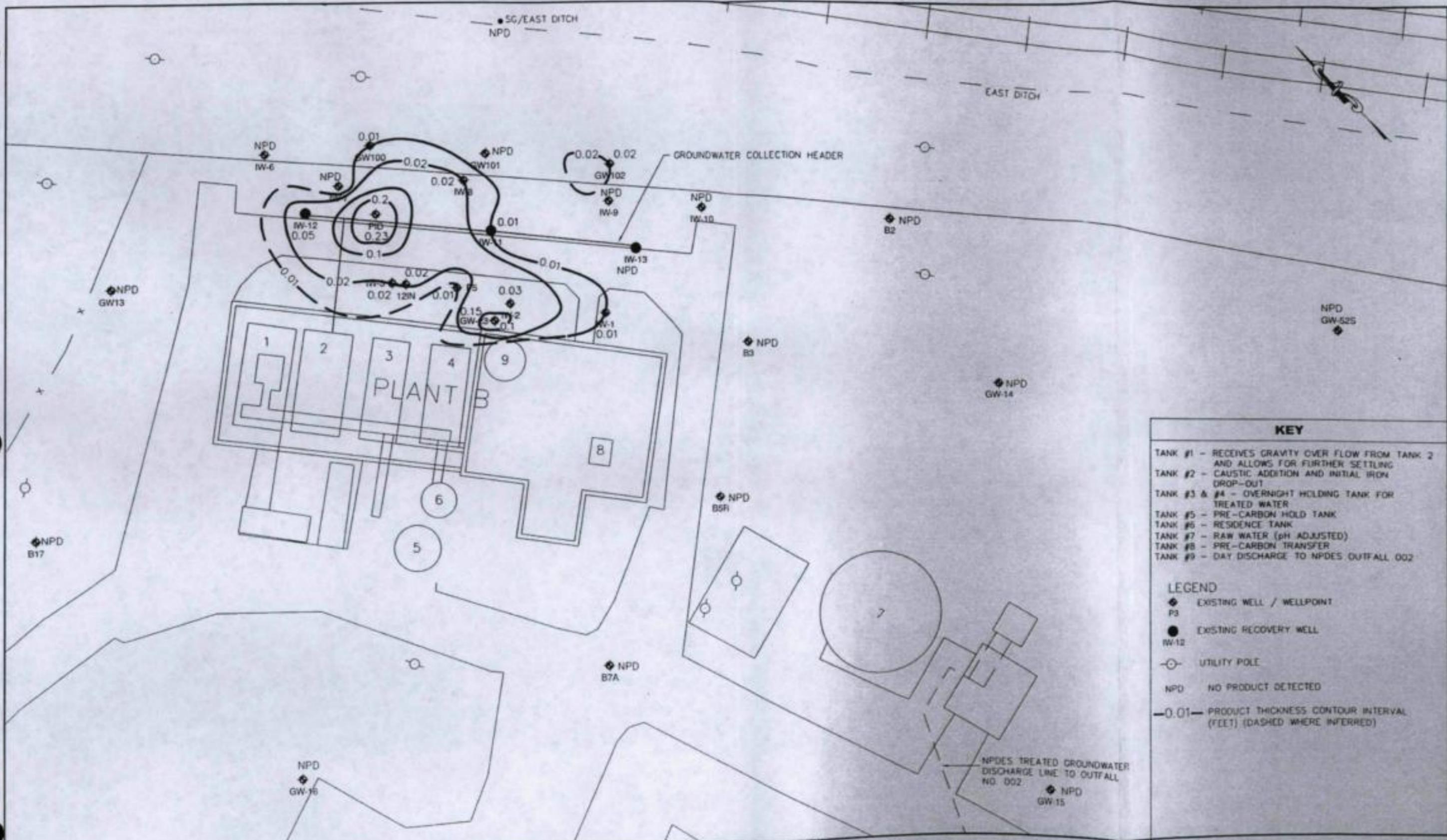


**lim**  
51 Eames Street  
Wilmington, Massachusetts

PREPARED BY: KJM 12/06/99  
DRAWN BY: KJM 12/01/99  
CHECKED BY: MWP 12/15/99  
DATE: 12/21/99

**LAW**  
ENVIRONMENTAL CONSULTANTS, INC.

PLANT B  
PRODUCT THICKNESS  
NOVEMBER 29, 1999



KEY	
TANK #1	- RECEIVES GRAVITY OVER FLOW FROM TANK 2 AND ALLOWS FOR FURTHER SETTLING
TANK #2	- CAUSTIC ADDITION AND INITIAL IRON DROP-OUT
TANK #3 & #4	- OVERNIGHT HOLDING TANK FOR TREATED WATER
TANK #5	- PRE-CARBON HOLD TANK
TANK #6	- RESIDENCE TANK
TANK #7	- RAW WATER (pH ADJUSTED)
TANK #8	- PRE-CARBON TRANSFER
TANK #9	- DAY DISCHARGE TO NPDES OUTFALL 002

LEGEND	
◆	EXISTING WELL / WELLPOINT
P3	
●	EXISTING RECOVERY WELL
IW-12	
○	UTILITY POLE
NPD	NO PRODUCT DETECTED
-0.01-	PRODUCT THICKNESS CONTOUR INTERVAL (FEET) (DASHED WHERE INFERRED)

SOURCE: CADD DRAWING FILES TITLED: 7074-030, 7040-61, 7040-62 AND OLM-NEW BY SMITH TECHNOLOGIES CORP.



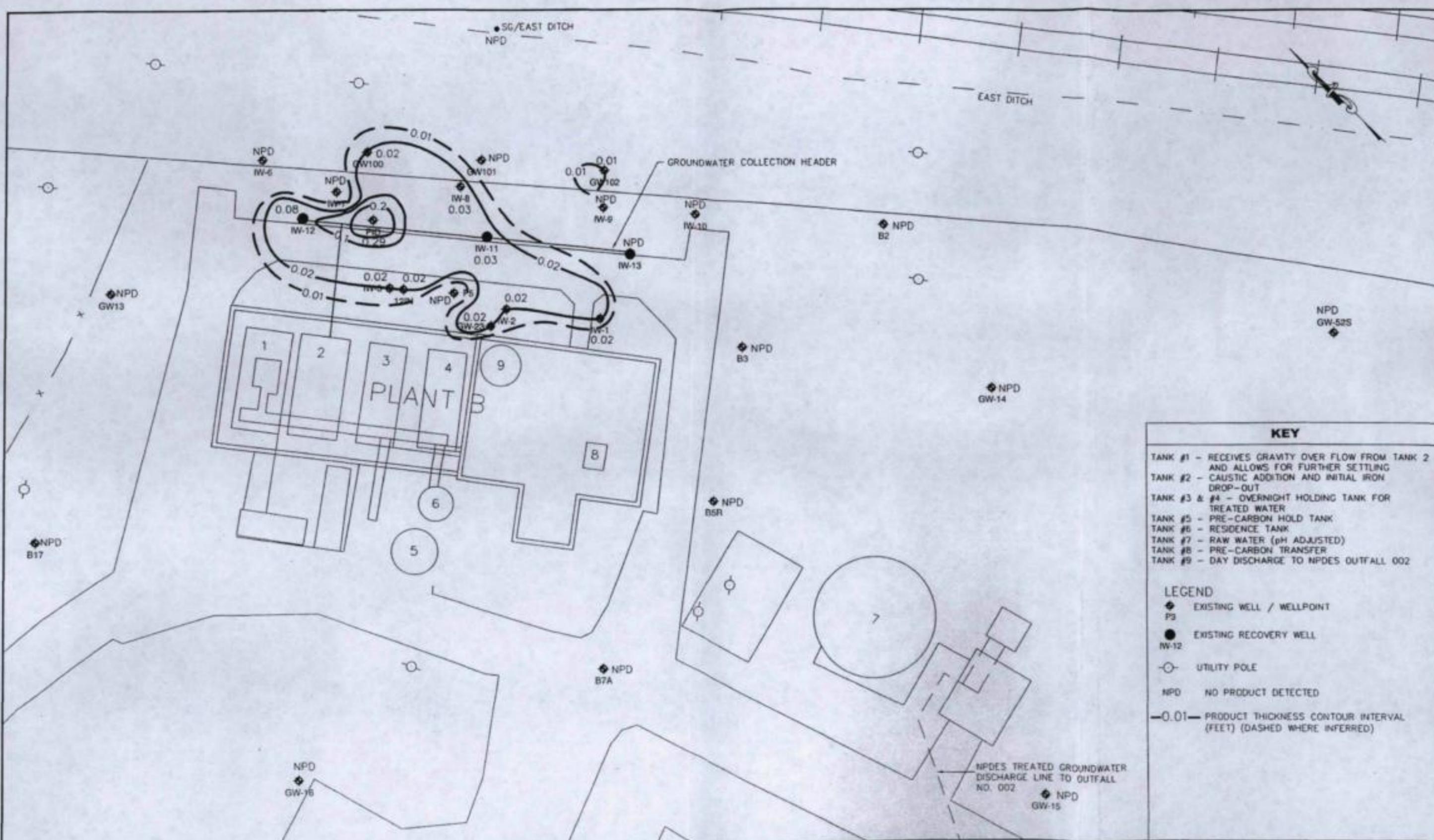
**lim**  
51 Eames Street  
Wilmington, Massachusetts

PREPARED BY: WJ 11/21/00  
DRAWN BY: WJ 11/21/00  
DESIGNED BY: SAH 11/21/00  
DATE: 12/01/00

**LAW**  
ENGINEERING & ENVIRONMENTAL SERVICES, INC.

PLANT B  
PRODUCT THICKNESS MAP  
JUNE 29, 2000  
PROJECT NO. 12000-0-2014  
FIGURE 10  
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C:\project\01\PlantB\June00\ALBANY\June-29-00\THC.dwg 12/05/00 12:00 pm



KEY	
TANK #1	- RECEIVES GRAVITY OVER FLOW FROM TANK 2 AND ALLOWS FOR FURTHER SETTLING
TANK #2	- CAUSTIC ADDITION AND INITIAL IRON DROP-OUT
TANK #3 & #4	- OVERNIGHT HOLDING TANK FOR TREATED WATER
TANK #5	- PRE-CARBON HOLD TANK
TANK #6	- RESIDENCE TANK
TANK #7	- RAW WATER (pH ADJUSTED)
TANK #8	- PRE-CARBON TRANSFER
TANK #9	- DAY DISCHARGE TO NPDES OUTFALL 002
LEGEND	
◆	EXISTING WELL / WELLPOINT
PS	EXISTING RECOVERY WELL
●	EXISTING RECOVERY WELL
○	UTILITY POLE
NPD	NO PRODUCT DETECTED
-0.01-	PRODUCT THICKNESS CONTOUR INTERVAL (FEET) (DASHED WHERE INFERRED)

SOURCE: CADD DRAWING FILES TITLED:  
7074-030, 7040-51, 7040-62 AND OLIN-NEW  
BY SMITH TECHNOLOGIES CORP



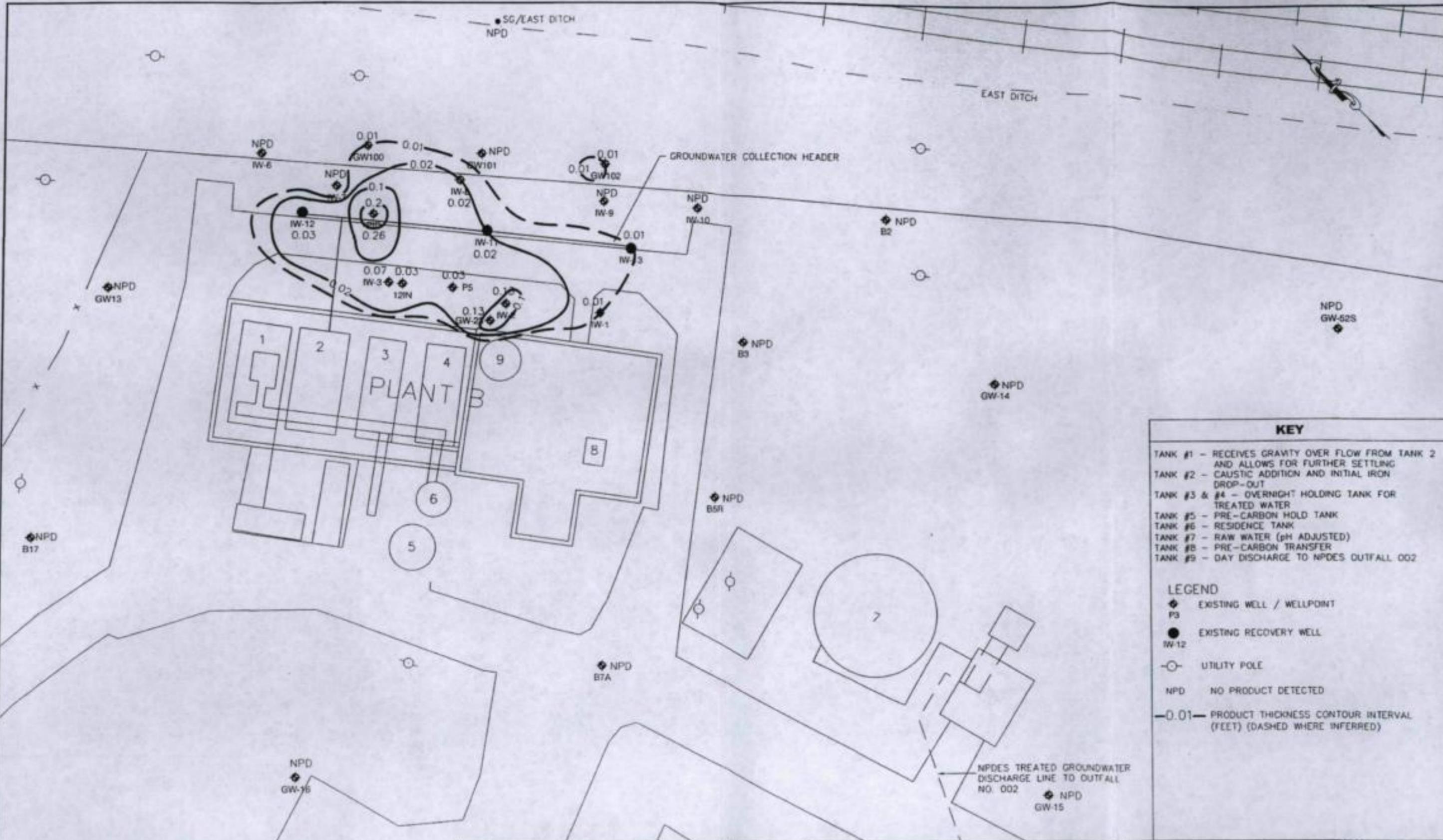
**olin**  
51 Eames Street  
Wilmington Massachusetts

PREPARED BY: KC 11/01/00  
DRAWN BY: SF 11/01/00  
CHECKED BY: SA 11/01/00  
DATE: 12/05/00

**LAW**  
ENGINEERING & ENVIRONMENTAL SERVICES, INC.

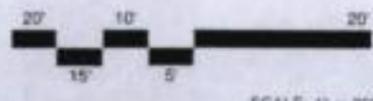
PLANT B  
PRODUCT THICKNESS MAP  
JULY 31, 2000

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KEY	
TANK #1	RECEIVES GRAVITY OVER FLOW FROM TANK 2 AND ALLOWS FOR FURTHER SETTLING
TANK #2	CAUSTIC ADDITION AND INITIAL IRON DROP-OUT
TANK #3 & #4	OVERNIGHT HOLDING TANK FOR TREATED WATER
TANK #5	PRE-CARBON HOLD TANK
TANK #6	RESIDENCE TANK
TANK #7	RAW WATER (pH ADJUSTED)
TANK #8	PRE-CARBON TRANSFER
TANK #9	DAY DISCHARGE TO NPDES OUTFALL 002
LEGEND	
◆	EXISTING WELL / WELLPOINT
P5	
●	EXISTING RECOVERY WELL
○	UTILITY POLE
NPD	NO PRODUCT DETECTED
-0.01-	PRODUCT THICKNESS CONTOUR INTERVAL (FEET) (DASHED WHERE INFERRED)

SOURCE: CADD DRAWING FILES TITLED: 7074-030, 7040-61, 7040-62 AND OLN-NEW BY SMITH TECHNOLOGIES CORP.



**lin**  
51 Eames Street  
Wilmington, Massachusetts

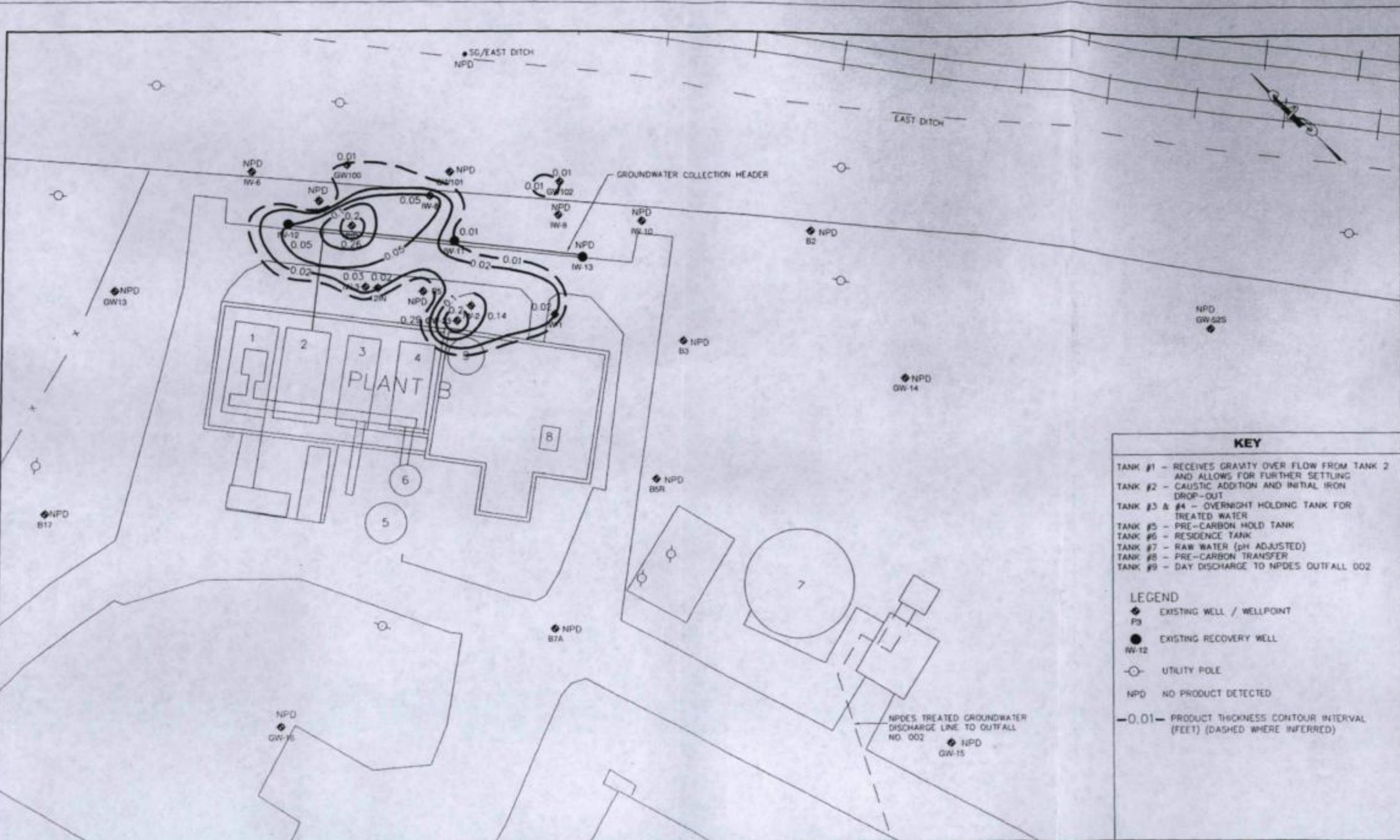
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DRAWN BY: SF 11/21/00  
CHECKED BY: SA 11/21/00  
DATE: 12/05/00

**LAW**  
ENGINEERING & ENVIRONMENTAL SERVICES, INC.

PLANT B  
PRODUCT THICKNESS MAP  
AUGUST 29, 2000

PROJECT NO. 12000-0-2014 FIGURE 12

G:\project\Dim\PlantB\June00\ALBANY\AUG-29-00\thc.dwg 12/05/00 12:00 pm

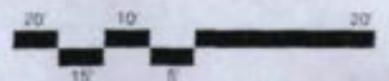


KEY	
TANK #1	- RECEIVES GRAVITY OVER FLOW FROM TANK 2 AND ALLOWS FOR FURTHER SETTLING
TANK #2	- CAUSTIC ADDITION AND INITIAL IRON DROP-OUT
TANK #3 & #4	- OVERNIGHT HOLDING TANK FOR TREATED WATER
TANK #5	- PRE-CARBON HOLD TANK
TANK #6	- RESIDENCE TANK
TANK #7	- RAW WATER (pH ADJUSTED)
TANK #8	- PRE-CARBON TRANSFER
TANK #9	- DAY DISCHARGE TO NPDES OUTFALL 002

LEGEND	
●	EXISTING WELL / WELLPOINT
PS	
●	EXISTING RECOVERY WELL
IW-12	
○	UTILITY POLE
NPD	NO PRODUCT DETECTED
-0.01-	PRODUCT THICKNESS CONTOUR INTERVAL (FEET) (DASHED WHERE INFERRED)

SOURCE: CADD DRAWING FILES TITLED: 7074-D30, 7040-61, 7040-62 AND OLIN-NEW BY SMITH TECHNOLOGIES CORP.



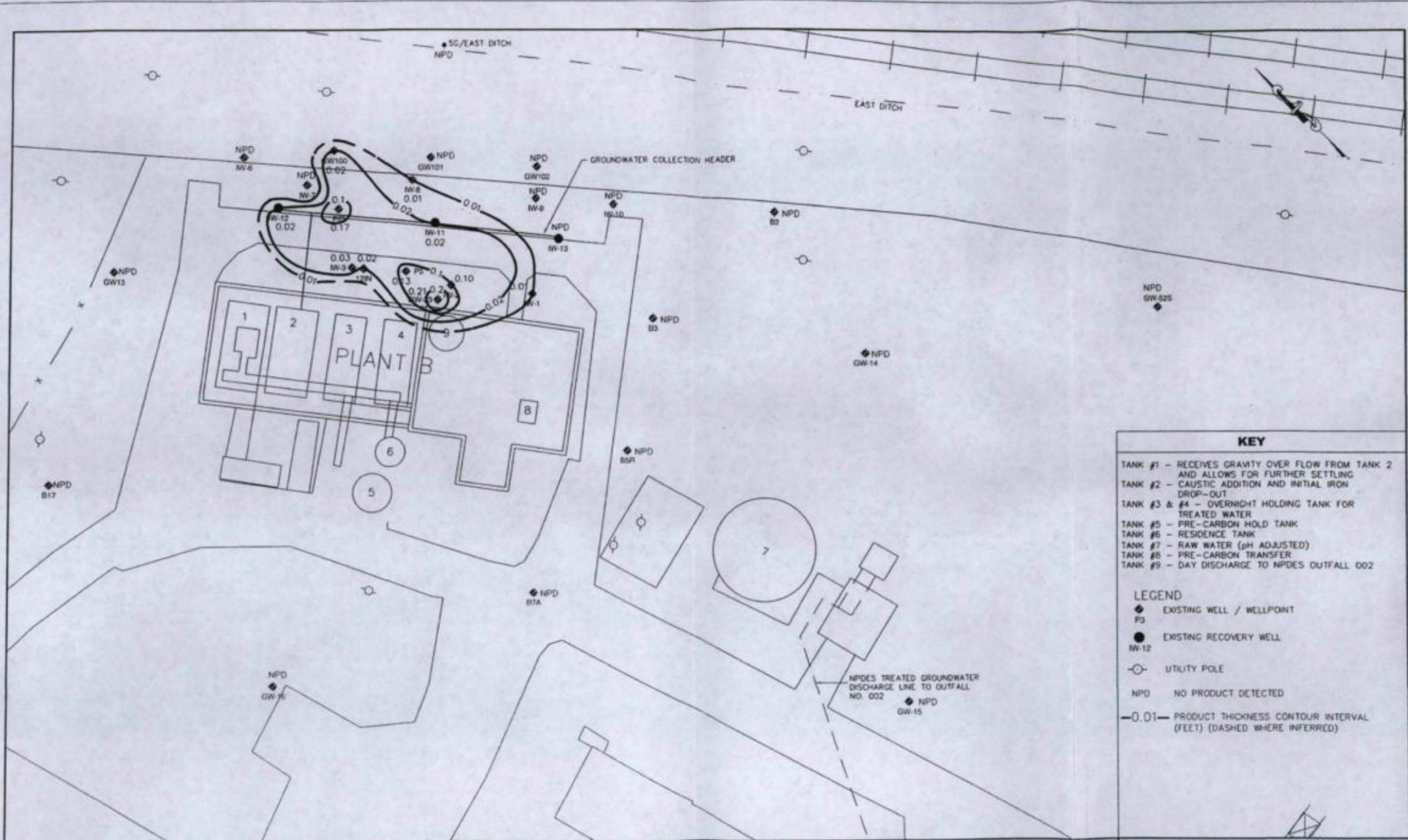
**olin**  
51 Eames Street  
Wilmington, Massachusetts

PREPARED BY: MC 11/21/00  
DRAWN BY: DJJ 11/21/00  
CHECKED BY: ELM 11/21/00  
DATE: 12/05/00

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ENGINEERING & ENVIRONMENTAL SERVICES, INC.

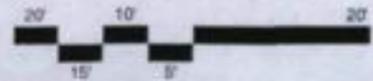
PLANT B  
PRODUCT THICKNESS MAP  
SEPTEMBER 28, 2000

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KEY	
TANK #1	- RECEIVES GRAVITY OVER FLOW FROM TANK 2 AND ALLOWS FOR FURTHER SETTLING
TANK #2	- CAUSTIC ADDITION AND INITIAL IRON DROP-OUT
TANK #3 & #4	- OVERNIGHT HOLDING TANK FOR TREATED WATER
TANK #5	- PRE-CARBON HOLD TANK
TANK #6	- RESIDENCE TANK
TANK #7	- RAW WATER (pH ADJUSTED)
TANK #8	- PRE-CARBON TRANSFER
TANK #9	- DAY DISCHARGE TO NPDES OUTFALL 002
LEGEND	
◆	EXISTING WELL / WELLPOINT
P3	EXISTING RECOVERY WELL
W-12	UTILITY POLE
NPD	NO PRODUCT DETECTED
-0.01-	PRODUCT THICKNESS CONTOUR INTERVAL (FEET) (DASHED WHERE INFERRED)

SOURCE: CADD DRAWING FILES TITLED 7074-030, 7040-61,7040-62 AND OLIN-NEW BY SMITH TECHNOLOGIES CORP



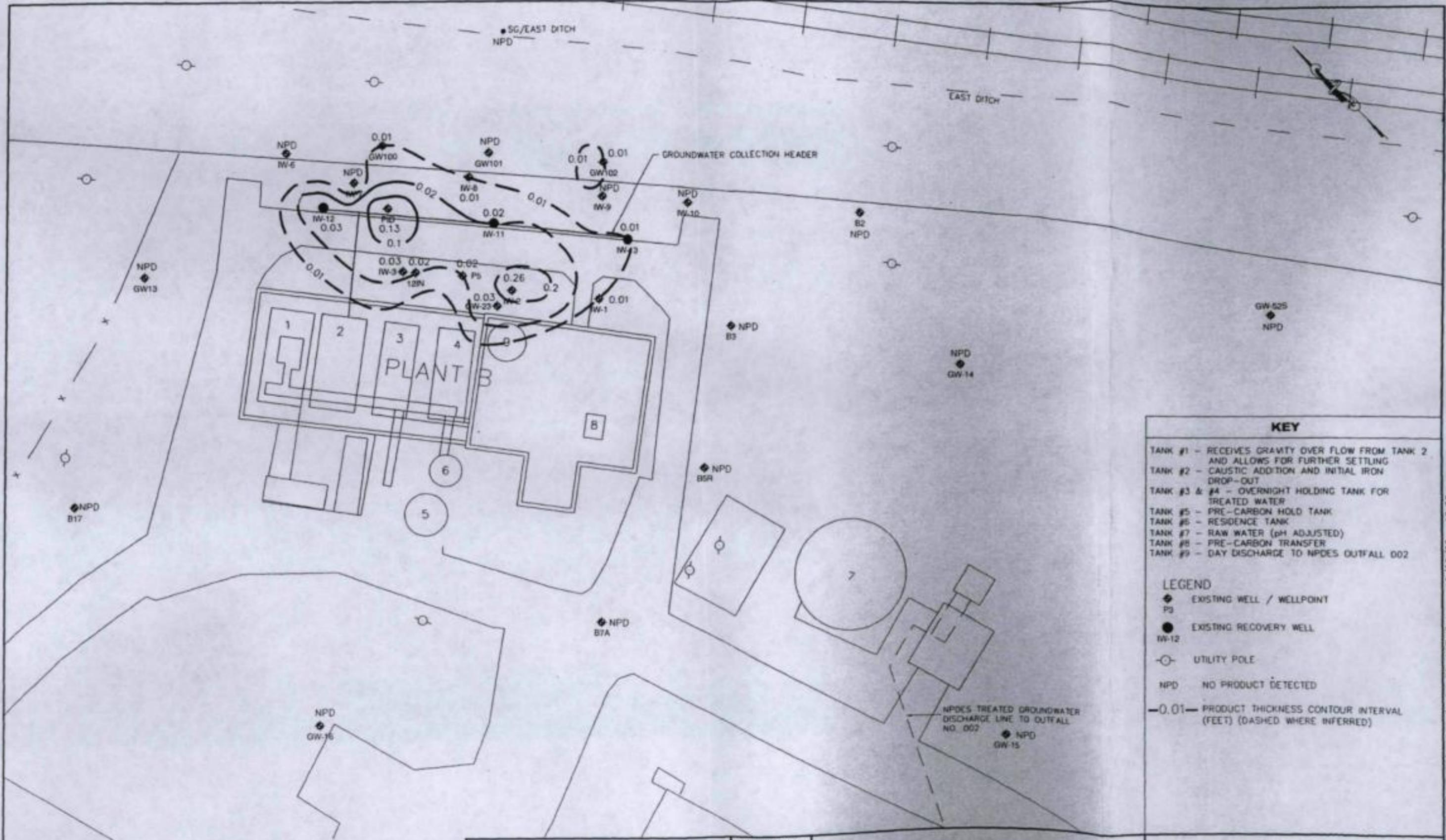
**olin**  
51 Eames Street  
Wilmington, Massachusetts

PREPARED BY: NC 11/21/00  
DRAWN BY: DF 11/21/00  
CHECKED BY: DM 11/21/00  
DATE: 12/05/00

**LAW**  
ENGINEERING & ENVIRONMENTAL SERVICES, INC.

PLANT B  
PRODUCT THICKNESS MAP  
OCTOBER 27, 2000  
PROJECT NO. 12000-0-2014  
FIGURE 14

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KEY	
TANK #1	- RECEIVES GRAVITY OVER FLOW FROM TANK 2 AND ALLOWS FOR FURTHER SETTLING
TANK #2	- CAUSTIC ADDITION AND INITIAL IRON DROP-OUT
TANK #3 & #4	- OVERNIGHT HOLDING TANK FOR TREATED WATER
TANK #5	- PRE-CARBON HOLD TANK
TANK #6	- RESIDENCE TANK
TANK #7	- RAW WATER (pH ADJUSTED)
TANK #8	- PRE-CARBON TRANSFER
TANK #9	- DAY DISCHARGE TO NPDES OUTFALL 002
LEGEND	
●	EXISTING WELL / WELLPOINT
PS	
●	EXISTING RECOVERY WELL
W-12	
○	UTILITY POLE
NPD	NO PRODUCT DETECTED
-0.01-	PRODUCT THICKNESS CONTOUR INTERVAL (FEET) (DASHED WHERE INFERRED)

SOURCE: CADD DRAWING FILES TITLED:  
7074-030, 7040-61, 7040-62 AND OLIN-NEW  
BY SMITH TECHNOLOGIES CORP.



**olin**  
51 Eames Street  
Wilmington, Massachusetts

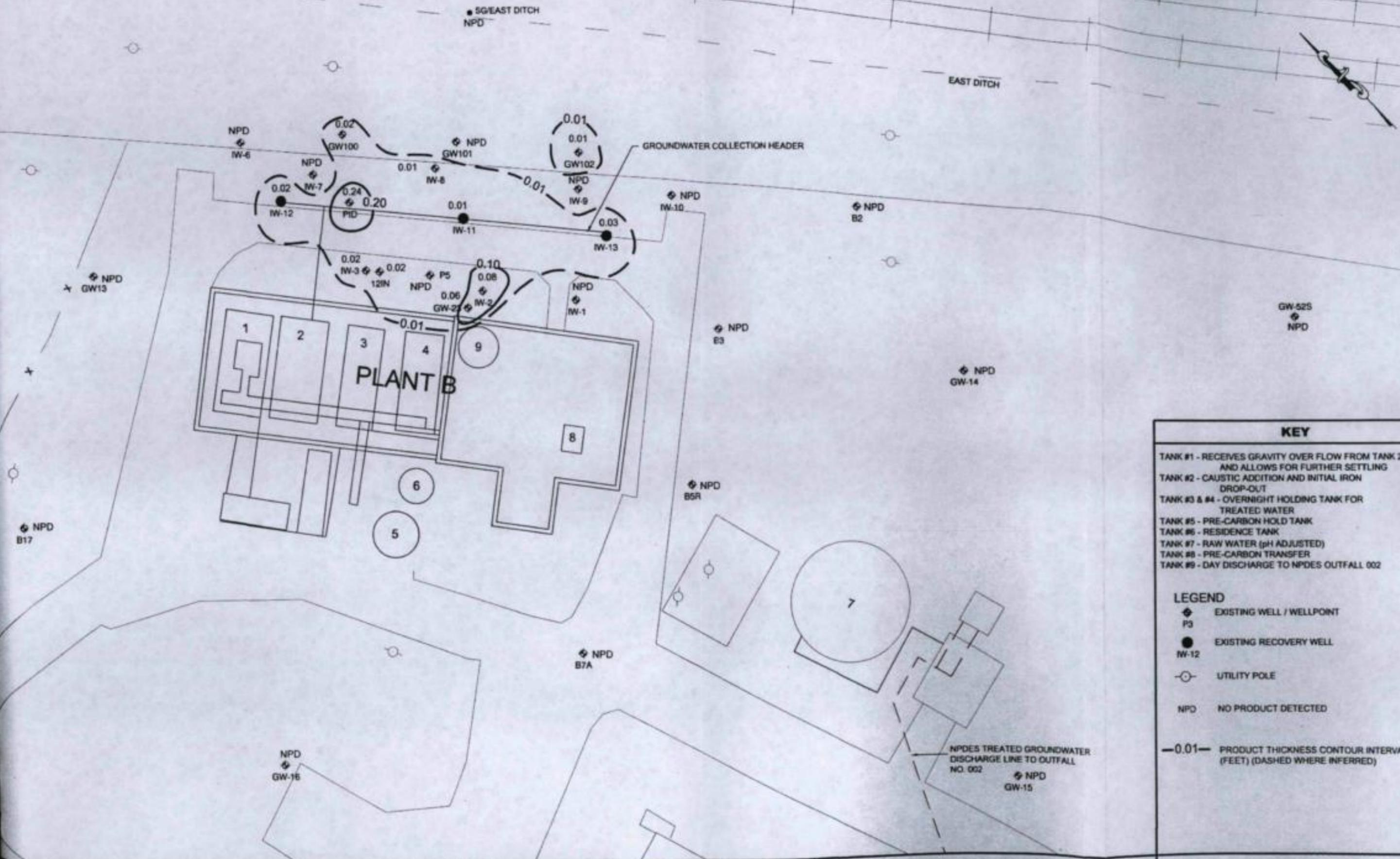
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DRAWN BY: SP 11/21/00  
CHECKED BY: SA 11/21/00  
DATE: 11/21/00

**LAW**  
ENGINEERING & ENVIRONMENTAL SERVICES, INC.

PLANT B  
PRODUCT THICKNESS MAP  
NOVEMBER 28, 2000

PROJECT NO. 12000-0-2014 FIGURE 15

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**KEY**

- TANK #1 - RECEIVES GRAVITY OVER FLOW FROM TANK 2 AND ALLOWS FOR FURTHER SETTLING
- TANK #2 - CAUSTIC ADDITION AND INITIAL IRON DROP-OUT
- TANK #3 & #4 - OVERNIGHT HOLDING TANK FOR TREATED WATER
- TANK #5 - PRE-CARBON HOLD TANK
- TANK #6 - RESIDENCE TANK
- TANK #7 - RAW WATER (pH ADJUSTED)
- TANK #8 - PRE-CARBON TRANSFER
- TANK #9 - DAY DISCHARGE TO NPDES OUTFALL 002

**LEGEND**

- ◉ EXISTING WELL / WELLPOINT
- P5
- EXISTING RECOVERY WELL
- IW-12
- UTILITY POLE
- NPD NO PRODUCT DETECTED
- 0.01- PRODUCT THICKNESS CONTOUR INTERVAL (FEET) (DASHED WHERE INFERRED)

SOURCE: CADD DRAWING FILES TITLED: 7074-030, 7040-61, 7040-62 AND OLIN-NEW

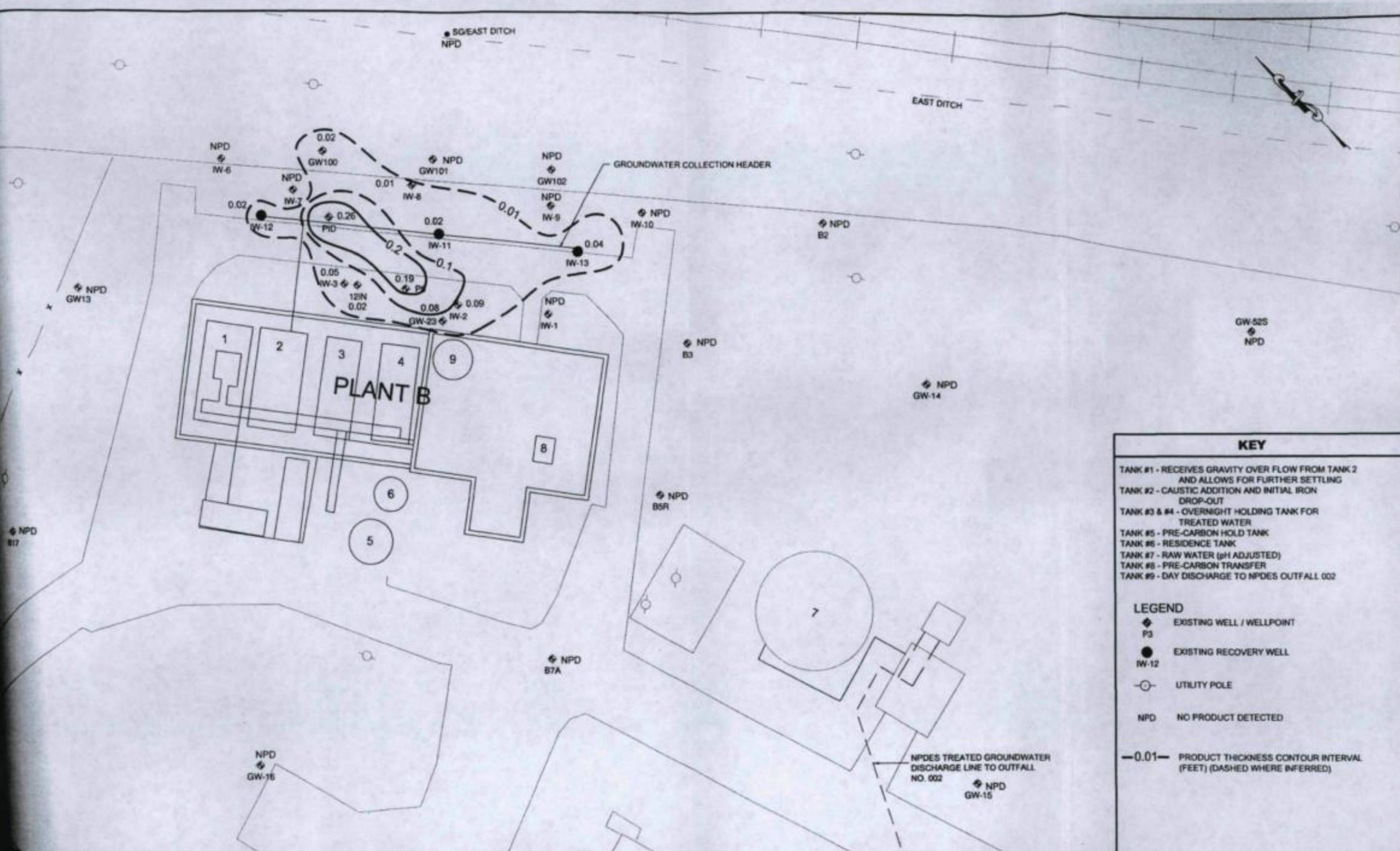


PREPARED BY: J. BERRY  
 DRAWN BY: D. BERRY  
 CHECKED BY: D. BERRY



**LAW**  
 ENGINEERING & ENVIRONMENTAL SERVICES, INC.

PLANT B  
 PRODUCT THICKNESS MAP  
 DECEMBER 29, 2000



KEY	
TANK #1	RECEIVES GRAVITY OVER FLOW FROM TANK 2 AND ALLOWS FOR FURTHER SETTLING
TANK #2	CAUSTIC ADDITION AND INITIAL IRON DROP-OUT
TANK #3 & #4	OVERNIGHT HOLDING TANK FOR TREATED WATER
TANK #5	PRE-CARBON HOLD TANK
TANK #6	RESIDENCE TANK
TANK #7	RAW WATER (pH ADJUSTED)
TANK #8	PRE-CARBON TRANSFER
TANK #9	DAY DISCHARGE TO NPDES OUTFALL 002
LEGEND	
	EXISTING WELL / WELLPOINT
	P3
	EXISTING RECOVERY WELL
	IW-12
	UTILITY POLE
	NPD
	NO PRODUCT DETECTED
	0.01 PRODUCT THICKNESS CONTOUR INTERVAL (FEET) (DASHED WHERE INFERRED)

ORICE CADD DRAWING FILES TITLED:  
 7940-61, 7940-62 AND OLIN-NEW  
 TECHNOLOGIES CORP.



