Memorandum

To: *Sean Sheldrake, U.S. EPA Region 10*

From: *Lance Peterson, RG*
Paula Kulis, Ph.D., PE

Date: *December 19, 2013*

Subject: *Application of Portland Harbor Recontamination Evaluation Framework to Proposed Treated Wastewater Outfall, Gasco Early Action Site*

On January 28, 2011, the Oregon Department of Environmental Quality (DEQ) received a National Pollutant Discharge Elimination System (NPDES) permit application from NW Natural. Supplemental information was received by DEQ on May 10, 2011, January 31, 2012 and October 31, 2012. The application was for a new NPDES permit to discharge treated groundwater and stormwater (collectively called wastewater in this evaluation) from the Gasco site to the Willamette River. Specifically the discharge will consist of treated groundwater from the upland hydraulic control and containment system and treated stormwater/groundwater removed from the site liquefied natural gas (LNG) basin. DEQ solicited public comments on the permit in April/May 2013. We understand the permit is pending the results of a National Marine Fisheries Service consultation regarding the treated wastewater outfall. While the wastewater treatment process is designed to reduce contaminant dissolved concentrations below proposed NPDES permit requirements in order to meet in-stream water quality standards, the impact of the discharge on sediments has not been evaluated. The U.S. Environmental Protection Agency (EPA) Region 10 requested that CDM Smith evaluate the potential for recontamination of clean, post-remediation sediment in the river resulting from the discharge of residual concentrations of pollutants in the treated wastewater outfall stream. The results of this evaluation are provided below.

Recontamination Evaluation Framework

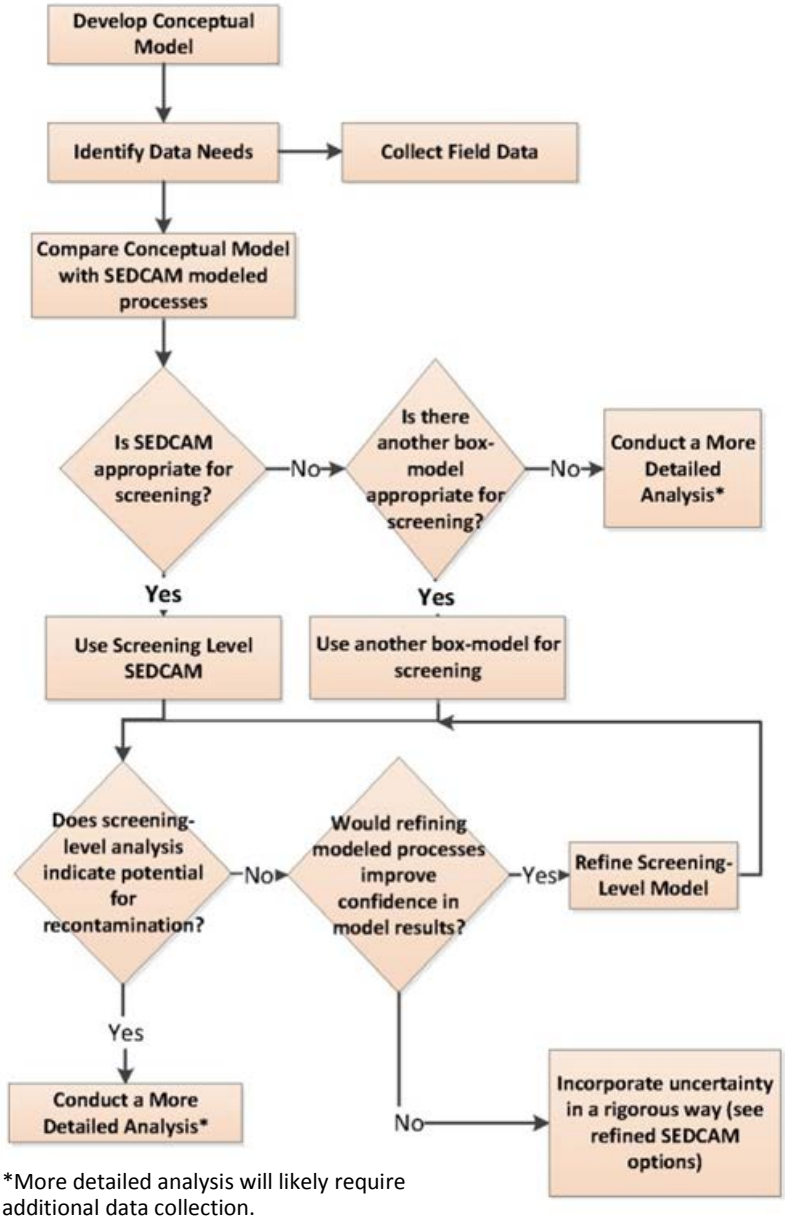
In January 2013, CDM Smith developed a draft Site Level Recontamination Evaluation Framework (Framework) on behalf of EPA Region 10 for the Portland Harbor Superfund Site (CDM Smith 2013). CDM Smith used this Framework as a guide to complete the recontamination evaluation of the Gasco treated wastewater outfall.

The basic elements of the Framework are depicted in **Figure 1**. The first steps of the Framework consist of the development of a conceptual model including assessment of contamination pathways and the identification of data needs. Following development of the conceptual model,

the Framework then recommends applying a simple screening-level tool such as the SEDCAM model (Jacobs et al. 1988), if appropriate, to assess "worst case scenario" conditions and order-of magnitude relationships. Results from this initial screening level tool can be used to inform additional, more detailed analyses as necessary.

The Gasco treated wastewater outfall analysis is limited to the initial screening steps in the Framework. Additional analysis is not considered part of the present evaluation.

Figure 1 – Recontamination Evaluation Key Elements



*More detailed analysis will likely require additional data collection.

In developing a conceptual model of the Gasco treated wastewater outfall into the Willamette River, pathways of contaminants into the river sediment were identified and quantified to the extent possible. Data gaps were identified that for the purposes of this study were incorporated using conservative assumptions and a sensitivity analysis on model input parameters. As noted above, collection of additional field data was beyond the scope of this study.

The proposed outfall (Outfall 001) in the Willamette River consists of a 6-inch diameter high-density polyethylene pipe extending below an existing dock at the Gasco site. The pipe will be at least 12 feet below the water surface during low water levels, and will terminate with a 12-foot long horizontal diffuser extending perpendicular to the Willamette River's flow direction. Treated water will exit the diffuser which consists of four 2-inch ports located on 2-foot risers having a spacing of 4 feet between ports. These ports will be oriented downstream. Figures depicting the plan and profile of the outfall are included in **Attachment 1**. A conceptual plan view depiction of the outfall is shown in **Figure 2**.

