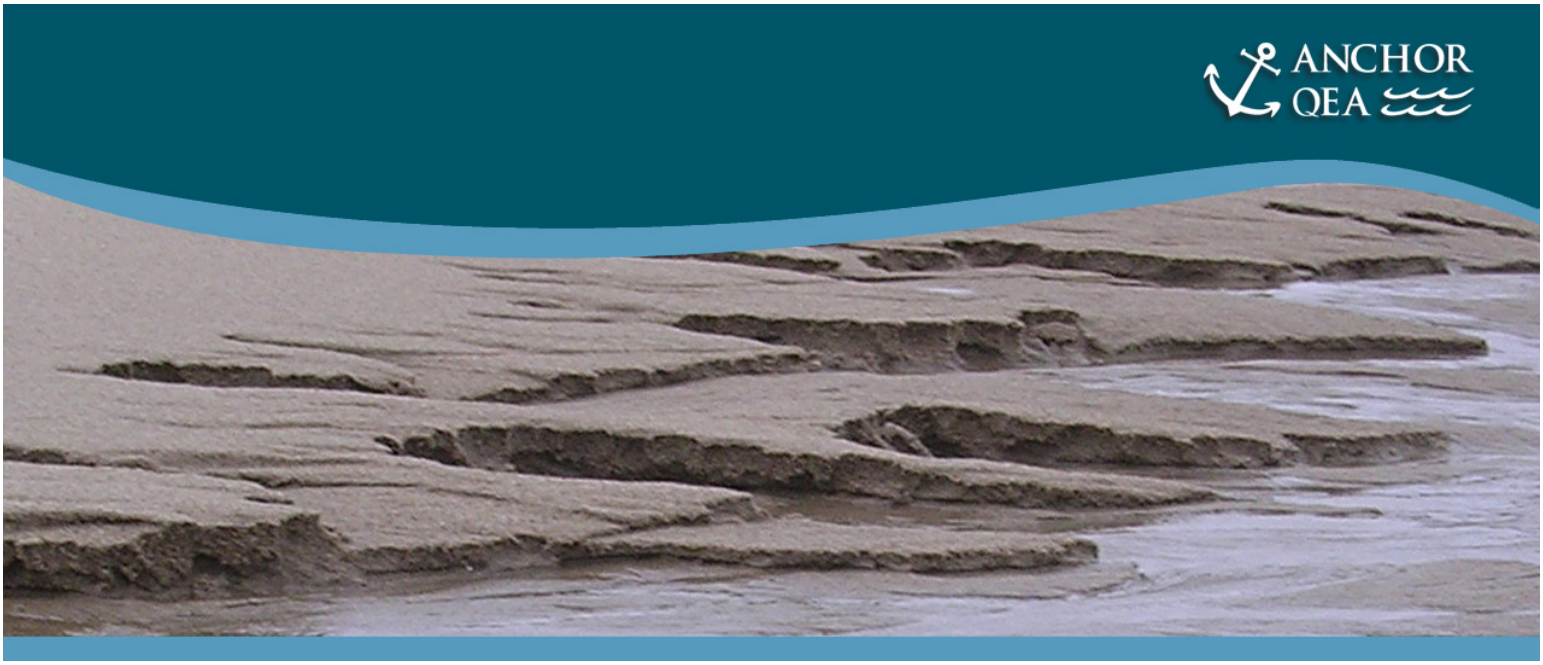

WORK PLAN
HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT
NW NATURAL GASCO SITE

Prepared for

Oregon Department of Environmental Quality
Northwest Region Portland Office
2020 Southwest Fourth Avenue, Suite 400
Portland, Oregon 97201

Prepared by

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6650 SW Redwood Lane, Suite 333
Portland, Oregon 97224

On behalf of

NW Natural
220 Northwest Second Avenue
Portland, Oregon 97209

March 2012

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LIST OF ACRONYMS AND ABBREVIATIONS

BEHRA	Baseline Level III Ecological and Human Health Risk Assessment
bgs	below ground surface
BTAG	Biological Technical Assistance Group
BTEX	benzene, toluene, ethylbenzene, and total xylene
BUD	Beneficial Use Determination
CAS	Chemical Abstracts Service
COI	contaminant of interest
COPC	contaminant of potential concern
DEQ	Oregon Department of Environmental Quality
EPA	United States Environmental Protection Agency
EPC	exposure point concentration
EPH	extractable petroleum hydrocarbon
ERA	Ecological Risk Assessment
ESL	Ecological Screening Level
FAMM	Fuel and Marine Marketing
FCV	Final Chronic Value
Final Screening Matrix	Human Health, Ecological, and Source Control Screening Criteria Matrix
former office	Office
former Retort/Koppers operations	Former Retort/Koppers
former spent oxide storage	Former Spent Oxide
former tar effluent settling pond	Former Tar Ponds
FS	Feasibility Study
FSP	Field Sampling Plan
HAI	Hahn and Associates, Inc.
HERA	Human Health and Ecological Risk Assessment
HHRA	Human Health Risk Assessment
HQ	hazard quotient
LNG	liquified natural gas
LOAEL	Lowest Observed Adverse Effect Level
mg/kg	milligram per kilogram

MGP	manufactured gas plant
NOAEL	No Observed Adverse Effect Level
PAHs	polycyclic aromatic hydrocarbon
RBC	risk-based concentration
RBDM	Risk-Based Decision Making
RI	Remedial Investigation
RSL	Risk Screening Level
Site	NW Natural "Gasco" Site
SLV	screening level value
SQG	Sediment Quality Guideline
SLV	Screening Level Value
SSL	soil screening level
TMB	trimethylbenzene
TPH	total petroleum hydrocarbon
TPH-Dx	total petroleum hydrocarbon-diesel range
TPH-Gx	total petroleum hydrocarbon-gasoline range
UCL	upper confidence limit
VPH	volatile petroleum hydrocarbon
WBZ	water-bearing zone

1 INTRODUCTION

This Human Health and Ecological Risk Assessment (HERA) Work Plan has been prepared for the NW Natural "Gasco" Site (Site) in Portland, Oregon (see Figure 1). The HERA is being completed by NW Natural under the Oregon Department of Environmental Quality's (DEQ's) Voluntary Cleanup Program.

The HERA will build on previous investigations including the Site Remedial Investigations (RIs; HAI 1998, 2007), risk assessments (Anchor 2001a, 2001b, 2003, 2004), subsequent data collections, and agreements reached during technical meetings and communications with DEQ subsequent to receipt of DEQ's comments to the 2004 draft risk assessment in March 2010 (DEQ 2010a).

1.1 Objectives

The objective of this Work Plan is to present the agreed upon process for completion of the human health and ecological risk assessments, as discussed by NW Natural and DEQ. In addition to the risk assessment issues that were negotiated between DEQ and NW Natural, this HERA Work Plan also presents the methods that will be used to complete both the Human Health Risk Assessment (HHRA) and the Ecological Risk Assessment (ERA) to ensure that the final HERA report will be approved by DEQ. The methods proposed for the completion of the HHRA and ERA, as detailed in Sections 7 and 8 of this Work Plan, incorporate important agreements that have been reached between DEQ and NW Natural. This Work Plan presents the following:

- The contaminants of interest (COIs) that will be evaluated in these risk assessments, including surrogates or additional screening agreed upon to evaluate data density limited COIs
- The agreed upon screening levels that will be used to screen each of the environmental media in the human health and ecological risk assessments
- The data management rules that will be applied during the HERA preparation and the methods to calculate exposure point concentrations (EPCs)
- The details of how the HHRA and ERA will be completed
- A preliminary outline of the HERA deliverable and schedule for completion

Potential hot spots of contamination will not be identified in the HERA but will be evaluated in a separate deliverable. In addition, the beneficial use of the lower Alluvial water-bearing zone (WBZ) has not been resolved and DEQ and NW Natural have agreed to meet to resolve this issue. This decision will be used to determine whether the human health screen of the Alluvial WBZ will be presented in the HERA.

1.2 Approach

The approach and methods that will be used to complete the HERA are based on DEQ guidance (DEQ 2001b, 2003b, 2010b, 2011b) and the agreements reached between DEQ and NW Natural between March 10, 2010, and February 23, 2012. Specific details of the procedures that will be used to complete the HERA are detailed in Sections 7 and 8 of this HERA Work Plan.

1.3 Organization

The HERA Work Plan is organized as follows:

- Section 2: Project History
- Section 3: Contaminants of Interest
- Section 4: Screening Criteria
- Section 5: Data Reduction and Transformation
- Section 6: Calculation of Exposure Point Concentrations
- Section 7: Human Health Risk Assessment
- Section 8: Ecological Risk Assessment
- Section 9: Outline for Risk Assessment Deliverables and Schedule
- Section 10: References

2 PROJECT HISTORY

Site investigations have been conducted at this Site from 1995 to 2012. The Site history and current Site conditions are described in detail by Hahn and Associates, Inc. (HAI), in the 2007 RI Report (HAI 2007).

