
Remedial Investigation/Feasibility Study Work Plan for the Harbor Oil Site

Prepared for the Voluntary Group
for the Harbor Oil Site RI/FS

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IN ASSOCIATION WITH

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AND

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Acronyms

ACDP	Air contaminant discharge permit
ACG	Analytical concentration goal
AOC	Administrative Settlement Agreement and Order on Consent for Remedial Investigation/Feasibility Study
AST	Aboveground storage tank
AWQC	Ambient water quality criteria
bgs	Below ground surface
BOD	Biological oxygen demand
BOP	Bureau of Planning
BTOC	Below top of casing
CEC	Coles Environmental Consulting
COP	City of Portland
COPC	Constituent of potential concern
cm/sec	Centimeters per second
CPT	Cone-penetrometer technology
CSM	Conceptual site model
CSP	Concrete sewer pipe
CU1	Confining Unit 1
CU2	Confining Unit 2
DCA	Dichloroethane
DCB	Dichlorobenzene
DCE	Dichloroethylene
DEQ	Oregon Department of Environmental Quality
DO	Dissolved oxygen
DQO	Data quality objective
E&E	Ecology and Environment
EMRI	Energy & Materials Recovery, Inc.
ERA	Ecological risk assessment
EPA	U.S. Environmental Protection Agency
FSP	Field Sampling Plan
GC	Gas chromatography

gpm	Gallons per minute
HHRA	Human Health Risk Assessment
HSP	Health and Safety Plan
LNAPL	Light non-aqueous phase liquid
MAO	Mutual Agreement and Order
MDL	Method detection limit
msl	Mean sea level
MTBE	Methyl tert-butyl ether
NAPL	Non-aqueous phase liquid
NFA	No Further Action
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRMP	Natural Resource Management Plan
ODFW	Oregon Department of Fish and Wildlife
OWRD	Oregon Water Resources Department
PA	Preliminary Assessment
PAH	Polynuclear aromatic hydrocarbon
PCB	Polychlorinated biphenyl
PCE	Perchloroethylene
PIR	Portland International Raceway
PM	Particulate matter
PMP	Project Management Plan
ppm	Parts per million
PRG	Preliminary remediation goal
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RAO	Remedial Action Objective
RI/FS	Remedial Investigation/Feasibility Study
RFO	Refined fuel oil
RL	Reporting limit
RME	Reasonable maximum exposure
ROC	Receptor of concern
RZA	Rittenhouse-Zeman and Associates
SAP	Sampling and Analysis Plan
SE/E	Sweet-Edwards/EMCON

SGA	Sand and Gravel Aquifer
SI	Site investigation
SOW	Statement of Work
SPCC	Spill Prevention, Control and Countermeasure
SVOC	Semi-volatile organic compound
USA	Unconsolidated Sedimentary Aquifer
UST	Underground storage tank
TAL	Target analyte list
TCA	Trichloroethane
TCE	Trichloroethylene
TCLP	Toxicity Characteristic Leaching Procedure
TEC	Threshold effects concentration
TGA	Troutdale Gravel Aquifer
TOC	Total organic carbon
TOX	Total halogenated organics
TPH	Total petroleum hydrocarbons
TSS	Total suspended solid
VOC	Volatile organic compound

1.0 INTRODUCTION

1.1 Project Purpose and Scope

On May 31, 2007, Portland General Electric Company, Bonneville Power Administration, Avista Corporation, NorthWestern Corporation, Union Oil Company of California, and Waste Management Disposal Services of Oregon, Inc. (Voluntary Group for the Harbor Oil Site RI/FS [Voluntary Group]) entered into an Administrative Settlement Agreement and Order on Consent for Remedial Investigation/Feasibility Study (the AOC), Docket No. CERCLA-10-2007-0106, with the U.S. Environmental Protection Agency (EPA) for the Harbor Oil Superfund Site (Site) in Portland, Oregon. In accordance with the AOC, the Site encompasses the Harbor Oil facility (facility), an approximately 4.1 acre parcel of property located at 11535 N. Force Avenue, and any areas of contamination extending from the facility area into the wetlands and Force Lake. The AOC Statement of Work (SOW) requires that the Voluntary Group prepare a Remedial Investigation/Feasibility Study (RI/FS) Work Plan (Work Plan) that includes a compilation and review of site data and information, and a site characterization plan.

Site characterization will be conducted in two phases. Phase 1 sampling is intended to provide most of the information needed to fill the data gaps identified for each medium of interest. Phase 2 sampling will be conducted following the evaluation of Phase 1 data. Phase 2 sampling will occur when additional data are needed to better characterize ecological or human health risks, to further refine the delineation of areas of contamination within the Site boundaries, or to determine the extent of contamination that may have migrated from the Harbor Oil facility to surrounding areas. The scope of the Phase 2 effort will be determined in consultation with EPA based on the results of Phase 1. Phase 1 of the RI includes the characterization of soils and groundwater on the facility, soils in the adjacent wetlands, and lake sediments and surface water in an area referred to as the "Study Area" (see Figure 1).

This document is the RI/FS Work Plan for the Site. The scope of the Work Plan includes those activities required to complete an RI and FS as defined in the SOW for purposes of meeting the following project objectives:

1. Further determine the nature and extent of contaminants at the Site.
2. Determine the nature and extent of facility-related contaminants of concern in the sediments of adjacent wetlands and, if appropriate, in Force Lake and surface water bodies, if any, downstream of and receiving facility-impacted discharges from Force Lake.
3. Develop a conceptual site model.

4. Estimate the contaminant migration pathways including fluxes and rates through zones of migration.
5. Characterize any non-aqueous phase liquids (NAPL) in soil or groundwater within the Site.
6. Identify potential Applicable and Relevant and Appropriate Requirements (ARARs) for Site remediation.
7. Evaluate the potential human health and ecological risks posed by contaminants of concern for all appropriate pathways and receptors at the Site.
8. Evaluate potential remedial action alternatives to address unacceptable risks identified at the Site, if any.

The Work Plan was prepared by Bridgewater Group, Inc., GeoDesign, Inc. (GeoDesign), and Windward Environmental, LLC (Windward) for the Voluntary Group.

1.2 Work Plan Documents

This Work Plan consists of a set of documents that will guide the RI/FS. It has been developed in general accordance with EPA guidance (EPA 1988). The individual elements of the Work Plan are briefly summarized below:

Work Plan – The main text of the Work Plan describes the site background and physical setting, preliminary conceptual site model, work plan rationale, and RI/FS tasks. The Work Plan includes supporting tables and figures.

Project Management Plan (PMP) – The PMP (Appendix A) describes the key personnel and subcontractors involved in the RI/FS project, reporting requirements, procedures for handling variations from the Work Plan, data management, and a proposed schedule of submittals and RI/FS activities.

Quality Assurance Project Plan (QAPP) – The QAPP (Appendix B) describes the quality assurance (QA) objectives, procedures for sampling, and procedures for chemical analyses of samples collected from the Harbor Oil facility, adjacent wetlands, Force Lake, and North Lake. It also includes the elements required in a Field Sampling Plan (FSP).

Health and Safety Plan (HSP) – An HSP describes the procedures to be used in the field to protect personnel from potential hazards that may exist during sampling activities. Appendix C contains the HSP for the field sampling subcontractors, GeoDesign and Windward.

Remedial Action Objective (RAO) Technical Memorandum – As required by the AOC, preliminary RAOs are identified and presented in a technical memorandum (Appendix D). The RAO technical memorandum also includes a preliminary identification of potential remedial alternatives, and state and federal ARARs.

2.0 SITE BACKGROUND AND PHYSICAL SETTING

2.1 Site Location

The Harbor Oil Site is located in north Portland, Multnomah County, Oregon. In accordance with the AOC, the Site encompasses the Harbor Oil facility (facility), an approximately 4.1 acre parcel of property located at 11535 N. Force Avenue, and any areas of contamination extending from the facility area into the wetlands and Force Lake. Figure 1 illustrates the location of the Harbor Oil facility and Force Lake; the wetlands are located to the northwest and southwest of the facility. Figure 1 also illustrates the “Study Area” where soil, groundwater, sediment and surface water samples will be collected during the first phase of the RI.

The Site is located in Township 2 North, Range 1 East of Section 33 of the Willamette Meridian. According to Ecology and Environment (E&E) (E&E 2001), the Site is located at latitude 45°36'24.5" N and longitude 122°40'59.47" W.

The Site is located in an industrial area of north Portland, south of Marine Drive and west of Interstate 5. The Site location is illustrated in Figure 1.

The Oregon Slough (identified as “Portland Harbor” on Figure 1), a side channel to the Columbia River, is located to the north of Marine Drive. The Heron Lakes Golf Courses, which include the Great Blue and Greenback Golf Courses, are located to the south of the Site.

2.2 Facility Description and Conditions

According to information at <http://www.portlandmaps.com/detail.cfm>, the Harbor Oil facility occupies 4.1 acres (Partition Plat 1994-164, Lot 2). The Site includes the Harbor Oil facility (bounded by N. Force Avenue to the east and by the Bulk Transportation facility to the north), adjacent wetlands, and Force Lake. Most of the Harbor Oil facility is unpaved and covered with gravel.

Figure 2 shows current features on the Harbor Oil facility. According to Coles Environmental Consulting (CEC) (2002), Energy & Materials Recovery, Inc. (EMRI) currently operates a treatment and processing facility on the Harbor Oil facility for used oil, oily water, and other water. In 2005, EMRI processed 3.3 million gallons of raw used oil.

EMRI's office/shop/warehouse building is located on the southeast side of the Harbor Oil facility, near the main entrance along N. Force Avenue. A portion of this building is also used by Wevco BioDiesel, Inc. to manufacture bio-

diesel. Another portion of the building is occupied by an asphalt coating business, Phoenix Asphalt. Immediately to the northwest of the building is a card lock fueling operation which is also operated by a tenant.

EMRI took over the operation on October 1, 1999 after Harbor Oil, Inc. ceased doing business on the property. Under both Harbor Oil, Inc. and EMRI, the facility has processed various types of oil, off-specification fuels, and oily waters to produce refined fuel oil (RFO).

A tank farm and used oil processing area is located along the northeast side of the Harbor Oil facility. Used oil is delivered at a covered unloading rack located immediately southwest of the processing area and is stored in the tank farm. It is heated and then processed (i.e., filtered, dehydrated and blended) to produce RFO.

To the northwest of the tank farm and processing area is a large steel tank referred to as Tank 23. Wastewater from the RFO process was historically discharged to Tank 12 (located at the northwest end of the tank farm and used oil processing area) for storage and then to Tank 23 for treatment.

The RFO is further processed in a new base-oil refining plant (constructed in 2003) which is located to the west of the tank farm and used oil processing area. A variety of petroleum products are produced by the new base-oil refining plant. Soils excavated during the construction of the new base-oil plant were stockpiled on the Harbor Oil facility to the northwest of the plant (Figure 2).

A stormwater treatment system, that includes an oil-water separator, is located near the southwest side of the Harbor Oil facility. Treated stormwater is discharged to the wetlands, southwest of the Harbor Oil facility, under a National Pollutant Discharge Elimination System (NPDES) Industrial Stormwater Discharge Permit 1200-COLS. Catch basins are used to collect stormwater and convey it to the stormwater treatment system. Figure 2 illustrates the location of underground piping from the catch basins to the treatment system based on information provided by D. Coles. According to D. Coles, the piping was installed by 1984, the same time as the treatment system. Additional piping was installed in 2002 when EMRI closed off the drainage ditch that ran along the northeastern property boundary and installed the two catch basins located in that area. Additional piping was also installed in 2006 when the catch basins near the card lock facility were installed. According to D. Coles, the system is in good condition. Based on DEQ file information, EMRI is required to sample four times per year, at least 14 calendar days apart. Two of the sampling events are to occur prior to December 31 each year and the remaining two are to occur between January 1 and June 30. The samples are collected at the point of discharge to the wetland and are analyzed for biochemical oxygen demand, oil & grease, pH, total phosphorus, total suspended solids, copper, lead, zinc, and E. coli. Section 2.3.7 summarizes information found in DEQ's water quality file related to NPDES permit violations and unpermitted discharges.

A soil berm extends along the southwest and northwest sides of the Harbor Oil facility; the berm is intended to prevent runoff from flowing into the adjacent wetlands (Figure 2). Facility history information indicates that the

soil berm was constructed shortly after the 1979 fire that occurred at the Harbor Oil facility.

According to D. Coles (personal communication November 16, 2007), the soil berm is approximately 2 to 3 feet high and 5 to 6 feet wide at its base. The soil berm is intact, covered with sparse vegetation, and there are no known areas of substantial erosion. The soil berm is effective in preventing stormwater runoff from discharging into the adjacent wetlands.

An open area to the northwest of the new base-oil refining plant and stormwater treatment system is used for storage of vehicles, equipment, and materials.

A tanker truck cleaning operation was previously located in the central portion of the Harbor Oil facility; the western portion of the area where the former tanker truck cleaning operation was located is currently leased to the asphalt coating business and the eastern portion is used for vehicle and equipment storage.

2.3 Facility History

This section provides a summary of information on facility history from CEC (2002), E&E (2001) and Golder Associates (1990), along with information gathered as part of the review of State of Oregon air quality, water quality, hazardous waste, and site cleanup files, as required by the SOW.

2.3.1 1940s

Based on a 1948 aerial photograph taken after the May 1948 flood, the Harbor Oil facility was essentially undeveloped in the late 1940s.¹ Piles of unknown materials were present on the facility. The only other feature was a railroad spur that ran southward from what is now the Peninsula Terminal Railroad switching yard (Figure 3). The rail spur ran parallel to and west of Force Avenue to about the location of the current office/shop/warehouse building.

The 1948 flood destroyed Vanport City, Oregon, which was located to the southwest of Force Lake (Figure 3). Vanport City was originally constructed in 1942 to house workers at shipyards located in Portland and in Vancouver, Washington. By the end of 1943, nearly 40,000 people lived in Vanport City. After World War II it provided housing for returning servicemen and their families.

2.3.2 1950s

An aerial photograph taken in 1956 indicates that the railroad spur was no longer present at this time. A portion of the current office/shop/warehouse building was present, and the aerial photograph shows what appear to be tanker trucks and a concrete slab located in the area where the former tanker

¹ The aerial photographs referenced in Section 2.3 are presented in CEC (2002).

truck cleaning operation was later located. As will be discussed below, this concrete slab may have been the “cement washing basin” observed by the Oregon Department of Environmental Quality (DEQ) in 1973 where cattle and tanker trucks were cleaned. Figure 4 shows the approximate location of the concrete slab and other former facility features.

CEC (2002) discusses a “C” shaped area of apparent “dumped material” that was located to the southwest of Tank 23 in the area where the new base-oil refining plant and current stormwater treatment system are located. CEC (2002) suggests that the “C” shaped area could have been fill material or the outline of a berm for a retention pond.

According to CEC (2002), EMRI indicated that during the 1950’s the Harbor Oil facility may have been occupied by a dust suppression service that used asphalt blended with lignite (waste paper mill liquor). Used oil was apparently added to thin the mixture.

2.3.3 1960s

According to E&E (2001), oil recycling activities started at the Harbor Oil facility in 1961 with Empire Industries, Inc. (Empire Industries). According to CEC (2002), Harbor Distributing (type of business unknown) and Industrial Cleaning Systems (truck cleaning) also operated at the facility at this time.

The Strategy Recommendation prepared by DEQ for the Harbor Oil facility refers to a pond with oil-stained soil that was filled sometime before 1964 (DEQ 1995). The location of the pond was not identified in the DEQ Strategy Recommendation.

Aerial photographs for 1965 and 1966 show that development was limited to the southeastern half of the facility. The office/shop/warehouse building and concrete slab were present during these years. It appears that the “C” shaped area identified in CEC (2002) was also present during these years, although the 1966 aerial photograph is of poor quality.

2.3.4 1970s

A 1972 aerial photograph illustrates that key facility features were limited to the office/shop/warehouse building and concrete pad. Numerous trailers or tanks were located around the perimeter of the Harbor Oil facility, which was developed only as far northwest as where the current stormwater treatment system is located. An upright tank was located in the “C” shaped area (Figure 4). Also visible in this photograph is a drainage ditch that starts at the north property line, approximately 250 feet northwest of N. Force Avenue. The drainage ditch loops to the north and then to the west through the wetlands. The current relationship between the drainage ditch and Harbor Oil facility is not obvious from the aerial photograph because fill may have been placed on the adjacent property to the north, particularly when a stormwater retention located immediately north of Tank 23 was filled sometime prior to 1987; the adjacent property is now several feet higher than the Harbor Oil facility. In addition, as will be discussed below, EMRI closed the portion of

the drainage ditch in approximately 2002 and installed catch basins to capture stormwater in this area.

2.3.4.1 1973 DEQ Site Visit

According to E&E (2001), DEQ conducted a site visit in May 1973 in response to a complaint that oil was flowing off the facility into the adjacent wetlands and Force Lake. Apparently, at this time Empire Industries repaired, stored, and cleaned trucks. Both cattle trucks and oil tankers were cleaned on a "cement washing basin" that had a curb and apron. The basin drained to an open ditch (likely the drainage ditch that was located on the northeast side of the Harbor Oil facility), which discharged into the wetlands. An October 16, 1979 DEQ memorandum states that 90 percent of Empire Industries' operation was washing cattle trucks (DEQ 1979). Approximately 10 percent of their operation was washing the inside and outside of oil tankers. Empire Industries also had two large storage tanks for oil. Animal waste was stockpiled on the ground, as was sawdust that was being used for oil cleanup (DEQ 1973). DEQ observed that the entire yard had been oiled for dust control.

2.3.4.2 1974 Oil Release

In March 1974, DEQ investigated a release of oil that reportedly spread across approximately two acres of wetland and created a sheen on Force Lake. A DEQ report entitled "*Investigation of Fish Kill at Force Lake, West Delta Park, Multnomah County, 3/19/74*" states that during the investigation DEQ observed that a thin film of oil was present on Force Lake and thick oil had accumulated (fresh and decomposed) on the shoreline (DEQ 1974a). The source was determined to be an approximately 80- by 100-yard work area used by Industrial Cleaning Systems to clean tanker trucks. Along the south edge of the work area were several small sumps filled with oil and water which drained toward Force Lake. Based on the DEQ file information, these sumps were probably excavated unlined sumps that were not part of the later truck washing system that used TCE (i.e., Detrex system). As will be discussed below, the work area was filled with sand and gravel after Chempro started its operations. The location of these two sumps is unknown. Just west and slightly north of the work area was a large sump (15 by 50 feet) filled with oil and water that drained toward the wetlands. Large piles of sawdust and wood chips were distributed around the area. These materials were used to soak up oil. DEQ observed a dead duck and coot. Dead bullhead catfish and goldfish were also observed in Force Lake.

An April 12, 1974 letter from Empire Industries states that oil residue in the wetlands came from 10 to 12 years of truck cleaning operations (Empire Industries 1974). The letter also states that dried grasses were not discolored by oil, but by manure from the adjoining Farmer's Plant Aide or Stockyards properties. In 1974, Empire Industries placed 1,146 cubic yards of rock fill in the area between the work area and Force Lake to provide containment for wash water. Empire Industries planned to install a skimmer system in the drainage ditch to remove oil residue, and then remove contaminated soil from the drainage ditch and surrounding area.

A July 17, 1974 DEQ letter indicates that Empire Industries had implemented a program to clean up oils and contaminated soils in the wetlands (DEQ 1974b). The scope of the program implemented by Empire Industries was not described in the DEQ letter.

2.3.4.3 Chempro Operations

Chempro of Oregon (Chempro) apparently started its operations in the mid-1970s. During this time, the Harbor Oil facility was owned by Canal Capital Corp. (fka United Stockyards Corp.). After Chempro started its operations, it filled the work area (where cattle trucks and oil tankers were cleaned) with sand and gravel (DEQ 1979).

According to a January 7, 1975 DEQ letter, DEQ noted that a wall surrounding the truck unloading rack (referred to in the letter as the “transfer area”) had not been completed and there was evidence of discharges into the drainage ditch along the northeast side of the facility (DEQ 1975).

To address the March 1974 oil release, DEQ ordered Chempro to make other improvements to its stormwater management system. Chempro made the improvements in 1975, at which time DEQ issued an NPDES Waste Discharge Permit (File No. 16045) on October 10, 1975. The permit allowed Chempro to discharge to the “North Ditch of Force Lake” until 1977, after which discharges were to go to the City of Portland (COP) sewer system. The permit contained discharge limits for oil & grease (10 mg/L monthly average and 15 mg/L daily maximum), suspended solids (50 mg/L), and pH (6.5 to 8.5).

In 1977, Chempro installed the “plant well”, a 100-foot-deep well located near the northeast corner of the office/shop/warehouse building. The use(s) of this well between 1977 and 1990 is uncertain.

DEQ received a complaint in November 1978 that Chempro was discharging oily wastes into the wetlands (DEQ 1988b). DEQ found that in 1978 oily and water wastes went to a large holding tank and were then sold as a dust suppressant. Oil sludge was hauled to Arlington.

In 1978, DEQ found that the sewer system hookup had not been completed as required by the 1975 permit. Chempro had an oil-water separator on order and was coordinating with the COP before installing it.

2.3.4.4 1979 Fire

In October 1979, a major fire destroyed the Chempro facility, and reportedly resulted in releases to the adjacent wetlands and Force Lake (DEQ 1995).

2.3.5 1980s

CEC (2002) discusses a 1980 aerial photograph that was taken after the fire. Based on that photograph, the office/shop/warehouse building had been expanded, and the tank farm and used oil processing area had been rebuilt and Tank 23 had been constructed. A new structure had been constructed in the area where the concrete pad was located. As will be discussed below,

this structure housed the tanker truck cleaning operation (i.e., Detrex system).

According to E&E (2001), the Harbor Oil facility was re-graded and covered with gravel when the facility was rebuilt. An unlined holding pond was constructed in the southwest corner of the Harbor Oil facility to serve as an oil-water separator (Figure 4). The far northwestern portion of the Harbor Oil facility still remained undeveloped. An earthen berm was constructed around the northwest and southwest sides of the facility, apparently from soil impacted by releases caused by the fire.

2.3.5.1 1980 EPA Site Inspection

A March 13, 1980 memorandum describes the results of a February 29, 1980 EPA site inspection (EPA 1980). The memorandum states that Chempro picked up waste oils from various sources including service stations. The oils were screened and filtered prior to resale to industrial customers. Some oils were used for road oiling. Chempro also picked up solvents and thinners, which were shipped to Resource Recovery, which was located in Seattle, Washington, for reprocessing. Non-recoverable thinners and solvents were shipped to Masterwash in Vancouver, B.C. for use as fuel supplements. Chempro also accepted oily wastewater and some liquid chemicals from various sources. It did not accept or handle polychlorinated biphenyls (PCBs). The waste generated from operations at the Harbor Oil facility consisted of oily sludges from tank bottoms, oily sludges from screening and reprocessing, and asphalt sludges from the tanker truck cleaning operation. Sludges were put into barrels and stored on the facility until they were transported to Arlington, Oregon.

Surface runoff was directed to the unlined holding pond. When the pond filled up, the water under the surface of floating oil was pumped off the facility to a "swamp on the exposition center property." The EPA memorandum does not identify the exact location of the discharge point for water from the holding pond. It is likely that the swamp referenced by EPA refers to the wetlands adjacent to the Harbor Oil facility. Truck washings were collected in a sump which was vacuumed out and pumped into one the storage tanks.

According to a DEQ Hazardous Waste/Used Oil Processor Compliance Evaluation Inspection report, Chempro submitted a Part A permit application for hazardous waste storage to EPA in November 1980. DEQ subsequently issued hazardous waste collection site license number HWC5 (a state-issued hazardous waste storage permit) to Chempro on April 23, 1981 (DEQ 1996b). The license expired on May 1, 1983. The inspection report states that DEQ records indicate that Harbor Oil, Inc. removed all hazardous waste in storage prior to the expiration of the license.

2.3.5.2 1983 NPDES Permit

Chempro (Oregon) changed its name to Harbor Oil, Inc. on September 23, 1983 and merged with Harbor Oil, Inc. (a Washington corporation) on October 31, 1985.

On December 5, 1983, DEQ issued NPDES Waste Discharge General Permit 1300-J to Harbor Oil, Inc. The permit covered treated stormwater runoff from

bulk petroleum storage, transfer, formulation, and packaging facilities. The permit contained a 10 mg/L monthly average and 15 mg/L daily maximum oil & grease discharge limit. It required that stormwater be collected and treated through an oil-water separator.

By 1984, Harbor Oil, Inc. had installed a new oil-water separator (i.e., the current stormwater treatment system) which initially discharged into the drainage ditch near the west corner of the Harbor Oil facility.

2.3.5.3 EPA 1984 and 1985 PA/SI

EPA conducted a Preliminary Assessment (PA) in June 1984, followed by a Site Investigation (SI) in 1985. As part of the SI, water in the stormwater treatment system was sampled and found to contain trichloroethylene (TCE).

2.3.5.4 1984 ACDP

On July 3, 1984, DEQ issued Air Contaminant Discharge Permit (ACDP) No. 26-3021 to Harbor Oil, Inc. The permit established emission limits for opacity, particulates, density, odors, and fugitive dusts.

2.3.5.5 Harbor Oil, Inc. Operations

According to Golder (1990), Harbor Oil, Inc. transported, collected and refined used oils and asphalt, and marketed virgin oils. Materials were accepted from Washington, Oregon, Idaho and western Montana. Active operations at the time included recycling waste oils for resale to industrial burners, and re-blending oils to meet client specifications. DEQ also listed Harbor Oil as a dust suppressant provider. Active facilities during this time included the tank farm and used oil processing area, a surge tank for collection and storage of separated water, the stormwater treatment system, a waste drum storage area, and the tanker truck cleaning operation.

On December 2, 1986, DEQ issued NPDES Waste Discharge General Permit 1300-J to Harbor Oil, Inc.

According to a February 4, 1988 Spill Prevention Control and Countermeasure (SPCC) Plan prepared for Harbor Oil, Inc., the Harbor Oil facility was bermed with an earthen dike approximately two feet high (HMS Environmental, Inc. 1988). Runoff drained to the southwest toward the stormwater treatment system. Stormwater collected in the treatment system was pumped to a nearby pond just west of the property line; the location of this pond was not identified in the SPCC plan. The "heated tank area" contained seven 20,000-gallon tanks with concrete containment. The truck loading and unloading rack area had a roof, was paved, and two sump drains to collect spills and transfer them to the stormwater treatment system. A 4,000-gallon aboveground storage tank (AST) was located in a concrete secondary containment outside the boiler house. The oil storage area consisted of one 210,000-gallon tank and eight 20,000 gallon tanks with concrete containment. A 320,000 gallon "water tank" (i.e., Tank 23) did not have secondary containment and was used to store water recovered from the oil recycling operation. A 6,000-gallon vertical gasoline AST, 20,000-gallon vertical diesel AST, and 275 gallon gas tank were located in a concrete containment in the truck fuel tank area.

2.3.5.6 1988 DEQ Site Inspection and Follow-Up Sampling Activities

A March 14, 1988 DEQ memorandum discusses observations made during a site inspection, including the potential for wash water from the tanker truck cleaning operation to go to the stormwater treatment system (DEQ 1988a).

DEQ subsequently observed and confirmed that the tanker truck cleaning operation discharged to the wetlands via the stormwater treatment system (DEQ 1988b). At this time, the tanker truck cleaning operation (Detrex system) consisted of a TCE distillation unit and storage tank located on a raised concrete pad adjacent to the cleaning area. Used TCE and truck wastes were pumped into the storage tank and then into the distillation unit for reprocessing. TCE sludges from the distillation process were drummed and shipped off the facility to Baron-Blakeslee in Portland for treatment.

The DEQ water quality file contained EPA Method 8270 analytical results for a sample collected on June 28, 1988 from the "bottom of the oil-water separator" (i.e., stormwater treatment system). The sample was analyzed by the DEQ laboratory. No acid-base/neutral compounds were detected. DDD, DDT, and DDE were also not detected. The sample did contain trans-1,2-dichloroethylene (trans-1,2-DCE) (~2.8 mg/L), 1,1,1-trichloroethane (1,1,1-TCA) (0.001 mg/L), TCE (0.035 mg/L), benzene (0.003 mg/L), toluene (0.002 mg/L) and chlorobenzene (0.004 mg/L). A sample collected from the "drain trench at the truck cleaning area" (i.e., curtain drain) contained no detectable acid-base/neutral compounds, but did contain TCE (70 mg/L), trans-1,2-DCE (6.1 mg/L), 1,1,1-TCA (0.7 mg/L) and 1,1,2,2-tetrachloroethylene (0.5 mg/L). A sample of the water layer collected from the "large oil-water tank" (i.e., Tank 23) contained phenol (1.9 mg/L), 2-methylphenol (1.3 mg/L) and 4-methylphenol (4.3 mg/L). Note that at the time these samples were collected, the stormwater treatment system discharged to the drainage ditch through a pipe located at the west corner of the property.

2.3.5.7 1988 NPDES Permit

On July 21, 1988, DEQ issued NPDES Waste Discharge Permit 1300-J to Harbor Oil, Inc. The permit covered:

- 1) Treated stormwater runoff,
- 2) Groundwater dewatering discharges, and
- 3) Water bottoms from facilities storing, transferring, formulating and/or packaging bulk petroleum products or vegetable oils; motor pools; and other facilities with oily discharges controlled by DEQ-approved oil-water separators.

The permit contained a 10 mg/L monthly average and 15 mg/L daily maximum oil & grease discharge limit.

DEQ proposed to revoke Harbor Oil's stormwater discharge permit in August 1988 (E&E 2001) because pollutants from the tanker truck cleaning operation were entering the stormwater treatment system which was not designed to treat them. Harbor Oil, Inc. subsequently settled with DEQ and agreed to a June 1989 Stipulation and Consent Agreement (No. WQ-WQ-NWR-89-28) that allowed Harbor Oil, Inc. to continue discharging stormwater to the

wetlands, if process wastewater was discharged to the sanitary sewer. In addition, Harbor Oil, Inc. agreed to collect and pre-treat waste water from the tanker truck cleaning operation. According to the Agreement, most of the facility stormwater went directly to the stormwater treatment system. Some stormwater flowed into an oil collection sump located at the truck loading and unloading rack, and was then transferred to Tank 23. Wastewater or oil bottoms from the bulk used oil storage tanks were also pumped to Tank 23. When the liquid level in Tank 23 reached capacity, some of the wastewater was transferred to a flocculation tank for further polishing and then released to a storm drain that flowed to the stormwater treatment system. The settled solids in the flocculation tank were returned to Tank 23.

According to a December 12, 1988 DEQ memorandum, discharges from the flocculation tank started in 1985 (DEQ 1988c). Also according to the memorandum, a 4,600 gallon AST was installed at the tanker truck cleaning operation to store truck wash water. DEQ observed that there was a storm drain located just south of the tanker truck cleaning operation that could have received spills during filling or off-loading of the wash water tank. The storm drain was connected to the stormwater treatment system.

2.3.5.8 Property Acquisition by Waste Management Disposal Services of Oregon

Waste Management Disposal Services of Oregon, Inc. acquired the facility on January 31, 1989 from Canal Capital Corp.

2.3.6 1990s

2.3.6.1 Facility Wastewater Treatment System

In August 1990, Harbor Oil, Inc. installed a wastewater treatment system to comply with COP sanitary sewer discharge requirements and to comply with the DEQ consent order. The system was designed to treat wastewater from waste oil processing and provide pre-treatment before discharge to the COP sanitary sewer system. Prior to this, wastewaters were stored and treated in Tank 23 and then further treated through flocculation, in Building 5 before being released to the stormwater treatment system (Figure 2). At this time, stormwater runoff flowed to the stormwater treatment system.

A document entitled *A Condensed Process General Description, Oil/Wastewater Treatment Facility* (Advanced Treatment Systems 1993) describes the wastewater treatment system. The document states that a concrete drip containment pad collected spills that occurred during the transfer of oil and oily wastewaters from tanker trucks to a 4,000-gallon screened sump tank. The pad also collected water used to wash down trucks following the discharge of their oily wastewater. The contents in the sump were pumped into either Tank 7 or Tank 15, or in rare cases into Tank 23. Tank 23 was only used when the water contained very little oil. Oily water pumped to Tank 7 was heated to separate most of the oil from the water; the water was pumped to Tank 15. The water and residual oil pumped into Tank 15 would physically separate. The floating oil was pumped to the oil processor for further refinement. After Tank 15 was at least half full it would

be pumped into the flocculator tank where it was mixed with caustic soda and ferric chloride to form a sludge containing organics and metals. The supernatant water was pumped to an oily water treatment system that included oil removal, particle filtration, and activated carbon, and was then stored in Tank 16; the sludge was pumped into a sludge tank for further separation (through settling) and treatment (through evaporation).

The 1993 document indicates that Tank 23 provided active bioremediation of sediment sludges through aeration, circulation, mechanical oil skimming, periodic addition of bacteria, and maintenance of nutrients. Water was pumped from Tank 23 for additional physical treatment (i.e., flocculation) in a tank located in Building 5. The treated water was then pumped to Tank 16 where it was tested prior to discharge to the COP sewer system.

Finally, the 1993 document discusses the Detrex tanker truck cleaning system. The Detrex system was used to clean the internal surfaces of trucks. The tanker truck cleaning operation included a diesel-fired heater which was used to heat a storage tank containing TCE and water. The TCE/steam mixture was used to clean tanker trucks. The spent cleaning solution was drained onto a concrete pad where it was collected in a curtain drain and pumped back to the heated storage tank. The truck cleaning operation was a closed-loop, stand-alone process that was not physically connected to the facility wastewater treatment system.

The 1993 document included a laboratory report for a sample collected from Activated Carbon Bed #1, in the facility wastewater treatment system, which contained acenaphthene, benzene, 1,1,1-TCA, 1,1-dichloroethane (1,1-DCA), 2-chlorophenol, 2,4-dimethylphenol, ethylbenzene, phenol, bis(2-ethylhexyl)phthalate, butyl benzyl phthalate, di-n-butyl phthalate, diethyl phthalate, dimethyl phthalate, acenaphthylene, anthracene, fluorene, phenanthrene, tetrachloroethylene (PCE), toluene, TCE and vinyl chloride. The document states that any TCE found in the wastewater treatment system's activated carbon filters came from its ubiquitous nature in numerous oils and oily wastewaters processed at the facility, not from the Detrex system.

2.3.6.2 Water Supply Well

In 1990, the plant well was being used to provide emergency fire control water supply; it was not being used as a potable water supply. The use(s) of this well between 1977 and 1990 is uncertain.

2.3.6.3 1991 Facility Conditions

A 1991 aerial photograph for the Harbor Oil facility shows the tank farm and used oil processing area with what appears to be secondary containment, as well as the covered, truck loading and unloading rack. The current stormwater treatment system was in place. The far northwestern end of the facility was still undeveloped.

2.3.6.4 1992 DEQ RCRA Inspection

A DEQ RCRA inspection conducted in June 1992 found an oily substance on the ground which Harbor Oil, Inc. stated was lignin that was being used as a

dust suppressant (DEQ 1995). DEQ determined that the Harbor Oil facility only generated one 55-gallon drum per month of F001 hazardous waste (TCE sludge), but because there were 170 drums (contents unspecified) on the facility during the visit, Harbor Oil was listed as a RCRA Large Quantity Generator. Two of the drums were open, and least one had leaked. DEQ cited Harbor Oil, Inc. for storage of hazardous waste without a permit, failure to make hazardous waste determinations, and failure to retain Land Disposal Restriction forms. DEQ assessed a civil penalty of \$10,777 for these violations, which Harbor Oil, Inc. paid in May 1993.

2.3.6.5 Cessation of Dust Suppression Business and Tanker Truck Cleaning

The dust suppression business ceased operating in 1993.

According to CEC (2002), the tanker truck cleaning operation ceased in 1994.

2.3.6.6 Stormwater Sampling

DEQ's water quality file contained stormwater sampling results submitted by Harbor Oil, Inc. to DEQ between 1994 and 1999. During that period, stormwater samples were analyzed for pH, total suspended solids (TSS), oil & grease, chemical oxygen demand (COD), total phosphorus, total organic carbon (TOC), arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc.

2.3.6.7 1994 DEQ Site Inspection

A June 30, 1994 DEQ inspection report states that Harbor Oil, Inc. was processing used oil by blending and cooking (DEQ 1994b). Used oil was stored in four tanks heated by two natural gas-fired boilers. Harbor Oil, Inc. also had one oil-fired boiler for the Detrex system. Incoming raw materials consisted of approximately 80 percent used motor oil and 20 percent oil containing less than 50 ppm PCBs that was tested and separated by concentration. Oil with PCB levels above 8 parts per million (ppm) was stored for shipment to Ash Grove Cement. Oil with PCB levels below 8 ppm was blended by Harbor Oil, Inc. into product, which had less than 0.5 ppm PCBs. Harbor Oil, Inc. burned some of the product in the oil-fired boiler.

2.3.6.8 1994 Sampling of North Drainage Ditch

In August and September 1994, at the request of Jordan Schnitzer Properties, Golder sampled soil from the drainage ditch, and installed and sampled a shallow monitoring well near the drainage ditch. Soil samples collected at 40-foot intervals (horizontal spacing) along the ditch at depths of between 0.5 and 1 feet contained diesel and heavy oil at concentrations ranging from 1,400 to 11,000 mg/kg. The 1995 DEQ Strategy Recommendation that discusses this sampling effort did not mention whether the soil samples were analyzed for analytes other than diesel and heavy oil (DEQ 1995).

2.3.6.9 1994 Limex Diesel Release

According to DEQ's February 21, 1995 Site Assessment Program Strategy Recommendation, 50 to 150 gallons of diesel was released in November

1994 by Limex Transportation, Inc. from a faulty valve on a 300-gallon AST located on the adjacent Limex property, located north of the facility (DEQ 1995). The diesel flowed into the drainage ditch between the Limex property and the facility, entering the wetlands. Cleanup involved product recovery and some soil removal from the most heavily impacted wetland areas. DEQ suspended soil removal activities after determining that an oily layer 16 inches below the surface represented pre-existing conditions. The Strategy Recommendation does not specify where the soil removal activities were conducted.

2.3.6.10 Property Sale to Harbor Oil, Inc.

Waste Management Disposal Services of Oregon sold the property to Harbor Oil, Inc. on December 14, 1994.

2.3.6.11 1995 DEQ Notification of Site Listing

In June of 1995, DEQ notified owners and operators of the Harbor Oil facility of the agency's proposal to place the property on its "Confirmed Release List" and "Inventory List."

2.3.6.12 1996 Mutual Agreement and Order

In 1996, Harbor Oil, Inc. proposed to install an off-gas/steam condensation system to reduce volatile organic and halogenated organic emissions produced from waste oil reprocessing operations. The proposal was in response to Mutual Agreement and Order (MAO) No. AQP-NWR-96-206 between DEQ and Harbor Oil, Inc. The MAO was issued because DEQ had received periodic complaints of strong, acrid odors (fugitive emissions) from the facility. The odors were documented by DEQ on December 11, 1995 and February 14, 1996. The MAO required Harbor Oil to:

- 1) Install controls adequate to abate nuisance conditions resulting from the heating of used oils or cease heating used fuel oils,
- 2) Limit production to 5.9 million gallons of used fuel oil and/or gasoline in calendar year 1996 unless satisfactory controls were installed,
- 3) Limit emissions from the re-refining facility to no more than 9.9 tons per calendar year of any hazardous air pollutant or 24.9 tons per calendar year of any combination of hazardous air pollutants, and
- 4) Submit a final control strategy to DEQ by August 29, 1996.

Analyses of incoming raw waste oil and refined fuel oil indicated that they contained detectable concentrations of benzene, sec-butylbenzene, ethylbenzene, isopropylbenzene, p-isopropyltoluene, naphthalene, n-propylbenzene, toluene, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, xylenes, methylene chloride, 1,1,1-TCA, TCE and PCE. The incoming raw waste oil and refined fuel oil were not analyzed for PCBs.

2.3.6.13 1996 DEQ Site Inspection

A 1996 DEQ inspection report discusses the February 14, 1996 odor observation (DEQ 1996a). It also describes the current facility processes as

blending and cooking of used oil which was placed in four vented, heated tanks to evaporate water. The tanks were heated by two natural gas-fired boilers, which had the capacity to burn oil as a backup fuel. In the process of evaporating water from used oil, volatile organic compounds (VOCs) and possibly some hazardous air pollutants were also evaporated. At the time, the heating oil tank vents were uncontrolled. Harbor Oil, Inc. also had a diesel storage tank and diesel-fired boiler for the Detrex system. The raw material received by Harbor Oil, Inc. was mainly used motor oil, although they did receive and process some oil containing <50 ppm PCBs. The 1996 DEQ inspection report did not include any analytical results to substantiate that PCB concentrations were less than 50 ppm. The report states that "Harbor Oil's raw materials consist of mostly used motor oil. They do receive and process some PCB contaminated oil (<50 ppm)".

According to the report, the facility also consisted of two heated storage tanks, Tank 23, the stormwater treatment system, six 20,000 gallon oil storage tanks, two 20,000 gallon wastewater tanks, one 205,000 gallon finished oil tank, one 20,000 gallon truck fuel storage tank (for shipment off the facility), and one truck fuel tank for use on the facility.

2.3.6.14 1996 RCRA Inspection

According to DEQ's updated Strategy Recommendation, a November 1996 RCRA inspection found that Harbor Oil received and processed used oil, off-specification fuels, and oily or petroleum-contaminated wastewater (DEQ 1998a). The facility also managed a limited quantity of used oil filters and waste antifreeze containers.

A November 19, 1996 DEQ letter to Harbor Oil, Inc. is a notice of noncompliance for violations of Oregon's hazardous waste and used oil management regulations (DEQ 1996c). At the time of a November 8, 1996 DEQ inspection, Harbor Oil was a Conditionally Exempt Small Quantity Hazardous Waste Generator. Violations included:

- 1) Storage of hazardous wastes at an un-permitted facility (specifically Harbor Oil, Inc. stored wastes from the tanker truck cleaning operation 90 days after it was generated).
- 2) Failure to correctly file annual hazardous waste generator reports (reports were not filed for shipments made in 1992 and 1993).
- 3) Failure to correctly develop a contingency plan designed to address potential facility releases as required under 40 CFR 279.52(b), as adopted in OAR 340-100-002.
- 4) Failure to develop an analysis plan for used oil management.

The inspection results are summarized in DEQ's November 8, 1996 Hazardous Waste/Used Oil Processor Compliance Evaluation Inspection report (DEQ 1996b). By December 1996, Harbor Oil, Inc. had taken actions to correct the violations (Harbor Oil, Inc. 1996b).

A 1996 Emergency Preparedness and Contingency Plan prepared by Harbor Oil, Inc. states that the facility stored and used the following materials: used oil, oily wastewater, used oil vapor-recovery condensate, diesel fuel, mineral

spirits (laboratory solvent), toluene (laboratory stock), caustic soda, ferric chloride, antifreeze (ethylene glycol), mixed fuels (gasoline, diesel, etc.), propane (forklift fuel), oxygen (welding tanks), and acetylene (welding tanks) (Harbor Oil, Inc. 1996a). Attached to the plan is a Used Oil and Petroleum-Contaminated Water Analysis Plan which states that used oil was tested for total metals (arsenic, cadmium, chromium and lead), total halogen content, PCBs, and sulfur content. Wastewater was tested for pH, ammonia, oil & grease, total metals (cadmium, chromium, nickel, and lead), flash point and chlorinated hydrocarbons.

A 1998 aerial photograph suggests facility conditions were very similar to those in 1991.

2.3.6.15 1998 DEQ Site Inspection

DEQ conducted a site inspection on March 19, 1998 (DEQ 1998b). Issues of concern identified during the site inspection included:

- 1) The combustion of condensate collected from the heating tanks would require quantification of metals and halogens concentrations in the condensate,
- 2) The approach used to calculate air emissions,
- 3) Vapors exiting the cable outlets on cooking tanks, and
- 4) Dust/fugitive emissions from truck traffic.

2.3.6.16 EMRI Operations

EMRI took over the operation on October 1, 1999 after Harbor Oil, Inc. ceased doing business on the property. That same year, DEQ issued EMRI an NPDES Industrial Stormwater Discharge Permit 1220-COLS for the stormwater treatment system.

On December 30, 1999, EMRI submitted an application to transfer ACDP No. 26-3021 from Harbor Oil, Inc. effective January 1, 2000.

Under its air quality permit, EMRI indicated that it processed 1.9 million gallons of raw used oil in 1999; the report did not contain information on the actual halogen content of used oil held for processing (estimated to be about 700 ppm), or the PCB, metals or halogen content of reprocessed fuel burned on the facility.

2.3.7 2000 to Present

A January 27, 2000 DEQ air quality file memorandum discusses the numerous odor complaints that had been received by DEQ, and that none had been received since EMRI took over the operation (DEQ 2000a). The memorandum indicates that the prior owner had failed to complete all monitoring and reporting requirements set forth in ACDP No. 26-3021. The memorandum states that the permit set limits on the metal, PCB and halogen content of reprocessed fuels burned on the facility: <2 ppm PCBs and 1,000 ppm total halogens. The memorandum states that EMRI wanted to burn oil

containing PCBs up to the allowable regulatory limit of 49 ppm (off-specification fuel) and increase the total halogen limit to 4,000 ppm.

2.3.7.1 2000 DEQ Site Inspection

A DEQ Northwest Region Multi-Media Checklist in the DEQ air quality file for a September 27, 2000 site inspection included the following observations (DEQ 2000b):

- 1) Opacity issue, potentially due to startup.
- 2) Stains were observed in the northwest corner of the truck loading and unloading rack area.
- 3) Stained soil was observed near the northwest corner of the pad where drums were being stored outside the containment pad. Leaks from the drums were the apparent source of contamination.
- 4) Clor-D-Tect kits and excess plastics were in the FPI kiln. DEQ had concerns regarding solid waste incineration and potential releases of mercury and cadmium.

In October 2000, DEQ issued a notice of noncompliance to the Harbor Oil facility for: 1) storage of drums outside the containment pad and 2) a gap between the wall and pad along part of the south side of the used oil processing area (DEQ 2000d). DEQ requested that the contaminated soil be removed and properly disposed, the gap be sealed, and a plan be submitted to prevent future releases from escaping the loading area. DEQ's findings were documented in a September 27, 2000 Used Oil Processor Inspection Report (DEQ 2000c). EMRI objected to each of DEQ's requested actions in a November 27, 2000 letter to DEQ (EMRI 2000). Based on the file information, it appears that EMRI did not remove the contaminated soils.

2.3.7.2 ACDP Permit Reporting

In its 2000 Annual Report for ACDP Permit No. 26-3021, EMRI reported that it processed 4.5 million gallons of raw used oil with a halogen content of 200 ppm. Maximum PCB and metals concentrations in reprocessed fuel burned on the facility were: PCBs (6.38 mg/kg) and lead (0.5 ppm). Cadmium, arsenic, chromium, and total halogens were not detected.

Laboratory data in the DEQ air quality file indicate that PCBs were present in fuel oil stored in Tank 24 at concentrations ranging from not detected, at a detection limit of 5 mg/kg, to 6.2 mg/kg in 2001 and 2002. No PCBs were detected in "incoming used oil" during that time. During 2001, incoming oil contained lead (8 to 37 ppm), cadmium (0.2 to 0.4 ppm), chromium (0.6 to 1.2 ppm), and total halogens (200 to 600 ppm). During 2001, the product in Tank 24 contained lead (0.5 to 2.2 ppm), cadmium (not detected to 0.06 ppm), chromium (not detected to 0.24 ppm), and total halogens (not detected to 3,700 ppm).

Under ACDP Permit No. 26-3021, EMRI submitted its 2002 Annual Air Quality Report stating that it processed 7.2 million gallons of raw used oil that had a halogen content ranging from 200 to 500 ppm. Reprocessed fuel burned on the facility contained no detectable PCBs, cadmium (0.02 ppm),

lead (19 ppm), chromium (0.3 ppm), chromium (not detected), and total halogens (100 ppm).

For 2003, 3.6 million gallons of raw used oil were processed; 49,000 gallons of low-level, less than 50 ppm PCB oil were blended into off-specification use fuels.

EMRI's 2005 annual report issued under its ACDP stated that it processed 3.3 million gallons of raw used oil.

2.3.7.3 Stormwater Sampling

Between 2000 and 2006, EMRI reported exceedances of permit benchmark values for one or more of the following in samples collected from the stormwater treatment system discharge: total phosphorus, total suspended solids (TSS), E. coli, lead, copper, oil & grease, and biological oxygen demand (BOD). During this time stormwater discharge samples collected by EMRI were analyzed for BOD, oil & grease, pH, total phosphorus, TSS, copper, lead, zinc, and E. coli.

In 2000, EMRI collected samples from the portion of the drainage ditch that ran along the northeast side of the Harbor Oil facility. The sampling results indicated that lead and E. coli were migrating onto the Harbor Oil facility from a source or sources located off the facility (CEC 2000). At the time the samples were collected, drainage entered this portion of the ditch from topographically higher properties immediately adjacent to and north of the Harbor Oil facility (e.g., Former Farmer's Plant Aide, Former Limex Transportation, and Bulk Transport facilities and Peninsula Terminal Railroad). The drainage would have flowed down the ditch along the northeast and northwest sides of the Harbor Oil facility and discharged into the wetlands near the southwest corner of the facility; the drainage would not have discharged into the current storm water treatment system. As will be discussed below, this drainage pattern changed in 2002 when EMRI closed off the portion of the drainage ditch that ran along the northeast side of the facility and installed catch basins connected to the current storm water treatment system.

On August 20, 2001, the COP notified EMRI that it was in violation of its stormwater permit because it failed to collect a sufficient number of samples for the year July 1, 2000 through June 30, 2001.

2.3.7.4 Resolution of Used Oil and Hazardous Waste Compliance Issues

On November 2, 2001 DEQ stated that Fuel Processors, Inc., EMRI, Oil Re-Refining Co. and Harbor Oil were in compliance with the Facility Management Plan and the used oil and hazardous waste regulations and statutes (DEQ 2001a). All alleged violations cited in Notices of Noncompliance or Notices of Assessment of Civil Penalty issued by DEQ had been resolved. The letter references Mutual Agreement and Order No. WMC/HW-NWR-99-207.

2.3.7.5 New Base-Oil Refining Plant Construction

EMRI constructed the new base-oil refining plant in 2003. Soils excavated during plant construction were stockpiled to the northwest of the plant.

2.3.7.6 Drainage Ditch Modification

According to personal communication with Dave Coles (July 10, 2007 site visit), EMRI closed off the drainage ditch that ran along the northeastern property boundary in approximately 2002. Stormwater from this area is now captured by catch basins and is then conveyed to the current stormwater treatment system; it no longer flows from this area into the wetlands northwest and southwest of the Harbor Oil facility (CEC 2002).

2.3.7.7 NPL Listing

The Harbor Oil Superfund Site was placed on the National Priorities List (NPL) on September 29, 2003.

2.3.7.8 2003 ACDP

DEQ issued ACDP No. 26-3021 on October 24, 2003. The permit allowed the use of fuel containing arsenic (5 to 10 ppm), cadmium (2 to 4 ppm), chromium (10 to 20 ppm), lead (100 to 300 ppm), PCBs (2 to 49 ppm), and total halogens (1,000 to 4,000 ppm). It established plant emission limits for particulate matter (PM), PM₁₀, sulfur dioxide (SO₂), NO_x, carbon dioxide (CO₂), and VOCs. It prohibited the processing or evaporation of any wastewater with a total halogen content greater than 1,000 ppm and total VOC content greater than 1,000 ppm.

According to the DEQ air quality file, between 2001 and 2006 DEQ received numerous complaints regarding odors potentially coming from the Harbor Oil facility.

2.3.7.9 2004 ATSDR Public Health Assessment

In 2004, the Agency to Toxic Substances and Disease Registry issued a public health assessment for the Harbor Oil facility (ATSDR 2004). The assessment concluded that:

- Exposure to chemicals found in the drainage area and wetlands adjacent to Force Lake represent a completed exposure pathway. Exposure to this area is not anticipated to result in adverse health effects. However, the existing data for this area are limited in sample number and geographic location.
- The level of contamination in fish tissue and information regarding populations that may consume fish from Force Lake are unknown. This lack of data limits the ability to completely characterize the risks to human health.
- Soils, groundwater, ambient air, soil vapor and surface water pathways from Harbor Oil facility were considered to be potential exposure pathways, based on the lack of data for these pathways.
- Based on the existing environmental data, the Superfund Health Investigation and Education program considers the Site to be a no apparent public health hazard.

2.3.7.10 2004 Facility Operations

A 2004 Emergency Preparedness and Contingency Plan prepared by EMRI indicates that materials handled by the facility included: used oil-asphalt, oily wastewater, used oil vapor recovery condensate, diesel fuel, mineral spirits (laboratory solvent), toluene (laboratory stock), caustic soda, antifreeze (ethylene glycol), mixed fuels (gasoline, diesel, etc.), propane (forklift fuel), oxygen (welding tanks), acetylene (welding tanks), boiler chemicals (Scalex, sodium sulfate, oxygen scavenger), water treatment chemicals (lime, soda ash, magnesium sulfate, magnesium oxide, sodium bicarbonate, and aluminum sulfate), water-based paints, oil-based paints, shop chemicals (WD-40 lubricant, penetrating oils, rust penetrants, never seize lubricants, cutting oils, and corrosion inhibitors and cleaners), carbon, and concrete sealers (EMRI 2004).

2.3.7.11 2005 Updated SPCC

In January 2005, EMRI submitted an updated Spill Prevention, Control and Countermeasure (SPCC) plan for the facility (EMRI 2005).