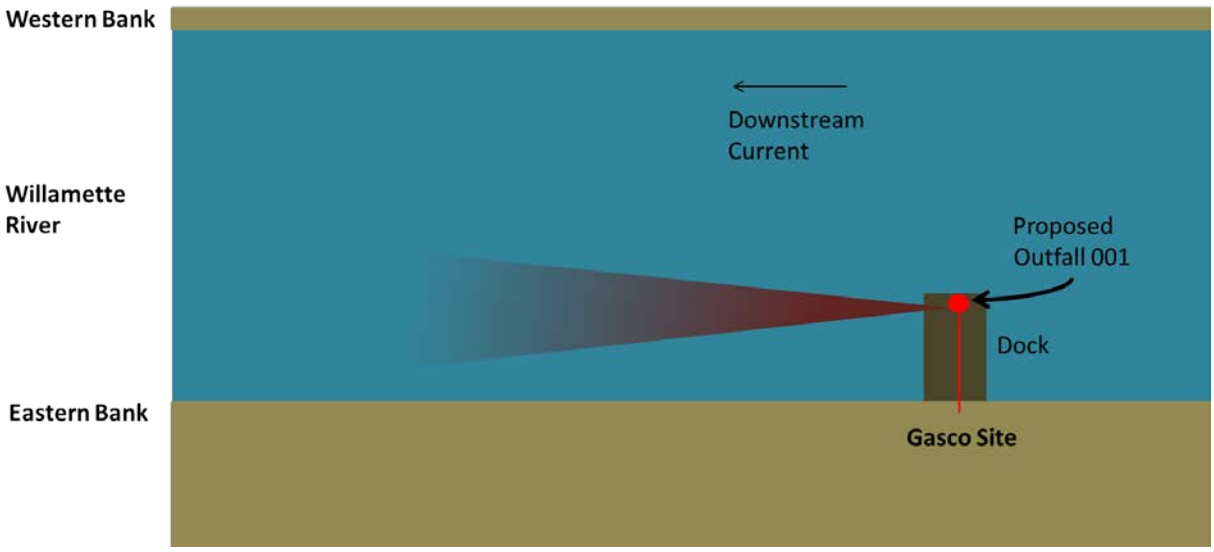


Figure 2. Treated Wastewater Outfall 001 Configuration

No suspended solids load is anticipated from the treated water discharge since bag filters are included in the treatment system design. However, dissolved residual contaminants in the treated wastewater flow may adsorb onto sediment particles suspended in the Willamette River. When these suspended particles subsequently sink, river bed contamination could result as this process continues over time. The top layer of sediment in the river bed generally experiences significant mixing, and from this layer particles with adsorbed contaminants may be buried into deeper sediment. The settling, mixing and burial process is depicted in cross section in **Figure 3**. *This contamination pathway is the only pathway explored in the Gasco treated wastewater outfall study.* Potential pathways not included in this study include contaminant loading originating

from upstream and stormwater runoff with the exception of the treated stormwater that discharges through Outfall 001 at the Gasco site.

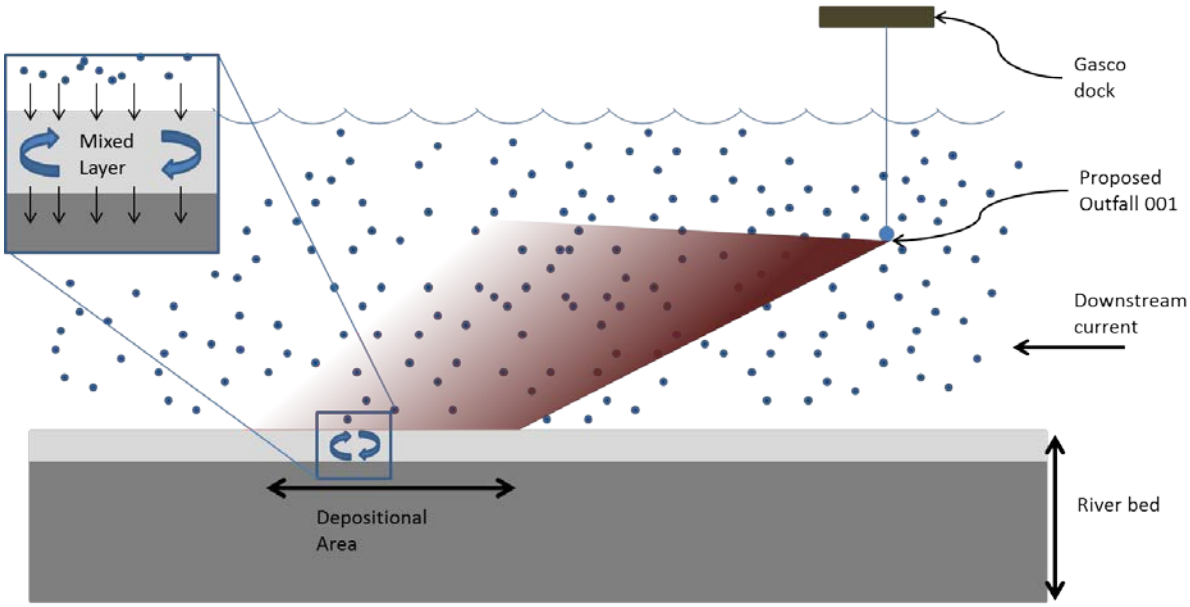


Figure 3: Conceptual Model of Contamination Pathway at Outfall 001

Methodology

Evaluation of SEDCAM's Applicability

Following the framework, SEDCAM was evaluated as a potential screening-level tool. SEDCAM is a 1-D mass balance box model that evaluates contamination of the sediment mixed layer over time. The model incorporates steady-state sedimentation and contaminant loading rates, and includes a decay rate for non-conservative constituents (though this term can also be used to account for in-sediment diffusion).

SEDCAM applications to the Portland Harbor site have historically been analyses of contaminated total suspended solids (TSS) loadings from an unfiltered point source that settle over a fixed depositional area. At the Gasco site, the contamination pathway involves adsorption to suspended sediment from upstream. This sediment has a much lower settling velocity than larger sediment particles from an unfiltered stormwater outfall (on the order of 10^{-5} m/s). Because of this low settling velocity, it is not appropriate to calculate a discrete depositional area. However, it is appropriate to estimate a "worst case" sediment concentration of adsorbed pollutant from Outfall 001. Using this estimate of adsorbed sediment concentrations in the water column, the principles of SEDCAM still represent the potential contamination pathway at Gasco Outfall 001 discussed above. For this reason, it was determined that the SEDCAM equations could be used as an initial screening tool to evaluate the Gasco treated wastewater discharge.

SEDCAM Application

The mass balance components of SEDCAM require information on sedimentation rates and contamination concentrations in incoming sediment. Information regarding the sediment characteristics, such as sediment density and the thickness of the surface mixed layer in the river bed, are also necessary. This information was determined based on previous studies at the Gasco and other Portland Harbor sites. Where documented values spanned several orders of magnitude (or varied sufficiently to potentially alter model results significantly), a range was used to define different model scenarios. **Table 1** summarizes the parameter values used in SEDCAM, and the source(s) of information used to determine these values. Additional details relating to some parameters are discussed below.