A Level II Risk Screening for Human Health and Ecological Receptors was completed for the Site in February 2001 (Anchor 2001a). This risk-screening document presented a conceptual Site model, which outlined the potential pathways from chemicals present in Site soils and groundwater to receptors potentially present on the Site. Later in 2001, a Technical Memorandum (Anchor 2001b) was submitted to DEQ in response to DEQ's request (2001a) for additional details regarding pathways and receptor selection. The agreements reached on the human health and ecological receptors, data sets, and pathways are described in letters from DEQ and NW Natural between 2002 and 2003 (DEQ 2002, 2003a; NW Natural 2002). These agreements also established an initial list of contaminants of potential concern (COPCs) for the Site.

A Draft Baseline Level III Ecological and Human Health Risk Assessment (BEHRA) was completed in June 2003 (Anchor 2003). In response to DEQ's comments and request to submit the ERA as a Level II risk assessment, NW Natural submitted a Revised BEHRA Report in December 2004 (Anchor 2004).

DEQ provided written comments on the 2004 Revised BEHRA to NW Natural in a March 10, 2010 letter. The 2010 comment letter included several issues that required resolution prior to the finalization of the risk assessment. Between March 2010 and February 2012, technical meetings were held with DEQ to resolve these issues. To support the technical meetings and resolution process, DEQ and NW Natural corresponded on the key issues and proposed resolutions. The correspondence included technical memoranda, comments and proposals through which key resolutions were reached. The risk assessments, technical meetings, and correspondence are summarized in Table 1.

Table 1
Summary of Risk Assessment Documents, Correspondence, and Technical Meetings, 2001 through 2012

Submittal Date	Submitted By	Title or Description
February 21, 2001	NW Natural (report)	Human Health and Ecological Risk Assessment Level II Screening Report
October 1, 2001	NW Natural (report)	Draft Risk Assessment Receptor/Pathway Selection Interim Technical Memorandum
March 15, 2002	DEQ (letter)	DEQ summary of issues related to completion of the RI/FS at the Former Gasco Site. Included a list of ecological receptors identified by DEQ for this Site.
December 3, 2002	NW Natural (letter)	NW Natural's response to DEQ's summary of issues and proposal to accept DEQ's ecological receptor list with the understanding that only upland site-specific risk will be considered.
January 22, 2003	DEQ (letter)	DEQ's response to NW Natural's December 3, 2002, letter providing additional clarification of DEQ's position and expectations regarding issues related to completion of the RI/FS.
June 1, 2003	NW Natural (report)	Draft Baseline Level III Ecological and Human Health Risk Assessment Report
August 23, 2003	NW Natural (memorandum)	Supplemental Information on Ecological Risk Methods for the Gasco Baseline Risk Assessment
January 13, 2004	DEQ (letter)	Comments on Baseline Level III Ecological and Human Health Risk Assessment
November 19, 2004	NW Natural (memorandum)	Response to DEQ Comments on Baseline Level III Ecological and Human Health Risk Assessment
December 15, 2004	NW Natural (report)	Revised Baseline Level III Ecological and Human Health Risk Assessment Report (BEHRA)
June 13 and July 15, 2008	NW Natural (emails)	Gasco Uplands Revised Level III RA Review Materials, including complete backup calculations requested by DEQ
March 10, 2010	DEQ (letter)	DEQ's March 10, 2010, comments (provides NW Natural with comments on the 2004 BEHRA)
June 21, 2010	NW Natural (memorandum and meeting)	Draft Proposal on Risk Methods (describes a proposal for completing the HERA). Discussed during a meeting with DEQ on the same date.
January 19, 2011	DEQ (email)	DEQ's list of topics for discussion at the January 25, 2011 meeting to resolve remaining issues on completion of the HERA.
January 25, 2011	Meeting	NW Natural and DEQ held a technical meeting to discuss the upland HERA approach and issues identified in DEQ's January 19, 2011, correspondence.

Submittal Date	Submitted By	Title or Description
February 23, 2011	DEQ (email)	DEQ compilation of upland screening criteria and drilling information, including waste observations and analytical data. Intended for discussion during March 17, 2011, meeting with NW Natural.
March 3, 2011	Meeting	NW Natural and DEQ held a technical meeting to discuss the regulatory framework for the riverbank and updating of the BUD.
March 8, 2011	DEQ (email)	DEQ clarification on the riverbank exposure area and the Tar Ponds risk screen prior to March 17, 2011, meeting.
March 10, 2011	NW Natural (email)	NW Natural provided DEQ with meeting materials for the March 17, 2011, technical meeting.
March 15, 2011	DEQ (email)	DEQ's response to NW Natural's March 10 email with their "general understandings and questions" for the March 17, 2011, technical meeting.
March 17, 2011	Meeting	NW Natural and DEQ held a technical meeting to discuss screening summary tables and other key issues.
March 23, 2011	NW Natural (meeting summary)	NW Natural's Draft Meeting Summary and Next Steps follow-up from the March 17, 2011, meeting
May 4, 2011	Meeting	Meeting between Ben Hung (Anchor QEA, LLC) and Dana Bayuk (DEQ) on HERA path forward issues.
May 12, 2011	DEQ (letter)	DEQ's response to NW Natural's Draft Meeting Summary and Next Steps follow-up from the March 17, 2011, meeting.
May 27, 2011	NW Natural (letter)	NW Natural's proposed process for finalizing the risk assessment (proposal for finalizing the risk assessment and proposed resolutions for the disagreements related to the HERA).
June 20, 2011	Meeting	NW Natural and DEQ held a technical meeting to discuss screening criteria, data gaps sampling, and other key issues.
June 22, 2011	NW Natural (meeting summary email)	NW Natural's email to DEQ summarizes the discussion on the outstanding HERA issues that took place during the June 20, 2011, technical meeting.
July 18, 2011	DEQ (email)	DEQ's response to NW Natural's summary of the June 20, 2011, technical meeting summary provided by NW Natural on June 22, 2011.
August 12, 2011	NW Natural (draft field sampling plan)	NW Natural's Draft Field Sampling Plan for TPH Fraction Data Gap Sampling (TPH FSP).
August 12, 2011	NW Natural (memorandum)	NW Natural's Riverbank Fill Monitoring Wells Proposal (proposal of monitoring wells for ecological screen).
August 12, 2011	NW Natural (cover letter)	NW Natural's cover letter to the Draft TPH FSP.

Submittal Date	Submitted By	Title or Description
August 15, 2011	Meeting	NW Natural and DEQ held a technical meeting to discuss TPH fraction data gap sampling and the proposals for shallow fill groundwater monitoring locations and addressing COI.
October 4, 2011	Call	Call between NW Natural and DEQ project managers to discuss finalization of the HERA; NW Natural agreed to organize the resolution of issues for completion of the HERA into the 6-Step Process framework.
October 10, 2011	NW Natural (email)	NW Natural's summary of project manager's call on October 4, 2011.
October 12, 2011	DEQ (email)	DEQ's response to NW Natural's summary of the project manager's call and request for clarification on schedule for HERA deliverables.
October 14, 2011	NW Natural (email)	NW Natural's response to DEQ feedback and questions contained in October 12, 2011, email.
October 21, 2011	DEQ (emails)	Two emails from DEQ to NW Natural responding to previous emails and clarifying DEQ's schedule for comments on FSP and their position on the 6-Step Process agreed upon for reaching final agreements to HERA finalization.
October 25, 2011	DEQ (letter)	DEQ's comments on the TPH FSP, indicating items needing resolution prior to DEQ approval.
October 31, 2011	NW Natural (memorandum)	NW Natural's submission of the Alternative Cyanide Soil Screening Level Memorandum to DEQ.
November 4, 2011	NW Natural (email)	NW Natural's summary of the 6-Step Process for completion of the HERA.
November 10, 2011	DEQ (email)	DEQ's response to the 6-Step Process for completion of the HERA.
November 18, 2011	Meeting	NW Natural and DEQ project managers held a technical meeting to discuss the remaining issues and agreements related to the risk assessment.
November 30, 2011	NW Natural (letter)	NW Natural's Summary of Agreements for Remaining Issues Related to the NW Natural Gasco Site Uplands Risk Assessment (Summary of Agreements).
January 5, 2012	DEQ (letter)	DEQ's response to NW Natural's November 30, 2011, Summary of Agreements letter and delivery to NW Natural of the Final Screening Matrix.
February 1, 2012	NW Natural (letter)	NW Natural's response to DEQ's January 5, 2012, letter.
February 15, 2012	NW Natural (email)	NW Natural's list of risk assessment issues to be resolved at the February 23, 2012, project managers meeting.
February 23, 2012	Meeting	NW Natural and DEQ project managers held a technical meeting to discuss the remaining issues and agreements related to the risk assessment.

Submittal Date	Submitted By	Title or Description
February 23, 2012	DEQ (email)	Summary of agreements reached with DEQ during the February 23, 2012, meeting.
March 2, 2012	DEQ (memorandum)	DEQ's submission of memorandum on derivation of alternative Level II Dibenzofuran Soil SLV.
March 8, 2012	NW Natural (Field Sampling Plan)	NW Natural's revised TPH FSP, submitted to DEQ for approval.