**olin**  
 51 Eames Street

PREPARED BY: J. WOOD  
 DRAWN BY: D. WOOD  
 CHECKED BY: S. WOOD  
 DATE: 1/22/01

**LAW**  
 ENGINEERING & ENVIRONMENTAL SERVICES INC.

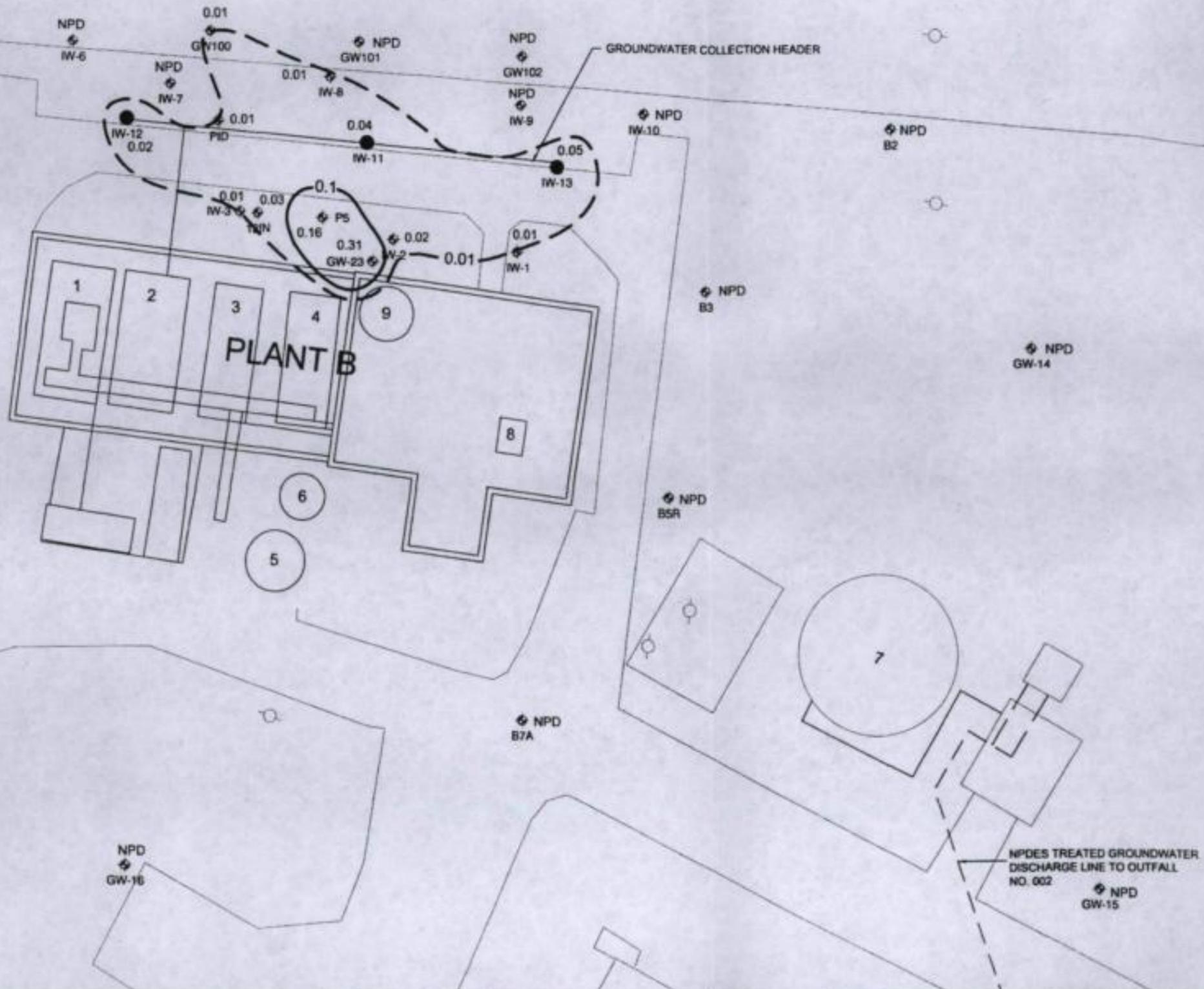
PLANT B  
 PRODUCT THICKNESS MAP  
 JANUARY 22, 2001

NY-G:\projects\Olin\2000-1-001B\PlantB\1st&2nd\tr01\CA00 VFC 11.dwg 6/27/01 12:00 pm

SG/EAST DITCH  
NPD

EAST DITCH

GROUNDWATER COLLECTION HEADER



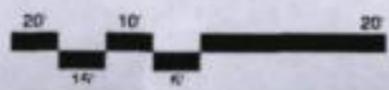
**KEY**

- TANK #1 - RECEIVES GRAVITY OVER FLOW FROM TANK 2 AND ALLOWS FOR FURTHER SETTLING
- TANK #2 - CAUSTIC ADDITION AND INITIAL IRON DROP-OUT
- TANK #3 & #4 - OVERNIGHT HOLDING TANK FOR TREATED WATER
- TANK #5 - PRE-CARBON HOLD TANK
- TANK #6 - RESIDENCE TANK
- TANK #7 - RAW WATER (pH ADJUSTED)
- TANK #8 - PRE-CARBON TRANSFER
- TANK #9 - DAY DISCHARGE TO NPDES OUTFALL 002

**LEGEND**

- ⊕ EXISTING WELL / WELLPOINT
- PS EXISTING RECOVERY WELL
- UTILITY POLE
- NPD NO PRODUCT DETECTED
- 0.01- PRODUCT THICKNESS CONTOUR INTERVAL (FEET) (DASHED WHERE INFERRED)

SOURCE: CADD DRAWING FILES TITLED: 7040-61, 7040-62 AND OLIN-NEW WITH TECHNOLOGIES CORP.



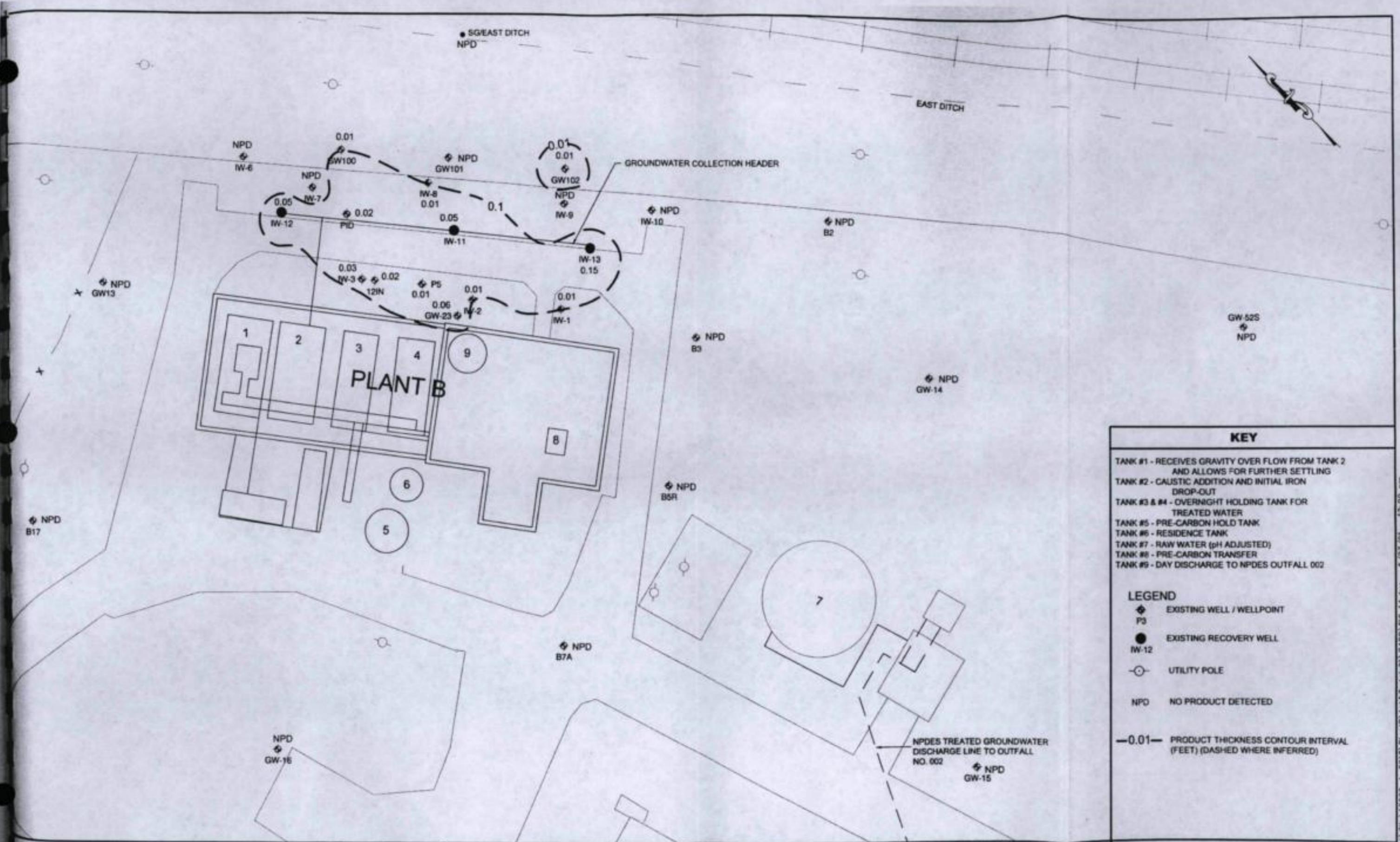
**lin**  
51 Eames Street

DATE:	02/27/01
DRAWN BY:	DAW/STW
CHECKED BY:	DAW/STW
DATE:	02/27/01

**LAW**  
ENGINEERING & ENVIRONMENTAL SERVICES, INC.

**PLANT B**  
PRODUCT THICKNESS MAP  
FEBRUARY 27, 2001

ENV-G: Agri project\Olin\12000-1-0018\PlantB\1st\2nd\qr01\CA00 V\FIG 12.dwg 6/27/01 12:00 pm



**KEY**

- TANK #1 - RECEIVES GRAVITY OVER FLOW FROM TANK 2 AND ALLOWS FOR FURTHER SETTLING
- TANK #2 - CAUSTIC ADDITION AND INITIAL IRON DROP-OUT
- TANK #3 & #4 - OVERNIGHT HOLDING TANK FOR TREATED WATER
- TANK #5 - PRE-CARBON HOLD TANK
- TANK #6 - RESIDENCE TANK
- TANK #7 - RAW WATER (pH ADJUSTED)
- TANK #8 - PRE-CARBON TRANSFER
- TANK #9 - DAY DISCHARGE TO NPDES OUTFALL 002

**LEGEND**

- EXISTING WELL / WELLPOINT
- PS
- EXISTING RECOVERY WELL
- IW-12
- UTILITY POLE
- NO PRODUCT DETECTED
- 0.01- PRODUCT THICKNESS CONTOUR INTERVAL (FEET) (DASHED WHERE INFERRED)

SOURCE: CADD DRAWING FILES TITLED: 704-030, 7040-61, 7040-62 AND OLIN-NEW BY SMITH TECHNOLOGIES CORP.



**lim**  
51 Eames Street

PROJECT BY: J.E. 6/21/01  
 DRAWN BY: M.F. 6/21/01  
 CHECKED BY: S.A. 6/21/01  
 DATE: 6/21/01

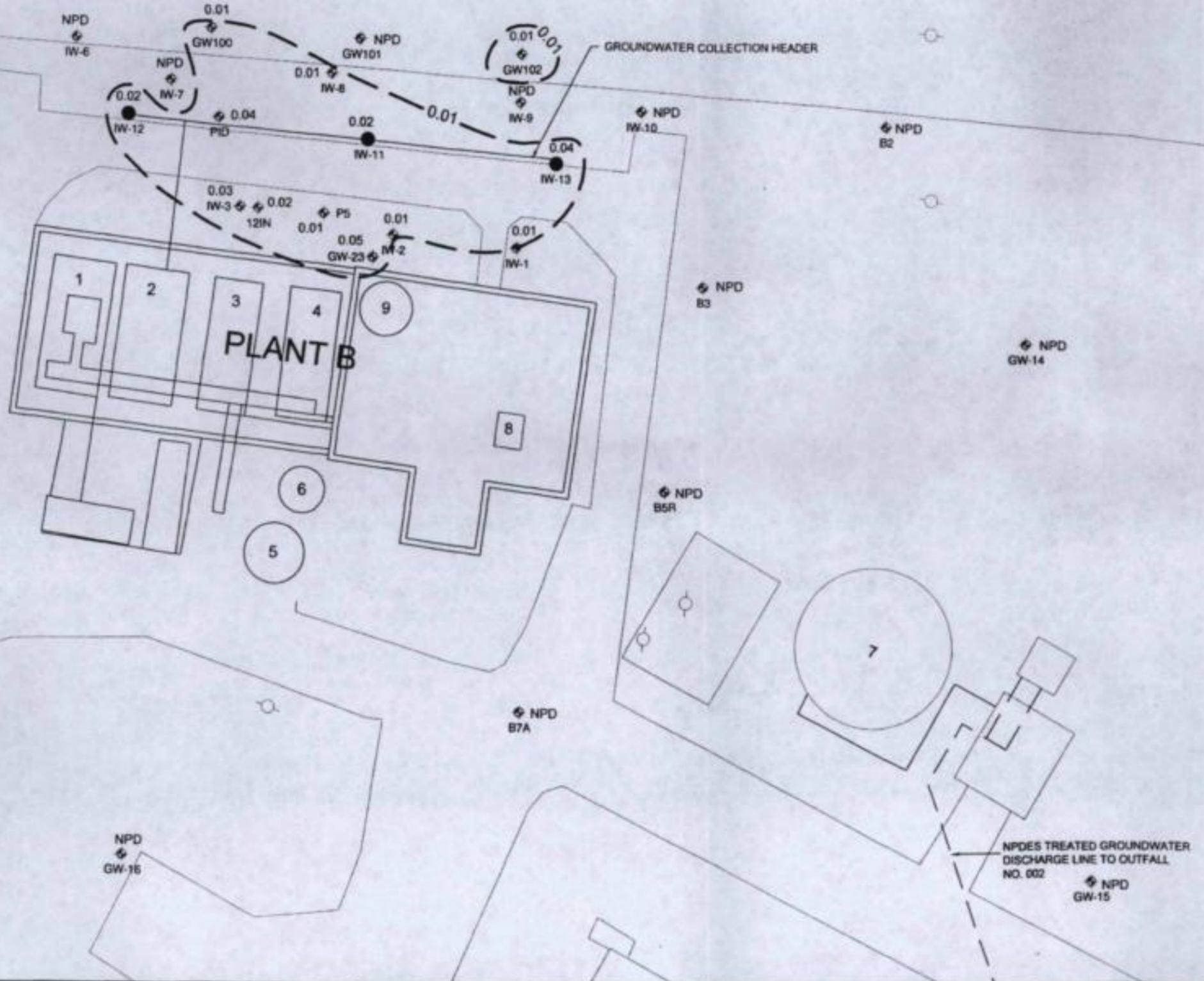
**LAW**  
ENGINEERING & ENVIRONMENTAL SERVICES, INC.

PLANT B  
PRODUCT THICKNESS MAP  
APRIL 26, 2001

W:\G:\Project\Olin\1\2000-1-0018\PlantB\1st&2nd\p101\CADD\FIG 14.dwg 6/27/01 12:00 pm

SGEAST DITCH  
NPD

EAST DITCH



KEY	
TANK #1	- RECEIVES GRAVITY OVER FLOW FROM TANK 2 AND ALLOWS FOR FURTHER SETTLING
TANK #2	- CAUSTIC ADDITION AND INITIAL IRON DROP-OUT
TANK #3 & #4	- OVERNIGHT HOLDING TANK FOR TREATED WATER
TANK #5	- PRE-CARBON HOLD TANK
TANK #6	- RESIDENCE TANK
TANK #7	- RAW WATER (pH ADJUSTED)
TANK #8	- PRE-CARBON TRANSFER
TANK #9	- DAY DISCHARGE TO NPDES OUTFALL 002
LEGEND	
◆	EXISTING WELL / WELLPOINT
P3	
●	EXISTING RECOVERY WELL
IW-12	
○	UTILITY POLE
NPD	NO PRODUCT DETECTED
-0.01-	PRODUCT THICKNESS CONTOUR INTERVAL (FEET) (DASHED WHERE INFERRED)

SOURCE: CADD DRAWING FILES TITLED: 7040-61, 7040-62 AND OLIN-NEW SMITH TECHNOLOGIES CORP.



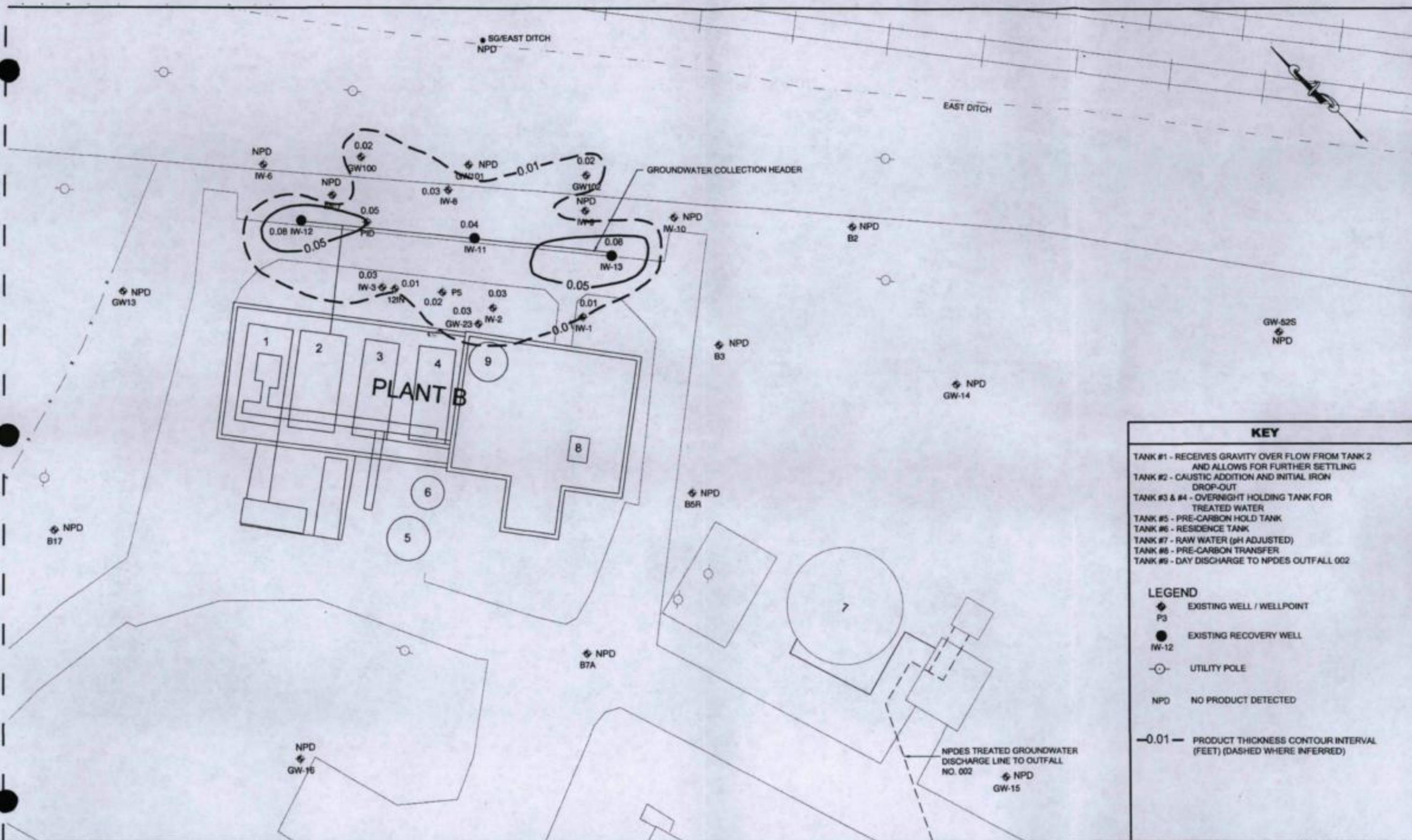
**lin**  
51 Eames Street

PREPARED BY: JF. BROWN  
 DRAWN BY: JF. BROWN  
 CHECKED BY: JF. BROWN

**LAW**

PLANT B  
 PRODUCT THICKNESS MAP  
 8/8/00 3:15 PM

-C:\project\Olin\12000-1-001B\Plan\B\1st&2nd\p01\CADD\FIG 15.dwg 6/27/01 12:00 pm



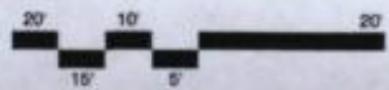
**KEY**

- TANK #1 - RECEIVES GRAVITY OVER FLOW FROM TANK 2 AND ALLOWS FOR FURTHER SETTLING
- TANK #2 - CAUSTIC ADDITION AND INITIAL IRON DROP-OUT
- TANK #3 & #4 - OVERNIGHT HOLDING TANK FOR TREATED WATER
- TANK #5 - PRE-CARBON HOLD TANK
- TANK #6 - RESIDENCE TANK
- TANK #7 - RAW WATER (pH ADJUSTED)
- TANK #8 - PRE-CARBON TRANSFER
- TANK #9 - DAY DISCHARGE TO NPDES OUTFALL 002

**LEGEND**

- ◆ EXISTING WELL / WELLPOINT
- P3 EXISTING RECOVERY WELL
- EXISTING RECOVERY WELL
- UTILITY POLE
- NPD NO PRODUCT DETECTED
- 0.01- PRODUCT THICKNESS CONTOUR INTERVAL (FEET) (DASHED WHERE INFERRED)

SOURCE: CADD DRAWING FILES TITLED: 7074-030, 7040-61, 7040-62 AND OLIN-NEW BY SMITH TECHNOLOGIES CORP.



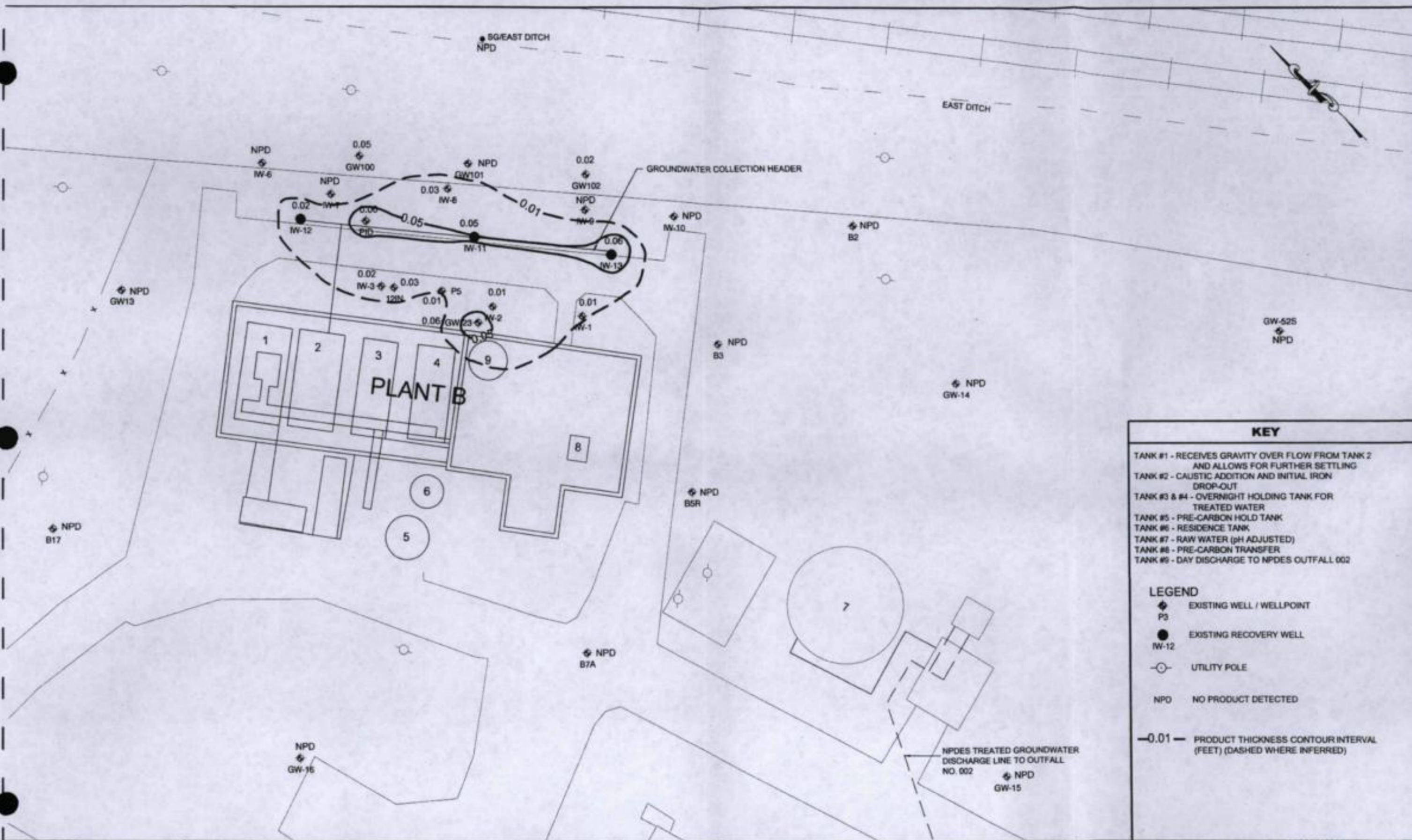
**olin**  
51 Eames Street

PREPARED BY: [blank]  
DRAWN BY: [blank]  
CHECKED BY: [blank]  
DATE: [blank]



**LAW**  
ENGINEERING & ENVIRONMENTAL SERVICES, INC.

PLANT B  
PRODUCT THICKNESS MAP  
JUNE 26, 2001



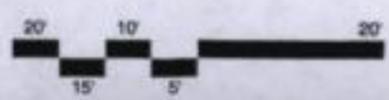
**KEY**

- TANK #1 - RECEIVES GRAVITY OVER FLOW FROM TANK 2 AND ALLOWS FOR FURTHER SETTLING
- TANK #2 - CAUSTIC ADDITION AND INITIAL IRON DROP-OUT
- TANK #3 & #4 - OVERNIGHT HOLDING TANK FOR TREATED WATER
- TANK #5 - PRE-CARBON HOLD TANK
- TANK #6 - RESIDENCE TANK
- TANK #7 - RAW WATER (pH ADJUSTED)
- TANK #8 - PRE-CARBON TRANSFER
- TANK #9 - DAY DISCHARGE TO NPDES OUTFALL 002

**LEGEND**

- ⊕ EXISTING WELL / WELLPOINT
- P5
- EXISTING RECOVERY WELL
- IW-12
- UTILITY POLE
- NPD NO PRODUCT DETECTED
- 0.01- PRODUCT THICKNESS CONTOUR INTERVAL (FEET) (DASHED WHERE INFERRED)

SOURCE: CADD DRAWING FILES TITLED: 7074-030, 7040-61, 7040-62 AND OLIN-NEW BY SMITH TECHNOLOGIES CORP.

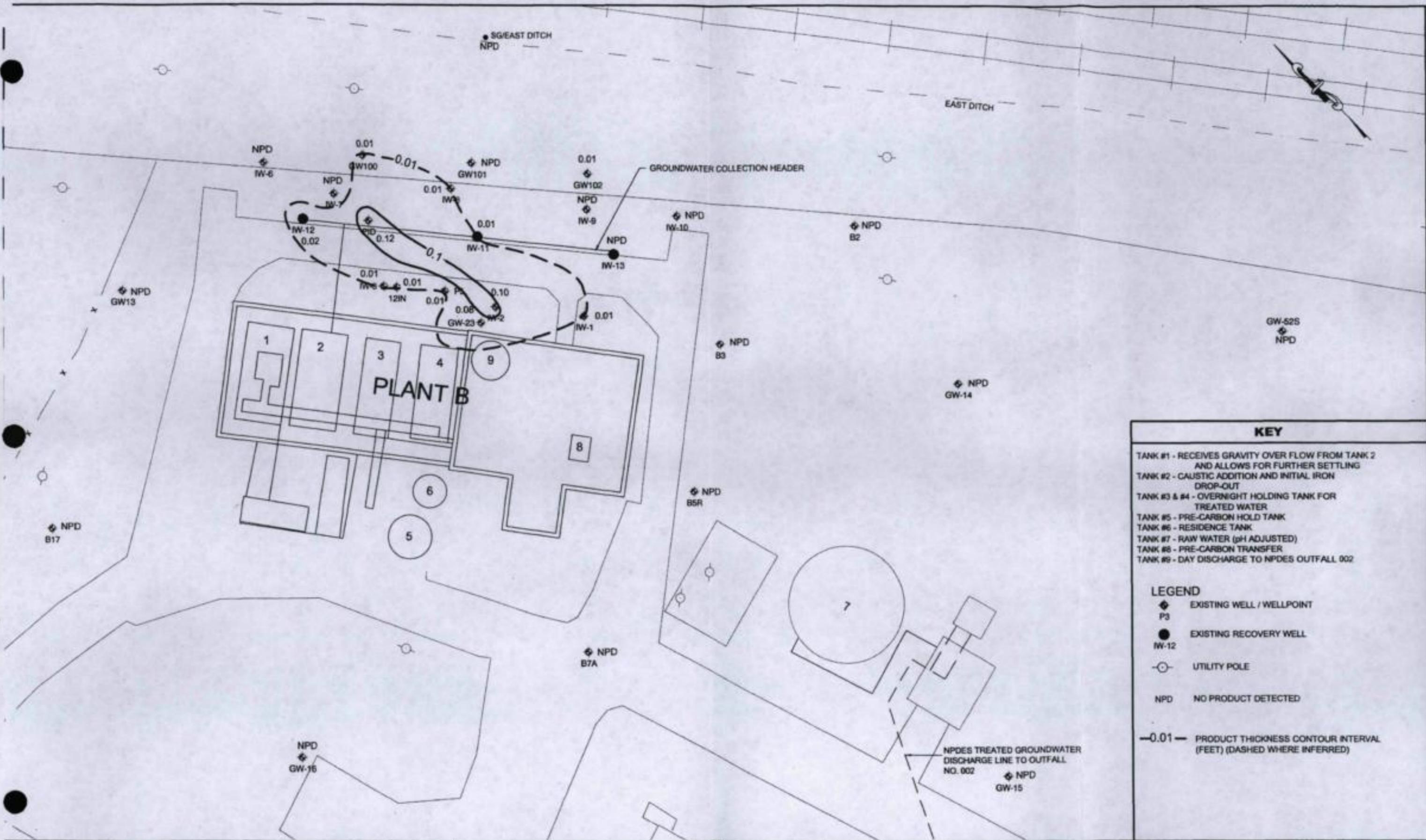


**lin**  
51 Eames Street  
Wilmington, Massachusetts

PREPARED BY:	REL 12/01
DRAWN BY:	SPS 12/01
CHECKED BY:	BS 12/01
DATE:	12/01

**LAW**  
ENGINEERING & ENVIRONMENTAL SERVICES, INC.

PLANT B  
PRODUCT THICKNESS MAP  
JULY 31, 2001



KEY	
TANK #1	- RECEIVES GRAVITY OVER FLOW FROM TANK 2 AND ALLOWS FOR FURTHER SETTLING
TANK #2	- CAUSTIC ADDITION AND INITIAL IRON DROP-OUT
TANK #3 & #4	- OVERNIGHT HOLDING TANK FOR TREATED WATER
TANK #5	- PRE-CARBON HOLD TANK
TANK #6	- RESIDENCE TANK
TANK #7	- RAW WATER (pH ADJUSTED)
TANK #8	- PRE-CARBON TRANSFER
TANK #9	- DAY DISCHARGE TO NPDES OUTFALL 002

LEGEND	
	EXISTING WELL / WELLPOINT
	EXISTING RECOVERY WELL
	UTILITY POLE
	NO PRODUCT DETECTED
	PRODUCT THICKNESS CONTOUR INTERVAL (FEET) (DASHED WHERE INFERRED)

SOURCE: CADD DRAWING FILES TITLED: 7074-030, 7040-61, 7040-62 AND OLIN-NEW BY SMITH TECHNOLOGIES CORP.

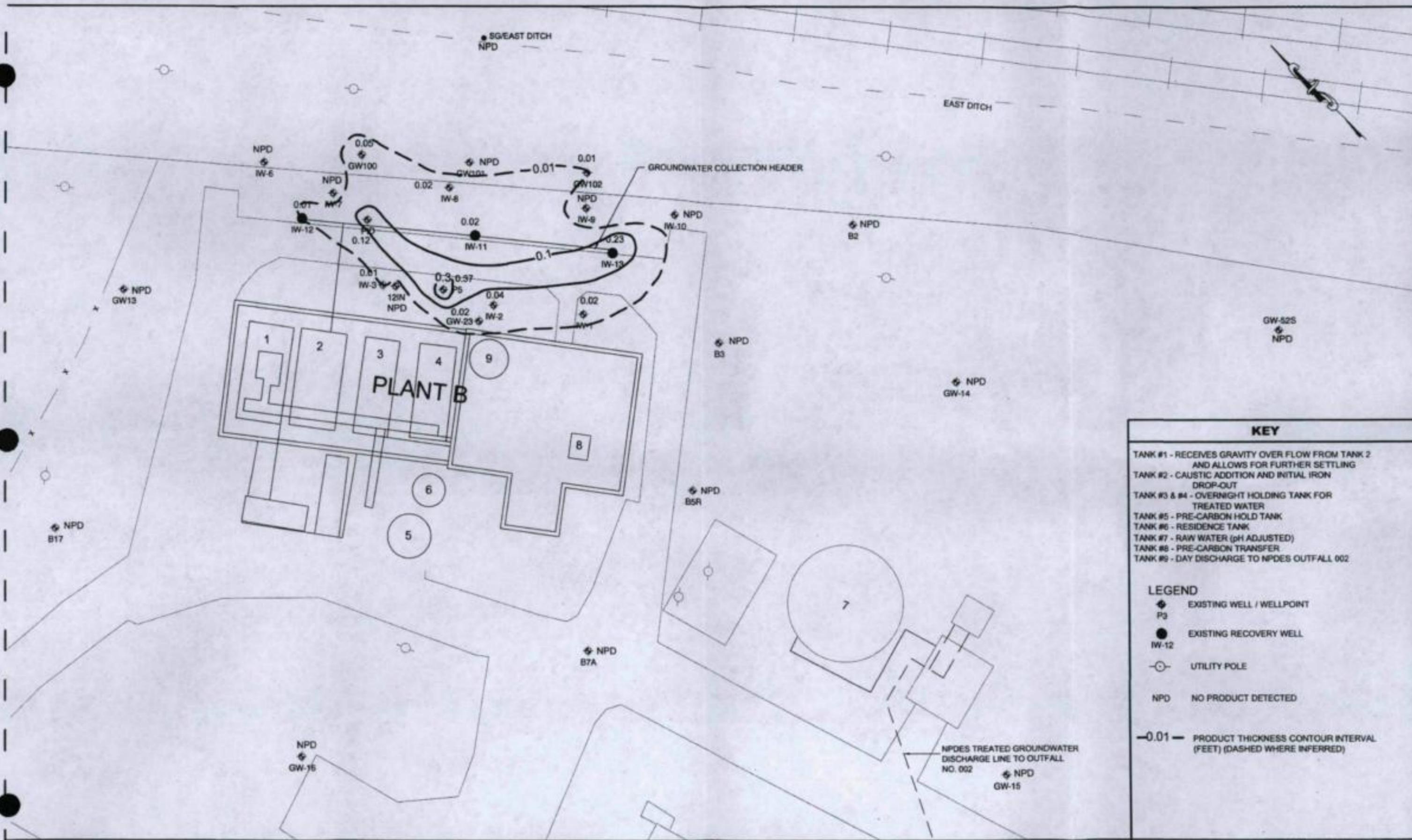


**olin**  
51 Eames Street

PREPARED BY:	WAL STANLEY
DRAWN BY:	OPS STANLEY
ENGINEERED BY:	BO STANLEY
DATE:	08/17/01

**LAW**  
ENGINEERING & ENVIRONMENTAL SERVICES, INC.

PLANT B  
PRODUCT THICKNESS MAP  
AUGUST 17, 2001



KEY	
TANK #1 - RECEIVES GRAVITY OVER FLOW FROM TANK 2 AND ALLOWS FOR FURTHER SETTLING	
TANK #2 - CAUSTIC ADDITION AND INITIAL IRON DROP-OUT	
TANK #3 & #4 - OVERNIGHT HOLDING TANK FOR TREATED WATER	
TANK #5 - PRE-CARBON HOLD TANK	
TANK #6 - RESIDENCE TANK	
TANK #7 - RAW WATER (pH ADJUSTED)	
TANK #8 - PRE-CARBON TRANSFER	
TANK #9 - DAY DISCHARGE TO NPDES OUTFALL 002	
LEGEND	
	EXISTING WELL / WELLPOINT
	EXISTING RECOVERY WELL
	UTILITY POLE
	NPD NO PRODUCT DETECTED
	0.01 PRODUCT THICKNESS CONTOUR INTERVAL (FEET) (DASHED WHERE INFERRED)

SOURCE: CADD DRAWING FILES TITLED: 7074-030, 7040-61, 7040-62 AND OLIN-NEW BY SMITH TECHNOLOGIES CORP.

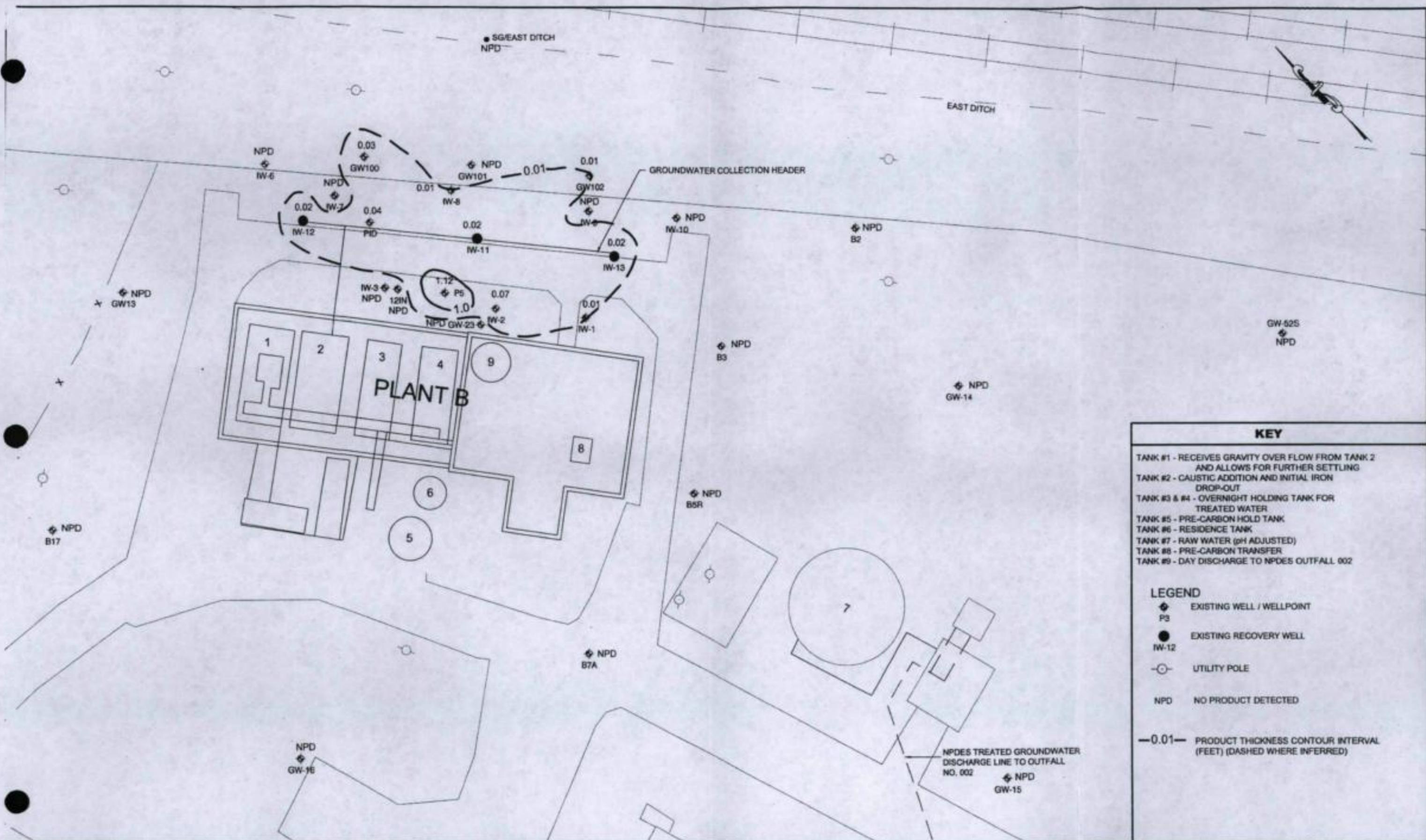


**olin**  
51 Earnes Street  
Wilmington, Massachusetts

PREPARED BY: [Name]  
DRAWN BY: [Name]  
CHECKED BY: [Name]  
DATE: [Date]

**LAW**  
ENGINEERING & ENVIRONMENTAL SERVICES, INC.

PLANT B  
PRODUCT THICKNESS MAP  
SEPTEMBER 26, 2001



KEY	
TANK #1	- RECEIVES GRAVITY OVER FLOW FROM TANK 2 AND ALLOWS FOR FURTHER SETTLING
TANK #2	- CAUSTIC ADDITION AND INITIAL IRON DROP-OUT
TANK #3 & #4	- OVERNIGHT HOLDING TANK FOR TREATED WATER
TANK #5	- PRE-CARBON HOLD TANK
TANK #6	- RESIDENCE TANK
TANK #7	- RAW WATER (pH ADJUSTED)
TANK #8	- PRE-CARBON TRANSFER
TANK #9	- DAY DISCHARGE TO NPDES OUTFALL 002
LEGEND	
◆	EXISTING WELL / WELLPOINT
P3	
●	EXISTING RECOVERY WELL
IW-12	
○	UTILITY POLE
NPD	NO PRODUCT DETECTED
-0.01-	PRODUCT THICKNESS CONTOUR INTERVAL (FEET) (DASHED WHERE INFERRED)

SOURCE: CADD DRAWING FILES TITLED: 7074-030, 7040-61, 7040-62 AND OLIN-NEW BY SMITH TECHNOLOGIES CORP.

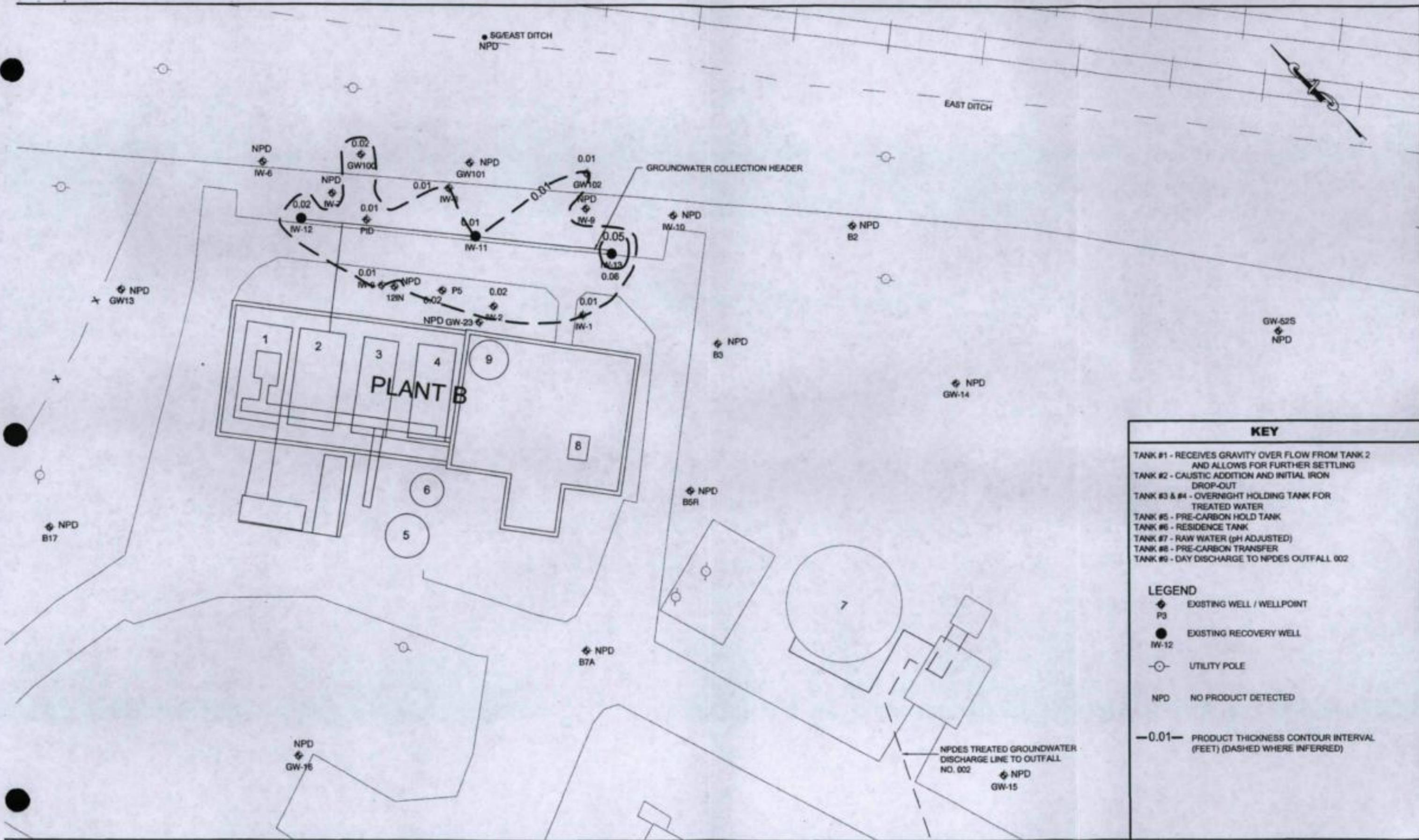


**lin**  
51 Eames Street

PREPARED BY: RAG 10/01  
DRAWN BY: DTS 10/01  
CHECKED BY: AG 10/01  
DATE: 10/01

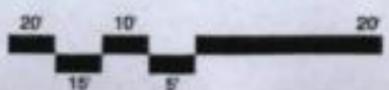
**LAW**  
ENGINEERING & ENVIRONMENTAL SERVICES, INC.