Table 1: SEDCAM Model Parameters

Model Parameter	Value	Source
Pollutant Concentrations in Suspended River Sediment	Listed in Table 2	Draft NPDES Permit (DEQ 2013)
Particle Density	1.1 g/cm^3	Estimate based on several Portland Harbor studies (Anchor QEA 2012b), (Newfields 2009), (Integral 2008)
Total Suspended Solids in River	2-60 mg/L	Draft Remedial Investigation Report (Lower Willamette Group 2009)
Sedimentation Rate	1-5 cm/year	Measured and observed values (Anchor QEA 2012a)
Mixed Layer Thickness	15 cm	(Newfields 2009)
Adsorption Rate	75-100%	Conservative estimate based on wide range of chemicals being analyzed and uncertainties regarding sediment adsorption properties
Decay Rate	0	(Integral 2008), (Newfields 2009)

Notes:
cm – centimeter
g/cm^3 – grams per cubic centimeter
mg/L – milligrams per liter

Adsorbed Contaminant Concentrations

Suspended sediment contaminant concentrations were determined based on the minimum dilution factor calculated at the edge of the Regulatory Mixing Zone (RMZ), as generated in the dilution study which is an addendum to the NPDES permit application (Sevenson 2012). A sensitivity analysis of the discharge plume showed a minimum of a 40-fold dilution beyond end of pipe concentrations. Upper limits for end of pipe concentrations are presented in Schedule A of the Draft NPDES Permit (DEQ 2013). End of pipe concentrations and concentrations at the RMZ

edge are summarized in **Table 2** below[1]. Cyanide was not included in the Gasco treated wastewater outfall study because of its low adsorption rate. A recontamination evaluation for pH was also not conducted as part of the study.

Table 2: Loadings

Water Quality Constituent	Permitted Monthly Average Concentration (µg/L)	Concentrations at RMZ Edge (µg/L)
Benzo(a)anthracene	0.0038	9.50E-05
Benzo(a)pyrene	0.0038	9.50E-05
Copper	15	3.75E-01
Dibenzo(a,h)anthracene	0.0038	9.50E-05
Indeno(1,2,3-cd)pyrene	0.0038	9.50E-05
Iron	820	2.05E+01
Lead	3.8	9.50E-02
Mercury	0.01	2.50E-04

Source: Draft NPDES Permit (DEQ 2013)
Notes:
µg/L – microgram per liter

Scenarios

Three scenarios were developed from the parameters in **Table 1.** The parameters that appeared to have a wide range of values that influenced model results include sedimentation rate, TSS, and adsorption of contaminants to sediment particles. The parameter values used in each scenario are summarized in **Table 3**, and are explained below in more detail. The scenarios were designed to represent more conservative (Scenario 1), medium (Scenario 2) and less conservative (Scenario 3) conditions.

Table 3: SEDCAM Model Scenarios

Model Parameter	Range	Scenario 1	Scenario 2	Scenario 3
Sedimentation Rate (cm/yr)	1-5	1	2.5	5
Total Suspended Solids (mg/L)	2-60	2	30	60
Adsorption rate (%)	75-100	100	90	75

Sedimentation Rate

Both modeled and measured sedimentation rates were provided in the Gasco Draft Engineering Evaluation/Cost Estimate (EE/CA) (Anchor QEA 2012a) as noted on EE/CA Figure 2-14. Several factors contribute to uncertainty associated with these values:

[1] Though limits for cyanide are included in the permit, they are excluded from this recontamination study. Because of cyanide's low adsorption rate, significant cyanide sediment concentrations are not anticipated.

- Sedimentation rates were estimated qualitatively by CDM Smith from figures in the EE/CA (numerical data was not requested from the authors).
- Sedimentation rates were not available for certain capping and dredging areas discussed in the EE/CA.
- A wide range of sedimentation rates were reported in the EE/CA over the estimated areas of deposition associated with the treated wastewater outfall.

Because of these uncertainties, the range defined in **Tables 1** and **3** was developed.

Total Suspended Solids
TSS measured near the Gasco site at River Mile 6 (Lower Willamette Group 2009) range between 2 and 60 mg/L. The values used in Scenarios 1 through 3 are intended to bracket these observed values.

Adsorption Rates
Adsorption rates of dissolved constituents to sediment particles are also a source of significant uncertainty in the Gasco treated wastewater outfall study. What data that is available to inform adsorption rates suggests that near 100% adsorption is possible. As a result, the Gasco treated wastewater outfall study uses the conservative estimate that 75-100% of the contaminant load exiting the outfall is instantly adsorped onto suspended sediment.

Assumptions and Limitations

The Gasco treated wastewater outfall study is limited to the first step of the Framework where a screening-level tool is applied. Consequently, only data available from existing sources was used for this analysis. Other limitations and assumptions include:

- Only pollutant pathways specific to the treated wastewater outfall are considered in this study. Contamination originating from upstream or other sources (e.g., stormwater) is not considered.
- The Gasco treated wastewater outfall study assumes that river sediments are initially clean, with zero contaminant concentrations.
- Some data limitations require conservative estimates, including:
    - Most (75-100%) of the contamination exiting the outfall pipe will adsorb to sediment particles.
    - The concentration at the edge of the RMZ defined in the dilution study, along with the in-river TSS concentration, is used to calculate a concentration adsorbed to the suspended sediments. This treatment of concentrations implies an assumption that no additional mixing occurs between the edge of the RMZ and particle deposition.

- Deposition rates vary temporally and spatially. In addition, river flow varies seasonally and in response to tidal elevation. As a result, an assumption of a single deposition rate is an oversimplification.

Results

Table 4 summarizes the SEDCAM simulated river bed concentrations for each water quality constituent listed in **Table 2** under all sensitivity scenarios after 30 years of constant sediment and contaminant loading as described in the above sections. The table compares model results with Portland Harbor site-specific Preliminary Remediation Goals (PRGs).

As can be seen from the table, SEDCAM results are highly sensitive to the parameters varied in Scenarios 1, 2 and 3. However, almost all constituents are below their respective PRGs. Results for copper in Scenario 1 (most conservative scenario) are slightly above the PRG. However, pilot plant measurements indicate that actual copper concentrations in discharged water will be below 10 µg/L (Sevenson 2012), while 15 µg/L is used for the present recontamination evaluation. If SEDCAM is run with an end of pipe concentration of 10 µg/L, steady state sediment copper concentrations are 125 mg/kg, below the PRG of 150 mg/kg. All polycyclic aromatic hydrocarbon (PAH) compounds are also close to the 0.05 mg/kg PRG limit in Scenario 1, though they do not exceed it.