Notes:
BEHRA = Baseline Level III Ecological and Human Health Risk Assessment Report
BUD = beneficial use determination
COI = contaminant of interest
DEQ = Oregon Department of Environmental Quality
FSP = Field Sampling Plan
HERA = Human Health and Ecological Risk Assessment
RI/FS = Remedial Investigation and Feasibility Study
SLV = screening level value
TPH = total petroleum hydrocarbon

3 CONTAMINANTS OF INTEREST

A list of site-specific COIs has been developed for this HERA Work Plan and documented in previous project deliverables and communications. These COIs will be quantitatively evaluated in the HERA according to the methods presented in this Work Plan. The COIs, Chemical Abstracts Service (CAS) numbers (where available), and the citation of the first document that identified the contaminant as a site-specific COI are presented in Table 2.

For this HERA Work Plan, the COI list includes the chemicals that were evaluated in the 2004 BEHRA (Anchor 2004), identified in the 2007 RI (HAI 2007), and the contaminants listed in Appendix B of NW Natural's June 21, 2010, Risk Methods Proposal (Anchor QEA 2010). The COI list also includes total petroleum hydrocarbons (TPH), 1,2,4-trimethylbenzene (TMB), and 1,3,5-TMB, as requested in DEQ's March 2010 comments; carbazole, dibenzofuran, 1-methylnaphthalene, 2-methylnaphthalene, and thiocyanate, as requested in DEQ's October 25, 2011 email/letter; and thiocyanate, as requested by DEQ at the January 25, 2011 meeting.

4 SCREENING CRITERIA

The screening criteria that will be used in the HERA are based on extensive discussions and negotiations between NW Natural and DEQ. The agreed upon criteria, and screening level hierarchy for the environmental media that will be screened in the HERA, are presented in the final version of DEQ's Human Health, Ecological, and Source Control Screening Criteria Matrix (Final Screening Matrix) that was provided by DEQ to NW Natural on January 5, 2012 (DEQ 2012a). The Final Screening Matrix is presented in Appendix A of this HERA Work Plan.

As described in the TPH Field Sampling Plan (FSP; Anchor QEA 2012), site-specific TPH risk-based concentrations (RBCs) will be calculated in accordance with DEQ's Risk-Based Decision Making (RBDM) Guidance (DEQ 2003b) using data obtained from the implementation of the TPH FSP. These TPH RBCs will be used as human health soil screening criteria according to the directions provided in the Final Screening Matrix. As directed in DEQ's RBC calculation worksheet (DEQ 2011c), the site-specific TPH RBCs will be calculated using the results from the following analyses: extractable petroleum hydrocarbons (EPHs); volatile petroleum hydrocarbons (VPHs); benzene, toluene, ethylbenzene, and total xylenes (BTEX); 1,2,4-TMB; 1,3,5-TMB; and naphthalene.

The agreements reached between NW Natural and DEQ regarding screening criteria at the February 23, 2012, project managers meeting are not presented in the Final Screening Matrix so are summarized here. As documented in DEQ's February 23, 2012, meeting summary, the DEQ alternative No Observed Adverse Effect Level (NOAEL) Based Level II Soil Screening Level Value (SLV) of 17 milligrams per kilogram (mg/kg) dibenzofuran will be used to assess the risk to ecological receptors from soil exposure. The dibenzofuran soil screening level (SSL) that will be used in the ERA will be 85 mg/kg, which is the alternative NOAEL Based Level II Soil SLV multiplied by the factor of 5 to estimate a Lowest Observed Adverse Effect Level- (LOAEL-) based SLV in accordance with DEQ's ERA Guidance (DEQ 2001b). Although there are no ecological or human health criteria available for carbazole, carbazole will be evaluated using the human health soil screening level for dibenzofuran and the DEQ alternative SLV for dibenzofuran, as requested in DEQ's October 25, 2011, comments (DEQ 2011a).

5 DATA REDUCTION AND TRANSFORMATION

This section describes the data reduction steps to be conducted in the HERA for the human health and ecological risk assessment datasets used in the risk screen and in exposure point calculations. This section also describes the specific methodology that will be used in the HERA to estimate concentrations of 1,2,4- TMB, 1,3,5-TMB, and 1- and 2-methylnaphthalene and calculate new and existing TPH values.

Results of field duplicates or replicate samples will be averaged prior to the calculation of EPCs. If both parent and duplicate results are detected, the resulting concentration will be the arithmetic mean of the two detected values. If one result is non-detect, the detected value will be averaged with one-half of the non-detect value. If both results are non-detect, the resulting concentration will be one-half of the higher of the two detection limits (if different).

Totals are calculated utilizing one-half of the detection limit for non-detect results. If all results are non-detect for a given sample, the resulting total concentration is the maximum detection limit of the set of analytes in the total. Chemical totals will be calculated according to the summation rules documented in Table 2.

5.1 Calculating Estimated Concentrations of 1,2,4-TMB, 1,3,5-TMB, and 1- and 2-Methylnapthalene

As described in the TPH FSP (Anchor QEA 2012), data obtained from the implementation of the TPH FSP will be used to develop correlations between 1,2,4-TMB; 1,3,5-TMB; 1-methylnapthalene and 2-methylnapthalene; and one analyte with sufficient existing Site data, as directed by DEQ (2011a). Regression equations developed from these correlations will be used to calculate estimated concentrations of 1,2,4-TMB; 1,3,5-TMB; 1-methylnapthalene; and 2-methylnapthalene in existing samples. Regression equations to estimate COI concentrations will be developed for each exposure area.

5.2 Calculating New and Existing TPH Values

As described in the TPH FSP (Anchor QEA 2012) and consistent with DEQ's October 25, 2011, comments, new and existing TPH values will be calculated as the sum of the TPH diesel-range (TPH-Dx) and TPH gasoline-range (TPH-Gx) results. Existing TPH data that were analyzed by the U.S. Environmental Protection Agency (EPA) Method 418.1 will also be screened against

site-specific TPH RBCs but will be adjusted to account for concentrations of benzene, ethylbenzene, toluene, and C5-C8 aliphatics, which are not quantified by the method. Consistent with DEQ's October 25, 2011, comments, the adjustment coefficient will be estimated by determining the percentage of TPH in each risk area made up of benzene, ethylbenzene, toluene, and C5-C8 aliphatic hydrocarbons. The Method 418.1 results will be increased by the estimated percentage prior to screening.

6 CALCULATION OF EXPOSURE POINT CONCENTRATIONS

This section describes how EPCs will be calculated for the human health and ecological risk assessments.

Soil EPCs will be calculated for each of the exposure areas described in Section 7.1 for the HHRA and Section 8.1 for the ERA, for all analytes. For soil samples that have four or more detected observations, the EPC will be estimated by the 90th percent upper confidence limit (UCL) of the mean (90 UCL). For samples with fewer than four detected results, the EPC will be represented by the maximum detected result or maximum non-detect value if all results are non-detect.

The 90 UCL will be calculated using EPA's ProUCL (version 4.1) for all data distributions. The EPC will be selected from the 90 UCL results based on ProUCL's recommendation. If the recommended 90 UCL is greater than the maximum detected result, the lower of the maximum detected concentration and the recommended 90 UCL will be selected as the EPC.

Site groundwater data from wells monitored in support of the RI will be screened on a point-by-point basis. The maximum concentrations from the 4 most recent monitoring events will represent the EPCs. If wells have been monitored fewer than four times, the maximum concentrations from the available data will represent the EPCs. Data from decommissioned wells will not be included in the groundwater risk screen.

7 HUMAN HEALTH RISK ASSESSMENT

This section describes the methods that will be used to conduct the HHRA. The HHRA will be performed in accordance with DEQ guidance for human health risk assessment (DEQ 2003b, 2010b, 2011b) and consistent with the agreements reached between DEQ and NW Natural between March 10, 2010, and February 23, 2012.

7.1 Exposure Areas

The Site was divided into seven study or exposure areas for the upland risk assessment. Five of the seven areas were identified by HAI during the RI (HAI 2007). The HAI study areas were defined primarily for risk assessment purposes to facilitate a focused evaluation based on Site use and overall contaminant distribution. The study or exposure areas, which were recommended to HAI by DEQ staff, include the former spent oxide storage (Former Spent Oxide) area, former office (Office) area, Fuel and Marine Marketing (FAMM) lease area, the former Retort/Koppers operations (Former Retort/Koppers) area, and the former tar effluent settling pond (Former Tar Ponds) area. Sub-areas within the Former Retort/Koppers area were further subdivided into the Liquified Natural Gas (LNG) Operations Area and LNG Containment Basin based on DEQ's March 10, 2010, comments. Human health exposure areas for this HHRA are shown on Figure 2. Figure 2 also shows the historical RI soil, wetland substrate and surface water sample locations.