2.3.7.12 2006 DEQ Site Inspection

According to information in DEQ's hazardous waste file for the Harbor Oil facility, DEQ performed a site inspection on June 22, 2006 and returned to collect oil and water samples from Tank 23 on July 4, 2006 (DEQ 2006a). DEQ did not discover any hazardous waste regulation violations, but did request that EMRI create policies and guidance documents for crack repair and for the elimination of standing water in secondary containments. DEQ observed cracks and a small hole in the secondary containment around the oil cooker units that required repair. DEQ also had concerns about the contents of Tank 23. These concerns prompted DEQ to return to the facility on July 5, 2006 to collect samples from Tank 23. The samples were collected to determine if oil and water in the tank contained any hazardous constituents and if EMRI could put the oil and water through their process. The samples collected by DEQ were analyzed for VOCs, semi-volatile organic compounds (SVOCs), PCBs, pesticides, toxicity characteristic leaching procedure (TCLP) metals, total halogenated organics (TOX), and pH. EMRI collected side-by-side samples. According to DEQ's July 5, 2006 site inspection report (DEQ 2006a) and subsequent letter to EMRI (DEQ 2006b), no listed hazardous constituents were detected in the EMRI samples and DEQ decided to allow EMRI to put the oil and water through their re-refining process. DEQ also requested that EMRI prepare a sampling plan for testing sludges in the bottom of Tank 23.

2.3.7.13 Wevco Bio Diesel Operation

In July 2006, Wevco Bio Diesel, Inc. notified DEQ of its intent to construct a process to convert fats, oils and greases into alternative food grade oil that would be blended with 20 percent of EMRI's 100N oil. The operation was to be located in the warehouse and awning area, and was projected to produce 250,000 to 300,000 gallons per month. DEQ issued air quality permit No. 26-0148 for the operation. A Notice of Approved Construction Completion was submitted to DEQ on September 1, 2006.

2.3.7.14 2006 NPDES Permit

According to information in DEQ's water quality file for the Harbor Oil facility, the current NPDES permit was issued on October 5, 2006.

On March 20, 2007, EMRI submitted a Written Action Plan under their 1200-COLS permit due to elevated total phosphorus and TSS levels (EMRI 2007a). The Written Action Plan stated that EMRI was in the process of implementing corrective actions, including the potential use of an alternative cooling tower corrosion inhibitor and anti-algae/fungus treatment chemicals that have lower phosphorus content. This source was identified in EMRI's January 19, 2007 Written Action Plan (EMRI 2007b), along with runoff from truck washing operations conducted on the adjacent Bulk Transport property.

2.3.7.15 Tank 23 Contents Characterization

In mid-2007, EMRI agreed with EPA to characterize the contents of Tank 23 under a separate AOC. On August 16, 2007, EMRI collected samples from four locations in Tank 23 following the procedures described in a work plan prepared by CEC (2007a). The Voluntary Group observed sample collection activities and collected split samples for analysis.

2.4 Land Use

2.4.1 COP Comprehensive Plan Designation

According to the October 2, 2006 Comprehensive Plan Designations map prepared by the City of Portland, the Harbor Oil facility has an "Industrial Sanctuary" designation, as do the surrounding properties to the northwest, northeast, and southeast. Property to the southwest has an "Open Space" designation. The Industrial Sanctuary designation, as defined in the COP Comprehensive Plan, is intended for areas where City policy is to reserve land for existing and future industrial development. Non-industrial uses are limited to prevent land use conflicts and to preserve land for industry.

2.4.2 COP Zoning Designation

The COP October 2, 2006 Zoning Designations Map indicates that the Harbor Oil facility and properties to the northwest, northeast, and southeast are zoned IG2, Industrial General 2. Property to the southwest is zoned OS, Open Space.

The COP 1/4 Section Zoning Map 1827 indicates that the Site is located within the Peninsula Drainage District No. 1 Natural Resource Management Plan (NRMP) area and has a specific zoning of IG2dh, as do the immediately surrounding properties to the northwest, northeast, and southeast. The "d" indicates that the Site is located in a Design Overlay Zone which, according to information at <http://www.portlandonline.com/planning/index/cfm>, promotes conservation, enhancement, and continued vitality of areas of the City with special scenic, architectural, or cultural value. The "h" indicates that the Site

is located in the Aircraft Landing Overlay Zone for the Portland International Airport.

The zoning and comprehensive plan designations for the facility indicate that the current and likely future land use of the facility is industrial, particularly given its Industrial Sanctuary designation.

2.4.3 Peninsula 1 NRMP

The Site is located within the Peninsula 1 (Pen 1) NRMP Area, one of a number of natural resource management planning areas established under Title 33, Planning and Zoning, Chapter 33.430 of the COP planning code. NRMPs provide a means to evaluate the cumulative effects of development and mitigation within a large ecosystem. The Peninsula One NRMP was adopted in 1997 and is contained in a document entitled Natural Resources Management Plan for Peninsula Drainage District No. 1 (COP 1997).

2.5 Physiography

Based on Figure 2-2 in Golder (1990), the land surface is relatively flat with a slight slope from northeast to southwest towards the wetlands. As was discussed above, a soil berm along the northwest and southwest sides of the Harbor Oil facility prevents runoff from flowing into the wetlands. Appendix E contains Figure 2-2 from Golder (1990), as well as other figures referenced in later in this section.

2.6 Climate

The Portland area has a temperate marine climate characterized by wet winters and dry summers. According to information at <http://www.wrh.noaa.gov/pqr/pdxclimate/PG105.html>, precipitation, temperature, and wind data for the Portland area are as follows:

Precipitation

Average Annual	37 inches (mostly rain)
Average Wettest Month	6.1 inches (December)
Average Driest Month	0.6 inches (July)

Temperature

Average Annual	54 °F
Average Coldest Month	40 °F (January)
Average Warmest Month	69 °F (August)

Wind

Average Wind Speed	7.9 miles per hour (mph)
Prevailing Direction	East southeast

2.7 Geology

2.7.1 Regional Geology

The Site is located in the central part of the Portland Basin physiographic province, which is bounded by the Tualatin Mountains to the west and south and the Cascade Range to the east and north. The Site is located along the southern bank of the Columbia River floodplain, east of the confluence with the Willamette River (Figure 1).

The geologic history of the Portland Basin is described by Trimble (1957 and 1963), Burns et al. (1998), and Beeson et al. (1991).

A basin formed from basalt of the Columbia River Basalt Group that flowed from the northeast corner of Oregon down the ancestral Columbia River 14 to 16 million years ago and solidified in the area. Afterward, the basin was faulted and pulled apart causing the middle part to sink and the edges to uplift to form the Tualatin Mountains to the south and west and the Cascade Mountains to the north and east. Concurrent with this structural deformation, over a 12 million year period ending about two million years ago the basin filled with up to 1,500 feet of ancestral Columbia River sediments (gravels, sands, silts, and clays) that comprise the Troutdale Formation (coarse-grained facies) and Sandy River Mudstone (fine-grained facies); volcanic vents formed throughout the eastern part of the basin and erupted basaltic Boring Lavas during a period starting two million years ago and ending approximately 260,000 years ago; and 12,700 to 15,300 years ago, numerous catastrophic floods caused by glacial ice dam breaks in Montana inundated the Portland Basin with flood water up to an elevation over 400 feet, and after the water receded silt deposits up to 100 feet thick were windblown onto surrounding slopes of the Tualatin Mountains forming the Portland Hills Silt Formation.

Given the geologic history, the regional stratigraphy from the surface downward, includes:

Poorly Consolidated Silt and Sand Alluvium – Holocene to Pleistocene age Columbia River and catastrophic flood deposits composed of discontinuous layers of silts, silty sands, and sands that are approximately 120 feet² thick in the Site vicinity (Beeson, et al. 1991 and Madin 1990).

Troutdale Formation – Pleistocene, Pliocene, and upper Miocene age (fluvial coarse-grained deposits of the ancestral Columbia River that are composed of poorly to moderately consolidated, poorly graded, and sub-rounded to rounded sand and gravel with occasional cobbles. Well logs indicate the Troutdale Formation extends to approximately 300 feet below ground surface (bgs) in the vicinity of the Site. The maximum thickness of the Troutdale Formation is over 600 feet and possibly up to 1,500 feet in the East Portland Well field study area (Hoffstetter 1984).

² Logs of wells near the project site indicate the sand and silt extend to a depth of 130 to 135 feet bgs.

Sandy River Mudstone - Miocene to Pleistocene age (1 to 5 million years old) fluvial and lacustrine fine-grained deposits of the ancestral Columbia River (Madin 1990) composed of silt and clay with some sand deposited in a broad delta in the Portland-Vancouver region. The mudstones extend beyond 980 feet bgs according to one well log in the vicinity of the Site, giving a combined thickness with the Troutdale Formation of approximately 1,100 feet in the Site vicinity (Swanson et al. 1993).

Columbia River Basalt Group - Miocene age (23 to 5 million years old) layered basalt flows that individually range in thickness from approximately 10 to 150 feet and comprises a total thickness of 100 feet to about 800 feet. The Columbia River Basalt Group is considered the geologic basement unit for this area.

2.7.2 Local Geology

Local geologic and subsurface conditions at the Site are based on environmental investigations by Sweet-Edwards/EMCON (SE/E) (1988), Golder (1990), and Redmond & Associates (2002) that included the facility; an Oregon Water Resources Department (OWRD) water well report for the plant well; and geotechnical investigations within a 1 to 3 mile radius of the facility by GeoDesign (2001a, 2001b, 2005, 2006a, and 2006b), GeoEngineers (1997), Golder Associates (1991b), and Patrick B. Kelly (1998). A detailed description of the subsurface geologic conditions encountered during these investigations is provided in Section 2.7.2.1 below.

Environmental investigations of the Harbor Oil facility that did not include soil boring logs and detailed descriptions of subsurface soil and groundwater conditions include:

- A Preliminary Environmental Site Audit, Waste Management of Oregon, Inc., Proposed Transfer Station Site, Portland, Oregon, performed in 1987 by SE/E, included general information about the geology, surface water resources, and hydrogeology of the Stockyards area, including the Harbor Oil facility. SE/E (1987) included information on three supply wells located near the facility, including a well at the James River/Crown Zellerbach plant to the west, the Stockyards well to the north, and the Exposition Center well to the east. The 163- to 215-foot-deep wells reportedly produced water from a sand and gravel aquifer at depths ranging from 138 to 183 feet.
- A Stockyards site assessment, that included the Harbor Oil facility, performed in 1990 by Black and Veatch Waste Science and Technology Corp. (Black & Veatch) and Rittenhouse-Zeman and Associates, Inc. (RZA). Of the 21 wells drilled during the assessment, three shallow wells (A-18 through A-20) and one deeper (91.5 feet) well (B-4) were completed at the Harbor Oil facility. The assessment identified 15 to 20 feet of fine, clean dredge sand underlain by 100 feet of interbedded sand and silt.
- The EPA PA/SI performed in 2001 by E&E. Surface soil samples, subsurface soil samples, and groundwater samples were collected

from locations on and off of the facility, which provided information regarding subsurface soil and groundwater conditions (E&E 2001). The maximum sampling depth was 20 feet bgs. The borings generally encountered fine sand and silt.

- A Review of Existing Environmental Data for the Harbor Oil Site performed in 2002 by CEC. The CEC (2002) report presents the analytical results of split soil, groundwater, and sediment samples collected by CEC during the EPA's PA/SI.

2.7.2.1 Subsurface Conditions

2.7.2.1.1 General

Subsurface conditions were defined for the Harbor Oil facility based on the following: SE/E (1988) logs for four 7.5 to 11.5-foot on-facility borings; Golder (1990) logs for four 16.5-foot on-facility borings; Redmond & Associates (2002) two on-facility 49.0-foot borings installed in the new base-oil plant area; OWRD's (1978) water well report for the 100-foot plant well boring; GeoDesign's (2001a, 2001b, 2005, 2006a, and 2006b) logs for three off-facility borings (86.5 feet to 125.5 feet depth) and seven off-facility cone penetrometer technology (CPT) soundings (40 feet to 112 feet depth); GeoEngineer's (1997) logs for one 86.5-foot off-facility boring and one 104-foot off-facility CPT sounding; and Patrick B. Kelly's (1998) logs for one 106-foot off-facility boring and one 108-foot off-facility CPT sounding. Copies of the Golder (1990) on-facility soil boring logs and geologic cross-section (Figure 6-1) are included in Appendix E. OWRD's (1978) water well report for the plant well is included in Appendix F.

2.7.2.1.2 Fill

Golder's (1990) drillers logs indicate that on the facility fill extends to depths of 3.5 to 6.0 feet in two of the four borings (GA-29 and GA-33). This material was described as fine to coarse gravel with brick fragments in a silty sand matrix. Golder (1990) also reported 6.0 to 11.0 feet of what is believed to be dredged fill in three of the four borings (GA-30, GA-33 and GA-34). This material was described as silty sand, silty fine sand, and fine to medium sand with trace coarse sand and occasional fine gravel. SE/E (1988) reported up to 2.5 feet of coarse, angular gravel fill underlain by 2.5 to 5.7 feet of silty fine sand fill in two of its borings (T-2 and T-3). This sand fill is believed to have been dredged from the Columbia River during the late 1890s and early 1900s (Golder 1990). Redmond & Associates (2002) reported surficial fill consisting of moderately compacted gravel to a depth of 1.5 feet. Golder's (1990) geologic cross-section (Figure 6-1) in Appendix E depicts fill areas at the Harbor Oil facility. Given the limited number of borings and available logs for borings, it is not possible to prepare a more detailed figure that illustrates the extent of fill placement on the facility. More detailed representations of fill will be prepared following completion of Phase 1 of the RI.

Similar materials that are also interpreted to be dredged fill were encountered at the Lacamas Laboratories site to the west³ – up to 7 feet of fill (Patrick B.

³ 3625 N. Suttle Road

Kelly, 1998), Fazio Industrial Park to the southeast⁴ – up to 7.5 feet of fill (GeoDesign 2001a and 2005), and at the Mt. Hood Chemical (former K-Line) site to the southeast⁵ - up to 7.5 feet of fill (GeoDesign 2006a). Because of similarities between the fill and the underlying native soils, it is difficult to differentiate between fill and native materials. Therefore, the noted fill thicknesses should be considered approximate.

2.7.2.1.3 Alluvium

Beneath the fill, SE/E (1988) borings encountered 2.0 to 6.0 feet of silty fine to medium sand alluvium underlain by clayey silt alluvium to the total depth explored of 11.5 feet bgs. Golder (1990) borings encountered clayey silt alluvium to the total depth explored of 16.5 feet bgs. Little to some fine sand is identified with the clayey silt in two of the boring logs (GA-33 and GA-34). Underlying the fill north of the Harbor Oil facility, Golder (1990) encountered 90 to 100 feet of interbedded clays, silts, and sands. Trace amounts of organics, wood and plant roots were observed in this unit. The organics along with the fine grain size are indicative of sedimentation in a quiet, backwater environment, according to Golder (1990). A 4.2 to 5.7 foot thick tuffaceous silt layer believed to be a remnant of Mount Mazama pyroclastic ash deposit, was encountered along with the interbedded sands and silts at a depth of approximately 80 feet bgs in the deep borings on the northern part of the Stockyards site⁶.

In the plant well log (OWRD 1978), medium sand is identified to a depth of 14 feet bgs, and sandy clay is identified between 14 to 96 feet bgs to the top of the Troutdale Formation.

Redmond & Associates (2002) reported that slightly sandy, clayey silt was present to a depth of 3.0 feet. The clayey silt soils were underlain by fine sand to a depth of 5 to 6 feet bgs. The sand was underlain by slightly sandy, clayey silt that became sandier with depth to a depth of 42 to 43 feet bgs. A dense to very dense silty sand was encountered to the maximum depth explored of 49 feet bgs.

In areas off the facility, interbedded alluvial silt and sand were encountered to the top of the Troutdale Formation occurring at depths of 105 feet bgs to the west (Patrick B. Kelly 1998), and 122 feet bgs to the southeast (GeoDesign 2006a). West of the Harbor Oil facility, the alluvium generally includes fine sandy silt to a depth of 18 feet bgs, clayey silt, silt, and organic silt to a depth of 59 feet bgs, silty to clean fine sand to a depth of 68 feet bgs, organic silt to a depth of 82 feet bgs, silty fine sand to a depth of 88 feet bgs, and silt to the top of the Troutdale Formation at 105 feet bgs (Patrick B. Kelly 1998). Southeast of the facility, the alluvium generally includes a layer of silt to sandy silt to depths of 22 to 32 feet bgs, silty sand and sandy silt to depths of approximately 55 to 60 feet bgs, and silt and clayey silt with interbeds of silty sand to the top of the Troutdale Formation at a depth of approximately 122 feet bgs (GeoDesign 2006a). Slightly further to the southeast, relatively

⁴ NE Gertz Road and NE Fazio Way

⁵ NE Vancouver Way and NE Gertz Road

⁶ Mt. Mazama began its most destructive eruption about 6,780 years ago. Ash deposits spread over parts of Oregon, Washington, Idaho, Montana, and Canada (<http://www.accuracyingenesis.com/mazama.html>).

thinner interbedded layers of sand were encountered in the silt unit, with the sand layer thickness generally increasing with depth (GeoDesign 2006b).

2.7.2.1.4 Troutdale Formation

Basaltic gravels, cobbles, and boulders with some silt and sand, comprising the Troutdale Formation were encountered at depths ranging from 91 to 122 feet bgs north of the Harbor Oil facility, and 96 feet bgs in the plant well boring (Golder 1990, OWRD 1978). Southeast of the facility, a deep boring encountered very dense materials, inferred to be gravels of the Troutdale Formation, at a depth of 122 feet bgs. Immediately above this very dense material, at a depth of 113 feet bgs, lenses of dense gravel were encountered within silty sand alluvial deposits. GeoDesign (2006a) interpreted these gravel lenses to be reworked gravels derived from the Troutdale Formation. Two CPT probes encountered refusal on dense materials at depths of 113.9 and 118.8 feet bgs, respectively. These dense materials were situated within dense silty sand alluvial deposits, and GeoDesign (2006a) inferred that they are also reworked gravels derived from the Troutdale Formation. The in-place Troutdale Formation is anticipated to be located within 5 to 10 feet of these reworked materials at depths between approximately 120 and 130 feet bgs.

2.8 Hydrogeology

2.8.1 Regional Hydrogeology

The Site is located in the lowlands of Peninsula Drainage District No. 1, whose perimeter is a levee intended to protect the lands in Pen 1 from high water in the Columbia River and Willamette River (COP 1997). Pen 1 and the Site are located within the alluvial floodplain of the Columbia River, bounded by the Oregon Slough channel of the Columbia River approximately 0.23 miles to the north and the Columbia Slough approximately 0.8 miles to the south (Figure 1). The Columbia Slough extends 18 miles from Fairview Lake on the east to the Willamette River at Kelley Point Park on the west. There are three sections or reaches of the Columbia Slough. The reach near the Site is the Lower Slough, the western reach.

Eight distinct hydrogeologic units have been mapped regionally in the alluvial flood plain of the Columbia River in the Portland Basin (Morgan and McFarland 1996a, Hartford and McFarland 1989, and Hoffstetter 1984). The inclusion of descriptions of these hydrogeologic units in this section does not infer that all eight units underlie the Site:

Unconsolidated Sedimentary Aquifer (USA) – Referred to as the Overbank Deposits by Hoffstetter (1984), consists mostly of catastrophic flood deposits of silt, clayey silt, and sand. Thickness is variable, but is 65 feet thick at the western edge of the East Portland Well Field study area. The USA thickens to the north from Sandy Boulevard to the Columbia River. The horizontal hydraulic conductivity in the USA is 175 feet/day (Morgan and McFarland 1996b). A spring 1988 groundwater level of -2.2 feet mean sea level (msl) was measured in a well near the Columbia Slough south of the Site (Morgan

and McFarland 1996a). A +1 foot change in water level was noted in this well between measurements taken in 1988 and 1989.

Troutdale Formation Hydrogeologic Units - Three major aquifers (TGA, TSA and SGA) and two major aquitards (CU1 and CU2) have been delineated within the Troutdale Formation as follows:

Troutdale Gravel Aquifer (TGA) – referred to as the Columbia River Sand Aquifer by Hoffstetter (1984), the TGA consists of late Pleistocene and Holocene medium quartzose sand occasionally layered with silt, clay, and basalt, andesite, dacite, and quartzite gravel zones that fill a Pleistocene Columbia River valley. The TGA attains a maximum thickness of approximately 400 feet; the TGA is approximately 195 feet thick at the western edge of the East Portland Well Field study area, not far from the Site. According to E&E (2000), most municipal wells are completed in this aquifer, the upper part of the TGA has been weathered to clay to form a discontinuous confining layer, but this confining layer has not been confirmed in the Site vicinity. The horizontal hydraulic conductivity for the TGA ranges from about 7 to 16 feet/day (Morgan and McFarland 1996).

Confining Unit 1 (CU1) – is composed of lenticular and interbedded zones of fine-grained, lacustrine deposits of consolidated sand, silt, and clay that act as hydraulic confining layers preventing rapid water movement between the CRSA and TSA. This unit is approximately 50 feet thick at the western edge of the East Portland Well Field study area. The horizontal hydraulic conductivity in CU1 and CU2 is approximately 1 foot/day (Morgan and McFarland 1996b). The horizontal hydraulic conductivity in CU1 is approximately 1 to 10 feet/day (Morgan and McFarland 1996b).

Troutdale Sandstone Aquifer (TSA) – according to Hoffstetter (1984), the TSA consists of a relatively uniform deposit of conglomerate and vitric sand and sandstone that extends throughout a large portion of the Portland Basin. A thin layer of silt separates the depositional mode of the aquifer into an Upper Unit (approximately 60 feet thick) consisting of fluvial vitric sand and sandstone and a Lower Unit (approximately 35 feet thick) consisting of fluvial-lacustrine conglomerate. Well yields for the TSA are 1,000 to 2,000 gpm.

Confining Unit 2 (CU2) –referred to as Rose City Aquitard by Hoffstetter (1984), is composed of lenticular and interbedded zones of fine-grained, lacustrine deposits of consolidated sand, silt, and clay that act as hydraulic confining layers preventing rapid water movement between the TSA and SGA. This unit is approximately 80 feet thick at the western edge of the East Portland Well Field study area. The horizontal hydraulic conductivity in CU2 is approximately 0.5 to 4 feet/day (Morgan and McFarland 1996b).

Sand and Gravel Aquifer (SGA) – referred to as Rose City Aquifer by Hoffstetter (1984), is composed of discontinuous lenses of sand, gravel, silt, and clay. Pump tests show the SGA is continuous throughout the East Portland Well Field study area, but each well shows a different sequence of materials. Various mixtures of gravel and sand dominate the Upper unit (approximately 120 feet thick) while thick layers of sand with occasional silt and clay beds predominate in the Lower unit (100+ feet thick). Most of the sand in the SGA is quartzose, with a minor amount of mica. Vitric sand is not as common in the SGA as in the TGA. The gravel in the SGA consists

almost entirely of basalt and quartzite clasts, and the cementation of the gravel is less tight than in the TSA. The horizontal hydraulic conductivity in the SGA is 150 feet/day (Morgan and McFarland 1996b). A spring 1988 groundwater level of approximately 10 feet msl was measured in the SGA east of the Site (Morgan and McFarland 1996a). Well yields for the SGA are 2,000 to 3,000 gpm.

2.8.2 Local Hydrogeology

Local hydrogeologic conditions such as groundwater levels, flow direction and gradient, and aquifer characteristics (e.g. hydraulic conductivity, transmissivity) were determined by Golder (1990) and later summarized by E&E (2000). SE/E (1988) provided groundwater levels for four borings drilled at the Harbor Oil facility.

Golder's hydrogeologic field investigations of the Stockyards (Golder 1990 and 1991a), which covered the Harbor Oil facility, included the following scope of work: surveying all groundwater monitoring points; measuring water levels in monitoring wells; monitoring water table and river fluctuations with electronic data loggers; installing shallow groundwater wells (four at the facility); conducting aquifer slug tests and pumping tests; and collecting groundwater samples for laboratory analysis from three deep production wells to assess deep groundwater quality on a regional basis.

Based on these investigations, there appears to be three distinct groundwater regimes beneath the facility: a shallow saturated zone that occurs to a depth of 15 to 20 feet bgs within the relatively more permeable, sand fill material; an intermediate saturated zone that occurs between 15 to 20 and approximately 90 feet bgs within the interbedded sands and silts that are of lower hydraulic conductivity than either the shallow or the deep saturated zones; and a deep saturated zone that occurs at depths greater than about 90 feet bgs that is associated with the TGA gravels.

2.8.2.1 Groundwater Flow Direction and Gradients

SE/E (1988) measured groundwater levels in four borings located on the facility at depths ranging from 0.87 feet bgs to 4.76 feet bgs on the southern part of the Harbor Oil facility. Later, Golder (1990) measured static groundwater levels between May 10 and 12, 1990, in seven shallow saturated zone (10 to 20 feet) wells (A-18, A-19, A-20, GA-29, GA-30, GA-33 and GA-34) and one deep saturated zone (91.5 feet) well (B-4) at the Harbor Oil facility (Figure 5). Well construction details are included in Appendix F.

Groundwater levels in shallow wells ranged from 0.00 feet below top of casing (BTOC) in GA-34 at the northeast corner of the Harbor Oil facility to 2.39 feet BTOC in A-19 near the southwest corner of the facility. The groundwater level in the deep zone well (B-4) was 1.42 feet BTOC. Golder developed a groundwater potentiometric map using groundwater level data collected at the facility, the former Farmer's Plant Aid facility, and the former Stockyards (see Figure 6-4 in Appendix E). North of the topographic divide, the flow directions in the shallow zone was northward toward the Oregon Slough. South of the topographic divide, the flow direction in the shallow

zone was southward toward and across the facility at a gradient ranging from 0.0107 to 0.0144 feet/feet.

Golder (1990) did not draw groundwater contours for the deep zone. However, Golder (1990) noted that deep zone groundwater flows to the northwest toward the Columbia River during periods of low river flow and southwest away from Columbia River during periods of high river flow⁷ at gradients ranging from zero (during flow reversal) to a maximum of 0.002 feet/feet.

Golder (1990) installed pressure transducers fitted with electronic data loggers in several wells, including shallow well A-19 and deep well B-4 at the Harbor Oil facility. A pressure transducer and data logger were also set up in the Oregon Slough. The purpose of this monitoring was to determine groundwater gradients, flow directions, and fluctuations. Data were collected from the middle of May 1990 through the end of July 1990. The resulting data were plotted along with Oregon Slough station elevation to determine if water level fluctuations were correlated. The resulting hydrograph did not show a clear correlation between the fluctuations in Columbia River stage and fluctuations in shallow groundwater (see Figure 6-5 in Appendix E). However, a correlation did exist between fluctuations in Columbia River stage and the fluctuation in deep groundwater (see Figure 6-7 in Appendix E). Such fluctuations may be due to tidal as well as seasonal influences.

Golder (1990) evaluated horizontal versus vertical hydraulic gradients in shallow, intermediate depth, and deep zones. They speculated that the interbedded silts and fine-grained sands comprising the lacustrine and overbank deposits should act hydraulically as a semi-confining stratum or an aquitard. As such, the intermediate zone should exhibit a high degree of anisotropy of horizontal versus vertical hydraulic conductivities (a 10:1 to 100:1 contrast). However, following the investigation Golder (1990) concluded that the interbedded sands and silts do not appear to isolate the shallow and deep zones but act as a continuous hydraulic system, both in terms of vertical and horizontal gradients. On the former Stockyards, vertical gradients were downward, allowing movement of near surface groundwater to depth. Golder (1990) notes that vertical gradients between the shallow and intermediate zones ranged from 0.14 to 0.17 feet/feet, and vertical gradients generally declined with depth. Slight downward vertical gradients also were noted between intermediate and deep well clusters north of the Harbor Oil facility. Vertical gradients were not as pronounced at the Harbor Oil facility (Golder, 1990), in part due to the recharge of the shallow groundwater system by the former Stockyard production well and leaky livestock water system.

⁷ Golder's (1990) conclusion is based on the relative water level elevations in a gage station on the Oregon Slough versus well B-4 at the Site. During periods of low river flow, the groundwater elevation in B-4 is higher than the surface water elevation in the Oregon Slough, so the flow is northward toward the Columbia River. Conversely, during periods of high river flow, the groundwater elevation in B-4 is lower than the surface water elevation in the Oregon Slough, so the flow is southward away from the Columbia River.

Shallow groundwater seasonally fluctuates 1 to 3 feet on the facility, with higher levels in the winter and spring and lower levels in the summer and fall (E&E 2000). Golder (1990) notes that water table fluctuations in shallow wells are more directly related to variations in rainfall rather than changes in river levels. However, water levels in wells completed in the intermediate and deep zones do correlate with river stage and tidal fluctuations.

2.8.2.2 Report on Deep Groundwater Sampling

Golder (1991a) identified several deep production wells (i.e., large capacity drinking water, industrial process and irrigation supply wells) in the vicinity of the Site that are completed in the Troutdale Gravel Aquifer. These wells include five former Vanport City wells (Wells No. 1-5), a golf course domestic well (Well No. 6), Exposition Center irrigation well, and five James River Corporation production wells, in addition to the Stockyards production well.

Former Vanport City wells No. 1 and 2 are at the present site of the Portland International Raceway (PIR). The exact locations and condition of these 152- and 148-foot-deep wells are not known. Wells No. 1 and 2 are both constructed of a 12-inch diameter casing which is perforated from 132 to 145 feet bgs and 125 to 142 feet bgs, respectively. At the time of the report in 1991, former Vanport City Wells No. 3 and 4 were sealed at the surface with a metal cap. There were plans to rehabilitate these 136- and 137-foot-deep wells to provide additional irrigation water for the expansion of the Heron Lakes Golf Courses. Wells No. 3 and 4 are constructed of 12- and 14-inch diameter casings which are perforated from 122 to 132 feet bgs and 115 to 130 feet bgs, respectively. At the time of the report in 1991, the 125-foot-deep former Vanport City Well No. 5 was being used by the golf course for irrigation, and the 86-foot-deep Well No. 6 was being used as a domestic supply for the club house. Well No. 5 is constructed of a 12-inch diameter casing which is perforated from 106 to 120 feet bgs. Well No. 6 is constructed of a 10-inch diameter casing, but the perforation interval is unknown.

According to J. Goodling, Heron Lakes Golf Courses Superintendent (personal communication November 28, 2007), the Vanport City Well No. 6 has been capped and is no longer used for any purpose. There are only two active wells on the Heron Lakes Golf Courses (i.e., Vanport City Wells No. 4 and 5) and both are used for irrigation only. The current use status and condition of the other Vanport City wells are not known.

The 166-foot-deep Exposition Center irrigation well was used periodically to irrigate land south of the Center complex. This well is constructed of a 12-inch diameter casing which is perforated from 147 to 162 feet bgs.

Information is only known about one of the five James River wells, a process production and water supply well that is 163 feet deep and has a casing perforated from 138 to 163 feet bgs. Golder (1991a) indicates that no information was found on the specific location and construction of the other four James River wells.

Approximate well locations are shown on Figure 6.

2.8.2.3 Aquifer Testing

2.8.2.3.1 Slug Tests

Golder (1990) provided slug test results for several shallow wells, including shallow well GA-30 at the Harbor Oil facility (Figure 5). The test apparatus consisted of an electronic pressure transducer, data logger, and “slug” which initiates the water level change. The slug was introduced into the well which caused an instantaneous change in water level, and the recovery of the water level to pretest levels was monitored using the pressure transducer/data logger. Interpretation of the data was performed in accordance with the Hvorslev method. A hydraulic conductivity of 4×10^{-3} centimeters per second (cm/sec) was reported for shallow well GA-30.

Hydraulic conductivities for intermediate and deep zone wells located north of the Harbor Oil facility ranged from 1×10^{-3} cm/sec (GB-5b) to 4×10^{-1} cm/sec (GA-25). Based on gradients and values of hydraulic conductivity derived from slug tests, Golder (1990) estimated pore water velocities varied over a range of about 0.03 to 23 feet/day, with typical values in the range of 0.3 to 3 feet per day⁸. GeoDesign calculated pore velocities for the facility in the vicinity of GA-30 ranging in value from 0.40 to 0.54 feet/day⁹.

2.8.2.3.2 Aquifer Pumping Test

Golder (1990) performed an aquifer pumping test utilizing the 210-foot-deep production well at the Stockyards. The production well was located approximately 750 feet north of the northern boundary of the Harbor Oil facility. Prior to the pumping test in July-August 1990, the Stockyard production well reportedly was being pumped continuously at a rate of 500 gpm and supplied a piping network in the stockyard pens to supply livestock watering. The majority of the surplus water not used by the livestock was diverted through a storm drain and discharged to the Columbia River (350 gpm). The remainder of the water that was leaking from pipes reportedly infiltrated into the ground (150 gpm) causing a groundwater mound in the stock watering area. Surface runoff towards the wetlands south of the Stockyards and adjacent to the Harbor Oil facility was reportedly negligible. Downward vertical gradients are reported for nested wells in the stock watering area due to the groundwater mound.

The purpose of the pumping test was to determine the impact of the production well on groundwater flow and provide more reliable estimates of deep aquifer hydraulic properties than had been obtained by slug tests. During the test, pressure transducers with data loggers were installed in 13 wells, including well B-4 at the Harbor Oil facility (Figure 5). An alternate water supply was provided for the Stockyards so that the production well could be started and stopped at will. The production well was shut down for 70 hours, and then the pump was restarted and pumped at a rate of about 490 gpm. Closely timed water level measurements were collected in the production well and monitoring wells.

Pump test analysis was complicated by the fact that the amplitude of tidal variations in the intermediate and deep zone wells of 0.1 to 0.4 feet is greater

⁸ Assuming an effective porosity of 30 percent.

⁹ Hydraulic conductivity of 4×10^{-3} cm/sec, gradients of 0.0107 to 0.0144 ft/ft, and effective porosity of 30 percent.

than the measured drawdowns in the observation wells (0.1 feet in wells located 100 feet away from the test well to 0.01 feet in wells located farther away. Nevertheless, Golder (1990) developed the following conclusions:

- Ten feet of drawdown was observed in the Stockyard's production well when it operated at a rate of approximately 490 gpm.
- Transmissivities for the deep zone range from about 2.3×10^5 to 3.5×10^6 feet/day, with a most likely value of 2×10^6 feet/day.
- Water level drawdown at the closest observation well is less than a maximum of 0.3 feet.
- Predicted maximum drawdowns in observation wells 100 feet or more away from the pumping well could have been as high as 0.25 feet but was probably only 0.03 feet.
- The observed drawdown in the production well was about 10 times greater than it should be due to well loss.

2.9 Hydrology

According to the NRMP for Peninsula Drainage District No. 1 (COP 1997), the Pen 1 drainage area is approximately 900 acres in size and is located within the Columbia River floodplain. The area was diked and drained in the early 1900s. Over time, the area has been filled to create housing sites and roads, develop the PIR and Heron Lakes Golf Courses, and to store surplus soil from other projects. The perimeter of the Pen 1 NRMP Area is surrounded by a levee to protect the area from flooding by the Willamette and Columbia Rivers. All runoff generated within the area is pumped over the levee into the Columbia Slough.

Given its floodplain setting, hydrologic resources in the vicinity of the Harbor Oil facility include: wetlands the southwest and northwest, the "radio tower" wetlands to the southeast, Force Lake, numerous small lakes within the Heron Lakes Golf Courses, and a network of sloughs, ditches, and culverts (Figure 7). Note that the Pump Station located in the northeast portion of the Pen 1 NRMP Area pumps water from the "Radio Tower" wetlands into the Northeast Drainageway. The Pump Station located near the south side of the Pen 1 NRMP Area pumps water from the Forebay Slough over the dike into the Columbia Slough.

2.9.1 Force Lake Drainage Basin

There are only two known, point discharges into Force Lake. According to J. Goodling (personal communication with S. Brown on June 29, 2007), a catch basin drains a small area along the east side of N. Force Avenue, just north of its intersection with N. Victory Boulevard. Stormwater captured in this catch basin is conveyed beneath N. Force Avenue and discharged into Force Lake. In addition, an underdrain for one of the greens on the Greenback Golf Course drains to the lake.

Note that the current stormwater treatment system located on the Harbor Oil facility does not discharge directly into Force Lake; it discharges into the wetlands near just south of the facility.

All of the other discharges to Force Lake are nonpoint source discharges of stormwater. According to the Pen 1 NRMP, Force Lake is located within drainage sub-basin A-7 which includes the Harbor Oil facility; properties between the facility and the Peninsula Terminal Railroad, west of N. Force Avenue; N. Force Avenue south of the Peninsula Terminal Railroad; and the wetlands between the Harbor Oil facility and Force Lake (see Figure 7). All of the surface water runoff south of an east-west trending topographic divide¹⁰ that represents the northeast boundary of sub-basin A-7 drains southward towards Force Lake. In addition, the portion of the Greenback Golf Course that borders the south and west sides of Force Lake also drains into Force Lake.

There are no other known surface water inflows to Force Lake.

During golf course construction in 1969 and 1970, the narrow west end of Force Lake was separated by fill to create another small lake (presumably North Lake) (DEQ 1974a).

2.9.2 Force Lake Hydraulics

The estimated drainage area to Force Lake is 17 acres and the estimated peak flow into Force Lake during a 5-year frequency storm event is 9 cubic feet per second.

Force Lake has a surface area of about 12 acres and an estimated storage volume of about 30 acre-feet. Based on these parameters, the average depth of Force Lake is 2.5 feet.

The NRMP further states that outflows from Force Lake are much less than inflows, and are minimal for storm events less than the 2-year event. This is due the fact that outflows from Force Lake are controlled by two, 30-inch concrete sewer pipes (CSPs), located on the west side of the lake, which have an invert elevation about 0.8 feet higher than the water levels in other downstream water bodies located in what is referred to as the upper "A" sub-basin. The upper "A" sub-basin includes Force Lake, North Lake, the North Drainageway, Frog Lake, and an unnamed lake (see Figure 7). The 30-inch corrugated metal pipe (CMP) that connects the unnamed lake to the Southwest Marsh hydraulically separates the upper "A" sub-basin and controls upstream water levels everywhere except in Force Lake. Thus, until water in Force Lake rises to the elevation of the pipe invert for the two, 30-inch CSPs there is no outflow from the lake. According to Mr. Goodling, Force Lake discharges to North Lake about 9 or 10 months per year.

Because of the hydraulic control on outflows from Force Lake, the NRMP states that pollutants conveyed to Force Lake by runoff from sub-basin A-7 and the Greenback Golf Course will remain in Force Lake and not be transported downstream.

¹⁰ The east-west topographic divide is located north of the Site by the railroad tracks, approximately halfway between the Site and N. Marine Drive.

The water elevation in Force Lake is controlled by the invert elevation of the pipes that connect Force Lake to North Lake. This hydraulic control keeps water impounded in Force Lake. Because inflows and outflows from the Lake are limited, the water velocity or current is small (i.e., the lake is a quiescent waterbody that behaves like a settling basin) and suspended solids that enter the lake tend to settle to the bottom, rather than being transported downstream. Chemicals entering the lake will tend to stay there because of the lake hydraulics, the tendency for solids to settle, and the fact that most of the constituents that have been detected above screening levels have a tendency to adsorb to solids that will settle. The dissolved fractions of these constituents would tend to be small and it is unlikely that there would be any significant migration of those constituents from Force Lake. As will be discussed below, sediment samples will be collected in North Lake to determine if there has been contaminant migration beyond Force Lake.

2.9.3 Downstream Surface Water Bodies

Force Lake discharges to North Lake which also receives runoff from the Greenback Golf Course.

North Lake discharges to the North Drainageway via a ditch and 24-inch culvert. The North Drainageway flows to the west through a wetland area and heron rookery, and then flows to the south near the northwest corner of the Greenback Golf Course. It is at this point that drainage from the area between the levee and the railroad tracks apparently enters the North Drainageway, and where the North Drainageway flows into a 24-inch culvert that flows to the south into Frog Lake. According to J. Goodling, the 24-inch culvert has settled and is partially clogged. To overcome this problem, the COP extended the North Drainageway to the west to connect to Frog Lake in approximately 1995 (personal communication with S. Brown on June 29, 2007).

From Frog Lake water flows to the south through a 30-inch culvert to a smaller unnamed lake and then through another 30-inch culvert where it enters the Southwest Marsh. According to the NRMP, the invert elevation for the second culvert controls upstream hydraulics, likely indicating that water only flows in the Southwest Marsh once upstream water levels are high enough to reach the invert for the culvert that discharges from Frog Lake.

From the Southwest Marsh, surface water flows to the south through several culverts and another unnamed lake to the Southwest Slough and then flows to the east to Forebay Slough where it is pumped over the levee into the Columbia Slough. Southwest Marsh receives runoff from a series of lakes located in the west central portion of the Heron Lakes Golf Courses. Prior to entering Forebay Slough, surface water from Southwest Slough combines with surface water drainage from the central portion of the Heron Lakes Golf Courses that collects in various unnamed lakes and Midwestern Slough. Note that Forebay Slough also receives runoff from PIR which is located in the southeastern portion of the Pen 1 NRMP Area.

Mr. Goodling said that he had worked at the Heron Lakes Golf Courses since 1986 and that the drainage system had not changed over that time, other than the extension of the North Drainageway to Frog Lake.

3.0 PRELIMINARY CONCEPTUAL SITE MODEL

3.1 Past Investigations

Since 1990, the following investigations have been conducted at the Site:

- 1990 Site Investigation and Preliminary Remediation Plan for Portland Stockyards by Golder
- 1997 surface water and sediment sampling of Force Lake by the COP
- 2001 Harbor Oil Site PA/SI by EPA
- 2003 soil sampling by CEC
- 2006 COP Heron Lakes Golf Courses water quality sampling

Other investigations (e.g., SE/E 1988 and the 1990 Black & Veatch and RZA Stockyards site assessment) are not discussed because of their incomplete documentation and uncertain data quality.

EMRI's work plan for the characterization of the contents of Tank 23 discusses various water, oil and sludge sampling events that occurred between 1988 and 2006 (CEC 2007a). The analytical results for these samples are not discussed in this Work Plan.

Figure 8 illustrates the locations where soil and surface water samples have been collected on the facility. Figure 9 illustrates the locations where wetland soil and surface water samples have been collected off the facility. Note that the COP did not identify the specific locations where sediment and surface water samples were collected in Force Lake (COP 1997). Finally, Figure 5 illustrates groundwater monitoring wells, extraction wells, and the plant well located on the facility.

3.1.1 1990 Portland Stockyards Site Investigation

The 1990 Portland Stockyards site investigation included the collection of samples on the Harbor Oil facility, in the wetlands, and on a number of nearby properties (e.g., the former Portland Livestock Auction, Inc. [Stockyards], Peninsula Terminal Railroad, Star Oil, and Former Farmer's Plant Aide/Former Limex Transportation/Bulk Transport facility) (Golder 1990). The following summarizes the samples that were collected on the Harbor Oil facility and in the adjacent wetlands.

Surface soil samples were collected at two locations: P-100 and P-275. Subsurface soil samples were collected, typically at depths of 2.0 or 2.5-feet bgs and/or 5.0 or 6.0 feet bgs at 14 locations: P-275, K-550, D-550A,

D-550B, K-500, J-550, J-600, J-630, J-650, C-0, J-400, J-475, L-500, T-550, WL-001 and WL-002 (see Figure 10). Deeper subsurface soil samples were collected at depths of 10.0 and/or 15.0 feet bgs at 10 locations: D-550B, K-500, J-550, K-600, J-630, J-650, J-300, J-400, J-475, and T-550. A total of 39 soil samples were analyzed in a field laboratory using gas chromatography (GC) for benzene, toluene, m,p-xylenes (and ethylbenzene), o-xylene, 1,1-dichloroethylene (1,1-DCE), trans-1,2-DCE, 1,1,1-TCA, TCE, PCE, and 1,3-dichlorobenzene (1,3-DCB), and thin layer chromatography (TLC) for total petroleum hydrocarbons. Ten of the subsurface soil samples were analyzed in the Close Analytical Support Facility in Redmond, Washington for total lead, chromium, and cadmium. Two surface soil samples (GAI-SS2 and GAI-SS3) and one subsurface soil sample (J-550 at 5.0 feet bgs) were submitted for fixed laboratory analysis of EPA Target Analyte List (TAL) inorganics. Soil samples collected from locations J-300, at a depth of 10.0 feet bgs, and J-550, at a depth of 5.0 feet bgs, were submitted for fixed laboratory analysis of organics, including VOCs, SVOCs, pesticides, PCBs, metals and total petroleum hydrocarbons (TPH).

Soil samples were collected in the wetlands west of the Harbor Oil facility, typically at depths of 0.0, 2.5 and 5.0 feet bgs, at 10 locations: M-150, M-300, M-450, M-600, N-150, N-300, N-600, O-000, O-100 and O-200. A total of 29 wetland soil samples were analyzed in the field lab for benzene, toluene, m,p-xylenes (and ethylbenzene), o-xylene, 1,1-DCE, trans-1,2-DCE, 1,1,1-TCA, TCE, PCE and 1,3-DCB, and TLC for TPH.

Surface water samples were also collected at six locations. Two samples were collected in the drainage ditch at the same locations as soil samples P-100 and P-275. Three samples were collected in the wetlands to the west of the Harbor Oil facility (SW-003, J-650-SW, and stormwater treatment system discharge). One sample was collected from the stormwater treatment system. Three surface water samples were also collected further to the west in the wetlands at locations N-600, O-100 and O-200. They were analyzed in the field laboratory using GC for benzene, toluene, m,p-xylenes (and ethylbenzene), o-xylene, 1,1-DCE, trans-1,2-DCE, 1,1,1-TCA, TCE, PCE and 1,3-DCB, and TLC for TPH.

Four groundwater monitoring wells already existed at the Harbor Oil facility when the 1990 investigation was conducted: A-18, A-19, A-20 and B-4. The "A" wells ranged in depth from 10 to 20 feet. Well B-2 is 91.5 feet deep. Golder installed four additional wells on the facility: GA-29, GA-30, GA-33 and GA-34. All four of these wells are 16.5 feet deep.

Following well installation and development, groundwater samples were collected from all of the newly installed wells and from selected previously installed monitoring wells. Groundwater samples collected from GA-30, A-18 and B-4 were analyzed for TAL inorganics. Groundwater samples collected from GA-29, GA-30, GA-34, A-18, A-19, A-20 and B-4 and the plant well were analyzed in the field laboratory. Finally, groundwater samples collected from A-18, GA-30 and B-4 were analyzed in the fixed laboratory for VOCs and SVOCs.

3.1.2 1997 Force Lake Sampling

As part of the development of the Pen 1 NRMP, the COP collected a water (W-1) and a sediment (S-1) sample from Force Lake. The COP also collected a water (W-2) and a sediment (S-2) sample from the intersection of the Midwestern Slough and Forebay Slough, and a water sample (W-3) from the northwest corner of the Forebay Slough near the road crossing (Figure 7). Note that sediment samples S-1 and S-2 were collected by combining grab samples to form a composite sample. The COP report did not identify where the grab samples were collected from Force Lake.

The samples were analyzed for general chemistry, ammonia, total solids, total dissolved solids, total suspended solids, total coliform, chemical oxygen demand, biological oxygen demand, total organic carbon, oil and grease (and total petroleum hydrocarbons), volatile organic compounds, metals (total and toxicity characteristic leaching procedure), pesticides and PCBs, herbicides, and SVOCs.

The samples were collected on January 2, 1992, except for the VOC sediment sample which was collected on February 6, 1992.

The following summarizes results for the water samples:

- Oil & grease was detected at a concentration of 0.18 mg/L in sample W-1. Samples W-2 and W-3 contained 0.17 and 0.08 mg/L, respectively, of oil & grease.
- No TPH was detected in W-1, W-2, or W-3 using Method 418.1, at a detection limit of 0.04 mg/L
- The following metals were detected in W-1: copper (0.011 mg/L), iron (0.816 mg/L), lead (0.126 mg/L) and zinc (0.019 mg/L); no arsenic, chromium, mercury or nickel were detected in W-1. W-2 contained detectable levels of copper (0.016 mg/L), iron (1.21 mg/L) and zinc (0.020 mg/L). W-3 contained detectable levels of copper (0.015 mg/L), iron (0.746 mg/L), nickel (0.051 mg/L), and zinc (0.026 mg/L).
- No herbicides, pesticides or PCBs were detected in W-1, except Lindane (0.04 ug/L). A higher Lindane concentration (0.06 ug/L) was detected at W-2. Lindane was not detected in W-3, at a detection limit of 0.003 ug/L.
- No VOCs or SVOCs detected were detected in any of the water samples.

The following summarizes the results for the sediment samples:

- Oil & grease was detected in S-1 at a concentration of 120 mg/kg, compared to 11 mg/kg detected in sample S-2.
- TPH was detected in S-1, using Method 418.1, at a concentration of 180 mg/kg, compared to 10 mg/kg at S-2.
- Arsenic (4.1 mg/kg), chromium (6.7 mg/kg), copper (106 mg/kg), iron (15,500 mg/kg), lead (18,600 mg/kg), nickel (11.7 mg/kg),

zinc (173 mg/kg) were detected in S-1; no mercury was detected. S-2 contained detectable concentrations of arsenic (2.91 mg/kg), chromium (15.0 mg/kg), copper (19.6 mg/kg), iron (11,100 mg/kg), nickel (14.6 mg/kg), and zinc (83.9 mg/kg); lead and mercury were not detected.

- No herbicides, pesticides or PCBs were detected in S-1, except 4,4-DDD (100 ug/kg); DDD not detected in S-2.
- No VOCs were detected in S-1; S-2 was not analyzed for VOCs. S-1 not analyzed for SVOCs; no SVOCs were detected in S-2.

3.1.3 2001 EPA Site Inspection

In July and August 2000, surface soil, subsurface soil, wetland soil, groundwater, and product samples were collected by EPA as part of its PA/SI.

Fifteen surface soil samples (DP01SS through DP03SS and SS01SS through SS10SS), including two samples that were referred to as “background” samples (BG01SS and BG03SS), were collected at the Site (Figures 8 and 9). It is important to note that sample BG03SS may or may not be representative of “background” conditions because it was collected on the Heron Lakes Golf Courses. As will be discussed below, pesticides were historically used at the Heron Lakes Golf Courses and the COP placed fill material south of Force Lake. In addition, as will be discussed below, DDT was historically used at Vanport City which was located south of Force Lake.

The surface soil samples were collected below the approximately 12-inch layer of hard-packed gravel at depths of 12 to 26 inches bgs.

Ten subsurface soil samples, including two background samples, were collected at locations DP01 through DP03 and BG01. The samples were collected at locations co-located with samples DP01SS, DP02SS, DP03SS, and BG01SS (Figure 8).

Six soil samples were collected from the wetlands south of the Harbor Oil facility at depths of 0 to 6 inches bgs. EPA refers to these samples as “Force Lake sediment” samples, even though some of them were collected from the wetlands rather than within the lake. The samples were collected at locations WL01SD through WS05SD and BG02SD (Figure 9). Note that background sample BG02SD was collected from the Heron Lakes Golf Courses. It may or may not be representative “background” conditions for the reasons mentioned above.

Groundwater samples were collected from monitoring wells (GA-29, GA-33, GA-34, A-18, A-19 and A-20) and the plant well. Note that EPA sampled the plant well to represent “background” conditions, even though the plant well is screened deeper than most of the other wells that EPA sampled.

The soil, groundwater and product samples were selectively analyzed for TAL metals, pesticides, PCBs, SVOCs, total organic carbon (TOC), TPH and VOCs.

Finally, a light non-aqueous phase liquid (LNAPL) sample was collected from monitoring well GA-30. A number of pesticides were detected in the sample, including: alpha-BHC (110 JK ug/kg), alpha Chlordane (61 JK ug/kg), beta-BHC (130 JK ug/kg), dieldrin (150 ug/kg), endosulfan sulfate (210 ug/kg), endrin aldehyde (160 ug/kg), gamma Chlordane (87 JK ug/kg), and heptachlor epoxide (61 JK ug/kg). PCBs were also detected as Aroclor 1242 (9,600 ug/kg) and Aroclor 1254 (5,300 JK ug/kg).

3.1.4 2003 CEC Soil Sampling

Between February 1 and April 17, 2003, CEC collected soil samples in several locations as part of the new base-oil plant construction and card lock fueling area projects (CEC 2007b).

Eleven soil samples were collected at sample locations HC-01 through HC-11 in the area where the new base-oil plant was constructed (Figure 8). The samples were collected at depths ranging from 1.0- to 7.0-feet bgs.

Three soil samples were collected at locations HC-12 through HC-14 to the southwest of the tank farm and used oil processing area, where new electrical equipment was installed in a vault. The samples were collected at depths ranging from 2- to 5.5-feet bgs.

Five soil samples were collected at locations HCL-01 through HCL-05 near the card lock fueling area. Sample HCL-01 was collected from a pipe trench near the laboratory for the card lock fueling area. Sample HCL-02 was collected from a soil stockpile generated during trench excavation. Sample HCL-03 was collected from a caisson hole near the south corner of the card lock fueling area awning. Samples HCL-04 and HCL-05 were collected in the area where an oil-water separator was installed. The samples were collected at depths ranging from 1.5- to 6-feet bgs.

The samples were analyzed for TPH and PCBs. Appendix G contains the laboratory analytical results, field notes and soil sample location map provided by CEC.