Table 4: SEDCAM Results for Water Quality Constituents after 30 Years

Constituent	PRG (mg/kg)	30-Year Sediment Concentration (mg/kg)		
		Scenario 1	Scenario 2	Scenario 3
Benzo(a)anthracene	0.05	4.22E-02	2.84E-03	1.19E-03
Benzo(a)pyrene	0.05	4.22E-02	2.84E-03	1.19E-03
Copper	150	**1.67E+02**	1.12E+01	4.69E+00
Dibenzo(a,h)anthracene	0.05	4.22E-02	2.84E-03	1.19E-03
Indeno(1,2,3-cd)pyrene	0.05	4.22E-02	2.84E-03	1.19E-03
Iron	NA	9.11E+03	6.12E+02	2.56E+02
Lead	91	4.22E+01	2.84E+00	1.19E+00
Mercury	NA	1.11E-01	7.47E-03	3.12E-03

Notes:
Bold indicates predicted concentration is above the PRG value
mg/kg – milligrams per kilogram
NA - Not available
TBD - To be determined

SEDCAM's parameters simulate a simplified river bed with constant inputs over time. SEDCAM results therefore tend to show convergence over time to a steady state river bed contaminant concentration. The Gasco treated wastewater outfall study discusses model results after 30 years

of simulation time, after which the steady state concentration is only reached for Scenario 3 (which has the highest sedimentation rate). In Scenario 1, where sedimentation rates are low, river bed concentrations have reached 89% of the final steady-state concentration after 30 years. For Scenarios 2 and 3, the river bed has reached its final steady state concentration 30 years into the simulation. **Figure 4** shows SEDCAM results for Benzo(a)pyrene. It is clear from the figure that the sediment concentration in Scenario 1 is still increasing slightly over time after 30 years of simulated outfall operation. Similar figures showing SEDCAM results for each contaminant are presented in **Attachment 2**. These figures also demonstrate the variation of model results among Scenarios 1, 2, and 3.

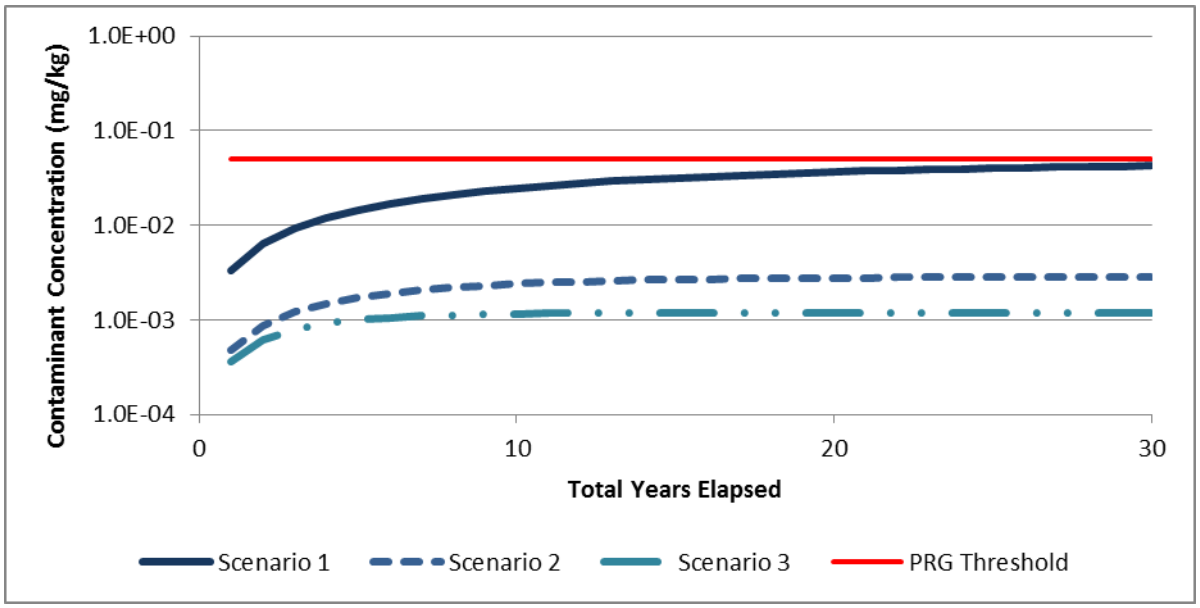


Figure 4: SEDCAM Results for Benzo(a)pyrene

Recommendations

SEDCAM is a very approximate model, and several conservative assumptions relative to in-river mixing and settling, chemical adsorption, and sedimentation rates were made in applying it to the recontamination evaluation of the Gasco treated wastewater outfall. Because of these assumptions, model scenarios were selected to bracket expected conditions in the Willamette River.

Most model scenarios showed sediment concentrations below desired concentration limits. Scenario 1 resulted in PAH concentrations close to the PRG. Copper simulations are slightly above the PRG in Scenario 1; however, conservative estimates of end of pipe concentrations may warrant lowering the copper and PAH concentration for all scenarios, as discussed above.

Because the scenarios investigated included conservative river and contaminant characteristics, this study indicates that future recontamination of sediment due to the Gasco treated wastewater outfall alone is unlikely.

References

Anchor QEA. 2012a. Draft Engineering Evaluation/Cost Estimate, Gasco Sediments Cleanup Site. Prepared for U.S. Environmental Protection Agency Region 10 on behalf of NW Natural. May 2012.

Anchor QEA. 2012b. Portland Harbor RI/FS Draft Feasibility Study. Prepared for the Lower Willamette Group. March 30, 2012.

CDM Smith, 2013. Draft Technical Memorandum, Site Level Recontamination Evaluation Framework, Portland Harbor Superfund Site. January 4, 2013.

Integral Consulting Inc. 2008. Draft Stormwater Interim Remedial Measures, Focused Feasibility Study Report, Arkema Portland Facility. Prepared for Legacy Site Services LLC. July 3, 2008.

Jacobs, L., R. Barrick, and T. Ginn. 1988. Application of a Mathematical Model (SEDCAM) to Evaluate the Effects of Source Control on Sediment Contamination in Commencement Bay. pp. 677 to 684. [In:] Proceedings; First Annual Meeting on Puget Sound Research; Volume 2. 18 to 19 March 1988; The Seattle Center; Seattle, Washington. Puget Sound Water Quality Authority; Seattle, Washington.

Lower Willamette Group. 2009. Portland Harbor Superfund Site Draft Remedial Investigation Report. October, 2009.

Newfields. 2009. Sediment Recontamination Analysis Approach. Terminal 4 Removal Action. Port of Portland, Portland, Oregon.