Samples that were previously identified as riverbank samples, including samples from the SS-series, GST-series, and GSM-series, will be integrated into the adjacent upland exposure areas. Consistent with DEQ's recommendation and the agreement described in DEQ's February 23, 2012, meeting summary, the riverbank samples will be incorporated into the Former Tar Ponds area or the Former Spent Oxide area as follows:

- Tar Ponds: SS-1, SS-2, SS-3, SS-4, SS-5, SS-11, GST-05, GST-06, GST-09, GSM-07, GSM-08
- Spent Oxide (or "Northern Exposure Area"): SS-6, SS-7, SS-8, SS-9, SS-10, GST-01, GST-02, GST-03, GST-04

7.2 Potentially Exposed Populations, Exposure Scenarios, and Exposure Routes

Potentially exposed human populations were evaluated and presented in the Level II Risk Screening (Anchor 2001a), the Receptor Pathway Selection Interim Technical Memorandum

(Anchor 2001b), the Revised BEHRA Report (Anchor 2004), and in the Gasco-Upland – Risk Proposal (Anchor QEA 2010). These documents described the human populations, exposure scenarios, and exposure routes that form the basis for the selection of the screening criteria that are presented in the Final Screening Matrix (see Appendix A) and will be used in the HHRA. This information is summarized in the following subsections.

7.2.1 Potentially Exposed Populations

The Site is, and will continue to be, an industrial facility. There are three potential general types of populations that could have current or reasonably likely future exposures to Site chemicals. These general types of populations are as follows:

- On-site workers expected to be present on a regular basis
- Construction workers working on longer-term redevelopment activities on site
- Excavation workers working on short-term utility or other excavation activities on site

No commercial, residential, or types of uses other than industrial exist for the Site. The general public that might periodically visit the Site for business purposes or gain unauthorized access to the Site on a one-time or irregular basis (trespassing) would be covered under the exposure assumptions for the occupational worker.

7.2.2 Exposure Scenarios

Based on current and future use, the most representative exposure scenarios for this Site are as follows:

- Occupational (on-site workers, visitors, and trespassers)
- Construction workers
- Excavation workers

7.2.3 Exposure Routes

Based on the potentially exposed populations present on site, the following exposure routes were selected for evaluation in the HHRA:

- Occupational (covers worker, visitor, and trespasser exposures)
  - Incidental ingestion of soil
  - Dermal contact with soil
  - Outdoor inhalation of airborne chemicals (dust and volatiles) from soil and groundwater
  - Indoor inhalation of airborne volatile chemicals from groundwater
- Construction Worker
  - Incidental ingestion of soil
  - Dermal contact with soil
  - Inhalation of airborne chemicals (dust and volatiles) from soils and groundwater
  - Dermal contact with groundwater (where present at shallower than 12 feet below ground surface [bgs])
- Excavation Worker
  - Incidental ingestion of soil
  - Dermal contact with soil
  - Inhalation of airborne chemicals (dust and volatiles) from soil and groundwater
  - Dermal contact with groundwater (where present at shallower than 12 feet bgs)

In the March 10, 2010, comments to NW Natural's Draft Risk Assessment, DEQ suggested that the lower Alluvial WBZ has a potential beneficial use as an industrial water supply. DEQ directed NW Natural to update the Beneficial Use Determination (BUD) for groundwater to determine appropriate risk-based screening for the lower Alluvial WBZ. The updated BUD for Groundwater, based on the current understanding of hydrogeological conditions, an updated well survey, and property owner interviews, was submitted to DEQ in correspondence dated October 21, 2011.

DEQ again determined on January 5, 2012, that future industrial use of the Alluvial WBZ was reasonably likely. NW Natural disagrees with this determination. NW Natural and DEQ have agreed to meet to discuss and resolve this issue with the goal of reaching resolution prior to the submittal of the HERA report. As documented in DEQ's February 23, 2012, meeting summary, the lower Alluvial WBZ will be screened against industrial use screening criteria in the HERA; however, NW Natural reserves the right to dispute the determination and to base inclusion of

the Alluvial WBZ screen in the HERA and subsequent remedy decision documents on the resolution of that dispute.

7.3 Screening Methodology

The human health risk screen will be conducted using the screening levels and hierarchy identified in the Final Screening Matrix (see Appendix A) and in accordance with the agreements reached between NW Natural and DEQ between March 10, 2010, and February 23, 2012. The screening assessment will be conducted by comparing the agreed upon screening levels to the appropriate EPCs, using a hazard quotient (HQ) approach. An HQ greater than 1 will indicate the screening value has been exceeded. The process for calculating EPCs is described in Section 6. The risk screen will not be limited to site-specific COIs, and contaminants analyzed will be screened against available criteria.

The remainder of this section describes the specific soil, groundwater, and surface water risk screens that will be conducted as part of the HHRA. The soil borings and monitoring well locations are shown on Figures 2 and 3 respectively.

7.3.1 Upland Soil Screen (Final Screening Matrix: Riverbank and Upland Soil Samples)

Soil data from the 0- to 3.5-foot interval will be used to evaluate human health exposure to surface soil. As requested by DEQ, data from deeper soil down to 6 feet will be used on a location-by-location basis, where data from the 0-to 3.5-foot interval is not available. The boring identification numbers and depth intervals of the soil samples included in the surface soil screen, including the specific deeper soil samples, were provided in the risk screening summary tables submitted to DEQ on March 10, 2011, as part of meeting briefing materials for the March 17, 2011, meeting. Consistent with the Final Screening Matrix, EPCs calculated for the surface soil interval will be screened against DEQ RBCs (DEQ 2011b) for occupational and construction worker direct contact and volatilization to outdoor air and leaching to groundwater (occupational). Where DEQ RBCs are not available, EPA Risk Screening Levels (RSLs; EPA 2011) will be used.

Soil data from the 0 to 12-foot interval will be used to evaluate human health exposure to subsurface soil. To improve spatial coverage, deeper data from soil down to 12.5 feet will be used on a location-by-location basis, where soil boring data from between 3.5 feet and 12 feet

are not available. The boring identification numbers and depth intervals of the soil samples to be included in the subsurface soil screen were also provided in the risk screening summary tables submitted to DEQ on March 10, 2011, as part of meeting briefing materials for the March 17, 2011, meeting. Subsequent to the March 17, 2011, meeting, NW Natural added soil data from three additional borings with data in the 12 to 12.5 foot interval to supplement the subsurface soil dataset. These borings are GT-3 (FAMM exposure area), B-11 (LNG Operations exposure area), B-25 (Former Retort/Koppers exposure area), and are shown on Figure 2.

Soil EPCs calculated for the subsurface interval will be screened against DEQ RBCs for construction, excavation worker direct contact and groundwater volatilization, occupational worker volatilization to outdoor air and vapor intrusion, and leaching to groundwater (occupational). Where DEQ RBCs are not available, EPA RSLs will be used.

As described in the TPH FSP (Anchor QEA 2012), new and existing TPH data will be screened against one of the five site-specific TPH RBCs. Existing TPH data will be assigned to a site-specific TPH RBC based on proximity to the risk area and not by exposure area assignment.

Historical soil sample locations are shown on Figure 2.

7.3.2 Surficial Fill Groundwater and LNG Tank Basin Screen (Final Screening Matrix: Fill WBZ)

Groundwater data from Fill WBZ monitoring wells and three Fill WBZ/Alluvial WBZ (hybrid) wells installed to support the RI will be used to evaluate human exposure to surficial fill groundwater. Groundwater EPCs will be screened against DEQ RBCs for vapor intrusion into buildings (occupational worker) and groundwater in excavations (construction and excavation worker). Monitoring wells, MW-06-32, MW-10-25, MW-11-32, and MW-13-30 will be used to evaluate human exposure to contaminants volatilizing from surficial fill groundwater near the LNG tank basin and will also be screened against the DEQ RBC for volatilization to outdoor air (occupational worker).

7.3.3 Alluvial Groundwater Screen (Final Screening Matrix: Alluvial WBZ)

Groundwater data from Alluvial WBZ monitoring wells and three hybrid wells installed to support the RI will be used to evaluate human exposure to alluvial groundwater for potential

industrial use. The alluvial groundwater EPCs will be screened against DEQ RBCs for occupational worker ingestion and inhalation from tap water.

As discussed in Section 7.2, NW Natural reserves the right to dispute the BUD determination and to base inclusion of the Alluvial WBZ screen in the HERA and subsequent remedy decision documents on the outcome of the beneficial use designation process. The locations of these monitoring wells are shown on Figure 3.

7.4 Risk Characterization

For the human health soil screen, unacceptable risk will be determined by comparing exposure area specific EPCs with DEQ RBCs and EPA RSLs using an HQ approach. If any exposure area specific surface or subsurface soil EPC exceeds its corresponding human health screening level, that environmental media will be assumed to have unacceptable risk for that exposure pathway for the entire exposure area. In addition, manufactured gas plant (MGP) residual observations will be used as qualitative indications of unacceptable human health risk to assist in the delineation of unacceptable risk areas at the Site where corresponding analytical data are not available. As documented in DEQ's February 23, 2012, meeting summary, MGP residual observations that will be used as qualitative indications of unacceptable risk are the presence of tar, oil, lampblack, or carbon pitch. Observations of sheen, odor, or stained soil will not be used as a basis to identify MGP residuals for the purposes of the risk assessments (DEQ 2012b).