3.1.5 2006 Heron Lakes Golf Courses Water Quality Sampling

According to J. Goodling, the COP Parks Department collects water samples from Force Lake, just before it discharges into the culverts that connect it to North Lake, and Southwestern Slough where it exits the southern boundary of the Heron Lakes Golf Courses, to compare the quality of surface water entering and leaving the Heron Lakes Golf Courses. Samples have been collected twice per year since 2001, and are analyzed for indicators of nutrient runoff and pesticides that had been applied to the golf course during the prior six months. The most recent sampling results provided by J. Goodling were for samples collected on October 10, 2006. Table 1 summarizes the analytical results for the water samples collected from Force Lake, including field parameters measured during sample collection.

The only pesticide that has been detected in Force Lake since 2001 is Clopyralid (Confront) (0.42 ug/L on October 20, 2003).

3.2 Known and Suspected Sources

3.2.1 On-Facility Sources

Based on the historical information the following are known or potential sources located on the facility:

- Former “C” shaped area
- Former unlined oil-water separator pond
- Former tank located in the “C” shaped area
- Former tanker and cattle truck cleaning “work area”, former concrete pad, and former tanker truck cleaning operation (Detrex system)¹¹
- Existing stormwater treatment system
- Tank 23
- Tank farm and used oil processing area
- Soil berm along the northwest and southwest sides of the Harbor Oil facility
- Soil stockpile generated during new base-oil refining plant construction
- Former drainage ditch along northeast and northwest sides of the Harbor Oil facility

Figure 10 illustrates where prior soil samples have been collected in relation to the location of these source areas.

The card lock fueling area and office/shop/warehouse are not considered to be potential sources. The card locking fueling area is a relatively recent operation with secondary containment around the fuel tanks. According to D. Coles (August 15, 2007 personal communication) it was constructed in approximately 2003. Similarly, the bio-diesel operation in the office/shop/warehouse did not start operating until 2006.

The containment area for Tanks 25 through 31 is part of the new base-oil plant that was constructed in 2003. It is also not considered to be a potential source. The PCBs and TPH detected in this area are not associated with Tanks 25 through 31. CEC collected these samples

¹¹ Note that the Detrex system consisted of a TCE distillation unit and storage tank. The available file information indicates that the storage tank was an aboveground storage tank (AST), and that the distillation unit and storage tank were located immediately east of the curtain drain on a raised concrete pad located in the same area as the former concrete pad. No underground storage tanks or piping were associated with this system.

before the new base-oil plant was constructed. As Section 3.1.4 discusses, CEC collected eleven subsurface soil samples in this area, of which only two samples contained detectable concentrations of PCBs and TPH (see Figure 12).

The former water treatment system that was located in Building 5 was a small aboveground tank where treatment occurred through flocculation. This treatment system started operating in 1985. According to D. Coles (November 16, 2007 email), the treatment system was located inside Building 5 on a concrete floor surrounded by a containment berm and was only used briefly by EMRI after it took over operations. Therefore, it is highly unlikely that releases to underlying soil occurred from the former water treatment system.

A number of soil samples have been collected in the former "C" shaped area, including J-500, DP02, SS05, J-475, J-475A, HC-01, HC-02 and HC-03. The surface and subsurface soil samples collected at location DP02 are the only samples that were analyzed in a fixed laboratory for a broad range of constituents.

Samples J-475 and J-475A were also collected in the area where the former oil-water separator pond was located. The subsurface soil samples collected at these two locations were only analyzed in the field screening laboratory.

Soil samples J-475A, L-500 and DP02 were collected next to or near the current stormwater treatment system. The surface and subsurface soil samples collected at location DP02 are the only samples that were analyzed in a fixed laboratory for a broad range of constituents.

Four soil samples were collected in the general area of the former tanker truck cleaning operation: SS02, SS03, J-300 and HCL-02. With the exception of the sample collected at HCL-02, these samples were analyzed in a fixed laboratory for a broad range of constituents.

No soil samples have been collected beneath or near Tank 23.

Soil samples collected at HC-12, HC-13 and HC-24 were collected near the tank farm and used oil processing area. These samples were only analyzed for TPH and PCBs.

It is unclear from the sampling approach described in Golder (1990) or E&E (2001) whether the samples collected along the northwest and southwest sides of the Harbor Oil facility were from the soil berm. If so, the only samples that were analyzed in a fixed laboratory for a broad range of constituents were surface soil samples GAI-SS3, SS06, SS07 and SS08.

Finally, although CEC collected samples from the sides and bottom of the excavation prior to constructing the new base-oil refining plant, no samples have been collected from the soil stockpile.

3.2.2 Off-Facility Sources

There are a number of potential off-site sources to the Harbor Oil facility, the wetlands northwest and southwest of the facility, and Force Lake. As was discussed in Section 2, industrial properties to the north and northeast, within sub-basin A-7, (e.g., Peninsula Terminal Railroad and Former Farmer's Plant Aide/Former Limex Transportation/Bulk Transport facility) are located on or to the south of the topographic divide that forms the northeast boundary of the sub-basin. Stormwater runoff from these properties flows to the southwest and west towards the Harbor Oil facility, the wetlands, and Force Lake.

Force Lake not only receives runoff from sub-basin A-7, which includes the Harbor Oil facility, it also receives runoff and subsurface drainage from a portion of the Heron Lakes Greenback Golf Course. The Greenback Golf Course also drains to North Lake and the North Drainageway.

Vanport City was located immediately south of Force Lake prior to the 1948 flood.

Finally, as was discussed in Section 2, shallow groundwater beneath the Peninsula Terminal Railroad, Former Farmer's Plant Aide/Former Limex Transportation/Bulk Transport facility, and portions of the former Stockyards and Star Oil properties flows to the southwest toward the Harbor Oil facility, the wetlands, and Force Lake (see Figure 6-4 in Appendix E).

The following summarizes information for potential sources located off the facility. Figure 3 illustrates where these potential source areas are or were located.

Note that in 1989 and 1990, Golder collected samples from the James River Corp. Well, Exposition Center production well, and Vanport City Wells No. 5 and 6 (Golder 1991a). TCE concentrations ranged from 7.1 to 20 ug/L, with the highest concentration detected in Vanport City Well No. 5 (see Figure 6). PCE concentrations ranged from less than 1 ug/L to 20 ug/L, with the highest concentration detected in the James River Corp. Well. Golder concluded that TCE and PCE contamination in deep groundwater is widespread in the area, but did not identify any potential source or source(s) located off the facility.

3.2.2.1 Heron Lakes Golf Courses

According to J. Goodling (personal communication with S. Brown on June 29, 2007), the Greenback Golf Course was constructed in 1969 and 1970. The Pen 1 NRMP states that the COP occasionally used pesticides at the Heron Lakes Golf Courses; the specific pesticides used by the COP were not identified. As was discussed above, regular monitoring of water quality only started in 2001 and is focused only on constituents associated with the fertilizer and herbicides applied during the prior six months.

In addition, the COP used the area to the southwest of the Greenback Golf Course, where the front nine of the Great Blue Golf Course is

located, to store fill material until 1992 when the front nine of the Great Blue Golf Course was constructed. The COP police department horse barn was also located in that area.

3.2.2.2 Former Vanport Townsite

Vanport City, a large public housing project, was constructed in 1942 to house workers for shipyards located in Portland and Vancouver, Washington. It was built on 650 acres of marshy pasture, slough, and truck farms near the Columbia Slough. Vanport City included almost 10,000 housing units, 700 apartment buildings and 45 special public aid service buildings. By late 1943, it housed nearly 40,000 people.

Information at <http://www.ccrh.org/comm/slough/primary/lifeatvp.htm> "Document: Chapter Two, 'Life in Vanport.' Vanport. Manly Maben. Portland: Oregon Historical Society Press, 22-31" indicates that residents frequently complained of bedbugs and cockroaches, and that DDT was used at a rate of one pint per apartment with "excellent results."

Information at <http://www.supercarsunlimited.com/pirbrackets/history/vanport/vanport.htm> includes a map showing that housing units were located along the south side of Force Lake. On Memorial Day 1948, floodwaters from the Columbia River breached a railroad dike along the western side of Vanport City destroying the town. The flood could have transported soils containing DDT into Force Lake and the wetlands, and potentially onto the Harbor Oil facility.

3.2.2.3 Former Farmer's Plant Aid Site

The former Farmer's Plant Aid facility was located immediately north and uphill of the Site. According to Golder (1990), a building and piles of unknown materials were located there in 1948. Golder suspects that the materials may have been coal that was unloaded and stockpiled at the end of the railroad spur that ran parallel to N. Force Avenue; the spur was dismantled by 1952. CEC (2002) states that the materials may have been manure from the Stockyards. By 1956, a large shed was located on the former Farmer's Plant Aid facility and piles of unknown materials were present to the south of the shed, near the northern boundary of the Harbor Oil facility.

Since at least the 1970s, a commercial fertilizer plant (J.W. Fertilizer) operated on the property. The operation stored and used manure from the Stockyards. They processed and sold soil additives, composted materials, and manure. In the mid-1970s, runoff from the manure piles to Force Lake prompted DEQ to require the facility to improve its handling of surface water runoff; this resulted in the construction of a stormwater retention pond that was located immediately north of Tank 23 and the tank farm. Prior to this, stormwater would have gone through the drainage ditch visible in 1972 aerial photograph to the wetlands. The retention pond was filled by 1987 and the property was occupied by a lumberyard and barkdust mulching facility. According to CEC (2002), the lumberyard and bark mulching business left the property in 1990.

No underground storage tanks (USTs) were located on the property; a diesel AST was located there.

Concrete was disposed on the northwest portion of the Former Farmer's Plant Aide property from the 1960s to the 1980s, and encroached into wetlands to the west. It is uncertain what, if any, other fill material were placed there.

The Farmer's Plant Aid operation moved to another location in 1990.

By 1991, a concrete retaining wall had been constructed along southern boundary of the Former Farmer's Plant Aide property. The construction of the retaining wall and filling of the retention pond increased the elevation of the property above the Harbor Oil facility.

The former Farmer's Plant Aid facility was occupied by Limex Transportation and is now occupied by Bulk Transport. As was discussed in Section 2.3.5, a 1995 Limex Transportation diesel release from an AST flowed into the drainage ditch.

3.2.2.4 Stockyards

The Portland Union Stockyards were built around 1910. In the 1920s and 1930s, additional pens, sheds and other structures were added. Additional pens were constructed later and then removed around 1970.

In the early 1990s, the Portland Livestock Auction Co. occupied and maintained the Stockyards facilities which consisted of livestock pens, an attached complex of covered pens, a hay barn, auction hall, and livestock receiving area. Livestock water came from a deep production well located south of the Exchange Building and was pumped at a rate of 500 gpm. Well pumping started in 1979. Golder (1990) states that one UST was suspected to be located east of the Portland Livestock Auction Co. office.

According to CEC (2002), the Stockyards were closed in 1988.

3.2.2.5 Peninsula Terminal Railroad

The railroad located north of Former Farmer's Plant Aid facility was constructed sometime before 1917 (Golder 1990). Railroad activity included off-loading chemicals, cattle, and coal. In 1948, a rail spur extended to the south parallel to N. Force Avenue. In the early 1990s, the railroad served primarily as a switching yard and serviced several industrial operations bordering the tracks to the west. Materials transported through the switching yard possibly included industrial solvents, acids, plastics, ether, "cleaning material" and latexes. Black residue from an iron ore plant was placed along the sloped area immediately south of the railroad tracks. The switching yard included a Locomotive House for engine repair. A floor drain in the Locomotive House drained to an unknown location. A 12,500-gallon waste-oil tank was located adjacent to the locomotive house; a smaller AST fuel tank was located there in about 1990.

A 1994 DEQ File Review Memorandum for the Peninsula Terminal Railroad site (DEQ 1994a), indicates that in addition to off-loading and switching, the site was used to transload (loading chemicals and chemical products from rail cars into tanker trucks). Solvents (toluene, acetone, and xylenes), petroleum, and paint products were transloaded. Spills (up to 50 gallons in size) were observed in 1990 according to DEQ. PCE (1.2 ug/L) and TCE (0.3 ug/L) were detected in groundwater near the Locomotive House, where locomotive engines were repaired, during the 1988 SE/E environmental audit (SE/E 1988). A soil sample collected from the east end of the tracks where tank cars were parked contained methyl isobutyl ketone, PCE, toluene, and 1,1,1-TCA. During the Golder (1990) site assessment, TCE (6 ug/L), PCE (6 ug/L) and TCA (2 ug/L) were detected in shallow groundwater. Soil samples collected as part of this investigation contained acetone, 2-butanone, benzene, toluene, xylenes, PCE, TPH, and polynuclear aromatic hydrocarbons (PAHs). A sample of the black residue contained lead (235 mg/kg), chromium (104 mg/kg), and barium (1,220 mg/kg).

According to DEQ's ECSI site summary report for the Peninsula Terminal Railroad site, DEQ issued a no further action (NFA) for this site in 1996.

3.2.2.6 Star Oil

During the early 1990s, Star Oil operated a card-lock fueling facility immediately north of the Peninsula Terminal Railroad tracks on the west side of N. Force Avenue. Two USTs were installed in approximately 1975 (Golder 1990).

3.3 Preliminary Constituents of Potential Concern

Preliminary Constituents of Potential Concern (COPCs) were identified by screening the available fixed laboratory analytical results against relatively conservative human health and ecological screening levels. The results of this screening were also used to identify the analyte list for soil, wetland soil, surface water, sediment and groundwater samples that will be collected during Phase 1 of the RI. Based on this screening, the following preliminary COPCs and target analytes were identified where detected concentrations exceeded human health or ecological screening levels:

- Gasoline-, diesel- and oil-range petroleum hydrocarbons
- Metals (antimony, arsenic, barium, cadmium, cobalt, copper, chromium, lead, mercury, nickel, selenium, vanadium and zinc)¹²
- SVOCs, including PAHs
- VOCs

¹² Crustal elements (i.e., aluminum, iron, and manganese) were not included as preliminary COPCs, as these are naturally occurring elements and there are no known or suspected Site-related sources.

- PCBs
- Pesticides

Dioxins/furans are not considered to be COPCs for a number of reasons. First, according to EPA's 1980 Site Inspection (see Section 2.3.5.1), Chempro did not accept or handle PCBs at the Harbor Oil facility; this inspection was conducted in February 1980, several months after the October 1979 fire. Second, according to members of the Voluntary Group, materials containing PCBs were not sent to the Harbor Oil facility until the 1980s, after Toxic Substance Control Act (TSCA) regulations that phased out certain uses of PCBs went into effect in 1979. Thus, there is no information to support that PCBs were present at the time of the fire.

Tables 2 and 3 summarize the human health and ecological screening results, respectively. The following subsections provide a detailed discussion of the media-specific (soil, wetland soil, surface water, sediment and groundwater) screening levels that were used and screening results for each media, including tables summarizing screening results for constituents detected in each media using fixed analytical laboratory analytical methods. Appendix H contains tables summarizing the complete laboratory analytical results by media, including screening level laboratory analyses.

Site data will ultimately be compared to regional background levels, as appropriate, as part of the RI.

The human health and ecological screening discussed below is based on the same set of screening levels that were used to establish analytical concentration goals (ACGs), as described in Attachment B2 in the QAPP. However, there were several differences in how the screening levels were applied. First, the analytical results for soil samples collected on the facility were compared to the lowest of the industrial soil screening levels (based on the current and likely future land use for the facility) and analytical results for soils off the facility were compared to the lowest of the residential screening levels in the screening analysis discussed below, instead of using the lowest residential screening levels only, as was done in establishing the ACGs. Second, residential soil screening levels for exposure through soil ingestion, dermal contact, and inhalation were compared to lake sediment analytical results in the screening analysis discussed below, instead of using the lowest of all the residential screening levels, including those for leaching to groundwater, to establish ACGs. Finally, the groundwater analytical results were compared to screening levels for exposure to tap water, volatilization to outdoor air, vapor intrusion to buildings, and groundwater in an excavation in the screening analysis discussed below, instead of the broader range of water screening levels, including Ambient Water Quality Criteria (AWQC), that were used to establish ACGs. As will be discussed below, the ecological risk assessment will include a comparison of groundwater data with AWQCs as part of the evaluation of risks to aquatic receptors associated with shallow groundwater discharge to Force Lake.

3.3.1 Soil Screening Results

Available fixed laboratory analytical data found in Golder (1990), E&E (2001), and CEC (2002 and 2007b) for surface and subsurface soil samples collected on the facility were compared to the lowest of the following human health and ecological screening levels:

- EPA Region 6 human health screening levels for industrial soils (EPA 2007). Screening levels for non-carcinogenic chemicals were adjusted to be protective of a hazard quotient (HQ) of 0.1 to account for cumulative risks.¹³ Screening levels for carcinogenic chemicals were not adjusted.
- DEQ risk-based concentrations (RBCs) for occupational, construction worker and excavation worker exposure through soil ingestion, dermal contact, and inhalation; occupational worker exposure through volatilization to outdoor air and vapor intrusion into buildings; and occupational worker exposure through leaching to groundwater (DEQ 2007). RBCs for non-carcinogenic chemicals were adjusted to be protective of an HQ of 0.1 to account for cumulative risks, except for those chemicals where DEQ based on the screening level on a saturation concentration or maximum value. RBCs for carcinogenic chemicals were not adjusted.
- EPA Ecological Soil Screening Levels (SSL) at <http://www.epa.gov/oswer/riskassessment/ecorisk/ecossl.htm>
- Oakridge National Laboratory soil data for invertebrates and plants (Efroymson et al. 1997a and 1997b).
- DEQ soil screening level values for wildlife (DEQ 2001b).

Industrial and occupational worker soil screening levels were selected for comparison because the current and likely future land use for the facility is industrial, as is discussed in Section 3.8.¹⁴

Tables 4 through 7 present the surface soil screening results for TPH and metals; VOCs; SVOCs; and PCBs and pesticides, respectively. Tables 8 through 11 present the subsurface soil screening results for TPH and metals; VOCs; SVOCs; and PCBs and pesticides, respectively.

As Tables 4 and 8 indicate, TPH is mainly present on the facility as diesel- and oil-range petroleum hydrocarbons; gasoline-range petroleum hydrocarbons were only detected in four surface soil samples (DP01, DP02, SS05 and SS09)¹⁵. Diesel- or oil-range petroleum hydrocarbons were detected at concentrations exceeding relevant human health screening levels only in subsurface soils at sampling locations HC-04 and

¹³ Region 6 and DEQ soil screening levels for human health are protective of an HQ of 1.0.

¹⁴ Note: As requested by EPA, the human health risk assessment will include a screening-level assessment of human health risks assuming a hypothetical future residential use of the facility.

¹⁵ Note that most of the "surface" soil samples collected at the site were collected below the existing gravel fill layer at depths of 1 to 1.5 or 1 to 2 feet bgs.

HC-07 in the northern portion of the area where the new base-oil refining plant was constructed.

Arsenic is the only metal detected in surface and subsurface soils above its industrial/occupational human health screening levels (see Tables 4 and 8, Figures 11 and 12). Aluminum, arsenic, barium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, vanadium and zinc were detected in surface soils at concentrations exceeding their ecological screening levels; aluminum, arsenic, cadmium, copper, iron, lead, manganese, vanadium and zinc were detected at concentrations exceeding their ecological screening levels in subsurface soils. Although this comparison is not being made at this time, it is important to note that some of the metals concentrations detected in soils are comparable to or less than regional background levels (DEQ 2002; Table 12).

VOCs detected in soil samples collected on the facility included benzene, (1-methylethyl)-benzene, 2-butanone, n-butylbenzene, sec-butylbenzene, chlorobenzene, cyclohexane, methyl-cyclohexane, 1,2-DCB, 1,3-DCB, 1,4-DCB, ethylbenzene, p-isopropyltoluene, naphthalene, cis-1,2-DCE, methyl tert-butyl ether (MTBE), naphthalene, n-propylbenzene, PCE, toluene, TCE, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, o-xylene, and m,p-xylene (Tables 5 and 9). Naphthalene, TCE, PCE and 1,3,5-trimethylbenzene were the only VOCs detected above their industrial/occupational human health screening levels and only in the split surface soil sample collected by CEC at SS05 (Figure 11). Note that TCE and PCE concentrations were below screening levels in the sample collected by E&E at location SS05. No VOCs were detected at concentrations exceeding their ecological screening levels.

Acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzaldehyde, benzo(g,h,i)perylene, benzo(k)fluoranthene, 1,1-biphenyl, butyl benzyl phthalate, 9H-carbazole, chrysene, di-n-butyl phthalate, dibenzo(a,h)anthracene, dibenzofuran, diethyl phthalate, 2,4-dimethylphenol, bis(2-ethylhexyl)phthalate, 1-phenyl-ethanone, fluoranthene, 9H-fluorene, indeno(1,2,3-cd)pyrene, isophorone, 2-methylnaphthalene, 2-methylphenol, 4-methylphenol, naphthalene, phenanthrene, phenol, and pyrene were detected in soils on the facility (Tables 6 and 10). Of these compounds, benzo(a)pyrene was detected above its industrial/occupational human health screening levels in the surface soil samples collected at locations DP01, SS02 and SS05 (Figure 11). Dibenzo(a,h)anthracene was detected above its industrial/occupational human health screening levels in the surface soil sample collected at location SS02. Naphthalene was detected above its industrial/occupational human health screening levels in the surface soils sample collected at location SS05. Dibenzofuran was detected at concentrations exceeding its ecological screening level in a number of surface soil samples and the subsurface sample collected at DP01. Bis(2-ethylhexyl)phthalate was detected at a concentration exceeding its ecological screening level in the surface sample collected at SS05.

Aroclor 1248, Aroclor 1254 and Aroclor 1260 were detected in surface soil samples; Aroclor 1248 and Aroclor 1260 were detected in subsurface

soils (Tables 7 and 11). The detected PCB concentrations exceeded their industrial/occupational human health screening levels in surface soils at locations SS01, SS02 and SS08 (Figure 11), and in subsurface soil samples HC-04 (5.0 feet bgs) and HC-07 (4.5 feet bgs) (Figure 12). Aroclor 1254 was detected at a concentration exceeding its ecological screening level in the split surface soil sample collected by CEC at location SS02. Note that Aroclor 1254 was not detected in the sample collected by E&E at this location.

Finally, endrin, DDD, DDE and DDT were detected in surface soil samples; DDD, DDE and DDT were detected in subsurface soil samples (Tables 7 and 11). DDD concentrations detected in the surface soil samples collected at DP01, DP02, SS02, SS05, and SS08 exceeded their industrial/occupational human health screen levels, as did the DDT concentration detected in the surface soil sample collected at DP01 (Figure 11). DDD, DDE and DDT concentrations detected in subsurface soil samples did not exceed their human health screening levels. DDD, DDE and DDT were detected at concentrations exceeding their ecological screening levels in several surface soil samples; DDD and/or DDE were detected above their ecological screening levels in the subsurface samples collected at DP01 (2 to 6 feet bgs) and DP02 (4 to 8 feet bgs).

3.3.2 Wetland Soil Screening Results

Available fixed laboratory analytical data found in E&E (2001) and CEC (2002) for wetland soil samples were compared to the lowest of the following human health and ecologic screening levels:

- EPA Region 6 human health screening levels for residential soils (EPA 2007). Screening levels for non-carcinogenic chemicals were adjusted to be protective of an HQ of 0.1 to account for cumulative risks.¹⁶ Screening levels for carcinogenic chemicals were not adjusted.
- DEQ RBCs for residential exposure through soil ingestion, dermal contact, and inhalation; residential exposure through volatilization to outdoor air and vapor intrusion into buildings; and residential exposure through leaching to groundwater (DEQ 2007). RBCs for non-carcinogenic soil thresholds were adjusted to be protective of an HQ of 0.1 to account for cumulative risks, except for those chemicals where DEQ based on the screening level on a saturation concentration or maximum value. RBCs for carcinogenic chemicals were not adjusted.
- EPA Ecological Soil Screening Levels (SSL) at <http://www.epa.gov/oswer/riskassessment/ecorisk/ecossl.htm>
- Oakridge National Laboratory soil data for invertebrates and plants (Efroymson et al. 1997a and 1997b).
- DEQ soil screening level values for wildlife (DEQ 2001b).

¹⁶ Region 6 and DEQ soil thresholds for human health are protective of an HQ of 1.0.

Residential soil screening levels were selected for comparison not because the wetlands are likely to be developed for residential purposes, but because they are not zoned for industrial use.

As Table 13 indicates, TPH is only present in wetland soils as diesel- and oil-range petroleum hydrocarbons; gasoline-range petroleum hydrocarbons were not detected in any of the wetland soil samples. Oil-range petroleum hydrocarbons were detected at concentrations exceeding relevant human health screening levels in the samples collected at locations WL01, WL02 and WL05 (Figure 13).

Aluminum (WL01 through WL04); arsenic, iron and manganese (BG02, and WL01 through WL05); and vanadium (WL01, WL02 and WL04) were detected in wetland soils above their residential human health screening levels (see Table 13 and Figure 13). Antimony (WL01), arsenic (WL01 and WL03), cadmium (WL01, WL02, WL04 and WL05), chromium (WL01 and WL02), cobalt (WL01 and WL02), copper (WL01, WL02 and WL05), lead (WL01 through WL05), mercury (WL01, WL02 and WL05), nickel (WL01), selenium (WL01), vanadium (BG02 and WL01 through WL05), and zinc (BG02 and WL01 through WL05) were detected at concentrations exceeding their ecological screening levels. Although this comparison is not being made at this time, it is important to note that some of the metals concentrations detected in wetland soils are comparable to or less than regional background levels (DEQ 2002; Table 12).

No VOCs were detected in any of the wetland soil samples.

Acenaphthylene, anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzaldehyde, 1,1-biphenyl, butyl benzyl phthalate, chrysene, dibenzofuran, 2,4-dimethylphenol, bis(2-ethylhexyl)phthalate, 1-phenyl-ethanone, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, 2-methylnaphthalene, naphthalene, 2-nitroaniline, phenanthrene, phenol, and pyrene were detected in wetland soils (Table 14). Of these compounds, benzo(a)pyrene and indeno(1,2,3-cd)pyrene were detected above their residential human health screening levels in the samples collected at locations WL01 and WL02 (Figure 13). Benzo(b)fluoranthene was detected above its residential human health screening levels at location WL01. Naphthalene was detected above its human health screening levels at WL01, WL02 and WL05. Dibenzofuran was detected above its ecological screening level in sample WL01.

Aroclor 1260 was detected in three wetland soil samples (WL01, WL02 and WL05), all at concentrations exceeding residential human health screening levels for Aroclor 1260 (Table 15 and Figure 13).

Finally, methoxychlor, DDD, DDE and DDT were detected in wetland soil samples (Table 15 and Figure 13). None of these pesticides were detected at concentrations exceeding their residential human health screening levels. The DDD, DDE and/or DDT concentrations detected in samples WL01, WL02, WL03 and WL05 exceed their ecological screening levels.

3.3.3 Surface Water Screening Results

Other than the semi-annual surface water sampling conducted by the COP for nutrients and selected pesticides, the only fixed laboratory analytical surface water data for Force Lake are the sample collected in 1997 (COP 1997). The 1997 surface water sample was analyzed for general chemistry, ammonia, total solids, total dissolved solids, total suspended solids, total coliform, chemical oxygen demand, biological oxygen demand, total organic carbon, oil and grease, VOCs, metals, pesticides, PCBs, herbicides, and SVOCs. The data were compared to the lowest of the following human health and ecologic screening levels:

- EPA National Recommended Water Quality Criteria, human health for consumption of water and organisms and for consumption of organisms only (EPA 2006b).
- EPA National Recommended Water Quality Criteria for chronic criteria for freshwater organisms (EPA 2006b).
- Tier II screening levels in Suter and Tsao (1996).

TPH was not detected in the only surface water sample that has been collected from Force Lake.

Copper, iron, lead and zinc were detected in the water sample collected by the COP (Table 16). The detected iron concentration exceeds its ambient water quality criteria (AWQC) for human consumption of water and organisms. The copper and lead concentrations exceed their ecological screening levels.

No VOCs, SVOCs or PCBs were detected in the COP water sample.

Lindane was the only pesticide that was detected; no herbicides were detected (Table 17). The Lindane concentration did not exceed its human health or ecological screening levels.

3.3.4 Sediment Screening Results

Available fixed laboratory analytical data found in COP (1997) for the one composite sediment sample collected from Force Lake were compared to the lowest EPA Region 6 human health screening levels for residential soils; DEQ risk-based concentrations for residential exposure through soil ingestion, dermal contact, and inhalation; and MacDonald et al. (2000) Threshold Effects Concentrations (TECs). RBCs for non-carcinogenic soil thresholds were adjusted to be protective of an HQ of 0.1 to account for cumulative risks, except for those chemicals where DEQ based on the screening level on a saturation concentration or maximum value. No human health screening levels are available for sediments.

As Table 18 indicates, TPH was detected in the one sediment sample that has been collected from Force Lake.

Arsenic, chromium, copper, iron, lead, nickel and zinc were detected in the sediment sample collected by the COP (Table 18). Arsenic, iron and lead were detected at concentrations exceeding their respective

residential soil screening levels. Copper, lead and zinc were all detected at concentrations exceeding their respective TECs.

No VOCs, SVOCs or PCBs were detected in the COP sediment sample.

DDD was the only pesticide that was detected; no herbicides were detected (Table 19). The DDD concentration detected in the Force Lake sediment sample exceeded its TEC, but not its residential soil screening levels.

3.3.5 Groundwater Screening Results

Available fixed laboratory analytical data found in Golder (1990), E&E (2001) and CEC (2002) for groundwater samples collected on the facility were compared to the lowest of the following human health screening levels:

- EPA Region 6 residential tap water screening levels (EPA 2007). Screening levels for non-carcinogenic chemicals soil thresholds were adjusted to be protective of an HQ of 0.1 to account for cumulative risks.¹⁷ Screening levels for carcinogenic chemicals were not adjusted.
- DEQ RBCs for occupational exposure through volatilization to outdoor air and vapor intrusion into buildings; and construction and excavation worker exposure to groundwater (DEQ 2007). RBCs for non-carcinogenic chemicals were adjusted to be protective of an HQ of 0.1 to account for cumulative risks, except for those chemicals where DEQ based on the RBC on a saturation concentration or maximum value. RBCs for carcinogenic chemicals were not adjusted.

Note that as part of the ecological risk assessment, risks to aquatic receptors via exposure to shallow groundwater discharging into Force Lake will be evaluated by comparing AWQC to chemical concentrations detected in shallow groundwater wells nearest to the lake and in Force Lake surface water.

As Table 20 indicates, TPH has been detected as gasoline-, diesel-, and oil-range petroleum hydrocarbons in groundwater samples collected on the facility. None of the detected concentrations exceed their occupational/construction/excavation worker screening levels.

Aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, sodium, thallium, vanadium, and zinc have been detected in groundwater samples collected on the facility (Table 20). Aluminum, antimony, arsenic, iron, lead, manganese, vanadium, and zinc concentrations in groundwater samples collected from one or more of the following wells exceeded their tap water screening levels: GA29, GA33, GA34, A-18, A-19, A-20, B-4 and the plant well (Figure 14).

¹⁷ Region 6 and DEQ soil thresholds for human health are protective of an HQ of 1.0.

Chlorobenzene, ethenylbenzene, (1-methylethyl)-benzene, 1,2-DCB, 1,3-DCB, 1,4-DCB, cis-1,2-DCE, 1,2-dichloropropane, 2-propanone, PCE, toluene, 1,1,1-TCA, TCE, and vinyl chloride were detected in groundwater (Table 21). Chlorobenzene and vinyl chloride were detected above their tap water screening levels in monitoring well GA-34 (Figure 14). Chlorobenzene was detected above its tap water screening level in monitoring well A20. PCE and TCE were detected above their tap water screening levels in the plant well. None of the detected VOC concentrations exceeded their DEQ RBCs.

Acenaphthene, benzaldehyde, 2-chlorophenol, di-n-butyl phthalate, diethyl phthalate, bis(2-ethylhexyl)phthalate, 1-phenyl-ethanone, fluoranthene, fluorene, phenol, and pyrene were detected in groundwater, but not at concentrations exceeding their tap water screening levels and DEQ risk-based concentrations for occupational/construction/excavation worker exposure to groundwater (Table 22).

No PCBs were detected in groundwater (Table 23).

DDD was the only pesticide detected in groundwater (Table 23). It was not detected at a concentration exceeding its tap water screening level and DEQ risk-based concentration for construction/excavation worker exposure to groundwater.

3.4 Areas of Potential Concern

Based on the preliminary COPC screening presented above and facility history discussed in Section 2, the following are areas of potential concern for the facility:

- West-central portion of the Harbor Oil facility where the former “C” shaped area, former unlined holding pond, and former tank were located
- Former tanker and cattle truck cleaning “work area”, former concrete pad, and former tanker truck cleaning operation
- Existing stormwater treatment system
- Tank farm and used oil processing area
- Tank 23
- Soil berm along the northwest and southwest sides of the Harbor Oil facility
- North side of the area where the new base-oil refining plant was constructed
- Soil stockpile generated during new base-oil refining plant construction
- Former drainage ditch along northeast and northwest sides of the Harbor Oil facility

- Wetland areas that received releases from the drainage ditch, existing stormwater treatment system (current and former discharge locations), former cattle and tanker truck cleaning operation, and the 1979 fire
- Force Lake and, potentially, downstream surface water bodies

3.5 Transport Mechanisms

Based on the information in Section 2, the following summarizes hydrogeologic and hydrology conditions at and near the Harbor Oil facility.

A shallow saturated zone (15 to 20 feet bgs) that is characterized by:

- Relatively high hydraulic conductivity sands,
- Groundwater levels that are not affected by tides or seasonal changes in Columbia River level,
- An east-west trending hydraulic divide north of the railroad tracks that creates a southward gradient in the vicinity of the Harbor Oil facility, and
- Downward leakage into the intermediate zone.

An intermediate saturated zone (between 15 to 20 and approximately 90 feet bgs) that is characterized by:

- Relatively lower hydraulic conductivity interbedded silts and fine sands,
- Groundwater levels that are affected by tides and seasonal changes in Columbia River level, and
- Relatively lower magnitude gradients and pore velocities.

A deep saturated zone (greater than about 90 feet bgs) that is characterized by:

- Relatively high hydraulic conductivity gravels,
- Groundwater levels that are affected by tides and seasonal changes in Columbia River level,
- Relatively lower magnitude gradients, and
- A flow direction that is northward during periods of low flow in the Columbia River and southward during periods of high flow in the Columbia River.

A surface water regime that is characterized by:

- Surface runoff to the wetlands and Force Lake;
- Shallow groundwater discharge to Force Lake;
- Accumulation of water in Force Lake until it reaches an elevation that exceeds the invert of the pipes that drain into North Lake (water typically only flows from Force Lake into North Lake during the wet season); and

- Sediment deposition and accumulation in Force Lake.

Potential mechanisms that have acted or could act to transport constituents along various migration pathways include:

- Vertical migration of dissolved phase constituents through the unsaturated zone to the shallow saturated zone due to rainfall infiltration and percolation.
- Horizontal migration in the shallow saturated zone via advection and dispersion.
- Vertical migration via advection and dispersion from the shallow saturated zone to the intermediate and, potentially, deep saturated zones.
- Vertical and horizontal migration in the unsaturated zone due to volatilization of VOCs in the unsaturated zone and from the shallow saturated zone.
- Horizontal and vertical migration of light and dense non-aqueous phase liquids.
- Direct runoff, soil erosion and releases to the drainage ditch and wetlands.
- Discharges from the former holding pond and current stormwater treatment system to the drainage ditch and wetlands.
- Runoff from the properties to the northeast and north into the drainage ditch, and into the wetlands and Force Lake.
- Shallow groundwater migration toward the Harbor Oil facility and Force Lake from properties located to the north.
- Runoff, subsurface drainage and shallow groundwater flow from the Greenback Golf Course into Force Lake.
- Sediment deposition in Force Lake.
- Surface water flow out of Force Lake, during the wet season, into North Lake.

3.6 Human Receptors and Exposure Pathways

This section presents information supporting the selection of preliminary human health exposure scenarios. Various potentially exposed human populations and exposure pathways were evaluated for the preliminary conceptual site model (CSM) developed for this Work Plan.

The preliminary human health exposure scenarios presented in this section will be re-evaluated in the Risk Assessment Scoping Memorandum. The final human health scenarios will be presented in the Risk Assessment Scoping Memorandum to be evaluated in the Baseline Human Health Risk Assessment (HHRA).

3.6.1 Potential Exposure Pathways and Exposed Populations

The area being investigated for the HHRA (the Study Area) includes three general areas including the Harbor Oil facility itself, the adjacent wetlands to the northwest and southwest of the facility, and Force Lake.

Pathways of exposure to contamination within these areas were evaluated by media type, including soils (on the Harbor Oil facility and wetland soils), sediment in Force Lake, water (surface water in Force Lake and shallow groundwater), fish tissue, and air. The potential exposure pathways and exposed populations to these media are presented in the following subsections.

3.6.1.1 Direct Contact with Soil

According to D. Coles (August 15, 2007 personal communication), there are currently 20 to 30 workers at the Harbor Oil facility, including tenant employees. Soils present on the facility are mostly covered by a layer of packed gravel that is approximately 1 foot deep, which reduces the potential for workers on the facility to come into direct contact with soils. However, workers may come into direct contact with surface soils on the facility in a few areas of the facility without this gravel cap. Workers may also come into direct contact with soils episodically during construction or remediation work, when the soils are disturbed from digging or other activities. Thus, significant direct contact with soils is expected to occur only during construction or remediation work activities, not during a typical workday.

Beyond the immediate boundaries of the working area of the facility is an emergent/forested wetland (Figure 3). Potential access points to the wetlands include vehicle pullouts at Force Lake, lookout point near an ecological interpretive sign to the south of Force Lake, or from Heron Lakes Golf Courses. Entry into this area is not expected to be a common occurrence because of the presence of dense vegetation and soft soils in the wetland. In addition, Force Lake borders the narrow stretch of wetlands to the south of the Harbor Oil facility, preventing most public access to the southern wetland area. Human exposure to the wetland soils is possible on rare occasions (by the public walking in this area), but would be limited, even on rare occurrences, because shoes and clothing would act as an exposure barrier to contact with wetland soils.

No residential areas are currently located or planned within or near the wetland soils area and the Harbor Oil facility. Nevertheless, a hypothetical residential future use scenario will be evaluated as a screening assessment. This scenario will include the potential for exposure to wetland and facility soils.

3.6.1.2 Direct Contact with Water

Direct contact with water could occur through two main pathways, either through contact with Force Lake surface water during recreational activities or through direct contact with shallow groundwater.

Recreational opportunities, including activities such as bird-watching, remote-control boating, and fishing and present the potential for exposure to Force Lake surface water. Public access points to Force Lake are located on Force Avenue where there are several vehicle pullouts. There is also a lookout point with an ecological interpretative sign to the south of Force Lake next to Heron Lakes Golf Courses.

Force Lake is shallow, with depths ranging from approximately 2 to 6 feet and an average depth of 2.5 feet (Fishman 1989). Thus, exposure to surface water in Force Lake occurs simultaneously with exposure to lake sediments. Activities resulting in exposures to surface water include launching and course set-up activities by remote-control boat users, and retrieval of lost golf balls from Force Lake by golfers. Such exposure scenarios are expected to have a low frequency of exposure. Anglers may also come into contact with water in Force Lake when retrieving fishing lines or netting hooked fish; the frequency of this exposure is also expected to be low. Note that a sign has been posted in the lake to warn anglers of the potential risks of consuming fish caught in the lake. Swimming is not expected to occur at Force Lake because there are no beach areas, the water is very shallow, and the sediments in the lake are assumed to be soft based on its hydrology.

The groundwater table is very shallow on the facility and in its vicinity. Monitoring wells located on the facility show that the water level lies only a few inches to several feet below the ground surface in some locations. Exposure to shallow groundwater may occur during construction activities and potential remediation activities.

The source of drinking water at the Harbor Oil facility is provided by the COP. Most of the COP's municipal water is drawn from the Bull Run watershed, which lies approximately 27 miles east of the COP (Ecology and Environment 2001).

A production well was installed on the facility to provide a source of water for use in fire prevention (Ecology and Environment 2001).

There are no known current uses of groundwater as a source of drinking water on the Site. Drinking water ingestion of groundwater will, however, be considered as a potential future exposure pathway even though it is highly unlikely that shallow groundwater would ever be used as a source drinking water. The shallow saturated zone is susceptible to contamination from Harbor Oil facility operations, may contain elevated concentrations of naturally occurring constituents, and it has a relatively low yield. In addition, it may not be possible to construct a water supply well that is screened in the shallow groundwater zone that would meet State of Oregon Water Resources Department rules and regulations.

There are no known uses of surface water as a source of drinking water on the Site. No drinking water intakes have been associated with Force Lake (E&E 2001). Drinking water ingestion of surface water is not considered to be a future exposure pathway. Given the small size of Force Lake and limited inflows, this surface water body would never be developed as a source of drinking water.

3.6.1.3 Direct Contact with Lake Sediments

The potential for human exposure to Force Lake sediments is limited to recreational users. Remote-control boat users and golfers may also have limited potential for exposure to sediments in Force Lake while launching boats and setting up boating courses or when retrieving lost golf balls from the lake. Local anglers may come into contact with sediments while

retrieving fishing lines or netting captured fish. Such exposure scenarios are expected to have a low frequency of exposure.

3.6.1.4 Fish Ingestion

Recreational anglers (including adults and children) have the potential for exposure through ingestion of fish from Force Lake. Force Lake is less than 150 feet from the southern boundary of the Harbor Oil facility and the use of Force Lake for recreational fishing was confirmed in the EPA PA/SI (Ecology and Environment 2001).

In 1967, the Oregon Department of Fish and Wildlife (ODFW) restocked Force Lake with sunfish (bluegill and pumpkinseed) following chemical treatment of the lake to remove non-game fish, such as carp and goldfish (Fishman 1989). Fishman (1989) conducted a fisheries evaluation of Force Lake in August 1988 and March 1989, and characterized Force Lake as a self-sustaining bullhead fishery and stunted bluegill fishery. Bullhead, commonly referred to as “catfish” by local anglers, ranged from 55 to 260 millimeters (mm) in length in the survey, but have been reported to be up to 12 inches (approximately 3,700 mm) by local anglers (Fishman 1989). The lake was characterized as a stunted fishery for bluegill because of the fish’s small size. Carp were also identified in Force Lake during the fisheries evaluation; however, only four fish were collected over the two one-day surveys. The size range of the carp ranged from 300 to 457 mm. Exposure to chemicals via fish ingestion from recreational fishing is expected to have a low frequency of exposure.

A sign has been posted in the lake to warn anglers of the potential health risks to women and children consuming fish from the lake because of potential contamination within the lake.

3.6.1.5 Inhalation of Volatile Compounds

Because of the nature of the chemicals thought to be present at the Harbor Oil facility, the possibility exists for exposure to VOC vapors. VOCs could migrate from soil, sediment, and water into the air, where they could be inhaled. Outdoor exposure to certain VOCs could occur when the soils on the facility are disturbed, or when shallow groundwater is exposed, potentially during construction or remediation activities on the facility. Indoor exposure to VOCs via vapors from surface soils or shallow groundwater could occur to workers at the Harbor Oil facility working in buildings. Depending on the concentrations present, vapors may also arise from the wetland soils or from the water and sediments in Force Lake.

3.6.2 Preliminary Conceptual Site Model

Figure 15 presents the preliminary CSM for the various potential human health exposures. The preliminary CSM is a graphical representation of media, exposure scenarios, exposure pathways, and potentially exposed populations. It provides the basis for developing exposure scenarios to be evaluated in the exposure assessment component of the HHRA.

Each exposure scenario (e.g., industrial work on the facility) includes a potentially exposed population (e.g., workers on the facility), a potential exposure pathway to contaminated media (e.g., dermal contact; incidental ingestion), and a potential exposure route through which chemicals can enter the body of an exposed individual (e.g., dermal absorption of chemicals through exposed skin surfaces; gastrointestinal absorption of ingested chemicals), although the importance of some combinations of pathway and route is minor for some scenarios. Because of the low exposure potential through some of these pathways, not all pathways are proposed for quantitative analysis in the baseline HHRA.

For the preliminary CSM, complete exposure pathways were identified and populations that may be exposed through these pathways were determined to develop exposure scenarios. Risk assessment scenarios were not developed for incomplete or insignificant pathways.

Table 24 summarizes the scenarios and pathways that will be evaluated *quantitatively* (numerically) in the HHRA. These scenarios and exposure pathways include:

- **Force Lake Recreational user:** dermal contact with lake water, incidental ingestion of lake water, dermal contact with lake sediment, and incidental ingestion of lake sediment.
- **Industrial (construction/trenching) worker:** dermal contact with soil, incidental ingestion of soil, inhalation (outdoor) of volatiles from soil vapor, dermal contact with shallow groundwater, and inhalation (outdoor) of volatiles from shallow groundwater vapor.
- **Industrial/commercial worker:** inhalation (indoor) of volatiles from soil vapor and inhalation (indoor) of volatiles from shallow groundwater vapor.
- **Future hypothetical resident:** drinking water ingestion (via groundwater), dermal contact with and incidental ingestion of groundwater (i.e., via showering), dermal contact with and incidental ingestion of wetland soil, and dermal contact with and incidental ingestion of soil on the facility.

The Risk Assessment Scoping Memorandum will define the exposure parameters that will be used to estimate exposure concentrations for each of these scenarios.

According to EPA guidelines (1989), the scenarios should represent reasonable maximum exposure (RME) scenarios, thus ensuring that the results of the risk assessment are health protective. The scenarios identified to date are based on current uses of the Site. For the future hypothetical residential scenario, a screening-level analysis will be conducted in the HHRA to help inform EPA decisions regarding remedy selection.

3.7 Ecological Receptors and Exposure Pathways

This section presents information supporting the selection of preliminary ecological receptors of concern (ROCs) and the rationale for the species selected. Key exposure pathways are also identified to support the selection process and to develop the preliminary CSM developed for this Work Plan.

The preliminary ROCs and key exposure pathways will be re-evaluated in the Risk Assessment Scoping Memorandum. The receptors and pathways selected in the Risk Assessment Scoping Memorandum will be evaluated in the Baseline Ecological Risk Assessment (ERA).

3.7.1 Environmental Setting

The area to be investigated for the ERA (the Study Area) includes the Harbor Oil facility itself (where ecological exposure is assumed to be negligible), the adjacent wetlands, and Force Lake.

The COP Bureau of Planning (BOP) conducted a natural resources management plan in a 900 acre area called Pen 1 that includes the Harbor Oil facility, adjacent wetlands, and Force Lake (City of Portland 1997) (Figure 7). Pen 1 was designated within the larger Columbia River watershed located between the Columbia River and the Columbia Slough.

Three primary habitats were classified within Pen 1: emergent wetlands (marshes), open water sloughs, and forested wetlands (City of Portland 1997). A variety of plant species are found within these habitat areas. Black cottonwood trees are found within the emergent wetlands, forested wetlands, and near open water sloughs. These trees provide high quality wildlife habitat for nesting and foraging. Willows are also a dominate tree species found in the forested and emergent wetland habitat areas. Dense stands of Himalayan blackberry dominate the open water slough shrub community, while wetland habitats include a more diverse plant community including reed canary grass, soft rush, cattails, beggar's tick, sedges, soft stem bulrush, speedwell, and various species of grasses (City of Portland 1997).

A great blue heron rookery is located to the west of the Site at the edge of an emergent/forested wetland area. The heron rookery habitat supports various native emergent wetland plant species, including black cottonwood and willow trees, snowberry, cottonwood seedlings, and redosier dogwood (City of Portland 1997).

The Heron Lakes Golf Courses is located next to Force Lake and wetlands area. The golf course is recognized as a New York Audubon Certified Cooperative Sanctuary because they meet the basis criteria of wildlife enhancement and environmental planning (City of Portland 1997).

Approximately 1 mile of wetland frontage and approximately 40 acres of emergent wetlands are associated with Force Lake (DEQ 1995 as cited in E&E 2001). A narrow stretch of natural forested wetlands borders the

Harbor Oil facility to the south and west of the facility, providing habitat for wetland and terrestrial species. The large wetland area to the west of the facility is classified as an emergent wetland. The dominant plant species in this riparian/wetland area are reed canary grass, black cottonwood, and willow trees (City of Portland 1997).

Force Lake provides aquatic wildlife and fish habitat for various species. The surface area of the lake is about 12 acres with a diameter of 200 feet, and an estimated storage volume of about 30 acre-feet (City of Portland 1997). The depth of Force Lake is shallow ranging from approximately 2 to 6 feet, with an average depth of 2 to 3 feet (Fishman 1989). The vegetation at Force Lake is relatively homogenous, consisting of mostly reed canary grass and soft rush (City of Portland 1997). Force Lake drains through two culverts to North Lake which is connected to a series of ditches and other water bodies in the Pen 1 area.

3.7.2 Resources Potentially at Risk

A number of species use the habitat in the wetland areas adjacent to the Harbor Oil facility and in Force Lake. This section presents a summary of the available information documenting the use by these species. Species have been divided into six groups: invertebrates, fish, birds, mammals, plants, and amphibians.

3.7.2.1 Invertebrates

Both aquatic benthic invertebrates and terrestrial invertebrates are present in habitat areas adjacent to the facility. Aquatic invertebrates are prey to higher-trophic-level organisms (fish and invertivorous birds) in Force Lake and terrestrial invertebrates are prey to organisms such as foraging invertivorous mammals in the surrounding wetland habitat. There are no known studies that have investigated the invertebrate communities in Force Lake or in the wetlands adjacent to the Harbor Oil facility.

3.7.2.2 Fish

Limited data have been compiled on the species inhabiting Force Lake. Fishman (1989) conducted a fisheries evaluation of Force Lake in August 1988 and March 1989 through the use of electroshocking, beach seining, and traps. All of the fish identified in the Fishman (1989) survey were omnivorous benthic or benthopelagic fish, with the exception of mosquitofish, which prey primarily on invertebrates (Table 25).

More than 2,000 mosquitofish were collected in the 1-day survey effort in 1988, indicating high densities of this fish in the late 1980s. Twenty-two bluegill were also collected during the 1988 1-day survey, however the length of most bluegill (25-44 mm) indicated that the bluegill collected were juvenile fish. Over 1,000 unidentified juvenile sunfish (bluegill or pumpkinseed) were also collected. Moderate numbers of carp (n=4), goldfish (n=9), pumpkinseed (n=7), and brown bullhead (n=18) also were collected. Fishman (1989) characterized Force Lake as a self-sustained bullhead fishery because the fish collected indicated a healthy,

reproducing population. Fishman (1989) characterized Force Lake as a stunted bluegill fishery because of their small size.

3.7.2.3 Birds

Numerous bird species inhabit Force Lake and the surrounding area. Tables 26 and 27 present the bird species observed on or near Force Lake and bird species observed within the 900 acre Pen 1 area based on the COP BOP survey conducted in 1997 (City of Portland 1997). Fifty birds have been observed on or near Force Lake (Table 26) and an additional 35 birds have been observed in Pen 1 (Table 27).

Birds from the following general feeding guilds based on the dominant prey items in their diet are listed in Tables 26 and 27:

- **Herbivorous birds**– including dabbling and diving ducks
- **Insectivore/invertivores birds** – including sediment-probing invertivores, birds that feed on flying insects, and terrestrial birds and aquatic ducks that feed on aquatic insect larvae and benthic invertebrates, respectively
- **Piscivorous birds** – including aquatic birds that feed predominately on fish
- **Carnivorous birds** – including terrestrial birds of prey that consume species at higher trophic levels (i.e., birds and mammals)
- **Omnivorous birds** – including birds with an opportunistic diet or a non-specific diet including plants and biota prey

Great blue heron and red-tailed hawk also have observed nesting areas near Force Lake (City of Portland 1997). Great blue heron, egrets, dabbling ducks, and songbirds were observed during a summer 2007 site visit. American wigeon and mallards are known to winter near Force Lake (City of Portland 1997). Force Lake represents the only breeding and nesting habitat within the Portland Urban Growth Boundary for ruddy ducks, which have been observed at Force Lake (Fishman 1989). A heron rookery is also located approximately one half mile west in the Pen 1 area.

Three birds have been observed in Pen 1 (Table 27) that are special-status species. Tri-colored blackbirds are Oregon state sensitive species and are a federal species of concern. Peregrine falcons are Oregon listed as endangered. Bald eagles are federally and Oregon listed as threatened and are also protected under the Migratory Bird Treaty Act and The Bald and Golden Eagle Protection Act.

3.7.2.4 Mammals

Several predominately herbivorous mammal species, including eastern cottontail, voles, beavers, and nutria have been observed near Force Lake based on the Portland BOP survey conducted in 1997 (City of Portland 1997). In addition, two opportunistic feeders, raccoon and opossum, have also been observed (City of Portland 1997) (Table 28).

It is suspected that invertivorous rodents, such as shrews, are also present in the wetland areas near Force Lake. Shrew (*Sorex* species) are found in aquatic habitats in northwestern Oregon, including marshes, and consume a variety of small invertebrates, including beetles, worms, sowbugs, snails, earthworms, centipedes, and some vegetable matter (Csuti et al. 2001). Other aquatic mammals that have not been observed but that could utilize the Site or nearby habitat include nutria and muskrats, which are omnivorous feeders. Nutria eat aquatic plants, grasses, fruit, and may also prey on some mollusks (Csuti et al. 2001). Muskrats have a diet similar to nutria, and they consume mostly plants, and will occasionally eat aquatic prey such as crayfish, fish, turtles, snails, or salamanders (Csuti et al. 2001).

No special status mammal species are known to be present at the Site or nearby habitat areas.

3.7.2.5 Amphibians

Bullfrogs and Pacific treefrogs have been observed in the emergent wetlands of Pen 1 (City of Portland 1997). Western pond turtles have been historically observed in slough habitat, but they were not observed in 1997 (City of Portland 1997).