PLANT B  
PRODUCT THICKNESS MAP  
OCTOBER 30, 2001



KEY	
TANK #1	- RECEIVES GRAVITY OVER FLOW FROM TANK 2 AND ALLOWS FOR FURTHER SETTLING
TANK #2	- CAUSTIC ADDITION AND INITIAL IRON DROP-OUT
TANK #3 & #4	- OVERNIGHT HOLDING TANK FOR TREATED WATER
TANK #5	- PRE-CARBON HOLD TANK
TANK #6	- RESIDENCE TANK
TANK #7	- RAW WATER (pH ADJUSTED)
TANK #8	- PRE-CARBON TRANSFER
TANK #9	- DAY DISCHARGE TO NPDES OUTFALL 002
LEGEND	
◆	EXISTING WELL / WELLPOINT
P3	
●	EXISTING RECOVERY WELL
IW-12	
○	UTILITY POLE
NPD	NO PRODUCT DETECTED
-0.01-	PRODUCT THICKNESS CONTOUR INTERVAL (FEET) (DASHED WHERE INFERRED)

SOURCE: CADD DRAWING FILES TITLED: 7074-030, 7040-61, 7040-62 AND OLIN-NEW BY SMITH TECHNOLOGIES CORP.

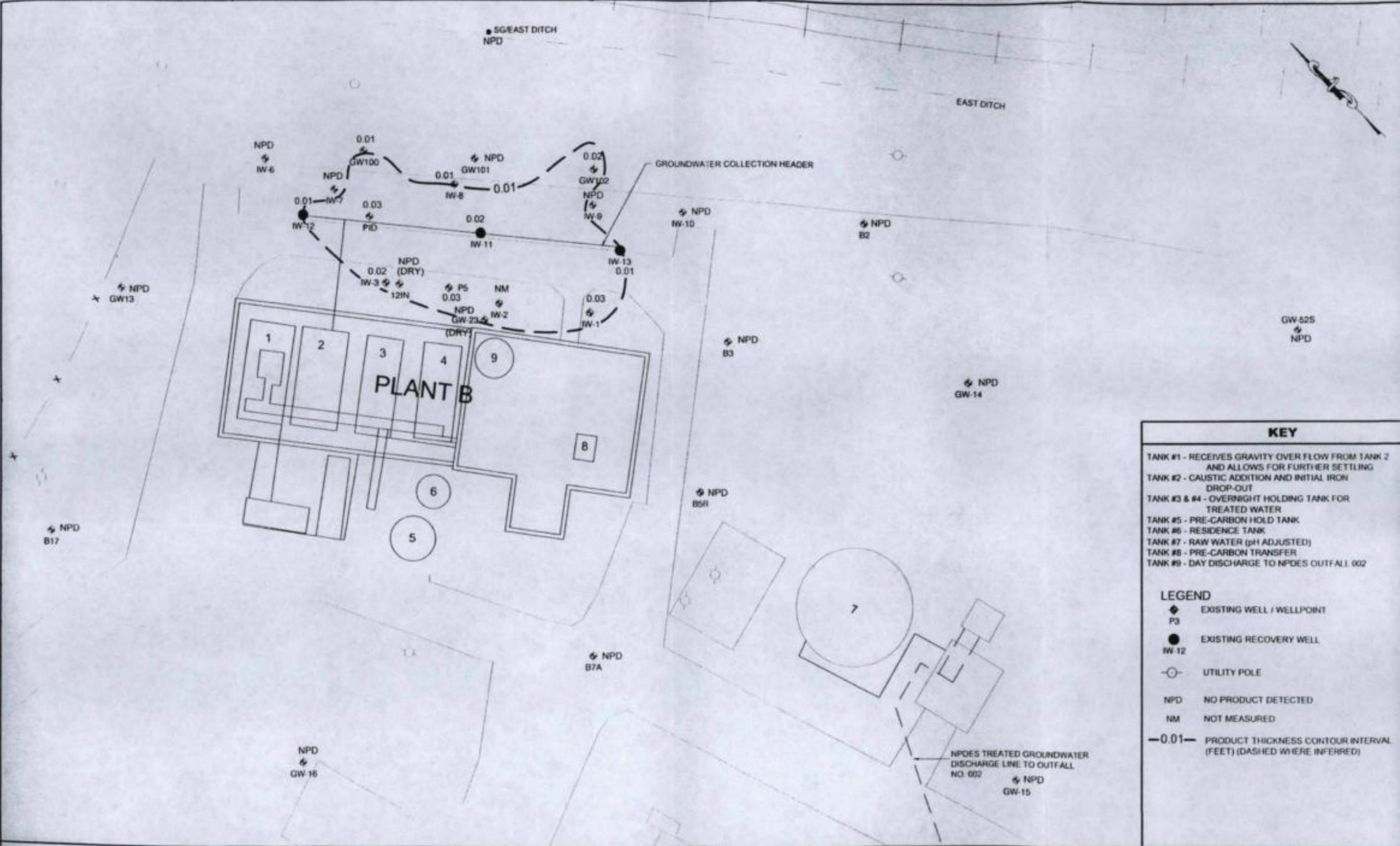


**lin**  
51 Eames Street

PREPARED BY: [unclear]  
DRAWN BY: [unclear]  
CHECKED BY: [unclear]  
DATE: [unclear]

**LAW**  
ENGINEERING & ENVIRONMENTAL SERVICES, INC.

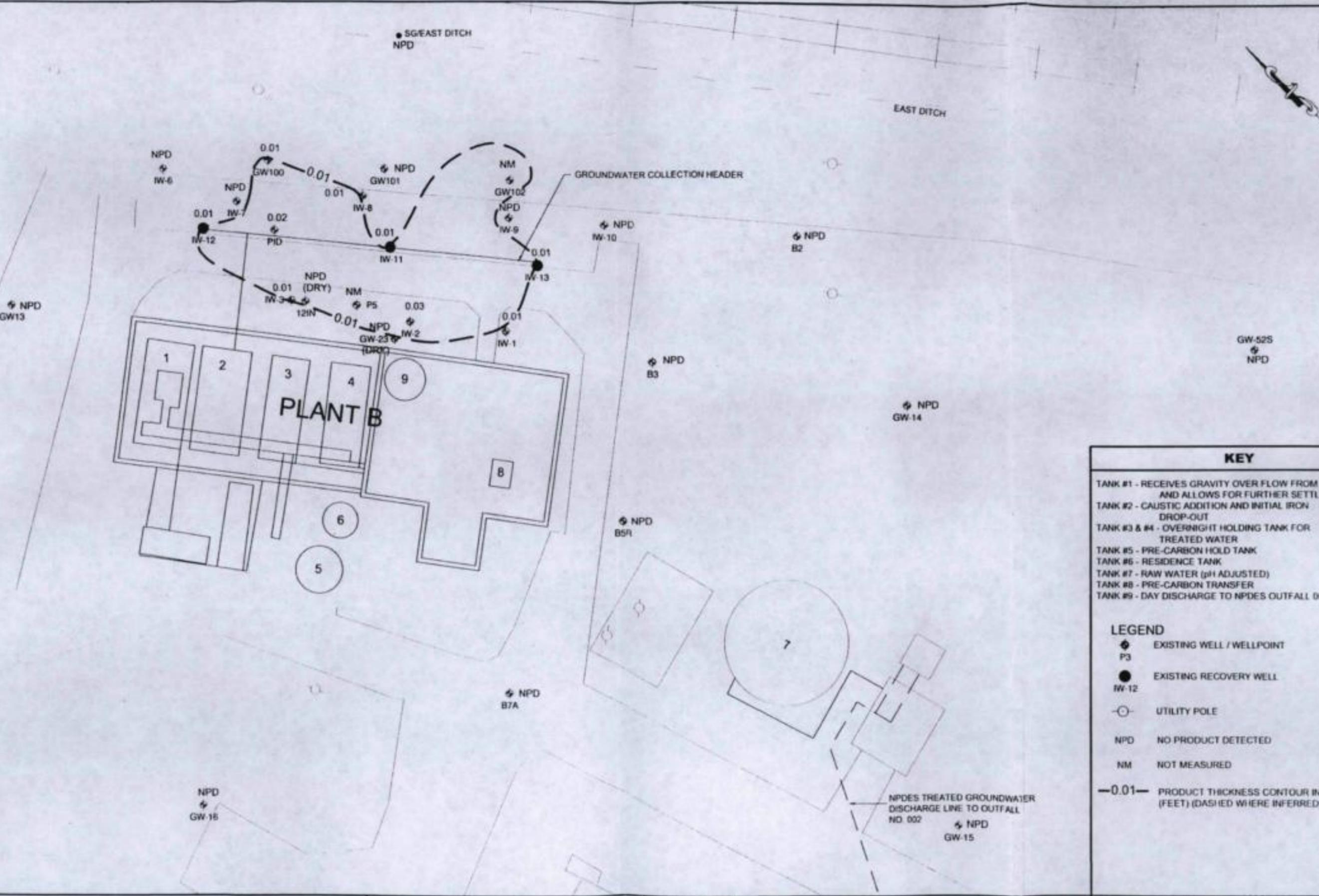
PLANT B  
PRODUCT THICKNESS MAP  
NOVEMBER 27, 2001



KEY	
TANK #1	RECEIVES GRAVITY OVER FLOW FROM TANK 2 AND ALLOWS FOR FURTHER SETTLING
TANK #2	CAUSTIC ADDITION AND INITIAL IRON DROP-OUT
TANK #3 & #4	OVERNIGHT HOLDING TANK FOR TREATED WATER
TANK #5	PRE-CARBON HOLD TANK
TANK #6	RESIDENCE TANK
TANK #7	RAW WATER (pH ADJUSTED)
TANK #8	PRE-CARBON TRANSFER
TANK #9	DAY DISCHARGE TO NPDES OUTFALL 002

LEGEND	
	EXISTING WELL / WELLPOINT
P3	
	EXISTING RECOVERY WELL
IW 12	
	UTILITY POLE
NPD	NO PRODUCT DETECTED
NM	NOT MEASURED
-0.01-	PRODUCT THICKNESS CONTOUR INTERVAL (FEET) (DASHED WHERE INFERRED)



KEY	
TANK #1	- RECEIVES GRAVITY OVER FLOW FROM TANK 2 AND ALLOWS FOR FURTHER SETTLING
TANK #2	- CAUSTIC ADDITION AND INITIAL IRON DROP-OUT
TANK #3 & #4	- OVERNIGHT HOLDING TANK FOR TREATED WATER
TANK #5	- PRE-CARBON HOLD TANK
TANK #6	- RESIDENCE TANK
TANK #7	- RAW WATER (pH ADJUSTED)
TANK #8	- PRE-CARBON TRANSFER
TANK #9	- DAY DISCHARGE TO NPDES OUTFALL 002

LEGEND	
	EXISTING WELL / WELLPOINT
P3	
	EXISTING RECOVERY WELL
IW-12	
	UTILITY POLE
NPD	NO PRODUCT DETECTED
NM	NOT MEASURED
-0.01-	PRODUCT THICKNESS CONTOUR INTERVAL (FEET) (DASHED WHERE INFERRED)

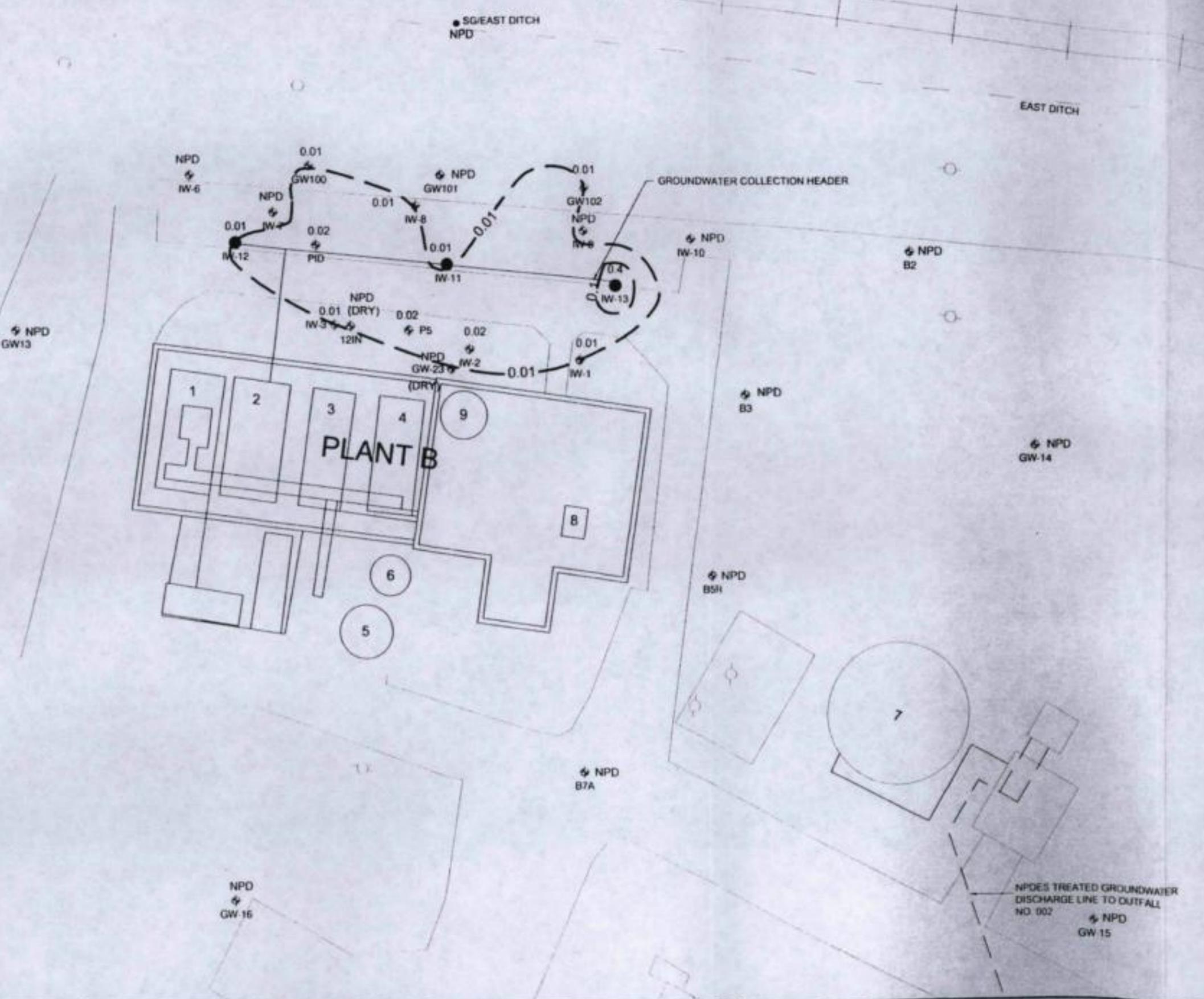
SOURCE: CADD DRAWING FILES TITLED 7074-030, 7040-61, 7040-62 AND OLIN-NEW BY SMITH TECHNICAL SERVICES CORP



DESIGNED BY: CK 05/09/02  
 DRAWN BY: RA 06/04/02  
 CHECKED BY: SC



PLANT B  
 PRODUCT THICKNESS MAP  
 JANUARY 25, 2002



**KEY**

- TANK #1 - RECEIVES GRAVITY OVER FLOW FROM TANK 2 AND ALLOWS FOR FURTHER SETTLING
- TANK #2 - CAUSTIC ADDITION AND INITIAL IRON DROP-OUT
- TANK #3 & #4 - OVERNIGHT HOLDING TANK FOR TREATED WATER
- TANK #5 - PRE-CARBON HOLD TANK
- TANK #6 - RESIDENCE TANK
- TANK #7 - RAW WATER (pH ADJUSTED)
- TANK #8 - PRE-CARBON TRANSFER
- TANK #9 - DAY DISCHARGE TO NPDES OUTFALL 002

**LEGEND**

- EXISTING WELL / WELLPOINT
- P3
- EXISTING RECOVERY WELL
- IW-12
- UTILITY POLE
- NO PRODUCT DETECTED
- 0.01 - PRODUCT THICKNESS CONTOUR INTERVAL (FEET) (DASHED WHERE INFERRED)

SOURCE: CADD DRAWING FILES TITLED: 7074-030, 7040-61, 7040-62 AND OLIN-NEW BY SMITH TECHNOLOGIES CORP



PREPARED: CK 05/09/02  
 DRAWN: RA 06/04/02  
 CHECKED: SG



**LAW**  
 ENGINEERING & ENVIRONMENTAL CONSULTANTS INC.

PLANT B  
 PRODUCT THICKNESS MAP  
 FEBRUARY 25, 2002

SE/EAST DITCH  
NM

EAST DITCH

NPD  
IW 6

0.01  
GW100

NPD  
GW101

NPD  
GW102

GROUNDWATER COLLECTION HEADER

NPD  
IW-7

NM  
PID

0.01

NPD  
IW-8

NM

NPD  
IW-9

NM

NPD  
IW-10

NPD  
B2

NM  
IW-12

NM  
IW-11

NM  
IW-13

NM  
GW13

0.01

NPD  
IW-3

12IN

0.01

P5

0.02

0.1

0.02

0.01

0.02

PLANT B

NPD  
B3

GW 52S  
NM

NM  
GW-14

NM  
B5R

NPD  
B17

NPD  
B7A

NPD  
GW-16

NPDES TREATED GROUNDWATER  
DISCHARGE LINE TO OUTFALL  
NO. 002

NM  
GW-15

**KEY**

- TANK #1 - RECEIVES GRAVITY OVER FLOW FROM TANK 2 AND ALLOWS FOR FURTHER SETTLING
- TANK #2 - CAUSTIC ADDITION AND INITIAL IRON DROP-OUT
- TANK #3 & #4 - OVERNIGHT HOLDING TANK FOR TREATED WATER
- TANK #5 - PRE-CARBON HOLD TANK
- TANK #6 - RESIDENCE TANK
- TANK #7 - RAW WATER (pH ADJUSTED)
- TANK #8 - PRE-CARBON TRANSFER
- TANK #9 - DAY DISCHARGE TO NPDES OUTFALL 002

**LEGEND**

- ◉ EXISTING WELL / WELLPOINT
- P3
- EXISTING RECOVERY WELL
- UTILITY POLE
- NPD NO PRODUCT DETECTED
- NM NOT MEASURED
- 0.01- PRODUCT THICKNESS CONTOUR INTERVAL (FEET) (DASHED WHERE INFERRED)

SOURCE: CADD DRAWING FILES TITLED 7074-030, 7040-61, 7040-62 AND OLIN-NEW BY SMITH TECHNOLOGIES CORP.



**lin**  
51 Eames Street

REVISION: CK 05/09/02  
DESIGNER: RA 06/04/02  
DRAWN BY: SG  
DATE: 05/21/02

**LAW**  
ENGINEERING & ENVIRONMENTAL SERVICES, INC.

PLANT B  
PRODUCT THICKNESS MAP  
APRIL 05, 2002

SG/EAST DITCH  
NPD

EAST DITCH

NPD  
IW-6

0.01  
GW100

NPD  
GW101

0.01  
GW102

GROUNDWATER COLLECTION HEADER

0.01  
IW-12

NPD  
IW-7

0.01  
PID

0.01  
IW-8

0.01  
IW-11

0.01  
IW-9

0.01  
NM

0.01  
IW-13

NPD  
IW-10

NPD  
B2

NPD  
GW13

0.01  
IW-3

0.01  
12IN

0.01  
P5

0.01  
GW-23

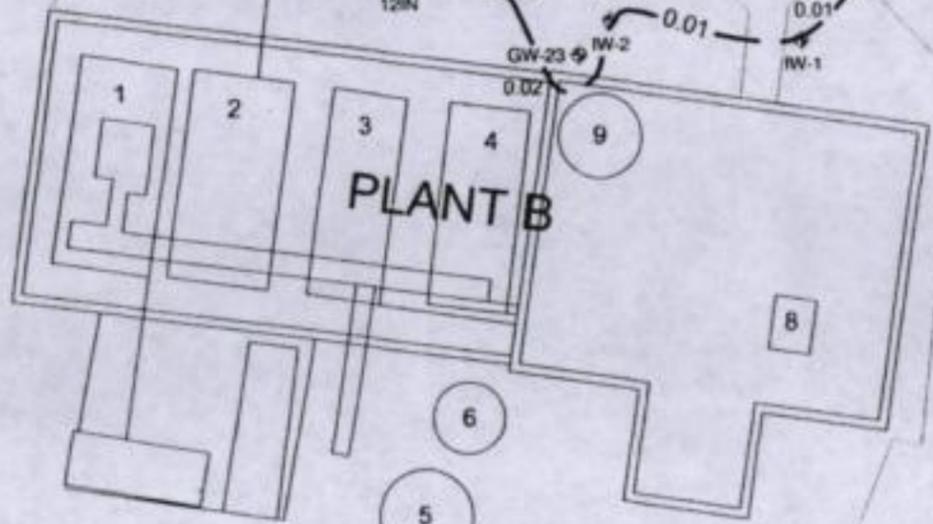
0.01  
IW-2

0.01  
IW-1

NPD  
B3

NPD  
GW-14

GW-525  
NPD



PLANT B

NPD  
B17

NPD  
B5R

NPD  
B7A

NPD  
GW-16

NPDES TREATED GROUNDWATER  
DISCHARGE LINE TO OUTFALL  
NO. 002

NPD  
GW-15

**KEY**

- TANK #1 - RECEIVES GRAVITY OVER FLOW FROM TANK 2 AND ALLOWS FOR FURTHER SETTLING
- TANK #2 - CAUSTIC ADDITION AND INITIAL IRON DROP-OUT
- TANK #3 & #4 - OVERNIGHT HOLDING TANK FOR TREATED WATER
- TANK #5 - PRE-CARBON HOLD TANK
- TANK #6 - RESIDENCE TANK
- TANK #7 - RAW WATER (pH ADJUSTED)
- TANK #8 - PRE-CARBON TRANSFER
- TANK #9 - DAY DISCHARGE TO NPDES OUTFALL 002

**LEGEND**

- ◊ EXISTING WELL / WELLPOINT
- P3
- EXISTING RECOVERY WELL
- IW-12
- UTILITY POLE
- NPD NO PRODUCT DETECTED
- NM NOT MEASURED
- 0.01- PRODUCT THICKNESS CONTOUR INTERVAL (FEET) (DASHED WHERE INFERRED)

SOURCE: CADD DRAWING FILES TITLED 7074-030, 7040-61, 7040-62 AND CLIN-NEW BY SMITH TECHNOLOGIES CORP



**lim**  
51 Eames Street

REVISION: CA 05/09/02  
DRAWN: RA 06/04/02  
CHECKED: SG  
DATE: 06/21/02

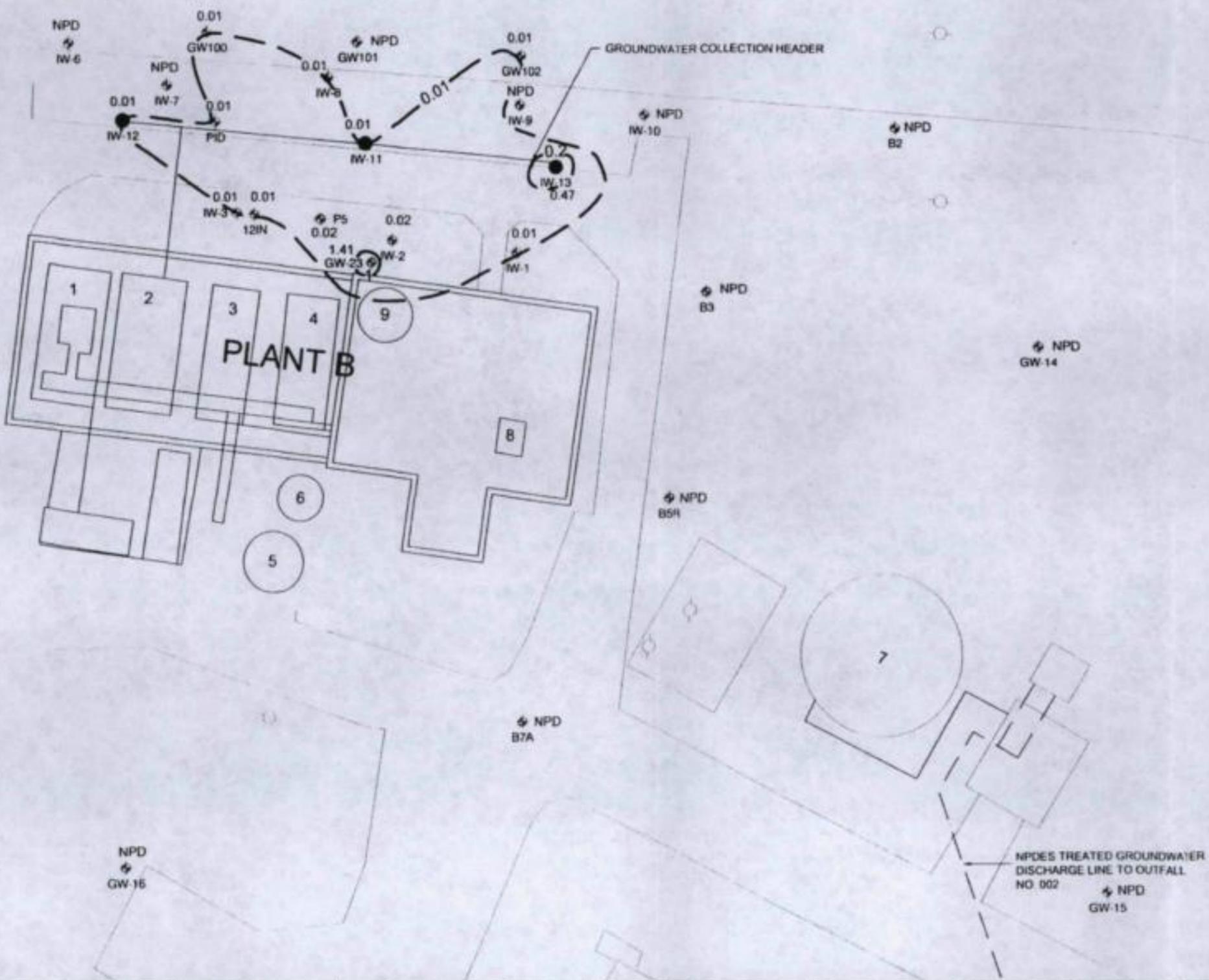


**LAW**  
ENGINEERING & ENVIRONMENTAL SERVICES, INC.

PLANT B  
PRODUCT THICKNESS MAP  
APRIL 30, 2002

SG/EAST DITCH  
NPD

EAST DITCH



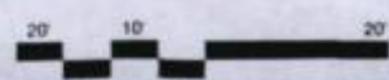
**KEY**

- TANK #1 - RECEIVES GRAVITY OVER FLOW FROM TANK 2 AND ALLOWS FOR FURTHER SETTLING
- TANK #2 - CAUSTIC ADDITION AND INITIAL IRON DROP-OUT
- TANK #3 & #4 - OVERNIGHT HOLDING TANK FOR TREATED WATER
- TANK #5 - PRE-CARBON HOLD TANK
- TANK #6 - RESIDENCE TANK
- TANK #7 - RAW WATER (pH ADJUSTED)
- TANK #8 - PRE-CARBON TRANSFER
- TANK #9 - DAY DISCHARGE TO NPDES OUTFALL 002

**LEGEND**

- ◆ EXISTING WELL / WELLPOINT
- P3
- EXISTING RECOVERY WELL
- W-12
- UTILITY POLE
- NPD NO PRODUCT DETECTED
- NM NOT MEASURED
- 0.01- PRODUCT THICKNESS CONTOUR INTERVAL (FEET) (DASHED WHERE INFERRED)

SOURCE: CADD DRAWING FILES TITLED 7074-030, 7040-61, 7040-62 AND OL IN NEW BY SMITH TECHNOLOGIES CORP

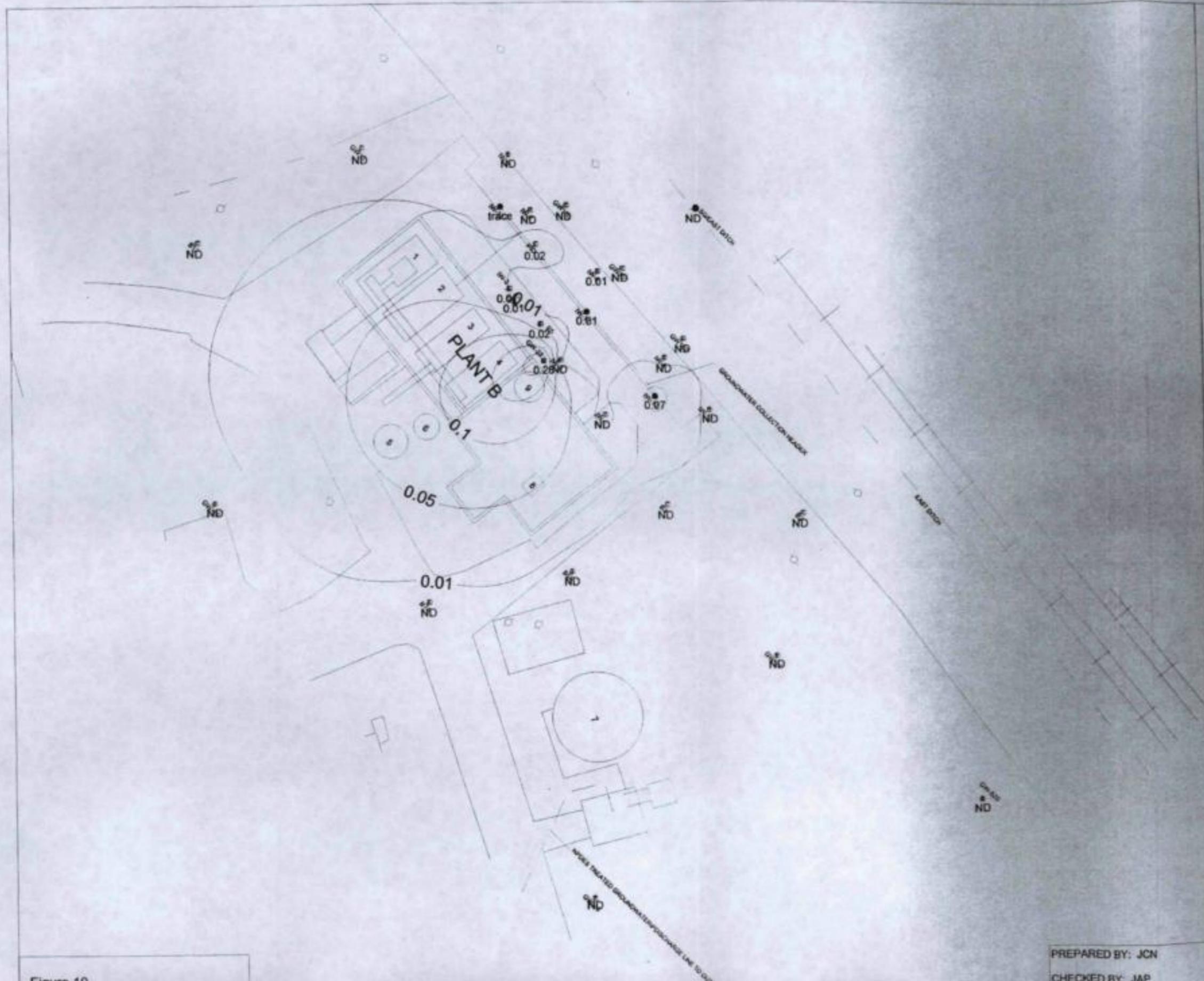


PROJECT: CK 050902  
 DRAWING: RA 050402  
 DESIGN: SG  
 DATE: 05/13/02



**LAW**  
 ENGINEERING & ENVIRONMENTAL SERVICES, INC.

PLANT B  
 PRODUCT THICKNESS MAP  
 MAY 31, 2002



- LEGEND**
- ⊕ EXISTING WELL / WELLPOINT
  - ⊙ EXISTING RECOVERY WELL
  - M-12 UTILITY POLE
  - GROUNDWATER ELEVATION CONTOUR (FTMSL) (DASHED WHERE INFERRED)
  - NA WELL DRY
  - ND NOT MEASURED

SOURCE: CADD DRAWING FILES, TITLED 7074-030, 7040-011, 7040-02 AND OLIN-NEW BY SMITH TECHNOLOGIES CORP.

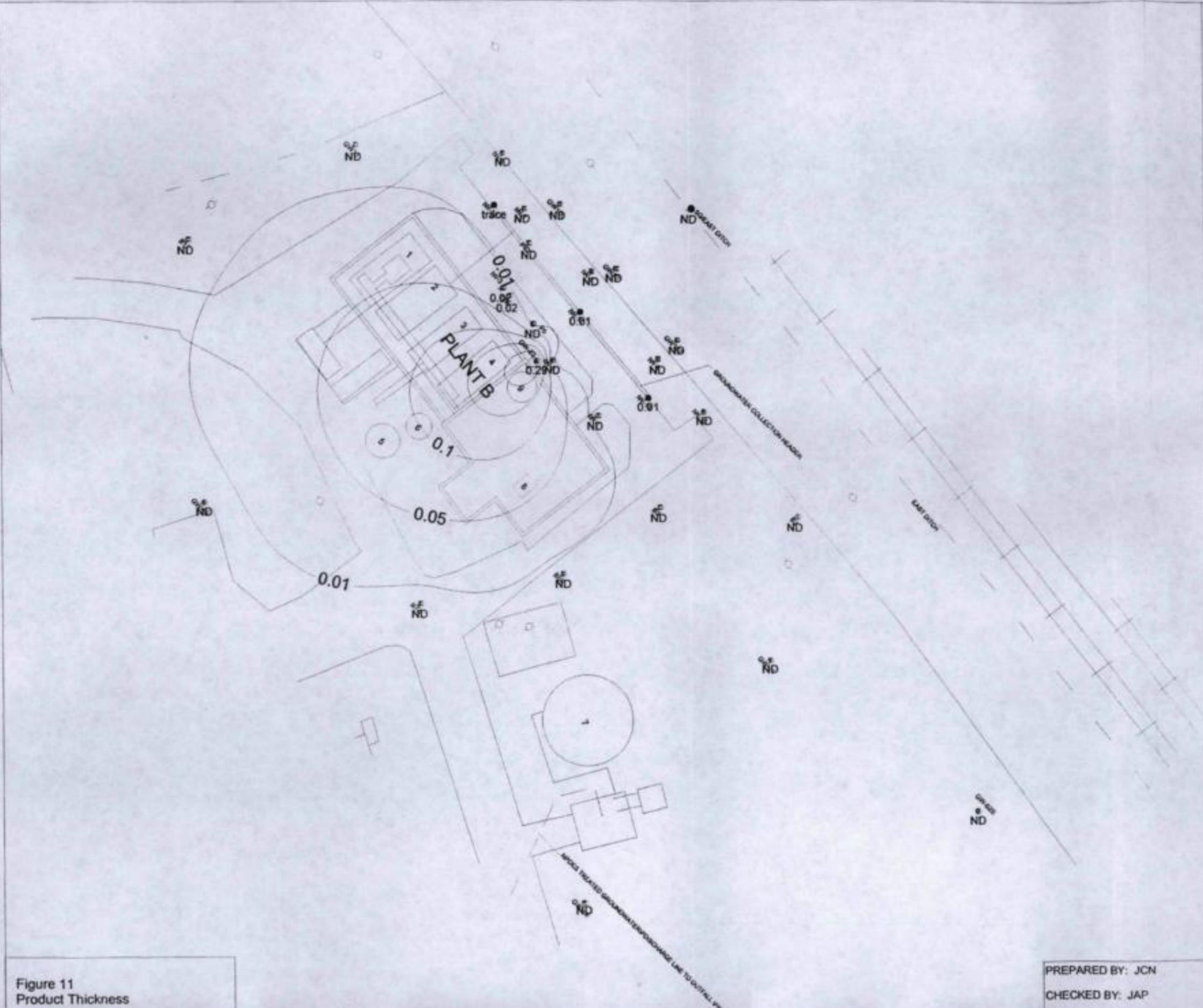
**Olin**  
51 Eames Street  
Wilmington, Massachusetts

**MACTEC**  
107 Audubon Road, Waltham, MA 01980 (781) 245-8608

PREPARED BY: JCN  
CHECKED BY: JAP

Figure 10

- LEGEND**
-  EXISTING WELL / WELLPOINT
  -  EXISTING RECOVERY WELL
  -  UTILITY POLE
  -  GROUNDWATER ELEVATION CONTOUR (FTMSL) (DASHED WHERE INFERRED)
  -  WELL DRY
  -  NOT MEASURED



SOURCE: CADD DRAWING FILES TITLED: 7074-030, 7040-61, 7040-62 AND OLIN-NEW BY SMITH TECHNOLOGIES CORP.

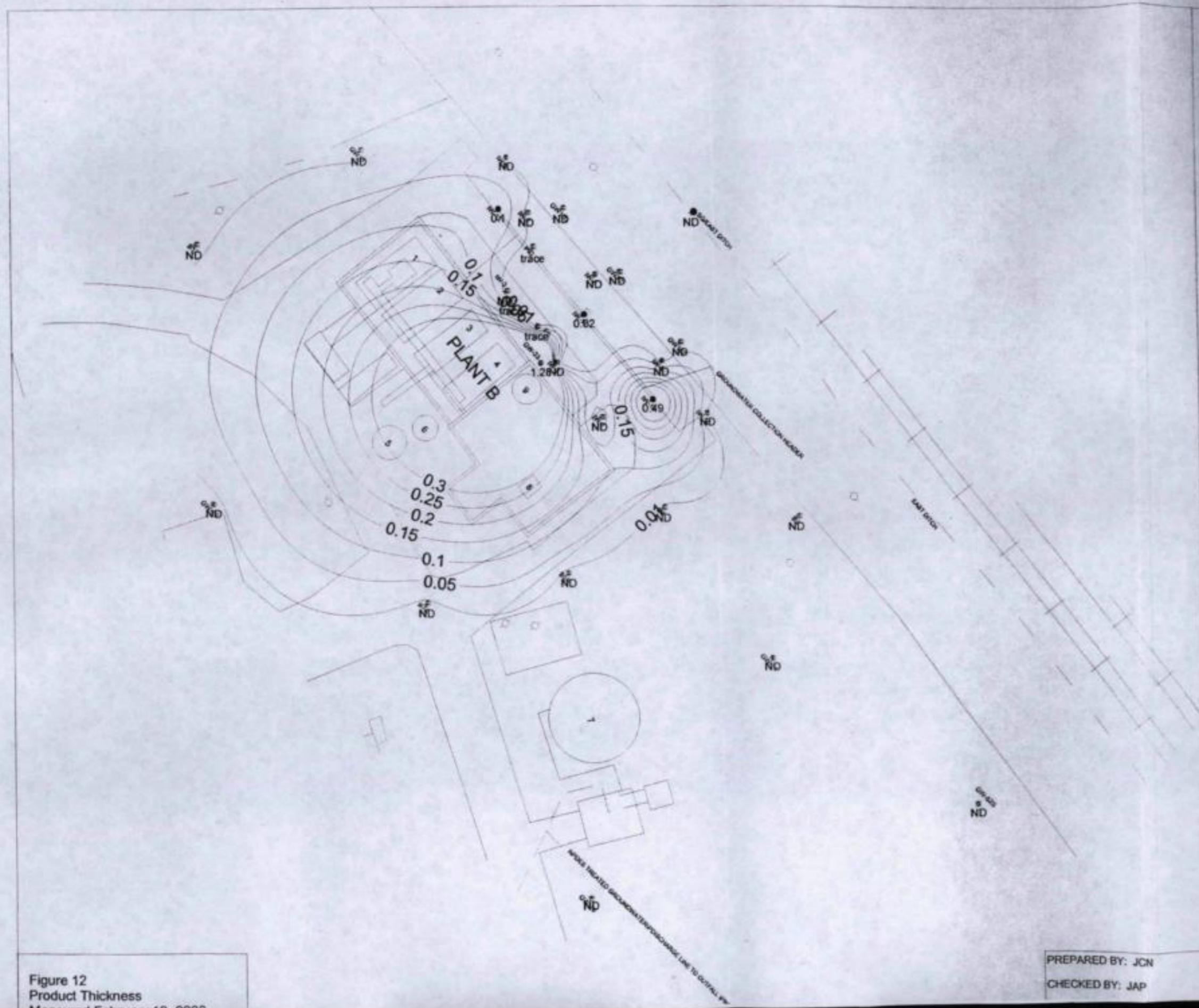
**olin**  
 51 Eames Street  
 Wilmington, Massachusetts

**MACTEC**  
 107 Auden Road - Waukegan, MA 01886 - (781) 245-6906

Figure 11  
 Product Thickness

PREPARED BY: JCN  
 CHECKED BY: JAP

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- LEGEND**
- ◻ EXISTING WELL / WELLPOINT
  - EXISTING RECOVERY WELL
  - UTILITY POLE
  - - - GROUNDWATER ELEVATION CONTOUR (FTMSL) (DASHED WHERE INFERRED)
  - NA WELL DRY
  - ND NOT MEASURED

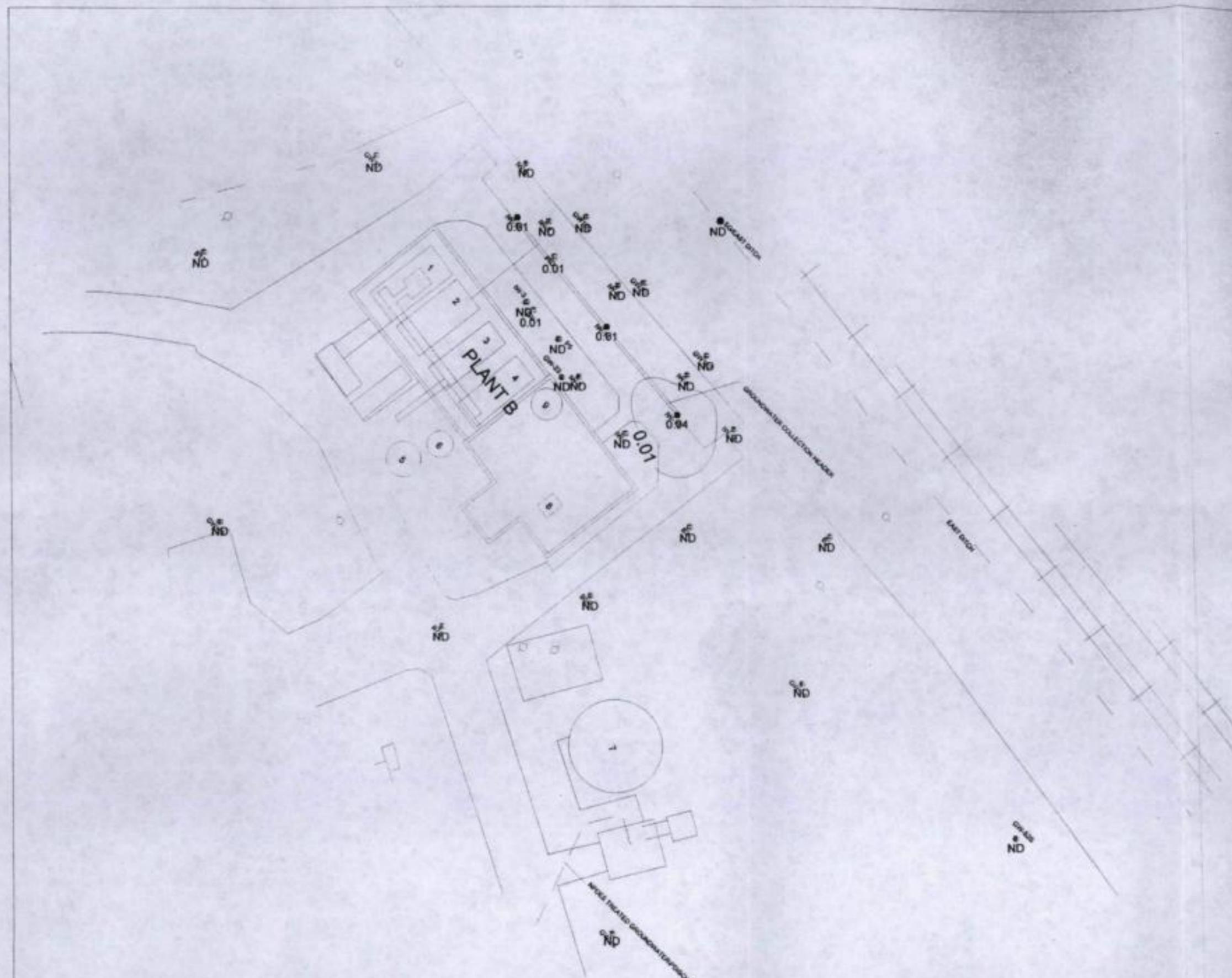
SOURCE: CADD DRAWING FILES TITLED: 7074-030, 7040-61, 7040-62 AND OLIN-NEW BY SMITH TECHNOLOGIES CORP.