For the human health groundwater screen, unacceptable risk will be determined on a point-by-point basis. The point-by-point groundwater EPCs will be based on the maximum concentrations from the four most recent monitoring events. If wells have been monitored fewer than four times, the maximum concentration from the available data will be selected for screening purposes. Similar to the soil screening methodology, any exceedance of the human health screening level within an exposure area will be assumed to indicate unacceptable risk for that exposure scenario for the entire exposure area.

7.5 Uncertainty Analysis

The HHRA will include a discussion of uncertainties associated with the risk assessment. The discussion will focus on issues likely to have the greatest effects on the results of the risk analyses.

For this risk assessment, the general sources of uncertainty to be addressed include the following:

- Data collection and evaluation assumptions
- Exposure assessment and exposure scenarios assumptions
- Toxicity assessment assumptions

8 ECOLOGICAL RISK ASSESSMENT

This section describes the methods that will be used to conduct the ERA for the Site. The purpose of the ERA is to determine risks to ecological receptors related to chemicals in upland matrices under existing and potential future Site conditions.

8.1 Exposure Areas

There are three ecological exposure areas that will be evaluated in the ERA. Based on discussions with DEQ, agreement was reached to focus the ERA on the areas of the Site that contain habitat. The three distinct exposure areas in this ERA are the Office area, the Former Spent Oxide area, and the Former Tar Ponds area. The Site ecological exposure areas are shown on Figure 2. As described in Section 7.1, samples that were previously identified as Riverbank samples will be integrated into the adjacent upland exposure areas.

8.2 Ecological Receptors and Exposure Pathways

Site-specific ecological receptors and exposure pathways are described in detail in the Revised BEHRA (Anchor 2004). The screening methodology and screening levels presented in the following sections are based on discussions and agreements with DEQ on the ERA.

8.3 Screening Methodology

The ecological risk screen for surface soils will be conducted using the screening levels and hierarchy identified in the Final Screening Matrix (see Appendix A). Mammalian and avian receptors will be evaluated by comparing ecological screening levels (ESLs) to exposure area specific EPCs using an HQ approach. The process for calculating EPCs is described in Section 6. Plants and invertebrates will be evaluated by a point-by-point screen using an HQ approach. An HQ greater than 1 will indicate the screening value has been exceeded.

The ecological risk screen for site groundwater will be conducted using the screening levels and hierarchy identified in the Final Screening Matrix (see Appendix A). Site groundwater will be screened on a point-by-point basis using an HQ approach. An HQ greater than 1 will indicate the screening value has been exceeded.

The risk screen will not be limited to site-specific COIs, and contaminants analyzed will be screened against available criteria.

Consistent with DEQ guidance, ecological SSLs that have been derived using NOAEL instead of LOAEL will be multiplied by five to account for the fact that a population level endpoint is appropriate for ecological receptors at the Site. The times-five multiplier will apply to DEQ, EPA, and Region 5 SSLs for birds and mammals, as appropriate.

The remainder of this section describes the specific soil, groundwater, and surface water risk screens that will be conducted as part of the ERA. The historical RI soil, wetlands substrate, and surface water sample locations are shown on Figure 2. The monitoring well locations are shown on Figure 3.

8.3.1 Surface Soil (Final Screening Matrix: Riverbank and Upland Soil Samples)

Soil data from 0 to 3.5 feet will be used to evaluate ecological exposure to surface soil. As requested by DEQ, data from deeper soil down to 6 feet will be used on a location-by-location basis, where data from the 0 to 3.5-foot surface interval are not available. The borings identification numbers and depth intervals for the soil samples to be included in the surface soil screen, including the specific deeper soil samples, were provided in the risk screening summary tables submitted to DEQ on March 10, 2011, as part of meeting briefing materials for the March 17, 2011, meeting. Consistent with DEQ's Final Screening Matrix, EPCs or point concentrations will be screened against the EPA ecological SSLs (EPA 2010), DEQ SLVs (2001b), or Region 5 SSLs (EPA 2003b) using the directions and hierarchy contained in the Final Screening Matrix.

Historical soil sample locations are shown on Figure 2.

8.3.2 Wetland Area Screen (Final Screening Matrix: Wetland Ponds Sediment and Wetland Ponds Surface Water)

Exposure to wetland substrates for both mobile and non-mobile receptors will be evaluated on a point-by-point basis by screening samples SD-1, SD-2, and SD-3 against DEQ Level II Toxicity Sediment Quality Guidelines (SQGs; 2001b), DEQ Bioaccumulation Sediment SLVs (2001b), or EPA Region III Biological Technical Assistance Group (BTAG) Freshwater Sediment Benchmarks (for analytes not included in DEQ Level II Toxicity Sediment SQGs; EPA 2006a).

Wetland surface water samples (SW-1 through SW-5) will be screened against National Ambient Water Quality Criteria, Tier II Chronic Values from Suter and Tsao (1996), Final Chronic Values (FCV) for polycyclic aromatic hydrocarbons (PAHs; EPA 2003a), and EPA Region III BTAG Freshwater Screening Criteria (EPA 2006b) following the hierarchy provided in the Final Screening Matrix.

8.3.3 LNG Tank Basin and Near-Shore Surficial Fill Groundwater Screen (Final Screening Matrix: Fill WBZ)

Groundwater data from Fill WBZ monitoring wells MW-06-32, MW-10-25, MW-11-32, and MW-13-30 will be used to evaluate ecological exposure to surface water within the LNG tank basin resulting from surficial fill groundwater discharges to the LNG tank basin. The groundwater EPCs will be screened against DEQ surface water SLVs (DEQ 2001b), the agreed upon hierarchy for aquatic life benchmarks, as presented for wetland surface water samples in the Final Screening matrix, and the cyanide screening level value from Eisler's *Cyanide Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review* (1991).

The near-shore surficial fill groundwater screen will consist of data from the DEQ approved monitoring wells listed in NW Natural's August 12, 2011, Riverbank Fill Monitoring Well Proposal. These wells will be screened against the same criteria as described previously for the LNG tank basin wells in accordance with the Final Screening Matrix.

8.3.4 Alluvial Groundwater Screen (Matrix: Alluvial WBZ)

Ecological exposure to site-wide alluvial groundwater will be evaluated by screening the groundwater EPCs against the National Ambient Water Quality Criteria, Tier II Chronic Values from Suter and Tsao (1996), FCV for PAHs (EPA 2003a), and EPA Region III BTAG Freshwater Screening Criteria (EPA 2006b) following the hierarchy presented in the Final Screening Matrix.

8.4 Risk Characterization

For the ecological soil screen, unacceptable risk for mammals and birds will be determined by comparing exposure area specific EPCs with ESLs. Unacceptable risk for plants and invertebrates will be determined on a point-by-point basis. If any exposure area specific surface soil EPC exceeds its corresponding ESL, that environmental media will be assumed to have unacceptable risk for that exposure pathway and receptor for the entire exposure area. In

addition, MGP residual observations will be used as qualitative indications of unacceptable ecological risk to assist in the delineation of unacceptable risk areas at the Site where corresponding analytical data is not available. As documented in DEQ's February 23, 2012, meeting summary, MGP residual observations that will be used as qualitative indications of unacceptable risk are the presence of tar, oil, lampblack, or carbon pitch. Observations of sheen, odor, or stained soil will not be used as a basis to identify MGP residuals for the purposes of the risk assessments (DEQ 2012b).

For the ecological screen of groundwater and wetland substrate samples, unacceptable risk will be determined on a point-by-point basis. Point-by-point concentrations will be based on either a single sample (e.g., wetland substrate) or the maximum concentration from the four most recent monitoring events (e.g., groundwater). Similar to the soil screening methodology, any exceedance of the ESL within an exposure area will be assumed to indicate unacceptable risk for that exposure pathway and receptor for the entire exposure area.

8.5 Uncertainty Analysis

The ERA will include a discussion of uncertainties associated with the risk assessment. The discussion will focus on issues likely to have the greatest effects on the results of the risk analyses.

For this risk assessment, the general sources of uncertainty to be addressed include the following:

- Data collection and evaluation assumptions
- Exposure assessment and exposure scenarios assumptions
- Toxicity assessment assumptions

Consistent with agreements reached between NW Natural and DEQ, the ERA uncertainty section will also include an evaluation of the methods and assumptions used to derive the EPA Region 5 ESL for cyanide and a discussion of the uncertainties associated with DEQ's Level II Mammalian Soil SLV for dibenzofuran.

9 OUTLINE FOR RISK ASSESSMENT DELIVERABLES AND SCHEDULE

This section describes the HERA deliverables and schedule as agreed to by NW Natural and DEQ.

NW Natural will prepare a revised HERA that will focus on the problem formulation and subsequent steps of the risk assessments. Sections related to Site history, Site description, Site use, and a summary of Uplands data will reference the existing 2004 *Revised Baseline Ecological and Human Health Risk Assessment Report* and the 2007 *Remedial Investigation Report, NW Natural – Gasco Facility, Portland, Oregon,* and will update this information to reflect the current status of the Site. A preliminary outline has been developed for this HERA report and is presented in Appendix B of this Work Plan.