3.7.2.6 Plants

No threatened or endangered plant species are known to occur at the Site and within the surrounding Pen 1 area (City of Portland 1997). Various wetland and upland plant species are present near Force Lake and within the wetland areas including: black cottonwood trees, willow trees, reed canary grass, rushes, blackberry, and several other species.

3.7.3 Preliminary Receptors of Concern

This section presents the preliminary ROCs selected to represent benthic invertebrates, fish, and wildlife species based on a set of ROC selection criteria. Final ROCs will be selected in the Risk Assessment Scoping Memorandum.

Inherent to the ROC selection process is the realization that not all species in the vicinity of the Site can be evaluated individually because of the large number and variety of species present. Instead, representative species are chosen to include species that are most likely to be exposed to contamination within the adjacent wetlands and in Force Lake. In this way, species not selected should also be protected.

A systematic process was followed to select representative species as preliminary ROCs based on the available information for the resources presented in Section 3.7.2. This process is consistent with available EPA guidance and the process commonly used in Superfund risk assessments.

Key considerations in the selection of preliminary ROCs included:

- Potential for direct or indirect (e.g., ingestion of fish or invertebrates) exposure to chemicals
- Human and ecological significance
- Site usage
- Sensitivity to COPCs
- Susceptibility to biomagnification of COPCs (i.e., higher-trophic-level species)

To ensure that ROCs were selected to represent all potential exposure pathways, key direct and indirect exposure pathways were identified. Groups of organisms that may be exposed via these pathways were then identified, and representative species that are thought to be most exposed were selected from these groups representing the greatest potential for exposure. Next, human or ecological significance was considered (i.e., species valued by society, have special regulatory status [threatened or endangered], or serve a unique ecological function).

Site usage and sensitivity to COPCs were also evaluated. Site usage is an important criterion because it determines the exposure of a species; species that use the Harbor Oil area during a significant part of the year or during sensitive periods, such as gestation and rearing of young, were preferred. Sensitivity to COPCs was evaluated based on available toxicological data. The following sections provide additional rationale for each of the preliminary ROCs selected.

3.7.3.1 Invertebrates

The aquatic benthic invertebrate community and the wetland invertebrate community were selected as ROCs. Invertebrate species are in direct contact with sediment and soil year round and have a limited home range. Invertebrates use various techniques to nourish themselves, and thus may be exposed to chemicals through several different pathways. Aquatic benthic invertebrates include sediment dwellers (benthic infauna) and organisms closely associated with the sediment surface (epibenthos). Soil invertebrates can also live within the soil (e.g., earthworms) or on the soil surface. Flying invertebrates are also important species in the ecosystem.

Invertebrates are an important food source for other invertebrates, fish, birds, and mammals, and perform essential functions, such as nutrient cycling. Thus, the diversity and abundance of invertebrates is an important component of the ecosystem. In addition, invertebrates have been shown to be sensitive to chemicals, and data are available to assess their exposure and predict or measure effects.

3.7.3.2 Fish

A total of six fish species have been observed in Force Lake in the late 1980s. Assuming this fish assemblage is still representative of fish in the lake, two feeding guilds were identified – omnivorous fish and insectivorous fish. Brown bullhead and mosquitofish were selected as the preliminary fish ROCs to be evaluated in the ERA, representing these two

different fish feeding guilds (see Table 25). Brown bullhead (omnivores) consume primarily invertebrate prey as juveniles, and adults consume multiple trophic levels, including small fish and macroinvertebrates. Mosquitofish are primarily invertivorous.

3.7.3.3 Birds

Over 90 bird species have been observed in or near Force Lake or in adjacent wetland areas (Tables 26 and 27). Five primary feeding guilds were identified: herbivore, insectivore/invertivore, piscivore, carnivore (raptors), and omnivore. Preliminary bird ROCs were selected from three feeding guilds: invertivore, piscivore, and raptor to represent higher trophic level birds that may be more exposed to bioaccumulative COPCs. Representative receptor species were not selected from herbivore or omnivore feeding guilds. Birds with omnivorous diets were assumed to be addressed based on the evaluation of other more specific feeding guilds (i.e., their diets would be intermediate between an invertivore and a piscivore, for example). An herbivorous bird receptor was not selected because exposures through plant consumption were assumed to be lower than exposure through higher trophic level species (e.g., invertebrates or fish) for bioaccumulative chemicals, and therefore, it was assumed that these trophic levels will also be protective of herbivorous birds.

The selected preliminary bird ROCs and the rationale for selection are as follows:

Ruddy Duck – The ruddy duck was selected to represent invertivorous birds, specifically invertebrate-feeding ducks. Force Lake represents a unique habitat for the ruddy duck, as it has been identified as the only breeding and nesting area for ruddy duck within the Portland Urban Growth Boundary (Fishman 1989). Ruddy ducks primarily consume invertebrates, feeding on aquatic insects, crustaceans, mollusks, zooplankton, or other invertebrates (Brua 2002, Marshall et al. 2003). Aquatic insects and aquatic invertebrates have been reported to comprise 73% or more of the ruddy duck's diet (Brua 2002). Ruddy ducks may also consume small amounts of aquatic vegetation and seeds (Brua 2002). In fact, one study indicated that plant material may comprise 75% of their diet, depending on the season (Csuti et al. 2001). For the ERA, the diet of the ruddy duck will be evaluated as an invertebrate-dominated diet. A ruddy duck was selected over hooded merganser to represent invertebrate-feeding ducks, because the portion of invertebrates in the ruddy duck diet (73% or greater) was estimated to be higher than that of the hooded merganser (50%) or other ducks (e.g., lesser scaup).

Great blue heron – Great blue heron were selected to represent piscivorous birds feeding in Force Lake. Their diet is comprised of aquatic prey, including small fish, some amphibians and invertebrates. Heron utilize the habitat at Force Lake, with observed nesting areas near Force Lake (City of Portland 1997) and were observed in the 2007 site visit. Great blue heron are also of interest because of the rookery located nearby.

Red-tailed hawk – Red tailed hawk were selected as a representative terrestrial raptor. Red-tailed hawk nesting areas have been observed in cottonwood trees near Force Lake (approximately 200 meters) (City of Portland 1997). Hawk likely feed on small mammals, such as eastern cottontails or shrew, as their main food source.

The listed species, tri-colored blackbirds, bald eagles, and peregrine falcons, were not selected as preliminary ROCs because risks to these species are assumed to be similar to or lower than risks to the selected ROCs based on diet and site usage.

3.7.3.4 Mammals

Six mammalian species have been observed or are suspected to utilize the habitat within the Site (Table 28). These species represent omnivorous and herbivorous wetland species. While shrew have not been observed within the Site (Table 28), they represent a small home range mammal receptor with a intermediate trophic level diet (invertebrates). Thus, shrew was selected as the mammalian ROC.

Shrew consume at a higher trophic level than herbivores (such as voles or beavers), and therefore, should have higher exposures of bioaccumulative COPCs than herbivores. In general, shrews feed primarily (or exclusively) on invertebrates and, depending on the species, will eat both aquatic insects and/or terrestrial invertebrates (e.g., beetles, worms, snails, sowbugs) (Csuti et al. 2001). Shrews also represent a species with a smaller home range than opportunistic feeders, such as raccoon and opossum, and therefore represent a more appropriate species to evaluate risks within the habitat area at the Site. The summer home range of a short-tailed shrew is <0.1 to 1.8 hectares (0.2 to 4.4 acres), with an average year-round home range of 0.39 hectares (approximately 1 acre) (EPA 1997c).

A piscivorous mammal receptor was not selected because there are no observed aquatic mammals in the Pen 1 area that would be strictly piscivorous feeders (Table 28). Some opportunistic feeders were observed, including raccoons, and other omnivorous feeders, such as nutria or muskrats, which may be present at the Site may also consume fish from Force Lake, on rare occasions. However, because the diets of these omnivores are varied and the home range variable, these species are not considered appropriate receptors to evaluate risks limited to the areas at the Site.

3.7.4 Potential exposure pathways

For COPCs to pose risk to ROCs, the exposure pathway must be complete. Identifying complete exposure pathways prior to a quantitative evaluation allows the assessment to focus on only those chemicals that can reach ecological receptors (EPA 1997a, 1997b). An exposure pathway is considered complete if a chemical can travel from a source to ecological receptors and the receptor is exposed via one or more exposure pathways (EPA 1997a, 1997b). Complete pathways can be of

varying importance, so key pathways that reflect maximum exposures to ecological receptors sensitive to that chemical (EPA 1997a, 1997b) are identified as having more importance than pathways likely to provide a very low fraction of the total exposure of an ROC to a chemical.

Pathways for the exposure of ROCs to chemicals were designated in one of four ways: complete and significant, complete and significance unknown, complete and insignificant, or incomplete. Each of the four designations is defined below, including whether it will be further evaluated in this ERA. The preliminary CSM is presented in Figures 16 and 17 for aquatic and terrestrial ecological receptors, respectively. Final pathways of exposure for the selected receptors and a final CSM will be presented in the Risk Assessment Scoping Memo.

- **Complete and significant:** There is a direct link between the receptor and chemical via this pathway, and the specific pathway is considered to be potentially important.
- **Complete and significance unknown:** There is a direct link between the receptor and the chemical via this pathway; however, there is insufficient data available to quantify the significance of the pathway in the overall assessment of exposure.
- **Complete and insignificant:** There is a direct link between the receptor and the chemical via this pathway; however, the significance of this pathway in terms of overall exposure is considered to be very low.
- **Incomplete:** There is no direct pathway between the receptor and the chemical.

Table 29 presents the key exposure pathways to ecological receptors identified for the Site. These are the pathways expected to represent complete and significant exposure pathways, although the significance of some of these pathways is unknown. These pathways include:

- **Aquatic invertebrates:** direct contact and ingestion of sediment, direct contact and ingestion of lake water, ingestion of biota prey (invertebrates and other prey items)
- **Terrestrial invertebrates:** direct contact and ingestion of wetland soil, ingestion of biota prey (invertebrates and other prey items)
- **Fish (mosquitofish and bullhead):** direct contact and ingestion of lake water, ingestion of biota prey (invertebrates and other prey items), direct contact and incidental ingestion of sediment
- **Aquatic birds (ruddy duck and great blue heron):** ingestion of biota prey (invertebrates and/or fish), and incidental ingestion of sediment
- **Terrestrial birds (red-tailed hawk):** ingestion of biota prey (terrestrial mammals) and incidental ingestion of wetland soil

- **Terrestrial mammals (shrew):** ingestion of biota prey (invertebrates) and incidental ingestion of wetland soil

The Risk Assessment Scoping Memo will define the exposure parameters that will be used to estimate exposure concentrations for all ecological receptors and exposure pathways identified above.

3.8 Future Uses

3.8.1 Land

As was discussed in Section 2.4, the facility has an “Industrial Sanctuary” designation, as do the surrounding properties to the northwest, northeast and southeast. Property to the southwest has an “Open Space” designation.

The COP Zoning Designations Map indicates that the facility and properties to the northwest, northeast, and southeast are zoned IG2, Industrial General 2. Property to the southwest is zoned OS, Open Space.

The COP 1/4 Section Zoning Map 1827 indicates that the facility is located within the Pen 1 NRMP area and has a specific zoning of IG2dh, as do the immediately surrounding properties to the northwest, northeast, and southeast.

The zoning and comprehensive plan designations for the facility indicate that it is currently and expected in the future to be used for industrial purposes, particularly given its Industrial Sanctuary designation.

3.8.2 Force Lake

According to the Pen 1 NRMP, Force Lake is an important recreational use area within the drainage district. The lake has no major inlet of water which leads to the buildup of organic and other sediments. The lake only receives runoff from the wetlands, Greenback Golf Courses, adjacent commercial and industrial sources, and roadways.

The Pen 1 NRMP indicates that the COP plans to develop a public access trail along Force Avenue and around the perimeter of the Heron Lakes Golf Courses. This trail would provide access to earlier improvements made to the south side of Force Lake as part of the construction of the final nine holes on the Great Blue Golf Course. The Pen 1 NRMP discusses the potential for additional recreation and access improvements to provide better access to Force Lake and nearby interpretive information.

According to CEC (2002), Force Lake has a self-sustained bullhead fishery coupled with a stunted bluegill fishery. Force Lake is only two to three deep on average, six feet maximum. Force Lake represents the only known breeding and nesting area within the Portland Urban Growth

Boundary for the ruddy duck. Section 3.7.2 provides additional information regarding the resources that use Force Lake.

4.0 WORK PLAN RATIONALE

4.1 RAOs and ARARs

Appendix D contains the RAO technical memorandum required by the SOW. Broadly defined preliminary RAOs were identified based on the current understanding of Site conditions presented in Section 2 and based on the general preliminary RAOs presented in the SOW. Table 35 presents the media-specific RAOs identified for the Site, along with identified data gaps and proposed samples to be collected during the first phase of the RI.

Appendix D also presents a range of potential remedial alternatives for the Site. The range of alternatives was developed by identifying general response actions and potential remedial technologies for each media. As required by the SOW, the range of potential alternatives encompasses, where appropriate, alternatives where treatment significantly reduces the toxicity, mobility, or volume of waste; alternatives that involve containment with little or no treatment; alternatives that include removal of waste; and a no action alternative.

Finally, Appendix D summarizes preliminary federal and state ARARs for the Site. The federal ARARs were identified based on EPA guidance (EPA 1988a). The state ARARs were identified by DEQ.

4.2 Data Quality Objectives

This RI/FS Work Plan is based on the data quality objective (DQO) process developed by EPA as outlined in the document *Guidance for the Data Quality Objectives Process* (EPA 2000) and in the updated DQO guidance (EPA 2006a). The DQO process is used to clarify study objectives in order to develop an appropriate data collection design to support decision making (EPA 2000 and 2006a). The seven-step DQO process developed by EPA was applied to identify field collection efforts needed to complete the RI/FS. Tables 30 through 33 describe the seven-step DQO process that was used to define the objectives of proposed sampling in order to support the following:

- Evaluate ecological risks (i.e., determine whether unacceptable risks are occurring),
- Evaluate human health risks (i.e., determine whether unacceptable risks are occurring),
- Characterize the nature and extent of chemical contamination, and

- Define the physical and hydrological systems.

These four elements are consistent with the general preliminary RAOs described in the SOW. As stated in the DQO tables, if unacceptable risks to humans or ecological receptors are determined, remedial alternatives will be evaluated in the FS. Step 7 of the DQO process provides a summary of the data needed to support the RI/FS. The QAPP (Appendix B) presents the sampling and analytical methods (including data quality indicators [DQIs], which are the parameters used to assess analytical data quality) that will be conducted to satisfy the objectives identified these DQO tables.

In addition to clarifying study objectives, a data quality screen is typically established as part of the DQO process to provide all parties with a common benchmark for determining data acceptability (i.e., identifying which data will be used to estimate risks and develop risk-based goals). This data quality screen ensures that existing data are of a quality adequate to characterize the problem and decision identified in the DQO process (Steps 1 and 2 of the DQO process identified in Tables 30 through 33).

A preliminary data quality screen was conducted for this Work Plan (Section 4.3). A more formal data quality screen will be included in the Risk Assessment Scoping Memorandum. As part of the preliminary screen, specific criteria were used to evaluate the acceptability of chemistry data collected from previous sampling events in order to identify data gaps (Section 4.4). All data collected through the RI/FS process outlined in this Work Plan will meet these criteria through compliance with the methods detailed in the QAPP (Appendix B).

The preliminary criteria required for chemistry data to be used in the RI for all purposes are as follows:

- Hard copy or original electronic copy of data report must be available.
- Field coordinates must be available.
- Data must have been collected using appropriate sampling methods.
- Sample depth sampled must be identified.
- Sample type must be clearly identified.
- Analytical methods must be identified.
- Quality assurance/quality control (QA/QC) information must be available.
- Data validation qualifiers must be present, or derivable from laboratory qualifiers or QA information, and must be applied in a manner consistent with EPA functional guidelines (EPA 1999b, 2002c). For non-detected results, detection limits and appropriate qualifiers must be given.

- Data reports should contain laboratory-generated forms (often called Form 1s) with the results for each sample.
- Existence and location of documentation supporting the dataset, including the analytical raw data, chain of custody forms, and sample handling descriptions, should be known for future reference, confirmation, and/or reproducibility by a third party.

While EPA has no established definitive guidelines specifying level of data validation required for Superfund investigations, EPA Order 5360.1 and OSWER Directive 9355.9-01 (EPA-540-G93-071 Data Quality Process for Superfund, Interim Final, September 1993) requires environmental measurements to be of known quality, verifiable, and defensible. EPA's information quality guidelines (EPA 2002b) require that a historical dataset to be used for decision-making must be of known quality, legally defensible, and must have undergone the same level of scrutiny and review as any other environmental data generated internally or externally by or for EPA.

Attachment B2 in QAPP describes how risk-based analytical concentration goals (ACGs) were established for TPH, metals, PCBs, organochlorine pesticides, PAHs, other SVOCs, and VOCs to ensure that the planned analyses, laboratory analytical methods and reporting limits will meet the objectives of the risk evaluations. ACGs were established using the lowest human health or ecological screening level for each of the proposed Phase 1 media: soil, sediment, and water (surface water and groundwater).

For soil, all target laboratory method detection limits (MDLs) and reporting limits (RLs) were less than the soil ACG for all chemicals with the exception of arsenic, selenium, three polycyclic aromatic hydrocarbons (PAHs; i.e., benzo(a)pyrene, dibenzo(a,h)anthracene, and dibenzofuran), one other SVOC (i.e., n-nitrosodi-n-propylamine), and three VOCs (i.e., 1,2-dibromo-3-chloropropane, 1,2-dibromoethane, and 1,2,3-trichloropropane). Using the more sensitive test method for PAHs, EPA 8270-SIM, the standard laboratory RLs are lower than the ACGs for benzo(a)pyrene and dibenzo(a,h)anthracene. The target MDLs were less than the ACGs for all of these chemicals, thus the specified methods should be sufficiently sensitive to provide data of acceptable quality for the baseline human health and ecological risk assessments.

For sediment, all target laboratory MDLs and RLs were less than the sediment ACGs for all chemicals, with the exception of arsenic, dieldrin, two PAHs (i.e., benzo(a)pyrene and dibenzo(a,h)anthracene), one other SVOC (i.e., n-nitrosodi-n-propylamine), and three VOCs (i.e., 1,2-dibromo-3-chloropropane, 1,2-dibromoethane, and 1,2,3-trichloropropane). Using the more sensitive test method for PAHs, EPA 8270-SIM, the standard laboratory RLs are lower than the ACGs for benzo(a)pyrene and dibenzo(a,h)anthracene. The target MDLs were less than the ACGs for all of these chemicals, thus the specified methods should be sufficiently sensitive to provide data of acceptable quality for the baseline human health and ecological risk assessments.

Laboratory MDLs were lower than the water ACGs for half of the chemicals. Many of the water ACGs are not practically achievable using standard test methods; however, special extraction and analytical techniques have been selected for preparation and analysis so that lower MDLs and RLs can be achieved. Additionally, PAHs will be analyzed using EPA 8270-SIM. For the non-detected chemicals with MDLs and RLs above the ACGs, the ramifications will be discussed in the uncertainty assessments of the baseline human health and ecological risk assessments.

4.3 Evaluation of Historical Data Quality

The data quality criteria presented in Section 4.2 were selected to conduct a preliminary evaluation of the acceptability of chemistry data collected from previous sampling events for use in the RI/FS. As summarized in Section 3.1, multiple sampling investigations at the Harbor Oil facility, adjacent wetland areas, and Force Lake have been conducted since 1990.

For this preliminary evaluation, historical data that were obtained using fixed laboratory methods were considered acceptable for the purpose of identifying data gaps (i.e., these data are likely to be acceptable for use in the RI/FS). Data from screening laboratory analyses were considered unacceptable for use in the RI/FS, but were reviewed to provide qualitative information to develop the study design summarized in Section 4.5. Historical data derived using fixed laboratory methods are summarized in Table 34.

4.4 Data Gaps

Based on the SOW, data for the RI are needed to fill the following primary objectives:

- To characterize the physical system of the Site by evaluating chemical migration pathways including fluxes and rates through zones of migration.
- Determine the nature and extent of contamination at the Harbor Oil facility and for facility-related chemicals in adjacent wetlands, Force Lake, and, if needed, downstream surface water bodies that received facility-impacted discharges from Force Lake.
- Characterize any non-aqueous phase liquids (NAPL) in soil or groundwater within the Site.
- Verify the preliminary CSM.
- Evaluate the potential human health and ecological risks posed by chemicals of concern for all appropriate pathways and receptors.

Existing data, summarized in Table 34, were reviewed to assess the sufficiency of these data to meet the primary objectives outlined in the SOW, which are consistent with the RAOs summarized in Section 4.1. Specific data needs were also determined based on the pathways outlined in the CSMs presented in Section 3 (Figures 15 through 17).

Based on the data gaps analysis, additional data are needed as outlined in Table 35. Details on the proposed sampling design are presented in the QAPP (Appendix B). Section 4.5 presents an overview of the sampling design proposed for the Harbor Oil facility, the adjacent wetland areas, Force Lake, and North Lake. Below is a summary of the data types needed.

- Chemical concentrations in surface and subsurface soil in known and suspected source areas located on the facility.
- Chemical concentrations in the soil berm (northwest and southwest).
- Chemical concentrations in the soil stockpile.
- Chemical concentrations in the shallow, intermediate, and deep saturated zones; hydrogeologic properties of the shallow and intermediate zones; vertical gradients between the shallow, intermediate, and deep zones; and horizontal gradients and directions of groundwater flow in the shallow and intermediate zones.
- Chemical concentrations in wetland soil.
- Chemical concentrations in Force Lake and North Lake sediments.
- Chemical concentrations in Force Lake surface water.

Table 37 presents a summary of the DQOs and data use objectives that will be addressed through the collection of RI/FS samples.

4.5 Sampling Design

This section presents an overview of the study design for collection of additional data for the Site. Tables 30 through 33 describe the DQO process used to define the objectives of proposed sampling: support the ecological and human health risk assessments (i.e., determine whether unacceptable risks are occurring); characterize of the nature and extent of chemical distribution and sources; and define the physical characteristics and hydrological system.

The data collection effort will occur in two phases. Phase 1 sampling is intended to provide most of the information needed to fill the data gaps identified in Table 35 for each media of interest. Phase 2 sampling will be conducted following the evaluation of Phase 1 data. The scope of the Phase 2 effort will be determined in consultation with EPA based on the results from Phase 1. In general, Phase 2 sampling will occur where

additional data are needed to better characterize ecological or human health risks and to further delineate areas of contamination for purposes of estimating remedial areas and volumes.

Table 36 presents a summary of the Phase 1 and Phase 2 sampling effort identified for each media type (on-facility soil, wetland soils, groundwater, sediment, surface water, and tissue). The following sections provide additional detail for each media to explain the phasing rationale on the sampling design. All media collected in Phase 1 will be analyzed for the following chemical groups: metals (antimony, arsenic, barium, cadmium, cobalt, copper, chromium, lead, mercury, nickel, selenium, vanadium and zinc¹⁸), TPH, PAHs, VOCs, organochlorine pesticides, and PCB Aroclors.

Selected on-facility soil and wetland soil samples will be analyzed for SVOCs. As was discussed in Section 3.3, other than certain PAHs, dibenzofuran and bis(2-ethylhexyl)phthalate were the only other SVOCs that were detected above screening levels in soil on the facility (in surface soil samples collected at DP01, DP02, SS03, SS04, SS05, SS06 and SS08 and the subsurface [2 to 6 foot bgs] sample collected at DP01); dibenzofuran was the only other SVOC detected in wetland soil (WL01). Thus, SVOCs, other than PAHs, may not be important COIs. However, the reporting limits for some of the SVOCs were higher than their screening levels.¹⁹ To evaluate the importance of SVOCs, other than PAHs, surface soil samples collected near potential source areas on the facility, wetland soil samples collected from the drainage ditch, and wetland soil samples collected along the southwest side of the facility. The specific sampling locations are described in the QAPP. The analytical results for these samples will be evaluated, in consultation with EPA, to determine if additional samples need to be analyzed for SVOCs during Phase 2.

Specific details on RI/FS sampling design, including field collection methods, laboratory analysis methods, and media analyte lists are provided in the QAPP (Appendix B). The QAPP was prepared in accordance with the main elements listed in *EPA requirements for Quality Assurance Project Plans for Environmental Data Operation* (EPA 2001a) and additional guidance from *EPA Guidance for Quality Assurance Project Plans* (EPA 2002a). The QAPP includes all of the details of the SOW-defined Sampling and Analysis Plan (SAP): Field Sampling Plan (FSP) details, project objectives and organization, functional activities, quality assurance and quality control (QA/QC) protocols, sampling procedures, sample custody, analytical procedures and ACGs, data

¹⁸ At the request of EPA, manganese and iron will also be analyzed in groundwater samples, as these analytes can be useful in characterizing the redox conditions of groundwater.

¹⁹ Note that most of the on-facility soil samples with elevated SVOC reporting limits were split samples collected by CEC (2002); the SVOC reporting limits for the E&E (2001) samples were generally lower, and except for 2,6-dinitrotoluene, dibenzofuran and N-nitrosodi-n-propylamine, were less than screening levels. The split wetland soil sample collected by CEC (2002) also had elevated SVOC detection limits; the SVOC reporting limits for the E&E (2001) wetland soil samples were generally lower, and except for 2,4-dinitrophenol, 2,6-dinitrotoluene, hexachlorobenzene, dibenzofuran, 4-nitrophenol, N-nitrosodi-n-propylamine and pentachlorophenol, were less than screening levels.

reduction, reporting, personnel qualifications, and data collection techniques.

4.5.1 Soils

Soil data for the facility will be used in the risk assessments to assess risks to workers on the facility and ecological receptors (from the soil berm bordering the wetlands). In addition, these data will be used to characterize the soil stockpile, and define the extent of contamination in known and potential source areas.

Historical surface soil data are available from four locations (GAI-SS-2, GAI-SS-3, P-275, and P-100) sampled by Golder (1990), and 19 locations (BG01, BG03, DP01, DP02, DP03, SS01 through SS10) sampled by E&E (2001), and four locations (SS02 through SS05) co-sampled by Coles (2002).

The soil berm may have been constructed from impacted soil shortly after the 1979 fire that destroyed the Chempro facility (Figure 2). Systematic sampling is proposed to characterize chemical concentrations in the soil berm. Depth composite samples will be collected at approximately 100-foot intervals at nine locations (SB-01 through SB-09) along both the southwest and northwest berms for laboratory analysis (Figure 18). At each sampling location, a single composite collected over a depth interval of approximately 0.5 to 2.0 feet, or approximately $\frac{1}{2}$ the thickness of the berm, will be submitted for laboratory analysis.

A soil stockpile was generated by EMRI during the construction of the new base-oil refining plant. The approximate volume of the soil stockpile is 3,000 cubic yards.²⁰ Although no prior sampling of the soil stockpile has been conducted, CEC collected 11 samples within the new base-oil refining plant footprint. Five of the samples contained diesel- and/or oil-range petroleum hydrocarbons and two of the samples contained Aroclor 1248 and/or Aroclor 1260. Systematic sampling is proposed to characterize chemical concentrations in the soil stockpile. Depth composite samples will be collected at approximately three evenly spaced locations (SP-01 through SP-03) across the stockpile for laboratory analysis (Figure 18). At each sampling location, a composite of samples collected over a depth interval of approximately 0.5 to 6.0 feet, or approximately $\frac{1}{2}$ the thickness of the stockpile, will be submitted for laboratory analysis.

The former north drainage ditch is confirmed to have received stormwater runoff and spills, including from potential sources located to the north of the facility. Fixed lab data available from prior analyses (e.g., SS09 and P-275) indicate that TPH, metals, PAHs, PCBs and pesticides are present in the area where the former north drainage ditch is located. However, only one of the samples (SS09) was analyzed for the full suite of constituents. Systematic sampling is proposed to characterize the chemical concentrations in former drainage ditch sediments. Shallow soil

²⁰ Note that this volume is based on rough dimensions obtained during a site visit, not on an accurate survey or detailed measurement of stockpile dimensions.

grab samples will be collected at approximately 100-foot intervals at four locations (SL-01 through SL-04) along the length of the former drainage ditch (Figure 18). The samples will be collected 0.5 to 1.0 foot below the base of ditch fill material that EMRI placed in the northwestern portion of the ditch in 2002, if the ditch fill can be differentiated from the former ditch sediments. The presence of sediments, buried vegetation, anthropogenic materials, and oily sheen may help differentiate the former ditch bottom from fill. If they cannot be differentiated, the sample will be collected approximately 2.0 to 3.0 feet below ground surface.

Historic aerial photographs show the "C" shaped area located on the western half of the Harbor Oil facility between the new base-oil refining plant and the stormwater treatment system (Figure 4). Limited data from samples collected in or near the former "C" shaped area (e.g., DP-02, J-500, SS05, J-475, J-475A, HC-01, HC-02 and HC-03) indicate that TPH, metals, VOCs, PAHs, PCBs, and pesticides are present in surface and/or subsurface soils. Targeted sampling is proposed to characterize chemical concentrations in this area. One surface and two subsurface soil samples collected at each of two borings (SL-05 and SL-06) drilled in the former "C" shaped area will be submitted for laboratory analysis (Figure 18). Note, as will be discussed below, the samples collected at boring SL-06 will also be used to characterize the current stormwater treatment system.

The current stormwater treatment system located south of the new base-oil refining plant currently receives stormwater from catch basins located throughout the Harbor Oil facility. One set of fixed lab analyses (DP-02) and two sets of screening lab analyses (L-500 and J-475A) available from points near of the current stormwater treatment system detected metals, VOCs, PAHs, and pesticides. Targeted soil sampling is proposed to characterize chemical concentrations in subsurface soils near the current stormwater treatment system. One surface and two subsurface soil samples collected from one drilled boring (SL-06) downgradient of the stormwater treatment system will be submitted for laboratory analysis (Figure 18).

Historically, TCE was used to clean out tanker trucks at the former tanker truck cleaning operation located in the center part of the facility. In addition, tanker trucks and cattle trucks were cleaned on or near the former concrete pad. Data from fixed lab analyses indicate TPH, VOCs, PAHs, PCBs, and pesticides are present in surface soil near the former tanker truck cleaning operation. Targeted soil sampling is proposed to characterize the nature and extent of contamination at the west side, center, and east side of the former tanker truck cleaning operation and former concrete pad. One surface and two subsurface soil samples collected at each of four drilled borings (SL-07 through SL-10) will be submitted for laboratory analysis (Figure 18). In addition, one surface soil sample will be collected at SL-14; the location of this surface sample was shifted from its originally proposed location to the east, so that it could be used characterize the nature and extent of contamination near the former tanker truck cleaning operation, as well as characterize the spatial

distribution of potential contamination in facility roadways and high-traffic areas as described below.

According to historical information for the facility, oil was used as a dust suppressant at the Harbor Oil facility. Fixed lab data from the analyses of surface soil samples indicate the presence of TPH, metals, PAHs, PCBs, and pesticides in areas of the facility where operations were minimal (e.g., north of the office/shop/warehouse building at SS01). Systematic sampling is proposed to characterize the spatial distribution in surface soil in facility roadways and high-traffic areas. One surface soil sample (beneath the gravel layer) will be collected from each of nine drilled borings (SL-11 through SL-19) for laboratory analysis (Figure 18).

Historic aerial photographs show a former unlined holding pond at approximately the location of the current stormwater treatment system. Targeted soil sampling is proposed to characterize the nature and depth of contamination within the former retention pond area. One surface and two subsurface soil samples collected from a boring (SL-20) drilled within the former retention pond footprint will be submitted for laboratory analysis (Figure 18).

Historic aerial photographs show a former tank that was located near the "C" shaped area. No soil samples have been collected near the former tank. Targeted soil sampling is proposed to characterize the nature and depth of contamination in this potential source area. One surface and two subsurface soil samples collected from a boring (SL-21) drilled near the former tank will be submitted for laboratory analysis (Figure 18).

Soil samples collected in the J-550/J-600 sample area indicate that constituents are present in subsurface soils in this area. Fixed lab analyses of a sample collected from boring J-550 detected TPH and metals in subsurface soil. Screening level analyses of samples collected from J-600 detected elevated TPH and VOC concentrations. Targeted soil sampling is proposed to characterize the nature and extent of chemicals in this area. One surface and two subsurface soil samples collected from each of two drilled borings (SL-22 and SL-23) will be submitted for laboratory analysis (Figure 18).

Free product was detected in monitoring well GA-30 by E&E (2001). Data from screening level analyses of a nearby soil sample detected elevated TPH. Targeted sampling is proposed to further define the spatial extent of free product impact in this area. One subsurface soil sample collected from each of the two drilled borings (SL-22 and SL-24) will be submitted for laboratory analysis (Figure 18).

At the tank farm and oil processing area, oily sheen has been observed seeping from underneath the concrete containment when groundwater levels are high. Three subsurface samples (HC-12, HC-13 and HC-14) were collected by CEC in 2003 near this area. TPH and PCBs were detected in one or more of the samples. Systematic sampling is proposed to determine the nature and extent of contamination in this area. One surface and two subsurface soil samples will be collected from each of four drilled borings (SL-25 through SL-28) placed at 50 to 75-foot intervals for laboratory analysis (Figure 18). There are no visible signs of

“failure” in the containment system, although some cracks are visible in the concrete containment. As Section 2.3.7.1 states, DEQ observed a gap between the wall and pad along the south side of the used oil processing area; the exact location was not identified in the DEQ multi-media checklist. DEQ requested that the gap be sealed. Section 2.3.7.11 also states that DEQ observed cracks and a small hole in the secondary containment around the oil cooker units, and requested that EMRI create policies and guidance documents for crack repair.

Tank 23, a 320,000-gallon open-top tank, was installed by 1980. No prior sampling or analyses has been performed around this tank. Targeted sampling is proposed to determine if soils underlying Tank 23 are impacted with facility-related COIs. Because most of the perimeter of Tanks 23 is inaccessible, two subsurface soil samples will be collected from one angled boring (SL-29) located near the south side of the tank. Additional sampling may be performed during Phase 2, depending upon the Phase 1 results, the tank sampling being conducted by EMRI, and the condition and future status of the tank.

Soil sampling conducted by CEC in 2003 during the construction of the new base-oil refining plant found soils containing elevated TPH and PCBs near the north corner of the foundation excavation at sampling locations HC-04 and HC-07. Targeted sampling is proposed to further define the spatial extent of contamination in this area. Two subsurface soil samples collected from each of two drilled borings (SL-30 and SL-31) will be submitted for laboratory analysis (Figure 18).

Table 37 presents a summary of the DQOs and data use objectives that will be addressed through the collection of soil samples on the facility.

The scope and need for Phase 2 sampling of soils on the facility will be determined based on a review of Phase 1 data. Considerations for Phase 2 soil sampling on the facility include the following key questions:

- Are additional soil data needed to define the extent of contamination for purposes of estimating remedial quantities for the FS?
- Are additional subsurface soils data needed to determine the depth of contamination?
- Are additional soil samples needed to determine if a release occurred from Tank 23?
- Are additional soil data needed from the soil stockpile?

These considerations will be discussed with EPA following receipt of preliminary Phase 1 data (i.e., prior to data validation).

4.5.2 Wetland soils

Wetland soil data will be used in the risk assessments to assess risks to ecological receptors and human health. In addition, these data will be used to characterize the nature and extent of contamination and to assess sources.

Historical wetland soil data are available from five sampling locations (WL01, WL02, WL03, WL04, and WL05) sampled by E&E (2001) (Figure 9). CEC collected a split sample at location WL05. Other wetland soil data have also been collected; however, these data were analyzed using field screening methods and had limited analyte lists. Therefore, they were considered in a qualitative sense only in the study design (i.e., indicator of potential extent of contamination).

Samples WL01, WL02, and WL05 are thought to be located in the ditch area where surface water formerly drained along the western boundary of the Harbor Oil facility and into Force Lake (Coles 2002). Currently, a shallow ditch is present about halfway between the southwest corner of the property and the bank of Force Lake, and sample WL-05 is located at the end of this ditch on the bank of Force Lake (Coles 2002). Data from these samples contained higher concentrations of TPH, metals, PCBs, and DDT compared to the samples collected at WL04 and WL03, which are located between the southern boundary of the Harbor Oil facility and Force Lake (Figure 13). Based on these data, higher variability in chemical concentrations is expected in wetland soils in the former ditch area and in its vicinity than in soils located in the wetland area to the south of the facility.

Two types of sampling efforts will be conducted: targeted sampling and systematic sampling. Based on the historical data, the ditch was selected for targeted sampling to verify and further characterize this area of potentially higher contamination. Five Phase 1 wetland surface (0-4 inches) soil samples will be collected in the ditch area on the western boundary of Harbor Oil facility to Force Lake (Figure 19; DS-01 through DS-05). Samples will be evenly distributed (approximately every 100 feet) along the ditch; the southern-most ditch sample is located at the point thought to be where the ditch formerly emptied into Force Lake (DS-05). Sample DS-03 will be collected to target the location of the former oil discharge location. The location of this sampling station will be determined in the field to target wetland soil within the discharge area from the former discharge pipe. In addition, three subsurface samples (DS-02, DS-03, and DS-05) are proposed to further characterize subsurface contamination in this area. Wetland soils depth intervals that will be collected using cores will include the following: 0-6, 6-12, and 24-36 inches.

To characterize the general spatial distribution of contamination in wetland soils, a systematic sampling design was selected for application within the wetland area bordering the southern and western portions of the Harbor Oil facility (Figure 19). The southern portion of wetland area is bounded by the facility and Force Lake. The western portion of the wetland area extends approximately 150 feet from the former ditch area on the western boundary of the facility (Figure 19).

A 50 x 50 feet grid that extends from the west and south border of the Harbor Oil facility was used as a means of stratifying the wetland area for sampling. Sampling locations (WS-01 through WS-21) were systematically placed in every other grid cell in the 50 x 50 feet grid that was superimposed over the "L" shaped wetland area extending from the

former ditch area (Figure 19). In the southern wetland portion, sampling locations (WS-22 through WS-33) were systematically placed in every third grid cell (Figure 19). The sampling density in the southern wetland area was less than the "L" shaped wetland area because concentrations in the southern wetland soils are expected to be less variable than wetland soils located in proximity to the ditch. This assumption will be assessed based on Phase 1 sampling. Sample WS-19 will be collected to target the current oil discharge location. The location of this sampling station will be determined in the field to target wetland soil within the area of discharge from the current discharge pipe. Three subsurface samples locations (WS-06, WS-19, and WS-26) were identified to characterize the depth of contamination. Wetland soils depth intervals that will be collected using cores will include the following: 0-6, 6-12, and 24-36 inches.

Sampling locations were systematically distributed within the grid design to evenly distribute samples throughout the wetland area to determine any potential chemical concentration gradients from east-west or north-south directions.

The former drainage ditch area may act as a potential hydrological barrier between the facility runoff towards Force Lake and the wetland soils to the northwest of the facility. Therefore, the evaluation of chemical concentrations in wetland soil samples collected northwest of the drainage ditch will be used to characterize contamination from sources other than those located on the facility. Similarly, the wetland samples collected to the south of the facility near N. Force Avenue will be used to characterize contamination that may have come from properties to the north of the facility that drain down and along N. Force Avenue. The remaining wetland soil samples will be used to characterize contamination associated with runoff and releases from the facility.

In total (both systematic and targeted samples), 38 wetland surface soil sampling locations were identified in the two wetland sampling areas. In addition, six subsurface samples locations were identified to characterize the depth of contamination. Table 37 presents a summary of the DQOs and data use objectives that will be addressed through the collection of wetland soil samples.

The scope and need for Phase 2 sampling of wetland soils will be determined based on a review of Phase 1 data. Considerations for Phase 2 wetland soil sampling include the following key questions:

- Are additional soil data needed to characterize the extent of facility-related contamination beyond the designated wetland soil sampling area in Phase 1?
- Are additional wetland soil data needed to refine the areas of localized contamination?
- Are additional subsurface soils data needed to determine the depth of contamination?

These considerations will be discussed with EPA following receipt of preliminary Phase 1 data (i.e., prior to data validation).

4.5.3 Groundwater

Groundwater data will be used in the risk assessments to assess human health and ecological risks. In addition, these data will be used to characterize the nature and extent of contamination in both the shallow, intermediate and deep saturated zones, determine if the Harbor Oil facility is a source of the VOCs detected in deep groundwater, and determine if chemicals are migrating onto the facility.

Historical groundwater samples have been collected from wells at the Harbor Oil facility during two sampling events: 1) Preliminary Site Investigation by Golder (1990) and 2) EPA PA/SI (E&E, 2001). Golder collected groundwater samples from eight monitoring wells; seven monitoring wells were installed as part of this investigation. These samples were collected in 1990 as part of a preliminary site assessment. The groundwater samples were analyzed using both fixed and field laboratory analysis; groundwater samples from three wells (A-18, GA-30 and B-4) were analyzed for metals by a fixed laboratory and groundwater samples from the eight wells (A-18, A-19, A-20, GA-29, GA-30, GA-33, GA-34, & B-4) were analyzed for VOCs by a field screening laboratory. The data from the field-screening laboratory analysis are not expected to meet the data quality criteria of the formal data review that will be presented in the Risk Assessment Scoping Memorandum.

As part of the EPA PA/SI, seven groundwater samples were collected from six monitoring wells (A-18, A-19, A-20, GA-29, GA-33 and GA-34) and the plant well (PW-01); one product sample was collected from monitoring well GA-30. The seven groundwater samples were analyzed for VOCs, metals, TPH, PCBs, pesticides, and SVOCs by a fixed laboratory. VOCs, metals, TPH, pesticides, and SVOCs were detected in one or more of the groundwater samples; no PCBs were detected. Data from the fixed laboratory analysis are expected to meet the data quality criteria of the formal data review presented in the Risk Assessment Scoping Memorandum.

During the EPA PA/SI, CEC collected three split groundwater samples from monitoring wells A-18, A-19 and GA-29. These samples were analyzed for VOCs, metals (lead and magnesium) and TPH by a fixed laboratory. VOCs, metals and TPH were detected in one or more of the groundwater samples. Data from the fixed laboratory analysis are expected to meet the data quality criteria of the formal data review presented in the Risk Assessment Scoping Memorandum.

To delineate the spatial distribution of the chemicals in the shallow and intermediate saturated zones, eight new monitoring wells will be installed at various locations across the Harbor Oil facility to address data gaps and complement the existing nine wells in the current monitoring well network. One new monitoring well (MW-3s) will be installed northwest of Tank 23 to provide additional information on the quality of shallow groundwater migrating onto the Harbor Oil facility. Two new shallow wells (MW-1s and MW-2s) will be installed on the south-southwest side of the Harbor Oil facility to further define the quality of shallow groundwater migrating towards Force Lake. One new shallow well will be installed

near Tank 23 and the tank farm and used oil processing area (MW-4s), and one new shallow well will be installed near the former tanker truck cleaning operation and former concrete pad (MW-5s) to determine if chemicals are present in shallow groundwater near these potential source areas. Finally, new intermediate wells will be installed at three locations (MW-2i, MW-4i and MW-5i) to provide paired shallow and intermediate wells near potential source areas (e.g., Tank 23, tank farm and used oil processing area, former tanker truck cleaning operation and former concrete pad, "C" shaped area, and former unlined holding pond). These three wells will make it possible to evaluate groundwater flow directions in the intermediate zone, as well as evaluate whether chemicals, if any, present in the shallow groundwater zone have migrated vertically into the intermediate zone. Because MW-2i will be installed near shallow well MW-2s and deep wells B-4, it will be possible to evaluate the direction and magnitude of vertical gradients between the shallow, intermediate and deep groundwater zones.

Prior to installing the new wells, continuous soil samples will be collected from each boring, and the samples will be described by a professional geologist or engineer. These boring logs will be used to select the screened intervals for the new intermediate monitoring wells and to produce detailed geologic and hydrogeologic cross sections. Based on the existing lithologic information, the new intermediate monitoring wells will likely be screened between 40 and 50 feet bgs. This target interval was selected based on the Redmond and Associates (2002) borings which indicate that a silty to slightly silty, fine to medium sand zone is present between 42 and 49 feet bgs. This silty sand zone should be more conductive than the intermediate clayey, sandy silt zones directly above this zone and more likely than these less conductive zones to contain any dissolve constituents migrating vertically from the shallow groundwater zone. The new shallow monitoring wells will be screened between 3 and 13 feet bgs so that the screen intersects the water table during most of the year and to accommodate the identification of LNAPL. This is the minimum depth at which the screen can be placed given the need to leave space for the surface monument and 2-foot seal and to avoid direct rainfall infiltration through the gravel fill into the screen; the proposed screened interval for the shallow wells is contingent upon receiving a variance from the OWRD prior to well installation. Note that the upper portion of each soil core will be examined by a professional geologist or engineer to determine if LNAPL may be present above the screened interval.

The final monitoring well network, consisting of new and existing wells, will have 12 shallow, three intermediate, and two deep wells (including the plant well) for a total of 17 wells. See Figure 20 for the proposed location of the new wells and the locations of the existing wells.

Also prior to installing the new wells, the integrity of each existing well will be evaluated and each existing well will be redeveloped until an adequate hydraulic connection is established between the screened interval and adjacent formation. If the integrity of any of the existing wells has been

compromised or they cannot be redeveloped, then new monitoring wells will be installed to replace them.

Once all of the Phase 1 monitoring wells have been installed, the water level in each well will be measured and each well will be sampled. The water elevation in Force Lake will be measured at the same time, using either a fixed measuring point or by installing a staff gage in the lake, so that the elevation of the lake can be compared to groundwater elevations. The inlet and outlet elevations of the pipes that connect Force Lake to North Lake will be surveyed at the same time that the fixed measuring point or staff gage is surveyed.

Thereafter, the water level in each monitoring well and in Force Lake will be measured on a monthly basis during Phase 1 and Phase 2 of the RI. Monthly water level monitoring should make it possible to evaluate how groundwater elevations change seasonally and in response to changes in Columbia River elevation.

Groundwater flow directions in the deep zone will not be determined during Phase 1 because water level measurements will only be made in the plant well and monitoring well B-4. However, water levels measured in these wells will be used during Phase 1 to estimate the vertical gradient and groundwater flow direction between the intermediate and deep zones.

The following techniques will be used to identify the presence of LNAPL during groundwater sampling and modifications to groundwater sampling methods should LNAPL be encountered in a monitoring well.

An oil and water interface probe suspended by a graduated tape will be used to identify measurable LNAPL, if any, in a well. The depths to the top of product layer and product and water interface will be measured and recorded to the nearest 0.01 feet. A clear disposable bailer will be used to confirm the presence of measurable LNAPL. A correction factor will be applied to subtract the effect of the overlying product on the apparent water-table configuration so that the water table can be analyzed at its ambient (undisturbed) level. The correction is made by subtracting the product thickness times its specific gravity relative to water from the depth to water measurement.

Should LNAPL be present in a new or existing monitoring well, a groundwater sample will not be collected. Instead, a sample of the LNAPL will be collected and analyzed for the same list of analytes using a disposable teflon bailer gently lowered into the well until the bailer is approximately one foot below the water table. Any LNAPL collected in the bailer will be transferred to the appropriate laboratory supplied sampling container(s) using a low-flow sampling tube that is included with the bailer. This will be performed by placing the tube in the bottom of the bailer and discharging the collected groundwater into the appropriate purged water storage container, then discharging the remaining LNAPL into the laboratory container(s) for analysis. If needed, the bailer will be lowered into the well multiple times to collect the necessary amount of LNAPL for laboratory analysis. LNAPL samples submitted to

the laboratory should be marked as LNAPL on the COC and sample bottle labels.

Table 37 presents a summary of the DQOs and data use objectives that will be addressed through the collection of groundwater samples.

The scope and need for Phase 2 sampling of groundwater will be determined based on a review of Phase 1 data. Considerations for Phase 2 groundwater sampling include the following key questions:

- Are additional groundwater data needed to characterize the vertical or lateral extent of constituents migrating off the Harbor Oil facility?
- Are additional groundwater data needed to determine whether facility-related chemicals have migrated to the deep groundwater zone?
- Are additional groundwater data needed to determine if chemicals are migrating onto the facility?

These considerations will be discussed with EPA following receipt of preliminary Phase 1 data (i.e., prior to data validation).

4.5.4 Force Lake Sediment

Sediment data will be used in the risk assessments to assess risks to ecological receptors and humans utilizing Force Lake for fishing and other recreational purposes. In addition, these data will be used to characterize the nature and extent of contamination.

Only one composite sediment sample (S-1) from Force Lake was available from the historical data. This sample was collected in 1992 (City of Portland 1997). The sediment sample was analyzed in a fixed laboratory; however, the sampling methods (e.g., sampling location, sampling depth) were poorly documented (based on information available at this time). The data from this sample are not expected to meet data quality criteria of the formal data review that will be presented in the Risk Assessment Scoping Memorandum. Therefore, additional sampling of sediment is needed.

To characterize the spatial distribution of chemical concentrations in Force Lake sediment, a stratified sampling design was used (Figure 19). Sampling locations were systematically placed in one of four grid cells in a 100 x100 feet grid²¹ that was superimposed over the area of Force Lake (Figure 19). Sampling locations were systematically placed in order to characterize chemical concentrations over the entire area of Force Lake. Using this sampling design, 11 surface (0-4 inches) sediment sampling locations were identified (SE-01 through SE-11).

²¹ It was assumed that fewer samples are needed to characterize lake sediments than wetland soils because of the potential for mixing in the lake; chemical concentrations are expected to be less variable than in wetland soils.

Three Phase 1 sediment samples will also be collected from North Lake (SE-101 through SE-103). It is not known if Force Lake is contaminated, and if it is, whether contamination extends to other hydraulically connected surface water bodies. To provide this information, which is relevant to nature and extent, surface sediment samples will be collected from locations 10 feet, 25 feet, and 100 feet from the end of the pipes that connect North Lake and Force Lake (Figure 19).

Table 37 presents a summary of the DQOs and data use objectives that will be addressed through the collection of sediment samples.

The scope and need for Phase 2 sampling of lake sediment will be determined based on a review of Phase 1 data. Considerations for Phase 2 sediment sampling include the following key questions:

- Are additional sediment data needed to refine the areas of localized contamination within Force Lake?
- Are additional sediment data needed to characterize the extent of facility-related contamination in sediments beyond Force Lake?
- Are subsurface sediment data needed to characterize the nature and extent of contamination and/or evaluate potential remedial quantities for the FS?
- If surface sediment is contaminated in Force Lake to a sufficient extent, are bioassays needed to assess risks to the benthic invertebrate community?

These considerations will be discussed with EPA following receipt of preliminary Phase 1 data (i.e., prior to data validation).

4.5.5 Force Lake Surface Water

Surface water data from Force Lake will be used in the risk assessments to assess risks to ecological receptors and humans utilizing Force Lake for fishing and other recreational purposes. In addition, these data will be used to characterize the nature and extent of contamination.

Only one surface water sample (W-1) from Force Lake was available from the historical data. This sample was collected in 1992 (City of Portland 1997). This sample was analyzed in a fixed laboratory; however, the sampling methods of this sample (e.g., sampling location, sampling depth) were poorly documented (based on information available at this time). The data from this sample are not expected to meet data quality criteria of the formal data review that will be presented in the Risk Assessment Scoping Memorandum. Therefore, additional sampling of water in Force Lake is needed.

Three surface water samples will be collected from Force Lake. These samples will be used to characterize chemical concentrations in the surface water at Force Lake. A water grab sample will be collected from each of three areas within Force Lake (Figure 19). Because of the shallow depth of Force Lake, all water samples in Force Lake will be collected at the surface. Surface water samples will be analyzed for

selected water quality parameters (dissolved oxygen [DO] and water hardness) in addition to the analysis for chemical concentrations. Table 37 presents a summary of the DQOs and data use objectives that will be addressed through the collection of lake surface water samples.

4.5.6 Biota Tissue

The extent of contamination from the Harbor Oil facility to adjacent wetland soils and Force Lake is largely unknown. No tissue data have been collected to date from Force Lake or from the wetland area, and soil, sediment, and water data are limited.

Therefore, Phase 1 soil, sediment, and water data will be assessed to evaluate whether collection of tissue data is warranted to refine risk estimates for ecological receptors. This assessment, as discussed in the QAPP (Appendix B), will be based on preliminary risk calculations conducted with Phase 1 data using conservative assumptions.

Based on these calculations and in consultation with EPA, a determination will be made regarding whether risk estimates warrant tissue data to reduce uncertainties. If warranted, fish and/or small mammal tissue data will be collected as part of Phase 2.

5.0 RI/FS TASKS

5.1 Community Relations

The SOW states that the development and implementation of community relations activities are the responsibility of EPA. As requested, the Voluntary Group will assist EPA by providing information for public meetings, participating in public meetings, and providing information for a community document repository established by EPA at or near the Site. While the extent of Respondent involvement in EPA-related community relations activities is up to EPA, the SOW states that EPA will provide Voluntary Group with advanced notice of any planned community relations activities.

5.2 Site Characterization

The SOW states that the overall objective of site characterization is to describe areas of a site that may pose a threat to human health or the environment. In the site characterization task, the physical characteristics (i.e., physiography, geology, and hydrology), pathways of migration, and sources of contamination will be identified, and risks to human health and ecological receptors will be defined. The nature and extent of contamination at the Harbor Oil facility, in wetlands adjacent to the Harbor Oil facility, and in Force Lake will also be defined.

5.2.1 Field Investigation

The QAPP²² (Appendix B) presents the proposed sampling plan for the field investigation. Section 4.5 presents an overview of the field sampling effort. The proposed field investigation will be conducted for the Site to provide sufficient data in order to define the nature and extent of contamination, complete baseline risk assessments, and support the identification and evaluation of remedial alternatives as part of the FS.