**olin**  
 51 Eames Street  
 Wilmington, Massachusetts

**MACTEC**  
 107 Audubon Road - Wakefield, MA 01880 - (781) 245-8938

PREPARED BY: JCN  
 CHECKED BY: JAP

Figure 12  
 Product Thickness  
 Measured February 19, 2002



- LEGEND**
- EXISTING WELL / WELLPOINT
  - P2 EXISTING RECOVERY WELL
  - UTILITY POLE
  - GROUNDWATER ELEVATION CONTOUR (FTMSL) (DASHED WHERE INFERRED)
  - NA WELL DRY
  - NM NOT MEASURED

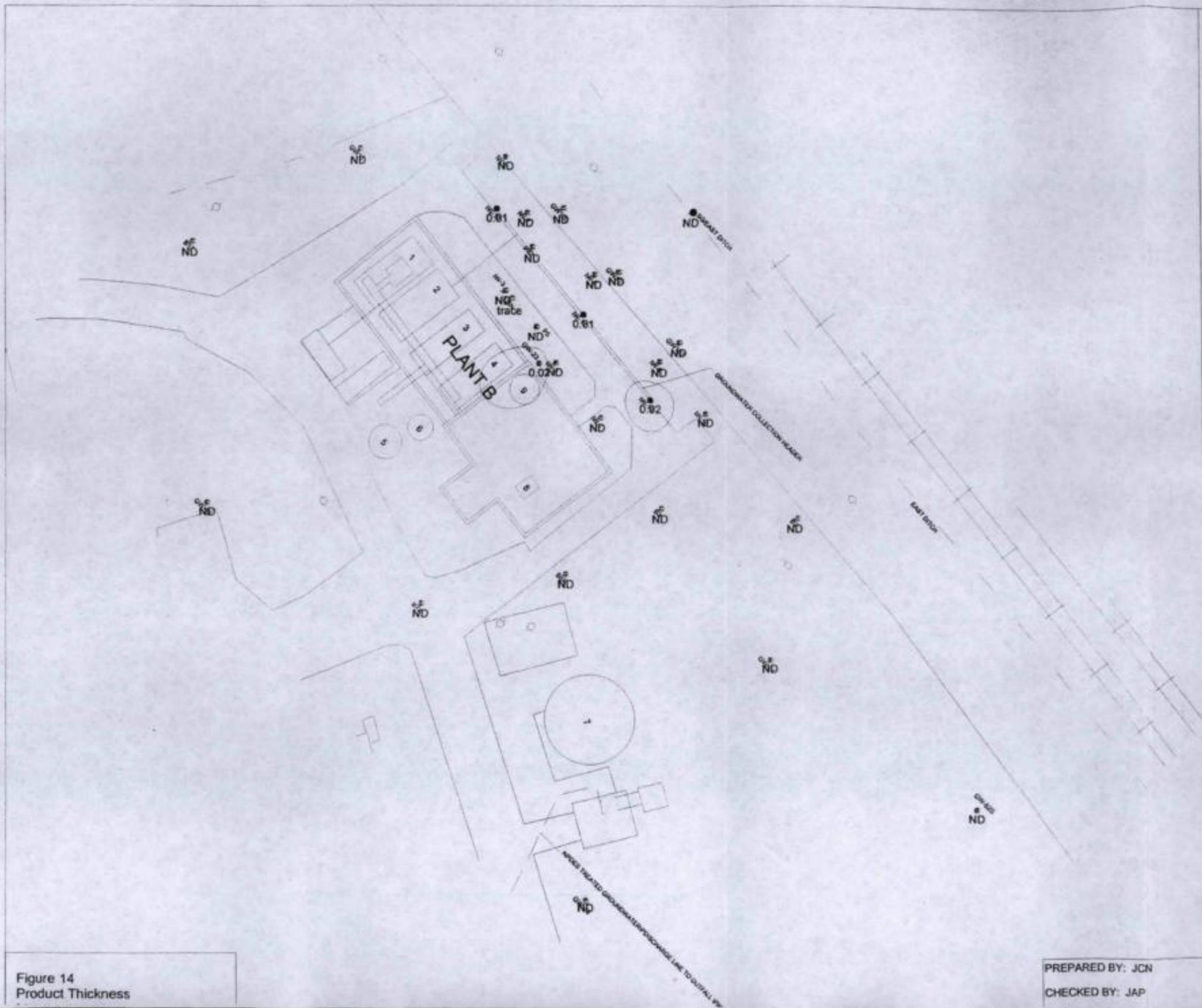
SOURCE: CADD DRAWING FILES TITLED:  
7574-030, 7540-61, 7540-62 AND CLIN-NEW  
BY SMITH TECHNOLOGIES CORP.

**olim**  
51 Eames Street  
Wilmington, Massachusetts

**MACTEC**  
127 Audubon Road - Woburn, MA 01890 - (781) 340-0908

PREPARED BY: JCN  
CHECKED BY: JAP

Figure 13  
Product Thickness



- LEGEND**
- ◻ EXISTING WELL / WELLPOINT
  - EXISTING RECOVERY WELL
  - EXISTING RECOVERY WELL
  - UTILITY POLE
  - GROUNDWATER ELEVATION CONTOUR (FTMSL) (DASHED WHERE INFERRED)
  - NA WELL DRY
  - NM NOT MEASURED

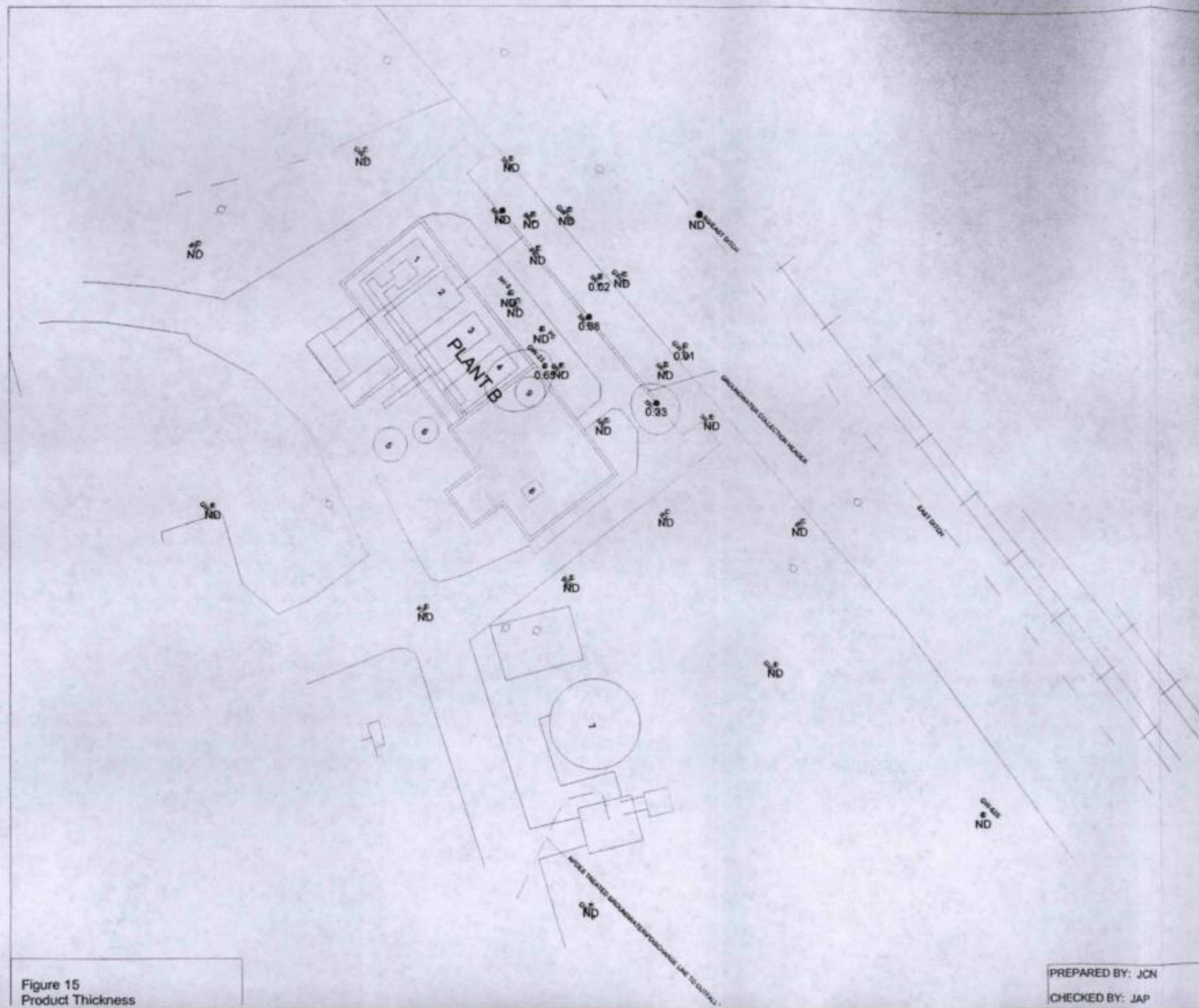
SOURCE: CADD DRAWING FILES TITLED 7074-030, 7040-61, 7040-62 AND OLIN-NEW BY SMITH TECHNOLOGIES CORP.

**lim**  
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 Wilmington, Massachusetts

**MACTEC**  
 107 Auburn Road, Woburn, MA 01890 (781) 245-8500

PREPARED BY: JCN  
 CHECKED BY: JAP

Figure 14  
 Product Thickness



**LEGEND**

	EXISTING WELL / WELLPOINT
	EXISTING RECOVERY WELL
	UTILITY POLE
	GROUNDWATER ELEVATION CONTOUR (FTMSL) (DASHED WHERE INFERRED)
	WELL DRY
	NOT MEASURED

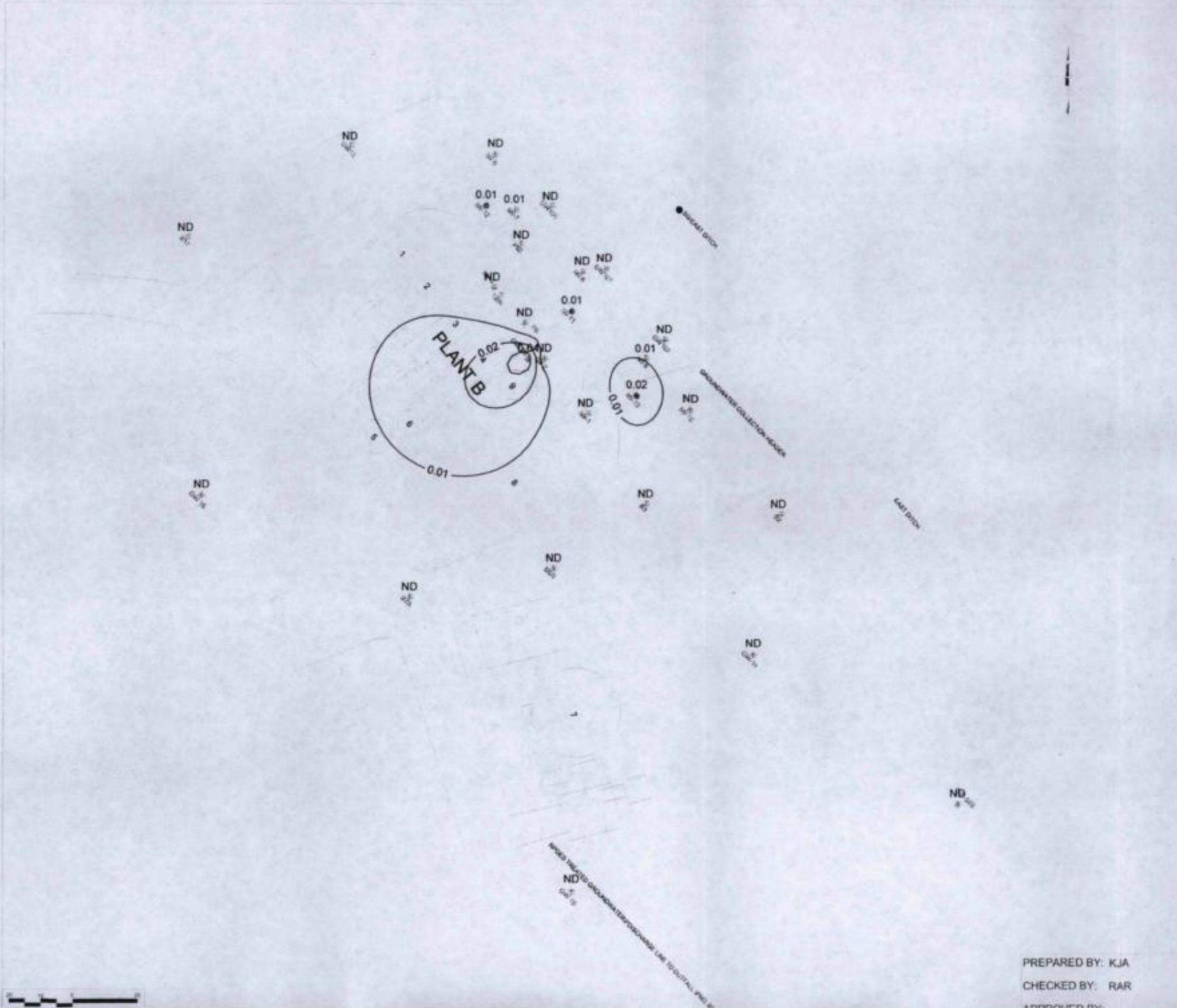
SOURCE: CADD DRAWING FILES TITLED:  
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BY SMITH TECHNOLOGIES CORP.

**lim**  
51 Eames Street  
Wilmington, Massachusetts

**MACTEC**  
277 South Street, Wilmington, MA 01897, (978) 744-8000

Figure 15  
Product Thickness

PREPARED BY: JCN  
CHECKED BY: JAP



- LEGEND**
- ⊕ EXISTING WELL / WELLPOINT
  - ⊙ EXISTING RECOVERY WELL
  - ⊙ MW-12
  - UTILITY POLE
  - GROUNDWATER ELEVATION CONTOUR (FTMSL) (DASHED WHERE INFERRED)
  - NA WELL DRY
  - NM NOT MEASURED

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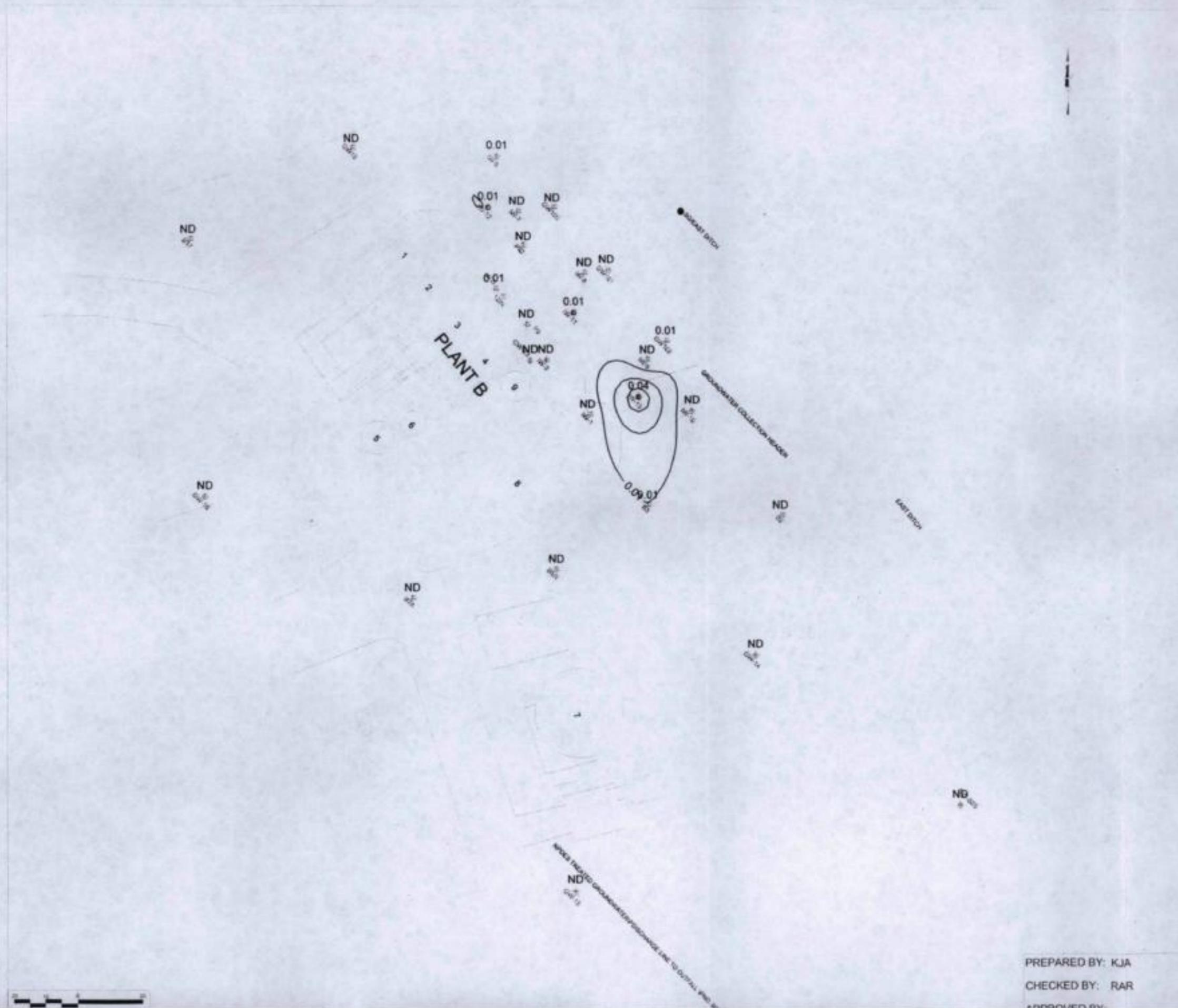


SOURCE: CADD DRAWING FILES TITLED: 7074-035, 7040-61, 7045-62 AND OLN-NEW BY SMITH TECHNOLOGIES CORP.

**Smith Technologies Corp.**  
51 Eames Street  
Wilmington, Massachusetts

PREPARED BY: KJA  
CHECKED BY: RAR

Figure 10  
Product Thickness  
Measured June 30, 2003

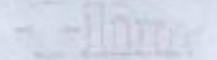


- LEGEND**
- EXISTING WELL / WELLPOINT
  - EXISTING RECOVERY WELL
  - ⊗ UTILITY POLE
  - GROUNDWATER ELEVATION CONTOUR (FTMSL) (DASHED WHERE INFERRED)
  - NA WELL DRY
  - NM NOT MEASURED

DATE: 07/03/03  
 DRAWN BY: KJA  
 CHECKED BY: RAR  
 APPROVED BY: [Signature]  
 PROJECT: 7074-035, 7040-61, 7040-62 AND OLIN-NEW  
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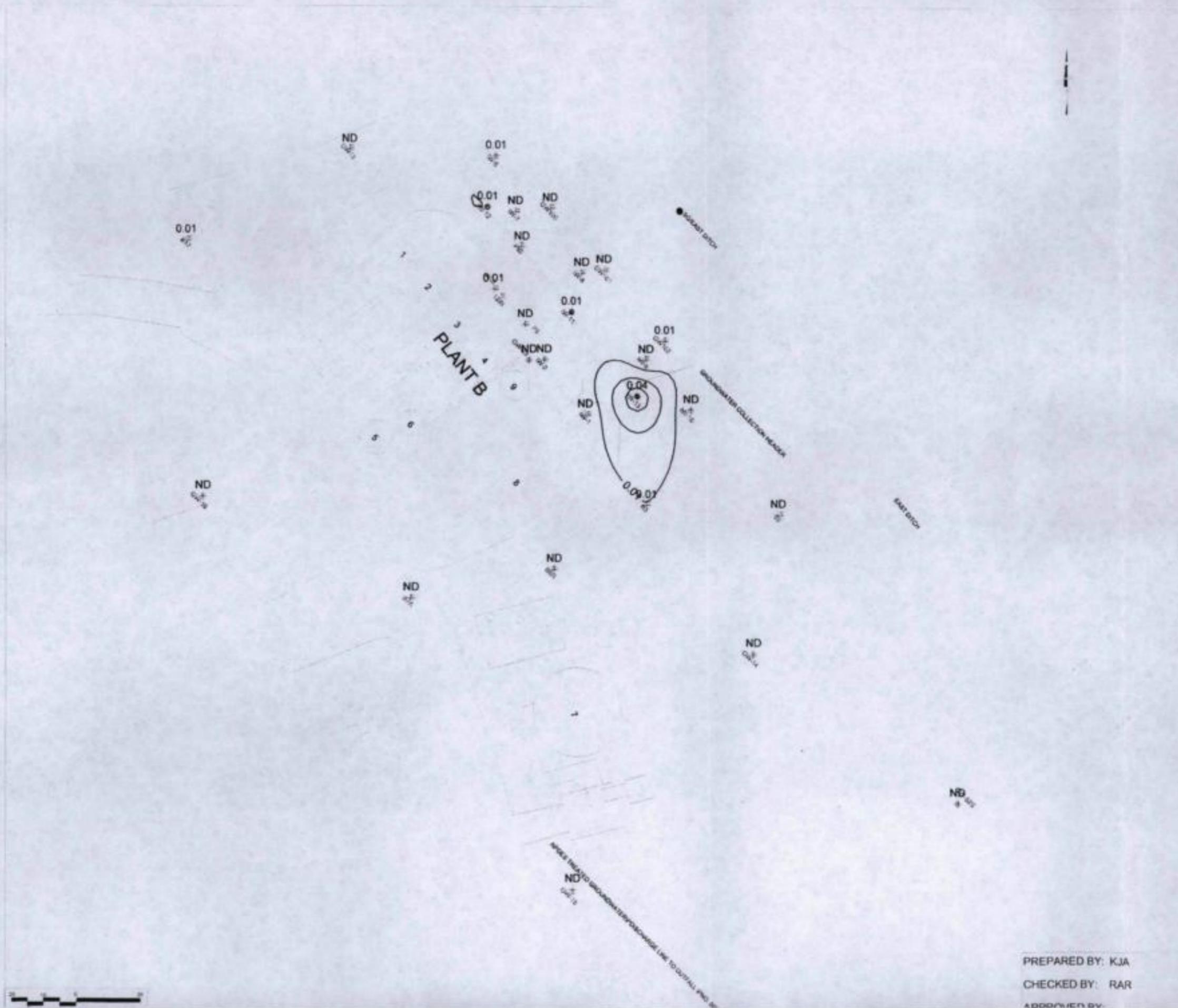
SOURCE: CADD DRAWING FILES TITLED:  
 7074-035, 7040-61, 7040-62 AND OLIN-NEW  
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 Wilmington, Massachusetts

PREPARED BY: KJA  
 CHECKED BY: RAR  
 APPROVED BY: [Signature]

Figure 11  
 Product Thickness  
 Measured July 3, 2003



- LEGEND**
- EXISTING WELL / WELLPOINT
  - P3 EXISTING RECOVERY WELL
  - EXISTING RECOVERY WELL
  - UTILITY POLE
  - GROUNDWATER ELEVATION CONTOUR (FTMSL) (DASHED WHERE INFERRED)
  - NA WELL DRY
  - NM NOT MEASURED

TABLE 1: PRODUCT THICKNESS MEASUREMENTS  
 TABLE 2: GROUNDWATER ELEVATION MEASUREMENTS  
 TABLE 3: GROUNDWATER ELEVATION MEASUREMENTS  
 TABLE 4: GROUNDWATER ELEVATION MEASUREMENTS  
 TABLE 5: GROUNDWATER ELEVATION MEASUREMENTS  
 TABLE 6: GROUNDWATER ELEVATION MEASUREMENTS  
 TABLE 7: GROUNDWATER ELEVATION MEASUREMENTS  
 TABLE 8: GROUNDWATER ELEVATION MEASUREMENTS  
 TABLE 9: GROUNDWATER ELEVATION MEASUREMENTS  
 TABLE 10: GROUNDWATER ELEVATION MEASUREMENTS

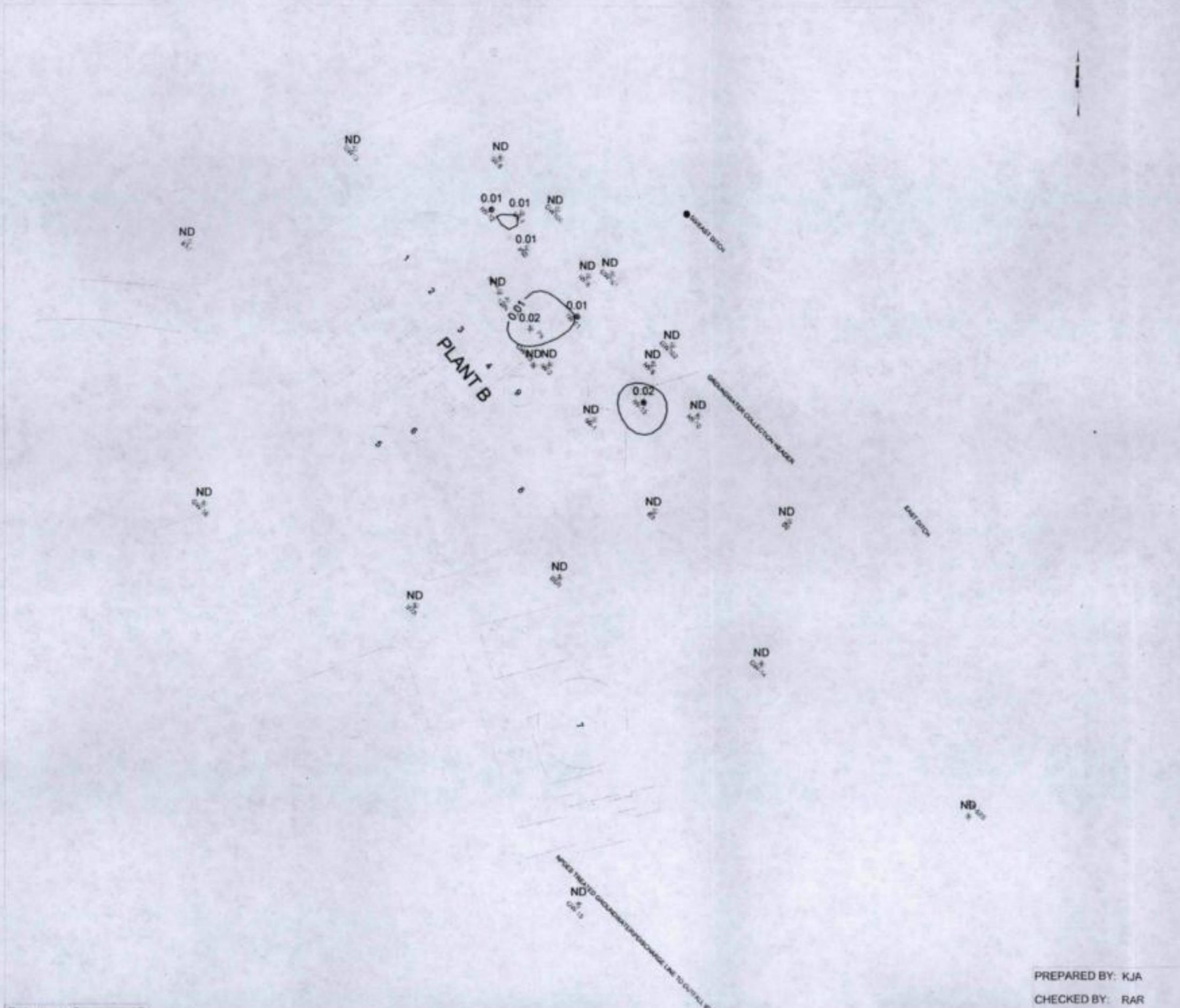


SOURCE: CADD DRAWING FILES TITLED:  
 7074-030, 7040-61, 7040-62 AND CLIN-NEW  
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 Wilmington, Massachusetts

PREPARED BY: KJA  
 CHECKED BY: RAR  
 APPROVED BY:

Figure 12  
 Product Thickness  
 Measured August 6, 2003



- LEGEND**
- EXISTING WELL / WELLPOINT
  - PS
  - EXISTING RECOVERY WELL
  - W-12
  - UTILITY POLE
  - GROUNDWATER ELEVATION CONTOUR (FTMSL) (DASHED WHERE INFERRED)
  - NA WELL DRY
  - NM NOT MEASURED

MAP BY: MACTEC CORP. 2003-09-18  
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 MAP BY: MACTEC CORP. 2003-09-18  
 MAP BY: MACTEC CORP. 2003-09-18



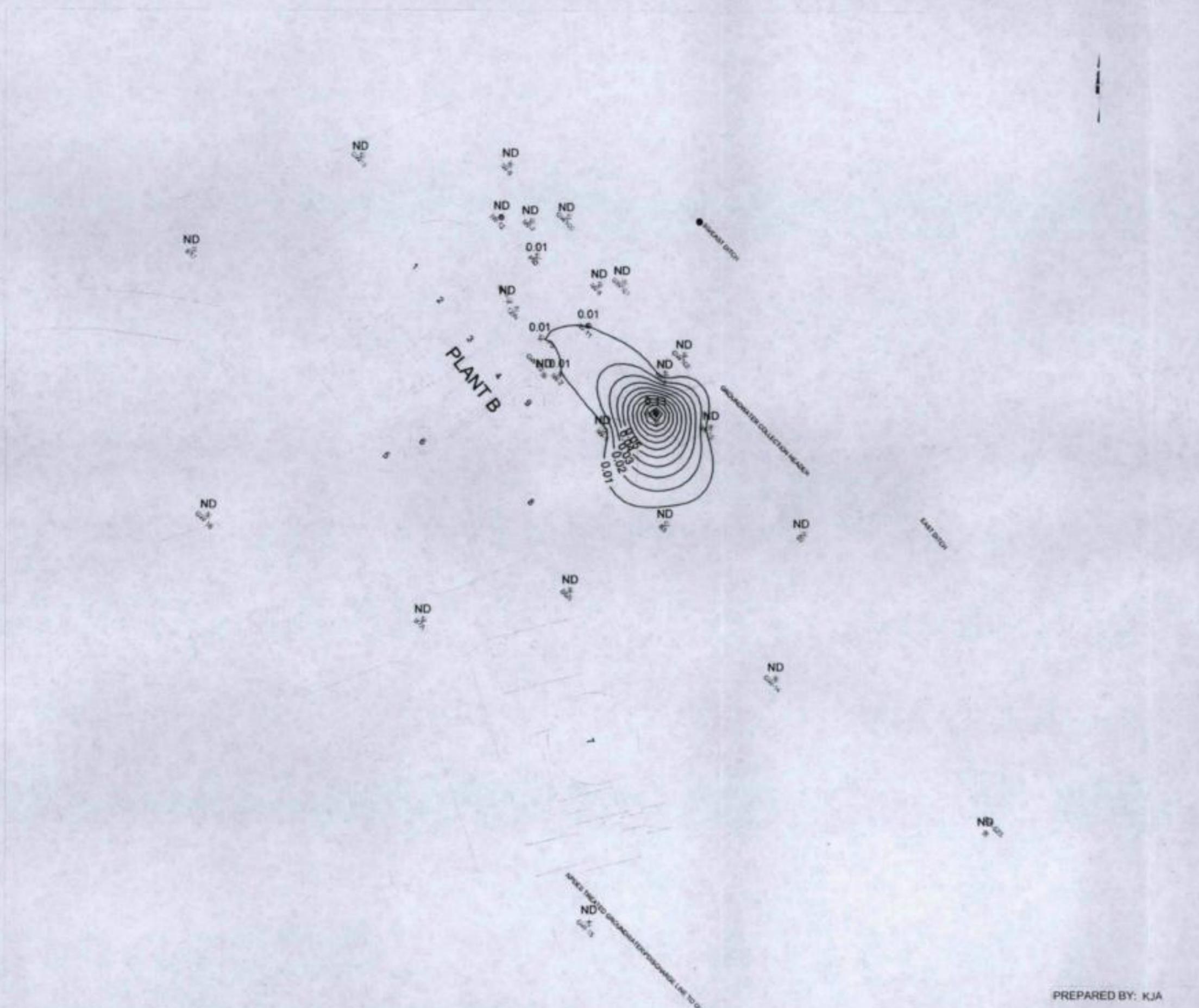
SOURCE: CADD DRAWING FILES TITLED:  
 7074-030, 7040-61, 7040-62 AND OLIN-NEW  
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 Wilmington, Massachusetts

**Figure 13**  
**Product Thickness**  
**Measured September 18, 2003**

PREPARED BY: KJA  
 CHECKED BY: RAR





- LEGEND**
- ⊕ EXISTING WELL / WELLPOINT
  - EXISTING RECOVERY WELL
  - ⊕ W-12
  - ⊕ UTILITY POLE
  - GROUNDWATER ELEVATION CONTOUR (FTMSL) (DASHED WHERE INFERRED)
  - NA WELL DRY
  - NM NOT MEASURED

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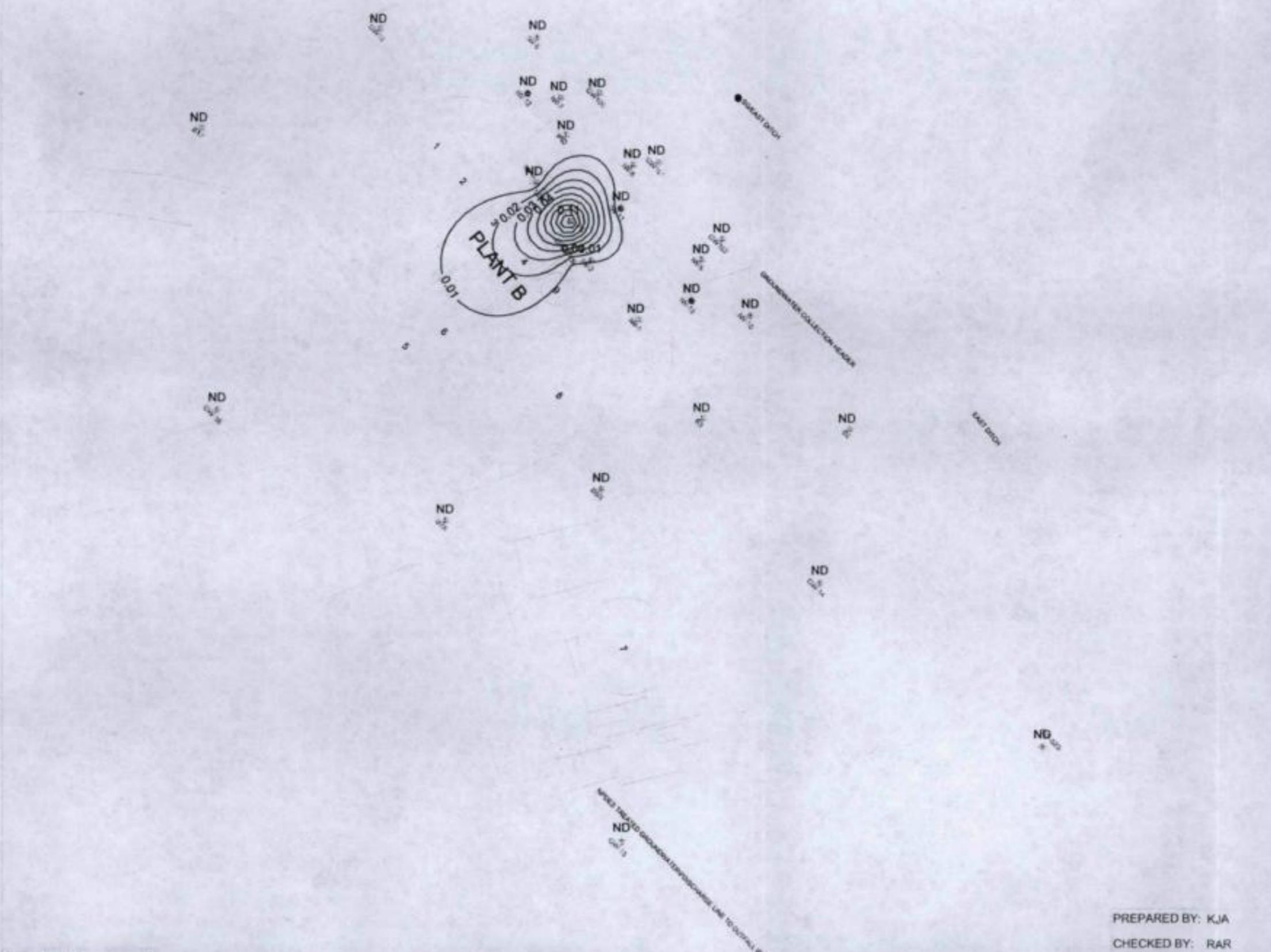
SOURCE: CADD DRAWING FILES TITLED:  
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 Wilmington, Massachusetts

PREPARED BY: KJA  
 CHECKED BY: RAR  
 APPROVED BY:

Figure 14  
 Product Thickness  
 Measured October 9, 2003

- LEGEND**
- ▲ EXISTING WELL / WELLPOINT
  - EXISTING RECOVERY WELL
  - UTILITY POLE
  - GROUNDWATER ELEVATION CONTOUR (FTMSL) (DASHED WHERE INFERRED)
  - NA WELL DRY
  - NM NOT MEASURED



DATE: 11/02/03  
 DRAWN BY: KJA  
 CHECKED BY: RAR  
 PROJECT: 7074-030, 7040-61, 7040-62 AND OLN-NEW  
 BY SMITH TECHNOLOGIES CORP.