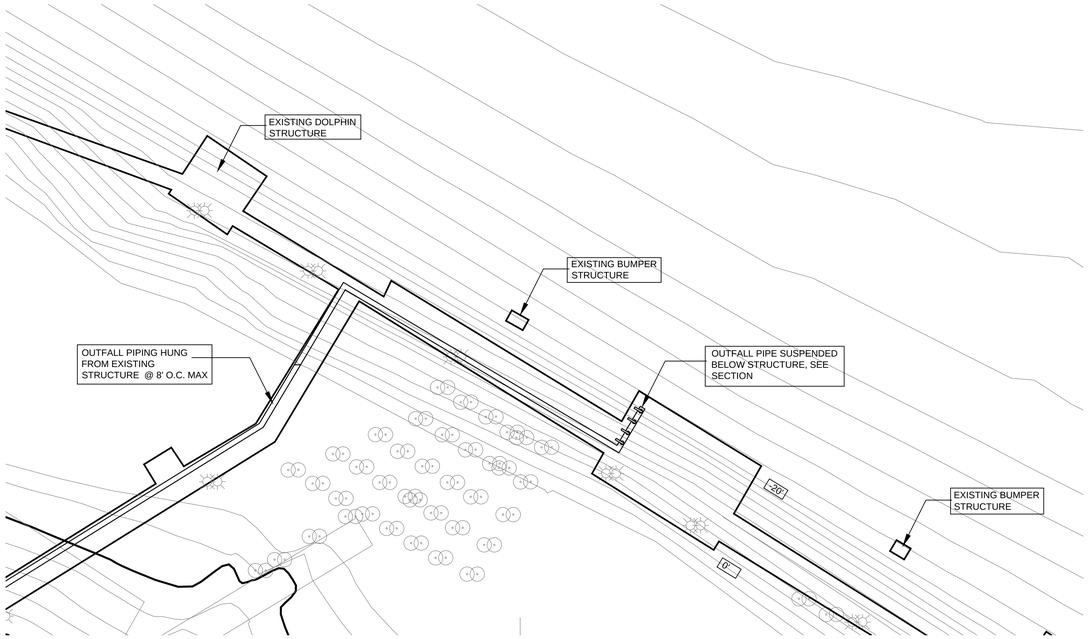
Oregon Department of Environmental Quality. 2013. Request for Comments, Proposed Issuance of NPDES Permit for NW Natural's "Gasco Site" Groundwater Source Control Measure. Issued April 18, 2013.

Sevenson Environmental Services, Inc. 2012. NW Natural and Siltronic Source Control Treatment Plant Mixing Zone/Dilution Study. Revised October 2012. Prepared for NW Natural Gas Company.

Attachment 1

Gasco Outfall Location and Profile

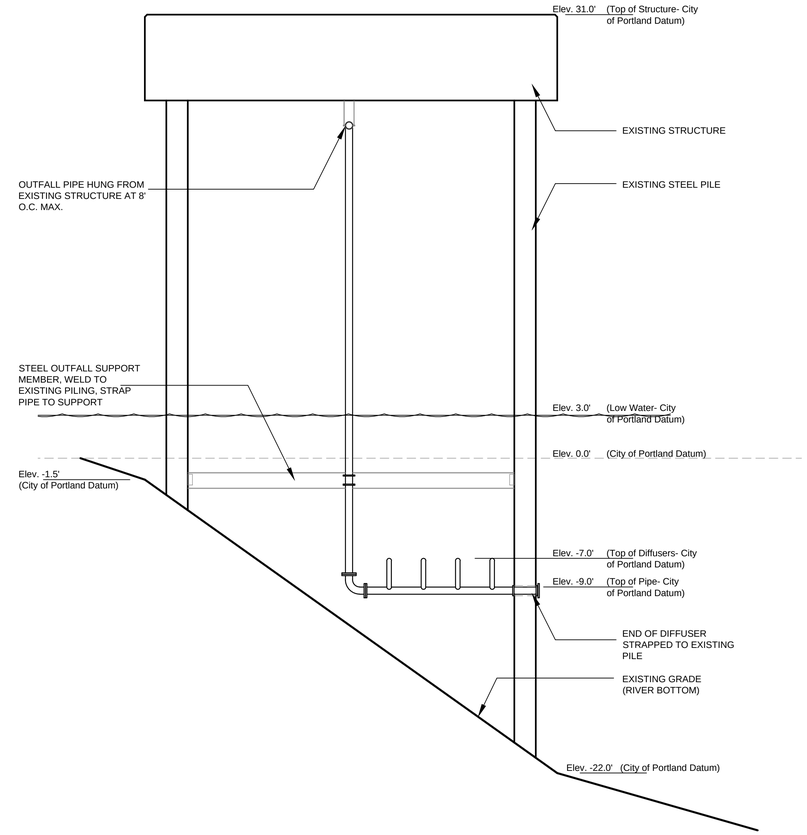
Figure 2 from Draft NPDES Permit (DEQ, 2013). Proposed outfall location.



DETAIL PLAN @ OUTFALL

SCALE: 1"= 20'

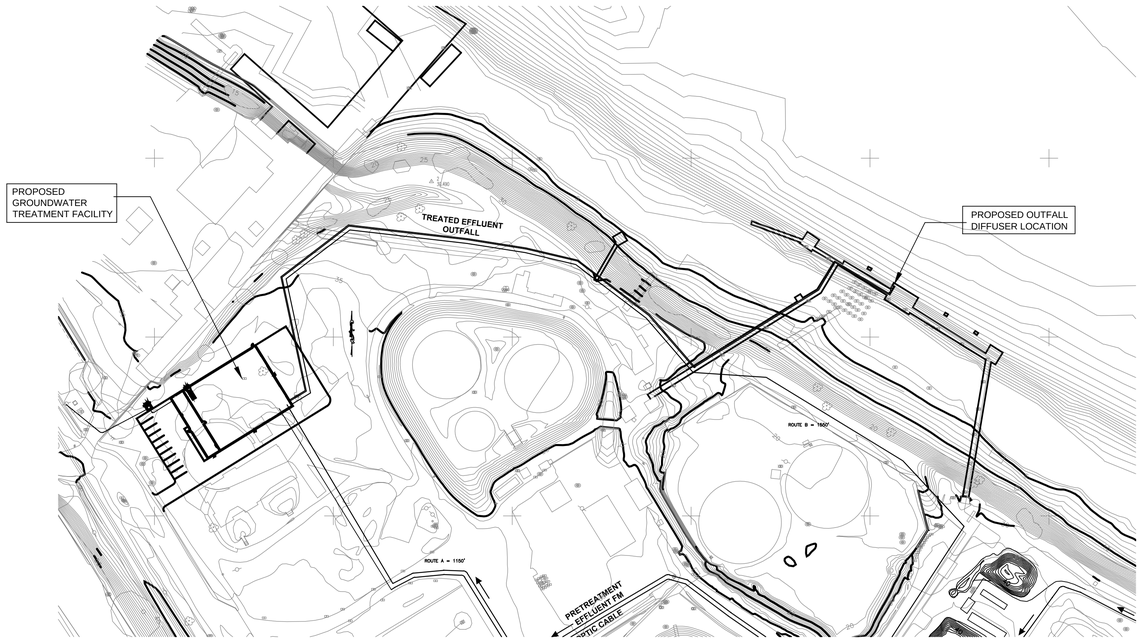
10' 0' 20' 40'



SECTION @ OUTFALL

SCALE: 1"= 5'

2.5' 0' 5' 10'



SITE PLAN- OUTFALL PIPING

SCALE: 1"= 100'

50' 0' 100' 200'

1" ON ORIGINAL DRAWING

SITE
OUTFALL PIPE

NW NATURAL GASCO
GROUNDWATER SOURCE CONTROL
WASTEWATER TREATMENT PLANT
PORTLAND, OREGON

SEVENSON ENVIRONMENTAL SERVICES, INC.