As stated in the SOW, the activities included as part of the field investigation will address the following:

- Define site physical and biological characteristics
- Characterize sources of contamination

²² The QAPP includes all of the details of the SOW-defined sampling and analysis plan: field sampling plan details, project objectives and organization, functional activities, quality assurance and quality control (QA/QC) protocols, sampling procedures, sample custody, analytical procedures and ACGs, data reduction, reporting, personnel qualifications, and data collection techniques.

- Define human and ecological use of the Harbor Oil facility, adjacent wetlands adjacent, and Force Lake
- Characterize the nature and extent of contamination

Field investigation activities will be performed in accordance with the methods and objectives outlined in this Work Plan, QAPP (Appendix B), and HSP (Appendix C). The Voluntary Group will notify EPA at least two weeks prior to initiating field support activities so that EPA may adequately schedule oversight tasks. EPA will be notified of any deviations from the RI/FS Work Plan or QAPP following the procedures outlined in the PMP (Appendix A). All deviations will be noted during field activities. As outlined in the QAPP, the proposed laboratory and laboratory analytical process meets the specific QA/QC requirements, data quality criteria, and the overall DQOs of the site investigation.

As presented in Section 4.5, the field investigation will be conducted in two phases. Phase 1 sampling is intended to provide most of the information needed to fill the data gaps identified for the Site. Phase 2 sampling will be conducted following the evaluation of Phase 1 data and a meeting with EPA to discuss the Phase 1 results. Phase 2 sampling will occur where additional data are needed to better characterize ecological or human health risks, to further refine the delineation of areas of contamination within the Site, or to determine the extent of contamination from the Harbor Oil facility in surrounding areas. The scope of the Phase 2 effort will be determined in consultation with EPA based on the results from Phase 1.

As indicated in the RI/FS schedule contained in the PMP, Phase 1 sampling will occur over three months from February through April 2008. Phase 2 sampling will occur between July and October 2008. Data collection, analysis, and evaluation will occur throughout the Phase 1 data collection and analysis phase in order to expedite the decision making process for determining whether Phase 2 data are needed. Phase 2 data needs will be determined at a meeting with EPA based on preliminary Phase 1 data. The schedule for the meeting is provided in the project schedule contained in the PMP.

The results of the field investigation will be used to identify site- and media-specific COPCs. As part of the RI, the Voluntary Group will meet with EPA technical representatives to develop human health and ecological preliminary remediation goals (PRGs) for COPCs. The schedule for the meeting is provided in the project schedule contained in the PMP.

5.2.2 Data Analysis

Data analysis for the RI will evaluate site characteristics (i.e., the nature and extent of contamination from the facility and potential sources for contamination) and will assess human health and ecological risks. Details on these two data analyses are presented in the following subsections.

5.2.2.1 Evaluation of Site Characteristics

Data collected during Phases 1 and 2 will be used to characterize chemical concentrations in various media. The Voluntary Group will analyze and evaluate the data collected to describe:

- The physical and biological characteristics of the Harbor Oil facility, adjacent wetlands, and Force Lake area.
- The chemical concentrations in areas affected by known or suspected sources.
- The nature and extent of contamination to evaluate human health and ecological exposures, including a comparison of concentrations to PRGs.
- The extent of horizontal and vertical contamination taking into consideration chemical mobility and persistence of chemicals.

As stated in the SOW, if the Voluntary Group consider the use of modeling for data evaluation, the models will be identified to EPA in a technical memorandum prior to their use. The information reviewed in this evaluation will include information necessary to assess the need for remedial actions or corrective measures, develop the baseline risk assessment, and develop and evaluate potential remedial alternatives, as appropriate.

5.2.2.2 Baseline Human Health and Ecological Risk Assessment

The data collected during Phase 1 and 2 will be used to support the baseline HHRA and ERA reports. The preliminary CSM defines the exposure pathways, human health scenarios, and ecological receptors that will be evaluated in the baseline HHRA and ERA (Section 3.6 and 3.7, respectively).

The Voluntary Group will prepare a risk assessment scoping memorandum as an interim deliverable prior to the submittal of the draft baseline HHRA and ERA. The risk assessment scoping memorandum will describe key elements of the human health and ecological risk assessments, including key exposure assumptions that will be evaluated in the baseline HHRA and ERA as well as methods for the selection of toxicity thresholds. The risk assessment scoping memorandum will revise the preliminary CSM presented in Section 3 to reflect any new information and data collected from the Site. Exposure assumptions will use available site-specific and regional information to optimize the site-specific nature of the exposure assessment. In addition, potential exposures associated with proposed future uses of the property will be considered. In consultation with EPA, the Voluntary Group will identify planned or projected developments and any other reasonably foreseeable future uses that may increase or decrease potential human or ecological exposure to chemicals at the Site.

The risk assessment scoping memorandum will also provide a list of any interim deliverables and a schedule for their submittal, as necessary, prior to the submittal of the draft RI. Consistent with the SOW and RI/FS

schedule in the PMP, the risk assessment scoping memorandum will be submitted within 240 days of receiving EPA approval of the RI/FS work plan and approval of Site access. The draft baseline HHRA and ERA reports will be submitted to EPA using the methods and assumptions outlined in the risk assessment scoping memorandum, per EPA comments and following EPA approval.

5.2.3 Data Management

The Voluntary Group has compiled (i.e., tabulated) the available historical data. Prior to including any of these data into the Site database, the Voluntary Group will evaluate the historical data to determine if it meets acceptability requirements under the data quality process. Data that meet the acceptable requirements will be considered acceptable for use during the RI/FS process. The Site database will be augmented with analytical data collected from Phase 1 and Phase 2 sampling.

After EPA reviews the available historical data and approves the data quality requirements, the Voluntary Group will incorporate the acceptable data into a database. Microsoft Access will be used to compile and organize a Site database. This database format will facilitate in data analysis, generating data tables for reports, and interfacing with GIS. The project database manager(s) will maintain the database. The Voluntary Group will present information and data relevant to the decision-making process, both in electronic and database formats, during the course of the RI/FS to EPA. Further details regarding data management are presented in the PMP and QAPP.

Data gathered during site characterization will be documented and adequately recorded by the Voluntary Group in field logs and laboratory reports. The QAPP (Appendix B) outlines the method for field log documentation and formats for laboratory reports. Field logs will be used to document observations, measurements, and significant events that have occurred during field activities. Laboratory reports will document sample custody; analytical responsibility; analytical results; adherence to prescribed protocols, nonconformity events and corrections thereof; and/or data deficiencies.

The Voluntary Group will document the quality and validity of field and laboratory data compiled and generated during the RI. As outlined in the QAPP (Appendix B), the Voluntary Group will maintain field reports, sample shipment records, analytical results, and QA/QC reports to ensure that only validated analytical data are reported and utilized in the characterization of the nature and extent of contamination and the development and evaluation of potential remedial alternatives. Analytical results will not be included in any site characterization reports unless accompanied by or cross-referenced to a corresponding QA/QC report. In addition, the Voluntary Group will establish a data security system to safeguard chain-of-custody forms and other project records to prevent loss, damage, or alteration of project documentation.

5.2.4 Site Characterization Deliverables

5.2.4.1 Preliminary Site Characterization Summary

In accordance with the AOC revision approved by EPA, the Voluntary Group will prepare a summary report that compiles data collected during Phase 1. The summary report will discuss the field investigation activities and any deviations from the RI/FS work plan. The summary report will present the locations and characteristics of surface and subsurface features, and the nature and extent of contamination. The spatial distribution of contamination in the vicinity of known sources and estimated chemical loadings will be presented, along with visual and tabular screening of the chemicals of concern against ARARs and PRGs. The extent of chemical migration through and from the Site will be presented. The Preliminary Site Characterization will identify data gaps that need to be filled during Phase 2. If requested by EPA, an addendum to the summary report will be issued after Phase 2 data have been collected and validated.

A schedule for submittal of the preliminary site characterization summary will be submitted to EPA after receiving EPA approval of the RI/FS work plan. The report will be provided to EPA in hardcopy and electronic format.

5.2.4.2 Baseline HHRA and ERA

The Voluntary Group will prepare and submit draft baseline HHRA and ERA reports for EPA review as part of the RI report that is organized to follow both national and regional (Region 10) EPA guidance for HH (EPA 1989, 1991, 1996, 1999a, 1998b, 2001b) and ERA (EPA 1989, 1997a, 1998a, 1997b).

The baseline risk assessments will include the following sections:

- Introduction
- Problem Formulation (for ERA only)
- Identification of chemicals of potential concern
- Exposure assessment
- Effects assessment
- Risk Characterization
- Uncertainty Evaluation
- Summary and Conclusions

Consistent with the SOW and RI/FS schedule in the PMP, the draft baseline risk assessments will be submitted to EPA within 360 days of receiving EPA approval of the RI/FS work plan and approval of Site access. The final baseline HHRA and ERA will be included as part of the RI report. The draft and final baseline risk assessments will be submitted to EPA in hardcopy and electronic format.

5.2.4.3 Remedial Investigation Report

The Voluntary Group will prepare and submit a draft RI report for EPA review that is organized to follow the format presented in EPA guidance (EPA 1988). The RI report will include the following sections:

- Introduction
- Study Area Investigation
- Physical Characteristics of the Study Area
- Nature and Extent of Contamination
- Chemical Fate and Transport
- Baseline Risk Assessment
- Summary and Conclusions

Consistent with the SOW and RI/FS schedule in the PMP, the draft RI report will be submitted to EPA within 540 days of receiving EPA approval of the RI/FS work plan and approval of Site access. Within 30 days of receiving comments from EPA, the Voluntary Group will submit the final RI report. The draft and final RI reports will be submitted to EPA in hardcopy and electronic format.

5.3 Treatability Studies

The need for and scope of any treatability studies conducted to complete the screening and evaluation of potential remedial alternatives cannot be determined at this time. If a treatability study or studies are needed, the Voluntary Group will prepare a draft treatability study work plan and submit it to EPA within 450 days of receiving EPA approval of the RI/FS work plan and approval of Site access. Consistent with EPA RI/FS guidance, the need for a treatability study or studies will be based on an evaluation of the adequacy of existing technology data and site data to screen and evaluate remedial technologies identified during the alternative development process. The outline and format of the treatability studies work plan will depend upon whether bench-scale or pilot-scale studies are performed.

The treatability studies work plan will be submitted to EPA within 360 days of receiving EPA approval of the RI/FS work plan and approval of Site access. Within 30 days of receiving comments from EPA, the Voluntary Group will submit the final treatability studies work plan.

Upon receipt of EPA approval of the final treatability studies work plan, the Voluntary Group will submit a treatability study SAP and HSP in accordance with the schedule in the AOC.

Following completion of the treatability study or studies, the Voluntary Group will prepare and submit a treatment alternatives technical memorandum that analyzes and interprets treatability testing data with

respect to the effectiveness, implementability and cost of the technology or technologies evaluated during the treatability studies.

The draft and final reports will be submitted to EPA in hardcopy and electronic format.

5.4 Development and Screening of Remedial Alternatives

The development and screening of remedial action alternatives will involve completing the process described in the SOW. Specifically, the Voluntary Group will review and, if necessary, modify the site-specific RAOs and PRGs, based on the baseline risk assessments and RI results. If the PRGs are revised, they will be documented in a remedial alternatives development and screening technical memorandum that will be submitted to EPA for review and approval.

The Voluntary Group will further develop general response actions for each media to satisfy the RAOs and identify areas and volumes of affected media. This step will be followed by the identification and screening of remedial technologies and process options that align with each general response action. Consistent with EPA RI/FS guidance, process options will be screened based on short- and long-term effectiveness, implementability, and cost. The screening results will be submitted to EPA in the remedial alternatives development and screening technical memorandum.

Remedial technologies that are retained during the screening process will be assembled to create a range of remedial alternatives that include containment and treatment technologies. Remedial alternatives will be developed for each affected medium (i.e., soils, groundwater, wetland soils and surface water/sediments). The Voluntary Group will prepare a summary of the assembled alternatives and their related action-specific and chemical-specific ARARs and PRGs for inclusion in the alternatives development and screening technical memorandum.

Finally, the Voluntary Group will screen the potential remedial alternatives based on their short- and long-term effectiveness, implementability, and relative cost. As appropriate, the screening will retain a range of alternatives that include containment and treatment technologies. The screening results will be presented in the alternatives development and screening technical memorandum that will be submitted to EPA for review. The Voluntary Group will meet with EPA to discuss the results of their alternative development and screening process, and to present the alternatives selected for detailed analysis. The Voluntary Group will modify the alternatives selected for detailed analysis if required by EPA.

5.5 Detailed Analysis of Remedial Alternatives

In accordance with the SOW, the Voluntary Group will conduct a detailed analysis of the retained alternatives against seven of the nine CERCLA evaluation criteria, including:

1. Overall protection of human health and the environment
2. Compliance with ARARs
3. Long-term effectiveness and permanence
4. Reduction in toxicity, mobility and volume
5. Short-term effectiveness
6. Implementability
7. Costs

EPA will address the remaining two CERCLA evaluation criteria: state acceptance and community acceptance.

The Voluntary Group will also conduct a comparative analysis using the same seven criteria.

The results of the detailed analysis of remedial alternatives will be summarized in a technical memorandum that will be submitted to EPA prior to preparing the FS report.

5.6 Feasibility Study Report

The Voluntary Group will prepare a draft FS report that will provide the basis for final remedy selection by EPA. The report will discuss the remedial alternatives development and screening results and detailed analysis of remedial alternatives. The format of the FS report will follow EPA guidance and will include:

- Introduction
- Identification and Screening of Technologies
- Development and Screening of Alternatives
- Detailed Analysis of Alternatives

Consistent with the SOW and RI/FS schedule in the PMP, the draft FS report will be submitted to EPA within 270 days of receiving EPA approval of the Treatability Study SAP or 120 day after EPA approval of the final RI report. Within 60 days of receiving comments from EPA, the Voluntary Group will submit the final FS report. The draft and final FS reports will be submitted to EPA in hardcopy and electronic format.

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Table 1
October 10, 2006 Heron Lakes Golf Courses Water Quality Sampling Results

Field Parameter	Force Lake	Southwestern Slough
pH	8.22	8.50
Specific conductance – uS/cm	281	253
Dissolved oxygen – mg/L	12.77	7.18
Laboratory Parameter		
Orthophosphate-Phosphorus – mg/L	0.24	0.04
Nitrate-Nitrogen – mg/L	0.1U	0.3
Clpyralid (Confront) – ug/L	0.08U	0.08U
Fludioxanil (Medallion) – ug/L	0.03U	0.03U
Glyphosate (Roundup) – ug/L	10U	10U
Propiconazole (Banner) – ug/L	0.12U	0.12U
Triadimefon (Bayleton) – ug/L	0.6U	0.6U

Table 2
Summary of Human Health Screening Results - Harbor Oil Site

Analyte group	Surface soils		Subsurface soils		Wetland soils		Groundwater		Sediment ^a		Surface Water ^b	
	Detect > HH SL	DL > HH SL	Detect > HH SL	DL > HH SL	Detect > HH SL	DL > HH SL	Detect > HH SL	DL > HH SL	Detect > HH SL	DL > HH SL	Detect > HH SL	DL > HH SL
Metals^a												
Aluminum					X ^c		X ^c					
Antimony					X		X					
Arsenic	X		X		X		X					X
Iron					X ^c		X ^c		X		X ^c	
Lead	X		X		X		X		X			
Manganese					X ^c		X ^c		X			
Thallium								X				
Vanadium					X		X					
Zinc							X					
VOCs												
Benzene		X				X		X				X
Bromodichloromethane		X				X		X				
Bromoform						X						X
Bromomethane		X				X		X				
Carbon tetrachloride		X				X		X				X
Chloroform		X				X		X				
Chlorobenzene						X	X					
Chloroethane						X						
Chloromethane		X				X		X				
1,2-Dibromo-3-chloropropane		X		X		X		X				
Dibromochloromethane								X				
1,2-Dibromomethane		X		X		X		X				
1,3-Dichlorobenzene						X						
1,4-Dichlorobenzene						X	X					
1,2-Dichloroethane		X				X		X				X
cis-1,2-Dichloroethene						X						
trans-1,2-Dichloroethene						X						
1,2-Dichloropropane						X	X					X
cis-1,3-Dichloropropane												X
trans-1,3-Dichloropropane												X
Hexachlorobutadiene								X				
Methyl tert-butyl ether						X						
Methylene chloride												X
1,1,1,2-Tetrachloroethane								X				
1,1,2,2-Tetrachloroethane						X		X				X
Tetrachloroethene	X					X	X					X
1,2,4-Trichlorobenzene								X				
1,1,2-Trichloroethane						X		X				X
Trichloroethene	X					X	X					X
1,2,3-Trichloropropane		X				X		X				
1,3,5-Trimethylbenzene	X											
Vinyl chloride		X				X	X					X
PAHs												
Benzo(a)anthracene		X				X		X				X
Benzo(a)pyrene	X			X	X			X		X		X
Benzo(b)fluoranthene		X			X			X		X		X
Benzo(k)fluoranthene						X		X				X
Chrysene												X
Dibenzo(a,h)anthracene	X			X		X		X		X		X
Indeno(1,2,3-cd)pyrene		X			X			X				X
Naphthalene	X				X			X				
Other SVOCs												
Bis(2-chloroethyl)ether		X				X		X				X
Bis(2-chloroisopropyl)ether								X				
4-Chloroaniline						X						
1,2-Dichlorobenzene		X				X						
1,3-Dichlorobenzene		X				X						
1,4-Dichlorobenzene		X				X						
3,3'-Dichlorobenzidine		X				X						X
2,4-Dinitrophenol		X		X		X		X				
2,4-Dinitrotoluene												X
2,6-Dinitrotoluene		X		X		X		X				
BEHP												X

Table 2
Summary of Human Health Screening Results - Harbor Oil Site

Analyte group	Surface soils		Subsurface soils		Wetland soils		Groundwater		Sediment ^a		Surface Water ^b	
	Detect > HH SL	DL > HH SL	Detect > HH SL	DL > HH SL	Detect > HH SL	DL > HH SL	Detect > HH SL	DL > HH SL	Detect > HH SL	DL > HH SL	Detect > HH SL	DL > HH SL
Hexachlorobenzene		X				X		X				X
Hexachlorobutadiene						X						X
Hexachloroethane		X				X						
N-Nitrosodi-n-propylamine		X				X		X		X		X
N-Nitrosodiphenylamine												X
Nitrobenzene		X				X		X				
Pentachlorophenol		X				X						X
2,4,6-Trichlorophenol		X				X						X
PCBs												
Aroclor 1221		X		X		X		X				
Aroclor 1232				X		X		X				
Aroclor 1242				X		X		X				
Aroclor 1248	X		X			X		X				
Aroclor 1254	X			X		X		X				
Aroclor 1260	X		X		X			X				
Total PCBs								X				X
Pesticides												
Aldrin								X				X
alpha-BHC												X
beta-BHC												X
p,p'-DDD	X											X
p,p'-DDE												X
p,p'-DDT												X
alpha-Chlordane	X											X
gamma-Chlordane												X
Dieldrin								X				X
Endrin												X
Hetachlor								X				X
Heptachlor epoxide								X				X
Toxaphene						X		X				X
Petroleum Hydrocarbons												
Diesel-Range			X									
Heavy Oil-Range			X		X							

^a Based on sediment sample collected from Force Lake

^b Based on surface water sample collected from Force Lake

^b Crustal elements (i.e., aluminum, iron and manganese) were not included as preliminary COPCs, as these elements are naturally occurring and there are no known or suspected Site-related sources.

BEHP - Bis(2-ethylhexyl)phthalate

Table 3
Summary of Ecological Screening Results - Harbor Oil Site

Analyte group	Surface soils		Subsurface soils		Wetland soils		Sediment ^a		Surface Water ^b	
	Detect > Eco SL	DL > Eco SL	Detect > Eco SL	DL > Eco SL	Detect > Eco SL	DL > Eco SL	Detect > Eco SL	DL > Eco SL	Detect > Eco SL	DL > Eco SL
Metals										
Aluminum	X ^c		X ^c		X ^c					
Antimony		X		X	X					
Arsenic	X				X					
Barium	X									
Cadmium	X		X		X					
Chromium	X		X		X					
Cobalt	X				X					
Copper	X		X		X		X		X	
Iron	X ^c		X ^c		X ^c				X ^c	
Lead	X		X		X		X		X	
Manganese	X ^c		X ^c		X ^c					
Mercury	X				X					
Nickel					X					
Selenium					X					
Vanadium	X		X		X					
Zinc	X		X		X		X			
VOCs										
Carbon disulfide										X
1,4-Dichlorobenzene		X								
1,1-Dichloroethene										X ^d
cis-1,3-Dichloropropene										X
trans-1,3-Dichloropropene										X
Trichloroethene									X ^d	
PAHs										
Anthracene								X		X
Benzo(a)anthracene										X
Benzo(a)pyrene										X
Dibenzo(a,h)anthracene								X		
9H-Fluorene								X		X
Other SVOCs										
BEHP	X					X				X
Benzyl alcohol										X
4-Bromophenyl phenylether										X
Dibenzofuran	X		X		X					X
2,4-Dinitrophenol		X				X				
Hexachlorocyclopentadiene		X				X				
4-Nitrophenol		X				X				
Pentachlorophenol		X				X				
2,4,5-Trichlorophenol		X				X				
2,4,6-Trichlorophenol		X								
PCBs										
Aroclor 1016								X		
Aroclor 1221								X		X
Aroclor 1232								X		
Aroclor 1242								X		X
Aroclor 1248								X		X
Aroclor 1254	X							X		X
Aroclor 1260								X		
Total PCBs										X

Table 3
Summary of Ecological Screening Results - Harbor Oil Site

Analyte group	Surface soils		Subsurface soils		Wetland soils		Sediment ^a		Surface Water ^b	
	Detect > Eco SL	DL > Eco SL	Detect > Eco SL	DL > Eco SL	Detect > Eco SL	DL > Eco SL	Detect > Eco SL	DL > Eco SL	Detect > Eco SL	DL > Eco SL
Pesticides										
p,p'-DDD	X		X		X		X			X
p,p'-DDE	X		X		X			X		X
p,p'-DDT	X				X			X		X
alpha-Chlordane								X		X
gamma-Chlordane								X		X
Dieldrin								X		
Endrin		X						X		X
Endosulfan II										X
Heptachlor epoxide								X		X
Lindane (gamma-BHC)								X		
Methoxychlor										X
Toxaphene										X

^a Based on sediment sample collected from Force Lake

^b Based on surface water sample collected from Force Lake, except where noted

^c Crustal elements (i.e., aluminum, iron and manganese) were not included as preliminary COPCs, as these elements are naturally occurring and there are no known or suspected Site-related sources.

^d Based on surface water collected on-site (not from Force Lake)

BEHP - Bis(2-ethylhexyl)phthalate

Table 4
Detected TPH and Metals Concentrations in Surface Soil - Harbor Oil Site

	Reporting Source	Date	Sample Location	Sample Number	Sample Depth (feet)	Duplicate	NWTPH-HCID (mg/kg)			NWTPH-Dx (mg/kg)		TPH (mg/kg)
							Gasoline Range TPH	Diesel Range TPH	Oil Range TPH	Diesel Range TPH	Oil Range TPH	Unknown Range
Type of Analysis												
Fixed Laboratory	E&E, 2001	7/31/2000	BG01	BG01SS-00314162	1-2		20 U	50 U	100 U			
	E&E, 2001	8/2/2000	BG03	BG03SS-00314184	0.5-1		20 U	50 U	100 U			
	E&E, 2001	7/31/2000	DP01	DP01SS-00314150	1-2		400	4,000	6,600	3,300	4,300	
	E&E, 2001	7/31/2000	DP02	DP02SS-00314153	1-2		190	7,300	12,000	6,200	8,500	
	E&E, 2001	7/31/2000	DP03	DP03SS-00314159	1-2		20 U	63	230	65	210	
	E&E, 2001	8/1/2000	SS01	SS01SS-00314174	0-1.5		20 U	660	1,000	820	940	
	E&E, 2001	8/1/2000	SS02	SS02SS-00314175	0-1.5		57 U	2,000	3,100	2,400	3,100	
	E&E, 2001	8/1/2000	SS03	SS03SS-00314176	1-1.5		20 U	59	230	440	730	
	E&E, 2001	8/1/2000	SS04	SS04SS-00314177	1-1.5		20 U	50 U	100 U			
	E&E, 2001	8/1/2000	SS05	SS05SS-00314178	1.5-2.5		2,600	11,000	12,000	13,000	12,000	
	E&E, 2001	8/1/2000	SS06	SS06SS-00314179	1-1.5		20 U	50 U	100 U			
	E&E, 2001	8/1/2000	SS07	SS07SS-00314180	1-1.5		20 U	100	340	140	280	
	E&E, 2001	8/2/2000	SS08	SS08SS-00314181	0.5-1		24 U	1,300	2,200	1,400	1,700	
	E&E, 2001	8/2/2000	SS09	SS09SS-00314182	1-1.5		22	650	1,400	640	1,300	
	E&E, 2001	8/2/2000	SS10	SS10SS-00314183	1-1.5		20 U	50 U	100 U			
	Golder, 1990	1990	GAI-SS2	GAI-SS2	0							
	Golder, 1990	1990	GAI-SS3	GAI-SS3	0							
	Golder, 1990	1990	P-275	P-275	0							
	Coles, 2002	8/1/2000	SS02	SS #2 (SS 02SS)	0-1.5		20 U	DET	DET	2,020	4,050	
	Coles, 2002	8/1/2000	SS03	SS #3 (SS 03SS) ¹	1-1.5		20 U	DET	DET	92.9	289	
	Coles, 2002	8/1/2000	SS04	SS #4 (SS 04SS)	1-1.5		20 U	50 U	100 U			
	Coles, 2002	8/1/2000	SS05	SS #5 (SS 05SS)	1.5-2.5		20 U	DET	DET	11,900	15,000	
Screening Levels Human Health Screening Value EPA Region 6 Screening Level ² Industrial DEQ RBCs ^{3,4} Soil Ing., Dermal Contact, Inhalation Vol. to Outdoor Air Vapor Intrusion into Buildings Leaching to GW Ecological Screening Value EPA Eco SSL, ORNL, or DEQ SLV ^{5,6,7}							NC	NC	NC	NC	NC	
							NC	NC	NC	23,000	23,000	
							NC	NC	NC	120,000	120,000	
							NC	NC	NC	120,000	120,000	
							NC	NC	NC	120,000	120,000	

Legend
Shading = Exceeds human health screening level
Solid outline = Exceeds ecological screening level
Bold = Detected concentration
NC = No criteria
DET = Detected
U = Not detected
J = Indicates an estimated value below the calculated detection limit.
K = Unknown bias.
L = Low bias.
H = High bias.
Q = The results is estimated because it is below the sample quantitation limit.

¹ With Acid/Silica Gel Cleanup.
² EPA Region 6 Screening Levels, 2007.
Most stringent industrial soil screening level. Adjusted to Hazard Quotient of 0.1 to account for cumulative risks.
³ DEQ, Risk-Based Decision Making for the Remediation of Petroleum-Contaminated Sites, 2007.
⁴ Most stringent occupational, construction or excavation worker Risk-Based Concentration (RBC).
⁵ EPA Soil Screening Levels at <http://www.epa.gov/oswer/riskassessment/ecorisk/ecossl.html>
⁶ Oak Ridge National Laboratory (Efroymson et al., 1997a and 1997b)
⁷ DEQ Level II Ecological Screening Level Values (SLVs) for wildlife (DEQ, 2001b)

Table 4
Detected TPH and Metals Concentrations in Surface Soil - Harbor Oil Site

	Reporting Source	Date	Sample Location	Sample Number	Sample Depth (feet)	Duplicate	Inorganics (mg/kg)									
							Aluminum	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron
Type of Analysis																
Fixed Laboratory	E&E, 2001	7/31/2000	BG01	BG01SS-00314162	1-2		4,990	1.22	80.9	0.18	0.20 U	2,600	9.49	8.81	8.4 JK	11,900
	E&E, 2001	8/2/2000	BG03	BG03SS-00314184	0.5-1		7,470	2.72	102	0.43	0.30	4,180	11.3	8.58	15.2	26,800
	E&E, 2001	7/31/2000	DP01	DP01SS-00314150	1-2		8,160	1.32	100	0.47	0.75	6,530	22.1	16.5	46 JK	43,300
	E&E, 2001	7/31/2000	DP02	DP02SS-00314153	1-2		10,300	3.37	148	0.59	0.71	7,740	21.8	25.5	85 JK	37,500
	E&E, 2001	7/31/2000	DP03	DP03SS-00314159	1-2		11,200	4.56	99.6	0.35	0.20 U	16,300	20.4	13.6	40 JK	25,900
	E&E, 2001	8/1/2000	SS01	SS01SS-00314174	0-1.5		7,020	2.22	113	0.32	1.17	5,920	32.2	11	120 JK	32,500
	E&E, 2001	8/1/2000	SS02	SS02SS-00314175	0-1.5		8,470	4.42	146	0.49	0.60	18,100	19.1	15.7	140 JK	43,200
	E&E, 2001	8/1/2000	SS03	SS03SS-00314176	1-1.5		7,110	3.29	218	0.579	0.34	7,480	10.2	7.37	25 JK	15,000
	E&E, 2001	8/1/2000	SS04	SS04SS-00314177	1-1.5		5,860	1.50	118	0.29	0.25	3,220	9.57	5.18	9.23	12,500
	E&E, 2001	8/1/2000	SS05	SS05SS-00314178	1.5-2.5		9,750	7.21	218	0.539	3.76	18,500	38.0	14.2	293	34,800
	E&E, 2001	8/1/2000	SS06	SS06SS-00314179	1-1.5		5,790	1.73	129	0.29	0.35	3,040	11.2	5.49	10.4	14,000
	E&E, 2001	8/1/2000	SS07	SS07SS-00314180	1-1.5		11,000	1.76	103	0.525	0.55	5,500	24.0	12.4	41.6	27,500
	E&E, 2001	8/2/2000	SS08	SS08SS-00314181	0.5-1		9,870	1.92	126	0.601	0.72	7,400	20.4	21.3	58.8	46,200
	E&E, 2001	8/2/2000	SS09	SS09SS-00314182	1-1.5		5,280	1.88	71	0.30	0.20 U	6,640	16.2	8.43	29.6	21,600
	E&E, 2001	8/2/2000	SS10	SS10SS-00314183	1-1.5		8,840	2.06	89.1	0.34	0.20 U	7,360	16.7	9.89	16.2	22,400
	Golder, 1990	1990	GAI-SS2	GAI-SS2	0			24	411				54.0			
	Golder, 1990	1990	GAI-SS3	GAI-SS3	0			4	133				21.0			
	Golder, 1990	1990	P-275	P-275	0											
	Coles, 2002	8/1/2000	SS02	SS #2 (SS 02SS)	0-1.5											
	Coles, 2002	8/1/2000	SS03	SS #3 (SS 03SS) ¹	1-1.5											
	Coles, 2002	8/1/2000	SS04	SS #4 (SS 04SS)	1-1.5											
	Coles, 2002	8/1/2000	SS05	SS #5 (SS 05SS)	1.5-2.5											
Screening Levels Human Health Screening Value EPA Region 6 Screening Level ² Industrial DEQ RBCs ^{3,4} Soil Ing., Dermal Contact, Inhalation Vol. to Outdoor Air Vapor Intrusion into Buildings Leaching to GW Ecological Screening Value EPA Eco SSL, ORNL, or DEQ SLV ^{5,6,7}							100,000	1.8	100,000	220	56	NC	450	1,900	4,200	100,000
							NC	1.7	6,200	61	8,600	NC	180	NC	1,100	NC
							NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
							NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
							NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
							50	18	330	21	0.36	NC	26	13	28	200

Legend
Shading = Exceeds human health screening level
Solid outline = Exceeds ecological screening level
Bold = Detected concentration
NC = No criteria
DET = Detected
U = Not detected
J = Indicates an estimated value below the calculated detection limit.
K = Unknown bias.
L = Low bias.
H = High bias.
Q = The results is estimated because it is below the sample quantitation limit.
¹ With Acid/Silica Gel Cleanup.
² EPA Region 6 Screening Levels, 2007.
Most stringent industrial soil screening level. Adjusted to Hazard Quotient of 0.1 to account for cumulative risks.
³ DEQ, Risk-Based Decision Making for the Remediation of Petroleum-Contaminated Sites, 2007.
⁴ Most stringent occupational, construction or excavation worker Risk-Based Concentration (RBC).
⁵ EPA Soil Screening Levels at <http://www.epa.gov/oswer/riskassessment/ecorisk/ecossl.htm>
⁶ Oak Ridge National Laboratory (Efroymsen et al., 1997a and 1997b)
⁷ DEQ Level II Ecological Screening Level Values (SLVs) for wildlife (DEQ, 2001b)

Table 4
Detected TPH and Metals Concentrations in Surface Soil - Harbor Oil Site

Type of Analysis	Reporting Source	Date	Sample Location	Sample Number	Sample Depth (feet)	Duplicate	Inorganics (mg/kg)										
							Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Vanadium	Zinc
Fixed Laboratory	E&E, 2001	7/31/2000	BG01	BG01SS-00314162	1-2		3.64	2,620	135	0.046 U	10.7	984	0.1 U	0.4 U	279	31.2	37.5
	E&E, 2001	8/2/2000	BG03	BG03SS-00314184	0.5-1	JL	11.8	4,360	387	0.038 U	12.4	1,250	0.1 U	0.72	200	69.6	57.8
	E&E, 2001	7/31/2000	DP01	DP01SS-00314150	1-2		105	3,060	645	0.04 U	9.86	769	0.5 U	1.4	524	149	146
	E&E, 2001	7/31/2000	DP02	DP02SS-00314153	1-2		67.8	4,360	720	0.049	14.1	1,130	0.14	0.96	355	97.1	158
	E&E, 2001	7/31/2000	DP03	DP03SS-00314159	1-2		16.8	4,410	329	0.043 U	19.6	716	0.1 U	0.83	616	75.4	89.4
	E&E, 2001	8/1/2000	SS01	SS01SS-00314174	0-1.5		100	3,460	385	0.052	16.9	942	0.1 U	1.1	625	111	194
	E&E, 2001	8/1/2000	SS02	SS02SS-00314175	0-1.5		100	3,850	977	0.072	12.9	1,150	0.5 U	1.3	444	105	239
	E&E, 2001	8/1/2000	SS03	SS03SS-00314176	1-1.5		19.7	3,100	277	0.05 U	10.7	1,030	0.43	0.76	473	37.5	60.4
	E&E, 2001	8/1/2000	SS04	SS04SS-00314177	1-1.5	JL	5.67	2,880	163	0.043 U	10.7	952	0.1	0.40 U	311	31.1	43.8
	E&E, 2001	8/1/2000	SS05	SS05SS-00314178	1.5-2.5		337	4,580	532	6.69	31.5	1,350	0.5 U	3.16	523	49.8	289
	E&E, 2001	8/1/2000	SS06	SS06SS-00314179	1-1.5	JL	6.28	2,890	158	0.049 U	11.3	1,080	0.1 U	0.48	286	38.4	52.6
	E&E, 2001	8/1/2000	SS07	SS07SS-00314180	1-1.5		37.7	5,370	473	0.042 U	18.4	1,720	0.5 U	0.76	463	74.6	86.4
	E&E, 2001	8/2/2000	SS08	SS08SS-00314181	0.5-1		103	3,500	784	0.06	10.8	831	0.5 U	1.0	513	151	170
	E&E, 2001	8/2/2000	SS09	SS09SS-00314182	1-1.5	JL	11.7	3,750	383	0.04 U	10.2	740	0.5 U	0.42	316	55.3	66.4
	E&E, 2001	8/2/2000	SS10	SS10SS-00314183	1-1.5	JL	6.92	4,060	247	0.041 U	18.1	576	0.5 U	0.64	419	66	58.3
	Golder, 1990	1990	GAI-SS2	GAI-SS2	0		76			"0"				U	2.0		
	Golder, 1990	1990	GAI-SS3	GAI-SS3	0		70			"0"				U	3.0		
	Golder, 1990	1990	P-275	P-275	0												
	Coles, 2002	8/1/2000	SS02	SS #2 (SS 02SS)	0-1.5		95.2										
	Coles, 2002	8/1/2000	SS03	SS #3 (SS 03SS) ¹	1-1.5		24.4										
	Coles, 2002	8/1/2000	SS04	SS #4 (SS 04SS)	1-1.5		10 U										
	Coles, 2002	8/1/2000	SS05	SS #5 (SS 05SS)	1.5-2.5		236										
Screening Levels Human Health Screening Value EPA Region 6 Screening Level ² Industrial DEQ RBCs ^{3,4} Soil Ing., Dermal Contact, Inhalation Vol. to Outdoor Air Vapor Intrusion into Buildings Leaching to GW Ecological Screening Value EPA Eco SSL, ORNL, or DEQ SLV ^{5,6,7}							800	NC	3,500	34	2,300	NC	570	570	NC	570	100,000
							800	NC	1,400	9.3	620	NC	NC	150	NC	NC	NC
							NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
							NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
							3	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
							11	NC	220	0.1	38	NC	1.0	4.2	NC	7.8	50

Legend
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K = Unknown bias.
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¹ With Acid/Silica Gel Cleanup.
² EPA Region 6 Screening Levels, 2007.
Most stringent industrial soil screening level. Adjusted to Hazard Quotient of 0.1 to account for cumulative risks.
³ DEQ, Risk-Based Decision Making for the Remediation of Petroleum-Contaminated Sites, 2007.
⁴ Most stringent occupational, construction or excavation worker Risk-Based Concentration (RBC).
⁵ EPA Soil Screening Levels at <http://www.epa.gov/oswer/riskassessment/ecorisk/ecosl.htm>
⁶ Oak Ridge National Laboratory (Efroymsen et al., 1997a and 1997b)
⁷ DEQ Level II Ecological Screening Level Values (SLVs) for wildlife (DEQ, 2001b)

Table 5
Detected VOC Concentrations in Surface Soil - Harbor Oil Site

Type of Analysis	Reporting Source	Date	Sample Location	Sample Number	Sample Depth (feet)	Duplicate	Volatile Organic Compounds (ug/kg)										
							Benzene	(1-methylethyl)-Benzene	2-Butanone	n-Butylbenzene	sec-Butylbenzene	Chlorobenzene	Cyclohexane	methyl-Cyclohexane	1,2-Dichlorobenzene	1,3-Dichlorobenzene	1,4-Dichlorobenzene
Fixed Laboratory	E&E, 2001	7/31/2000	BG01	BG01SS-00314162	1-2		2.2 U	2.2 U	60.2			2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U
	E&E, 2001	8/2/2000	BG03	BG03SS-00314184	0.5-1		2.2 U	2.2 U	21.5 U			2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U
	E&E, 2001	7/31/2000	DP01	DP01SS-00314150	1-2		18.7 JH	97.6 JH	94.6 JH			269	31.6 JH	185 JL	54.2 JH	3.5 U	21.3
	E&E, 2001	7/31/2000	DP02	DP02SS-00314153	1-2		2.2 JQ	3.5 UJK	73.2 JH			3.5 U	3.5 U	3.5 U	3.5 U	3.5 U	3.5 U
	E&E, 2001	7/31/2000	DP03	DP03SS-00314159	1-2		2.2 U	2.2 U	22.5 U			2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U
	E&E, 2001	8/1/2000	SS01	SS01SS-00314174	0-1.5		2.5 U	2.6	25.0 U			2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U
	E&E, 2001	8/1/2000	SS02	SS02SS-00314175	0-1.5		2.4 U	7.2 JH	25.5 U			8.7	2.5 U	10	6.6	2.7	14.2
	E&E, 2001	8/1/2000	SS03	SS03SS-00314176	1-1.5		2.6 U	3.2 JH	26.3 UJK			2.6 U	1.3 JQ	6.5	2.6 UJK	2.6 UJK	2.6 UJK
	E&E, 2001	8/1/2000	SS04	SS04SS-00314177	1-1.5		2.6 U	2.6 U	26.3 UJK			2.6 U	2.6 U	2.6 U	2.6 U	2.6 U	2.6 U
	E&E, 2001	8/1/2000	SS05	SS05SS-00314178	1.5-2.5		7.2 U	72.9 JH	98.3 JH			4.7 U	17.8 JH	96.9 JL	4.7 U	4.7 U	4.7 U
	E&E, 2001	8/1/2000	SS06	SS06SS-00314179	1-1.5		2.2 U	2.2 U	22.2 UJK			2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U
	E&E, 2001	8/1/2000	SS07	SS07SS-00314180	1-1.5		2.3 U	2.3 U	23.0 UJK			2.3 U	2.3 U	2.3 U	2.3 U	2.3 U	2.3 U
	E&E, 2001	8/2/2000	SS08	SS08SS-00314181	0.5-1		2.4 U	2.4 UJK	24.4 UJK			2.4 U	2.4 U	3.7	2.4 UJK	2.4 UJK	2.4 UJK
	E&E, 2001	8/2/2000	SS09	SS09SS-00314182	1-1.5		2.4 U	2.4 U	23.8 UJK			2.4 U	2.4 U	2.4 U	2.4 U	2.4 U	2.4 U
	E&E, 2001	8/2/2000	SS10	SS10SS-00314183	1-1.5		2.5 U	2.5 U	25.0 UJK			2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U
	Coles, 2002	8/1/2000	SS02	SS #2 (SS 02SS)	0-1.5		100 U		1,000 U	500 U	100 U	100 U			100 U	100 U	100 U
	Coles, 2002	8/1/2000	SS03	SS #3 (SS 03SS)	1-1.5		100 U		1,000 U	500 U	100 U	100 U			100 U	100 U	100 U
	Coles, 2002	8/1/2000	SS04	SS #4 (SS 04SS)	1-1.5		100 U		1,000 U	500 U	100 U	100 U			100 U	100 U	100 U
	Coles, 2002	8/1/2000	SS05	SS #5 (SS 05SS)	1.5-2.5		100 U		1,000 U	593	224	100 U			100 U	100 U	100 U
Screening Levels																	
Human Health Screening Value																	
EPA Region 6 Screening Level ¹																	
Industrial							1,500	NC	NC	240,000	220,000	46,000	140,000	NC	370,000	13,000	7,500
DEQ RBCs ^{2,3}																	
Soil Ing., Dermal Contact, Inhalation							34,000	NC	NC	2.3E+06	2.3E+06	4.2E+06	NC	NC	5.2E+06	650,000	57,000
Vol. to Outdoor Air							48,000	NC	NC	4.7E+06	4.7E+06	6.5E+06	NC	NC	3.2E+06	1.1E+06	54,000
Vapor Intrusion into Buildings							1,200	NC	NC	7.7E+06	940,000	700,000	NC	NC	1.9E+06	500,000	25,000
Leaching to GW							52	NC	NC	210,000	16,000	2,600	NC	NC	3,800	1,100	540
Ecological Screening Value																	
EPA Eco SSL, ORNL, or							3.3E+06	NC	NC	NC	NC	40,000	NC	NC	NC	NC	20,000
DEQ SLV ^{5,6,7}																	

Legend
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¹ With Acid/Silica Gel Cleanup.
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Most stringent industrial soil screening level. Adjusted to Hazard Quotient of 0.1 to account for cumulative risks.
³ DEQ, Risk-Based Decision Making for the Remediation of Petroleum-Contaminated Sites, 2007.
⁴ Most stringent occupational, construction or excavation worker Risk-Based Concentration (RBC).
⁵ EPA Soil Screening Levels at <http://www.epa.gov/oswer/riskassessment/ecorisk/ecossl.htm>
⁶ Oak Ridge National Laboratory (Efroymson et al., 1997a and 1997b)
⁷ DEQ Level II Ecological Screening Level Values (SLVs) for wildlife (DEQ, 2001b)

Table 5
Detected VOC Concentrations in Surface Soil - Harbor Oil Site

Type of Analysis	Reporting Source	Date	Sample Location	Sample Number	Sample Depth (feet)	Duplicate	Volatile Organic Compounds (ug/kg)											
							cis-1,2-Dichloroethene	Ethylbenzene	p-Isopropyltoluene	Naphthalene	n-Propylbenzene	Tetrachloroethene	Toluene	Trichloroethene	1,2,4-Trimethylbenzene	1,3,5-Trimethylbenzene	o-Xylene	m,p-Xylene
Fixed Laboratory	E&E, 2001	7/31/2000	BG01	BG01SS-00314162	1-2		2.2 U	2.2 U				2.2 U	2.2 U	2.2 U			2.2 U	4.3 U
	E&E, 2001	8/2/2000	BG03	BG03SS-00314184	0.5-1		2.2 U	2.2 U				2.2 U	2.2 U	2.2 U			2.2 U	4.3 U
	E&E, 2001	7/31/2000	DP01	DP01SS-00314150	1-2		3.5 U	212				3.5 U	44.2 JH	3.5 U			1,230	497 JH
	E&E, 2001	7/31/2000	DP02	DP02SS-00314153	1-2		3.5 U	5.5				5.7 JH	14.7	3.5 U			10	17.9
	E&E, 2001	7/31/2000	DP03	DP03SS-00314159	1-2		2.2 U	2.2 U				2.2 U	2.2 U	2.2 U			2.2 U	4.5 U
	E&E, 2001	8/1/2000	SS01	SS01SS-00314174	0-1.5		2.5 U	2.5 U				2.5 U	2.5 U	2.5 U			2.5 U	5.0 U
	E&E, 2001	8/1/2000	SS02	SS02SS-00314175	0-1.5		2.5 U	3.4 U				2.5 U	5.8 U	2.5 U			11.3	14.7 U
	E&E, 2001	8/1/2000	SS03	SS03SS-00314176	1-1.5		2.6 U	2.6 U				2.6 U	3.2 U	2.6 U			2.6 U	5.3 U
	E&E, 2001	8/1/2000	SS04	SS04SS-00314177	1-1.5		2.6 U	2.6 U				2.6 U	2.6 U	2.6 U			2.6 U	5.2 U
	E&E, 2001	8/1/2000	SS05	SS05SS-00314178	1.5-2.5		4.7 U	80.6 JH				10.8 JH	25.8 U	3.3 JH			157	269
	E&E, 2001	8/1/2000	SS06	SS06SS-00314179	1-1.5		2.2 U	2.2 U				2.2 U	2.2 U	2.2 U			2.2 U	4.4 U
	E&E, 2001	8/1/2000	SS07	SS07SS-00314180	1-1.5		2.3 U	2.3 U				2.3 U	2.3 U	2.3 U			2.3 U	4.6 U
	E&E, 2001	8/2/2000	SS08	SS08SS-00314181	0.5-1		2.4 U	2.4 U				2.4 U	5.0 U	2.4 U			5.4 U	9.5 U
	E&E, 2001	8/2/2000	SS09	SS09SS-00314182	1-1.5		2.4 U	2.4 U				2.4 U	2.4 U	2.4 U			2.4 U	4.8 U
	E&E, 2001	8/2/2000	SS10	SS10SS-00314183	1-1.5		2.5 U	2.5 U				2.5 U	2.5 U	2.5 U			2.5 U	5.0 U
	Coles, 2002	8/1/2000	SS02	SS #2 (SS 02SS)	0-1.5		100 U	100 U	200 U	200 U	100 U	100 U	122	100 U	115	100 U	100 U	200 U
	Coles, 2002	8/1/2000	SS03	SS #3 (SS 03SS)	1-1.5		100 U	100 U	200 U	209	100 U	100 U	140	100 U	162	100 U	153	236
	Coles, 2002	8/1/2000	SS04	SS #4 (SS 04SS)	1-1.5		100 U	100 U	200 U	200 U	100 U	100 U	100 U	100 U	117	100 U	100 U	200 U
	Coles, 2002	8/1/2000	SS05	SS #5 (SS 05SS)	1.5-2.5		337	202	364	4,620	371	2,700	206	280	4,420	1,300	272	596
Screening Levels																		
Human Health Screening Value																		
EPA Region 6 Screening Level ¹																		
Industrial							15,000	230,000	NC	19,000	240,000	1,700	520,000	92	17,000	7,000	280,000	210,000
DEQ RBCs ^{2,3}																		
Soil Ing., Dermal Contact, Inhalation							2.3E+06	2.8E+07	NC	710,000	2.3E+06	5,100	2.4E+07	3,400	1.4E+06	1.4E+06	1.9E+07	1.9E+07
Vol. to Outdoor Air							4.7E+06	1.4E+08	NC	940,000	4.7E+06	62,000	6.5E+08	3,300	79,000	790,000	1.4E+07	1.4E+07
Vapor Intrusion into Buildings							11,000	1.1E+07	NC	3.4E+06	1.6E+06	1,500	2.8E+07	94	84,000	14,000	1.3E+06	1.3E+06
Leaching to GW							400	620,000	NC	1,500	210,000	37	560,000	9.9	5,500	1,200	10,000	10,000
Ecological Screening Value																		
EPA Eco SSL, ORNL, or							NC	NC	NC	3.9E+06	NC	NC	200,000	NC	NC	NC	NC	NC
DEQ SLV ^{5,6,7}																		

Legend
Shading = Exceeds human health screening level
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Bold = Detected concentration
NC = No criteria
DET = Detected
U = Not detected
J = Indicates an estimated value below the calculated detection limit.
K = Unknown bias.
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Q = The results is estimated because it is below the sample quantitation limit.
¹ With Acid/Silica Gel Cleanup.
² EPA Region 6 Screening Levels, 2007.
Most stringent industrial soil screening level. Adjusted to Hazard Quotient of 0.1 to account for cumulative risks.
³ DEQ, Risk-Based Decision Making for the Remediation of Petroleum-Contaminated Sites, 2007.
⁴ Most stringent occupational, construction or excavation worker Risk-Based Concentration (RBC).
⁵ EPA Soil Screening Levels at <http://www.epa.gov/oswer/riskassessment/ecorisk/ecossl.htm>
⁶ Oak Ridge National Laboratory (Efroymsen et al., 1997a and 1997b)
⁷ DEQ Level II Ecological Screening Level Values (SLVs) for wildlife (DEQ, 2001b)

Table 6
Detected SVOC Concentrations in Surface Soil - Harbor Oil Site

Type of Analysis	Reporting Source	Date	Sample Location	Sample Number	Sample Depth (feet)	Duplicate	Semivolatile Organic Compounds (ug/kg)									
							Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	1,1-Biphenyl	Butyl benzyl phthalate
Fixed Laboratory	E&E, 2001	7/31/2000	BG01	BG01SS-00314162	1-2		141 U	141 U	141 U	141 U	282 U	282 U	704 U	141 U	141 U	704 U
	E&E, 2001	8/2/2000	BG03	BG03SS-00314184	0.5-1		119 U	119 U	119 U	119 U	238 U	238 U	596 U	119 U	119 U	596 U
	E&E, 2001	7/31/2000	DP01	DP01SS-00314150	1-2		908	124 U	1,030	889	540	1,040	908	326	124 U	619 U
	E&E, 2001	7/31/2000	DP02	DP02SS-00314153	1-2		314	133 U	334	254	265 U	265 U	590 JQ	133 U	163	499 JQ
	E&E, 2001	7/31/2000	DP03	DP03SS-00314159	1-2		119 U	119 U	119 U	119 U	238 U	238 U	596 U	119 U	119 U	596 U
	E&E, 2001	8/1/2000	SS01	SS01SS-00314174	0-1.5		121 U	121 U	51.2 JQ	70.6 JQ	102 JQ	212 JQ	493 JQ	57 JQ	121 U	403 JQ
	E&E, 2001	8/1/2000	SS02	SS02SS-00314175	0-1.5		519	254 U	717	697	949	1,020	1,320	271	254 U	537 JQ
	E&E, 2001	8/1/2000	SS03	SS03SS-00314176	1-1.5		134 U	134 U	309	210	196 JQ	291	474 JQ	74.3 JQ	392	669 U
	E&E, 2001	8/1/2000	SS04	SS04SS-00314177	1-1.5		133 U	133 U	191	160	124 JQ	198 JQ	428 JQ	57.9 JQ	98.8 JQ	667 U
	E&E, 2001	8/1/2000	SS05	SS05SS-00314178	1.5-2.5		1,040	597	862	506	786	623	1,400 JQ	288 U	1,000	1,440 U
	E&E, 2001	8/1/2000	SS06	SS06SS-00314179	1-1.5		133	133 U	34.5 JQ	133 U	133 U	266 U	665 U	133 U	133 U	665 U
	E&E, 2001	8/1/2000	SS07	SS07SS-00314180	1-1.5		123 U	123 U	54.4 JQ	103 JQ	117 JQ	167 JQ	419 JQ	123 U	123 U	613 U
	E&E, 2001	8/2/2000	SS08	SS08SS-00314181	0.5-1		74.3 JQ	133 U	224	133 U	198 JQ	268	834	53.1 JQ	44.7 JQ	664 U
	E&E, 2001	8/2/2000	SS09	SS09SS-00314182	1-1.5		131 U	131 U	131 U	131 U	262 U	262 U	348 JQ	131 U	131 U	656 U
	E&E, 2001	8/2/2000	SS10	SS10SS-00314183	1-1.5		120 U	120 U	120 U	120 U	241 U	241 U	603 U	120 U	120 U	603 U
	Coles, 2002	8/1/2000	SS02	SS #2 (SS 02SS)	0-1.5		3,300 U	3,300 U	3,300 U	3,340	3,300 U	3,300 U	3,300 U	6,600 U		3,300 U
	Coles, 2002	8/1/2000	SS03	SS #3 (SS 03SS)	1-1.5		660 U	660 U	660 U	660 U	660 U	660 U	660 U	660 U		660 U
	Coles, 2002	8/1/2000	SS04	SS #4 (SS 04SS)	1-1.5		330 U	330 U	330 U	330 U	330 U	330 U	330 U	330 U		330 U
	Coles, 2002	8/1/2000	SS05	SS #5 (SS 05SS)	1.5-2.5		16,500 U	16,500 U	16,500 U	16,500 U	16,500 U	16,500 U	16,500 U	16,500 U		16,500 U
Screening Levels Human Health Screening Value EPA Region 6 Screening Level ¹ Industrial DEQ RBCs ^{2,3} Soil Ing., Dermal Contact, Inhalation Vol. to Outdoor Air Vapor Intrusion into Buildings Leaching to GW Ecological Screening Value EPA Eco SSL, ORNL, or DEQ SLV ^{5,6,7}							3.3E+06	NC	1.0E+08	2,300	230	2,300	NC	23,000	NC	240,000
							1.6E+07	NC	9.0E+07	2,700	270	2,700	NC	27,000	NC	NC
							7.0E+08	NC	6.5E+10	NC	NC	NC	NC	NC	NC	NC
							2.6E+09	NC	2.4E+11	NC	NC	NC	NC	NC	NC	NC
							2.2E+06	NC	6.5E+07	67,000	17,000	210,000	NC	210,000	NC	NC
							20,000	NC	NC	NC	125,000	NC	NC	NC	60,000	NC