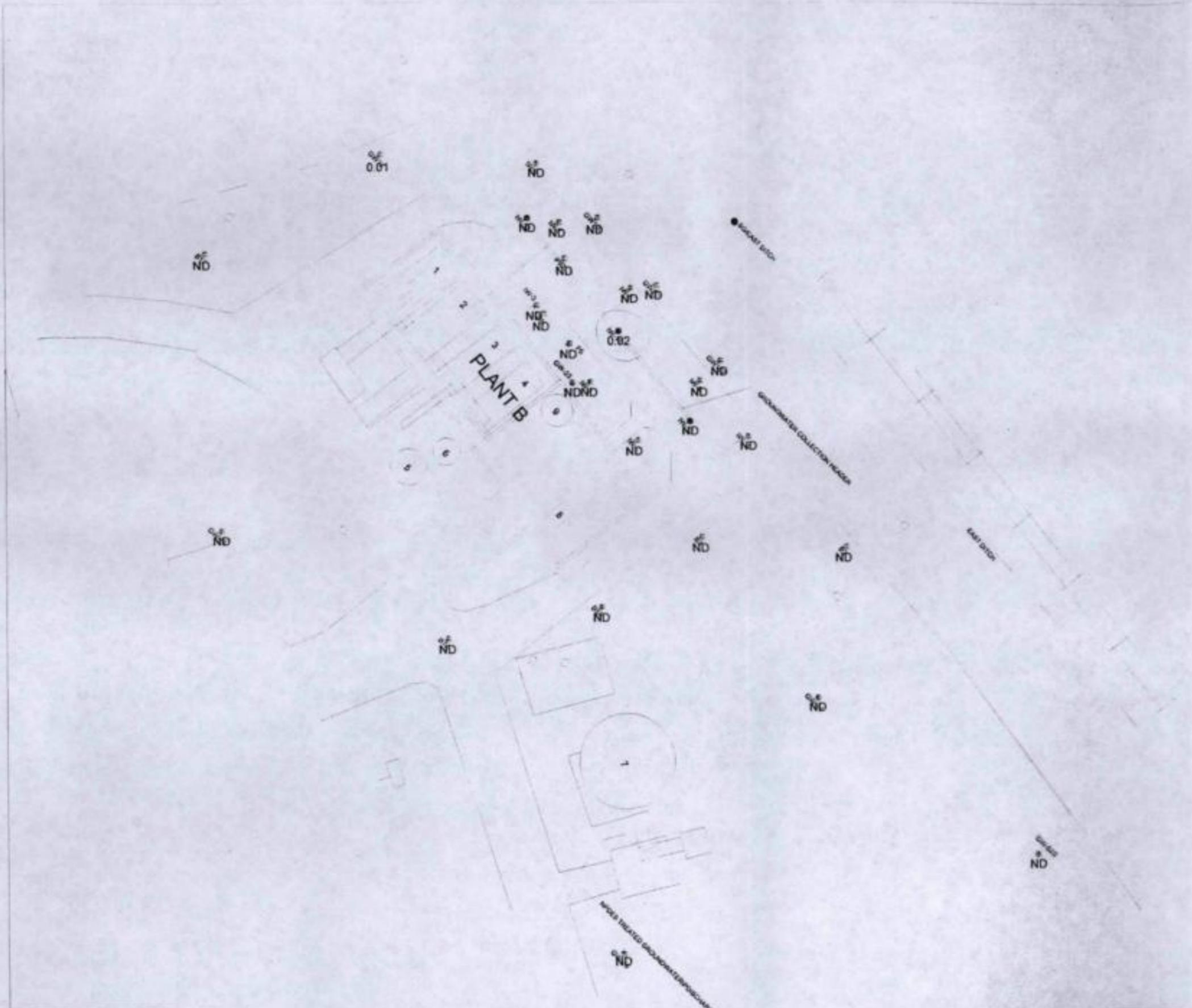
SOURCE: CADD DRAWING FILES TITLED:  
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51 Eames Street  
 Wilmington, Massachusetts

Figure 15  
 Product Thickness  
 Measured November 2, 2003

PREPARED BY: KJA  
 CHECKED BY: RAR





- LEGEND**
- ⊕ EXISTING WELL / WELLPOINT
  - ⊕ EXISTING RECOVERY WELL
  - ⊕ W-12
  - UTILITY POLE
  - GROUNDWATER ELEVATION CONTOUR (FTMSL) (DASHED WHERE INFERRED)
  - NA WELL DRY
  - NM NOT MEASURED

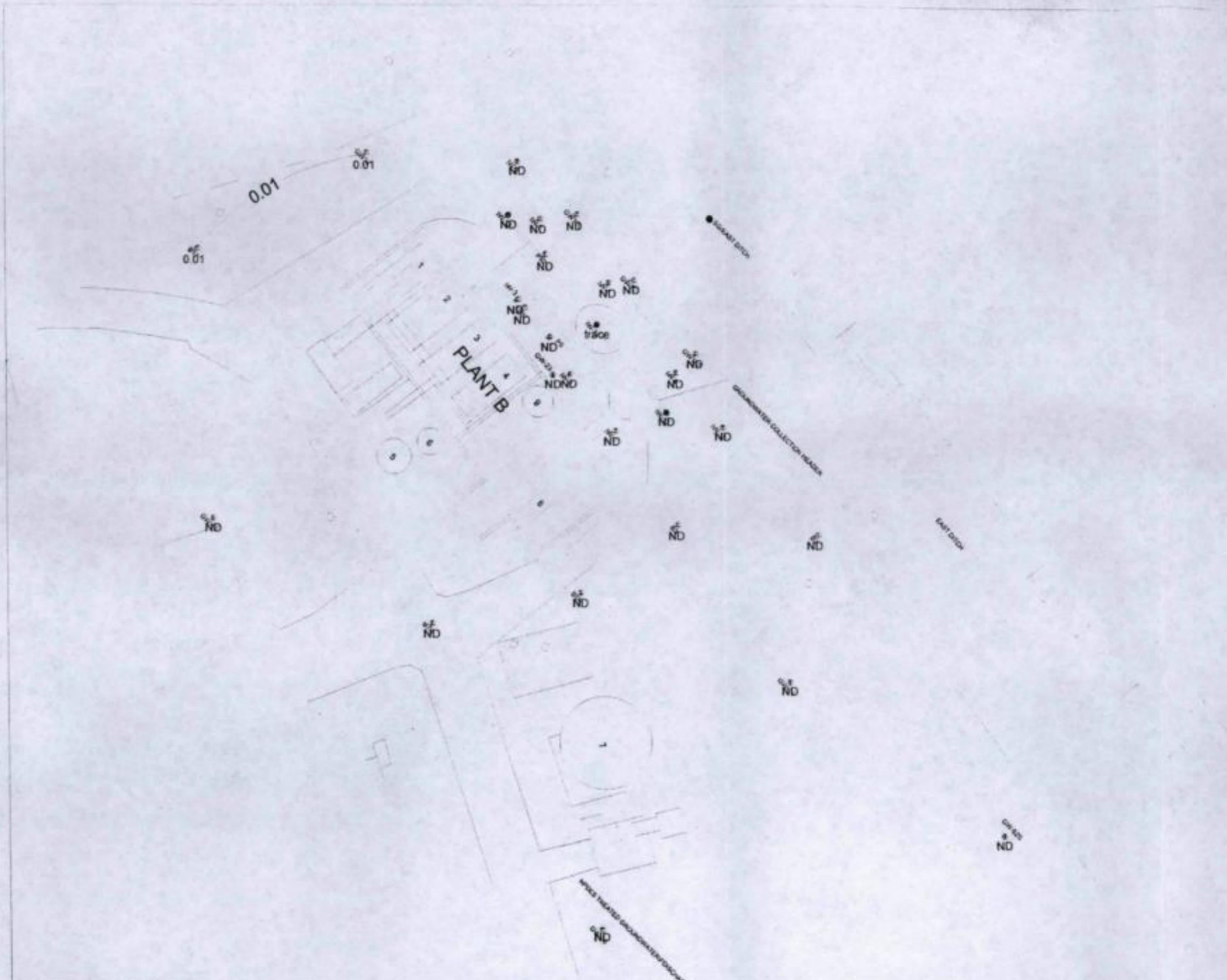
SOURCE: CADD DRAWING FILES, TITLED 7074-030, 7040-01, 7040-02 AND 01-IN-NEW BY SMITH TECHNOLOGIES CORP.

51 Eames Street  
Wilmington, Massachusetts



Figure 10  
Product Thickness

PREPARED BY: JCN  
CHECKED BY: MAA



- LEGEND**
- EXISTING WELL / WELLPOINT
  - EXISTING RECOVERY WELL
  - UTILITY POLE
  - GROUNDWATER ELEVATION CONTOUR (FTMSL) (DASHED WHERE INFERRED)
  - NA WELL DRY
  - NM NOT MEASURED

SOURCE: CADD DRAWING FILES TITLED: 7074-030, 7040-61, 7040-62 AND OLN-NEW BY SMITH TECHNOLOGIES CORP.

51 Eames Street  
Wilmington, Massachusetts

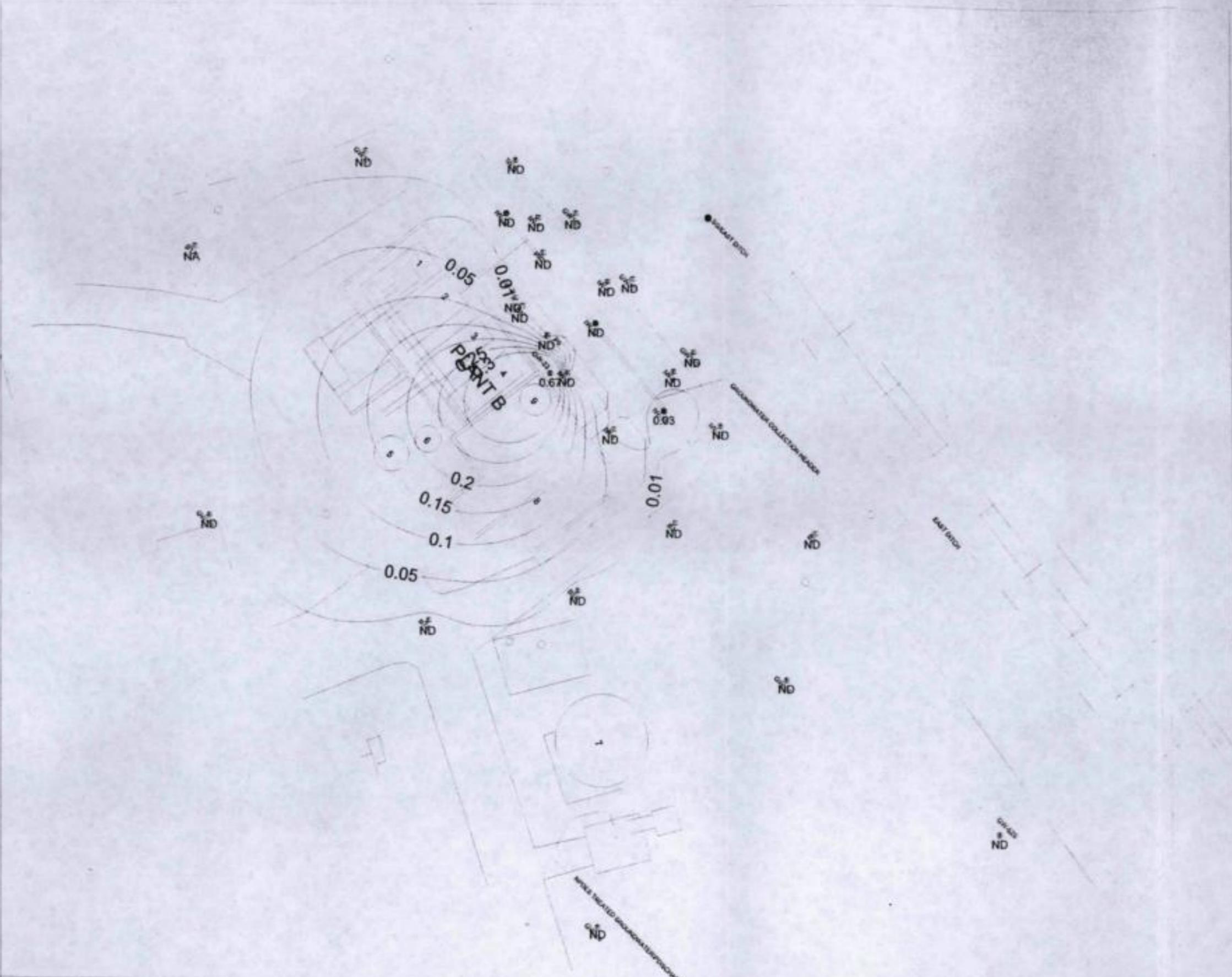


Figure 11  
Product Thickness

PREPARED BY: JCN  
CHECKED BY: MAA

**LEGEND**

- ⊕ EXISTING WELL / WELLPOINT
- P3 EXISTING RECOVERY WELL
- W-12
- UTILITY POLE
- GROUNDWATER ELEVATION CONTOUR (FTMSL) (DASHED WHERE INFERRED)
- NA WELL DRY
- NM NOT MEASURED



SOURCE: CADD DRAWING FILES TITLED:  
7074-030, 7040-61, 7040-62 AND OLM-NEW  
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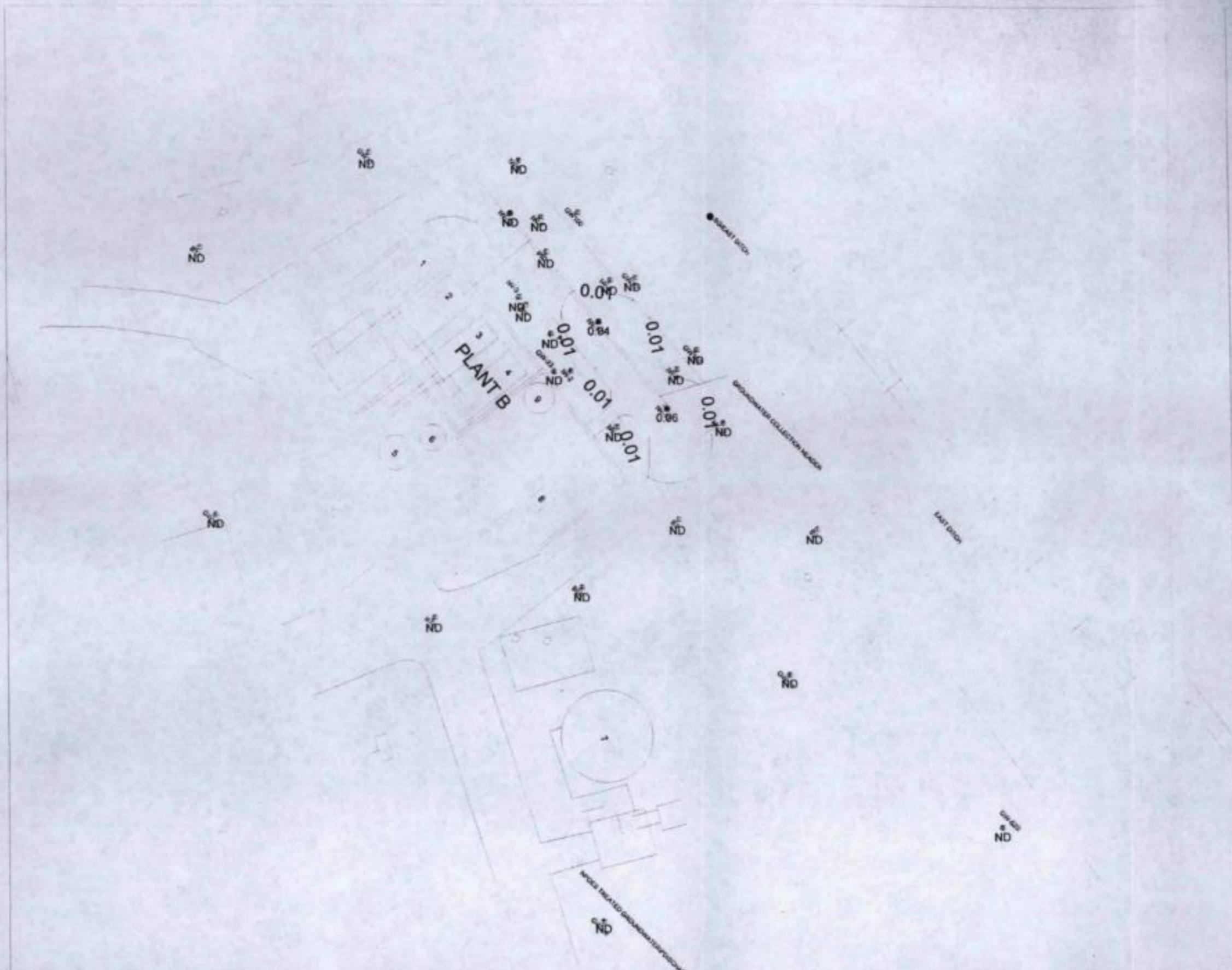
51 Eames Street  
Wilmington, Massachusetts



Figure 12  
Product Thickness

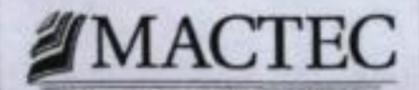
PREPARED BY: JCN  
CHECKED BY:

- LEGEND**
- + EXISTING WELL / WELLPPOINT
  - EXISTING RECOVERY WELL
  - UV-12 UTILITY POLE
  - GROUNDWATER ELEVATION CONTOUR (FT TMSL) (DASHED WHERE INFERRED)
  - NA WELL DRY
  - NM NOT MEASURED



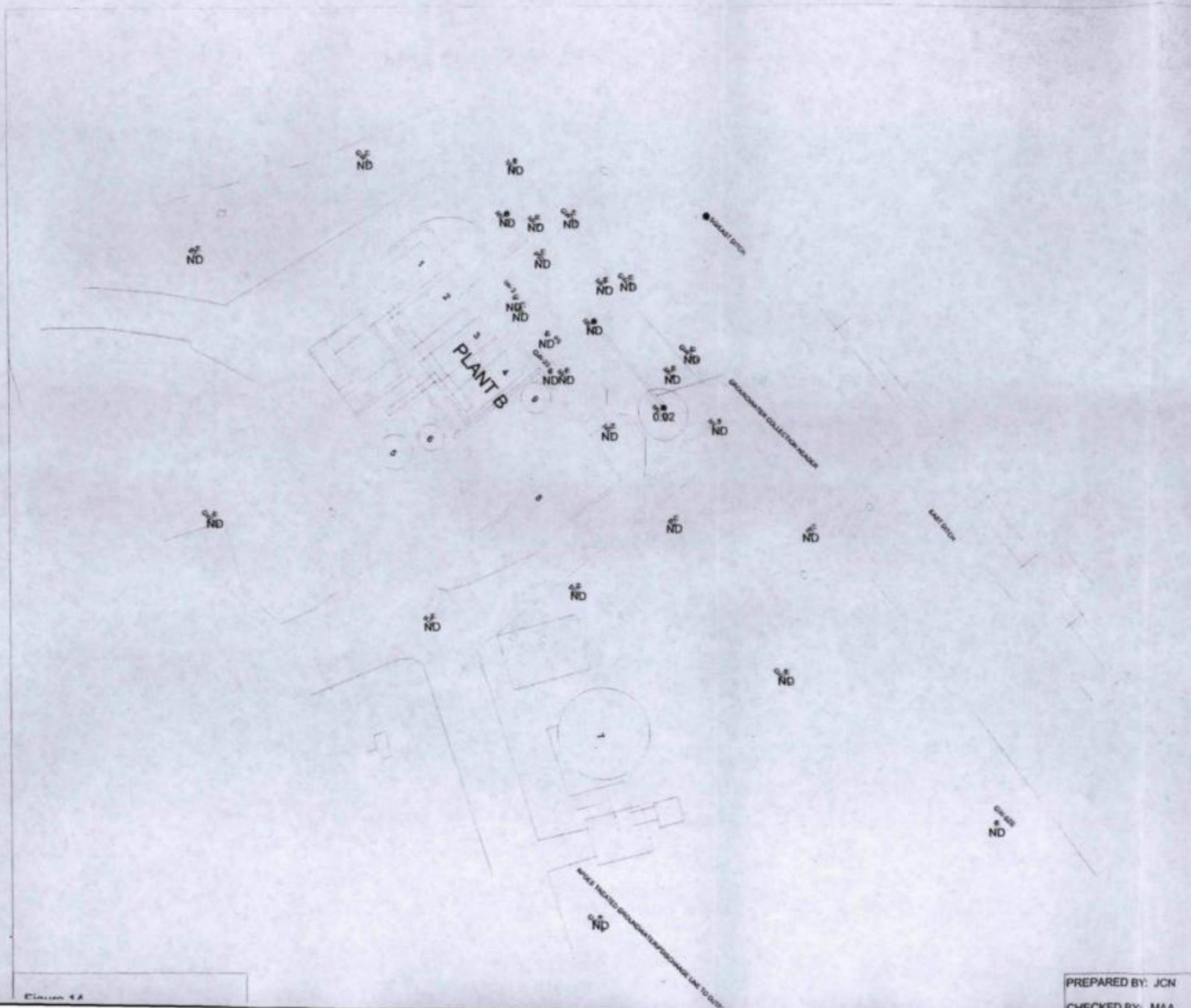
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PREPARED BY: JCN  
CHECKED BY: MAA

Figure 13



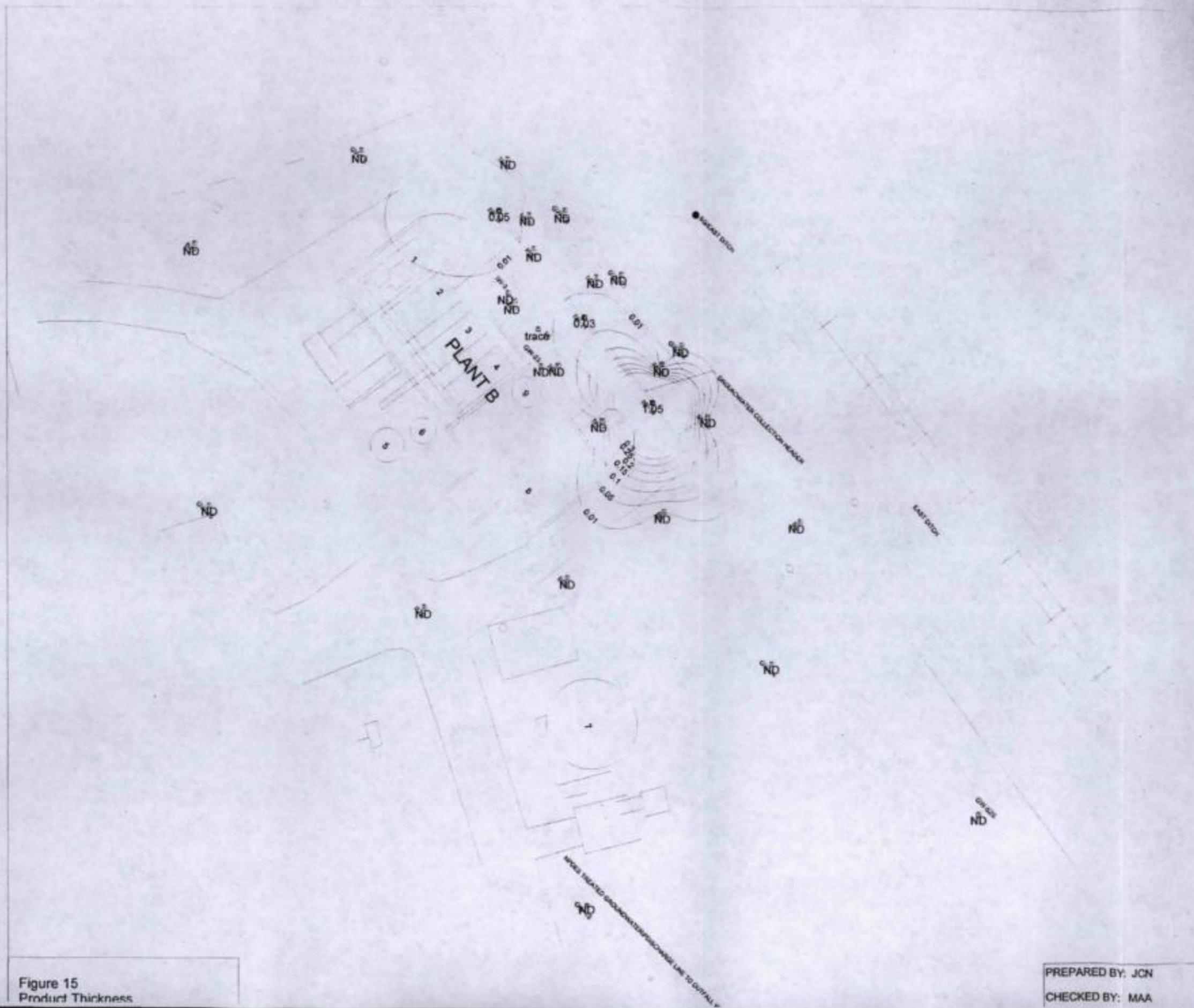
- LEGEND**
- EXISTING WELL / WELLPOINT
  - EXISTING RECOVERY WELL
  - UTILITY POLE
  - GROUNDWATER ELEVATION CONTOUR (FTMSL) (DASHED WHERE INFERRED)
  - NA WELL DRY
  - NM NOT MEASURED

SOURCE: CADD DRAWING FILES TITLED:  
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PREPARED BY: JCN  
CHECKED BY: MAA



- LEGEND**
- ⊕ EXISTING WELL / WELLPOINT
  - ⊖ EXISTING RECOVERY WELL
  - ⊙ UTILITY POLE
  - GROUNDWATER ELEVATION CONTOUR (FTMSL) (DASHED WHERE INFERRED)
  - NA WELL DRY
  - NM NOT MEASURED

SOURCE: CADD DRAWING FILES TITLED:  
7074-030, 7040-61, 7040-62 AND QLM-NEW  
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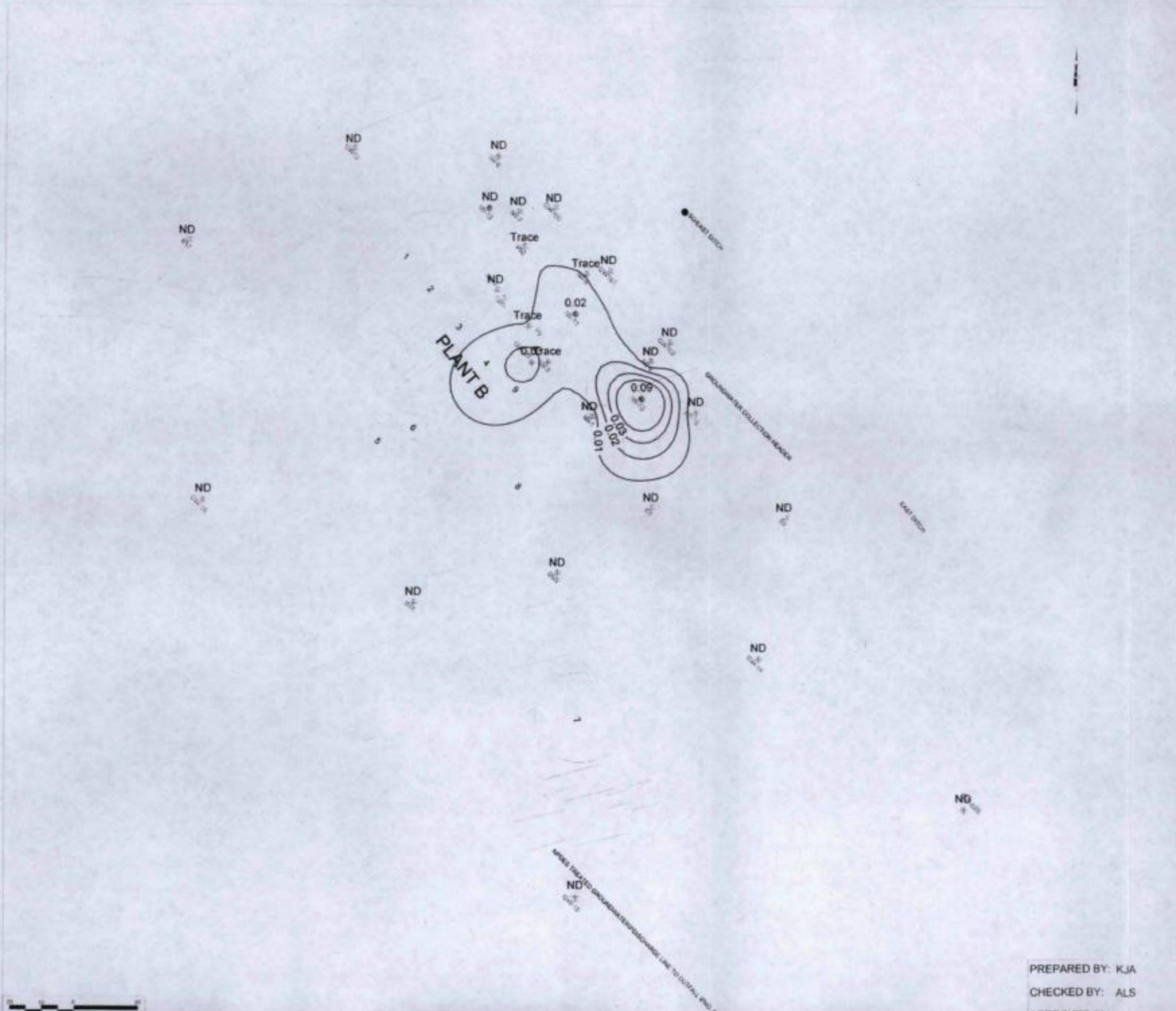


PREPARED BY: JCN  
CHECKED BY: MAA

Figure 15  
Product Thickness

LEGEND

- ⊕ EXISTING WELL / WELLPOINT
- P2 EXISTING RECOVERY WELL
- EXISTING RECOVERY WELL
- UTILITY POLE
- GROUNDWATER ELEVATION CONTOUR (FTMSL) (DASHED WHERE INFERRED)
- NA WELL DRY
- NM NOT MEASURED



Smith Technologies Corp. 51 Eames Street  
 Wilmington, Massachusetts 01897  
 (781) 245-4000  
 www.smith-tech.com

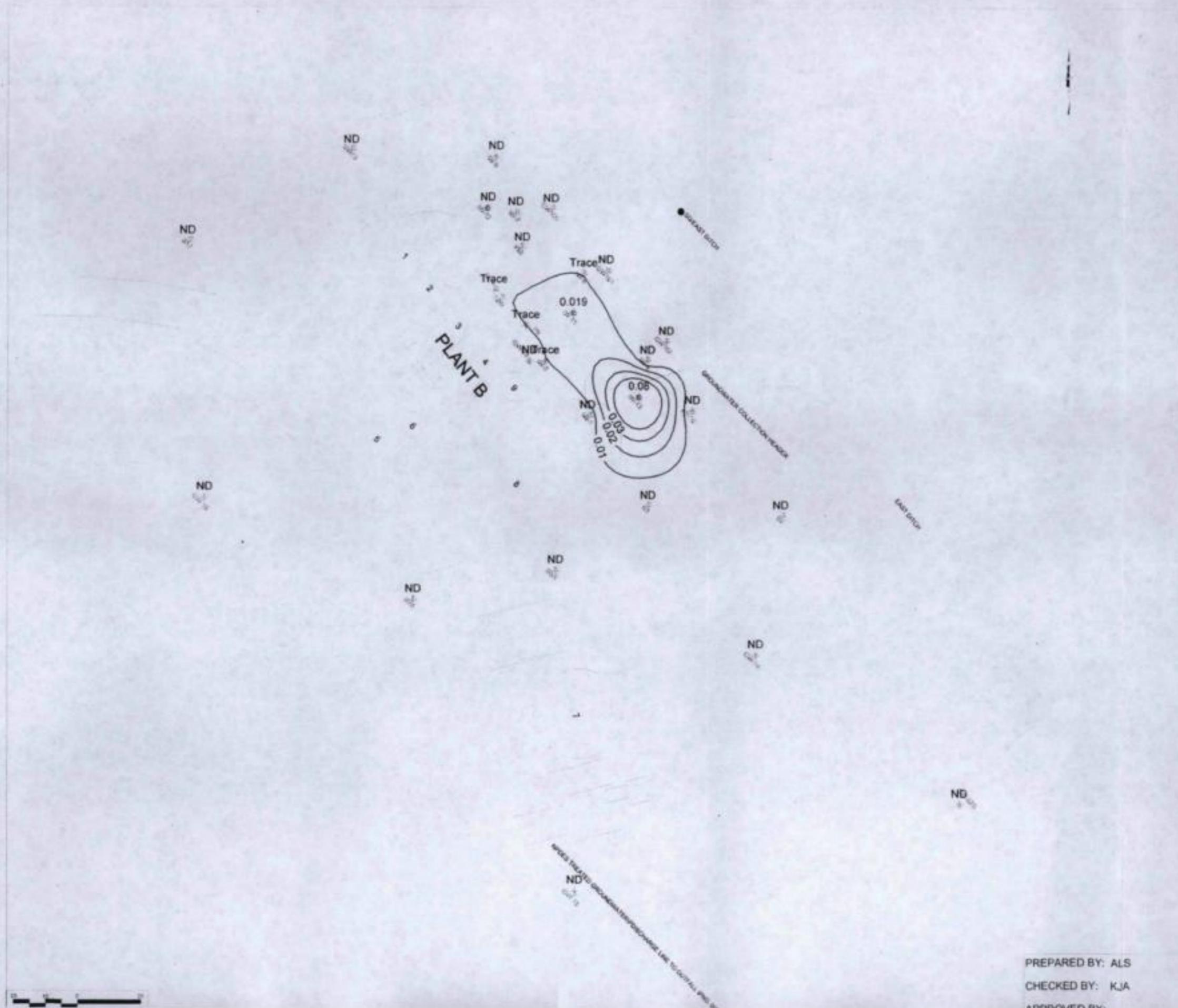


SOURCE: CADD DRAWING FILES TITLED:  
 7074-030, 7040-61, 7040-63 AND OLIN-NEW  
 BY SMITH TECHNOLOGIES CORP.

51 Eames Street  
 Wilmington, Massachusetts

PREPARED BY: KJA  
 CHECKED BY: ALS  
 APPROVED BY:

Figure 10  
 Product Thickness  
 Measured June 29, 2004



- LEGEND**
- ⊕ EXISTING WELL / WELLPOINT
  - P3
  - EXISTING RECOVERY WELL
  - W-12
  - ⊕ UTILITY POLE
  - GROUNDWATER ELEVATION CONTOUR (FTMSL) (DASHED WHERE INFERRED)
  - NA WELL DRY
  - NM NOT MEASURED

DATE: 07/23/04  
 TIME: 10:00 AM  
 PROJECT: 7074-030, 7040-61, 7040-62 AND OLN-NEW  
 BY: SMITH TECHNOLOGIES CORP.  
 DRAWN BY: ALS  
 CHECKED BY: KJA  
 APPROVED BY:

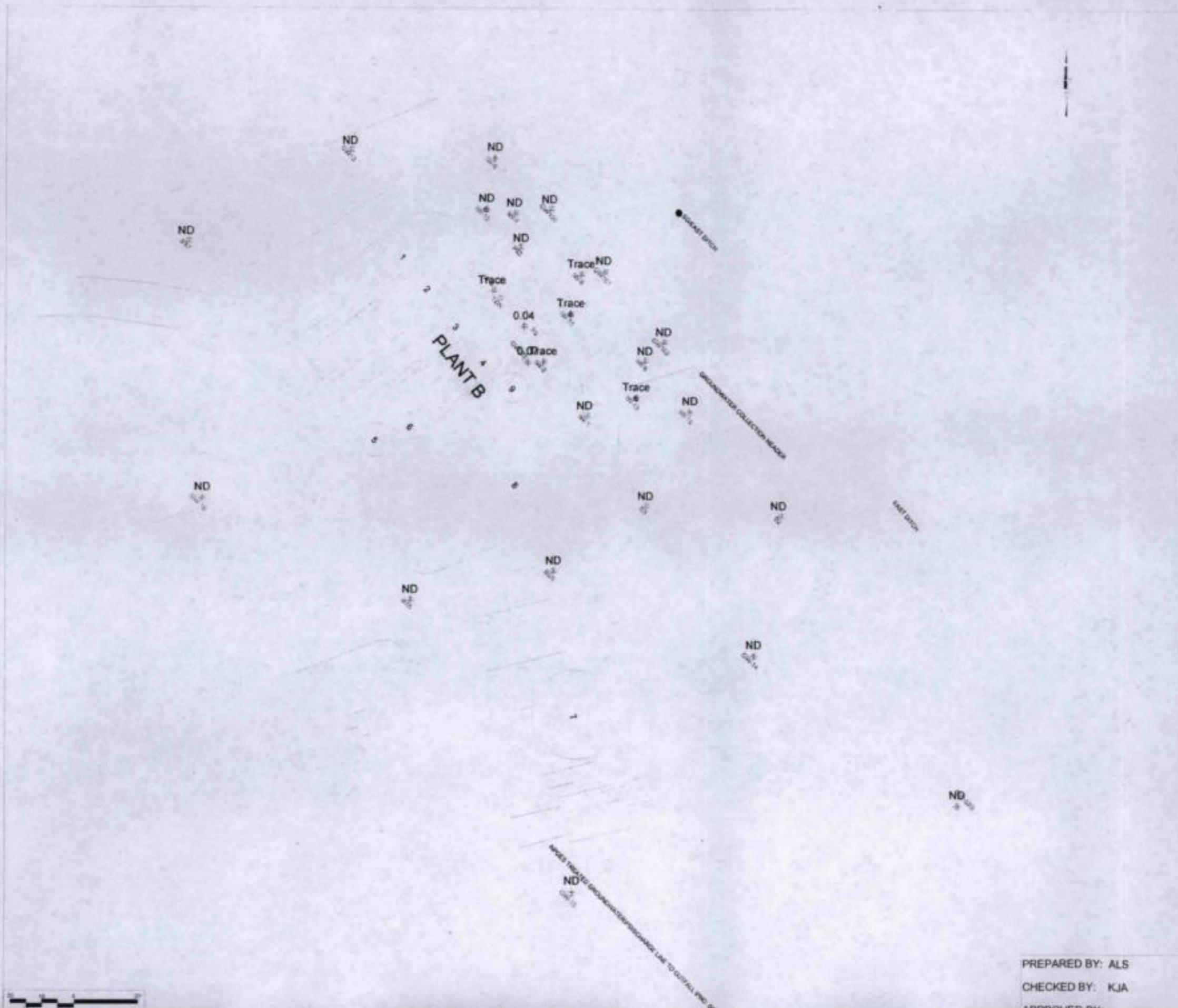


SOURCE: CADD DRAWING FILES TITLED:  
 7074-030, 7040-61, 7040-62 AND OLN-NEW  
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 Wilmington, Massachusetts

PREPARED BY: ALS  
 CHECKED BY: KJA  
 APPROVED BY:

Figure 11  
 Product Thickness  
 Measured July 23, 2004



- LEGEND**
- EXISTING WELL / WELLPOINT
  - F3
  - EXISTING RECOVERY WELL
  - WY-12
  - UTILITY POLE
  - GROUNDWATER ELEVATION CONTOUR (FTMSL) (DASHED WHERE INFERRED)
  - NA WELL DRY
  - NM NOT MEASURED

**MACTEC**  
 107 Auburn Road Woburn, MA 01890 (781) 245-8006

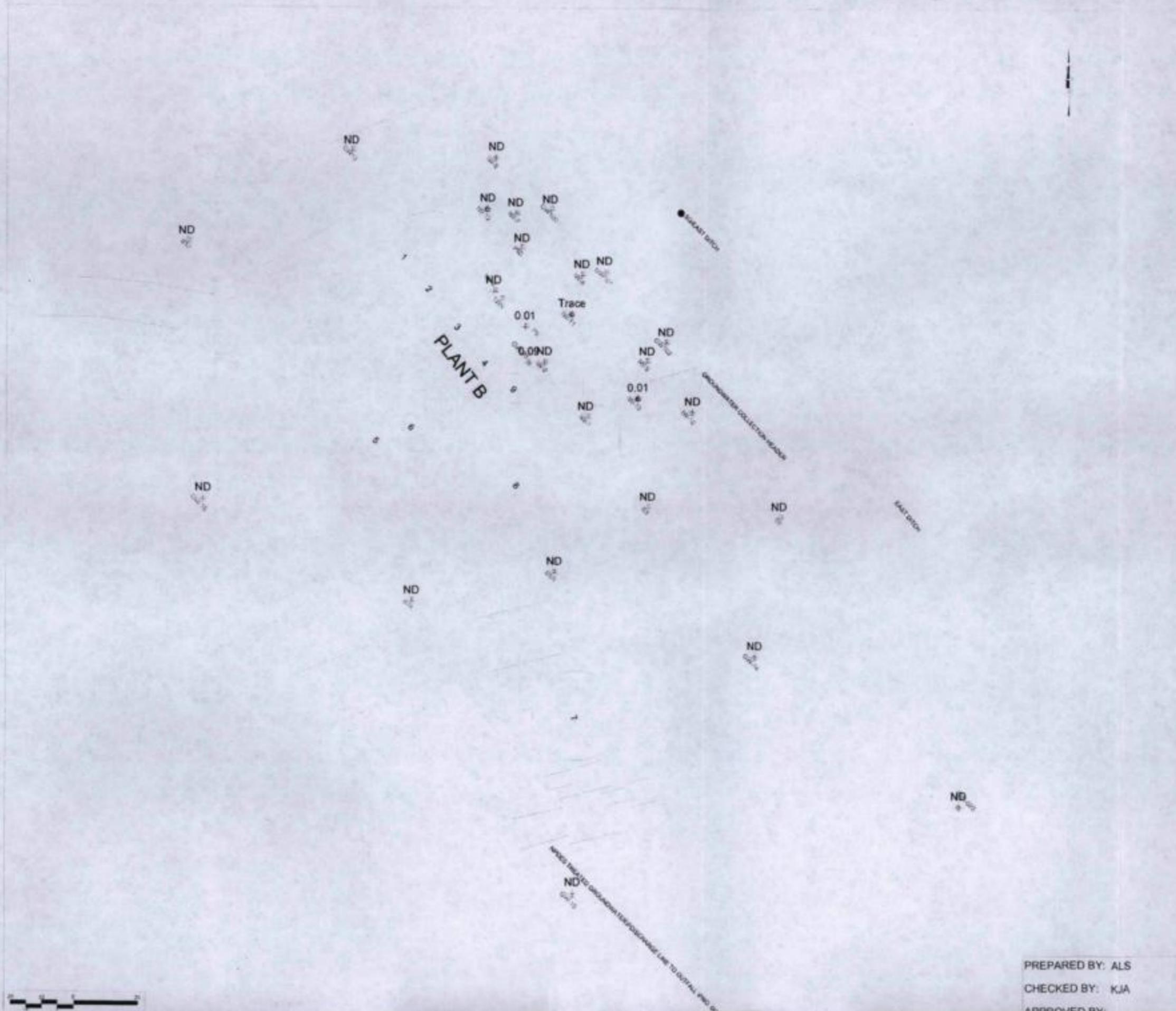
SOURCE: CADD DRAWING FILES TITLED 7074-C30, 7040-S1, 7040-S2 AND CLIN-NEW BY SMITH TECHNOLOGIES CORP.

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 Wilmington, Massachusetts

Figure 12  
 Product Thickness  
 Measured August 25, 2004

PREPARED BY: ALS  
 CHECKED BY: KJA  
 APPROVED BY:





- LEGEND**
- ⊕ EXISTING WELL / WELLPOINT
  - P3 EXISTING RECOVERY WELL
  - EXISTING RECOVERY WELL
  - UTILITY POLE
  - GROUNDWATER ELEVATION CONTOUR (FTASL) (DASHED WHERE INFERRED)
  - NA WELL DRY
  - NM NOT MEASURED

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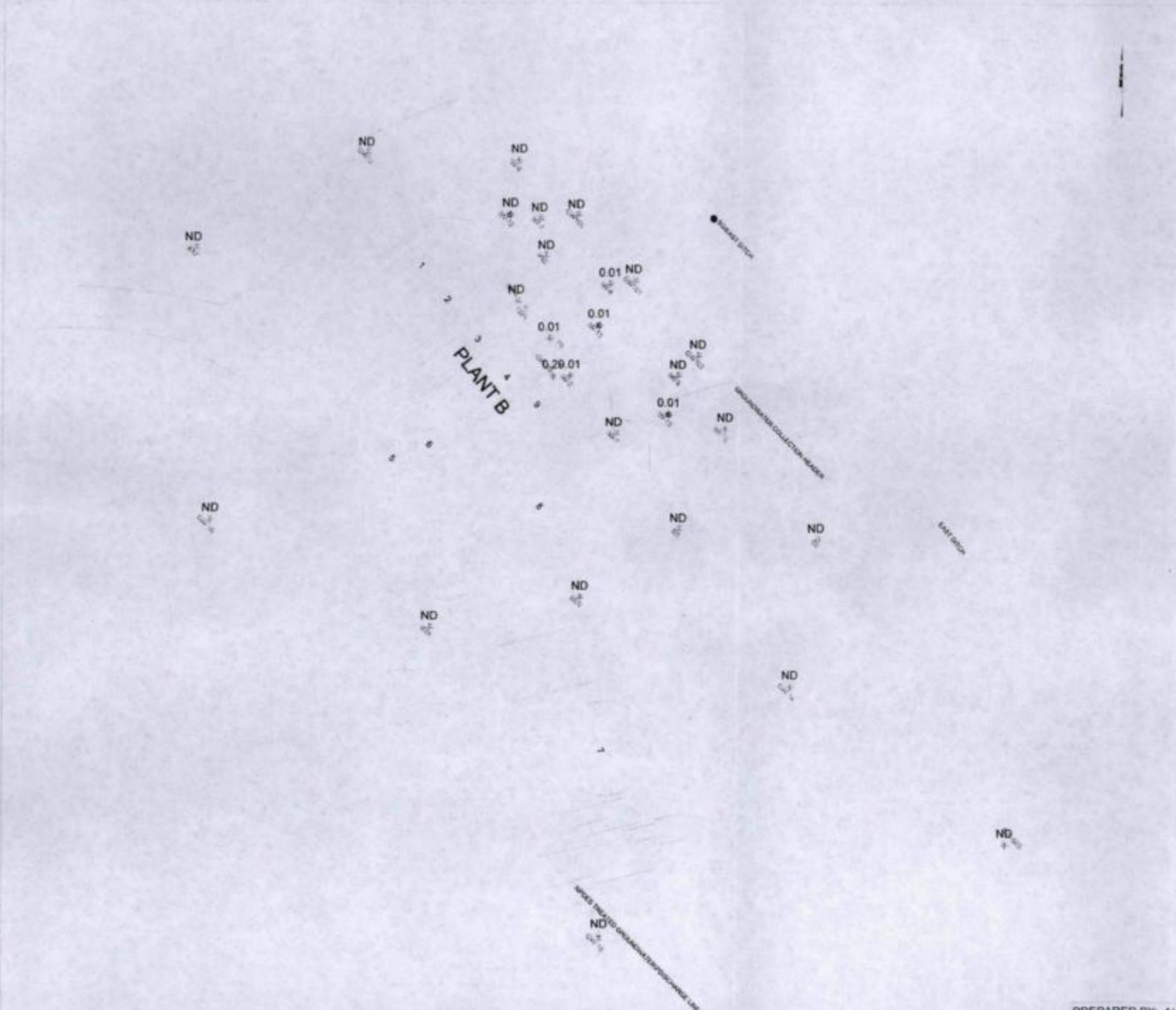
SOURCE: CADD DRAWING FILES TITLED: 7074-030, 7040-61, 7040-62 AND OLIN-NEW BY SMITH TECHNOLOGIES CORP.