ADA
APONOWICH, DRISCOLL & ASSOCIATES, INC.

TS JONES CONSULTING

DRAWING OF-1

DATE:	10.11.12
DRAWN BY:	
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CAD FILE:	
SCALE:	AS NOTED

Attachment 2

Gasco SEDCAM Results

This attachment contains figures of SEDCAM model results for all chemical constituents assessed in the Gasco treated wastewater outfall recontamination evaluation.

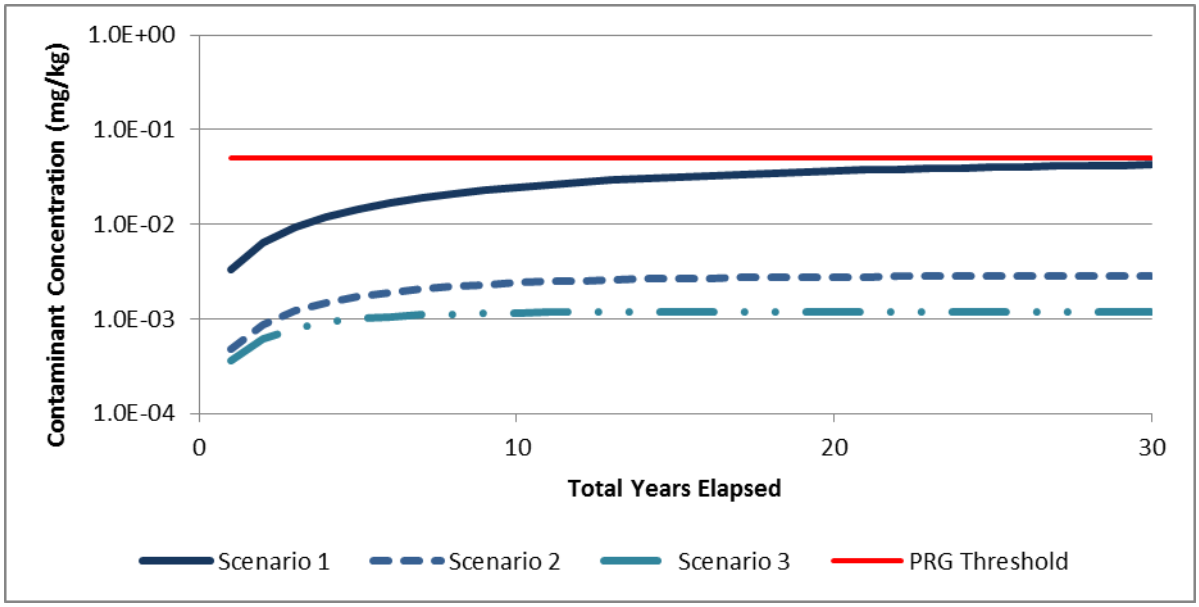

Figure 2.1: Benzo(a)anthracene.

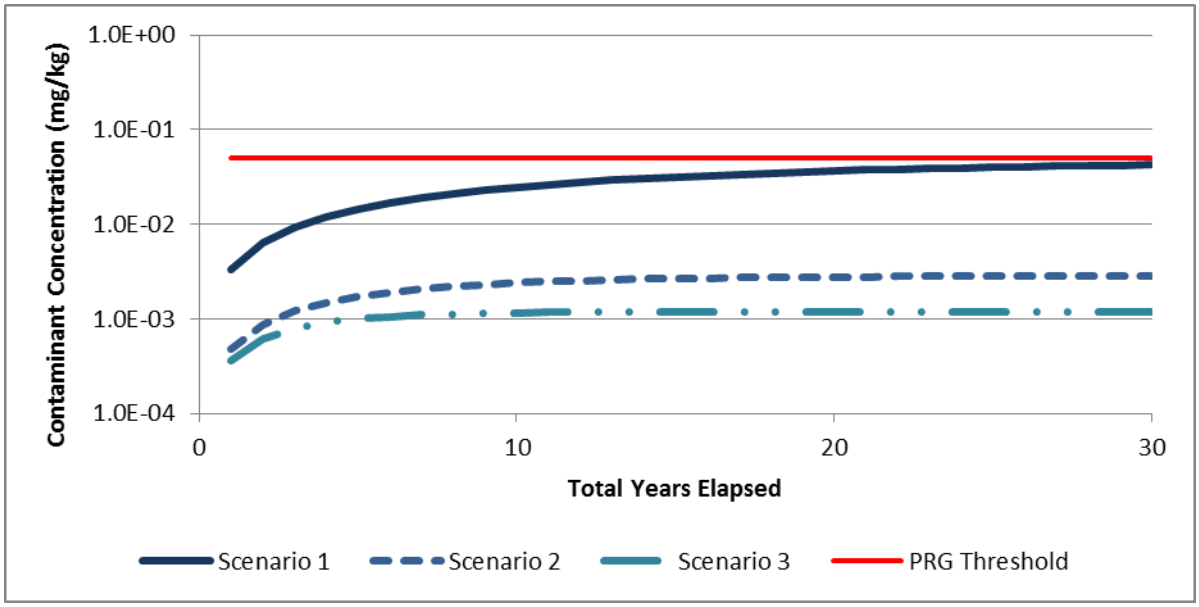

Figure 2.2: Benzo(a)pyrene.