The HERA report will be completed on the following schedule, which is consistent with agreements reached during the February 23, 2012, meeting:

- Risk Assessment Work Plan Submittal to DEQ Review – March 22, 2012
- DEQ Review and Approve Risk Assessment Work Plan – on or before May 22, 2012
- Submittal of draft HERA to DEQ for review – NW Natural will submit the draft HERA report within 60 days of receiving DEQ approval of the Risk Assessment Work Plan or validated data from the TPH Fraction Data Gap FSP, whichever is later.

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TABLE 2

Table 2
Gasco Site-specific Contaminants of Interest

Analyte	CAS	Document/Date Identified as COI
Conventional Parameters (mg/kg)		
Cyanide, total	57-12-5	Risk Assessment (Anchor 2004)
Thiocyanate	302-04-5	January 25, 2011 Meeting
Metals (mg/kg)		
Antimony	7440-36-0	Risk Assessment (Anchor 2004)
Arsenic	7440-38-2	Risk Assessment (Anchor 2004)
Beryllium	7440-41-7	Risk Assessment (Anchor 2004)
Cadmium	7440-43-9	Risk Assessment (Anchor 2004)
Chromium	7440-47-3	Risk Assessment (Anchor 2004)
Copper	7440-50-8	Risk Assessment (Anchor 2004)
Lead	7439-92-1	Risk Assessment (Anchor 2004)
Mercury	7439-97-6	Risk Assessment (Anchor 2004)
Nickel	7440-02-0	Risk Assessment (Anchor 2004)
Selenium	7782-49-2	Risk Assessment (Anchor 2004)
Silver	7440-22-4	Risk Assessment (Anchor 2004)
Thallium	7440-28-0	Risk Assessment (Anchor 2004)
Zinc	7440-66-6	Risk Assessment (Anchor 2004)
Polycyclic Aromatic Hydrocarbons (µg/kg)		
1-methylnaphthalene	90-12-0	Remedial Investigation (HAI 2007)
2-methylnaphthalene	91-57-6	Remedial Investigation (HAI 2007)
Acenaphthene	83-32-9	Risk Assessment (Anchor 2004)
Acenaphthylene	208-96-8	Risk Assessment (Anchor 2004)
Anthracene	120-12-7	Risk Assessment (Anchor 2004)
Benzo(a)anthracene	56-55-3	Risk Assessment (Anchor 2004)
Benzo(a)pyrene	50-32-8	Risk Assessment (Anchor 2004)
Benzo(b)fluoranthene	205-99-2	Risk Assessment (Anchor 2004)
Benzo(g,h,i)perylene	191-24-2	Risk Assessment (Anchor 2004)
Benzo(k)fluoranthene	207-08-9	Risk Assessment (Anchor 2004)
Chrysene	218-01-9	Risk Assessment (Anchor 2004)
Dibenzo(a,h)anthracene	53-70-3	Risk Assessment (Anchor 2004)
Fluoranthene	206-44-0	Risk Assessment (Anchor 2004)
Fluorene	86-73-7	Risk Assessment (Anchor 2004)
Indeno(1,2,3-c,d)pyrene	193-39-5	Risk Assessment (Anchor 2004)
Naphthalene	91-20-3	Risk Assessment (Anchor 2004)
Phenanthrene	85-01-8	Risk Assessment (Anchor 2004)
Pyrene	129-00-0	Risk Assessment (Anchor 2004)
Total cPAH TEF (EPA 1993) [1,4]	NA	Risk Methods Proposal (Anchor 2010)
Total HPAH [1,3]	NA	Risk Methods Proposal (Anchor 2010)
Total LPAH [1,2]	NA	Risk Methods Proposal (Anchor 2010)
Semi-volatile Organics (µg/kg)		
1,2,4-trimethylbenzene	95-63-6	DEQ's March 2010 Comments
1,3,5-trimethylbezene	108-67-8	DEQ's March 2010 Comments
2,3,4,6-Tetrachlorophenol	58-90-2	Risk Assessment (Anchor 2004)
2,4,5-Trichlorophenol	95-95-4	Risk Assessment (Anchor 2004)
2,4,6-Trichlorophenol	88-06-2	Risk Assessment (Anchor 2004)

Table 2
Gasco Site-specific Contaminants of Interest

Analyte	CAS	Document/Date Identified as COI
Semi-volatile Organics (µg/kg; continued)		
2,4-Dichlorophenol	120-83-2	Risk Assessment (Anchor 2004)
2,4-Dimethylphenol	105-67-9	Remedial Investigation (HAI 2007)
2,4-Dinitrophenol	51-28-5	Risk Assessment (Anchor 2004)
2-Chlorophenol	95-57-8	Risk Assessment (Anchor 2004)
2-Methyl-4,6-dinitrophenol	534-52-1	Risk Assessment (Anchor 2004)
2-Methylphenol	95-48-7	Risk Assessment (Anchor 2004)
2-Nitrophenol	88-75-5	Risk Assessment (Anchor 2004)
3-Methylphenol	108-39-4	Risk Assessment (Anchor 2004)
3,4-Dimethylphenol	95-65-8	Remedial Investigation (HAI 2007)
4-Chloro-3-methylphenol	59-50-7	Risk Assessment (Anchor 2004)
4-Methylphenol (p-Cresol)	106-44-5	Risk Assessment (Anchor 2004)
4-Nitrophenol	100-02-7	Risk Assessment (Anchor 2004)
Carbazole	86-74-8	Remedial Investigation (HAI 2007)
Dibenzofuran	132-64-9	Remedial Investigation (HAI 2007)
Pentachlorophenol	87-86-5	Risk Assessment (Anchor 2004)
Phenol	108-95-2	Risk Assessment (Anchor 2004)
Total Petroleum Hydrocarbons (mg/kg)		
Total Petroleum Hydrocarbons (TPH) [1,5]	TPH	DEQ's March 2010 Comments
Volatile Organics (µg/kg)		
Benzene	71-43-2	Risk Assessment (Anchor 2004)
Ethylbenzene	100-41-4	Risk Assessment (Anchor 2004)
Toluene	108-88-3	Risk Assessment (Anchor 2004)
Total Xylene	1330-20-7	Risk Assessment (Anchor 2004)

Notes:

1. Totals are calculated as the sum of all detected results and 0.5 the reporting limit. If all are undetected results, the highest reporting limit value is reported as the sum.

2. Total LPAH is the total of 2-Methylnaphthalene, Naphthalene, Acenapthylene, Acenaphthene Flourene, Phenanthrene, and Anthracene.

3. Total HPAH is the total of Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Benzo(x)fluoranthenes, Benzo(a)pyrene, Indeno(1,2,3-c,d)pyrene, Dibenzo(a,h)anthracene, and Benzo(g,h,i)perylene

4. Total cPAH (EPA 1993) includes Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Chrysene, Dibenzo(a,h)anthracene, and Indeno(1,2,3-c,d)pyrene.

5. TPH is calculated as the sum of diesel and oil (often reported as motor oil; NWTPH-Dx) and gasoline range hydrocarbons (NWTPH-Gx).

Acronyms:

µg/kg = microgram per kilogram
CAS = Chemical Abstracts Service
COI = contaminant of interest
cPAH = carcinogenic polycyclic aromatic hydrocarbon
EPA = U.S. Environmental Protection Agency
HPAH = high molecular weight polycyclic aromatic hydrocarbon
LPAH = low molecular weight polycyclic aromatic hydrocarbon
mg/kg = milligram per kilogram
NA = not available
NWTPH-Dx = Northwest Total Petroleum Hydrocarbon – Diesel Range
NWTPH-Gx = Northwest Total Petroleum Hydrocarbon – Gasoline Range
PAH = polycyclic aromatic hydrocarbon
TEF = toxicity equivalence factors
TPH = total petroleum hydrocarbon