**Smith**  
51 Eames Street  
Wilmington, Massachusetts

PREPARED BY: ALS  
CHECKED BY: KJA  
APPROVED BY:

Figure 13  
Product Thickness  
Measured September 17, 2004





- LEGEND**
- ⊗ EXISTING WELL / WELLPPOINT
  - EXISTING RECOVERY WELL
  - W-12 UTILITY POLE
  - GROUNDWATER ELEVATION CONTOUR (FT. MSL) (DASHED WHERE INFERRERD)
  - NA WELL DRY
  - NM NOT MEASURED

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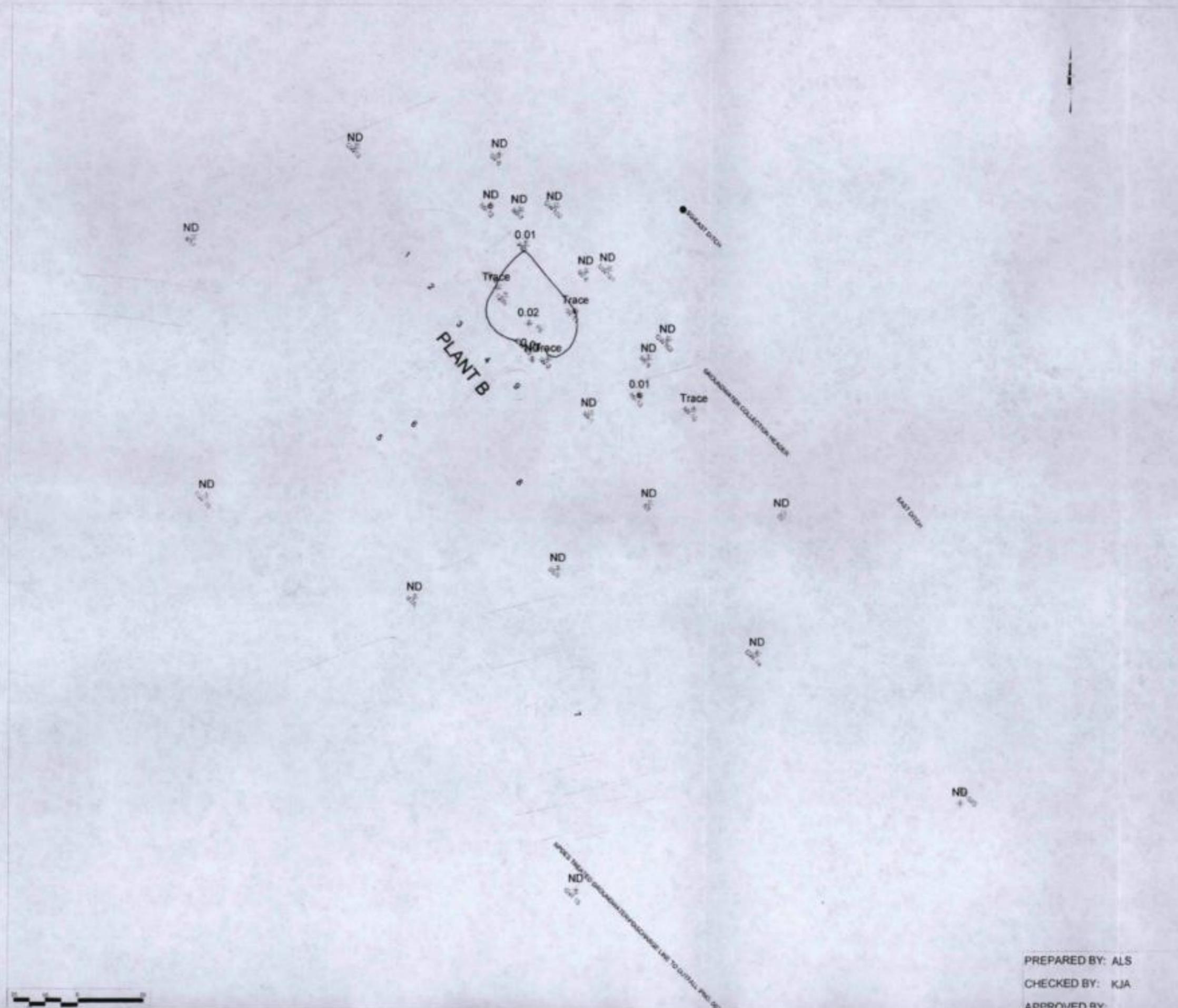


SOURCE: CADD DRAWING FILES TITLED 7074-030, 7040-61, 7040-62 AND OLW-NEW BY SMITH TECHNOLOGIES CORP.

51 Eames Street  
Wilmington, Massachusetts

PREPARED BY: ALS  
CHECKED BY: KJA  
APPROVED BY:

Figure 14  
Product Thickness  
Measured October 21, 2004



- LEGEND**
- ⊕ EXISTING WELL / WELLPOINT
  - ⊖ EXISTING RECOVERY WELL
  - W-12 UTILITY POLE
  - GROUNDWATER ELEVATION CONTOUR (FTMSL) (DASHED WHERE INFERRED)
  - NA WELL DRY
  - ND NOT MEASURED

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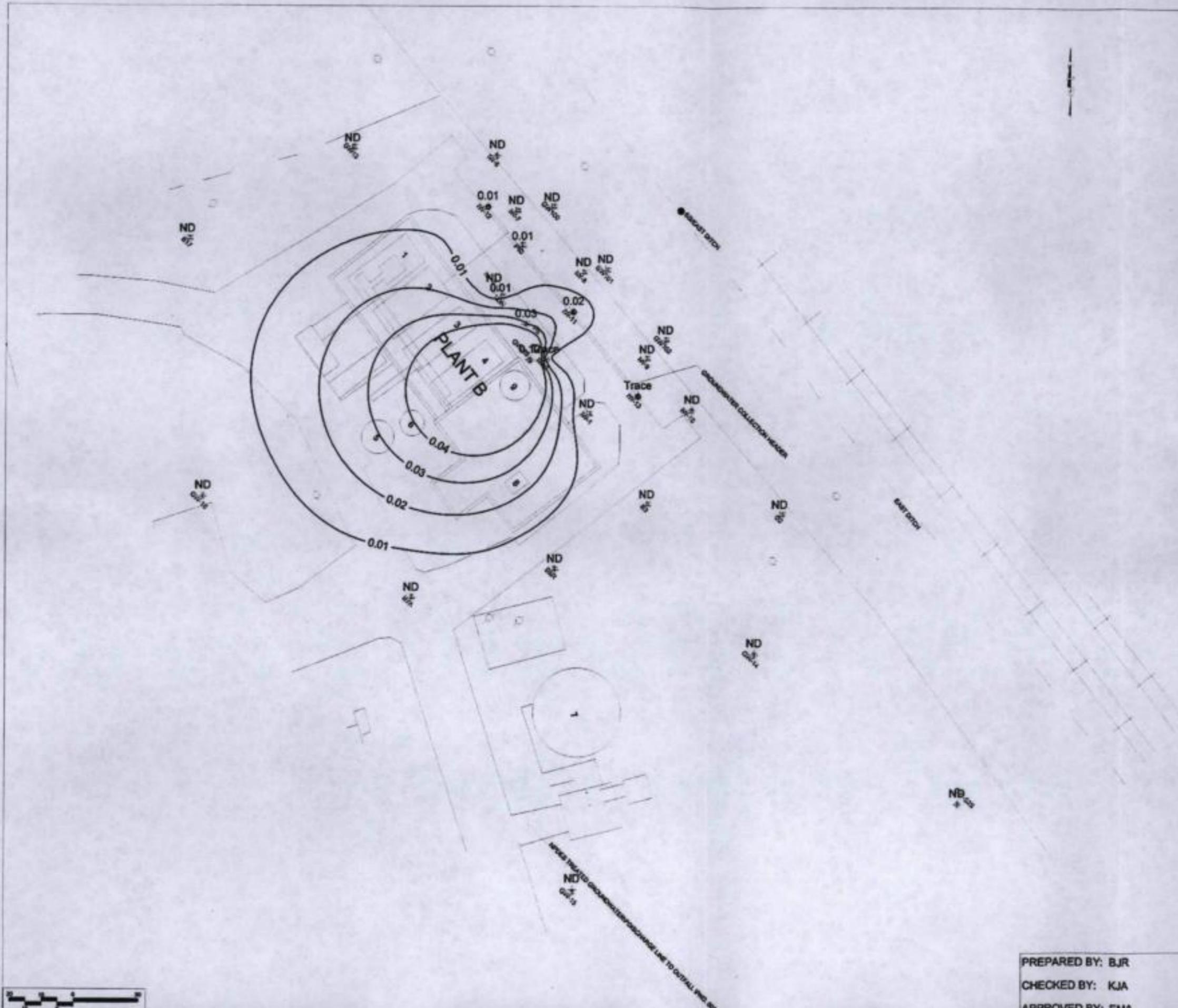
SOURCE: CADD DRAWING FILES TITLED: 7574-030, 7545-61, 7545-62 AND OLIN-NEW BY SMITH TECHNOLOGIES CORP.

51 Eames Street  
Wilmington, Massachusetts

Figure 15  
Product Thickness  
Measured November 30, 2004

PREPARED BY: ALS  
CHECKED BY: KJA  
APPROVED BY:





- LEGEND**
- + EXISTING WELL / WELLPOINT
  - P3
  - EXISTING RECOVERY WELL
  - NW-12
  - UTILITY POLE
  - 77 GROUNDWATER ELEVATION CONTOUR (FTMSL) (DASHED WHERE INFERRED)
  - NA WELL DRY
  - NM NOT MEASURED

TANK #1 - RECEIVES GRAVITY OVER FLOW FROM TANK #2 AND ALL TANKS FOR FURTHER SETTLING  
 TANK #2 - CAUSTIC ADDITION AND INITIAL IRON TROUBLE  
 TANK #3 & #4 - OVERNIGHT HOLDING TANK FOR TREATED WATER  
 TANK #5 - FINE CAPSULE HOLD TANK  
 TANK #6 - RESIDENCE TANK  
 TANK #7 - RAW WATER (PH ADJUSTED)  
 TANK #8 - FINE CAPSULE TRANSFER  
 TANK #9 - GY DISCHARGE TO UPPER OUTFALL #2

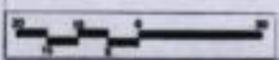


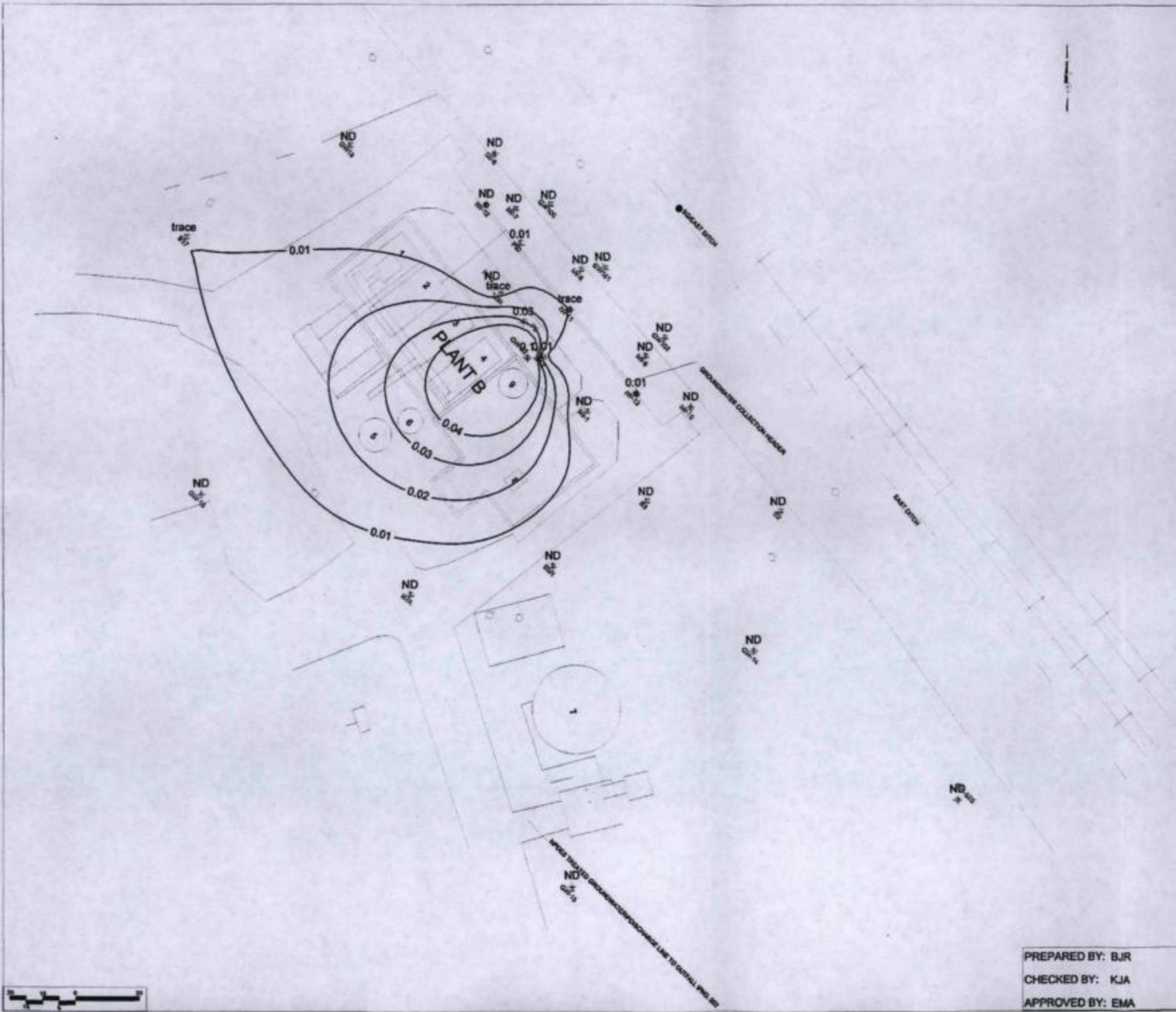
SOURCE: CADD DRAWING FILES TITLED: 7074-030, 7040-61, 7040-62 AND OLN-NEW BY SMITH TECHNOLOGIES CORP.



PREPARED BY: BJR  
 CHECKED BY: KJA  
 APPROVED BY: EMA

Figure 10  
 Product Thickness  
 Measured December 27, 2004





- LEGEND**
- ⊕ EXISTING WELL / WELLPOINT
  - PS EXISTING RECOVERY WELL
  - W-12 EXISTING RECOVERY WELL
  - ⊕ UTILITY POLE
  - 77 GROUNDWATER ELEVATION CONTOUR (FT/MSL) (DASHED WHERE INFERRED)
  - NA WELL DRY
  - NM NOT MEASURED

TANK #1 - RECEIVES GRAVITY OVER FLOW FROM TANK #2 AND ALLOWS FOR FURTHER SETTLING  
 TANK #2 - CHEMICAL ADDITION AND INITIAL MIXING TANK  
 TANK #3 - OVERNIGHT HOLDING TANK FOR TREATED WATER  
 TANK #4 - PRE-CARBON HOLD TANK  
 TANK #5 - RESERVE TANK  
 TANK #6 - RAW WATER pH ADJUSTED  
 TANK #7 - PRE-CARBON DRAINAGE  
 TANK #8 - DAY DISCHARGE TO TAPER CURFALL SW

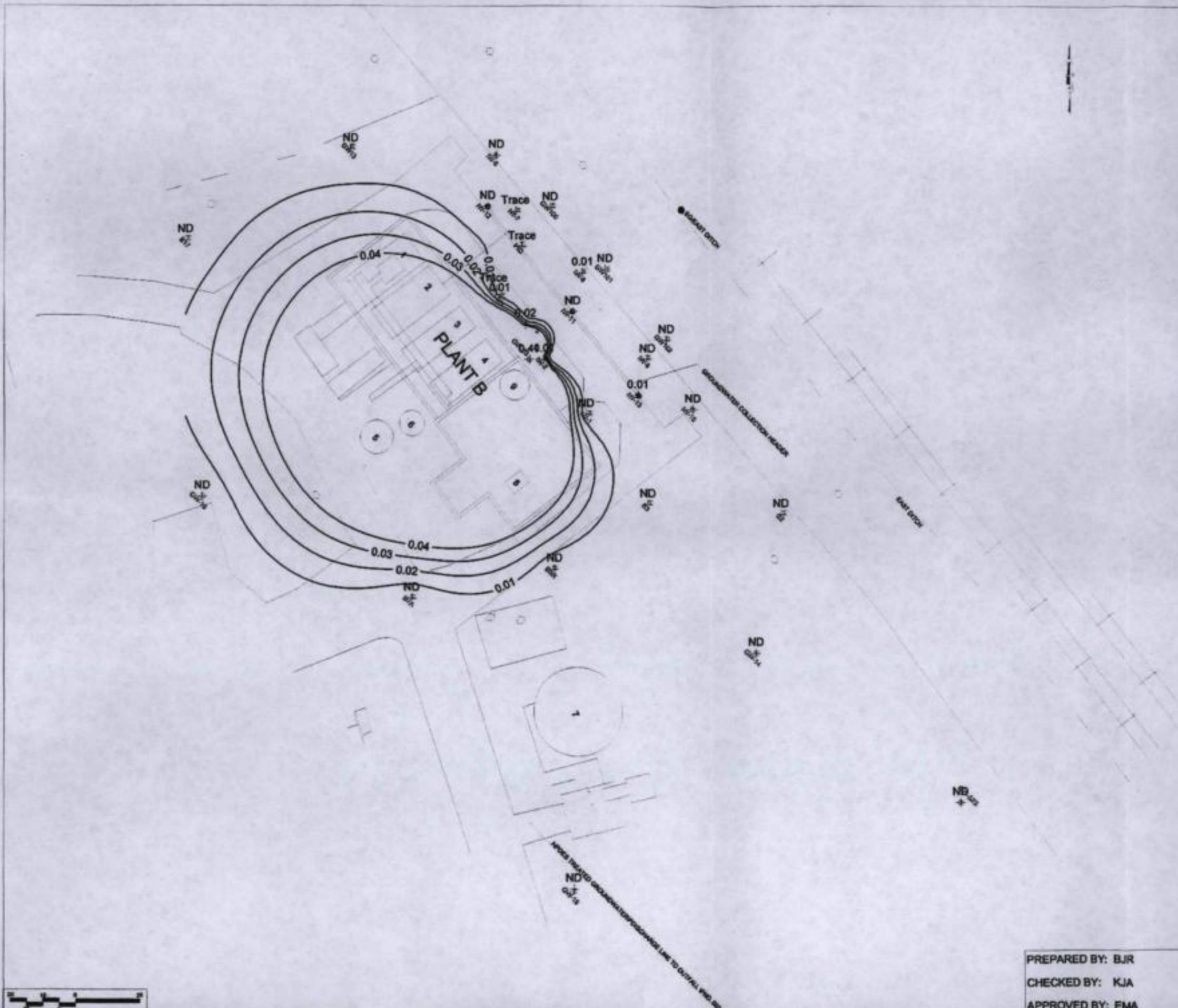


SOURCE: CADD DRAWING FILES TITLED: 7074-030, 7045-61, 7045-62 AND OLN-NEW BY SMITH TECHNOLOGIES CORP.



PREPARED BY: BJR  
 CHECKED BY: KJA  
 APPROVED BY: EMA

Figure 11  
 Product Thickness  
 Measured January 31, 2005



- LEGEND**
- + EXISTING WELL / WELLPOINT
  - PS
  - EXISTING RECOVERY WELL
  - W-12
  - UTILITY POLE
  - 77 GROUNDWATER ELEVATION CONTOUR (FTMSL) (DASHED WHERE INFERRED)
  - NA WELL DRY
  - NM NOT MEASURED

TANK #1 - RECEIVES EFFLUENT OVER FLOW FROM TANK #2 AND ALLOWS FOR FURTHER SETTLING  
 TANK #2 - GAUSTIC ADDITION AND INITIAL BIOCLOGIC  
 TANK #3 & #4 - OVERNIGHT HOLDING TANK FOR TREATED WATER  
 TANK #5 - PRE-CARBON HOLD TANK  
 TANK #6 - PRE-CARBON TANK  
 TANK #7 - RAW WATER pH ADJUSTED  
 TANK #8 - PRE-CARBON TRANSFER  
 TANK #9 - EFF DISCHARGE TO SPDES OUTFALL MW

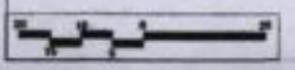


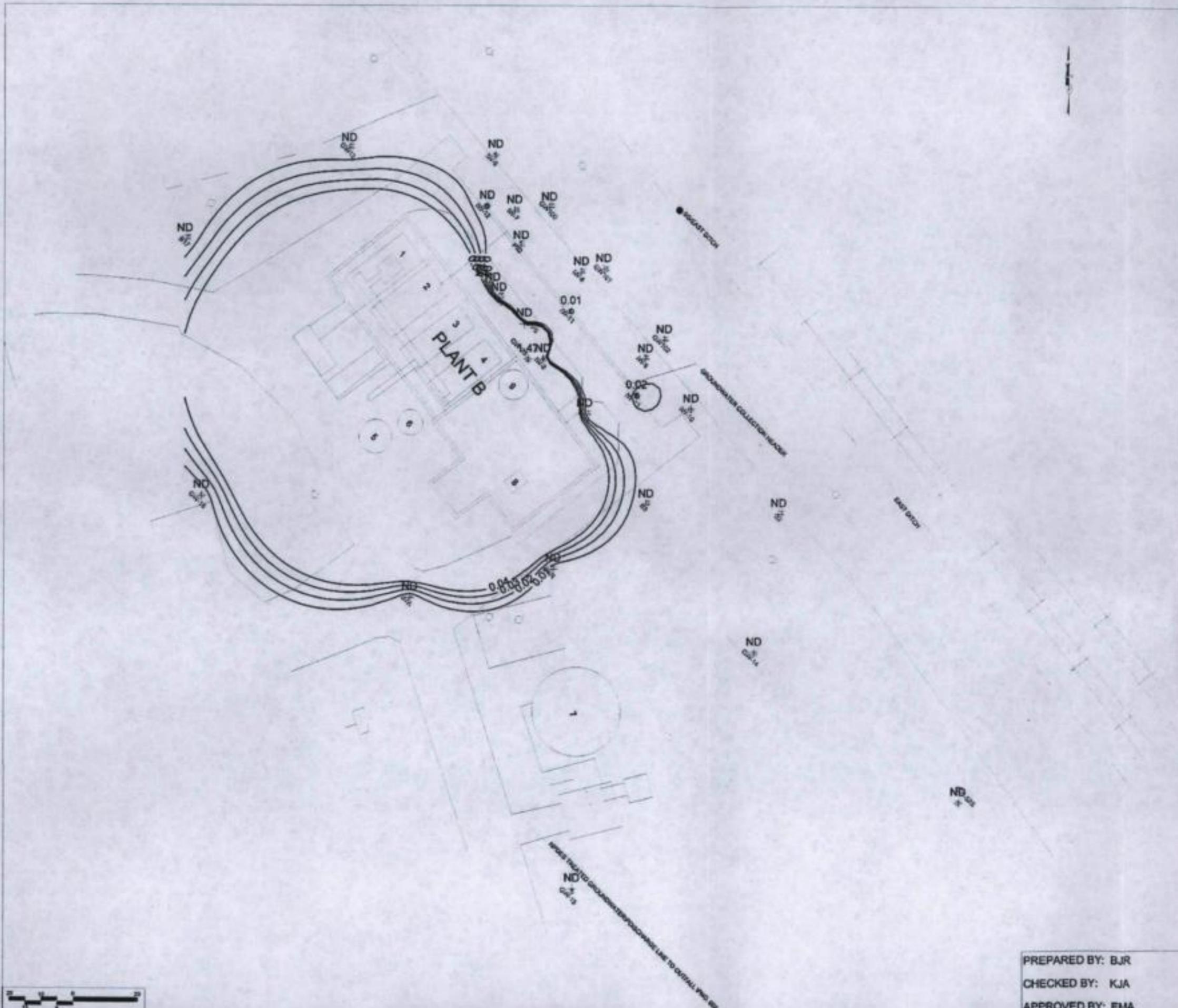
SOURCE: CADD DRAWING FILES TITLED:  
 7574-030, 7040-61, 7040-62 AND OLIN-NEW  
 BY SMITH TECHNOLOGIES CORP.



PREPARED BY: BJR  
 CHECKED BY: KJA  
 APPROVED BY: EMA

Figure 12  
 Product Thickness  
 Measured February 28, 2005





- LEGEND**
- ⊕ EXISTING WELL / WELLPOINT
  - ⊕ P3
  - EXISTING RECOVERY WELL
  - ⊕ W-12
  - ⊕ UTILITY POLE
  - 77 GROUNDWATER ELEVATION CONTOUR (FTMSL) (DASHED WHERE INFERRED)
  - NA WELL DRY
  - NM NOT MEASURED

TANK #1 - RECEIVES BRACKISH OVER FLOW FROM TANK 2 AND ALL DING FOR FURTHER SETTLING  
 TANK #2 - CHEMICAL ADDITION AND INITIAL FLOTATION  
 TANK #3 - DROPOUT  
 TANK #4 & #5 - OVERNIGHT HOLDING TANK FOR TREATED WATER  
 TANK #6 - FINE CARBON HOLD TANK  
 TANK #7 - RESIDENCE TANK  
 TANK #8 - RAW WATER (PH ADJUSTED)  
 TANK #9 - FINE CARBON TRANSFER  
 TANK #10 - GRY DISCHARGE TO REUSE OUTFALL DITCH



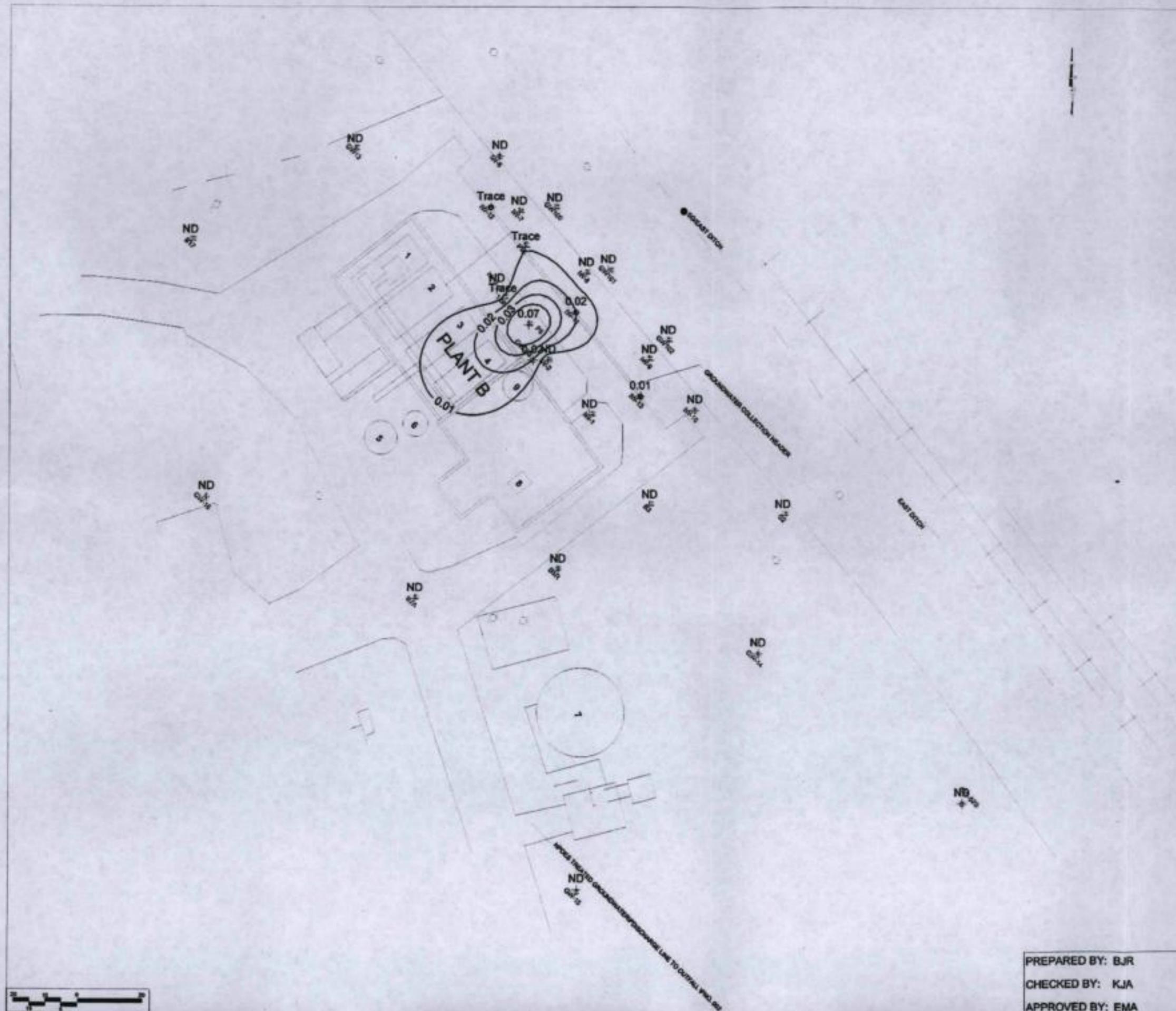
SOURCE: CADD DRAWING FILES TITLED: 7074-030, 7040-61, 7040-62 AND CLIN-NEW BY SMITH TECHNOLOGIES CORP.



PREPARED BY: BJR  
 CHECKED BY: KJA  
 APPROVED BY: EMA

Figure 13  
 Product Thickness  
 Measured March 31, 2005





- LEGEND**
- ⊕ EXISTING WELL / WELLPOINT
  - P3
  - EXISTING RECOVERY WELL
  - MW-12
  - UTILITY POLE
  - 77 GROUNDWATER ELEVATION CONTOUR (FTMSL) (DASHED WHERE INFERRED)
  - NA WELL DRY
  - NM NOT MEASURED

TANK #1 - RECEIVES DRAINY OVER FLOW FROM TANK #2 AND ALLOWS FOR FUMER BOTTLES  
 TANK #2 - CALIBIC ACETON AND RAYOL FROM BRIC-GLT  
 TANK #1 & #4 - OVERNIGHT HOLDING TAN. FOR TREATED WATER  
 TANK #5 - PRE-CIPROG HOLD TANK  
 TANK #6 - RESIDENCE TANK  
 TANK #7 - ADD WATER W/40 FIBER  
 TANK #8 - PRE CARSON TRANSFER  
 TANK #9 - DAY DISCHARGE TO TIDES OUTFALL DRY

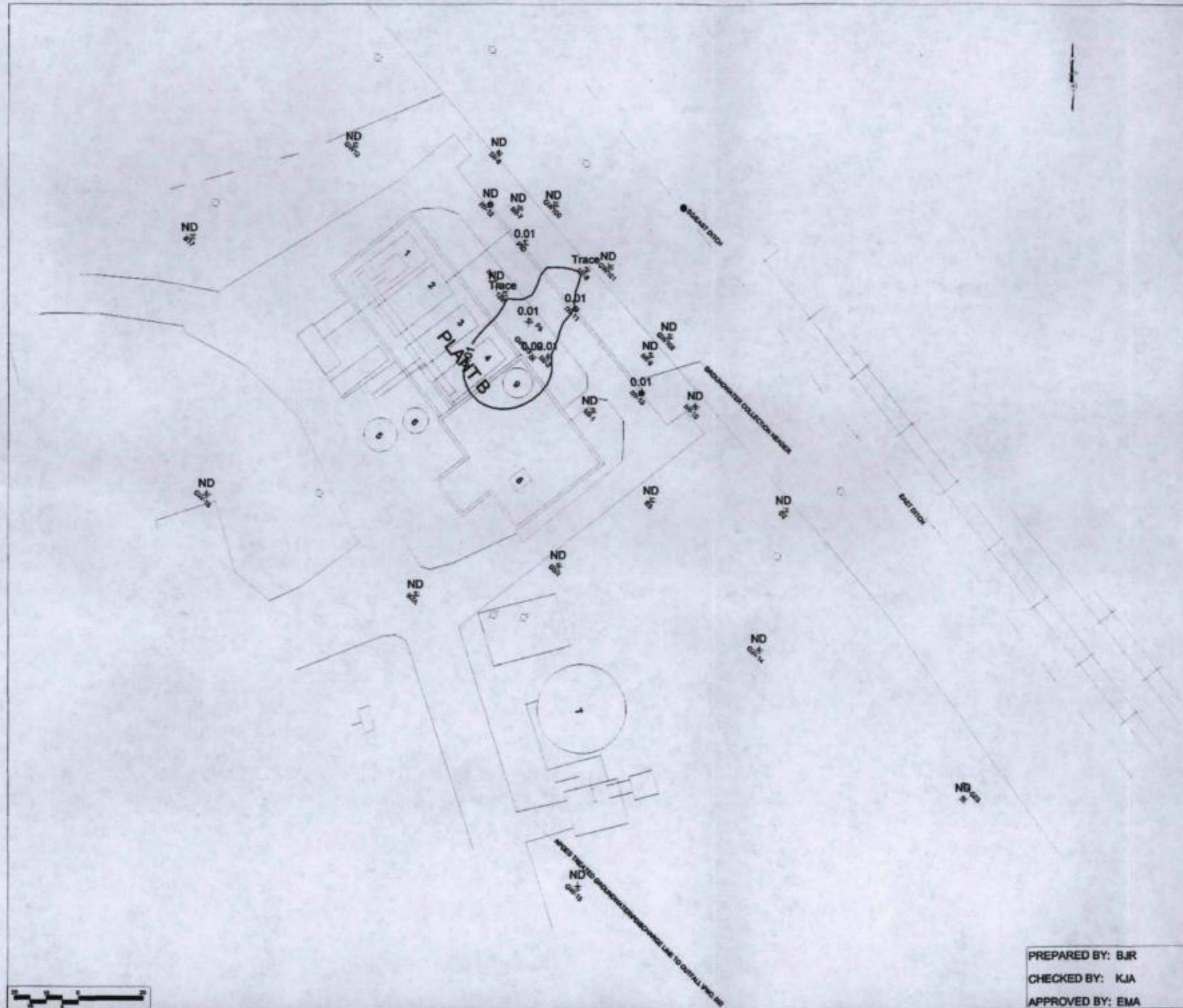


SOURCE: CADD DRAWING FILES TITLED: 7074-030, 7040-61, 7040-62 AND OLIN-NEW BY SMITH TECHNOLOGIES CORP.



PREPARED BY: BJR  
 CHECKED BY: KJA  
 APPROVED BY: EMA

Figure 14  
 Product Thickness  
 Measured April 29, 2005



- LEGEND**
- ⊕ EXISTING WELL / WELLPOINT
  - ⊕ P3 EXISTING RECOVERY WELL
  - ⊕ W-12 EXISTING RECOVERY WELL
  - ⊕ UTILITY POLE
  - 77 GROUNDWATER ELEVATION CONTOUR (FTMSL) (DASHED WHERE INFERRED)
  - NA WELL DRY
  - NM NOT MEASURED

TANK 11 - RECEIVES GRAVITY OVER FLOW FROM TANK 2 AND ALLOWS FOR FURTHER SETTLING.  
 TANK 12 - GUSTIG ADDITION AND EXTRA PEDI DROG OUT  
 TANK 13 & 14 - OVERFLOWS HOLDING TANK FOR TREATED WATER  
 TANK 15 - PRE-CARBON HOLD TANK  
 TANK 16 - RESIDENCE TANK  
 TANK 17 - RAW WATER PH ADJUSTED  
 TANK 18 - PRE-CARBON TRANSFER  
 TANK 19 - DRY DISCHARGE TO NPDES OUTFALL 104



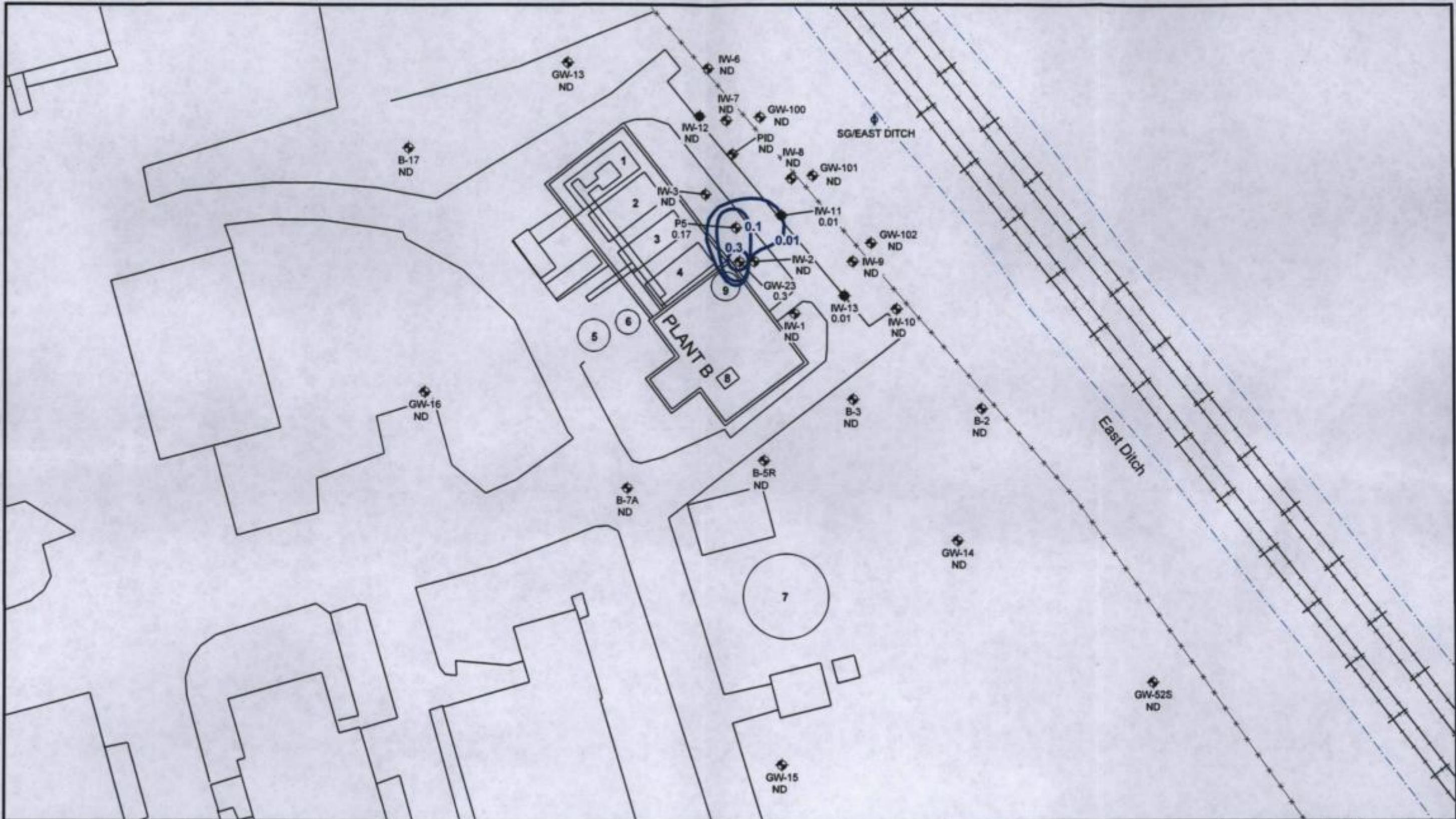
SOURCE: CADD DRAWING FILES TITLED: 7074-030, 7040-61, 7040-62 AND OLIN-NEW BY SMITH TECHNOLOGIES CORP.