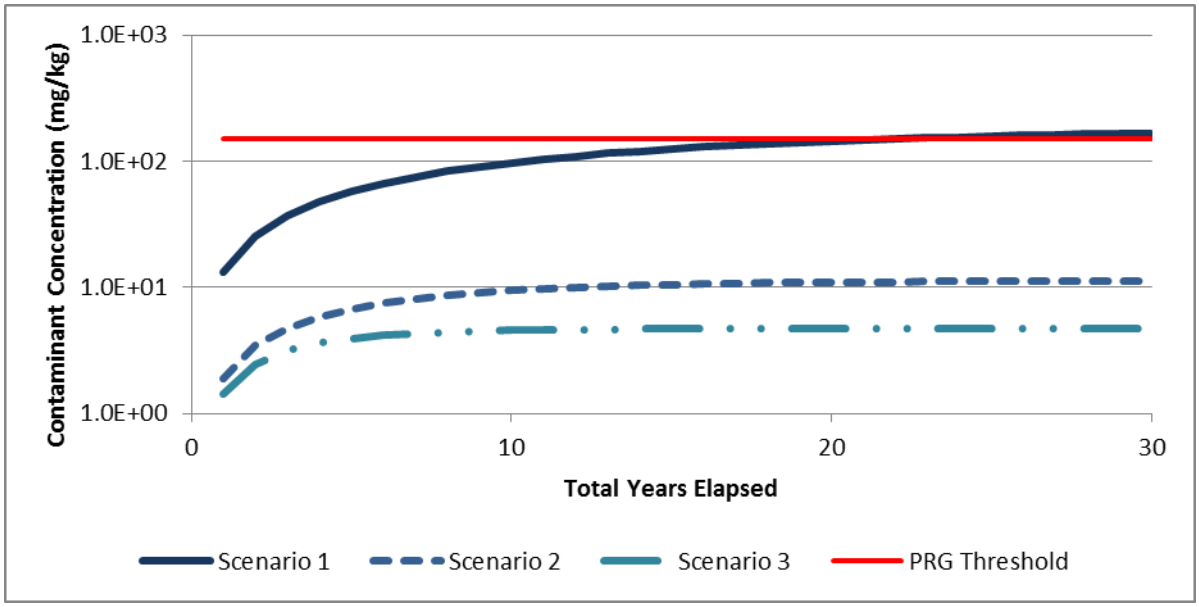

Figure 2.3: Copper.

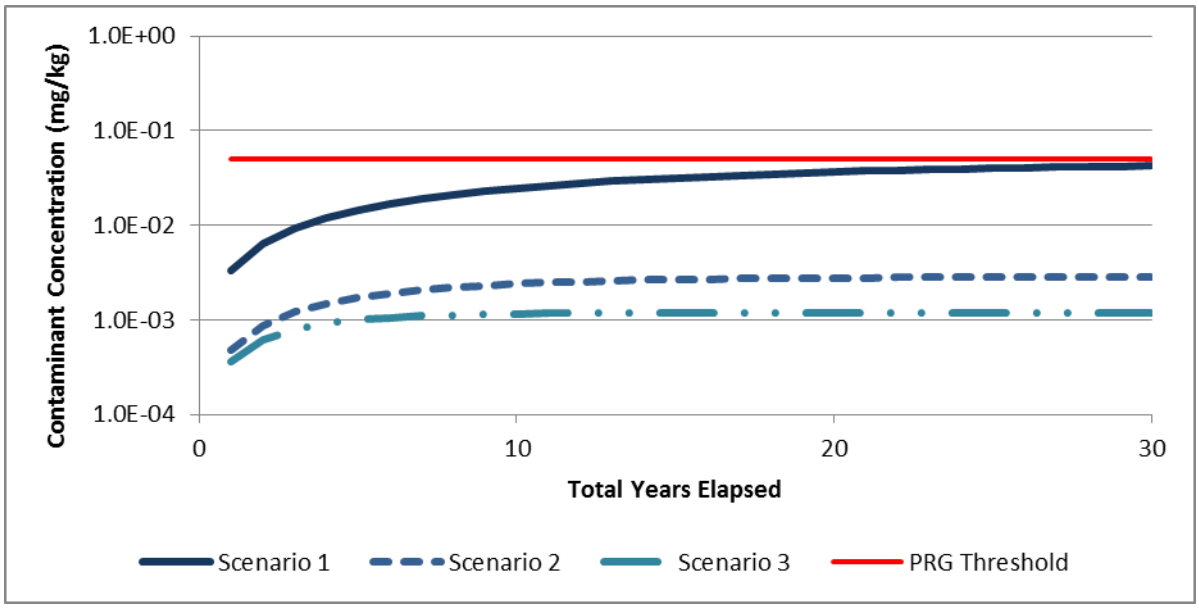

Figure 2.4: Dibenzo(a,h)anthracene.

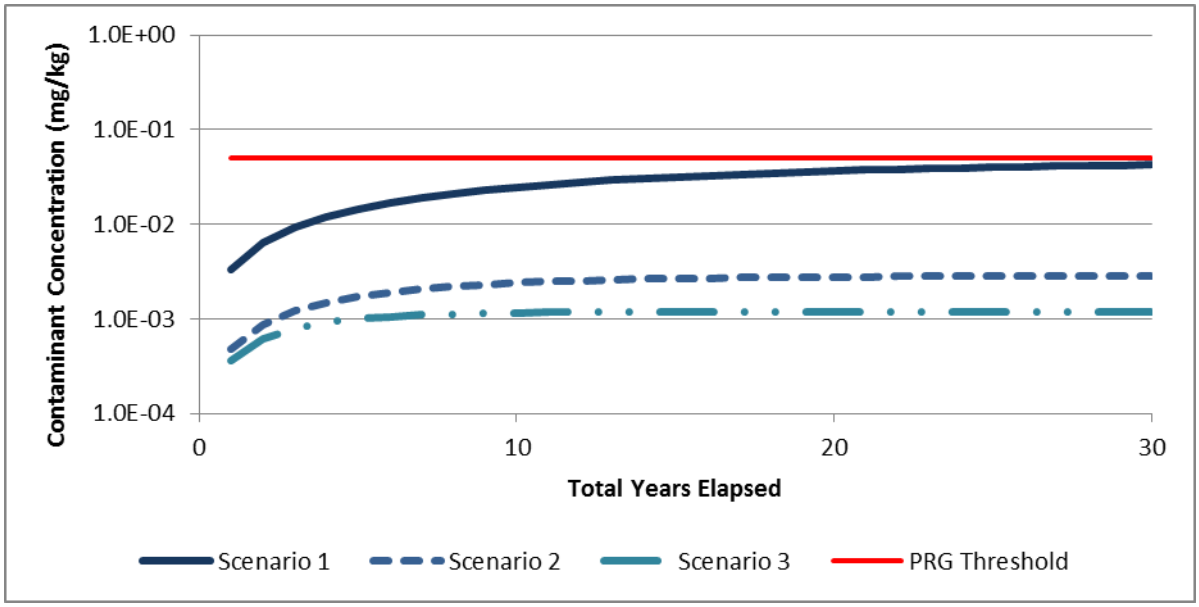

Figure 2.5: Indeno(1,2,3-cd)pyrene.