FIGURES

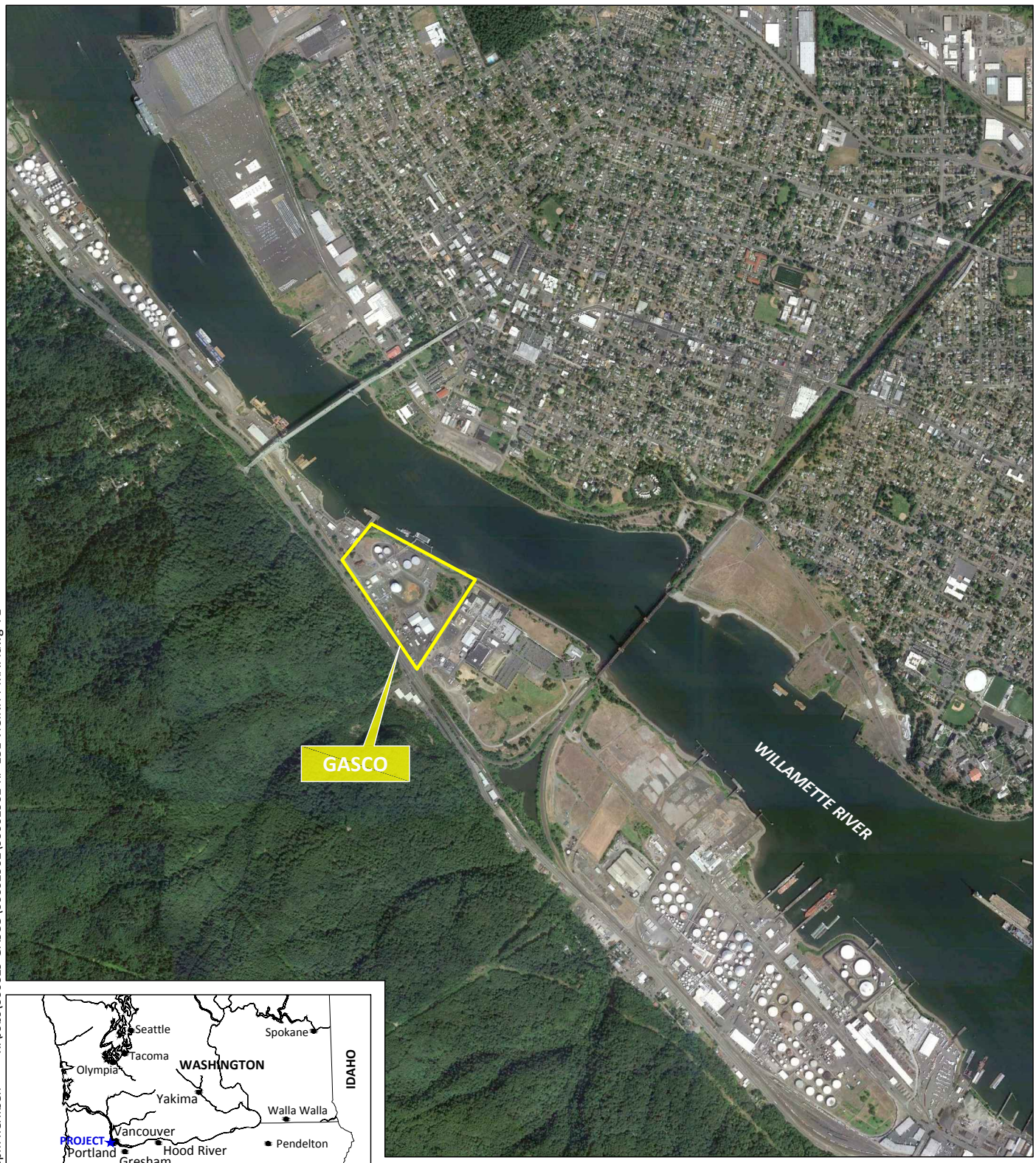

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Figure 1
Site Vicinity Map
Human Health and Ecological Risk Assessment Work Plan
NW Natural Gasco Site

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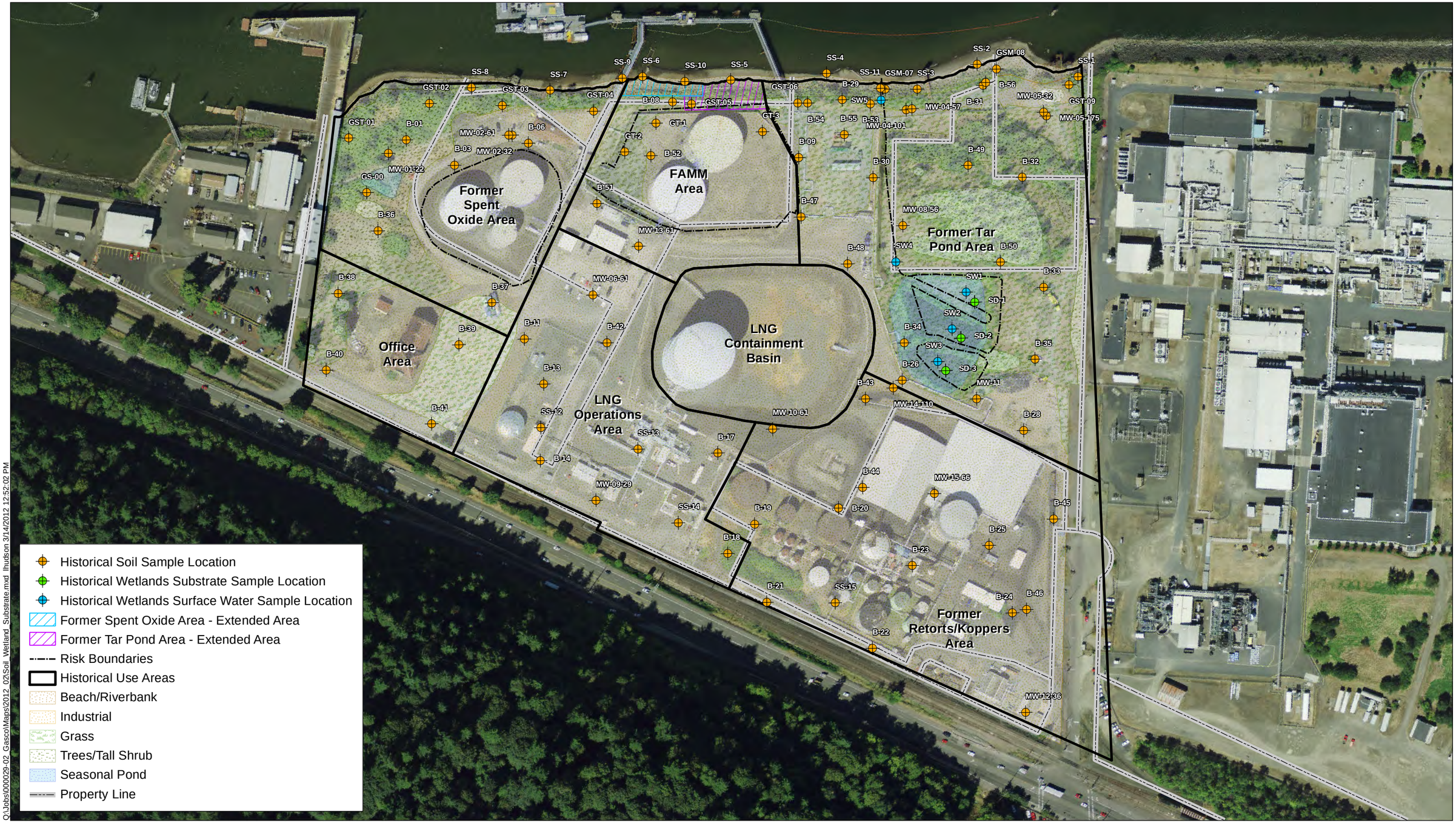

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Figure 2
Historical Soil, Wetlands Substrate, and Surface Water Sample Location and Exposure Area Map
Human Health and Ecological Risk Assessment Work Plan
NW Natural Gasco Site