PREPARED BY: BJR  
 CHECKED BY: KJA  
 APPROVED BY: EMA

Figure 15  
 Product Thickness  
 Measured May 31, 2005





Tank#1 - Receives gravity overflow from Tank 2 and allows for further settling  
 Tank#2 - Caustic addition and initial iron drop-out  
 Tank#3 & #4 - Overnight holding tank for treated water  
 Tank#5 - Pre-carbon hold tank  
 Tank#6 - Residence tank  
 Tank#7 - Raw water (pH adjusted)  
 Tank#8 - Pre-carbon transfer  
 Tank#9 - Day discharge to NPDES Outfall 002

- Legend**
- Trace - Trace Product (0.01 assigned for contour)
  - ND - Not Detected
  - ◆ Staff Gauge
  - ◆ Existing Well/Wellpoint
  - ◆ Existing Recovery Well
  - 0.1 — Product Thickness Contour (FT)
  - Building
  - Road
  - Railroad
  - - - Ditch

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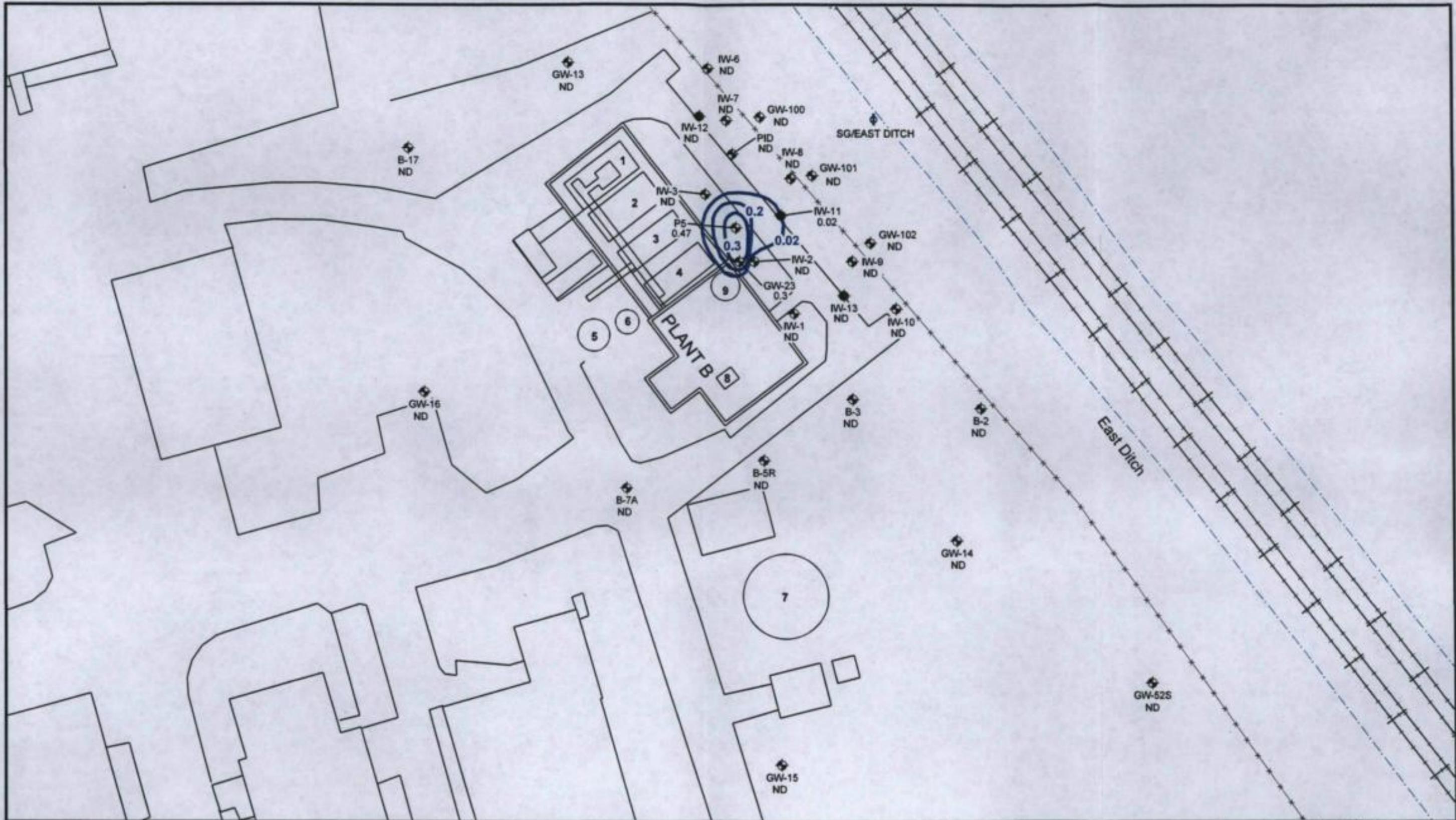
N

0 15 30 60 Feet

**Figure 10**  
 Interpreted Product Thickness  
 Product Measured June 28, 2005

51 Eames Street  
 Wilmington, Massachusetts

PROJ NO	6300030008 52.02	Prepared by BRP
DWG NO		Checked by PHT



Tank#1 - Receives gravity overflow from Tank 2 and allows for further settling  
 Tank#2 - Caustic addition and initial iron drop-out  
 Tank#3 & #4 - Overnight holding tank for treated water  
 Tank#5 - Pre-carbon hold tank  
 Tank#6 - Residence tank  
 Tank#7 - Raw water (pH adjusted)  
 Tank#8 - Pre-carbon transfer  
 Tank#9 - Day discharge to NPDES Outfall 002

**Legend**

Trace - Trace Product (0.01 assigned for contour)  
 ND - Not Detected

◆ Staff Gauge  
 ◆ Existing Well/Wellpoint  
 ◆ Existing Recovery Well

0.1 — Product Thickness Contour (FT)

— Building  
 — Road  
 — Railroad  
 - - - Ditch

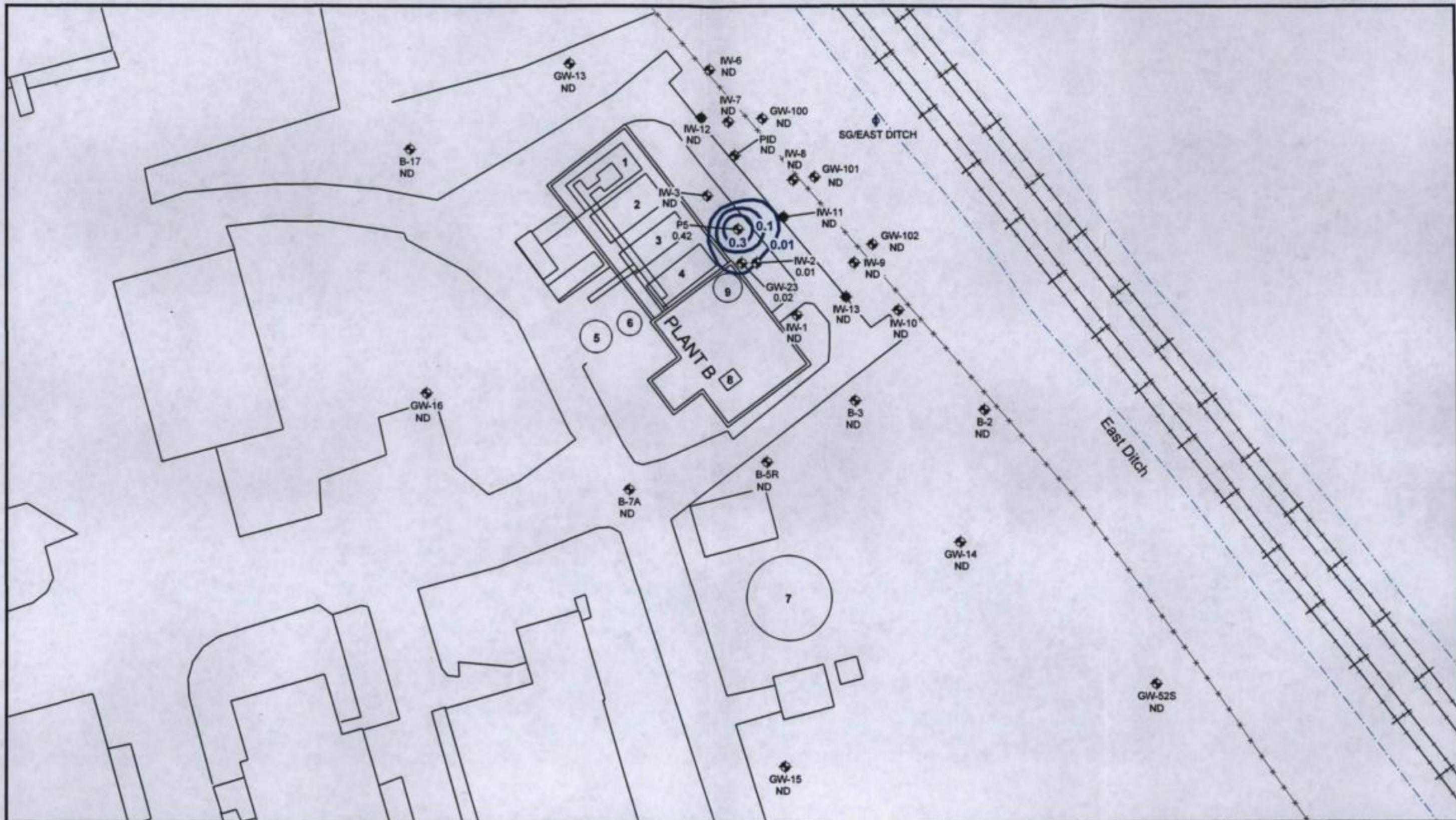
**MACTEC** MACTEC Engineering and Consulting  
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 Warefield, MA 01660

N  
 0 15 30 60 Feet

**Figure 11**  
 Interpreted Product Thickness  
 Product Measured July 26, 2005

51 Eames Street  
 Wilmington, Massachusetts

PRJ NO	6300030008 52.02	Prepared by BRP
DWG NO		Checked by PHT

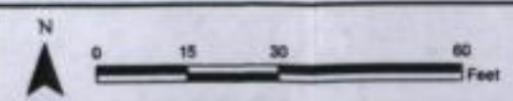


Tank#1 - Receives gravity overflow from Tank 2 and allows for further settling  
 Tank#2 - Caustic addition and initial iron drop-out  
 Tank#3 & #4 - Overnight holding tank for treated water  
 Tank#5 - Pre-carbon hold tank  
 Tank#6 - Residence tank  
 Tank#7 - Raw water (pH adjusted)  
 Tank#8 - Pre-carbon transfer  
 Tank#9 - Day discharge to NPDES Outfall 002

Trace - Trace Product  
 (0.01 assigned for contour)  
 ND - Not Detected

- Legend**
- ◆ Staff Gauge
  - ◆ Existing Well/Wellpoint
  - ◆ Existing Recovery Well
  - Building
  - Road
  - Railroad
  - Ditch
- 0.1 — Product Thickness Contour (FT)

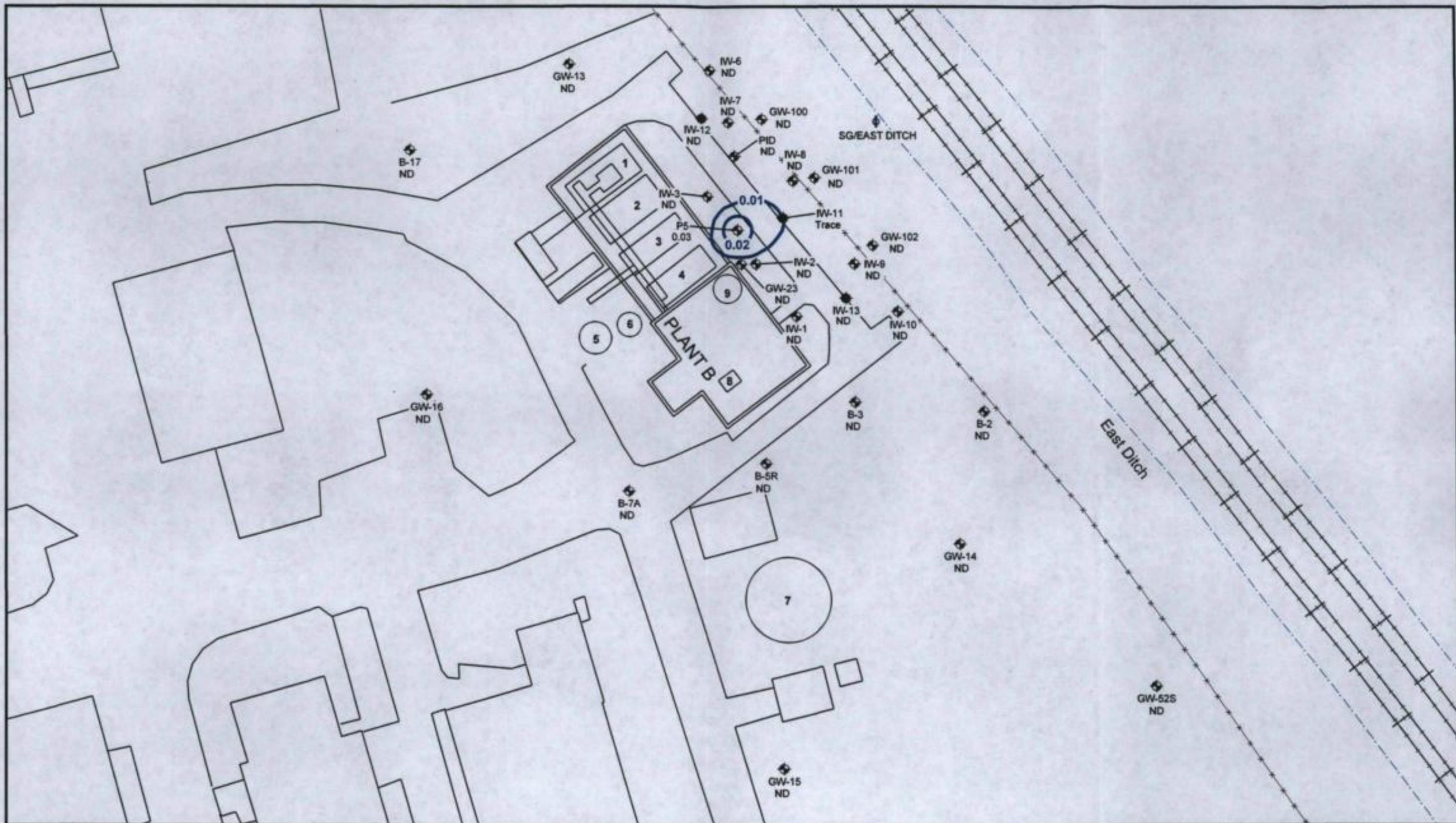
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 Wakefield, MA 01880



**Figure 12**  
 Interpreted Product Thickness  
 Product Measured August 25, 2005

51 Eames Street  
 Wilmington, Massachusetts

PROJ NO	6300030006 52.02	Prepared by BRP
DWG NO		Checked by PHT



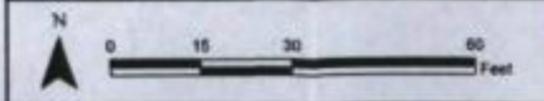
- Tank#1 - Receives gravity overflow from Tank 2 and allows for further settling
- Tank#2 - Caustic addition and initial iron drop-out
- Tank#3 & #4 - Overnight holding tank for treated water
- Tank#5 - Pre-carbon hold tank
- Tank#6 - Residence tank
- Tank#7 - Raw water (pH adjusted)
- Tank#8 - Pre-carbon transfer
- Tank#9 - Day discharge to NPDES Outfall 002

**Legend**

Trace - Trace Product (0.01 assigned for contour) ND - Not Detected	<ul style="list-style-type: none"> <li>◆ Staff Gauge</li> <li>◆ Existing Well/Wellpoint</li> <li>◆ Existing Recovery Well</li> </ul>	<ul style="list-style-type: none"> <li>— Building</li> <li>— Road</li> <li>— Railroad</li> <li>- - - Ditch</li> </ul>
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0.1 — Product Thickness Contour (FT)

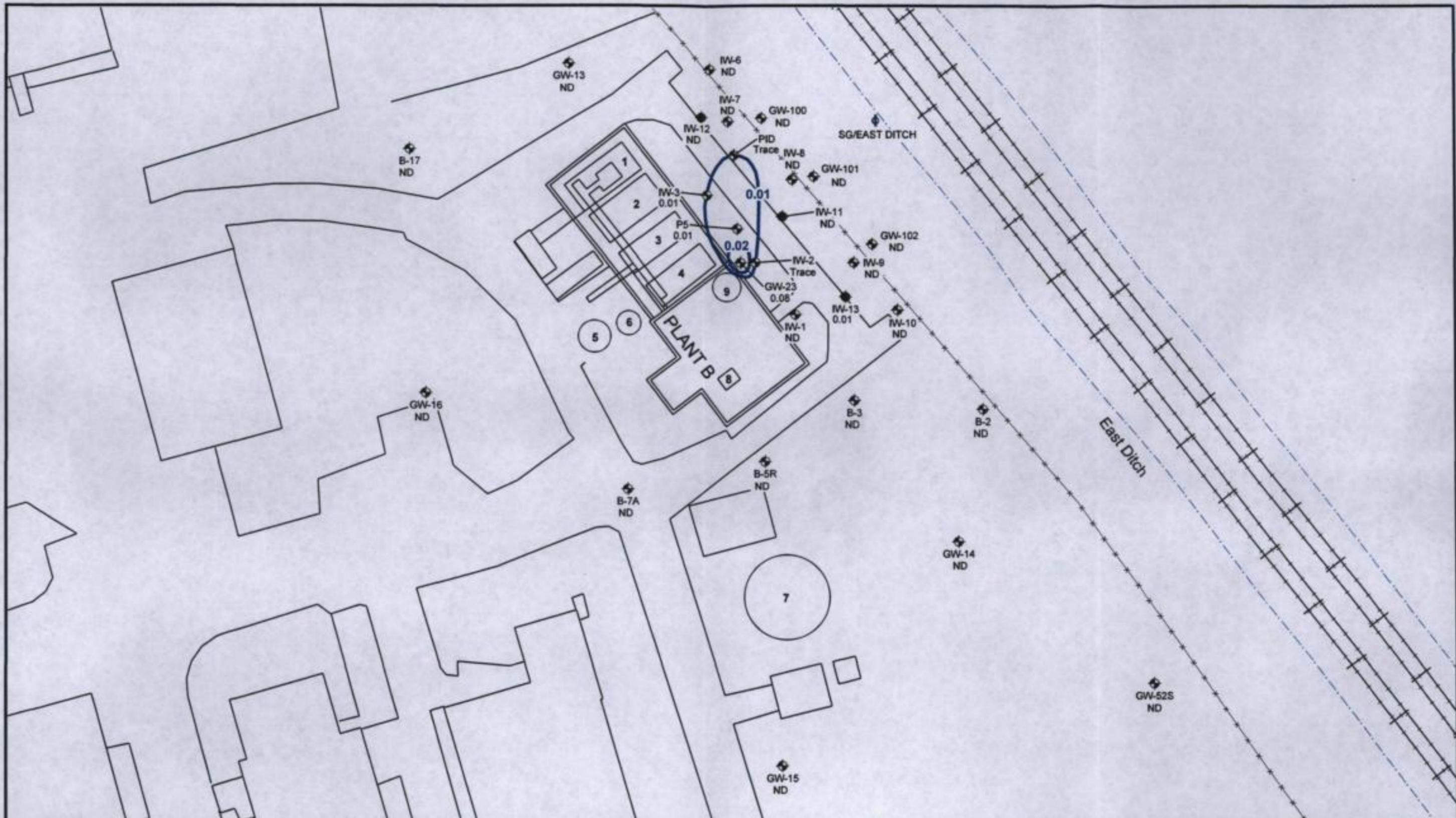
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 Westfield, MA 01080



**Figure 13**  
 Interpreted Product Thickness  
 Product Measured September 20, 2005

**51 Eames Street**  
 Wilmington, Massachusetts

PROJ NO	6300030008 52.02	Prepared by BRP
DWG NO		Checked by PHT



- Tank#1 - Receives gravity overflow from Tank 2 and allows for further settling
- Tank#2 - Caustic addition and initial iron drop-out
- Tank#3 & #4 - Overnight holding tank for treated water
- Tank#5 - Pre-carbon hold tank
- Tank#6 - Residence tank
- Tank#7 - Raw water (pH adjusted)
- Tank#8 - Pre-carbon transfer
- Tank#9 - Day discharge to NPDES Outfall 002

**Legend**

Trace - Trace Product (0.01 assigned for contour)	<ul style="list-style-type: none"> <li>◆ Staff Gauge</li> <li>◆ Existing Well/Wellpoint</li> <li>◆ Existing Recovery Well</li> </ul>	<ul style="list-style-type: none"> <li>— Building</li> <li>— Road</li> <li>— Railroad</li> <li>- - - Ditch</li> </ul>
ND - Not Detected	◆ Product Thickness Contour (FT)	

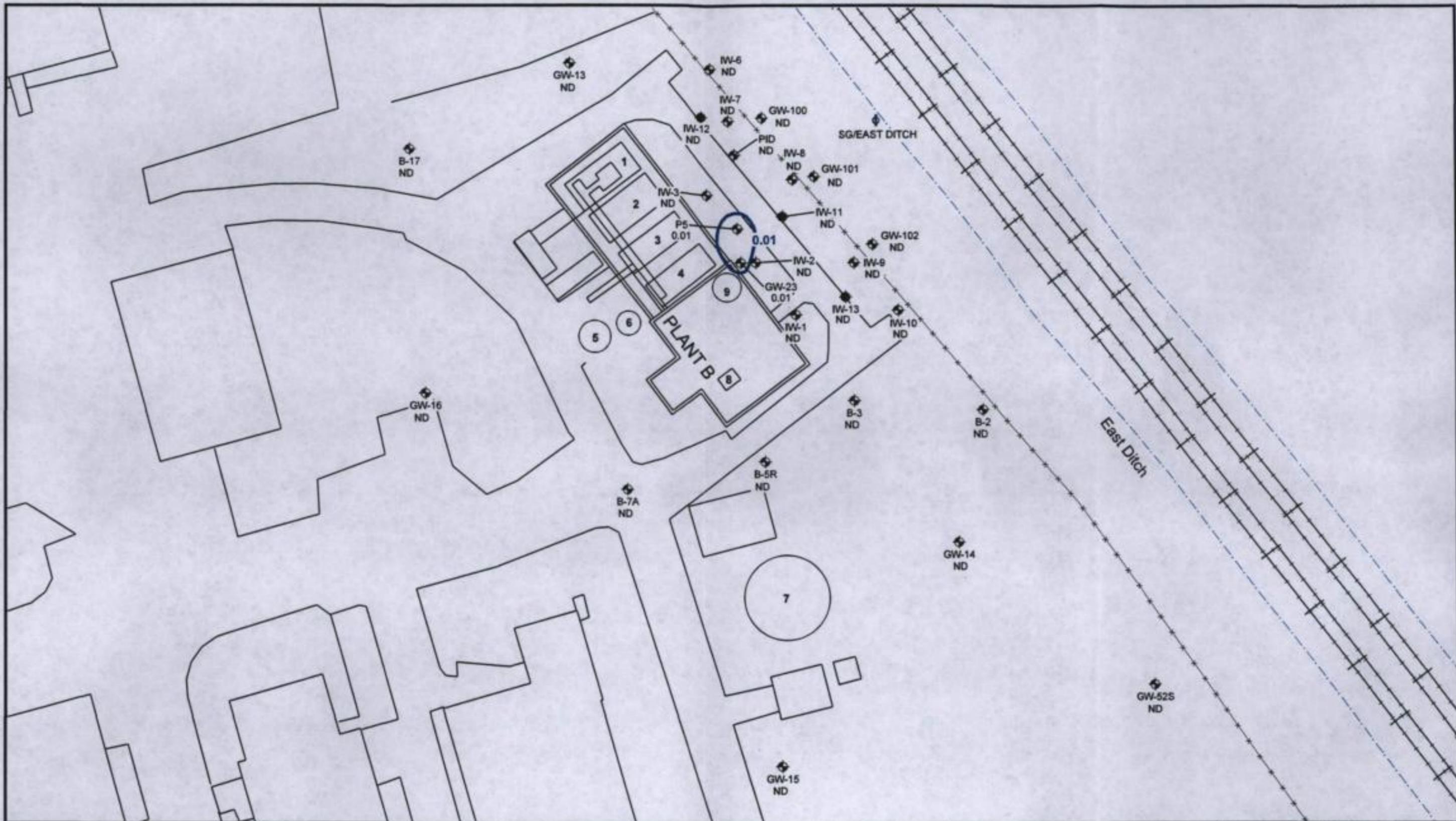
**MACTEC** MACTEC Engineering and Consulting  
107 Audubon Road, Suite 301  
Warefield, MA 01880

N

**Figure 14**  
Interpreted Product Thickness  
Product Measured October 13, 2005

51 Eames Street  
Wilmington, Massachusetts

PROJ NO	6300030008 52.02	Prepared by BRP
DWG NO		Checked by PHT

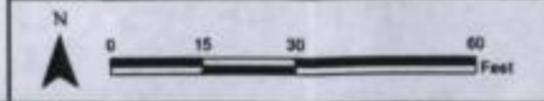


- Tank#1 - Receives gravity overflow from Tank 2 and allows for further settling
- Tank#2 - Caustic addition and initial iron drop-out
- Tank#3 & #4 - Overnight holding tank for treated water
- Tank#5 - Pre-carbon hold tank
- Tank#6 - Residence tank
- Tank#7 - Raw water (pH adjusted)
- Tank#8 - Pre-carbon transfer
- Tank#9 - Day discharge to NPDES Outfall 002

**Legend**

Trace - Trace Product (0.01 assigned for contour)	<ul style="list-style-type: none"> <li>◆ Staff Gauge</li> <li>◆ Existing Well/Wellpoint</li> <li>◆ Existing Recovery Well</li> </ul>	<ul style="list-style-type: none"> <li>— Building</li> <li>— Road</li> <li>— Railroad</li> <li>- - - Ditch</li> </ul>
ND - Not Detected	◆	◆
0.1	—	—
—	—	—

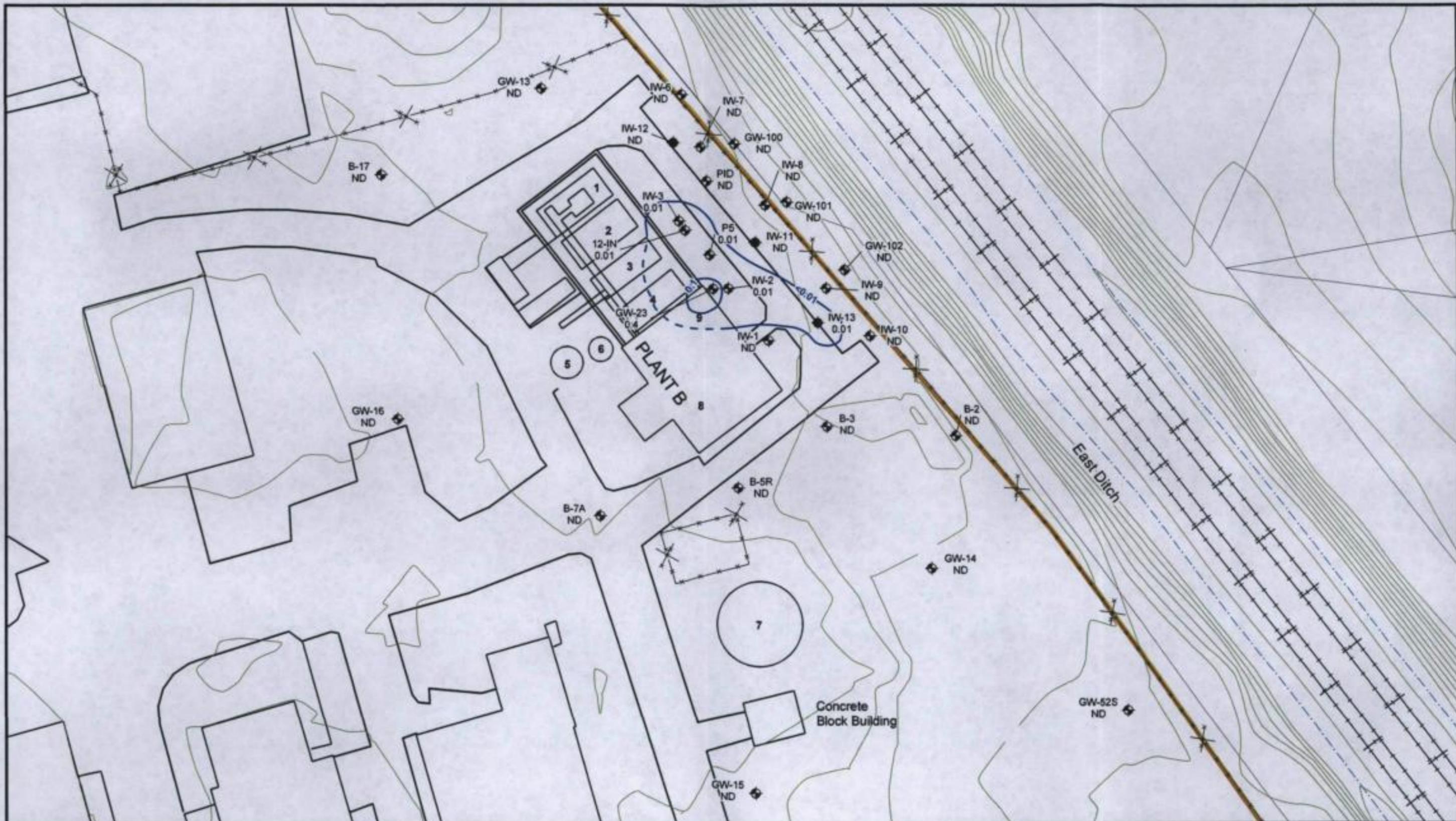
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Wakefield, MA 01880



**Figure 15**  
Interpreted Product Thickness  
Product Measured November 9, 2005

**51 Eames Street**  
Wilmington, Massachusetts

PROJ NO	6300030008 52.02	Prepared by BRP
DWO NO		Checked by PHT

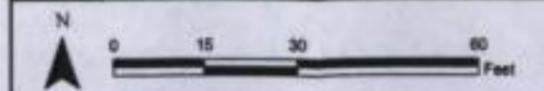


- Tank #1 - Receives gravity overflow from Tank 2 and allows for further settling
- Tank #2 - Caustic addition and initial iron drop-out
- Tank #3 & #4 - Overnight holding tank for treated water
- Tank #5 - Pre-carbon hold tank
- Tank #6 - Residence tank
- Tank #7 - Raw water (pH adjusted)
- Tank #8 - Pre-carbon transfer
- Tank #9 - Day discharge to NPDES Outfall 002

**Legend**

- Interpreted LNAPL Thickness Contour (ft)
- - - Inferred LNAPL Thickness Contour (ft)
- ◆ Recovery Well
- ◇ Monitoring Well
- - - Ditch
- Elevation Contours
- ND Not Detected

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**Plant B Interpreted LNAPL Thickness Contours**  
 December 2005

Olin Chemical Superfund Site  
 Wilmington, Massachusetts

Prepared/Date: BJR 03/05/06 Checked/Date: PHT 03/05/06

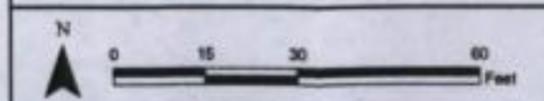


- Tank #1 - Receives gravity overflow from Tank 2 and allows for further settling
- Tank #2 - Caustic addition and initial iron drop-out
- Tank #3 & #4 - Overnight holding tank for treated water
- Tank #5 - Pre-carbon hold tank
- Tank #6 - Residence tank
- Tank #7 - Raw water (pH adjusted)
- Tank #8 - Pre-carbon transfer
- Tank #9 - Day discharge to NPDES Outfall 002

**Legend**

- Interpreted LNAPL Thickness Contour (ft)
- - - Inferred LNAPL Thickness Contour (ft)
- ◆ Recovery Well
- ◆ Monitoring Well
- - - Ditch
- Elevation Contours
- ND Not Detected

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 107 Audubon Road, Suite 301  
 Waverlet, MA 01983



**Plant B Interpreted LNAPL Thickness Contours**  
 January 2006

Olin Chemical Superfund Site  
 Wilmington, Massachusetts

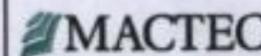
Prepared/Date: EJR 03/05/06 Checked/Date: PHT 03/05/06



- Tank #1 - Receives gravity overflow from Tank 2 and allows for further settling
- Tank #2 - Caustic addition and initial iron drop-out
- Tank #3 & #4 - Overnight holding tank for treated water
- Tank #5 - Pre-carbon hold tank
- Tank #6 - Residence tank
- Tank #7 - Raw water (pH adjusted)
- Tank #8 - Pre-carbon transfer
- Tank #9 - Day discharge to NPDES Outfall 002

**Legend**

- Interpreted LNAPL Thickness Contour (ft)
- - - Inferred LNAPL Thickness Contour (ft)
- ◆ Recovery Well
- ⊕ Monitoring Well
- - - Ditch
- Elevation Contours
- ND Not Detected

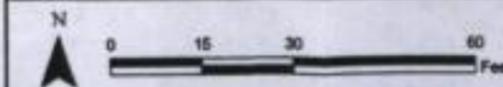


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**Plant B Interpreted LNAPL Thickness Contours  
February 2006**

Olin Chemical Superfund Site  
Wilmington, Massachusetts

Prepared/Date: SJR 03/05/06 Checked/Date: PHT 03/05/06

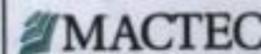




- Tank #1 - Receives gravity overflow from Tank 2 and allows for further settling
- Tank #2 - Caustic addition and initial iron drop-out
- Tank #3 & #4 - Overnight holding tank for treated water
- Tank #5 - Pre-carbon hold tank
- Tank #6 - Residence tank
- Tank #7 - Raw water (pH adjusted)
- Tank #8 - Pre-carbon transfer
- Tank #9 - Day discharge to NPDES Outfall 002

**Legend**

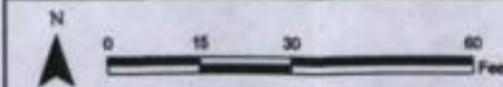
- Interpreted LNAPL Thickness Contour (ft)
- - - Inferred LNAPL Thickness Contour (ft)
- ◆ Recovery Well
- ◆ Monitoring Well
- Ditch
- Elevation Contours
- ND Not Detected



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**Plant B Interpreted LNAPL Thickness Contours  
March 2006**

Olin Chemical Superfund Site  
Wilmington, Massachusetts



Prepared Date: BJR 03/05/06    Checked Date: PHT 03/05/06

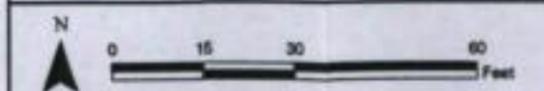


- Tank #1 - Receives gravity overflow from Tank 2 and allows for further settling
- Tank #2 - Caustic addition and initial iron drop-out
- Tank #3 & #4 - Overnight holding tank for treated water
- Tank #5 - Pre-carbon hold tank
- Tank #6 - Residence tank
- Tank #7 - Raw water (pH adjusted)
- Tank #8 - Pre-carbon transfer
- Tank #9 - Day discharge to NPDES Outfall 002

**Legend**

- Interpreted LNAPL Thickness Contour (ft)
- - - Inferred LNAPL Thickness Contour (ft)
- ◆ Recovery Well
- ◆ Monitoring Well
- - - Ditch
- Elevation Contours
- ND Not Detected

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**Plant B Interpreted LNAPL Thickness Contours**  
 April 2006

Olin Chemical Superfund Site  
 Wilmington, Massachusetts

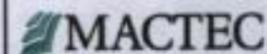
Prepared/Date: BJR 03/05/08 Checked/Date: PHT 03/05/08



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- Tank #8 - Pre-carbon transfer
- Tank #9 - Day discharge to NPDES Outfall 002

**Legend**

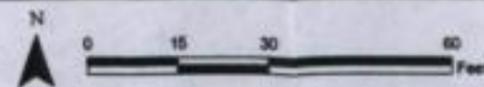
- Interpreted LNAPL Thickness Contour (ft)
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- ◆ Recovery Well
- ⊕ Monitoring Well
- - - Ditch
- Elevation Contours
- ND Not Detected



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**Plant B Interpreted LNAPL Thickness Contours  
May 2006**

Olin Chemical Superfund Site  
Wilmington, Massachusetts



Prepared/Date: BJR 03/05/06    Checked/Date: PHT 03/05/06

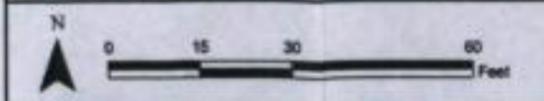


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- Tank #8 - Pre-carbon transfer
- Tank #9 - Day discharge to NPDES Outfall 002

**Legend**

- Interpreted LNAPL Thickness Contour (ft)
- - - Inferred LNAPL Thickness Contour (ft)
- Ditch
- Elevation Contours
- ◆ Recovery Well
- ND Not Detected
- ⊕ Monitoring Well

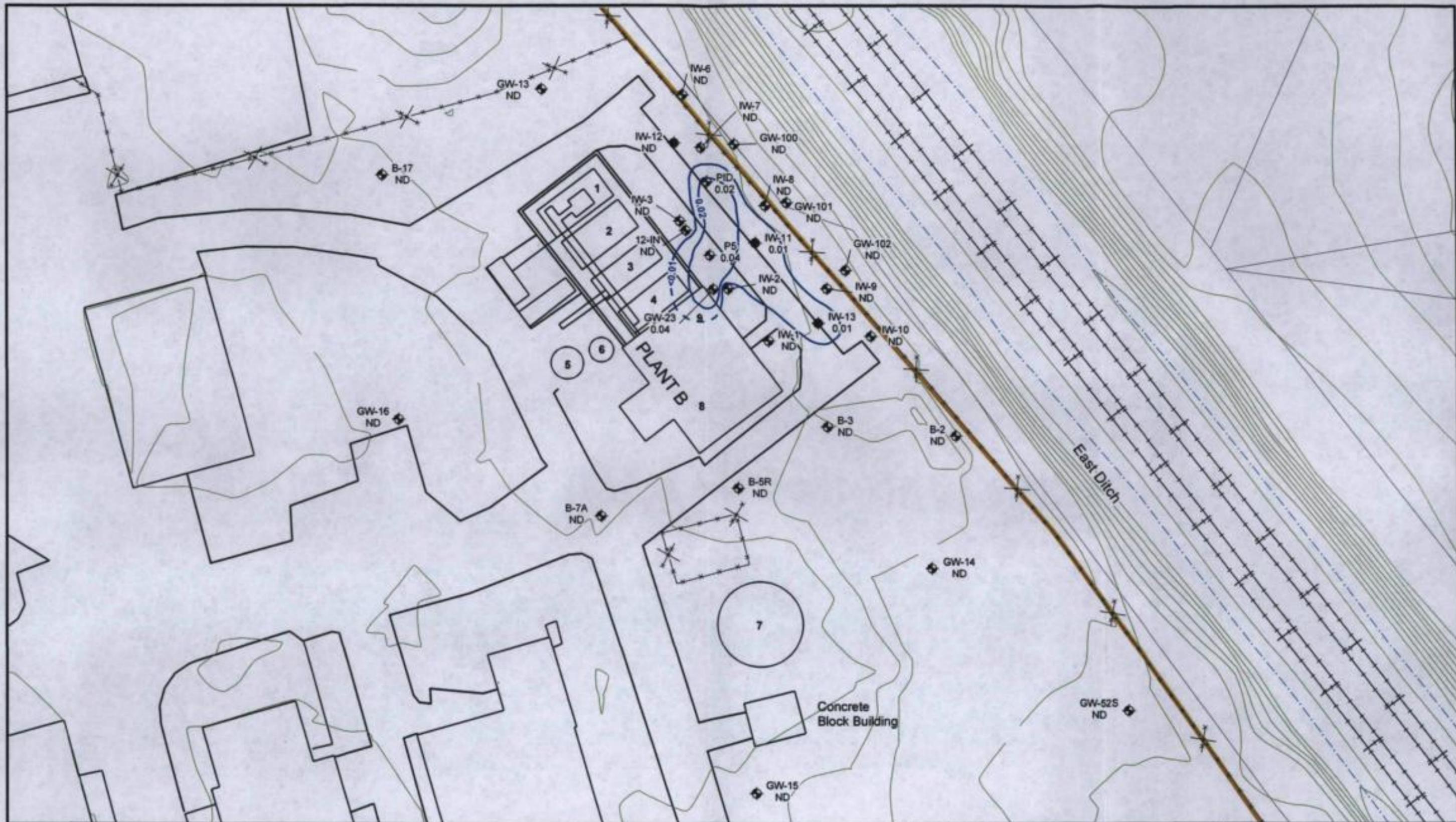
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**Plant B Interpreted LNAPL Thickness Contours**  
 June 2006

**Olin Chemical Superfund Site**  
 Wilmington, Massachusetts

Prepared/Date: SJR 03/05/08    Checked/Date: PHT 03/05/08

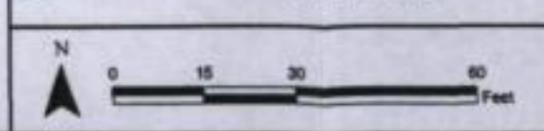


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- Tank #6 - Residence tank
- Tank #7 - Raw water (pH adjusted)
- Tank #8 - Pre-carbon transfer
- Tank #9 - Day discharge to NPDES Outfall 002

**Legend**

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- - - Inferred LNAPL Thickness Contour (ft)
- ◆ Recovery Well
- ⊕ Monitoring Well
- - - Ditch
- Elevation Contours
- ND Not Detected

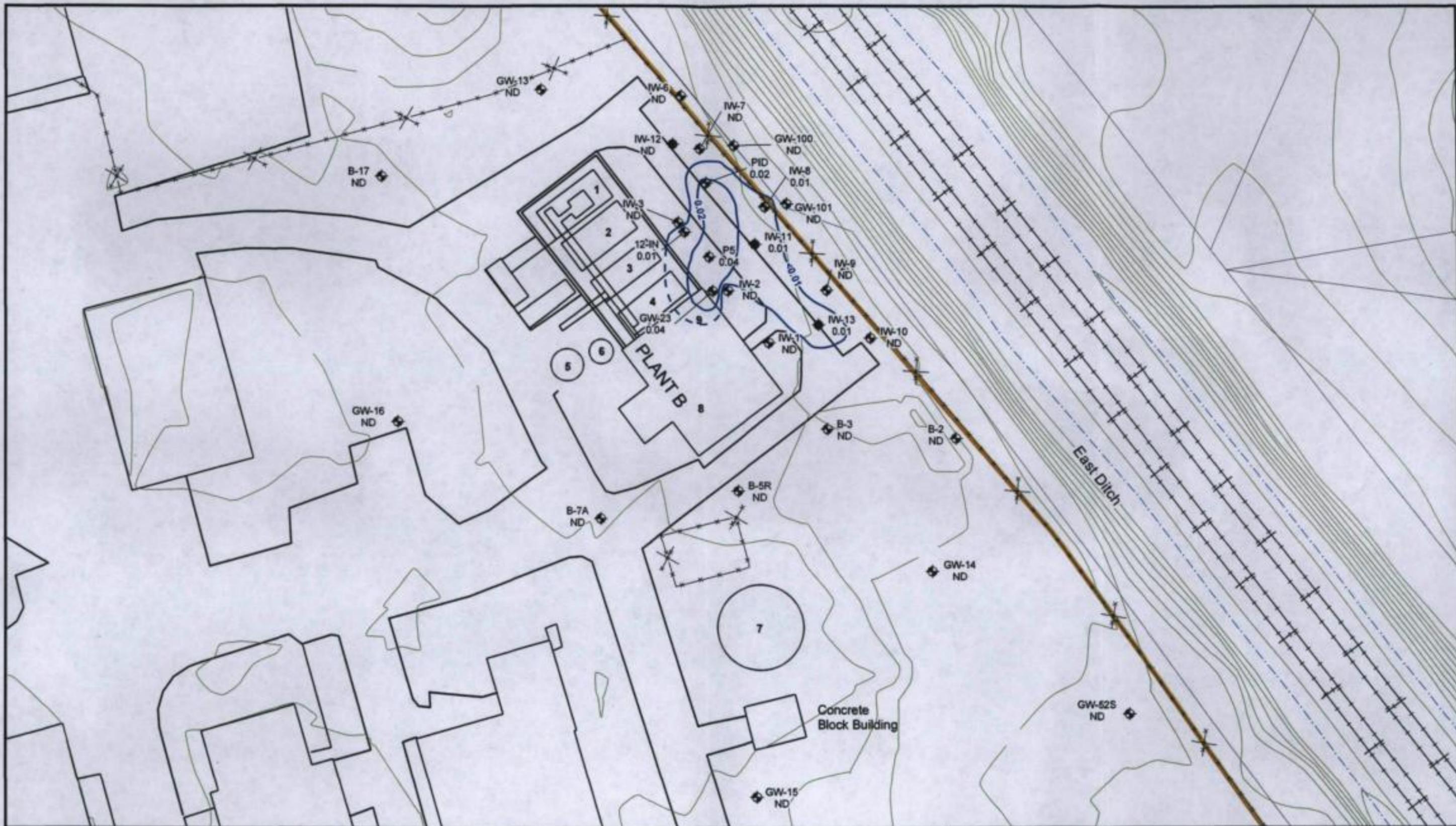
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**Plant B Interpreted LNAPL Thickness Contours**  
 July 2006

Olin Chemical Superfund Site  
 Wilmington, Massachusetts

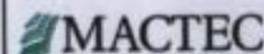
Prepared/Date: BJR 03/05/08 Checked/Date: PHT 03/05/08



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**Legend**

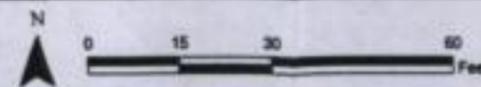
- Interpreted LNAPL Thickness Contour (ft)
- - - Inferred LNAPL Thickness Contour (ft)
- ◆ Recovery Well
- ◆ Monitoring Well
- - - Ditch
- Elevation Contours
- ND Not Detected