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⁵ EPA Soil Screening Levels at <http://www.epa.gov/oswer/riskassessment/ecorisk/ecossl.htm>
⁶ Oak Ridge National Laboratory (Efroymsen et al., 1997a and 1997b)
⁷ DEQ Level II Ecological Screening Level Values (SLVs) for wildlife (DEQ, 2001b)

Table 6
Detected SVOC Concentrations in Surface Soil - Harbor Oil Site

Type of Analysis	Reporting Source	Date	Sample Location	Sample Number	Sample Depth (feet)	Duplicate	Semivolatile Organic Compounds (ug/kg)									
							9H-Carbazole	Chrysene	Di-n-butyl phthalate	Dibenzo(a,h)anthracene	Dibenzofuran	Diethyl phthalate	2,4-Dimethylphenol	Bis(2-ethylhexyl)phthalate	1-phenyl-Ethanone	
Fixed Laboratory	E&E, 2001	7/31/2000	BG01	BG01SS-00314162	1-2		141 U	141 U	141 U	1,410 U	141 U	141 U	141 U	141 U	141 U	
	E&E, 2001	8/2/2000	BG03	BG03SS-00314184	0.5-1		119 U	30.1 JQ	119 U	1,190 U	119 U	119 U	119 U	119 U	119 U	
	E&E, 2001	7/31/2000	DP01	DP01SS-00314150	1-2		221	1,320	124 U	154 JQ	348	124 U	124 U	733	448 U	
	E&E, 2001	7/31/2000	DP02	DP02SS-00314153	1-2		133 U	505	194	1,330 U	193	133 U	133 U	2,520	133 U	
	E&E, 2001	7/31/2000	DP03	DP03SS-00314159	1-2		119 U	119 U	119 U	1,190 U	119 U	119 U	119 U	119 U	119 U	
	E&E, 2001	8/1/2000	SS01	SS01SS-00314174	0-1.5		121 U	133	121 U	42.5 JQ	121 U	212 U	121 U	812	121 U	
	E&E, 2001	8/1/2000	SS02	SS02SS-00314175	0-1.5		195 JQ	1,370	254 U	236 JQ	177 JQ	184 JQ	254 U	2,610	254 U	
	E&E, 2001	8/1/2000	SS03	SS03SS-00314176	1-1.5		134 U	307	134 U	1,300 U	518	134 U	480	160	508 U	
	E&E, 2001	8/1/2000	SS04	SS04SS-00314177	1-1.5		133 U	182	133 U	1,330 U	328	133 U	243	133 U	307	
	E&E, 2001	8/1/2000	SS05	SS05SS-00314178	1.5-2.5		356 U	840	288 U	2,880 U	1,570	288 U	288 U	5,730	1,730 U	
	E&E, 2001	8/1/2000	SS06	SS06SS-00314179	1-1.5		133 U	43.1 JQ	133 U	1,330 U	47.2 JQ	133 U	133 U	133 U	68.2 JQ	
	E&E, 2001	8/1/2000	SS07	SS07SS-00314180	1-1.5		123 U	163	123 U	1,230 U	123 U	123 U	123 U	228	123 U	
	E&E, 2001	8/2/2000	SS08	SS08SS-00314181	0.5-1		84.8 JQ	183	133 U	1,330 U	86.8 JQ	133 U	133 U	178	133 U	
	E&E, 2001	8/2/2000	SS09	SS09SS-00314182	1-1.5		131 U	48.5 JQ	131 U	1,310 U	131 U	131 U	131 U	542	131 U	
	E&E, 2001	8/2/2000	SS10	SS10SS-00314183	1-1.5		120 U	120 U	120 U	1,200 U	120 U	120 U	120 U	120 U	120 U	
	Coles, 2002	8/1/2000	SS02	SS #2 (SS 02SS)	0-1.5			4,200	10,000 U	3,300 U	3,300 U	3,300 U	10,000 U	20,000 U		
	Coles, 2002	8/1/2000	SS03	SS #3 (SS 03SS)	1-1.5			660 U	2,000 U	660 U	660 U	660 U	2,000 U	4,000 U		
	Coles, 2002	8/1/2000	SS04	SS #4 (SS 04SS)	1-1.5			330 U	1,000 U	330 U	330 U	330 U	1,000 U	2,000 U		
	Coles, 2002	8/1/2000	SS05	SS #5 (SS 05SS)	1.5-2.5			16,500 U	50,000 U	16,500 U	16,500 U	16,500 U	50,000 U	100,000 U		
Screening Levels																
Human Health Screening Value																
EPA Region 6 Screening Level ¹																
Industrial							96,000	230,000	NC	230	1.7E+05	1.0E+08	1.4E+06	140,000	NC	
DEQ RBCs ^{2,3}																
Soil Ing., Dermal Contact, Inhalation							NC	270,000	NC	270	NC	NC	NC	150,000	NC	
Vol. to Outdoor Air							NC	NC	NC	NC	NC	NC	NC	NC	NC	
Vapor Intrusion into Buildings							NC	NC	NC	NC	NC	NC	NC	NC	NC	
Leaching to GW							NC	6.7E+06	NC	64,000	NC	NC	NC	970,000	NC	
Ecological Screening Value																
EPA Eco SSL, ORNL, or							NC	NC	200,000	NC	2	100,000	NC	4,500	NC	
DEQ SLV ^{5,6,7}																

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Table 6
Detected SVOC Concentrations in Surface Soil - Harbor Oil Site

Type of Analysis	Reporting Source	Date	Sample Location	Sample Number	Sample Depth (feet)	Duplicate	Semivolatile Organic Compounds (ug/kg)									
							Fluoranthene	9H-Fluorene	Indeno(1,2,3-cd)pyrene	2-Methylnaphthalene	2-Methylphenol	4-Methylphenol	Naphthalene	Phenanthrene	Phenol	Pyrene
Fixed Laboratory	E&E, 2001	7/31/2000	BG01	BG01SS-00314162	1-2		141 U	141 U	1,410 U	141 U	141 U	141 U	141 U	141 U	141 U	141 U
	E&E, 2001	8/2/2000	BG03	BG03SS-00314184	0.5-1		119 U	119 U	1,190 U	66 JQ	119 U	119 U	43.6 JQ	35.9 JQ	163 JH	119 U
	E&E, 2001	7/31/2000	DP01	DP01SS-00314150	1-2		1,910	703	931 JQ	3,000	124 U	124 U	242 U	2,200	124 U	2,450
	E&E, 2001	7/31/2000	DP02	DP02SS-00314153	1-2		489	473	679 JQ	966	133 U	133 U	324	1,040	133 U	1,040
	E&E, 2001	7/31/2000	DP03	DP03SS-00314159	1-2		119 U	119 U	1,190 U	119 U	119 U	119 U	119 U	48.1 JQ	119 U	58.2 JQ
	E&E, 2001	8/1/2000	SS01	SS01SS-00314174	0-1.5		197	121 U	620 JQ	46 JQ	121 U	121 U	121 U	121 JQ	121 U	206
	E&E, 2001	8/1/2000	SS02	SS02SS-00314175	0-1.5		977	286	1,480 JQ	937	254 U	254 U	260	1,060	254 U	2,290
	E&E, 2001	8/1/2000	SS03	SS03SS-00314176	1-1.5		374	134 U	639 JQ	2,170	518	1,240	1,410	818	825	518
	E&E, 2001	8/1/2000	SS04	SS04SS-00314177	1-1.5		296	133 U	570 JQ	1,400	163	393	824	668	156	322
	E&E, 2001	8/1/2000	SS05	SS05SS-00314178	1.5-2.5		865	2,640	1,500 JQ	23,300	288 U	288 U	5,880	6,800	288 U	2,030
	E&E, 2001	8/1/2000	SS06	SS06SS-00314179	1-1.5		53.1 JQ	133 U	1,330 U	201	133 U	133 U	146	114 JQ	133 U	59.7 JQ
	E&E, 2001	8/1/2000	SS07	SS07SS-00314180	1-1.5		187	123 U	574 JQ	44 JQ	123 U	123 U	59.9 JQ	164	123 U	234
	E&E, 2001	8/2/2000	SS08	SS08SS-00314181	0.5-1		238	66.7 JQ	850 JQ	570	133 U	133 U	410	379	133 U	329
	E&E, 2001	8/2/2000	SS09	SS09SS-00314182	1-1.5		131 U	131 U	1,310 U	131 U	131 U	131 U	131 U	131 U	131 U	69.8 JQ
	E&E, 2001	8/2/2000	SS10	SS10SS-00314183	1-1.5		120 U	120 U	1,200 U	120 U	120 U	120 U	120 U	120 U	120 U	120 U
	Coles, 2002	8/1/2000	SS02	SS #2 (SS 02SS)	0-1.5		3,950	3,300 U	3,300 U	3,300 U	3,300 U	3,300 U	3,300 U	3,300 U	3,300 U	6,160
	Coles, 2002	8/1/2000	SS03	SS #3 (SS 03SS)	1-1.5		660 U	660 U	660 U	660 U	660 U	660 U	660 U	660 U	660 U	660 U
	Coles, 2002	8/1/2000	SS04	SS #4 (SS 04SS)	1-1.5		330 U	330 U	330 U	330 U	330 U	330 U	330 U	330 U	330 U	330 U
	Coles, 2002	8/1/2000	SS05	SS #5 (SS 05SS)	1.5-2.5		16,500 U	16,500 U	16,500 U	19,900	16,500 U	16,500 U	16,500 U	16,500 U	16,500 U	16,500 U
Screening Levels Human Health Screening Value EPA Region 6 Screening Level ¹ Industrial DEQ RBCs ^{2,3} Soil Ing., Dermal Contact, Inhalation Vol. to Outdoor Air Vapor Intrusion into Buildings Leaching to GW Ecological Screening Value EPA Eco SSL, ORNL, or DEQ SLV ^{5,6,7}							2.4E+06	2.6E+06	2,300	NC	3.4E+07	3.4E+06	21,000	NC	1.0E+08	3.2E+06
							8.9E+06	1.2E+07	2,700	NC	NC	NC	710,000	NC	NC	6.7E+06
							NC	3.7E+09	NC	NC	NC	NC	940,000	NC	NC	NC
							NC	1.3E+10	NC	NC	NC	NC	3.4E+06	NC	NC	NC
							1.9E+08	4.0E+06	580,000	NC	NC	NC	1,500	NC	NC	1.4E+08
							NC	30,000	NC	NC	1.6E+07	NC	3.9E+06	NC	30,000	NC

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⁵ EPA Soil Screening Levels at <http://www.epa.gov/oswer/riskassessment/ecorisk/ecossl.htm>
⁶ Oak Ridge National Laboratory (Efroymsen et al., 1997a and 1997b)
⁷ DEQ Level II Ecological Screening Level Values (SLVs) for wildlife (DEQ, 2001b)

Table 7
Detected PCB and Pesticide Concentrations in Surface Soil - Harbor Oil Site

Type of Analysis	Reporting Source	Date	Sample Location	Sample Number	Sample Depth (feet)	Duplicate	Polychlorinated Biphenyls (ug/kg)			Pesticides (ug/kg)			
							Aroclor 1248	Aroclor 1254	Aroclor 1260	Endrin	p,p'-DDD	p,p'-DDE	p,p'-DDT
Fixed Laboratory	E&E, 2001	7/31/2000	BG01	BG01SS-00314162	1-2		18 U	18 U	18 U	0.70 U	2.9	0.70 U	0.70 U
	E&E, 2001	8/2/2000	BG03	BG03SS-00314184	0.5-1		15 U	15 U	15 U	0.60 U	1.0 U	16	22
	E&E, 2001	7/31/2000	DP01	DP01SS-00314150	1-2		15 U	15 U	635	51 U	64,000	5,200 JH	8,400
	E&E, 2001	7/31/2000	DP02	DP02SS-00314153	1-2		16 U	16 U	620	65 U	14,000	440	630
	E&E, 2001	7/31/2000	DP03	DP03SS-00314159	1-2		15 U	15	36	0.600 U	37	3.2	0.60 U
	E&E, 2001	8/1/2000	SS01	SS01SS-00314174	0-1.5		12,000	15 U	4,600	23 U	2,400	260	210 JH
	E&E, 2001	8/1/2000	SS02	SS02SS-00314175	0-1.5		1,100	16 U	2,200	14 U	11,000	810 JH	16 JH
	E&E, 2001	8/1/2000	SS03	SS03SS-00314176	1-1.5		17 U	17 U	17 U	2.60	130	2.4 U	0.67 U
	E&E, 2001	8/1/2000	SS04	SS04SS-00314177	1-1.5		17 U	17 U	17 U	1.1 U	0.67 U	0.67 U	0.67 U
	E&E, 2001	8/1/2000	SS05	SS05SS-00314178	1.5-2.5		18 U	18 U	700	57 U	48,000	895 JH	2,300
	E&E, 2001	8/1/2000	SS06	SS06SS-00314179	1-1.5		33 U	33 U	33 U	1.3 U	9.0	1.6	5.6
	E&E, 2001	8/1/2000	SS07	SS07SS-00314180	1-1.5		15 U	15 U	210	0.61 U	1,300	45	60
	E&E, 2001	8/2/2000	SS08	SS08SS-00314181	0.5-1		17 U	17 U	1,100	5.6 U	40,000	850 JH	1,900
	E&E, 2001	8/2/2000	SS09	SS09SS-00314182	1-1.5		16 U	16 U	11 JQ	0.66 U	6.6	0.66 U	0.66 U
	E&E, 2001	8/2/2000	SS10	SS10SS-00314183	1-1.5		15 U	15 U	4.9 JQ	0.60 U	0.60 U	0.60 U	0.60 U
	Coles, 2002	8/1/2000	SS02	SS #2 (SS 02SS)	0-1.5		670 U	3,500	886				
	Coles, 2002	8/1/2000	SS03	SS #3 (SS 03SS)	1-1.5		67 U		67 U				
	Coles, 2002	8/1/2000	SS04	SS #4 (SS 04SS)	1-1.5		67 U	67 U	67 U				
	Coles, 2002	8/1/2000	SS05	SS #5 (SS 05SS)	1.5-2.5		8,710 U	9,380 U	361				
Screening Levels Human Health Screening Value EPA Region 6 Screening Level ¹ Industrial DEQ RBCs ^{2,3} Soil Ing., Dermal Contact, Inhalation Vol. to Outdoor Air Vapor Intrusion into Buildings Leaching to GW Ecological Screening Value EPA Eco SSL, ORNL, or DEQ SLV ^{5,6,7}							830	830	830	21,000	11,000	7,800	7,800
							980	980	980	71,000	11,000	7,700	7,700
							NC	NC	NC	NC	NC	NC	NC
							NC	NC	NC	NC	NC	NC	NC
							4,600	4,600	4,600	160,000	510,000	1.6E+06	950,000
							NC	700	NC	40	10	10	10

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⁵ EPA Soil Screening Levels at <http://www.epa.gov/oswer/riskassessment/ecorisk/ecossl.htm>
⁶ Oak Ridge National Laboratory (Efroymson et al., 1997a and 1997b)
⁷ DEQ Level II Ecological Screening Level Values (SLVs) for wildlife (DEQ, 2001b)

Table 8
Detected TPH and Metals Concentrations in Subsurface Soil - Harbor Oil Site

Type of Analysis	Reporting Source	Date	Sample Location	Sample Number	Sample Depth (feet)	Duplicate	NWTPH-HCID (mg/kg)			NWTPH-Gx (mg/kg)	NWTPH-Dx (mg/kg)		TPH (mg/kg)
							Gasoline Range TPH	Diesel Range TPH	Oil Range TPH	Gasoline Range TPH	Diesel Range TPH	Oil Range TPH	Unknown Range
Fixed Laboratory	E&E, 2001	7/31/2000	BG01	BG01SB04-00314163	4-8		20 U	50 U	100 U				
	E&E, 2001	7/31/2000	DP01	DP01SB02-00314151	2-6		20 U	50 U	100 U				
	E&E, 2001	7/31/2000	DP02	DP02SB04-00314155	4-8		20 U	110	150		56	100	
	E&E, 2001	7/31/2000	DP03	DP03SB04-00314160	4-8		20 U	50 U	100 U				
	E&E, 2001	7/31/2000	BG01	BG01SB08-00314164	8-12		20 U	50 U	100 U				
	E&E, 2001	7/31/2000	DP01	DP01SB06-00314152	6-10		20 U	50 U	100 U				
	E&E, 2001	7/31/2000	DP02	DP02SB08-00314156	8-12		20 U	50 U	100 U				
	E&E, 2001	7/31/2000	DP02	DP02SB12-00314157	12-16		20 UJ	50 UJ	100 UJ				
	E&E, 2001	7/31/2000	DP02	DP02SB16-00314158	16-20		20 U	50 U	100 U				
	E&E, 2001	7/31/2000	DP03	DP03SB08-00314161	8-12		20 U	50 U	100 U				
	Coles, 2003	2/1/2003	HC-01	HC-01	6.0						25 U	50 U	
	Coles, 2003	2/1/2003	HC-02	HC-02	3.0						595	1,930	
	Coles, 2003	2/1/2003	HC-03	HC-03	7.0						25 U	50 U	
	Coles, 2003	2/1/2003	HC-04	HC-04	5.0						103,000	48,600	
	Coles, 2003	2/1/2003	HC-05	HC-05	6.5						25 U	50 U	
	Coles, 2003	2/1/2003	HC-06	HC-06	6.0						25 U	50 U	
	Coles, 2003	2/20/2003	HC-07	HC-07	4.5						100,000	73,800	
	Coles, 2003	2/20/2003	HC-08	HC-08	5.5						413	522	
	Coles, 2003	2/20/2003	HC-09	HC-09	6.5						25 U	50 U	
	Coles, 2003	2/20/2003	HC-10	HC-10	1.0						25 U	858	
	Coles, 2003	2/20/2003	HC-11	HC-11	6.5						25 U	50 U	
	Coles, 2003	4/17/2003	HC-12	HC-12	3.5						5,800	7,560	
	Coles, 2003	4/17/2003	HC-13	HC-13	2.0						2,230	2,180	
	Coles, 2003	4/17/2003	HC-14	HC-14	5.5						25 U	50 U	
	Coles, 2003	2/18/2003	HCL-01	HCL-01	2.0		20 U	DET	DET		280	777	
	Coles, 2003	2/18/2003	HCL-02	HCL-02	Composite		DET	DET	DET	343	5,180	937	
	Coles, 2003	2/20/2003	HCL-03	HCL-03	6.0		20 U	DET	DET		222	245	
	Coles, 2003	4/11/2003	HCL-04	HCL-04	1.5						25 U	50 U	
	Coles, 2003	4/11/2003	HCL-05	HCL-05	2.5						55.4	75.4	
	Golder, 1990	1990	C-0		2.5								100 U
	Golder, 1990	1990	C-0		5.0								100 U
	Golder, 1990	1990	C-100		5.0								200
	Golder, 1990	1990	C-200		8.0								100 U
	Golder, 1990	1990	C-250		2.0								200
	Golder, 1990	1990	C-250		10.0								100 U
	Golder, 1990	1990	C-250		15.0								100 U
	Golder, 1990	1990	J-475		5.0								100 U
	Golder, 1990	1990	J-475		10.0								100 U
	Golder, 1990	1990	J-475A		5.0								100 U
	Golder, 1990	1990	J-400		5.0								100 U
	Golder, 1990	1990	J-400		10.0								100
	Golder, 1990	1990	J-500		2.5								100 U
	Golder, 1990	1990	J-500		5.0								100 U
	Golder, 1990	1990	J-500		10.0								100 U
	Golder, 1990	1990	C-600		10.0								100 U
	Golder, 1990	1990	J-600		2.5								8,000
	Golder, 1990	1990	J-600		5.0								4,000
	Golder, 1990	1990	J-550		10.0								100 U
	Golder, 1990	1990	J-630		6.0								100 U
	Golder, 1990	1990	J-630		10.0								100 U
	Golder, 1990	1990	J-630		15.0								100 U
	Golder, 1990	1990	L-500		5.0								100 U
	Golder, 1990	1990	L-600		5.0								800
	Golder, 1990	1990	L-600		10.0								200
	Golder, 1990	1990	T-550		2.0								1,000
	Golder, 1990	1990	T-550		5.0								100 U
	Golder, 1990	1990	T-550		10.0								100 U
	Golder, 1990	1990	T-550		15.0								100 U
	Golder, 1990	1990	WL-002		2.5								250
	Golder, 1990	1990	D-550		2.5								700
	Golder, 1990	1990	D-550		5A								

Table 8
Detected TPH and Metals Concentrations in Subsurface Soil - Harbor Oil Site

	Reporting Source	Date	Sample Location	Sample Number	Sample Depth (feet)	Duplicate	NWTPH-HCID (mg/kg)			NWTPH-Gx (mg/kg)	NWTPH-Dx (mg/kg)		TPH (mg/kg)
							Gasoline Range TPH	Diesel Range TPH	Oil Range TPH	Gasoline Range TPH	Diesel Range TPH	Oil Range TPH	Unknown Range
Type of Analysis													
	Golder, 1990	1990	D-550		5.0								100 U
	Golder, 1990	1990	D-550		10.0								100 U
	Golder, 1990	1990	D-600		2.5								100
	Golder, 1990	1990	K-500		2.5								250
	Golder, 1990	1990	K-500		5.0								500
	Golder, 1990	1990	K-500		10.0								500
	Golder, 1990	1990	K-550		2.5								200
	Golder, 1990	1990	K-550		5.0								100
	Golder, 1990	1990	K-550		10.0								100 U
	Golder, 1990	1990	P-275		2.5								500
	Golder, 1990	1990	P-275		5.0								250
	Golder, 1990	1990	J-300	J-300-10.0	10.0								87 U
	Golder, 1990	1990	J-550	J-550-5.0	5.0								13,700
Screening Levels Human Health Screening Value EPA Region 6 Screening Level ² Industrial DEQ RBCs ^{3,4} Soil Ing., Dermal Contact, Inhalation Vol. to Outdoor Air Vapor Intrusion into Buildings Leaching to GW Ecological Screening Value EPA Eco SSL, ORNL, or DEQ SLV ^{5,6,7}							NC	NC	NC	NC	NC	NC	
							NC	NC	NC	13,000	23,000	23,000	
							NC	NC	NC	100,000	120,000	120,000	
							NC	NC	NC	120,000	120,000	120,000	
							NC	NC	NC	110	120,000	120,000	

Legend
Shading = Exceeds human health screening level
Solid outline = Exceeds ecological screening level
Bold = Detected concentration
NC = No criteria
DET = Detected
U = Not detected
J = Indicates an estimated value below the calculated detection limit.
K = Unknown bias.
L = Low bias.
H = High bias.
Q = The results is estimated because it is below the sample quantitation limit.
¹ With Acid/Silica Gel Cleanup.
² EPA Region 6 Screening Levels, 2007.
Most stringent industrial soil screening level. Adjusted to Hazard Quotient of 0.1 to account for cumulative risks.
³ DEQ, Risk-Based Decision Making for the Remediation of Petroleum-Contaminated Sites, 2007.
⁴ Most stringent occupational, construction or excavation worker Risk-Based Concentration (RBC).
⁵ EPA Soil Screening Levels at <http://www.epa.gov/oswer/riskassessment/ecorisk/ecossl.htm>
⁶ Oak Ridge National Laboratory (Efroymsen et al., 1997a and 1997b)
⁷ DEQ Level II Ecological Screening Level Values (SLVs) for wildlife (DEQ, 2001b)

Table 8
Detected TPH and Metals Concentrations in Subsurface Soil - Harbor Oil Site

Type of Analysis	Reporting Source	Date	Sample Location	Sample Number	Sample Depth (feet)	Duplicate	Inorganics (mg/kg)									
							Aluminum	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron
Fixed Laboratory	E&E, 2001	7/31/2000	BG01	BG01SB04-00314163	4-8		11,200	3.13	143	0.51	0.20 U	3,930	18.5	9.26	18 JK	20,600
	E&E, 2001	7/31/2000	DP01	DP01SB02-00314151	2-6		10,100	3.98	196	0.526	0.35	4,650	16.5	11.1	23 JK	20,700
	E&E, 2001	7/31/2000	DP02	DP02SB04-00314155	4-8		12,100	4.27	184	0.617	0.49	6,620	20.0	9.8	27 JK	23,000
	E&E, 2001	7/31/2000	DP03	DP03SB04-00314160	4-8		10,600	3.45	187	0.70	0.42	4,770	21.5	8.05	33 JK	18,900
	E&E, 2001	7/31/2000	BG01	BG01SB08-00314164	8-12		11,500	2.17	158	0.821	0.24	4,400	21.8	8.47	25 JK	19,900
	E&E, 2001	7/31/2000	DP01	DP01SB06-00314152	6-10		11,800	3.98	171	0.642	0.24	5,300	21.2	10.5	26 JK	24,500
	E&E, 2001	7/31/2000	DP02	DP02SB08-00314156	8-12		9,680	1.64	137	0.616	0.27	4,810	15.9	7.63	22 JK	19,600
	E&E, 2001	7/31/2000	DP02	DP02SB12-00314157	12-16		11,500	2.91	155	0.783	0.37	5,290	21.0	10.9	26 JK	21,000
	E&E, 2001	7/31/2000	DP02	DP02SB16-00314158	16-20		11,900	2.23	154	0.663	0.20	5,500	21.2	9.86	24 JK	22,900
	E&E, 2001	7/31/2000	DP03	DP03SB08-00314161	8-12		8,400	1.88	154	0.678	0.35	4,470	17.1	7.24	26 JK	12,100
	Coles, 2003	2/1/2003	HC-01	HC-01	6.0											
	Coles, 2003	2/1/2003	HC-02	HC-02	3.0											
	Coles, 2003	2/1/2003	HC-03	HC-03	7.0											
	Coles, 2003	2/1/2003	HC-04	HC-04	5.0											
	Coles, 2003	2/1/2003	HC-05	HC-05	6.5											
	Coles, 2003	2/1/2003	HC-06	HC-06	6.0											
	Coles, 2003	2/20/2003	HC-07	HC-07	4.5											
	Coles, 2003	2/20/2003	HC-08	HC-08	5.5											
	Coles, 2003	2/20/2003	HC-09	HC-09	6.5											
	Coles, 2003	2/20/2003	HC-10	HC-10	1.0											
	Coles, 2003	2/20/2003	HC-11	HC-11	6.5											
	Coles, 2003	4/17/2003	HC-12	HC-12	3.5											
	Coles, 2003	4/17/2003	HC-13	HC-13	2.0											
	Coles, 2003	4/17/2003	HC-14	HC-14	5.5											
	Coles, 2003	2/18/2003	HCL-01	HCL-01	2.0											
	Coles, 2003	2/18/2003	HCL-02	HCL-02	Composite											
	Coles, 2003	2/20/2003	HCL-03	HCL-03	6.0											
	Coles, 2003	4/11/2003	HCL-04	HCL-04	1.5											
	Coles, 2003	4/11/2003	HCL-05	HCL-05	2.5											
	Golder, 1990	1990	C-0		2.5											
	Golder, 1990	1990	C-0		5.0											
	Golder, 1990	1990	C-100		5.0											
	Golder, 1990	1990	C-200		8.0						0.1 U		41 U			
	Golder, 1990	1990	C-250		2.0											
	Golder, 1990	1990	C-250		10.0											
	Golder, 1990	1990	C-250		15.0											
	Golder, 1990	1990	J-475		5.0											
	Golder, 1990	1990	J-475		10.0											
	Golder, 1990	1990	J-475A		5.0											
	Golder, 1990	1990	J-400		5.0					0.5			36 U			
	Golder, 1990	1990	J-400		10.0											
	Golder, 1990	1990	J-500		2.5						1 U		30 U			
	Golder, 1990	1990	J-500		5.0											
	Golder, 1990	1990	J-500		10.0											
	Golder, 1990	1990	C-600		10.0					0.7			39 U			
	Golder, 1990	1990	J-600		2.5					0.1			30			
	Golder, 1990	1990	J-600		5.0					1			90 U			
	Golder, 1990	1990	J-550		10.0											
	Golder, 1990	1990	J-630		6.0											
	Golder, 1990	1990	J-630		10.0											
	Golder, 1990	1990	J-630		15.0											
	Golder, 1990	1990	L-500		5.0											
	Golder, 1990	1990	L-600		5.0											
	Golder, 1990	1990	L-600		10.0											
	Golder, 1990	1990	T-550		2.0											
	Golder, 1990	1990	T-550		5.0											
	Golder, 1990	1990	T-550		10.0											
	Golder, 1990	1990	T-550		15.0											
	Golder, 1990	1990	WL-002		2.5											
	Golder, 1990	1990	D-550		2.5											
	Golder, 1990	1990	D-550		5A											

Table 8
Detected TPH and Metals Concentrations in Subsurface Soil - Harbor Oil Site

Type of Analysis	Reporting Source	Date	Sample Location	Sample Number	Sample Depth (feet)	Duplicate	Inorganics (mg/kg)									
							Aluminum	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron
	Golder, 1990	1990	D-550	J-300-10.0 J-550-5.0	5.0						0.1 U		40 U			
	Golder, 1990	1990	D-550		10.0											
	Golder, 1990	1990	D-600		2.5											
	Golder, 1990	1990	K-500		2.5											
	Golder, 1990	1990	K-500		5.0											
	Golder, 1990	1990	K-500		10.0											
	Golder, 1990	1990	K-550		2.5											
	Golder, 1990	1990	K-550		5.0											
	Golder, 1990	1990	K-550		10.0											
	Golder, 1990	1990	P-275		2.5											
	Golder, 1990	1990	P-275		5.0											
	Golder, 1990	1990	J-300		10.0											
	Golder, 1990	1990	J-550		5.0											
Screening Levels Human Health Screening Value EPA Region 6 Screening Level ² Industrial DEQ RBCs ^{3,4} Soil Ing., Dermal Contact, Inhalation Vol. to Outdoor Air Vapor Intrusion into Buildings Leaching to GW Ecological Screening Value EPA Eco SSL, ORNL, or DEQ SLV ^{5,6,7}							100,000	1.8	100,000	220	56	NC	450	1,900	4,200	100,000
							NC	1.7	6,200	61	8,600	NC	180	NC	1,100	NC
							NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
							NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
							NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
							50	18	330	21	0.36	NC	26	13	28	200

Legend
Shading = Exceeds human health screening level
Solid outline = Exceeds ecological screening level
Bold = Detected concentration
NC = No criteria
DET = Detected
U = Not detected
J = Indicates an estimated value below the calculated detection limit.
K = Unknown bias.
L = Low bias.
H = High bias.
Q = The results is estimated because it is below the sample quantitation limit.
¹ With Acid/Silica Gel Cleanup.
² EPA Region 6 Screening Levels, 2007.
Most stringent industrial soil screening level. Adjusted to Hazard Quotient of 0.1 to account for cumulative risks.
³ DEQ, Risk-Based Decision Making for the Remediation of Petroleum-Contaminated Sites, 2007.
⁴ Most stringent occupational, construction or excavation worker Risk-Based Concentration (RBC).
⁵ EPA Soil Screening Levels at <http://www.epa.gov/oswer/riskassessment/ecorisk/ecossl.htm>
⁶ Oak Ridge National Laboratory (Efroymsen et al., 1997a and 1997b)
⁷ DEQ Level II Ecological Screening Level Values (SLVs) for wildlife (DEQ, 2001b)

Table 8
Detected TPH and Metals Concentrations in Subsurface Soil - Harbor Oil Site

Type of Analysis	Reporting Source	Date	Sample Location	Sample Number	Sample Depth (feet)	Duplicate	Inorganics (mg/kg)											
							Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Vanadium	Zinc	
Fixed Laboratory	E&E, 2001	7/31/2000	BG01	BG01SB04-00314163	4-8		6.95	4,120	223	0.057 U	15.4	1,110	0.14	0.70	334	54.2	57.6	
	E&E, 2001	7/31/2000	DP01	DP01SB02-00314151	2-6		11.2	4,740	308	0.052 U	17.6	2,000	0.50 U	0.88	407	44.5	77.8	
	E&E, 2001	7/31/2000	DP02	DP02SB04-00314155	4-8		15.9	4,870	405	0.056 U	18.0	1,750	0.50 U	0.89	427	51.6	81.8	
	E&E, 2001	7/31/2000	DP03	DP03SB04-00314160	4-8		15.8	4,370	306	0.088	17.3	2,030	0.14	0.76	382	48.3	77.9	
	E&E, 2001	7/31/2000	BG01	BG01SB08-00314164	8-12		8.69	4,330	201	0.069 U	16.5	821	0.59	0.78	323	54.4	55.3	
	E&E, 2001	7/31/2000	DP01	DP01SB06-00314152	6-10		12.7	5,140	382	0.080	19.1	1,310	0.22	0.95	349	57.5	73.0	
	E&E, 2001	7/31/2000	DP02	DP02SB08-00314156	8-12		7.30	3,550	283	0.074 U	14.5	900	0.50 U	0.76	468	37.8	51.1	
	E&E, 2001	7/31/2000	DP02	DP02SB12-00314157	12-16		8.22	5,130	296	0.075 U	21.2	1,240	0.50 U	0.88	405	50.4	65.9	
	E&E, 2001	7/31/2000	DP02	DP02SB16-00314158	16-20		7.30	5,560	333	0.058 U	19.9	1,160	0.50 U	0.72	413	55.5	59.5	
	E&E, 2001	7/31/2000	DP03	DP03SB08-00314161	8-12		9.44	3,550	220	0.062 U	14.7	1,570	0.23	0.50	356	35.2	55.8	
	Coles, 2003	2/1/2003	HC-01	HC-01	6.0													
	Coles, 2003	2/1/2003	HC-02	HC-02	3.0													
	Coles, 2003	2/1/2003	HC-03	HC-03	7.0													
	Coles, 2003	2/1/2003	HC-04	HC-04	5.0													
	Coles, 2003	2/1/2003	HC-05	HC-05	6.5													
	Coles, 2003	2/1/2003	HC-06	HC-06	6.0													
	Coles, 2003	2/20/2003	HC-07	HC-07	4.5													
	Coles, 2003	2/20/2003	HC-08	HC-08	5.5													
	Coles, 2003	2/20/2003	HC-09	HC-09	6.5													
	Coles, 2003	2/20/2003	HC-10	HC-10	1.0													
	Coles, 2003	2/20/2003	HC-11	HC-11	6.5													
	Coles, 2003	4/17/2003	HC-12	HC-12	3.5													
	Coles, 2003	4/17/2003	HC-13	HC-13	2.0													
	Coles, 2003	4/17/2003	HC-14	HC-14	5.5													
	Coles, 2003	2/18/2003	HCL-01	HCL-01	2.0													
	Coles, 2003	2/18/2003	HCL-02	HCL-02	Composite													
	Coles, 2003	2/20/2003	HCL-03	HCL-03	6.0													
	Coles, 2003	4/11/2003	HCL-04	HCL-04	1.5													
	Coles, 2003	4/11/2003	HCL-05	HCL-05	2.5													
	Golder, 1990	1990	C-0		2.5													
	Golder, 1990	1990	C-0		5.0													
	Golder, 1990	1990	C-100		5.0													
	Golder, 1990	1990	C-200		8.0		4.1											
	Golder, 1990	1990	C-250		2.0													
	Golder, 1990	1990	C-250		10.0													
	Golder, 1990	1990	C-250		15.0													
	Golder, 1990	1990	J-475		5.0													
	Golder, 1990	1990	J-475		10.0													
	Golder, 1990	1990	J-475A		5.0													
	Golder, 1990	1990	J-400		5.0		9.5											
	Golder, 1990	1990	J-400		10.0													
	Golder, 1990	1990	J-500		2.5		2.6											
	Golder, 1990	1990	J-500		5.0													
	Golder, 1990	1990	J-500		10.0													
	Golder, 1990	1990	C-600		10.0		11.8											
	Golder, 1990	1990	J-600		2.5		7											
	Golder, 1990	1990	J-600		5.0		41											
	Golder, 1990	1990	J-550		10.0													
	Golder, 1990	1990	J-630		6.0													
	Golder, 1990	1990	J-630		10.0													
Golder, 1990	1990	J-630		15.0														
Golder, 1990	1990	L-500		5.0														
Golder, 1990	1990	L-600		5.0														
Golder, 1990	1990	L-600		10.0														
Golder, 1990	1990	T-550		2.0														
Golder, 1990	1990	T-550		5.0														
Golder, 1990	1990	T-550		10.0														
Golder, 1990	1990	T-550		15.0														
Golder, 1990	1990	WL-002		2.5														
Golder, 1990	1990	D-550		2.5														
Golder, 1990	1990	D-550		5A														

Table 8
Detected TPH and Metals Concentrations in Subsurface Soil - Harbor Oil Site

Type of Analysis	Reporting Source	Date	Sample Location	Sample Number	Sample Depth (feet)	Duplicate	Inorganics (mg/kg)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
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⁵ EPA Soil Screening Levels at <http://www.epa.gov/oswer/riskassessment/ecorisk/ecossl.htm>
⁶ Oak Ridge National Laboratory (Efroymsen et al., 1997a and 1997b)
⁷ DEQ Level II Ecological Screening Level Values (SLVs) for wildlife (DEQ, 2001b)

Table 9
Detected VOC Concentrations in Subsurface Soil - Harbor Oil Site

Type of Analysis	Reporting Source	Date	Sample Location	Sample Number	Sample Depth (feet)	Duplicate	Volatile Organic Compounds (ug/kg)			
							2-Butanone	Chlorobenzene	methyl-Cyclohexane	Methyl tert-butyl ether
Fixed Laboratory	E&E, 2001	7/31/2000	BG01	BG01SB04-00314163	4-8		26.8 U	2.7 U	2.7 U	2.7 U
	E&E, 2001	7/31/2000	DP01	DP01SB02-00314151	2-6		30.6 U	3 JH	3.8	3.0 U
	E&E, 2001	7/31/2000	DP02	DP02SB04-00314155	4-8		73.8	2.7 U	2.7 U	4.1
	E&E, 2001	7/31/2000	DP03	DP03SB04-00314160	4-8		73.5	3.0 U	3.0 U	3.0 U
	E&E, 2001	7/31/2000	BG01	BG01SB08-00314164	8-12		77.4	3.9 U	3.9 U	3.9 U
	E&E, 2001	7/31/2000	DP01	DP01SB06-00314152	6-10		93.5	3.3 U	3.3 U	3.3 U
	E&E, 2001	7/31/2000	DP02	DP02SB08-00314156	8-12		117	3.0 U	3.0 U	3.0 U
	E&E, 2001	7/31/2000	DP02	DP02SB12-00314157	12-16		64.7	3.0 U	3.0 U	3.0 U
	E&E, 2001	7/31/2000	DP02	DP02SB16-00314158	16-20		40.6	3.1 U	3.1 U	3.1 U
	E&E, 2001	7/31/2000	DP03	DP03SB08-00314161	8-12		58.9	3.8 U	3.8 U	3.8 U
Screening Levels Human Health Screening Value EPA Region 6 Screening Level ¹ Industrial ^{2,3} DEQ RBCs ^{2,3} Soil Ing., Dermal Contact, Inhalation Vol. to Outdoor Air Vapor Intrusion into Buildings Leaching to GW Ecological Screening Value EPA Eco SSL, ORNL, or DEQ SLV ^{5,6,7}							NC	46,000	NC	72,000
							NC	4.2E+06	NC	1.0E+06
							NC	6.5E+06	NC	1.4E+06
							NC	700,000	NC	70,000
							NC	2,600	NC	500
							NC	40,000	NC	NC

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Most stringent industrial soil screening level. Adjusted to Hazard Quotient of 0.1 to account for cumulative risks.
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⁴ Most stringent occupational, construction or excavation worker Risk-Based Concentration (RBC).
⁵ EPA Soil Screening Levels at <http://www.epa.gov/oswer/riskassessment/ecorisk/ecossl.htm>
⁶ Oak Ridge National Laboratory (Efroymsen et al., 1997a and 1997b)
⁷ DEQ Level II Ecological Screening Level Values (SLVs) for wildlife (DEQ, 2001b)

Table 10
Detected SVOC Concentrations in Subsurface Soil - Harbor Oil Site

Type of Analysis	Reporting Source	Date	Sample Location	Sample Number	Sample Depth (feet)	Duplicate	Semivolatile Organic Compounds (ug/kg)									
							Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzaldehyde	1,1-Biphenyl	Chrysene	Dibenzofuran	2,4-Dimethylphenol	Bis(2-ethylhexyl)phthalate
Fixed Laboratory	E&E, 2001	7/31/2000	BG01	BG01SB04-00314163	4-8		149 U	149 U	298 U	298 U	149 UJK	149 U	149 U	149 U	149 U	149 U
	E&E, 2001	7/31/2000	DP01	DP01SB02-00314151	2-6		52.1 JQ	61 JQ	42.2 JQ	55.4 JQ	157 UJK	74.2 JQ	49.7 JQ	90.4 JQ	69.4 JQ	184
	E&E, 2001	7/31/2000	DP02	DP02SB04-00314155	4-8		40.3 JQ	175 U	350 U	70.8 JQ	175 UJK	175 U	97.6 JQ	175 U	175 U	175 U
	E&E, 2001	7/31/2000	DP03	DP03SB04-00314160	4-8		172 U	172 U	344 U	344 U	172 UJK	172 U	172 U	172 U	172 U	172 U
	E&E, 2001	7/31/2000	BG01	BG01SB08-00314164	8-12		185 U	185 U	370 U	370 U	185 UJK	185 U	185 U	185 U	185 U	185 U
	E&E, 2001	7/31/2000	DP01	DP01SB06-00314152	6-10		64 JQ	177 U	354 U	354 U	177 UJK	177 U	51.1 JQ	177 U	177 U	177 U
	E&E, 2001	7/31/2000	DP02	DP02SB08-00314156	8-12		176 U	176 U	352 U	352 U	176 UJK	176 U	176 U	176 U	176 U	176 U
	E&E, 2001	7/31/2000	DP02	DP02SB12-00314157	12-16		177 U	177 U	354 U	354 U	49.3 JQ	177 U	177 U	177 U	177 U	177 U
	E&E, 2001	7/31/2000	DP02	DP02SB16-00314158	16-20		172 U	172 U	344 U	344 U	172 UJK	172 U	172 U	172 U	172 U	172 U
	E&E, 2001	7/31/2000	DP03	DP03SB08-00314161	8-12		191 U	191 U	382 U	382 U	191 UJK	191 U	191 U	191 U	191 U	191 U
Screening Levels Human Health Screening Value EPA Region 6 Screening Level ¹ Industrial DEQ RBCs ^{2,3} Soil Ing., Dermal Contact, Inhalation Vol. to Outdoor Air Vapor Intrusion into Buildings Leaching to GW Ecological Screening Value EPA Eco SSL, ORNL, or DEQ SLV ^{5,6,7}							1.0E+05	2,300	230	2,300	6.8E+06	NC	230,000	1.7E+05	1.4E+06	140,000
							9.0E+07	2,700	270	2,700	NC	NC	270,000	NC	NC	150,000
							6.5E+10	NC	NC	NC	NC	NC	NC	NC	NC	NC
							2.4E+11	NC	NC	NC	NC	NC	NC	NC	NC	NC
							6.5E+07	67,000	17,000	210,000	NC	NC	6.7E+06	NC	NC	970,000
							NC	NC	125,000	NC	NC	60,000	NC	2	NC	4,500

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⁵ EPA Soil Screening Levels at <http://www.epa.gov/oswer/riskassessment/ecorisk/ecossl.htm>
⁶ Oak Ridge National Laboratory (Efroymson et al., 1997a and 1997b)
⁷ DEQ Level II Ecological Screening Level Values (SLVs) for wildlife (DEQ, 2001b)

Table 10
Detected SVOC Concentrations in Subsurface Soil - Harbor Oil Site

Type of Analysis	Reporting Source	Date	Sample Location	Sample Number	Sample Depth (feet)	Duplicate	Semivolatile Organic Compounds (ug/kg)									
							Fluoranthene	Indeno(1,2,3-cd)pyrene	Isophorone	2-Methylnaphthalene	2-Methylphenol	4-Methylphenol	Naphthalene	Phenanthrene	Phenol	Pyrene
Fixed Laboratory	E&E, 2001	7/31/2000	BG01	BG01SB04-00314163	4-8		149 U	1,490 U	149	149 U	149 U	149 U	149 U	149 U	149 U	149 U
	E&E, 2001	7/31/2000	DP01	DP01SB02-00314151	2-6		62.9 JQ	609 JQ	157 U	380	78 JQ	990	509	150 JQ	91.5 JQ	70.1 JQ
	E&E, 2001	7/31/2000	DP02	DP02SB04-00314155	4-8		137 JQ	1,750 U	175 U	276	175 U	175 U	226	208	175 U	197
	E&E, 2001	7/31/2000	DP03	DP03SB04-00314160	4-8		172 U	1,720 U	172 U	172 U	172 U	172 U	172 U	172 U	172 U	172 U
	E&E, 2001	7/31/2000	BG01	BG01SB08-00314164	8-12		185 U	1,850 U	185 U	185 U	185 U	185 U	185 U	185 U	185 U	185 U
	E&E, 2001	7/31/2000	DP01	DP01SB06-00314152	6-10		58.9 JQ	1,770 U	177 U	134 JQ	177 U	194	60.4 JQ	105 JQ	177 U	67.9 JQ
	E&E, 2001	7/31/2000	DP02	DP02SB08-00314156	8-12		176 U	1,760 U	176 U	176 U	176 U	176 U	176 U	176 U	176 U	176 U
	E&E, 2001	7/31/2000	DP02	DP02SB12-00314157	12-16		177 U	1,770 U	177 U	177 U	177 U	177 U	177 U	177 U	177 U	177 U
	E&E, 2001	7/31/2000	DP02	DP02SB16-00314158	16-20		172 U	1,720 U	172 U	172 U	172 U	172 U	172 U	172 U	172 U	172 U
	E&E, 2001	7/31/2000	DP03	DP03SB08-00314161	8-12		191 U	1,910 U	191 U	191 U	191 U	191 U	191 U	191 U	191 U	191 U
Screening Levels Human Health Screening Value EPA Region 6 Screening Level ¹ Industrial DEQ RBCs ^{2,3} Soil Ing., Dermal Contact, Inhalation Vol. to Outdoor Air Vapor Intrusion into Buildings Leaching to GW Ecological Screening Value EPA Eco SSL, ORNL, or DEQ SLV ^{5,6,7}							2.4E+06	2,300	2.0E+06	NC	3.4E+07	3.4E+06	21,000	NC	1.0E+08	3.2E+06
							8.9E+06	2,700	NC	NC	NC	NC	71,000	NC	NC	6.7E+06
							NC	NC	NC	NC	NC	NC	940,000	NC	NC	NC
							NC	NC	NC	NC	NC	NC	3.4E+06	NC	NC	NC
							1.9E+08	580,000	NC	NC	NC	NC	1,500	NC	NC	1.4E+08
							NC	NC	NC	NC	1.6E+07	NC	3.9E+06	NC	30,000	NC

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⁵ EPA Soil Screening Levels at <http://www.epa.gov/oswer/riskassessment/ecorisk/ecossl.htm>
⁶ Oak Ridge National Laboratory (Efroymson et al., 1997a and 1997b)
⁷ DEQ Level II Ecological Screening Level Values (SLVs) for wildlife (DEQ, 2001b)

Table 11
Detected PCB and Pesticide Concentrations in Subsurface Soil - Harbor Oil Site

Type of Analysis	Reporting Source	Date	Sample Location	Sample Number	Sample Depth (feet)	Duplicate	Polychlorinated Biphenyls (ug/kg)		Pesticides (ug/kg)		
							Aroclor 1248	Aroclor 1260	p,p'-DDD	p,p'-DDE	p,p'-DDT
Fixed Laboratory	E&E, 2001	7/31/2000	BG01	BG01SB04-00314163	4-8		18 U	18 U	0.74 U	0.74 U	0.74 U
	E&E, 2001	7/31/2000	DP01	DP01SB02-00314151	2-6		20 U	20 U	12	2.2	0.95
	E&E, 2001	7/31/2000	DP02	DP02SB04-00314155	4-8		22 U	22 U	570	23	3.4
	E&E, 2001	7/31/2000	DP03	DP03SB04-00314160	4-8		21 U	21 U	0.86 U	0.86 U	0.86 U
	E&E, 2001	7/31/2000	BG01	BG01SB08-00314164	8-12		23 U	23 U	0.93 U	0.93 U	0.93 U
	E&E, 2001	7/31/2000	DP01	DP01SB06-00314152	6-10		22 U	22 U	0.88 U	0.88 U	0.88 U
	E&E, 2001	7/31/2000	DP02	DP02SB08-00314156	8-12		22 U	22 U	0.88 U	0.88 U	0.88 U
	E&E, 2001	7/31/2000	DP02	DP02SB12-00314157	12-16		22 U	22 U	0.88 U	0.88 U	0.88 U
	E&E, 2001	7/31/2000	DP02	DP02SB16-00314158	16-20		22 U	22 U	0.86 U	0.86 U	0.86 U
	E&E, 2001	7/31/2000	DP03	DP03SB08-00314161	8-12		24 U	24 U	0.95 U	0.95 U	0.95 U
	Coles, 2003	2/1/2003	HC-01	HC-01	6.0		67 U	67 U			
	Coles, 2003	2/1/2003	HC-02	HC-02	3.0		702 U	702 U			
	Coles, 2003	2/1/2003	HC-03	HC-03	7.0		67 U	67 U			
	Coles, 2003	2/1/2003	HC-04	HC-04	5.0		1,180	283 U			
	Coles, 2003	2/1/2003	HC-05	HC-05	6.5		67 U	67 U			
	Coles, 2003	2/1/2003	HC-06	HC-06	6.0		67 U	67 U			
	Coles, 2003	2/20/2003	HC-07	HC-07	4.5		10,800	2,820			
	Coles, 2003	2/20/2003	HC-08	HC-08	5.5		264 U	264 U			
	Coles, 2003	2/20/2003	HC-09	HC-09	6.5						
	Coles, 2003	2/20/2003	HC-10	HC-10	1.0		67 U	67 U			
	Coles, 2003	2/20/2003	HC-11	HC-11	6.5						
	Coles, 2003	4/17/2004	HC-12	HC-12	3.5		67 U	236			
	Coles, 2003	4/17/2004	HC-13	HC-13	2.0		1,340 U	1,340 U			
	Coles, 2003	4/17/2004	HC-14	HC-14	5.5						
	Coles, 2003	2/18/2003	HCL-01	HCL-01	2.0		67 U	67 U			
	Coles, 2003	2/18/2003	HCL-02	HCL-02	Composite		67 U	80.2			
	Coles, 2003	2/20/2003	HCL-03	HCL-03	6.0		67 U	67 U			
	Coles, 2003	4/11/2004	HCL-04	HCL-04	1.5						
	Coles, 2003	4/11/2004	HCL-05	HCL-05	2.5		67 U	67 U			
Screening Levels Human Health Screening Value EPA Region 6 Screening Level ¹ Industrial DEQ RBCs ^{2,3} Soil Ing., Dermal Contact, Inhalation Vol. to Outdoor Air Vapor Intrusion into Buildings Leaching to GW Ecological Screening Value EPA Eco SSL, ORNL, or DEQ SLV ^{5,6,7}											
							830	830	11,000	7,800	7,800
							980	980	11,000	7,700	7,700
							NC	NC	NC	NC	NC
							NC	NC	NC	NC	NC
							4,600	4,600	510,000	1.6E+06	950,000
							NC	NC	10	10	10

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Most stringent industrial soil screening level. Adjusted to Hazard Quotient of 0.1 to account for cumulative risks.