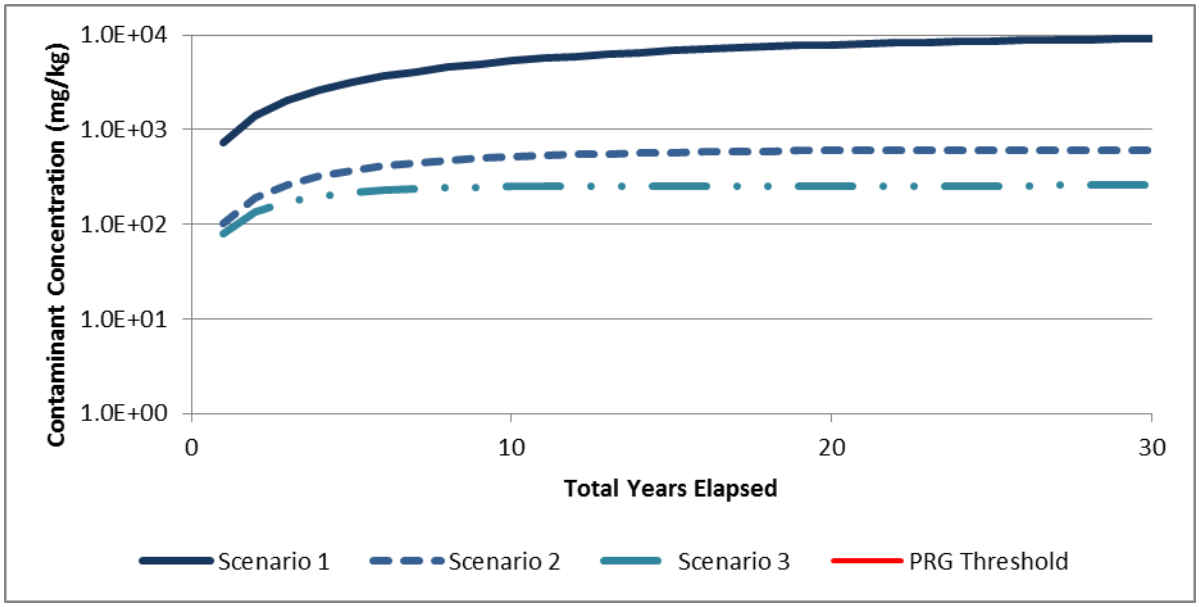

Figure 2.6: Iron

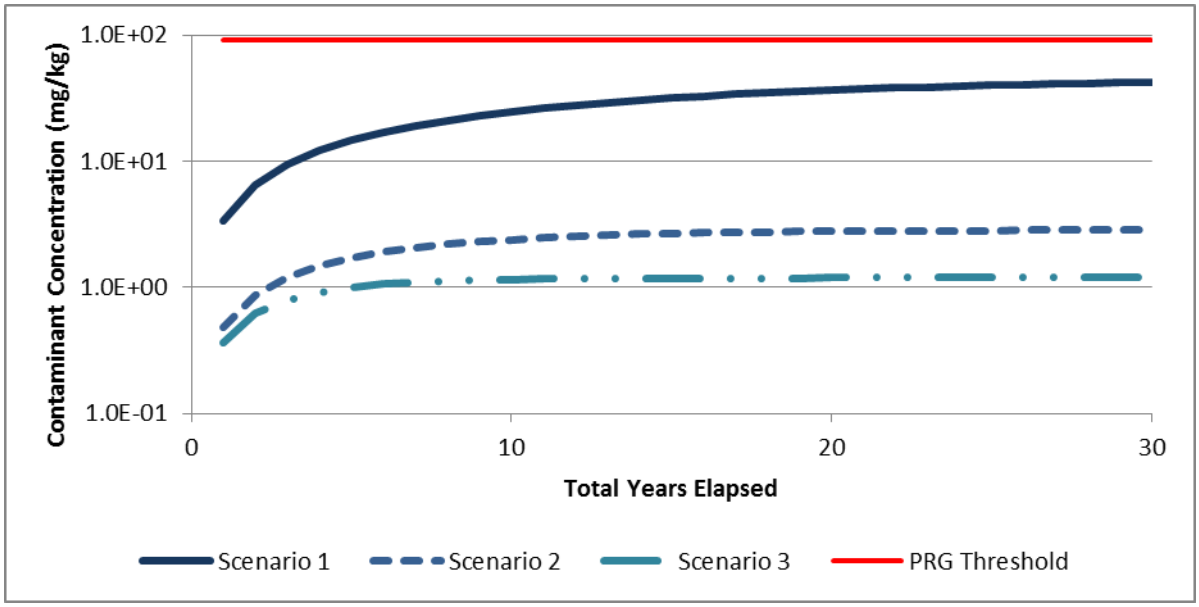

Figure 2.7: Lead.

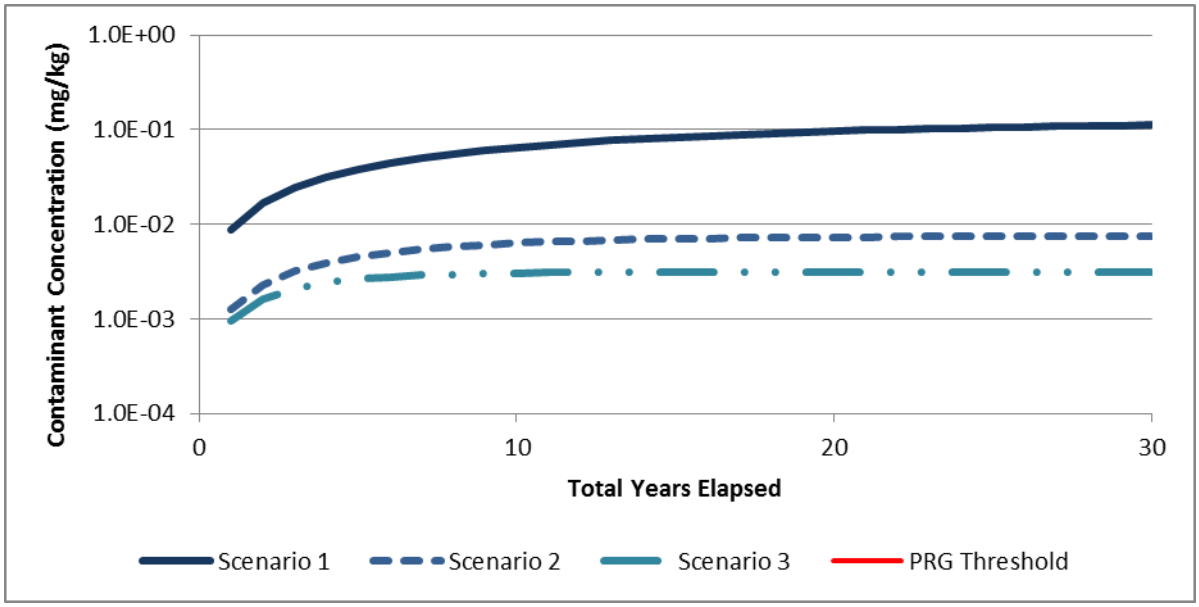

Figure 2.8: Mercury.