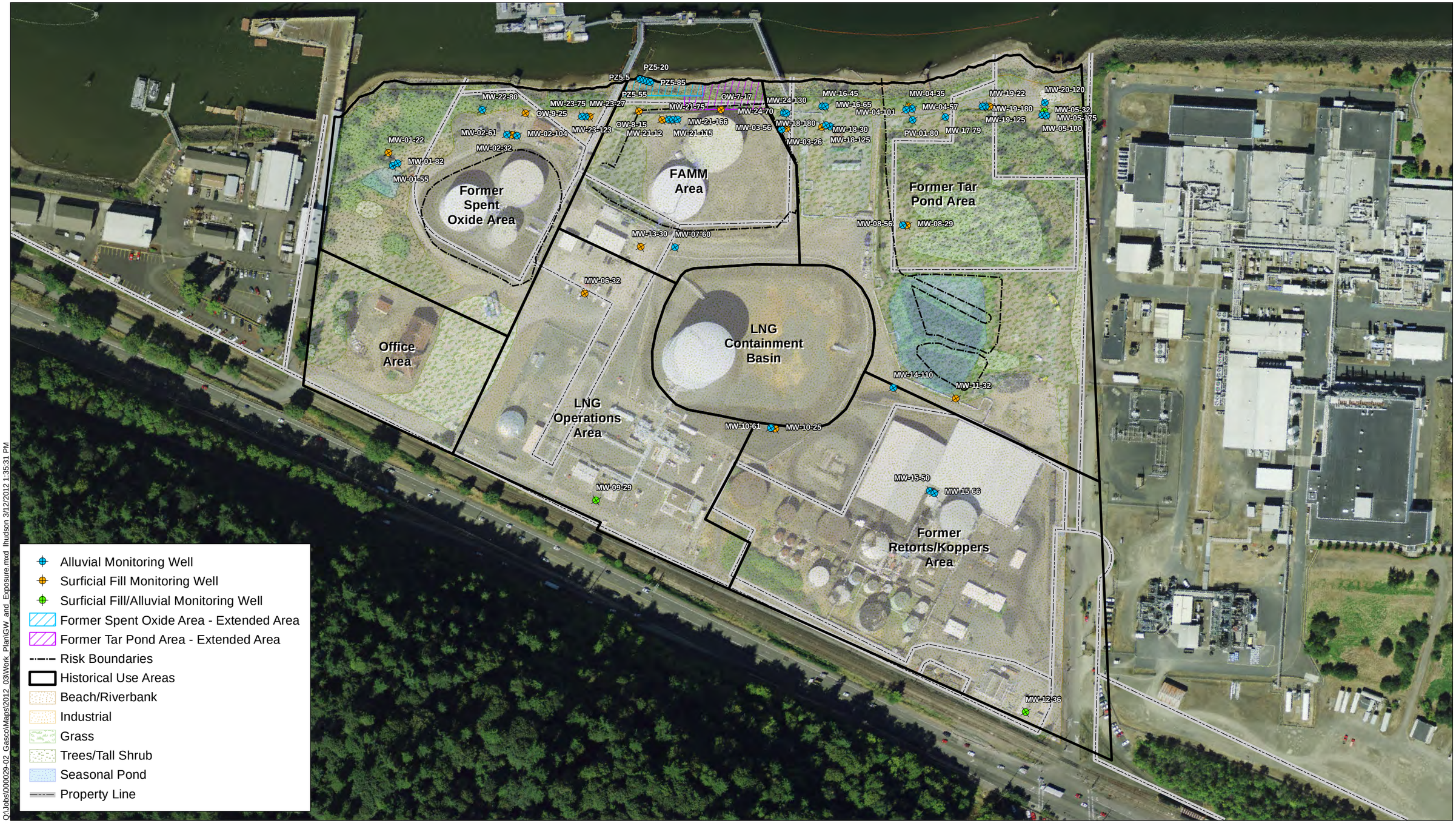

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Figure 3
Groundwater Monitoring Well Station ID and Exposure Area Map
Human Health and Ecological Risk Assessment Work Plan
NW Natural Gasco Site

APPENDIX A
HUMAN HEALTH, ECOLOGICAL, AND SOURCE CONTROL SCREENING CRITERIA MATRIX

ATTACHMENT

Human Health, Ecological, and Source Control Screening Criteria Matrix

	Human Health Criteria		Ecological Receptor Criteria	Source Control Criteria (see Note #3)
Soil Depth Interval (feet)	0-3.5	0-12	0-3.5	0-1
River Bank Soil Samples (See Notes #4 and #7)	1) DEQ RBCs - Occupational & Construction Worker direct contact and outdoor air volatilization pathways 2) EPA RSLs (see Note #1)	1) DEQ RBCs - Construction & Excavation Worker direct contact and volatilization to outdoor air; Occupational Worker vapor intrusion and outdoor air 2) EPA RSLs (see Note #1)	1) EPA Eco-SSLs for LPAHs and HPAHs (soil invertebrates and mammals) and metals (plants, soil invertebrates, birds, mammals) 2) DEQ Terrestrial SLVs, direct contact and ingestion (terrestrial invertebrates, plants, mammals, and bird values) 3) EPA Region 5 soil direct contact and ingestion ESLs (see Note #2)	Not Applicable (will be included in Gasco Sediment Project)
Upland Soil Samples (see Notes #6 and #7)	1) DEQ RBCs - Occupational & Construction Worker direct contact and volatilization to outdoor air; Leaching to groundwater 2) EPA RSLs (see Note #1)	1) DEQ RBCs - Construction & Excavation Worker direct contact and groundwater volatilization; Occupational Worker volatilization to outdoor air and vapor intrusion; Leaching to groundwater 2) EPA RSLs (see Note #1)	1) EPA Eco-SSLs for LPAHs and HPAHs (soil invertebrates and mammals) and metals (plants, soil invertebrates, birds, mammals) 2) DEQ Terrestrial SLVs, direct contact using mammals, bird, soil invertebrate and plant values 3) EPA Region 5 ESLs, soil direct contact and ingestion (See Note #2)	1a) DEQ Bioaccumulative Sediment SLVs (JSCS Dec 2005, see Note #5 below), and 1b) MacDonald PECs and other SQVs (JSCS December 2005, see Note #5 below)
Catch Basin Solids Samples	Not Applicable		Not Applicable	1a) DEQ Bioaccumulative Sediment SLVs, and 1b) MacDonald PECs and Other SQVs (JSCS Dec 2005)
Wetland Ponds Sediment Samples (see Note #6)	Not Applicable (see Note #9)		1a) DEQ Level II Toxity Sediment SQGs, and 1b) DEQ Bioaccumulative Sediment SLVs (see Note #8) 2) EPA (2006a) Region III BTAG Freshwater Sediment Benchmarks (for COI not included in the list of DEQ toxicity SQGs)	Not Applicable
Storm Water Samples	Not Applicable		Not Applicable	Lower of either federal human health or ecological criteria per JSCS (see Note #3)
Wetland Ponds Surface Water	Not Applicable (see Fill WBZ for LNG Basin)		1) National Ambient Water Quality Criteria (NAWQC), hardness adjusted to 25 mg/L calcium carbonate for hardness dependent COIs 2) Tier II Chronic Values from Suter and Tsao, 1996 (ORNL) 3) EPA, 2003. Final Chronic Values (FCV) for PAHs 4) EPA, 2006b, EPA Region III BTAG, Freshwater Screening Criteria	Not Applicable
Fill WBZ	DEQ RBCs - Occupational Worker volatilization to outdoor (LNG Tank Basin) & indoor air; Construction & Excavation Worker groundwater in excavation		1a) Lower of DEQ water SLVs for mammals, birds, invertebrates and plants (groundwater discharging onto riverbank &/or beach and LNG Tank Basin); and 1b) Aquatic life benchmarks - see hierarchy for wetland ponds/surface water (groundwater discharging into river below mean high water and LNG Tank Basin); and 1c) Water SLV protective of wildlife to cyanide exposure from Eisler, 1991 of <50 mg/L water (LNG Tank Basin).	Fill WBZ previously determined to be a high priority contaminant transport pathway to the Willamette River requiring source control
Alluvial WBZ	DEQ RBCs - Occupational Worker ingestion and inhalation of tapwater		Same as hierarchy presented above for wetland ponds / surface water	Alluvial WBZ previously determined to be a high priority contaminant transport pathway to the Willamette River requiring source control

Notes:

1. For any COI without corresponding DEQ soil, air, and/or groundwater RBCs, the EPA regional screening levels (RSLs) should be used.
2. For any COI without a corresponding EPA Eco SSL or DEQ ecologcial SLV, including cyanide; EPA Region 5 ecological screening levels (ESLs) should be used.
   Region 5 soil ESLs are based on mammalian exposure to soil (shrew) unless otherwise indicated. The alternative cyanide soil screening value (398.9 mg/kg) proposed by NW Natural will be further discussed in the uncertainty section of the risk assessment.
3. The Joint Source Control Strategy finalized in December 2005 (see http://www.deq.state.or.us/nwr/PortlandHarbor/JSCS.htm) should be referred to for source control criteria.
4. Riverbank samples include SS-1 through SS-11 and those collected along/near the top of bank as part of the uplands RI and AIR & Data Gaps scope of work.
5. Applies to upland surface soil samples within 100 feet of a catch basin and/or the top of the riverbank. Toxicity and bioaccumulation values should be used concurrently where available
6. Samples SD-1, SD-2, and SD-3 collected in the Wetland Ponds area should be used for sediment and uplands soil screening purposes. Refer to upland soil for ecological receptors for additonal criteria.
7. The ecological hierarchy applies to plants, invertebrates, birds and mammals separately. Eco-SSLs for LPAHs and HPAHs should be applied on an individual and total basis (e.g. Total LPAH and Total HPAH compared to the Eco SSL).
8. Screening should include birds, mammals, and fish/shellfish for lead, fluoranthene, and pyrene.
9. The Wetlands Ponds do not "currently" represent a human health exposure pathway. Depending on potential future use scenarios this pathway may need to be evaluated.

References:

EPA, 2003. Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: PAH Mixtures. Table 3-4

EPA, 2006a. Region III BTAG Freshwater Sediment Screening Benchmarks; http://www.epa.gov/reg3hwmd/risk/eco/btag/sbv/fwsed/R3_BTAG_FW_Sediment_Benchmarks_8-06.pdf

EPA, 2006b, Region III BTAG, Freshwater Screening Criteria, http://www.epa.gov/reg3hwmd/risk/eco/btag/sbv/fw/R3_BTAG_FW_Benchmarks_07-06.pdf

Eisler, Ronald. 1991. Cyanide Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review- U.S. Fish Wildl. Serv., Biol. Rep. 85(1.23).

Suter and Tsao, 1996. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision

Prepared by DEQ for NW Natural to use in preparing materials for the March 17, 2011 risk assessment scoping meeting and initially sent via e-mail February 23, 2011.

Revised consistent with DEQ's July 18, 2011 e-mail replying to NW Natural's June 20, 2011 meeting summary, a July 20, 2011 meeting, and incorporation of riverbank source control into the in-water project.

Finalized based on agreements reached during a meeting on November 18, 2011. Meeting agreements are documented in letters from NW Natural and DEQ dated November 30, 2011 and January 5, 2012, respectively.

APPENDIX B
HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT REPORT (PRELIMINARY OUTLINE)

HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT REPORT (PRELIMINARY OUTLINE)

Prepared for

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March 2012

PRELIMINARY OUTLINE FOR HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT (HERA) DELIVERABLE

List of Tables (to be determined)

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