Table 11
Detected PCB and Pesticide Concentrations in Subsurface Soil - Harbor Oil Site

³ DEQ, Risk-Based Decision Making for the Remediation of Petroleum-Contaminated Sites, 2007.
⁴ Most stringent occupational, construction or excavation worker Risk-Based Concentration (RBC).
⁵ EPA Soil Screening Levels at <http://www.epa.gov/oswer/riskassessment/ecorisk/ecossl.htm>
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⁷ DEQ Level II Ecological Screening Level Values (SLVs) for wildlife (DEQ, 2001b)

Table 12
Summary of Regional Soil Background
Values (DEQ 2002)

Chemical	Soil Default Background Concentrations (mg/kg)
Aluminum	not available
Antimony	4
Arsenic	7
Beryllium	not available
Cadmium	1
Chromium	42
Copper	36
Iron	not available
Lead	17
Manganese	not available
Mercury	0.07
Nickel	38
Selenium	2
Zinc	86

Table 13
Detected TPH and Metals Concentrations in Wetland Soil - Harbor Oil Site

	Reporting Source	Date	Sample Location	Sample Number	Sample Depth (feet)	Duplicate	NWTPH-HCID (mg/kg)			NWTPH-Dx (mg/kg)	
							Gasoline Range TPH	Diesel Range TPH	Oil Range TPH	Diesel Range TPH	Oil Range TPH
Type of Analysis											
Fixed Laboratory	E&E, 2001	8/1/2000	BG02	BG02SD-00314173	0-0.5		20 U	50 U	110	30	80
	E&E, 2001	8/1/2000	WL01	WL01SD-00314168	0.5-1		380 U	6,400	23,000	2,100	6,600
	E&E, 2001	8/1/2000	WL02	WL02SD-00314169	0.5-1		170 U	5,300	15,000	2,200	5,500
	E&E, 2001	8/1/2000	WL03	WL03SD-00314170	0.5-1		22 U	50 U	170	31	150
	E&E, 2001	8/1/2000	WL04	WL04SD-00314171	0.5-1		20 U	50 U	100 U		
	E&E, 2001	8/1/2000	WL05	WL05SD-00314172	0.5-1		69 U	770	2,300	1,400	5,000
	Coles, 2002	8/1/2000	WL05	Force Lake Sed (550) ¹	0.5-1		145 U	362 U	DET	181 U	1,880
Screening Levels Human Health Screening Value EPA Region 6 Screening Level ² Residential DEQ RBCs ^{3,4} Soil Ing., Dermal Contact, Inhalation Vol. to Outdoor Air Vapor Intrusion into Buildings Leaching to GW Ecological Screening Value EPA Eco SSL, ORNL, or DEQ SLV ^{5,6,7}											
							NC	NC	NC	NC	NC
							NC	NC	NC	3,900	3,900
							NC	NC	NC	120,000	120,000
							NC	NC	NC	120,000	120,000
							NC	NC	NC	3,200	3,200

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⁵ EPA Soil Screening Levels at <http://www.epa.gov/oswer/riskassessment/ecorisk/ecossl.htm>
⁶ Oak Ridge National Laboratory (Efroymson et al., 1997a and 1997b)
⁷ DEQ Level II Ecological Screening Level Values (SLVs) for wildlife (DEQ, 2001b)

Table 13
Detected TPH and Metals Concentrations in Wetland Soil - Harbor Oil Site

Type of Analysis	Reporting Source	Date	Sample Location	Sample Number	Sample Depth (feet)	Duplicate	Inorganics (mg/kg)										
							Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron
Fixed Laboratory	E&E, 2001	8/1/2000	BG02	BG02SD-00314173	0-0.5		5,850	4.5 U	1.26	73	0.34	0.22	3,990	8.96	9.56	10.2	27,800
	E&E, 2001	8/1/2000	WL01	WL01SD-00314168	0.5-1		12,100	8.4 JK	25.7	279	0.42	1.98	18,500	95.5	13.8	150 JK	32,200
	E&E, 2001	8/1/2000	WL02	WL02SD-00314169	0.5-1		10,700	4.5 U	13.9	178	0.50	1.73	10,600	44.3	19.4	89 JK	56,500
	E&E, 2001	8/1/2000	WL03	WL03SD-00314170	0.5-1		8,630	4.5 U	1.97	204	0.36	0.33	3,960	12.9	8.69	16.8	17,400
	E&E, 2001	8/1/2000	WL04	WL04SD-00314171	0.5-1		10,100	4.5 U	1.68	206	0.544	0.72	4,590	17.5	9.32	27 JK	20,400
	E&E, 2001	8/1/2000	WL05	WL05SD-00314172	0.5-1		5,990	4.5 U	7.16	166	0.44	0.72	7,850	21.6	10.3	41.8	20,900
	Coles, 2002	8/1/2000	WL05	Force Lake Sed (550) ¹	0.5-1												
Screening Levels Human Health Screening Value EPA Region 6 Screening Level ² Residential DEQ RBCs ^{3,4} Soil Ing., Dermal Contact, Inhalation Vol. to Outdoor Air Vapor Intrusion into Buildings Leaching to GW Ecological Screening Value EPA Eco SSL, ORNL, or DEQ SLV ^{5,6,7}							7,600	3.1	0.39	1,600	15	3.9	NC	210	900	290	5,500
							NC	NC	0.39	1,600	15	1,500	NC	100,000	NC	290	NC
							NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
							NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
							NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
							50	0.27	18	330	21	0.36	NC	26	13	28	200

Legend
Shading = Exceeds human health screening level
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Bold = Detected concentration
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K = Unknown bias.
L = Low bias.
H = High bias.
Q = The results is estimated because it is below the sample quantitation limit.
¹ With Acid/Silica Gel Cleanup.
² EPA Region 6 Screening Levels, 2007.
Residential soil screening level. Adjusted to Hazard Quotient of 0.1 to account for cumulative risks.
³ DEQ, Risk-Based Decision Making for the Remediation of Petroleum-Contaminated Sites, 2007.
⁴ Residential Risk-Based Concentration (RBC).
⁵ EPA Soil Screening Levels at <http://www.epa.gov/oswer/riskassessment/ecorisk/ecossl.htm>
⁶ Oak Ridge National Laboratory (Efroymson et al., 1997a and 1997b)
⁷ DEQ Level II Ecological Screening Level Values (SLVs) for wildlife (DEQ, 2001b)

Table 13
Detected TPH and Metals Concentrations in Wetland Soil - Harbor Oil Site

Type of Analysis	Reporting Source	Date	Sample Location	Sample Number	Sample Depth (feet)	Duplicate	Inorganics (mg/kg)										
							Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Vanadium	Zinc
Fixed Laboratory	E&E, 2001	8/1/2000	BG02	BG02SD-00314173	0-0.5		5.25 JL	3,970	368	0.047 U	10.7	809	0.1 U	0.61	189	82	51.7
	E&E, 2001	8/1/2000	WL01	WL01SD-00314168	0.5-1		257	3,480	1,090	0.396	43.3	1,530	1.1	0.98	538	101	664
	E&E, 2001	8/1/2000	WL02	WL02SD-00314169	0.5-1		124	3,920	942	0.180	21.1	1,510	0.55	1.5	850	136	748
	E&E, 2001	8/1/2000	WL03	WL03SD-00314170	0.5-1		11.9 JL	4,110	429	0.100 U	14.4	1,970	0.1 U	0.55	393	34.2	83.7
	E&E, 2001	8/1/2000	WL04	WL04SD-00314171	0.5-1		17.4	4,700	417	0.069	17.8	2,440	0.5 U	0.74	384	42.7	104
	E&E, 2001	8/1/2000	WL05	WL05SD-00314172	0.5-1		38.6	2,800	744	0.26 U	17.1	993	0.5 U	0.71	311	46	219
	Coles, 2002	8/1/2000	WL05	Force Lake Sed (550) ¹	0.5-1		72.3 U										
Screening Levels Human Health Screening Value EPA Region 6 Screening Level ² Residential DEQ RBCs ^{3,4} Soil Ing., Dermal Contact, Inhalation Vol. to Outdoor Air Vapor Intrusion into Buildings Leaching to GW Ecological Screening Value EPA Eco SSL, ORNL, or DEQ SLV ^{5,6,7}							400	NC	320	2.3	160	NC	39	39	NC	39	2,300
							400	NC	330	2.3	160	NC	NC	39	NC	NC	NC
							NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
							NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
							3	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
							11	NC	220	0.1	38	NC	1	4.2	NC	7.8	50

Legend
Shading = Exceeds human health screening level
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Bold = Detected concentration
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¹ With Acid/Silica Gel Cleanup.
² EPA Region 6 Screening Levels, 2007.
Residential soil screening level. Adjusted to Hazard Quotient of 0.1 to account for cumulative risks.
³ DEQ, Risk-Based Decision Making for the Remediation of Petroleum-Contaminated Sites, 2007.
⁴ Residential Risk-Based Concentration (RBC).
⁵ EPA Soil Screening Levels at <http://www.epa.gov/oswer/riskassessment/ecorisk/ecossl.htm>
⁶ Oak Ridge National Laboratory (Efroymson et al., 1997a and 1997b)
⁷ DEQ Level II Ecological Screening Level Values (SLVs) for wildlife (DEQ, 2001b)

Table 14
Detected SVOC Concentrations in Wetland Soil - Harbor Oil Site

Type of Analysis	Reporting Source	Date	Sample Location	Sample Number	Sample Depth (feet)	Duplicate	Semivolatile Organic Compounds (ug/kg)															
							Acehaphthylene	Anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzaldehyde	1,1-Biphenyl	Butyl benzyl phthalate	Chrysene	Dibenzofuran	2,4-Dimethylphenol	Bis(2-ethylhexyl)phthalate	1-phenyl-Ethanone	Fluoranthene	9H-Fluorene	Indeno(1,2,3-cd)pyrene
Fixed Laboratory	E&E, 2001	8/1/2000	BG02	BG02SD-00314173	0-0.5		146 U	146 U	292 U	292 U	731 U	146 UJK	146 U	731 U	146 U	146 U	146 U	146 U	146 U	146 U	146 U	1,460 U
	E&E, 2001	8/1/2000	WL01	WL01SD-00314168	0.5-1		836 JQ	904	628 JQ	1,210 JQ	3,390 JQ	1,080 JQ	836 JQ	3,140 JQ	1,140	781 JQ	883 U	2,180	630 JQ	2,690	417 JQ	3,830 JQ
	E&E, 2001	8/1/2000	WL02	WL02SD-00314169	0.5-1		735 U	735 U	397 JQ	1,470 U	2,480 JQ	216 JQ	735 U	3,680 U	735 U	735 U	735 U	1,730	735 U	528 JQ	735 U	3,430 JQ
	E&E, 2001	8/1/2000	WL03	WL03SD-00314170	0.5-1		277 U	277 U	555 U	555 U	1,390 U	160 JQ	277 U	1,390 U	277 U	277 U	277 U	277 U	277 U	277 U	277 U	2,770 U
	E&E, 2001	8/1/2000	WL04	WL04SD-00314171	0.5-1		195 U	195 U	389 U	389 U	973 U	59.6 JQ	195 U	973 U	195 U	195 U	195 U	195 U	100 JQ	195 U	1,950 U	
	E&E, 2001	8/1/2000	WL05	WL05SD-00314172	0.5-1		782 U	338 JQ	1,560 U	1,560 U	3,910 U	814 JQ	782 U	3,910 U	555 JQ	782 U	782 U	1,180	782 U	1,220	240 JQ	7,820 U
	Coles, 2002	8/1/2000	WL05	Force Lake Sed (550)	0.5-1		4,770 U	4,770 U	4,770 U	4,770 U	4,770 U			4,770 U	4,770 U	4,770 U	14,500 U	28,900 U		4,770 U	4,770 U	4,770 U
Screening Levels Human Health Screening Value EPA Region 6 Screening Level ¹ Residential DEQ RBCs ^{2,3} Soil Ing., Dermal Contact, Inhalation Vol. to Outdoor Air Vapor Intrusion into Buildings Leaching to GW							NC	2.2E+06	15	150	NC	6.1E+05	NC	240,000	15,000	15,000	1.2E+05	35,000	NC	2.3E+05	2.6E+05	150
							NC	2.1E+07	15	150	NC	NC	NC	NC	15,000	NC	NC	35,000	NC	2.3E+06	2.6E+06	150
							NC	1.6E+10	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	9.2E+08	NC
							NC	2.0E+10	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	1.1E+09	NC
							NC	1.6E+07	900	11,000	NC	NC	NC	NC	350,000	NC	NC	140,000	NC	4.7E+07	1.0E+06	31,000
Ecological Screening Value EPA Eco SSL, ORNL, or DEQ SLV ^{5,6,7}							NC	NC	125,000	NC	NC	NC	60,000	NC	NC	2	NC	4,500	NC	NC	30,000	NC

Legend
Shading = Exceeds human health screening level
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Bold = Detected concentration
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H = High bias.
Q = The results is estimated because it is below the sample quantitation limit.
¹ With Acid/Silica Gel Cleanup.
² EPA Region 6 Screening Levels, 2007.
Residential soil screening level. Adjusted to Hazard Quotient of 0.1 to account for cumulative risks.
³ DEQ, Risk-Based Decision Making for the Remediation of Petroleum-Contaminated Sites, 2007.
⁴ Residential Risk-Based Concentration (RBC).
⁵ EPA Soil Screening Levels at <http://www.epa.gov/oswer/riskassessment/ecorisk/ecossl.html>
⁶ Oak Ridge National Laboratory (Efroymson et al., 1997a and 1997b)
⁷ DEQ Level II Ecological Screening Level Values (SLVs) for wildlife (DEQ, 2001b)

Table 14
Detected SVOC Concentrations in Wetland Soil - Harbor Oil Site

Type of Analysis	Reporting Source	Date	Sample Location	Sample Number	Sample Depth (feet)	Duplicate	Semivolatile Organic Compounds (ug/kg)					
							2-Methylnaphthalene	Naphthalene	2-Nitoraniline	Phenanthrene	Phenol	Pyrene
Fixed Laboratory	E&E, 2001	8/1/2000	BG02	BG02SD-00314173	0-0.5		146 U	146 U	292 U	146 U	146 U	146 U
	E&E, 2001	8/1/2000	WL01	WL01SD-00314168	0.5-1		2,880	4,210	1,770 U	4,370	498 JQ	4,560
	E&E, 2001	8/1/2000	WL02	WL02SD-00314169	0.5-1		231 JQ	398 JQ	1,470 U	482 JQ	350 JQ	857
	E&E, 2001	8/1/2000	WL03	WL03SD-00314170	0.5-1		277 U	277 U	555 U	277 U	277 U	277 U
	E&E, 2001	8/1/2000	WL04	WL04SD-00314171	0.5-1		195 U	195 U	389 U	52.1 JQ	195 U	96 JQ
	E&E, 2001	8/1/2000	WL05	WL05SD-00314172	0.5-1		380 JQ	1,210	1,560	1,260	782 U	1,410
	Coles, 2002	8/1/2000	WL05	Force Lake Sed (550)	0.5-1		4,770 U	4,770 U	4,770 U	4,770 U	4,770 U	4,770 U
Screening Levels Human Health Screening Value EPA Region 6 Screening Level ¹ Residential DEQ RBCs ^{2,3} Soil Ing., Dermal Contact, Inhalation Vol. to Outdoor Air Vapor Intrusion into Buildings Leaching to GW Ecological Screening Value EPA Eco SSL, ORNL, or DEQ SLV ^{5,6,7}							NC	12,000	18,000	NC	1.8E+06	2.3E+05
							NC	3,400	NC	NC	NC	1.7E+06
							NC	24,000	NC	NC	NC	NC
							NC	29,000	NC	NC	NC	NC
							NC	380	NC	NC	NC	3.4E+07
							NC	3.9E+06	NC	NC	30,000	NC

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¹ With Acid/Silica Gel Cleanup.
² EPA Region 6 Screening Levels, 2007.
Residential soil screening level. Adjusted to Hazard Quotient of 0.1 to account for cumulative risks.
³ DEQ, Risk-Based Decision Making for the Remediation of Petroleum-Contaminated Sites, 2007.
⁴ Residential Risk-Based Concentration (RBC).
⁵ EPA Soil Screening Levels at <http://www.epa.gov/oswer/riskassessment/ecorisk/ecossl.htm>
⁶ Oak Ridge National Laboratory (Efroymson et al., 1997a and 1997b)
⁷ DEQ Level II Ecological Screening Level Values (SLVs) for wildlife (DEQ, 2001b)

Table 15
Detected PCB, Pesticide and Total Organic Carbon Concentrations in Wetland Soil- Harbor Oil Site

Type of Analysis	Reporting Source	Date	Sample Location	Sample Number	Sample Depth (feet)	Duplicate	Polychlorinated Biphenyls (ug/kg)	Pesticides (ug/kg)				TOC (mg/kg)
							Aroclor 1260	Methoxychlor	p,p'-DDD	p,p'-DDE	p,p'-DDT	Total Organic Carbon
Fixed Laboratory	E&E, 2001	8/1/2000	BG02	BG02SD-00314173	0-0.5		18 U	0.73 U	5.8	3.1	0.73 U	0.96
	E&E, 2001	8/1/2000	WL01	WL01SD-00314168	0.5-1		2,300	20 U	300	22	17 U	20
	E&E, 2001	8/1/2000	WL02	WL02SD-00314169	0.5-1		900	0.92 U	820	18	68	7.9
	E&E, 2001	8/1/2000	WL03	WL03SD-00314170	0.5-1		35 U	1.4 U	17	24	1.4 U	4.2
	E&E, 2001	8/1/2000	WL04	WL04SD-00314171	0.5-1		24 U	4.6 JH	4.2	3.8	0.97 U	
	E&E, 2001	8/1/2000	WL05	WL05SD-00314172	0.5-1		98 U	3.9 U	420	230	4.5 U	20
	Coles, 2002	8/1/2000	WL05	Force Lake Sed (550)	0.5-1		557					
Screening Levels Human Health Screening Value EPA Region 6 Screening Level ¹ Residential DEQ RBCs ^{2,3} Soil Ing., Dermal Contact, Inhalation Vol. to Outdoor Air Vapor Intrusion into Buildings Leaching to GW Ecological Screening Value EPA Eco SSL, ORNL, or DEQ SLV ^{5,6,7}							220	31,000	2,400	1,700	1,700	
							220	NC	2,400	1,700	1,700	
							NC	NC	NC	NC	NC	
							NC	NC	NC	NC	NC	
							640	NC	71,000	220,000	130,000	
							NC	500,000	10	10	10	

Legend
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¹ With Acid/Silica Gel Cleanup.
² EPA Region 6 Screening Levels, 2007.
Residential soil screening level. Adjusted to Hazard Quotient of 0.1 to account for cumulative risks.
³ DEQ, Risk-Based Decision Making for the Remediation of Petroleum-Contaminated Sites, 2007.
⁴ Residential Risk-Based Concentration (RBC).
⁵ EPA Soil Screening Levels at <http://www.epa.gov/oswer/riskassessment/ecorisk/ecossl.htm>
⁶ Oak Ridge National Laboratory (Efroymson et al., 1997a and 1997b)
⁷ DEQ Level II Ecological Screening Level Values (SLVs) for wildlife (DEQ, 2001b)

Table 16
Detected Metals Concentrations in Surface Water - Harbor Oil Site

	Reporting Source	Date	Sample Location	Sample Number	Inorganics (ug/L)							
					Arsenic	Chromium	Copper	Iron	Lead	Mercury	Nickel	Zinc
Type of Analysis												
Fixed Laboratory	COP, 1997	1992	W-1	W-1	1.5 U	2 U	11	816	126	0.3 U	30 U	19
Screening Levels												
Human Health Screening Value												
EPA Human Health AWQC ¹												
Water/Organism Consumption					0.018	NC	1,300	300	NC	NC	610	7,400
Organism Consumption Only					0.14	NC	NC	NC	NC	NC	4600	26,000
Ecological Screening Value												
Freshwater CCC AWQC or Tier II ^{1,2}					150	74	9.0	158	2.5	0.77	52	120

Legend
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Bold = Detected concentration
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DET = Detected
U = Not detected
J = Indicates an estimated value below the calculated detection limit.
K = Unknown bias.
L = Low bias.
H = High bias.
Q = The results is estimated because it is below the sample quantitation limit.
¹ National Recommended Water Quality Criteria, EPA, 2006.
² Suter and Tsao (1996)

Table 17
TPH and Metals Sediment Sampling Results - Harbor Oil Site

Type of Analysis	Reporting Source	Date	Sample Location	Sample Number	Sample Depth (feet)	Duplicate	NWTPH-HCID (mg/kg)	NWTPH-Gx (mg/kg)	NWTPH-Dx (mg/kg)	TPH (mg/kg)
							Gasoline Range TPH Diesel Range TPH Oil Range TPH	Gasoline Range TPH	Diesel Range TPH Oil Range TPH	Unknown Range
Fixed Laboratory	COP, 1997	1992	S-1	S-1	Surface					180
Screening Levels Human Health Screening Level EPA Region 6 Screening Level ¹ Residential DEQ RBCs ^{2,3} Soil Ing., Dermal Contact, Inhalation Ecological Screening Value Threshold Effects Concentrations ⁴										NC NC NC

Legend
Shading = Exceeds human health screening level
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Bold = Detected concentration
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J = Indicates an estimated value below the calculated detection limit.
K = Unknown bias.
L = Low bias.
H = High bias.
Q = The results is estimated because it is below the sample quantitation limit.
¹ EPA Region 6 Screening Levels, 2007. Adjusted to Hazard Quotient of 0.1 to account for cumulative risks.
² DEQ, Risk-Based Decision Making for the Remediation of Petroleum-Contaminated Sites, 2007.
³ Residential Risk-Based Concentration (RBC).
⁴ MacDonald et al. (2000)

Table 17
TPH and Metals Sediment Sampling Results - Harbor Oil Site

	Reporting Source	Date	Sample Location	Sample Number	Sample Depth (feet)	Duplicate	Inorganics (mg/kg)										
							Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron
Type of Analysis																	
Fixed Laboratory	COP, 1997	1992	S-1	S-1	Surface			4.1					6.7		106		15,500
Screening Levels																	
Human Health Screening Level																	
EPA Region 6 Screening Level ¹																	
Residential							7,600	3.1	0.39	1,600	15	3.9	NC	210	900	290	5,500
DEQ RBCs ^{2,3}																	
Soil Ing., Dermal Contact, Inhalation							NC	NC	0.39	1,600	15	1,500	NC	100,000	NC	290	NC
Ecological Screening Value																	
Threshold Effects Concentrations ⁴							NC	NC	9.79	NC	NC	0.99	NC	43.4	NC	31.6	NC

Legend
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Bold = Detected concentration
NC = No criteria
DET = Detected
U = Not detected
J = Indicates an estimated value below the calculated detection limit.
K = Unknown bias.
L = Low bias.
H = High bias.
Q = The results is estimated because it is below the sample quantitation limit.
¹ EPA Region 6 Screening Levels, 2007. Adjusted to Hazard Quotient of 0.1 to account for cumulative risks.
² DEQ, Risk-Based Decision Making for the Remediation of Petroleum-Contaminated Sites, 2007.
³ Residential Risk-Based Concentration (RBC).
⁴ MacDonald et al. (2000)

Table 17
TPH and Metals Sediment Sampling Results - Harbor Oil Site

Type of Analysis	Reporting Source	Date	Sample Location	Sample Number	Sample Depth (feet)	Duplicate	Inorganics (mg/kg)										
							Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Vanadium	Zinc
Fixed Laboratory	COP, 1997	1992	S-1	S-1	Surface		18,600			0.03 U	11.7						173
Screening Levels																	
Human Health Screening Level																	
EPA Region 6 Screening Level ¹																	
Residential							400	NC	320	2.3	160	NC	39	39	NC	39	2,300
DEQ RBCs ^{2,3}																	
Soil Ing., Dermal Contact, Inhalation							400	NC	320	2.3	160	NC	NC	39	NC	NC	NC
Ecological Screening Value																	
Threshold Effects Concentrations ⁴							35.8	NC	NC	0.18	22.7	NC	NC	NC	NC	NC	121

Legend
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Bold = Detected concentration
NC = No criteria
DET = Detected
U = Not detected
J = Indicates an estimated value below the calculated detection limit.
K = Unknown bias.
L = Low bias.
H = High bias.
Q = The results is estimated because it is below the sample quantitation limit.
¹ EPA Region 6 Screening Levels, 2007. Adjusted to Hazard Quotient of 0.1 to account for cumulative risks.
² DEQ, Risk-Based Decision Making for the Remediation of Petroleum-Contaminated Sites, 2007.
³ Residential Risk-Based Concentration (RBC).
⁴ MacDonald et al. (2000)

Table 18
Detected TPH and Metals Concentrations in Sediment - Harbor Oil Site

	Reporting Source	Date	Sample Location	Sample Number	Sample Depth (feet)	TPH (mg/kg)					Inorganics (mg/kg)		
						Unknown Range	Arsenic	Chromium	Copper	Iron	Lead	Nickel	Zinc
Type of Analysis													
Fixed Laboratory	COP, 1997	1992	S-1	S-1	Surface	180	4.1	6.7	106	15,500	18,600	11.7	173
Screening Levels													
Human Health Screening Level													
EPA Region 6 Screening Level ¹													
Residential						NC	0.39	210	290	5,500	400	160	2,300
DEQ RBCs ^{2,3}													
Soil Ing., Dermal Contact, Inhalation						NC	0.39	100,000	290	NC	400	160	NC
Ecological Screening Value													
Threshold Effects Concentrations ⁴							9.79	43.4	31.6		35.8	22.7	121

Legend
Shading = Exceeds human health screening level
Solid outline = Exceeds ecological screening level
Bold = Detected concentration
NC = No criteria
DET = Detected
U = Not detected
J = Indicates an estimated value below the calculated detection limit.
K = Unknown bias.
L = Low bias.
H = High bias.
Q = The results is estimated because it is below the sample quantitation limit.
¹ EPA Region 6 Screening Levels, 2007. Adjusted to Hazard Quotient of 0.1 to account for cumulative risks.
² DEQ, Risk-Based Decision Making for the Remediation of Petroleum-Contaminated Sites, 2007.
³ Residential Risk-Based Concentration (RBC).
⁴ MacDonald et al. (2000)

Table 19
Detected Pesticide Concentrations in Sediment - Harbor Oil Site

	Reporting Source	Date	Sample Location	Sample Number	Sample Depth (feet)	Pesticides (ug/kg)
						p,p'-DDD
Type of Analysis						
Fixed Laboratory	COP, 1997	1992	S-1	S-1	Surface	<div>100</div>
Screening Levels Human Health Screening Level EPA Region 6 Screening Level ¹ Residential DEQ RBCs ^{2,3} Soil Ing., Dermal Contact, Inhalation Ecological Screening Value Threshold Effects Concentrations ⁴						<div>2,400</div> <div>2,400</div> <div>4.88</div>

Legend
Shading = Exceeds human health screening level
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¹ EPA Region 6 Screening Levels, 2007. Adjusted to Hazard Quotient of 0.1 to account for cumulative risks.
² DEQ, Risk-Based Decision Making for the Remediation of Petroleum-Contaminated Sites, 2007.
³ Residential Risk-Based Concentration (RBC).
⁴ MacDonald et al. (2000)

Table 20
Detected TPH and Metals Concentrations in Groundwater - Harbor Oil Site

	Reporting Source	Date	Sample Location	Sample Number	NWTPH-HCID (mg/L)			NWTPH-Gx (mg/L)	NWTPH-Dx (mg/L)	
					Gasoline Range TPH	Diesel Range TPH	Oil Range TPH	Gasoline Range TPH	Diesel Range TPH	Oil Range TPH
Type of Analysis										
Fixed Laboratory	E&E, 2001	8/2/00	PW01	PW01GW-00314194	0.25 U	0.50 U	0.50 U	0.25 U	0.50 U	0.50 U
	E&E, 2001	8/2/00	GA34	GA34GW-00314187	5.9	0.5 U	0.5 U	5.9	0.5 U	0.5 U
	E&E, 2001	8/2/00	A18	A18GW-00314188	0.25 U	1.8	1.4 J	0.25 U	1.8	1.4 J
	E&E, 2001	8/2/00	GA29	GA29GW-00314190	0.40	2.0	0.5 U	0.4	2.0	0.5 U
	E&E, 2001	8/2/00	A19	A19GW-00314191	0.49	0.99	0.50 U	0.49	0.99	0.50 U
	E&E, 2001	8/2/00	GA33	GA33GW-00314192	0.25 U	0.50 U	0.50 U	0.25 U	0.50 U	0.50 U
	E&E, 2001	8/2/00	A20	A20GW00314193	0.25 U	0.50	0.50 U	0.25 U	0.50	0.50 U
	Coles, 2002	8/2/00	A18	MW A-18	0.25 U	DET	DET		0.49 U	2.41
	Coles, 2002	8/2/00	GA29	MW GA-29	0.25 U	DET	0.63 U		0.50 U	1.00 U
	Coles, 2002	8/2/00	A19	MW A-19	0.25 U	DET	0.63 U		0.49 U	0.98 U
	Golder, 1990	1990	A18							
	Golder, 1990	1990	GA30							
	Golder, 1990	1990	B4							
Screening Levels Human Health Screening Value EPA Region 6 Screening Level ¹ Tap Water Screening Level DEQ RBCs ² Vol. to Outdoor Air Vapor Intrusion into Buildings Groundwater in Excavation					NC	NC	NC	NC	NC	NC
					NC	NC	NC	2,500	2,400	2,400
					NC	NC	NC	480	490	490
					NC	NC	NC	13	10	10

Legend
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¹ EPA Region 6 Screening Levels, 2007. Adjusted to Hazard Quotient of 0.1 to account for cumulative risks.
² DEQ, Risk-Based Decision Making for the Remediation of Petroleum-Contaminated Sites, 2007.

Table 20
Detected TPH and Metals Concentrations in Groundwater - Harbor Oil Site

Type of Analysis	Reporting Source	Date	Sample Location	Sample Number	Inorganics (ug/L)										
					Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron
Fixed Laboratory	E&E, 2001	8/2/00	PW01	PW01GW-00314194	20	1.6 U	1.4	11.6	1.0 U	0.2 U	33,800	5.0 U	5.0 U	4.0 U	34.7
	E&E, 2001	8/2/00	GA34	GA34GW-00314187	621	1.6 U	18.8	192	1.0 U	0.2 U	89,900	5.0 U	5.0 U	9.0	23,300
	E&E, 2001	8/2/00	A18	A18GW-00314188	537	1.6 U	18.9	314	1.0 U	1.31	140,000	8.1	5.0 U	25.1	40,100
	E&E, 2001	8/2/00	GA29	GA29GW-00314190	193	1.6 U	9.35	366	1.0 U	0.2 U	134,000	5.0 U	5.0 U	4.0 U	44,400
	E&E, 2001	8/2/00	A19	A19GW-00314191	206	1.6 U	20.5	497	1.0 U	0.2 U	208,000	5.0 U	5.0 U	4.0 U	57,200
	E&E, 2001	8/2/00	GA33	GA33GW-00314192	552	1.6 U	25.3	284	1.0 U	0.2 U	104,000	5.0 U	5.0 U	4.0 U	30,800
	E&E, 2001	8/2/00	A20	A20GW00314193	5,890	1.6	5.55	365	1.5	0.869	80,200	7.4	12	4.0 U	28,800
	Coles, 2002	8/2/00	A18	MW A-18											
	Coles, 2002	8/2/00	GA29	MW GA-29											
	Coles, 2002	8/2/00	A19	MW A-19											
	Golder, 1990	1990	A18		U		3.6	298			117,000			U	8,320
	Golder, 1990	1990	GA30		U		2.1 B	U			151,000			U	284,000
	Golder, 1990	1990	B4		U		6.3 B	433			190,000			U	89
Screening Levels Human Health Screening Value EPA Region 6 Screening Level ¹ Tap Water Screening Level DEQ RBCs ² Vol. to Outdoor Air Vapor Intrusion into Buildings Groundwater in Excavation					3,700	1.5	0.045	730	7.3	1.8	NC	5,475	73	140	2,600
					NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
					NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
					NC	NC	5.8	2,500	25	NC	NC	19,000	NC	460	NC

Legend
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¹ EPA Region 6 Screening Levels, 2007. Adjusted to Hazard Quotient of 0.1 to account for cumulative risks.
² DEQ, Risk-Based Decision Making for the Remediation of Petroleum-Contaminated Sites, 2007.

Table 20
Detected TPH and Metals Concentrations in Groundwater - Harbor Oil Site

	Reporting Source	Date	Sample Location	Sample Number	Inorganics (ug/L)											
					Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
Type of Analysis																
Fixed Laboratory	E&E, 2001	8/2/00	PW01	PW01GW-00314194	0.21	12,900	3.6	0.1 U	10 U	4,160	2.0 U	1.0 U	9,150	1.0 U	11.9	57.3
	E&E, 2001	8/2/00	GA34	GA34GW-00314187	2.54	27,100	3,350	0.1 U	10	17,700	2.0 U	1.0 U	21,100	0.0272	4.3	49.9
	E&E, 2001	8/2/00	A18	A18GW-00314188	19.6	40,500	3,880	0.1 U	25	38,900	2.0 U	1.0 U	56,000	0.0527	15.9	1,180
	E&E, 2001	8/2/00	GA29	GA29GW-00314190	0.36	52,200	3,860	0.1 U	10 U	63,300	3.8	1.0 U	150,000	0.0115	7.4	4.0 U
	E&E, 2001	8/2/00	A19	A19GW-00314191	1.00	95,800	7,860	0.1 U	18	31,000	4.7	1.0 U	125,000	0.00894	3.4	11
	E&E, 2001	8/2/00	GA33	GA33GW-00314192	2.99	33,600	4,820	0.1 U	10 U	21,900	2.0 U	1.0	30,800	0.015	5.3	8.7
	E&E, 2001	8/2/00	A20	A20GW00314193	8.51	24,900	2,200	0.14	20	23,700	2.0 U	1.0 U	15,600	0.0301	54.4	208
	Coles, 2002	8/2/00	A18	MW A-18	44.6	52,800										
	Coles, 2002	8/2/00	GA29	MW GA-29	2.38	75,500										
	Coles, 2002	8/2/00	A19	MW A-19	1.0 U	132,000										
	Golder, 1990	1990	A18		U	55,500	5,070			29,300			45,300		U	115
	Golder, 1990	1990	GA30		U	56,700	6,130			120,000			157,000		U	62.6
	Golder, 1990	1990	B4		U	70,500	2,190			8,210			30,800		U	112
Screening Levels																
Human Health Screening Value																
EPA Region 6 Screening Level ¹																
Tap Water Screening Level					15	NC	170	1.1	73	NC	18	18	NC	0.26	18	1,100
DEQ RBCs ²																
Vol. to Outdoor Air					NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Vapor Intrusion into Buildings					NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Groundwater in Excavation					NC	NC	590	3.7	1,200	NC	NC	100	NC	NC	NC	NC

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² DEQ, Risk-Based Decision Making for the Remediation of Petroleum-Contaminated Sites, 2007.

Table 21
Detected VOC Concentrations in Groundwater - Harbor Oil Site

Type of Analysis	Reporting Source	Date	Sample Location	Sample Number	Volatile Organic Compounds (ug/L)													
					(1-methylethyl)-Benzene	Chlorobenzene	Etheny/benzene	1,2-Dichlorobenzene	1,3-Dichlorobenzene	1,4-Dichlorobenzene	cis-1,2-Dichloroethene	1,2-Dichloropropane	2-Propanone	Tetrachloroethene	Toluene	1,1,1-Trichloroethane	Trichloroethene	Vinyl chloride
Fixed Laboratory	E&E, 2001	8/2/00	PW01	PW01GW-00314194	1 U	1 U	2 U	1 U	1 U	1 U	0.79 JQ	0.18 JQ	2 U	4.2	1 U	0.52 JQ	6.1	1 U
	E&E, 2001	8/2/00	GA34	GA34GW-00314187	1 U	99.4	0.24 JQ	1 U	0.35 JQ	1	0.23 JQ	1 U	2 U	1 U	1 U	1 U	1 U	0.22 JQ
	E&E, 2001	8/2/00	A18	A18GW-00314188	1 U	3.8	2 U	1 U	1 U	0.18 JQ	1 U	1 U	15.6 U	1 U	1 U	1 U	1 U	1 U
	E&E, 2001	8/2/00	GA29	GA29GW-00314190	1 U	0.2 JQ	2 U	1 U	1 U	1 U	1 U	1 U	2.2 U	1 U	1 JQ	1 U	1 U	1 U
	E&E, 2001	8/2/00	A19	A19GW-00314191	1 U	1 U	2 U	1 U	1 U	1 U	1 U	1 U	2 U	1 U	1 U	1 U	1 U	1 U
	E&E, 2001	8/2/00	GA33	GA33GW-00314192	1 U	1 U	2 U	1 U	1 U	1 U	1 U	1 U	12.7	1 U	1 U	1 U	1 U	1 U
	E&E, 2001	8/2/00	A20	A20GW00314193	0.039 JQ	19.1	2 U	0.22 JQ	0.20 JQ	1.4	1 U	1 U	2 U	1 U	1 U	1 U	1 U	1 U
	Coles, 2002	8/2/00	A18	MW A-18		3.44		1 U	1 U	1 U	1 U	1 U		1 U	1 U	1 U	1 U	1 U
	Coles, 2002	8/2/00	GA29	MW GA-29		1 U		1 U	1 U	1 U	1 U	1 U		1 U	1 U	1 U	1 U	1 U
	Coles, 2002	8/2/00	A19	MW A-19		1 U		1 U	1 U	1 U	1 U	1 U		1 U	1 U	1 U	1 U	1 U
Screening Levels Human Health Screening Value EPA Region 6 Screening Level ¹ Tap Water Screening Level DEQ RBCs ² Vol. to Outdoor Air Vapor Intrusion into Buildings Groundwater in Excavation					NC	9.1	NC	4.9	1.4	0.47	6.1	0.16	NC	0.105	230	84	0.028	0.015
					NC	2.7E+06	NC	2.0E+06	600,000	31,000	1.6E+05	NC	NC	8,600	1.7E+08	4.0E+07	650	6,400
					NC	650,000	NC	640,000	170,000	8,700	41,000	NC	NC	1,300	3.1E+07	6.2E+06	110	870
					NC	960	NC	540	130	1,600	760	NC	NC	240	20,000	13,000	130	1,200

Legend
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¹ EPA Region 6 Screening Levels, 2007. Adjusted to Hazard Quotient of 0.1 to account for cumulative risks.
² DEQ, Risk-Based Decision Making for the Remediation of Petroleum-Contaminated Sites, 2007.

Table 22
Detected SVOC Concentrations in Groundwater - Harbor Oil Site

Type of Analysis	Reporting Source	Date	Sample Location	Sample Number	Semivolatile Organic Compounds (ug/L)											
					Acenaphthene	Benzaldehyde	2-Chlorophenol	D-n-butyl phthalate	Diethyl phthalate	Bis(2-ethylhexyl)phthalate	1-phenyl-Ethanone	Fluoranthene	9H-Fluorene	2-Methylnaphthalene	Phenol	Pyrene
Fixed Laboratory	EPA, 2000	8/2/00	PW01	PW01GW-00314194	0.38 U	0.38 UJK	0.38 U	0.38 U	0.38 U	0.38 U	0.38 U	0.38 U	0.38 U	0.38 U	0.38 U	0.38 U
	EPA, 2000	8/2/00	GA34	GA34GW-00314187	0.40 U	0.40 UJK	0.97	0.40 U	0.40 U	1.6	0.16 JQ	0.40 U	0.40 U	0.10 JQ	0.37 JQ	0.40 U
	EPA, 2000	8/2/00	A18	A18GW-00314188	0.18 JQ	0.37 UJK	0.37 U	0.10 JQ	0.37 U	1.8	0.37 U	0.37 U	0.25 JQ	0.37 U	0.095 JQ	0.12 JQ
	EPA, 2000	8/2/00	GA29	GA29GW-00314190	0.38 U	0.12 JQ	0.38 U	0.38 U	0.38 U	0.59	0.38 U	0.38 U	0.38 U	0.38 U	0.38 U	0.38 U
	EPA, 2000	8/2/00	A19	A19GW-00314191	0.38 U	0.13 JQ	0.38 U	0.38 U	0.38 U	0.38 U	0.38 U	0.38 U	0.38 U	0.38 U	0.096 JQ	0.38 U
	EPA, 2000	8/2/00	GA33	GA33GW-00314192	0.37 U	0.37 UJK	0.37 U	0.37 U	0.37 U	1.2	0.37 U	0.37 U	0.37 U	0.37 U	0.13 JQ	0.37 U
	EPA, 2000	8/2/00	A20	A20GW00314193	3.2	0.37 UJK	0.37 U	0.15 JQ	0.25 JQ	0.62	0.37 U	0.64	1.9	0.37 U	0.23 JQ	0.53
	Coles, 2002	8/2/00	A18	MW A-18												
	Coles, 2002	8/2/00	GA29	MW GA-29												
	Coles, 2002	8/2/00	A19	MW A-19												
Screening Levels Human Health Screening Value EPA Region 6 Screening Level ¹ Tap Water Screening Level DEQ RBCs ² Vol. to Outdoor Air Vapor Intrusion into Buildings Groundwater in Excavation					37	370	3	NC	2,900	4.8	NC	150	24	NC	1,100	18
					1.E+08	NC	NC	NC	NC	NC	NC	NC	1.7E+08	NC	NC	NC
					1.E+08	NC	NC	NC	NC	NC	NC	NC	2.0E+08	NC	NC	NC
					25,000	NC	NC	NC	NC	3,100	NC	9,600	14,000	NC	NC	5,800

Legend
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¹ EPA Region 6 Screening Levels, 2007. Adjusted to Hazard Quotient of 0.1 to account for cumulative risks.
² DEQ, Risk-Based Decision Making for the Remediation of Petroleum-Contaminated Sites, 2007.

Table 23
Detected Pesticide Concentrations in Groundwater - Harbor Oil Site

	Reporting Source	Date	Sample Location	Sample Number	Pesticides (ug/L)
					p,p'-DDD
Type of Analysis					
Fixed Laboratory	E&E, 2000 E&E, 2000 E&E, 2000 E&E, 2000 E&E, 2000 E&E, 2000 E&E, 2000 Coles, 2002 Coles, 2002 Coles, 2002	8/2/00 8/2/00 8/2/00 8/2/00 8/2/00 8/2/00 8/2/00 8/2/00 8/2/00 8/2/00	PW01 GA34 A18 GA29 A19 GA33 A20 A18 GA29 A19	PW01GW-00314194 GA34GW-00314187 A18GW-00314188 GA29GW-00314190 A19GW-00314191 GA33GW-00314192 A20GW00314193 MW A-18 MW GA-29 MW A-19	0.018 U 0.018 U 0.018 JQ 0.019 U 0.018 U 0.054 0.24 JL
Screening Levels Human Health Screening Value EPA Region 6 Screening Level ¹ Tap Water Screening Level DEQ RBCs ² Vol. to Outdoor Air Vapor Intrusion into Buildings Groundwater in Excavation					0.28 NC NC 40

Legend
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L = Low bias.
H = High bias.
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¹ EPA Region 6 Screening Levels, 2007. Adjusted to Hazard Quotient of 0.1 to account for cumulative risks.
² DEQ, Risk-Based Decision Making for the Remediation of Petroleum-Contaminated Sites, 2007.

Table 24
Human Health Scenarios and Pathways that will be Quantitatively Evaluated

Exposure Scenario	Exposure Point	Exposure Medium	Receptor Age	Exposure Route	Rationale for Exposure Pathway
Industrial (construction/trenching) worker	Construction or trenching work	Soil	adult	dermal; ingestion	Construction activities will disrupt the gravel layer or soils in trench areas and allow contact with soils.
		Ground-water	adult	dermal	Limited contact with shallow groundwater may occur within disturbed soils.
		Air (soil and groundwater vapor)	adult	inhalation	Disturbed soils or shallow groundwater may emit vapors leading to outdoor exposure.
Industrial/commercial worker	Indoor occupational work	Air (soil and groundwater vapor)	adult	inhalation	Disturbed soils or shallow groundwater may emit vapors leading to indoor exposure.
Force Lake Recreational user ^a	Recreational use of Force Lake	Sediment	adult	dermal; ingestion	Limited potential for exposure to Force Lake sediments during recreational activities.
			child	dermal; ingestion	
		Water (Force Lake)	adult	dermal; ingestion	Recreational activities involve contact with Force Lake water
			child	dermal; ingestion	
Hypothetical future resident ^b	Future residential use	Wetland soil	adult	dermal; ingestion	Potential future residential exposure to soils in yards and common areas.
			child	dermal; ingestion	
		Ground-water	adult	dermal; ingestion	Potential future use associated with groundwater ingestion as drinking water.
			child	dermal; ingestion	

^a Recreational non-angler activities include remote-control boat operator, birdwatcher, retrieval of golf balls from Force Lake, and recreational fishing. Fish ingestion is expected to have a very low frequency, and thus will not be evaluated quantitatively.

^b The hypothetical future resident scenario will be assessed using a screening-level approach.

Table 25
Fish Species Identified in Force Lake (Fishman 1989)

Common Name	Scientific Name	Feeding Guild	Juvenile Diet	Adult Diet
Brown Bullhead	<i>Ameiurus nebulosus</i>	omnivore	chironomid larvae, cladocerans, ostracods, amphipods, insects (Scott and Crossman 1973)	benthic macroinvertebrates, detritus, and small fish (Scott and Crossman 1973; Wydoski and Whitney 2003)
Goldfish	<i>Carassius auratus</i>	omnivore	zooplankton, plants (Wydoski and Whitney 2003)	plants, small crustaceans, insects, and detritus (Wydoski and Whitney 2003)
Pumpkinseed	<i>Lepomis gibbosus</i>	omnivore	no data	aquatic insects, mollusks, crustaceans (Wydoski and Whitney 2003)
Bluegill	<i>Lepomis macrochirus</i>	omnivore	zooplankton, aquatic insects, fish eggs (Wydoski and Whitney 2003)	aquatic insects, mollusks, crayfish, amphipods, fish eggs (Scott and Crossman 1973; Wydoski and Whitney 2003)
Carp	<i>Cyprinus carpio</i>	omnivore	zooplankton, plants (Wydoski and Whitney 2003)	algae, vegetation, clams, insects, zooplankton (Wydoski and Whitney 2003)
Mosquitofish*	<i>Gambusia affinis</i>	invertivore	insect larvae, diatoms, zooplankton (Wydoski and Whitney 2003)	insects, benthic invertebrates, diatoms (Sandercock 1991; Page and Burr 1991)

Table 26
Birds Observed on or near Force Lake (COP 1997)

Common Name	Scientific Name	Feeding Guild	Diet ^a	Notes
Canvasback	<i>Aythya valisineria</i>	Herbivore	seeds and tubers of pondweed, along with a variety of other plants; may substitute mollusks or other shellfish when plants not available	
American wigeon	<i>Anas americana</i>	Herbivore	plants (mostly grasses and clover); may also eat fish eggs	Winter in various areas, including Force Lake
Ring-necked duck	<i>Aythya collaris</i>	Herbivore	plant-based diet	
Gadwall	<i>Anas strepera</i>	Herbivore	primarily aquatic plants and seeds, with invertebrates becoming important during the breeding season	
Band-tailed pigeon	<i>Columba fasciata</i>	Herbivore	diet varies seasonally by location; includes buds, flowers, and fruits of deciduous trees and shrubs	
American goldfinch	<i>Carduelis tristis</i>	Herbivore	seeds; also feeds opportunistically on grasses, insects, fruit trees buds	
Dark-eyed junco	<i>Junco hyemalis</i>	Herbivore	mostly seeds, some insects, especially during nesting season	
Eurasian wigeon	<i>Anas Penelope</i>	Herbivore	prefer leaves and plant material(mostly grasses and clover); may also eat fish eggs	
Canada goose	<i>Branta canadensis</i>	Herbivore	aquatic and terrestrial plants (e.g., grasses)	
Cedar waxwing	<i>Bombycilla cedrorum</i>	Herbivore	prefers fruit, will also eat insects and flowers; during mating period, may eat up to ¼ of diet may be insects	
Downy woodpecker	<i>Picodes pubescens</i>	Insectivore	mostly insects, beetles and spiders, some consumption of plant matter	
Tree swallow	<i>Tachycineta bicolor</i>	Insectivore	insects; including gnats, flies and beetles, also will prey on mayflies and ants	
Violet-green swallow	<i>Tachycineta thalassina</i>	Insectivore	insects; including leafhoppers, leafbugs, flies, ants, and beetles	
Northern rough-winged swallow	<i>Stelgidopteryx serripennis</i>	Insectivore	flying insects; including ants, bees, wasps, flies, and beetles	

Table 26
Birds Observed on or near Force Lake (COP 1997)

Common Name	Scientific Name	Feeding Guild	Diet ^a	Notes
Orange-crowned warbler	<i>Vermivora celata</i>	Insectivore	mostly insects, sometimes take fruit in winter	
Bushtit	<i>Psaltiriparus minimus</i>	Insectivore	mostly insects; including plant lice, bark lice and spiders), some plant matter	
Golden-crowned kinglet	<i>Regulus satrapa</i>	Insectivore	insects from branches of trees	
Barn swallow	<i>Hirundo rustica</i>	Insectivore	opportunistic forager of insects; primarily flies, beetles, leafhoppers and ants	
Rudy-crowned kinglet	<i>Regulus calendula</i>	Insectivore	insects; including wasps, ants, bugs, beetles, adult and larval butterflies and moths, flies and spiders; also feeds on plant material (fruit and seeds)	
Vaux's swift	<i>Chaetura vauxi</i>	Insectivore	insects; including flies, ants, bees, planthoppers, aphids, spindbugs, lanternflies, beetles, moths, and spiders	
Northern shoveler	<i>Anas clypeata</i>	Invertivore	primarily crustaceans and invertebrates; occasionally consume plant seeds	
Common yellowthroat	<i>Geothlypis trichas</i>	Invertivore	insects and invertebrates	
American robin	<i>Turdus migratorius</i>	Invertivore	earthworms and beetles; occasionally feeding on fruits and berries	
Spotted sandpiper	<i>Aetitis macularia</i>	Invertivore	invertebrates, including terrestrial and aquatic prey such as flying insects, insect larvae, grasshoppers, crickets, grubs, worms, beetles, young fish and small crustaceans	
Fox sparrow	<i>Passerella iliaca</i>	Omnivore	Insects, spiders, seeds and berries	
White-crowned sparrow	<i>Zonotrichia leucophrys</i>	Omnivore	arthropods, seeds, grass, fruit, and buds	
Spotted towhee	<i>Pipilo maculatus</i>	Omnivore	eats insects during the breeding season and seeds in winter	
Red-winged blackbird	<i>Agelaius phoeniceus</i>	Omnivore	cultivated grain, seeds, insects and beetles	
Song sparrow	<i>Melospiza melodia</i>	Omnivore	insects, grass and weed seeds, fruits, and berries, possibly even small minnows	

Table 26
Birds Observed on or near Force Lake (COP 1997)

Common Name	Scientific Name	Feeding Guild	Diet ^a	Notes
Black-capped chickadee	<i>Poecile atricapilla</i>	Omnivore	diet includes caterpillars, spiders, snails, slugs, centipedes, insect eggs, seeds, and fruit	
Sora	<i>Porzana carolina</i>	Omnivore	weeds, insects, plant leaves and stems, and aquatic invertebrates	
Virginia rail	<i>Rallus limicola</i>	Omnivore	worms, insects, caterpillars, spiders, slugs, snails, small aquatic invertebrates, small fish, amphipods, crustaceans, frogs, small snakes, aquatic plants and seeds	
Wood duck	<i>Aix sponsa</i>	Omnivore	seeds, shrubs, aquatic plants, fruits	
American coot	<i>Fulica americana</i>	Omnivore	aquatic vegetation, aquatic invertebrates; may prey on eggs and young of other birds	
Ring-billed gull	<i>Larus delawarensis</i>	Omnivore	insects, fish, small mammals, earthworms, crustaceans, garbage, and grain	
Cinnamon teal	<i>Anas cyanoptera</i>	Omnivore	aquatic plants, mollusks, invertebrates (midges and larvae)	
American crow	<i>Corvus brachyrhynchos</i>	Omnivore	seeds, nuts, berries, caterpillars, frogs, mice, bird eggs, nestlings, and garbage; will eat mollusks if available	
Green-winged teal	<i>Anas carolinensis</i>	Omnivore	seeds and invertebrates	
Glaucous-winged gull	<i>Larus glaucescens</i>	Carnivore	fish and aquatic invertebrates, mollusks, garbage, and carrion	
Lesser scaup	<i>Aythya affinis</i>	Omnivore	mollusks, crustaceans, aquatic insects, fish eggs, and vegetation	
Ruddy duck	<i>Oxyura jamaicensis</i>	Omnivore	aquatic insects (e.g., midge larvae), crustaceans mollusks, zooplankton, and other aquatic organisms; diet also may include seeds and aquatic vegetation	Force Lake represents the only breeding and nesting areas within the Portland Urban Growth Boundary (Fishman 1989)
Greater and lesser yellowleg	<i>Tringa</i> spp.	Carnivore	small fish, crustaceans, snails, and small worms; dietary information not available for lesser yellowleg from Oregon	
Hooded merganser	<i>Lophodytes cucullatus</i>	Carnivore	small fish, crayfish, aquatic insects, crustaceans, and amphibians	

Table 26
Birds Observed on or near Force Lake (COP 1997)

Common Name	Scientific Name	Feeding Guild	Diet ^a	Notes
Common merganser	<i>Mergus merganser</i>	Carnivore	freshwater and marine fish (prefer <20 cm), some invertebrates (shrimp, clams, nematodes, fly larvae and adults, sowbugs, centipedes, and beetle larvae); occasionally moss and spruce and hemlock needles	
Bufflehead	<i>Bucephala albeola</i>	Omnivore	diet varies seasonally; animal matter, especially midge larvae, also consumes water boatmen, snails, and seeds, and occasionally fish eggs	
Pied-billed grebe	<i>Podilymbus podiceps</i>	Carnivore	fish, crustaceans, dragonfly nymphs, bugs, beetles, amphibians, and other aquatic and terrestrial insects	
Horned grebe	<i>Podiceps auritus</i>	Carnivore	fish, crayfish, aquatic insects, shrimp, and prawns	
Double-crested cormorant	<i>Phalacrocorax auritus</i>	Piscivore	fish, few crayfish	
American bittern	<i>Botaurus lentiginosus</i>	Piscivore	fish, crustaceans, frogs, insects, snakes and small mammals	
Western gull	<i>Larus occidentalis</i>	Piscivore	intertidal and pelagic fish, invertebrates, seabirds, bivalves, scavenge from garbage	
Belted kingfisher	<i>Ceryle alcyon</i>	Piscivore	primarily small fish (<10 cm), but also crustaceans, insects, amphibians, reptiles, young birds and small mammals	
Great Blue Heron	<i>Ardea herodias</i>	Piscivore	feeds primarily on fish, but also amphibians, aquatic invertebrates, reptiles, mammals and birds.	Heron rookery W of Site; heron observed at Force Lake; nesting areas in cottonwoods; Observed on site visit
Great egret	<i>Ardea alba</i>	Piscivore	Small fish; also consume frogs, lizards, snakes, mice, moles, crustaceans, snails and insects	Observed on site visit
Green-backed heron	<i>Butorides virescens</i>	Piscivore	small fish; also consume inverts (crustaceans, snails) and some terrestrial species such as mice, snakes and snails	
Red-tailed hawk	<i>Buteo jamaicensis</i>	Raptor	small to medium sized rodents; may also eat snakes	nesting areas in cottonwoods about 200 m from Force Lake; likely prey on eastern cottontails as main food source

^a Diet information based on Csuti et al. (2001) and Marshall et al. (2003).