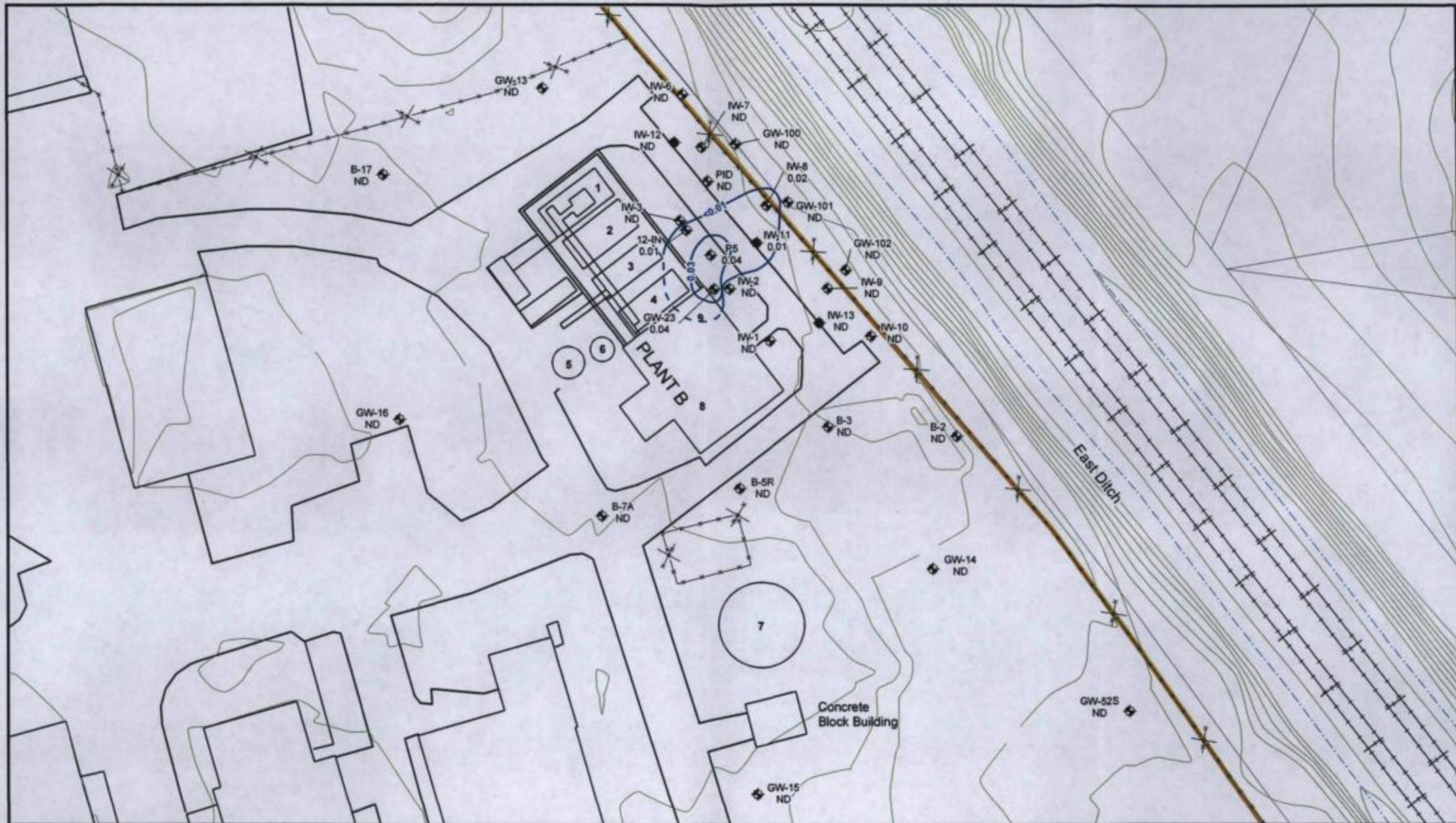
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**Plant B Interpreted LNAPL Thickness Contours  
August 2006**

Olin Chemical Superfund Site  
Wilmington, Massachusetts



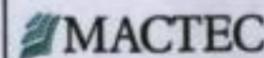
Prepared/Date: BUR 03/05/06    Checked/Date: PHT 03/05/06



- Tank #1 - Receives gravity overflow from Tank 2 and allows for further settling
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- Tank #7 - Raw water (pH adjusted)
- Tank #8 - Pre-carbon transfer
- Tank #9 - Day discharge to NPDES Outfall 002

**Legend**

- Interpreted LNAPL Thickness Contour (ft)
- - - Inferred LNAPL Thickness Contour (ft)
- ◆ Recovery Well
- ⊕ Monitoring Well
- - - Ditch
- Elevation Contours
- ND Not Detected



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**Plant B Interpreted LNAPL Thickness Contours**  
September 2006

Olin Chemical Superfund Site  
Wilmington, Massachusetts



Prepared/Date: BUR 03/05/06    Checked/Date: PHT 03/05/06

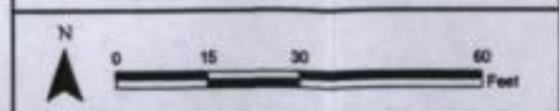


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- Tank #8 - Pre-carbon transfer
- Tank #9 - Day discharge to NPDES Outfall 002

**Legend**

- Interpreted LNAPL Thickness Contour (ft)
- - - Inferred LNAPL Thickness Contour (ft)
- Ditch
- Elevation Contours
- ◆ Recovery Well
- ND Not Detected
- ⊕ Monitoring Well

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**Plant B Interpreted LNAPL Thickness Contours**  
 October 2006

**Olin Chemical Superfund Site**  
 Wilmington, Massachusetts

Prepared/Date: BJR 03/05/08 Checked/Date: PHT 03/05/08

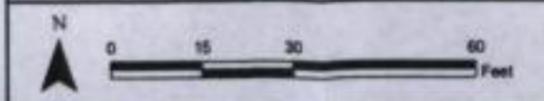


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- Tank #5 - Pre-carbon hold tank
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**Legend**

- Interpreted LNAPL Thickness Contour (ft)
- - - Inferred LNAPL Thickness Contour (ft)
- ◆ Recovery Well
- ◻ Monitoring Well
- - - Ditch
- Elevation Contours
- ND Not Detected

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**Plant B Interpreted LNAPL Thickness Contours**  
 November 2006

Olin Chemical Superfund Site  
 Wilmington, Massachusetts

Prepared/Date: BJR 03/05/08 Checked/Date: PHT 03/05/08



- Tank #1 - Receives gravity overflow from Tank 2 and allows for further settling
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- Tank #7 - Raw water (pH adjusted)
- Tank #8 - Pre-carbon transfer
- Tank #9 - Day discharge to NPDES Outfall 002

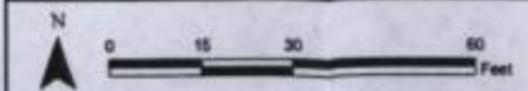
**Legend**

- Interpreted LNAPL Thickness Contour (ft)
- - - Inferred LNAPL Thickness Contour (ft)
- ◆ Recovery Well
- ⊕ Monitoring Well
- - - Ditch
- Elevation Contours
- ND Not Detected

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**Plant B Interpreted LNAPL Thickness Contours**  
 December 2006

Olin Chemical Superfund Site  
 Wilmington, Massachusetts



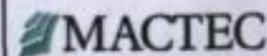
Prepared/Date: BJR 03/05/06 Checked/Date: PHT 03/05/06



Tank #1 - Receives gravity overflow from Tank 2 and allows for further settling  
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 Tank #3 & #4 - Overnight holding tank for treated water  
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 Tank #6 - Residence tank  
 Tank #7 - Raw water (pH adjusted)  
 Tank #8 - Pre-carbon transfer  
 Tank #9 - Day discharge to NPDES Outfall 002

**Legend**

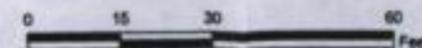
- Product Thickness Contour (ft)
- - - Inferred Product Thickness Contour (ft)
- ◆ Recovery Well
- ◆ Monitoring Well
- - - Ditch
- Elevation Contours
- ND Not Detected



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**Plant B Interpreted LNAPL Thickness Contours**  
 January 2007

Olin Chemical Superfund Site  
 Wilmington, Massachusetts



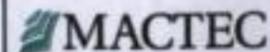
Prepared/Date: BJR 03/05/08 Checked/Date: PHT 03/05/08



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- Tank #8 - Pre-carbon transfer
- Tank #9 - Day discharge to NPDES Outfall 002

**Legend**

- Product Thickness Contour (ft)
- Ditch
- - - Inferred Product Thickness Contour (ft)
- Elevation Contours
- ◆ Recovery Well
- ND Not Detected
- ◆ Monitoring Well



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**Plant B Interpreted LNAPL Thickness Contours**  
February 2007

Olin Chemical Superfund Site  
Wilmington, Massachusetts



Prepared/Date: BJR 03/05/08    Checked/Date: PHT 03/05/08



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- Tank #7 - Raw water (pH adjusted)
- Tank #8 - Pre-carbon transfer
- Tank #9 - Day discharge to NPDES Outfall 002

**LNAPL\_Thickness\_Contours\_Dec05\_Oct07**

Type	---	Ditch
—	—	Elevation Contours
—	—	Product Thickness Contour (ft)
- - -	- - -	Inferred Product Thickness Contour (ft)
◆	ND	Recovery Well Not Detected
⊕		Monitoring Well

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N  
 0 15 30 60 Feet

**Plant B Interpreted LNAPL Thickness Contours**  
 March 2007

Olin Chemical Superfund Site  
 Wilmington, Massachusetts

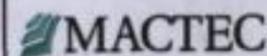
Prepared/Date: BJR 03/05/08 Checked/Date: PHT 03/05/08



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**Legend**

- Product Thickness Contour (ft)
- - - Ditch
- - - Inferred Product Thickness Contour (ft)
- Elevation Contours
- ◆ Recovery Well
- ND Not Detected
- ◆ Monitoring Well

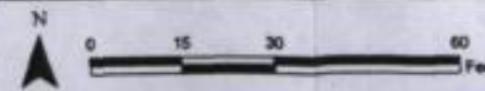


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**Plant B Interpreted LNAPL Thickness Contours  
April 2007**

Olin Chemical Superfund Site  
Wilmington, Massachusetts

Prepared/Date: BJR 03/05/08    Checked/Date: PHT 03/05/08

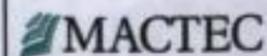




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- Tank #9 - Day discharge to NPDES Outfall 002

**Legend**

- Product Thickness Contour (ft)
- - - Ditch
- - - Inferred Product Thickness Contour (ft)
- Elevation Contours
- ◆ Recovery Well
- ND Not Detected
- ◆ Monitoring Well



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**Plant B Interpreted LNAPL Thickness Contours  
May 2007**

Olin Chemical Superfund Site  
Wilmington, Massachusetts

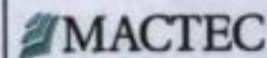
Prepared/Date: EJR 03/05/08    Checked/Date: PHT 03/05/08



Tank #1 - Receives gravity overflow from Tank 2 and allows for further settling  
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**Legend**

- Product Thickness Contour (ft)
- - - Inferred Product Thickness Contour (ft)
- ◆ Recovery Well
- ⊕ Monitoring Well
- - - Ditch
- Elevation Contours
- ND Not Detected

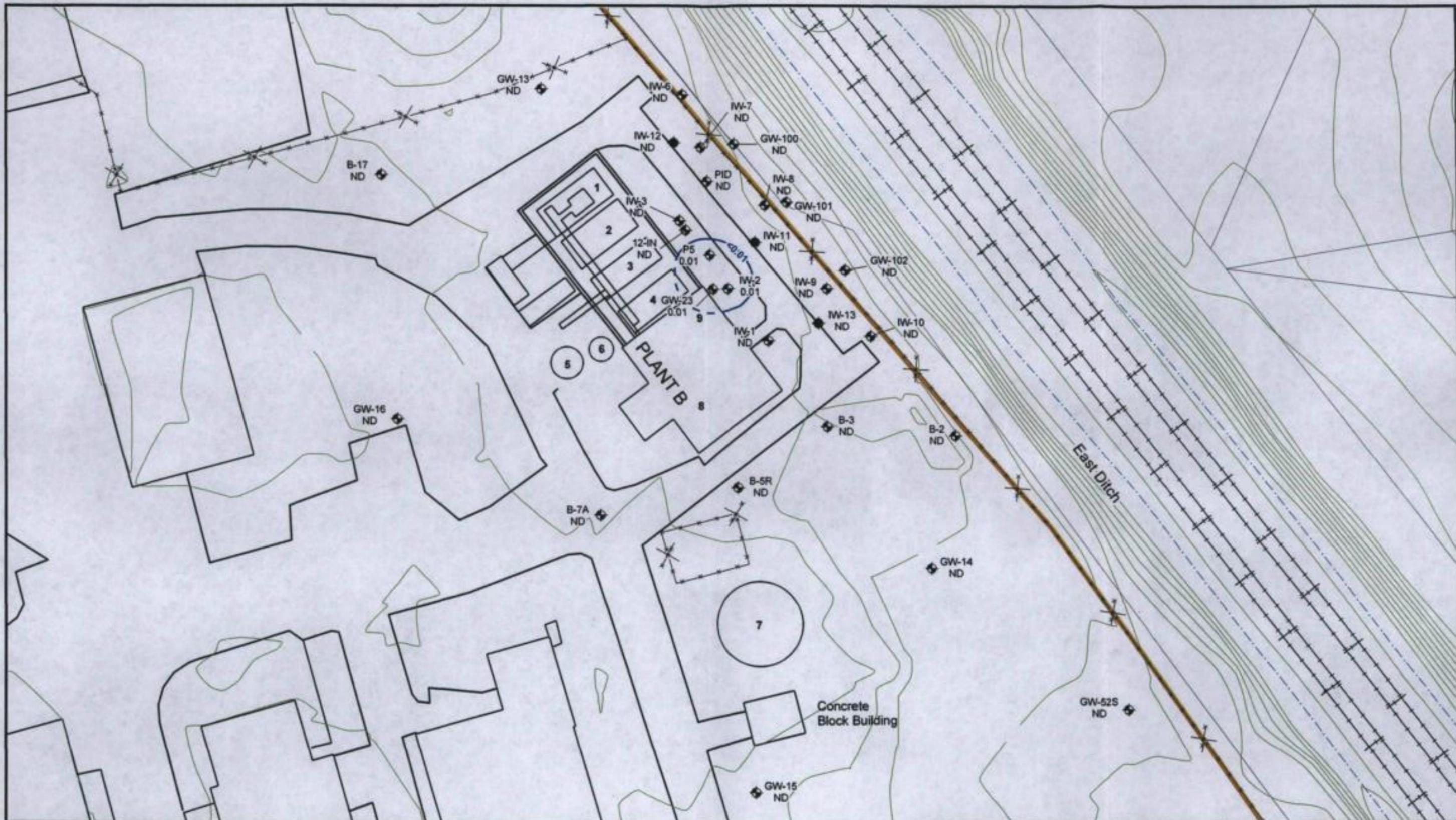


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**Plant B Interpreted LNAPL Thickness Contours  
 June 2007**

Olin Chemical Superfund Site  
 Wilmington, Massachusetts

Prepared/Date: BJR 03/05/08    Checked/Date: PHT 03/05/08

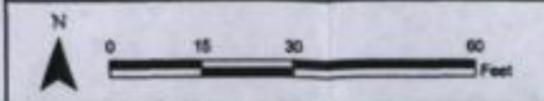


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**Legend**

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- Ditch
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- ND Not Detected
- ⊕ Monitoring Well

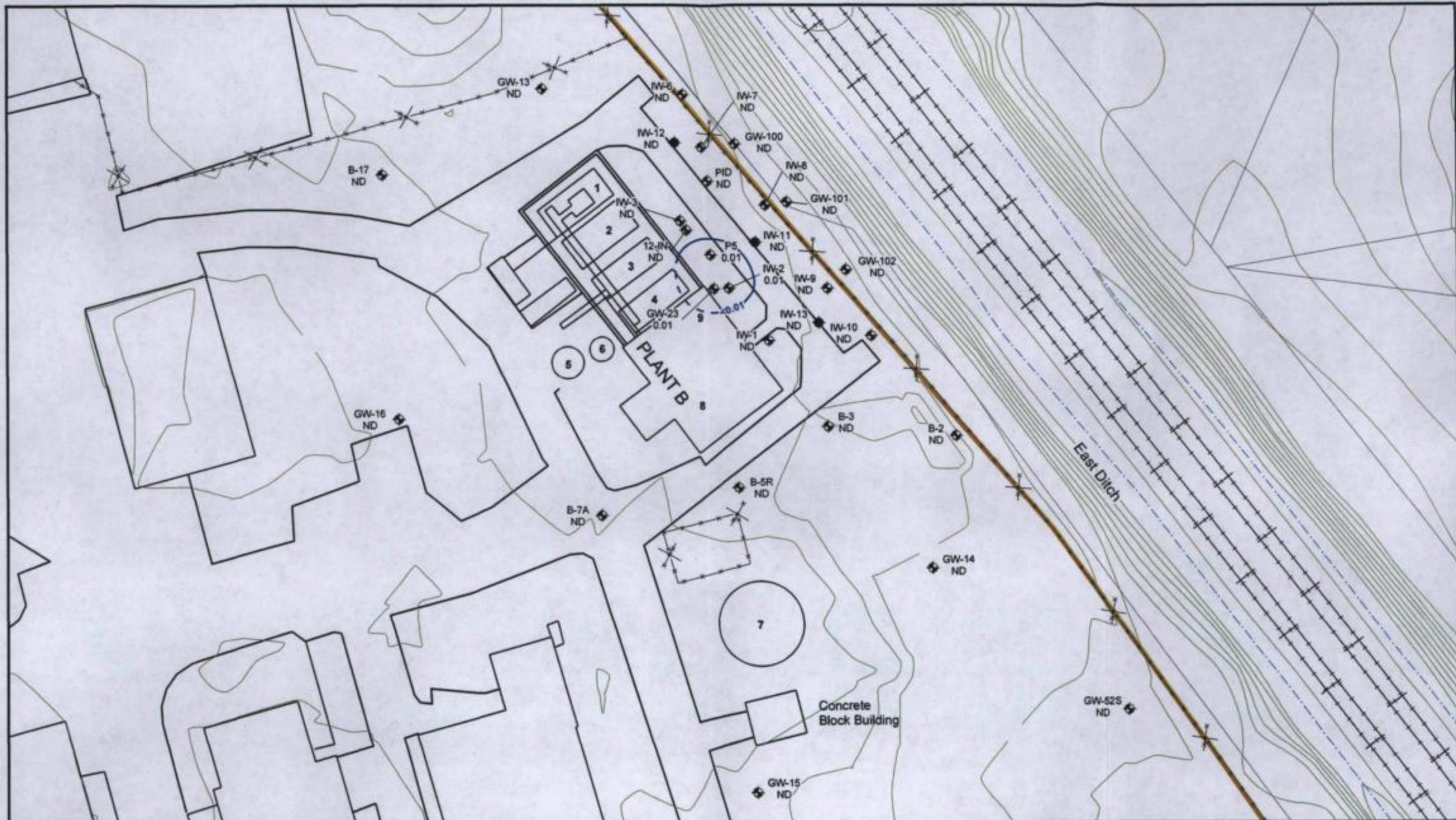
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 Wakefield, MA 01880



**Plant B Interpreted LNAPL Thickness Contours  
 July 2007**

Olin Chemical Superfund Site  
 Wilmington, Massachusetts

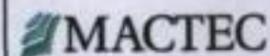
Prepared/Date: BJR 03/05/08 Checked/Date: PHT 03/05/08



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- Tank #9 - Day discharge to NPDES Outfall 002

**Legend**

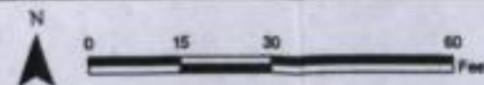
- Interpreted LNAPL Thickness Contour (ft)
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- ◆ Monitoring Well
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- Elevation Contours
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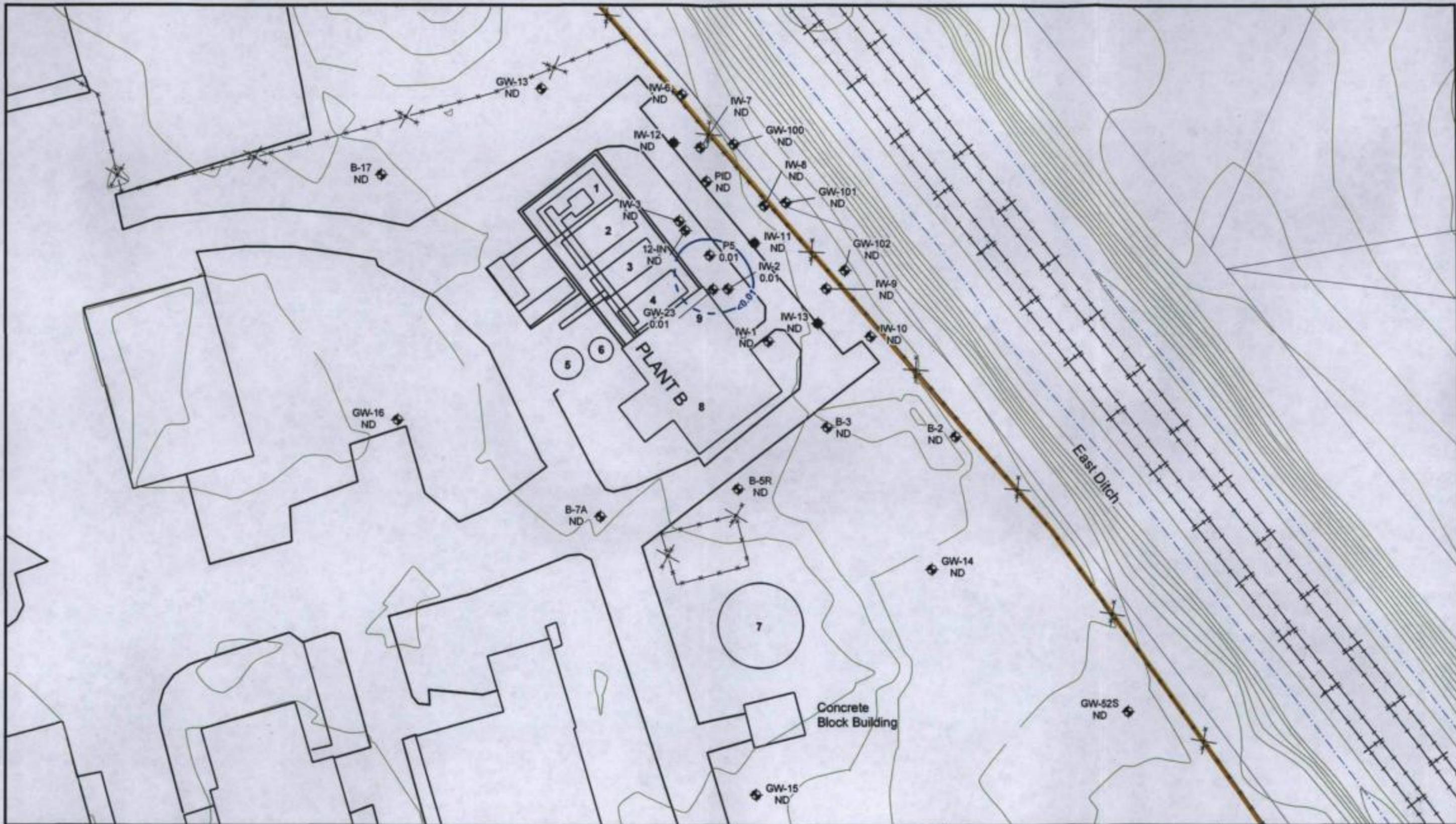
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**Plant B Interpreted LNAPL Thickness Contours  
August 2007**

Olin Chemical Superfund Site  
Wilmington, Massachusetts



Prepared/Date: BJR 03/05/08    Checked/Date: PHT 03/05/08

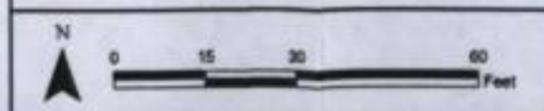


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- Tank #8 - Pre-carbon transfer
- Tank #9 - Day discharge to NPDES Outfall 002

**Legend**

- Interpreted LNAPL Thickness Contour (ft)
- - - Ditch
- - - Inferred Product Thickness Contour (ft)
- Elevation Contours
- ◆ Recovery Well
- ND Not Detected
- ⊕ Monitoring Well

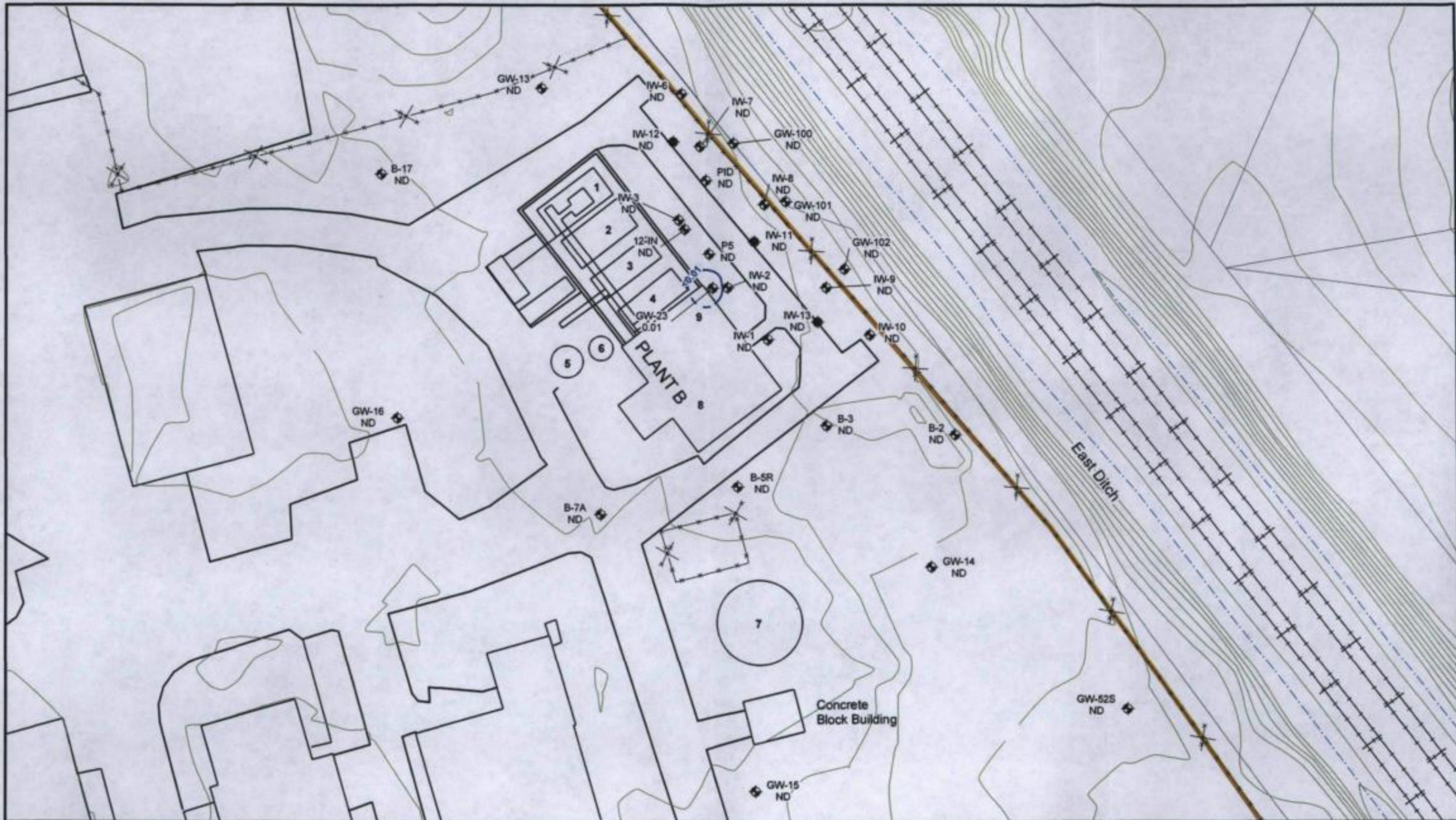
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**Plant B Interpreted LNAPL Thickness Contours**  
 September 2007

Olin Chemical Superfund Site  
 Wilmington, Massachusetts

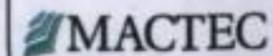
Prepared/Date: BJR 03/05/08    Checked/Date: PHT 03/05/08



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- Tank #9 - Day discharge to NPDES Outfall 002

**Legend**

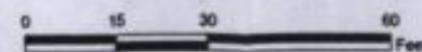
- Interpreted LNAPL Thickness Contour (ft)
- - - Inferred LNAPL Thickness Contour (ft)
- ◆ Recovery Well
- ◆ Monitoring Well
- - - Ditch
- Elevation Contours
- ND Not Detected



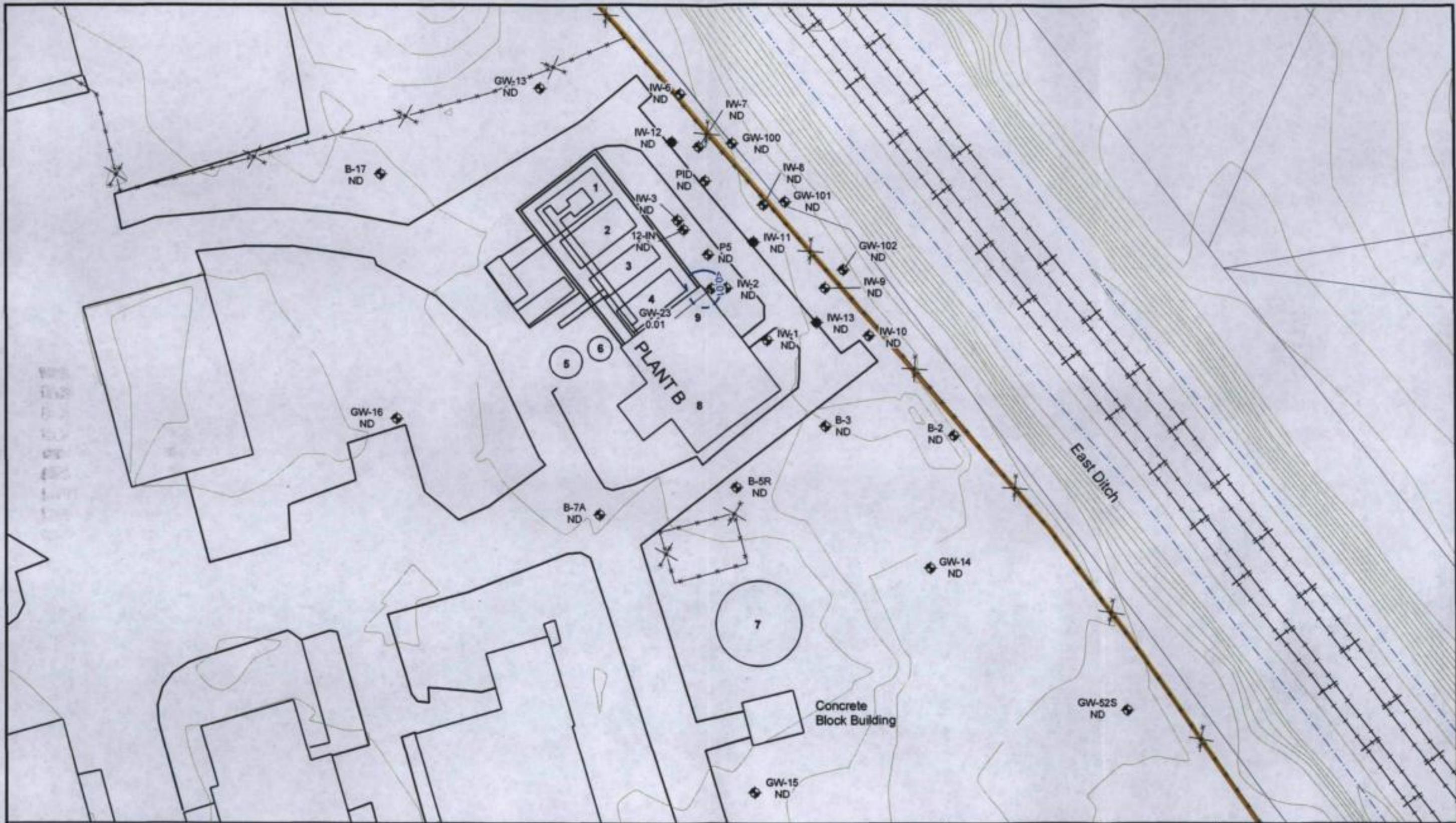
MACTEC Engineering and Consulting  
107 Audubon Road, Suite 301  
Waketek, MA 01880

**Plant B Interpreted LNAPL Thickness Contours**  
October 2007

Olin Chemical Superfund Site  
Wilmington, Massachusetts



Prepared/Date: BJR 03/05/08    Checked/Date: PHT 03/05/08



- Tank #1 - Receives gravity overflow from Tank 2 and allows for further settling
- Tank #2 - Caustic addition and initial iron drop-out
- Tank #3 & #4 - Overnight holding tank for treated water
- Tank #5 - Pre-carbon hold tank
- Tank #6 - Residence tank
- Tank #7 - Raw water (pH adjusted)
- Tank #8 - Pre-carbon transfer
- Tank #9 - Day discharge to NPDES Outfall 002

**Legend**

- Interpreted LNAPL Thickness Contour (ft)
- - - Inferred LNAPL Thickness Contour (ft)
- Ditch
- Elevation Contours
- ◆ Recovery Well
- ◆ Monitoring Well
- ND Not Detected

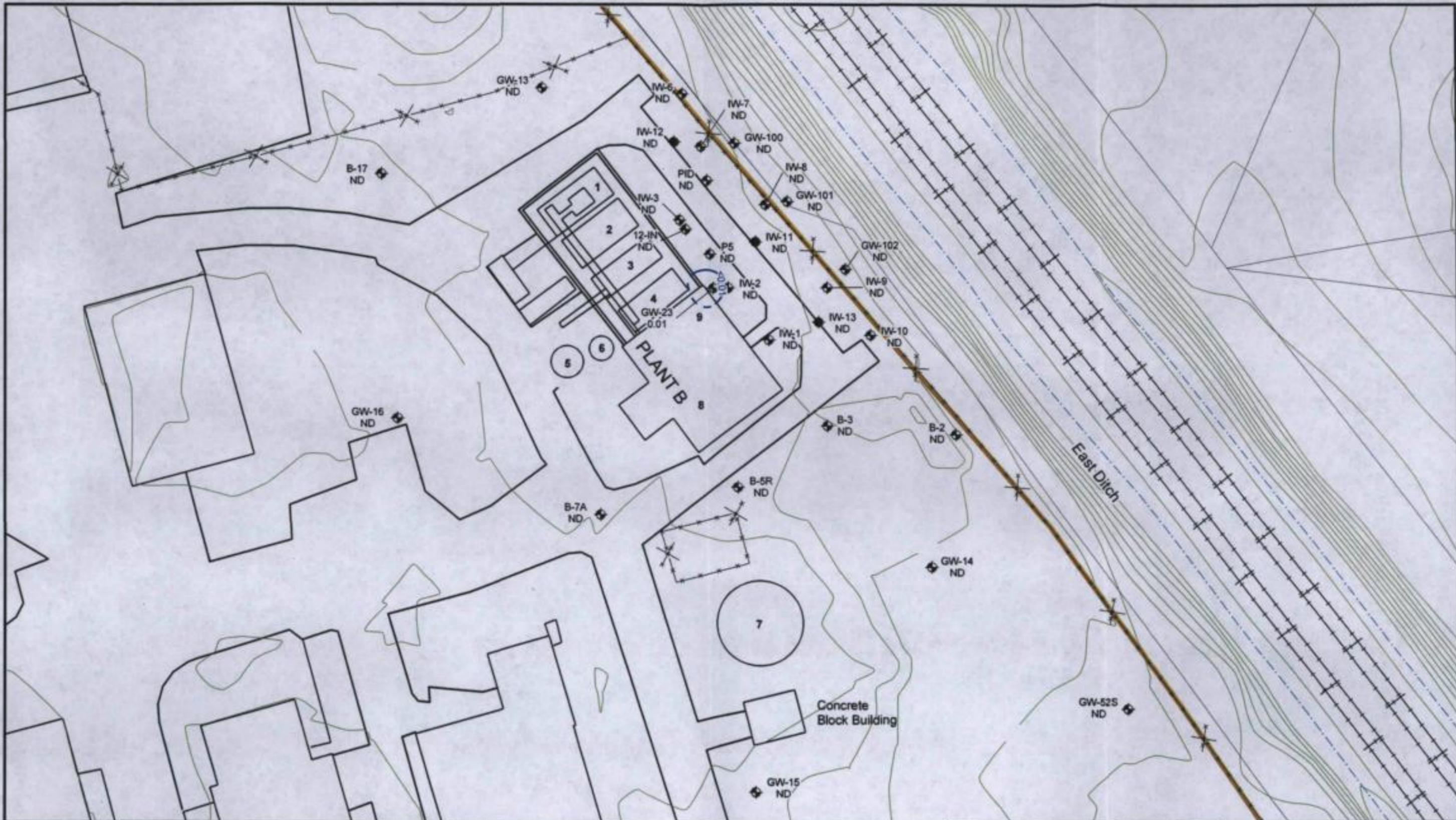
**MACTEC** MACTEC Engineering and Consulting  
 107 Audubon Road, Suite 301  
 Wakefield, MA 01880

N  
 0 15 30 60  
 Feet

**Plant B Interpreted LNAPL Thickness Contours**  
 January 2008

Olin Chemical Superfund Site  
 Wilmington, Massachusetts

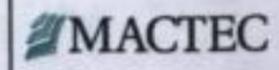
Prepared/Date: EJR 03/06/08 Checked/Date: PHT 03/06/08



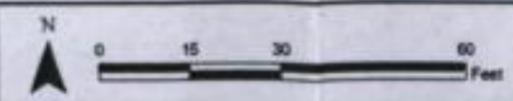
- Tank #1 - Receives gravity overflow from Tank 2 and allows for further settling
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- Tank #9 - Day discharge to NPDES Outfall 002

**Legend**

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- - - Inferred LNAPL Thickness Contour (ft)
- ◆ Recovery Well
- ⊕ Monitoring Well
- - - Ditch
- Elevation Contours
- ND Not Detected



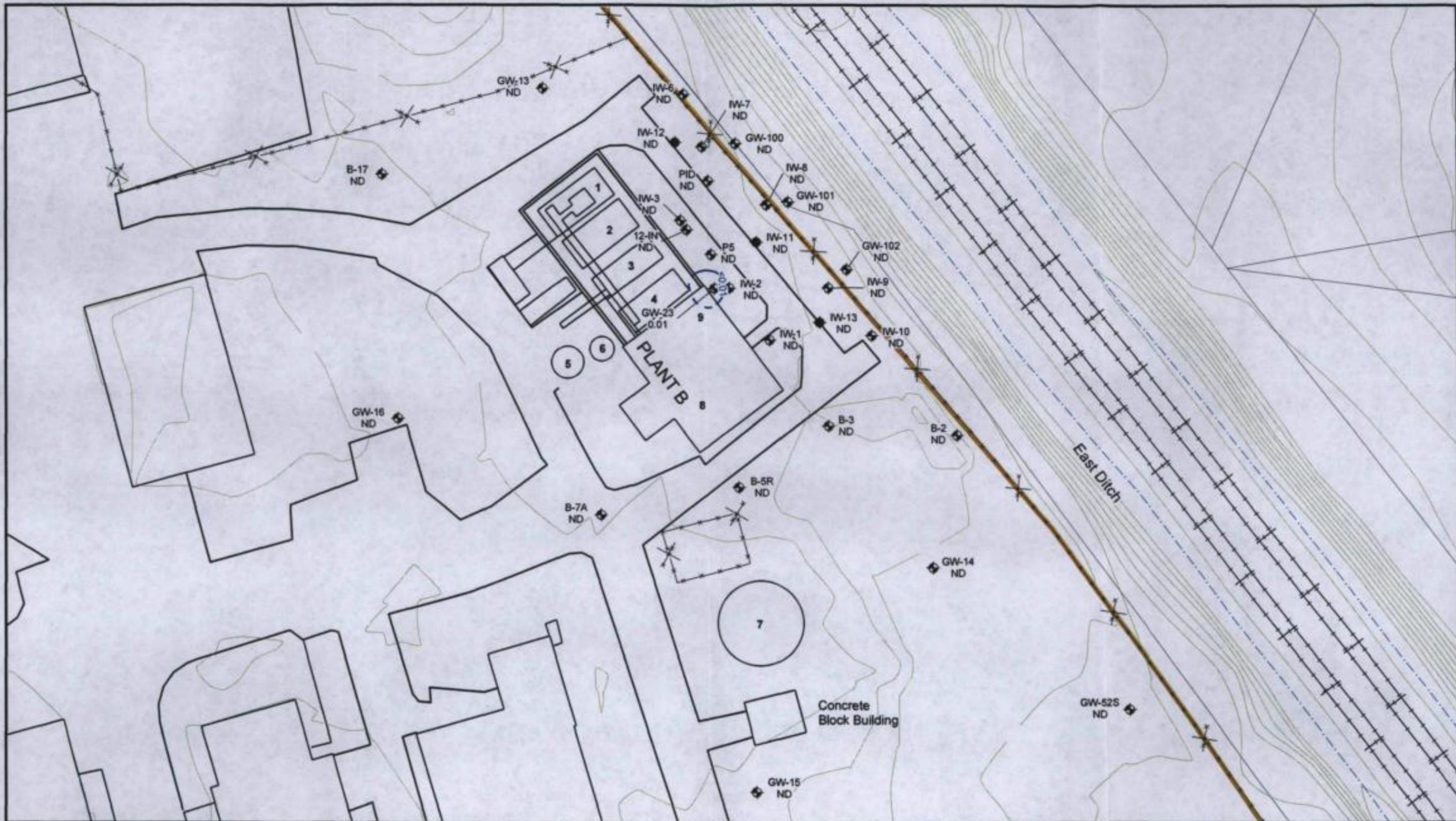
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Wilketts, MA 01580



**Plant B Interpreted LNAPL Thickness Contours**  
November 2007

Olin Chemical Superfund Site  
Wilmington, Massachusetts

Prepared/Date: BJR 03/05/08    Checked/Date: PHT 03/05/08

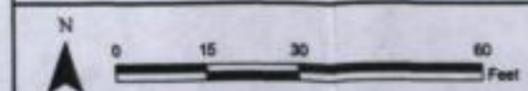


Tank #1 - Receives gravity overflow from Tank 2 and allows for further settling  
 Tank #2 - Caustic addition and initial iron drop-out  
 Tank #3 & #4 - Overnight holding tank for treated water  
 Tank #5 - Pre-carbon hold tank  
 Tank #6 - Residence tank  
 Tank #7 - Raw water (pH adjusted)  
 Tank #8 - Pre-carbon transfer  
 Tank #9 - Day discharge to NPDES Outfall 002

**Legend**

- Interpreted LNAPL Thickness Contour (ft)
- - - Inferred LNAPL Thickness Contour (ft)
- ◆ Recovery Well
- ◇ Monitoring Well
- - - Ditch
- Elevation Contours
- ND Not Detected

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**Plant B Interpreted LNAPL Thickness Contours**  
 December 2007

Olin Chemical Superfund Site  
 Wilmington, Massachusetts

Prepared/Date: BJR 03/06/08 Checked/Date: PHT 03/06/08