Table 27
Birds Observed in Pen 1 (COP 1997)

Common Name	Scientific Name	Feeding Guild	Diet ^a	Notes
Mourning dove	<i>Zenaida macroura</i>	Herbivore	grains and seeds	
Purple finch	<i>Carpodacus purpureus</i>	Herbivore	mainly vegetative matter, occasionally consume insects in summer	
Ringed-neck pheasant	<i>Phasianus colchicus</i>	Herbivore	green vegetation; fruits and berries	range throughout Pen 1
Northern Pintail duck	<i>Anas acuta</i>	Herbivore	feeds on aquatic plants and seeds; will feed on invertebrates during breeding	Observed by staff at Heron Lakes Golf Courses
California quail	<i>Callipepla californica</i>	Herbivore	primarily green plant material and seeds, insects, <1% invertebrates	Observed by staff at Heron Lakes Golf Courses
Mallard	<i>Anas platyrhynchos</i>	Herbivore	mostly aquatic plants and seeds occasionally grain and some invertebrates	Winter in various areas, including Force Lake
House sparrow	<i>Passer domesticus</i>	Herbivore	primarily vegetable matter; will consume some insects during spring and summer	
Tree swallow	<i>Tachycineta bicolor</i>	Insectivore	primarily insects; will consume berries and seeds when insects not available	
Bewick's wren	<i>Thryomanes bewickii</i>	Insectivore	mostly insects (97% of diet) gleaned from branches and leaves	
House wren	<i>Troglodytes aedon</i>	Insectivore	eats arthropods from surface of leaves	
Western wood peewee	<i>Contopus sordidulus</i>	Insectivore	99% insects and spiders, small amount of vegetable matter included seeds, berries and fruits	
Killdeer	<i>Charadrius vociferous</i>	Invertivore	terrestrial and aquatic invertebrates; includes flying insects, spiders, worms, beetles, crayfish, and snails	
Marsh wren	<i>Cistothorus palustris</i>	Invertivore	generalist feeder of invertebrates	
Swainson's thrush	<i>Catharus ustulatus</i>	Omnivore	invertebrates, fruits, moss and lichens	
Varied thrush	<i>Ixoreus naevius</i>	Omnivore	berries, invertebrates, and insects	observed as wintering birds
Northern flicker	<i>Colaptes auratus</i>	Omnivore	primarily insects (ants, beetles), spiders, plant matter	

Table 27
Birds Observed in Pen 1 (COP 1997)

Common Name	Scientific Name	Feeding Guild	Diet ^a	Notes
Black-headed grosbeak	<i>Pheucticus melanocephalus</i>	Omnivore	seeds, insects, beetles and cicadas, weevils, cultivated fruit, butterflies and moths	
Black-headed cowbird	<i>Molothrus ater</i>	Omnivore	insects, grasses, seeds, fruits and berries	
European starling	<i>Sturnus vulgaris</i>	Omnivore	opportunistic feeders; includes insects, small inverts, earthworms, plant matter; also may scavenge in dumpsters	
Rock dove	<i>Columba livia</i>	Omnivore	forages for food refuse, handouts from humans, weed seeds, and grain spilled at shipping locations	
Western meadowlark	<i>Sturnella neglecta</i>	Omnivore	diet varies seasonally; insects, seeds, and grain	Observed by staff at Heron Lakes Golf Courses
Western tanager	<i>Piranga ludoviciana</i>	Omnivore	opportunistic feeders; includes wasps, ants, beetles, wood borers, and will consume fruit and berries when available.	Observed by staff at Heron Lakes Golf Courses
Tri-colored blackbird	<i>Agelaius tricolor</i>	Omnivore	insects, invertebrates, and plant matter	Observed at Heron Lakes Golf Courses; only known colony in the Willamette Valley near Pen 1; Oregon state sensitive species federal species of concern
Cattle egret	<i>Bubulcus ibis</i>	Omnivore	opportunistic feeder; includes grasshoppers, flies, moths, crickets, spiders, frogs, and earthworms	Observed by staff at Heron Lakes Golf Courses
Brewer's blackbird	<i>Euphagus cyanocephalus</i>	Omnivore	insects, plant seeds, cultivated grains, will also forage in garbage	
Yellow-crown blackbird	<i>Xanthocephalus xanthocephalus</i>	Omnivore	diet varies seasonally; includes insects, grains and seeds	Observed by staff at Heron Lakes Golf Courses
Merlin	<i>Falco columbaris</i>	Carnivore	small to medium sized birds, also large flying insects like dragonflies, small mammals, and reptiles	Observed by staff at Heron Lakes Golf Courses
Common goldeneye	<i>Bucephala clangula</i>	Carnivore	mainly animal diet, supplemented with plant food	Observed by staff at Heron Lakes Golf Courses
Common cormorant	<i>Phalacrocorax carbo</i>	Piscivore	mainly fish, some mollusks and crustaceans	Observed by staff at Heron Lakes Golf Courses

Table 27
Birds Observed in Pen 1 (COP 1997)

Common Name	Scientific Name	Feeding Guild	Diet ^a	Notes
Osprey	<i>Pandion halieatus</i>	Piscivore	fish (almost 100% of diet; 4-12 inches in length); may also eat reptiles, small mammals, birds and amphibians	Observed by staff at Heron Lakes Golf Courses
Bald eagle	<i>Haliaeetus leucocephalus</i>	Raptor	fish, birds, and mammals	Observed at Heron Lakes Golf Courses and at Portland International Raceway; observed over- wintering in Columbia Blvd Sewage treatment Plant
Peregrine falcons	<i>Falco peregrinus</i>	Raptor	Birds (doves, starlings, and sandpipers); may also consume bats, squirrels, lizards and insects	Been observed flying overhead at Pen 1
Marsh hawk (Northern harrier)	<i>Circus cyaneus</i>	Raptor	small and medium sized mammals (voles and mice); may also eat birds	Observed by staff at Heron Lakes Golf Courses
Snow owl	<i>Nyctea scandiaca</i>	Raptor	small to medium sized mammals	Observed by staff at Heron Lakes Golf Courses
Barn owl	<i>Tyto alba</i>	Raptor	mammals; mostly field mice and voles; also eats deer mice, cotton tails and small birds	Observed by staff at Heron Lakes Golf Courses
Great horned owl	<i>Bubo virginianus</i>	Raptor	small mammals; rabbits, hares, mice, and voles	nesting areas in cottonwoods; likely prey on eastern cottontails as main food source

^a Diet information based on Csuti et al. (2001) and Marshall et al. (2003).

Table 28
Mammals Observed in Pen 1 (COP 1997)

Common Name	Scientific Name	Feeding Guild	Diet ^a	Notes
Eastern cottontail	<i>Sylvilagus floridanus</i>	Herbivore	grasses and other plants	
Vole	<i>Microtus</i> spp.	Herbivore	varies among species; generally includes plants (grasses and forbs), seeds, berries, roots, bark, fungi	
American Beaver	<i>Castor canadensis</i>	Herbivore	terrestrial plants (especially willow and aspen) and aquatic plants	commonly found in sloughs
Nutria	<i>Myocastor coypus</i>	Herbivore	aquatic plants, grasses, fruit, some mollusks	commonly found in sloughs
Raccoon	<i>Procyon lotor</i>	Omnivore	opportunists; includes small mammals, fish, frogs, birds, fruit, nuts, berries	range throughout Pen 1
Opossum	<i>Didelphis virginiana</i>	Omnivore	opportunists; includes insects, invertebrates, small vertebrates, and also fruit, grain, bird eggs	range throughout Pen 1

^a Diet information based on Csuti et al. (2001).

Table 29
Summary of Complete and Significant Ecological Pathways for the Harbor Oil Site
(Significance of Some of these Pathways is Unknown)

Receptor Group	Exposure Route	Ecological Significance
Aquatic invertebrates	Direct contact and ingestion of Force Lake sediments and surface water, diet	Food source for other invertebrates, fish, birds, and mammals, aquatic nutrient cycling
Wetland/ terrestrial invertebrates	Direct contact and ingestion of wetland soils, diet	Food source for other invertebrates, birds, and mammals, terrestrial nutrient cycling
Fish	Direct contact and ingestion of Force Lake sediments and surface water, diet	Prey item for other fish, birds, and mammals, intermediate trophic level in aquatic food chain,
Aquatic birds	Direct contact and ingestion of Force Lake sediments and surface water, diet	Prey item for other birds, represent intermediate to high trophic level in aquatic food chain
Terrestrial/wetland birds	Direct contact and ingestion of wetland soils, diet	Prey item for other birds, represent intermediate to high trophic level in terrestrial food chain
Mammals	Direct contact and ingestion of wetland soils, diet, limited direct contact and ingestion of Force Lake sediments and surface water	Prey item for birds, represent intermediate to high trophic level in wetland food chain

Table 30
DQO Process for Ecological Risk Evaluation

DQO Step	Output
1. State the problem	Aquatic receptors (i.e., benthic invertebrates, fish, and fish-eating birds) and terrestrial receptors (i.e., terrestrial invertebrates, small invertivorous/omnivorous mammals, and raptors) may be at risk from exposure to chemicals resulting from facility sources.
2. Identify the decision	Determine whether exposure to chemicals in Force Lake and chemicals in the wetlands adjacent to the Harbor Oil facility pose an unacceptable risk to ecological receptors.
3. Identify inputs to the decision	<p>Historical data and existing site-specific information were evaluated to define the CSM and identify data gaps.</p> <p>Site-specific parameters (e.g., life history, site-use, diet) based on available literature and observations will be used to define exposure concentrations and exposure areas for selected receptor species.</p> <p>Toxicological literature will be evaluated to determine adverse effect levels in sediment, soil, surface water, and/or tissue, and/or bioavailability issues associated with contaminants of potential concern.</p> <p>The following data will be collected: Force Lake surface sediment and surface water, shallow groundwater, and surface soil data from the wetland area adjacent to the Harbor Oil facility. Biota (fish) tissue data may be collected from Force Lake, if needed to reduce uncertainty based on sediment and surface water data. Biota (small mammal) tissue data may be collected from the wetland area, if needed to reduce uncertainty based on sediment and surface water data.</p>
4. Define the boundaries to the study	<p>For evaluating risks to aquatic receptors, the exposure area is defined as Force Lake.</p> <p>For evaluating risks to terrestrial receptors, the exposure area is defined as the wetland area bordering the Harbor Oil facility to the west and south. The western portion of the wetland area extends approximately 150 feet from the drainage ditch that runs along the western boundary of the Harbor Oil facility and the southern portion of the wetland is defined as the area between the southern boundary of the Harbor Oil facility and Force Lake.</p>
5. Develop a decision rule	If unacceptable risks to ecological receptors, then remedial alternatives will be evaluated in the FS.
6. Specify tolerable limits on decision errors	<p>Evaluate ecosystem and receptor characteristics that may modify/impact risk management decision.</p> <p>Evaluate uncertainty of exposure concentrations relative to sample design.</p> <p>Evaluate uncertainty of toxicity values relative to decision rule.</p>
7. Optimize the design for obtaining data	<p>For aquatic receptors: Collect surface water and shallow groundwater samples to evaluate direct exposure to aquatic organisms using effects-based criteria (e.g., AWQC). Collect sediment samples to evaluate direct exposure to benthic invertebrates using effects-based criteria. Collect sediment samples to model biota tissue concentrations in fish to evaluate risks to fish and aquatic birds. If warranted, collect fish tissue from Force Lake to reduce uncertainty in risk estimates for fish and/or fish-eating birds.</p> <p>For terrestrial receptors: Collect soil samples to evaluate direct exposure using effects-based criteria. Collect soil samples to model biota tissue concentrations in small mammals to evaluate risks to small mammals and raptors. If warranted, collect small mammal (i.e., shrew and/or mouse) tissue from designated wetland areas to reduce uncertainty in risk estimates for small mammals and/or raptors.</p>

Table 31
DQO Process for Human Health Risk Evaluation

DQO Step	Output
1. State the problem	Human health risks may be associated with workers conducting work activities at the Harbor Oil facility, with people utilizing Force Lake for recreational purposes, and if people were to utilize groundwater as a drinking water supply. Human health risks could also be associated with a hypothetical future residential use of the Harbor Oil facility.
2. Identify the decision	<p>Determine whether chemicals pose an unacceptable human health risk to workers on the facility and whether exposure to chemicals in Force Lake pose an unacceptable risk to people utilizing Force Lake for recreational purposes, including recreational fishing and fish ingestion.</p> <p>Determine whether chemicals in deep groundwater pose potential unacceptable human health risk from drinking water ingestion.</p>
3. Identify inputs to the decision	<p>Historical data and existing site-specific information were evaluated to define the CSM and identify data gaps.</p> <p>Information will be gathered to estimate exposure for workers on the facility, recreational users, and potential drinking water supply users located off the facility.</p> <p>Toxicity information will be derived in concordance with EPA Directive OSWER Direction 9285.7-53, Human Health Toxicity Values in Superfund Risk Assessments (December 5, 2003).</p> <p>The following data will be collected: soil and groundwater data on the facility, and Force Lake surface sediment and surface water data. Fish tissue data may be collected from Force Lake, if needed, to reduce uncertainty based on sediment data.</p>
4. Define the boundaries to the study	<p>For evaluating risks to workers on the facility users and future use drinking scenario, the former Harbor Oil facility and immediate surroundings is defined as the exposure area.</p> <p>For evaluating risks to recreational users, Force Lake is defined as the exposure area.</p>
5. Develop a decision rule	If unacceptable risks to humans, then remedial alternatives will be evaluated in the FS.
6. Specify tolerable limits on decision errors	Evaluate a range of exposure values for determining the potential for human health exposure.
7. Optimize the design for obtaining data	<p>For on-facility worker: Collect surface soil, subsurface soil, and groundwater samples from the Harbor Oil facility to evaluate human health risks from dermal exposure, incidental ingestion, and/or (indoor and outdoor) vapor inhalation exposure.</p> <p>For Force Lake recreational user: Collect Force Lake sediment and surface water samples to evaluate human health risks from dermal exposure and incidental ingestion.</p> <p>For hypothetical future resident: Collect groundwater samples to evaluate potential for hypothetical future resident exposure from future drinking water ingestion, and direct contact and incidental ingestion of groundwater. Collect on-facility soils and wetland soils to evaluate potential for hypothetical future resident exposure from dermal contact and incidental ingestion of soils.</p>

Table 32
DQO Process for Characterizing the Nature and Extent of Chemical Distribution and Sources

DQO Step	Output
1. State the problem	<p>Chemicals of interest have been detected in various media on the Harbor Oil Superfund Site, in adjacent wetland soils, and in Force Lake; documentation of chemical concentrations are limited, particularly in areas outside the Harbor Oil facility.</p> <p>The distribution of chemical concentrations in soil and groundwater on the facility has not been adequately characterized.</p> <p>The extent of contamination in adjacent wetland areas and Force Lake has not been adequately characterized.</p> <p>The extent of contamination in known and potential source areas has not been adequately characterized.</p>
2. Identify the decision	<p>Determine the nature and extent of chemical concentrations at the Harbor Oil facility, and in adjacent wetlands, and Force Lake</p> <p>Determine spatial trends in chemical distributions.</p> <p>Determine whether known and potential source areas influence chemical distributions</p> <p>Identify areas with elevated chemical concentrations associated with sources of contamination.</p>
3. Identify inputs to the decision	<p>Historical data of acceptable data quality will to be used to characterize chemical concentrations at the Site.</p> <p>Soil and groundwater samples will be collected from the Harbor Oil facility.</p> <p>Sediment and surface water data will be collected in Force Lake; sediment samples will be collected in North Lake.</p> <p>Wetland soil data will be collected from adjacent wetland area.</p>
4. Define the boundaries to the study	<p>Samples will be collected on the facility, in Force Lake and where the pipes from Force Lake discharge into North Lake.</p> <p>Samples will also be collected in the adjacent wetland area bordering the Harbor Oil facility to the west and south. The western portion of the wetland area extends approximately 150 feet from the former ditch area along the western boundary of the Harbor Oil facility and the southern portion of the wetland is defined as the area between the southern boundary of the Harbor Oil facility and Force Lake.</p>
5. Develop a decision rule	<p>If unacceptable risks to humans or ecological receptors, define extent of contamination sufficient to support the estimate of remedial quantities for the FS.</p>
6. Specify tolerable limits on decision errors	<p>Sampling density is sufficient to characterize spatial extent of contamination.</p> <p>Targeted sampling areas adequately identify localized areas of elevated concentration levels of chemicals.</p>
7. Optimize the design for obtaining data	<p>Collect soil and groundwater samples from the Harbor Oil facility to characterize the nature and extent of chemical concentrations, identify spatial concentrations trends, and identify localized areas of elevated contamination. Soil sampling will focus on the following areas: the soil berm on the southwest and northwest border of the Harbor Oil facility, the soil stockpile from the foundation excavation of the new base-oil refining plant, and surface and subsurface soil in various known and suspected source areas.</p> <p>Collect Force Lake sediment and surface water samples, North Lake sediment samples, and wetland soil samples from the adjacent wetland areas to determine extent of contamination and to identify localized areas of elevated chemical concentrations.</p>

Table 33
DQO Process for Understanding the Physical Characteristics/Hydrological System

DQO Step	Output
1. State the problem	<p>Chemicals of interest have been detected in shallow and deep groundwater on the Harbor Oil Superfund Site; the distribution of chemical concentrations in groundwater on the facility has not been comprehensively characterized by previous environmental investigations.</p> <p>The local hydrogeology at the Site is poorly characterized and chemicals in the groundwater maybe migrating off the facility or vertically toward the deep zone based on the local hydrogeologic properties.</p> <p>Physical processes at the Site may affect the migration of chemicals in the groundwater both in shallow, intermediate and deep saturated zones.</p>
2. Identify the decision	<p>Determine the effects of the local hydrology and hydrogeology on risk estimates.</p> <p>Determine whether physical processes could contribute to a larger area of contamination, increasing the size and migration of plume(s).</p> <p>Determine short and long-term potential for contaminant migration and development of applicable remedial solutions.</p>
3. Identify inputs to the decision	<p>Historical data of acceptable data quality will to be used to characterize chemical concentrations on the facility.</p> <p>Groundwater and lithologic samples will be collected on the facility.</p> <p>Groundwater elevations will be measured and related data will be collected during slug tests to calculate hydrogeologic properties.</p> <p>Force Lake elevations will be measured.</p>
4. Define the boundaries to the study	<p>Continuous lithologic samples will be collected from borings prior to the installation of each of the 8 new monitoring wells.</p> <p>Groundwater samples will be collected from 17 wells on the facility, nine existing and 8 new monitoring wells.</p> <p>Aquifer slug tests will be performed on selected wells on the facility.</p> <p>Groundwater and Force Lake elevations will be measured monthly.</p>
5. Develop a decision rule	<p>If migration from facility sources to deep groundwater has occurred or could occur and result in unacceptable risks to humans, then remedial alternatives will be evaluated in the FS.</p>
6. Specify tolerable limits on decision errors	<p>Sampling density based on the new monitoring well network is sufficient to characterize the local hydrogeology and spatial extent of contamination.</p> <p>Targeted well locations and subsequent samples adequately identify localized areas of elevated concentration levels of chemicals.</p>

Table 33
DQO Process for Understanding the Physical Characteristics/Hydrological System

DQO Step	Output
7. Optimize the design for obtaining data	<p>Collect lithologic soil samples from well borings to aid in the selection of the screened intervals in the new monitoring wells and characterize the geology and hydrogeology beneath the facility.</p> <p>Develop a monitoring well network to augment the existing network for groundwater sampling. Sample existing and new monitoring wells to characterize groundwater flow direction across the facility, and vertical groundwater gradients and flow directions underneath the facility</p> <p>Perform aquifer slug testing on selected wells on the facility to obtain the hydraulic conductivity and transmissivity of the formation adjacent to the wells.</p> <p>Measure groundwater and Force Lake elevations monthly to evaluate seasonal changes in the magnitude and direction of horizontal flow in the shallow and intermediate zones, and magnitude and direction of vertical groundwater flow between the shallow, intermediate and deep zones beneath the facility.</p>

Table 34
Preliminary List of Acceptable Historical Data

Sampling Event	Sampling Date	No. Samples	Analyte groups
Surface soil			
Harbor Oil Preliminary Assessment/ Site Inspection (Ecology and Environment 2001)	2000	15	TPH-HCID, TPH-G, -D, -O, metals, VOCs, SVOCs, PCB Aroclors, and pesticides
Preliminary Risk Assessment Problem Formulation (Coles 2002)	2000	4	TPH-G, -D, -O, Pb, VOCs, SVOCs, and PCB Aroclors
Site investigation and preliminary remediation plan for Portland Stockyards (Golder Associates 1990)	1990	2	Metals (As, Ba, Cr, Pb, Hg, Se, Ag)
Subsurface soil			
Harbor Oil Preliminary Assessment/ Site Inspection (Ecology and Environment 2001)	2000	10	TPH-HCID, TPH-D, -O, metals, VOCs, SVOCs, PCB Aroclors, and pesticides
Soil Analysis Results for the 2003 Excavations Required for Construction of the EMRI Base-Oil Plant (CEC 2007b)	2003	19	TPH and PCBs
Site investigation and preliminary remediation plan for Portland Stockyards (Golder Associates 1990)	1990	9	Metals (As, Ba, Cd, Cr, Pb, Hg, Se, Ag)
Wetland soil			
Harbor Oil Preliminary Assessment/ Site Inspection (Ecology and Environment 2001)	2000	6	TPH-HCID, TPH-D and -O, metals, VOCs, SVOCs, PCB Aroclors, and pesticides
Preliminary Risk Assessment Problem Formulation (Coles 2002)	2000	1	TPH-HCID, TPH-D and -O, VOCs, SVOCs, PCB Aroclors
Site investigation and preliminary remediation plan for Portland Stockyards (Golder Associates 1990)	1990	3	Metals (As, Ba, Cd, Cr, Pb, Hg, Se, Ag)
Groundwater			
Harbor Oil Preliminary Assessment/ Site Inspection (Ecology and Environment 2001)	2000	7	TPH-HCID, TPH-G,-D,-O, metals, VOCs, SVOCs, PCB Aroclors, and pesticides
Preliminary Risk Assessment Problem Formulation (Coles 2002)	2000	3	TPH-HCID, TPH-D and -O, metals (Pb and Mg), and VOCs
Site investigation and preliminary remediation plan for Portland Stockyards (Golder Associates 1990)	1990	3	Metals
Force Lake Surface Water			
Pen 1 NRMP (City of Portland 1997)	1992	1 ^a	TPH (Unknown range), metals, VOCs, SVOCs, PCB Aroclors, pesticides, and herbicides
Force Lake Sediment			
Pen 1 NRMP (City of Portland 1997)	1992	1 ^a	TPH (Unknown range), metals, VOCs, SVOCs, PCB Aroclors, pesticides, herbicides

^a The data from the Pen 1 NRMP (City of Portland 1997) sampling event are not expected to meet data quality requirements of the formal existing data screen because (based on information available at this time) the sampling methods (e.g., sampling location, sampling depth) were poorly documented.

Table 35
Identified Data Gaps by Media Type

Media	Preliminary RAO	Identified Data Gaps	Proposed Phase 1 Sampling Locations ^a
Soil	Reduce industrial/construction/excavation worker and hypothetical residential receptor exposure to facility-related chemicals in soil that may result in unacceptable risk.	Chemical concentrations in surface and subsurface soils in known and suspected source areas.	31 surface, 18 subsurface, 3 stockpile soil samples
	Control migration of facility-related chemicals from soil berm that may result in unacceptable risks to ecological receptors or humans.	Chemical concentrations in the soil berm.	9 soil berm samples
Groundwater	Reduce industrial/construction/excavation worker exposure to facility-related chemicals in shallow saturated zone groundwater that may result in unacceptable risk.	Chemical concentrations in the shallow saturated zone near potential source areas.	12 shallow saturated zone, 3 intermediate, and 2 deep saturated zone samples, and monthly groundwater and Force Lake elevation measurements
	Control migration of facility-related chemicals in groundwater that may result in unacceptable risks to ecological receptors or humans.	Chemical concentrations in the shallow saturated zone on the downgradient side of the Harbor Oil facility. Hydrogeologic properties, horizontal gradients, and groundwater flow directions for the shallow saturated zone.	
	Reduce exposure to facility-related chemicals that may result in unacceptable risk to humans using groundwater as a potential future drinking water supply.	Chemical concentrations in shallow, intermediate, and deep saturated zone groundwater. Hydrogeologic properties of the shallow and intermediate saturated zones. Horizontal gradients and flow directions in shallow and intermediate saturated zones, and vertical gradients and flow directions between the shallow, intermediate and deep saturated zones.	
Wetland Soil	Reduce ecological receptor exposure to facility-related chemicals in wetland soil that may result in unacceptable risk.	Chemical concentrations in surface and subsurface wetland soils.	38 surface and 6 subsurface wetland soil samples
	Control migration of facility-related chemicals in wetland soils that may result in unacceptable risks to ecological receptors or humans.		
Lake Surface Water	Reduce recreational user exposure to facility-related chemicals in lake surface water that may result in unacceptable risk.	Chemical concentrations in Force Lake surface water.	3 Force Lake surface water samples
	Reduce ecological receptor exposure to facility-related chemicals in lake surface water that may result in unacceptable		

Table 35
Identified Data Gaps by Media Type

Media	Preliminary RAO	Identified Data Gaps	Proposed Phase 1 Sampling Locations ^a
	risk.		
Lake Sediment	Reduce recreational user exposure to facility-related chemicals in lake sediment that may result in unacceptable risk.	Chemical concentrations in Force Lake and North Lake sediments.	11 Force Lake sediment samples; 3 North lake sediment samples
	Reduce ecological receptor exposure to facility-related chemicals in lake sediment that may result in unacceptable risk.		
	If contaminated, control migration of facility-related chemicals in lake sediment to connected water bodies and exposures that may result in unacceptable risks to ecological receptors or humans.		

^a Additional samples may be collected in Phase 2 sampling, following the analysis of Phase 1 results, based on the considerations outlined in the QAPP and in consultation with EPA (Appendix B).

Table 36
Summary of Phase 1 and Phase 2 Sampling

Medium	Phase 1	Phase 2 (final scope contingent on Phase 1 results and consultation with EPA)
Soil (on-facility)	<p>1) Characterize spatial distribution of chemical concentrations in the soil berm and soil stockpile for characterizing the nature and extent of facility-related contamination.</p> <p>2) Characterize spatial distribution of chemical concentrations in surface soils for use in the human health risk evaluation and for characterizing the nature and extent of facility-related contamination.</p> <p>3) Characterize spatial distribution of chemical concentrations in subsurface soils for use in the human health risk evaluation and for characterizing the nature and extent of facility-related contamination.</p> <p>4) Target areas associated with potential sources of contamination, (e.g., former drainage ditch along northeast side of Harbor Oil facility, former "C" shaped area, former tank, current stormwater treatment system, Tank 23, tank farm and used oil processing area, former stormwater holding pond, former tanker truck cleaning operation, J-550 sample area, J-600 sample area, and D-550 sample area).</p>	<p>1) Further characterize the extent of contamination in surface and subsurface soils for estimating remedial quantities for the FS, as needed</p> <p>2) Further characterize the depth of subsurface soil chemical, as needed</p> <p>3) Refine areas of localized contamination (i.e., from Tank 23), as needed</p>
Wetland soil	<p>1) Characterize spatial distribution of chemical concentrations in surface soil for use in the human health and ecological risk evaluations, and for characterizing the nature and extent of facility-related contamination.</p> <p>2) Target areas that received runoff and releases from the facility (e.g., drainage ditch and former discharge location for the stormwater treatment system) for use in the human health and ecological risk evaluations, and for characterizing the nature and extent of facility-related contamination.</p> <p>3) Characterize nature and extent of contamination in subsurface soil in areas where historical data indicated surface soil contamination.</p>	<p>1) Further characterize the extent of facility-related contamination in soil beyond the designated Phase 1 wetland soil sampling area, as needed</p> <p>2) Refine areas of localized contamination, as needed</p> <p>3) Further characterize subsurface soils to determine potential for risks following remediation, as needed</p>

Table 36
Summary of Phase 1 and Phase 2 Sampling

Medium	Phase 1	Phase 2 (final scope contingent on Phase 1 results and consultation with EPA)
Groundwater	1) Characterize spatial distribution of chemical concentrations in shallow (3 to 13 ft bgs), intermediate (40 to 50 ft bgs) and deep (90 to 100 ft bgs) saturated zone groundwater for use in the human health and ecological risk evaluations, and for characterizing the nature and extent of facility-related contamination. 2) Determine the horizontal direction and magnitude of groundwater flow through the shallow and intermediate saturated zones, and the vertical direction and magnitude of groundwater flow between the shallow, intermediate and deep saturated zones. 3) Determine if the facility is a potential source of the VOCs detected in deep groundwater. 4) Determine chemical concentrations in shallow saturated zone groundwater flowing onto the facility. 5) Determine chemical concentrations in shallow groundwater migrating towards Force Lake.	1) Further characterize the extent of facility-related chemicals detected in groundwater, if Phase I groundwater data indicate that facility-related chemicals have migrated into the intermediate zone and measured gradients indicate that facility-related chemicals have the potential to migrate vertically to the deep saturated zone 2) Further characterize migration of chemicals from off-facility sources onto the Site, as needed 3) Characterize the lateral or vertical extent of chemicals migrating off the facility, as needed
Lake sediment	1) Characterize spatial distribution of chemical concentrations in surface sediment for use in the human health and ecological risk evaluations, and for characterizing the nature and extent of facility-related contamination. 2) Determine whether contamination exists in North Lake near the hydrologic connection to Force Lake.	1) Refine localized areas of contamination, as needed 2) Characterize the nature and extent of contamination in subsurface sediments and/or estimate remedial quantities for the FS, as needed 3) Collect sediments for bioassay testing in discrete locations of contamination, as needed 4) Further characterize the extent of facility-related contamination in sediments beyond Force Lake, as needed
Lake surface water	1) Characterize spatial distribution of chemical concentrations for use in the human health and ecological risk evaluations, and for characterizing the nature and extent of facility-related contamination.	None proposed
Biota tissue	None proposed – use screening approach to determine need for Phase 2 sampling.	1) Determine chemical concentrations in fish tissue from Force Lake to assess risks to ecological receptors via fish consumption, if warranted based on sediment and surface water data and in consultation with EPA 2) Determine chemical concentrations in small mammals from wetland area to assess risks to ecological receptors, if warranted based on wetland soil data and in consultation with EPA

Table 37
Summary of DQOs, Data Use Objectives, and Phase 1 Sampling

DQO and Data Use Objective	Data Use in the RI	Phase 1 Samples Used to Satisfy DQO
DQO #1: Evaluate ecological risks		
1a. Determine whether chemical concentrations in water may result in unacceptable risk to aquatic receptors	Estimate risks to aquatic benthic invertebrates and fish from exposure to surface water using effects-based criteria for aquatic organisms (e.g., AWQC). AWQC will also be compared to chemical concentrations in shallow groundwater that may recharge Force Lake.	All Force Lake surface water samples and shallow groundwater samples for wells located closest to Force Lake.
1b. Determine whether chemical concentrations in lake sediment may result in unacceptable risk to aquatic receptors	Estimate risks to aquatic benthic invertebrates from exposure to surface sediment using effects-based criteria.	All Force Lake surface sediment samples. Surface sediment depth interval defined as top 4 inches (biologically active layer, representing potential exposure depth).
	Estimate risks to fish and aquatic birds from exposure to biota prey using surface sediment to model biota concentrations and using dietary TRVs.	
1c. Determine whether chemical concentrations in wetland soil may result in unacceptable risk to terrestrial receptors	Estimate risks to terrestrial invertebrates from exposure to wetland surface soil using effects-based criteria.	All wetland surface soil samples. Wetland surface soil depth interval defined as top 6 inches (biologically active layer, representing potential exposure depth).
	Estimate risks to shrews and raptors from exposure to biota prey using wetland surface soil to model biota concentrations and using dietary TRVs.	
DQO #2: Evaluate risks to human health		
2a. Determine whether chemical concentrations in soil on the facility may result in unacceptable human health risks	Estimate risks to construction/trenching workers from exposure to soil on the facility.	All soil samples on the facility within relevant exposure areas and depths.
	Estimate risks to commercial/industrial and construction/trenching workers from exposure to VOC vapors from soils on the facility.	All soil samples on the facility within relevant exposure areas and depths.
	Screen soil concentrations on the facility relative to residential human health thresholds for hypothetical future residents.	All soil samples on the facility (excluding soil berm and stockpile soil) within relevant depths.

Table 37
Summary of DQOs, Data Use Objectives, and Phase 1 Sampling

DQO and Data Use Objective	Data Use in the RI	Phase 1 Samples Used to Satisfy DQO
2b. Determine whether chemical concentrations in groundwater may result in unacceptable human health risks	Estimate risks to construction/trenching workers from exposure to groundwater.	All groundwater samples from proposed new and existing wells within relevant exposure areas and depths.
	Estimate risks to commercial/industrial and construction/trenching workers from exposure to VOC vapors from groundwater.	
	Screen groundwater concentrations relative to residential human health drinking water thresholds for hypothetical future residents.	
2c. Determine whether chemical concentrations in wetland soil may result in unacceptable human health risks	Screen wetland soil concentrations relative to residential human health thresholds for hypothetical future use residents.	All wetland soil samples at relevant depths.
2d. Determine whether chemical concentrations in lake sediment may result in unacceptable human health risks	Estimate risks to recreational users from exposure to Force Lake sediment.	All Force Lake surface sediment samples; samples near the edge of the lake are likely to be more relevant.
2e. Determine whether chemical concentrations in water may result in unacceptable human health risks	Estimate risks to recreational users from exposure to Force Lake water.	All surface water samples.
DQO #3: Characterize the Nature and Extent		
3a. Characterize spatial distributions of chemical concentrations in soil on the facility.	Use on-facility soil concentrations in soil berm, soil stockpile, surface soil, and subsurface soil to determine the nature and extent of chemical concentrations; identify spatial patterns; identify localized areas of elevated contamination; and determine whether releases have occurred from known or suspected sources located on the facility.	All surface and subsurface soil samples collected on the facility, including soil berm and stockpile soil.
3b. Characterize spatial distributions in groundwater.	Use shallow, intermediate and deep groundwater concentrations to characterize the nature and extent of chemical concentrations. Use	All groundwater samples from proposed new and existing wells, including shallow, intermediate, and deep

Table 37
Summary of DQOs, Data Use Objectives, and Phase 1 Sampling

DQO and Data Use Objective	Data Use in the RI	Phase 1 Samples Used to Satisfy DQO
	presence of VOCs in the shallow and intermediate groundwater zones and vertical direction of groundwater flow between the shallow, intermediate and deep groundwater zones to determine if the facility is a source of the VOCs detected in deep groundwater. Use chemical concentrations detected in shallow groundwater near known and suspected sources located on the facility and in wells located near the upgradient and downgradient sides of the facility to determine if chemicals are migrating onto the facility.	groundwater.
3c. Characterize spatial distributions in wetland soil, lake sediment, and surface water.	Use concentrations in wetland soil, lake sediment, and lake surface water to determine the nature and extent of chemical concentrations; identify spatial patterns; identify localized areas of elevated contamination; and assess releases from the facility.	All wetland soil samples, all surface water samples, and all lake sediment samples
DQO #4: Define the Physical Characteristics/Hydrological System		
4a. Characterize the magnitude and direction of horizontal flow in the shallow and intermediate zones, and magnitude and direction of vertical groundwater flow between the shallow, intermediate and deep zones beneath the facility.	Establish a surface water elevation measurement location in Force Lake and develop a monitoring well network to augment the existing network for groundwater sampling to better characterize groundwater flow.	All water levels collected from proposed new and existing shallow, intermediate, and deep groundwater zone monitoring wells. All water level elevations measured in Force Lake.
	Use the results of slug testing on selected wells to determine the hydraulic conductivity and transmissivity of the formation adjacent to the wells.	All slug testing results.
4b. Characterize the geology and hydrogeology beneath the facility.	Collect lithologic soil samples to characterize the geology and hydrogeology beneath the facility.	All lithological soil samples.



Source: Force Lake, USGS Portland (OR,WA) Topo Map from TopoZone



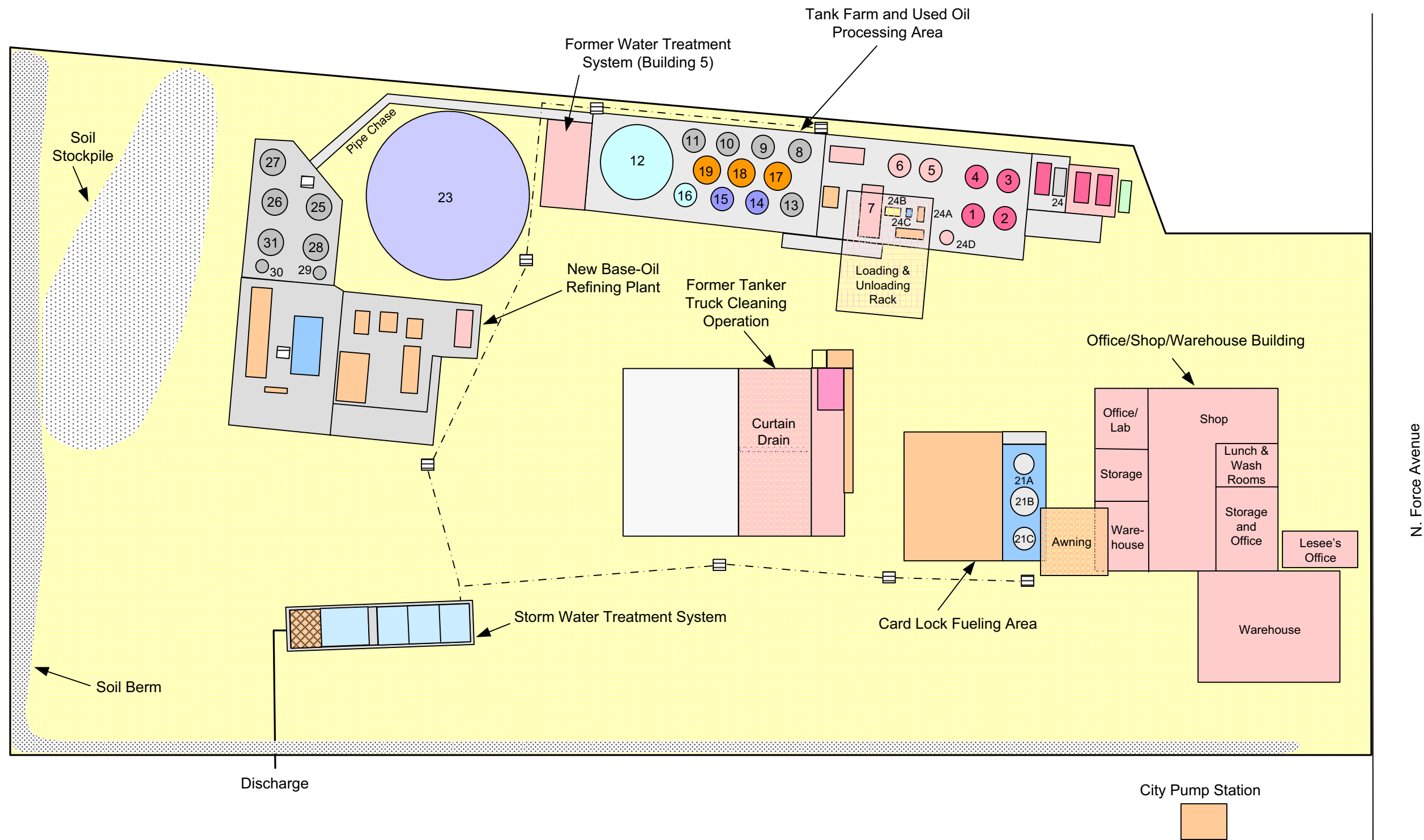
0.5 Mile



Approximate Scale

Figure 1
Location Map
 Harbor Oil Site

BRIDGEWATER GROUP, INC.



Legend:

- Catch Basin
- Storm Water System Piping



50 ft
Approximate Scale

Source: Coles Environmental Consulting, Inc., Energy & Materials Recovery, Inc. Site Diagram (Formerly Harbor Oil, Inc.), March 2005.

Figure 2
Current Facility Features
Harbor Oil Site

BRIDGEWATER GROUP, INC.



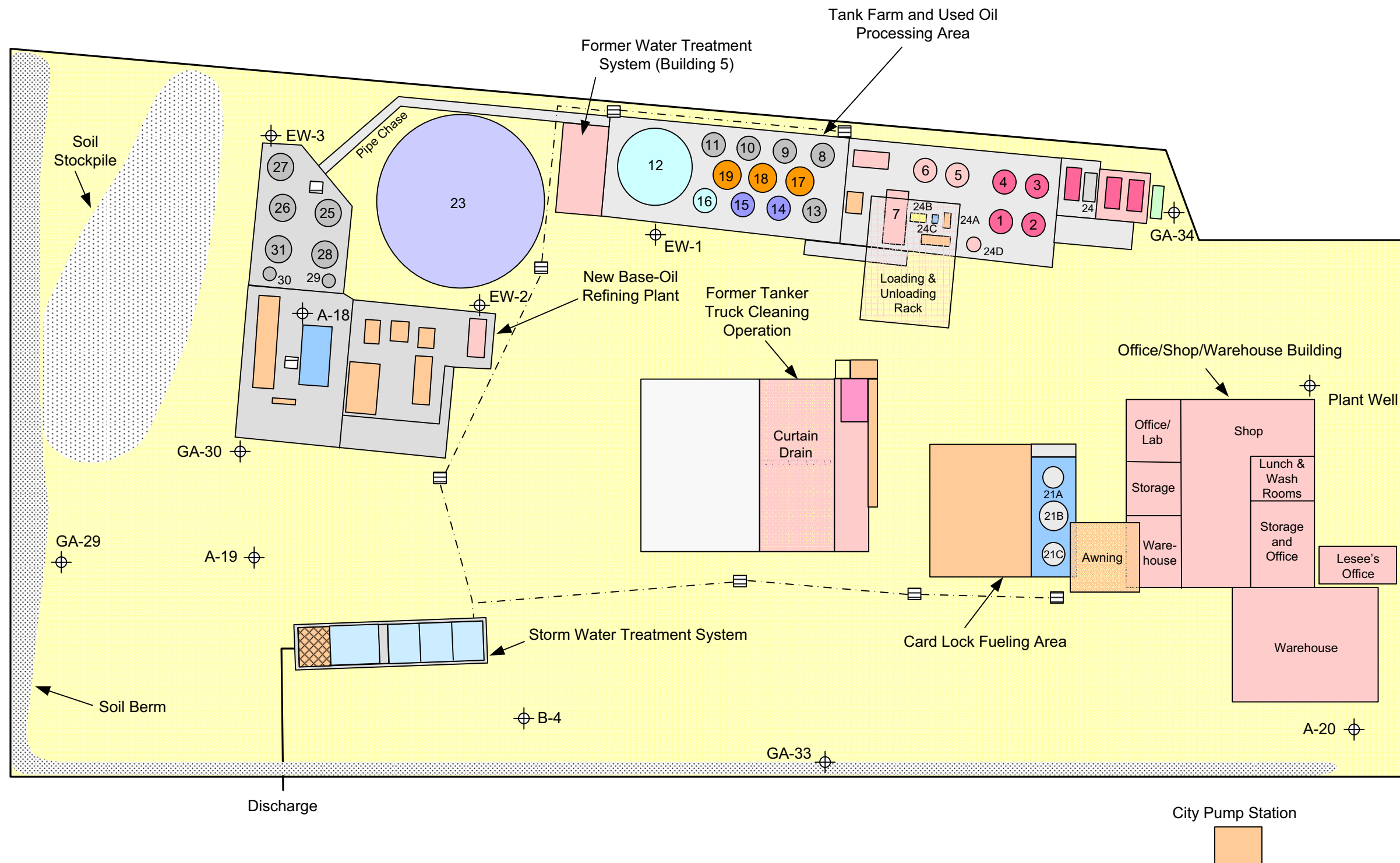
200 Feet
Approximate Scale

Legend:




- Harbor Oil Facility Boundary
- Former Vanport City Boundary
- Golf Course Boundary
- Other Potential Off-Facility Source Boundary
- Phase 1 RI Study Area Boundary

*Note: Potential Off-Facility Source
Boundaries are Approximate*

Figure 3
Potential Off-Facility Sources
Harbor Oil Site



Legend:

-  Catch Basin
-  Storm Water System Piping
-  Existing Well Location



50 ft

Approximate Scale

Source: Coles Environmental Consulting, Inc., Energy & Materials Recovery, Inc. Site Diagram (Formerly Harbor Oil, Inc.), March 2005.

Figure 5
On-Facility Well Locations
Harbor Oil Site

BRIDGEWATER GROUP, INC.



Sources: Force Lake, USGS Portland (OR,WA) Topo Map from TopoZone. Well locations from Golder (1990).

Note: Four more supply wells may be located on the James River Corporation facility; their locations are unknown.



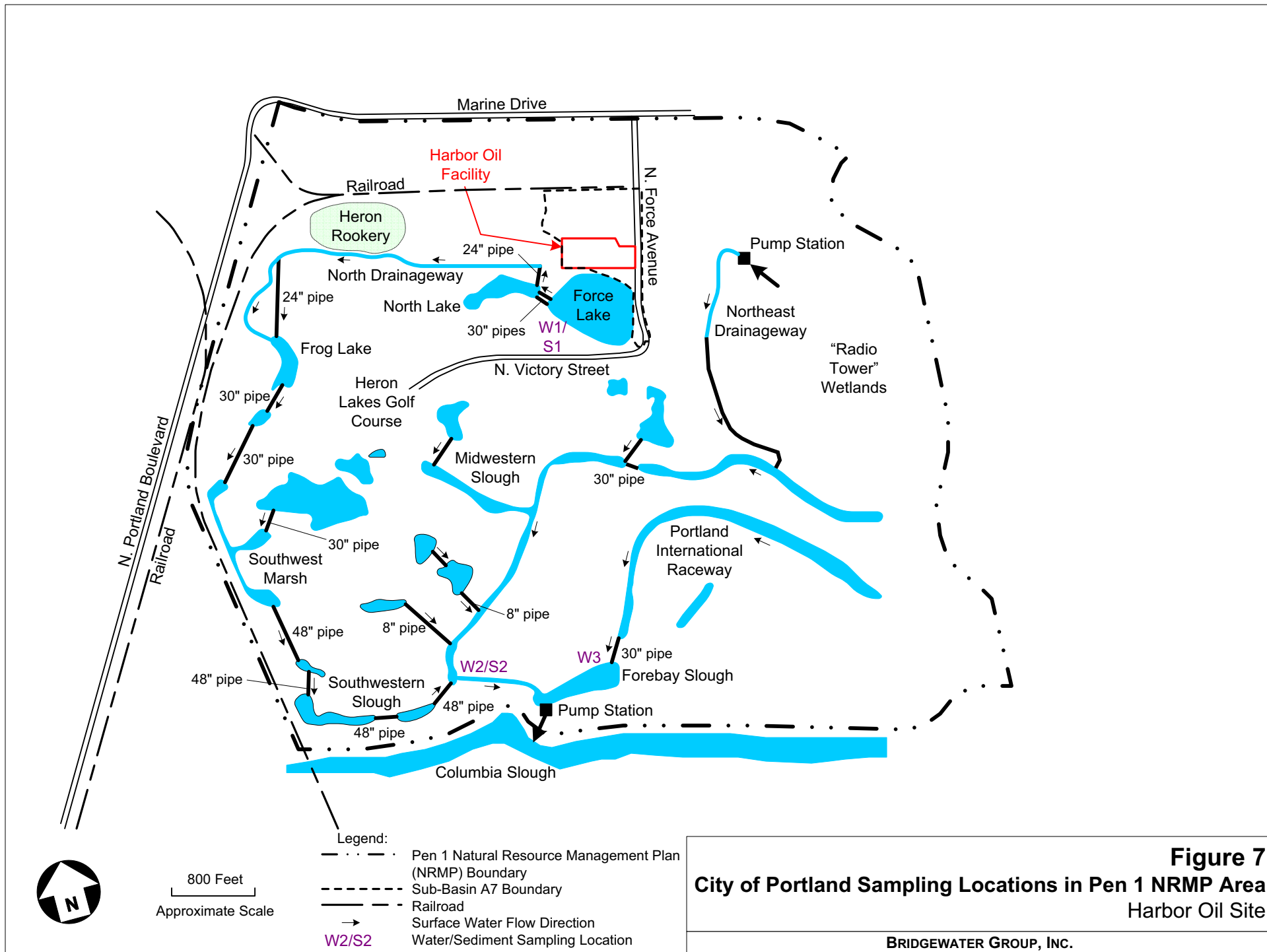
0.5 Mile



Approximate Scale

Figure 6
Off-Facility Well Locations
Harbor Oil Site

BRIDGEWATER GROUP, INC.



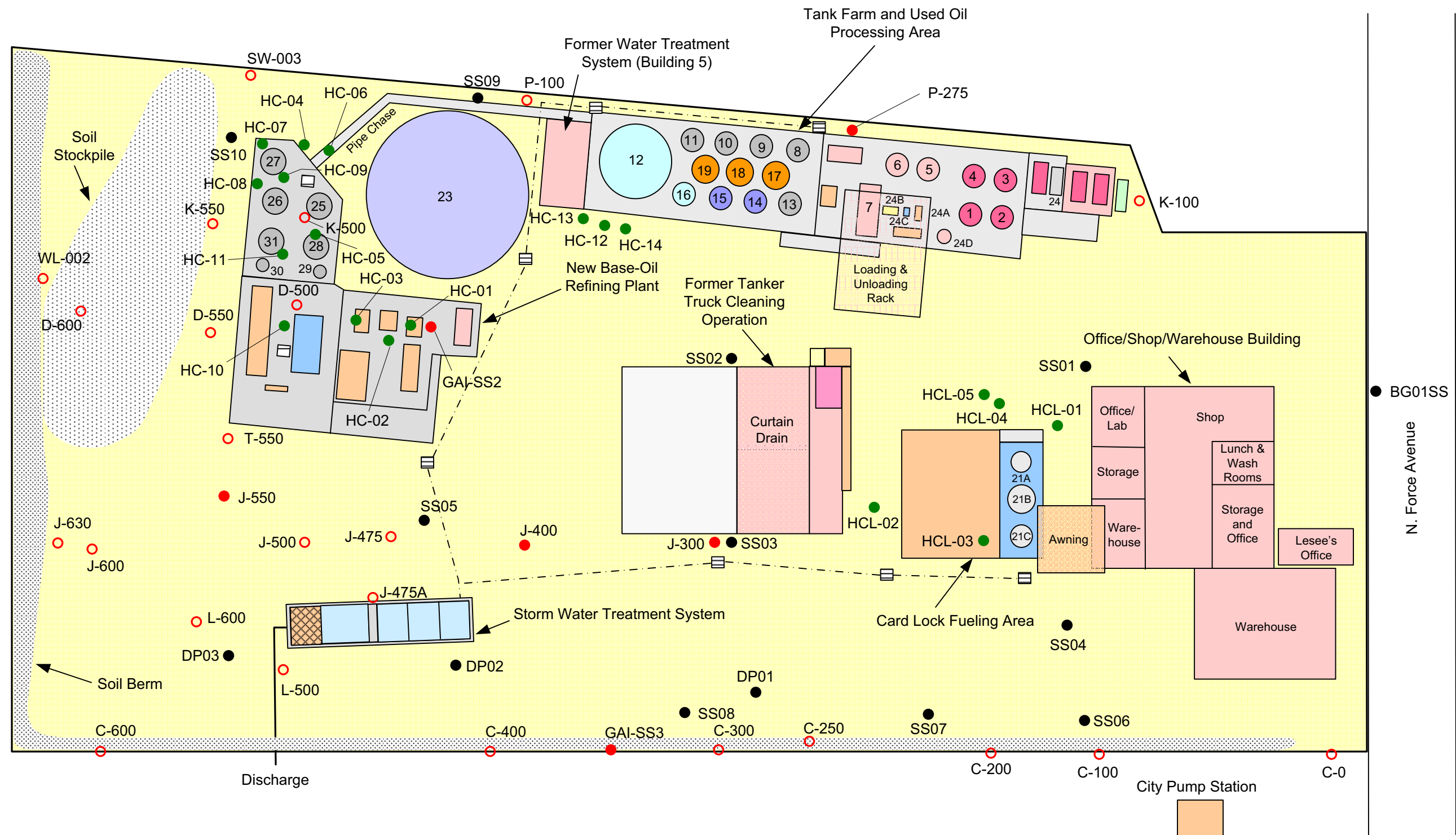


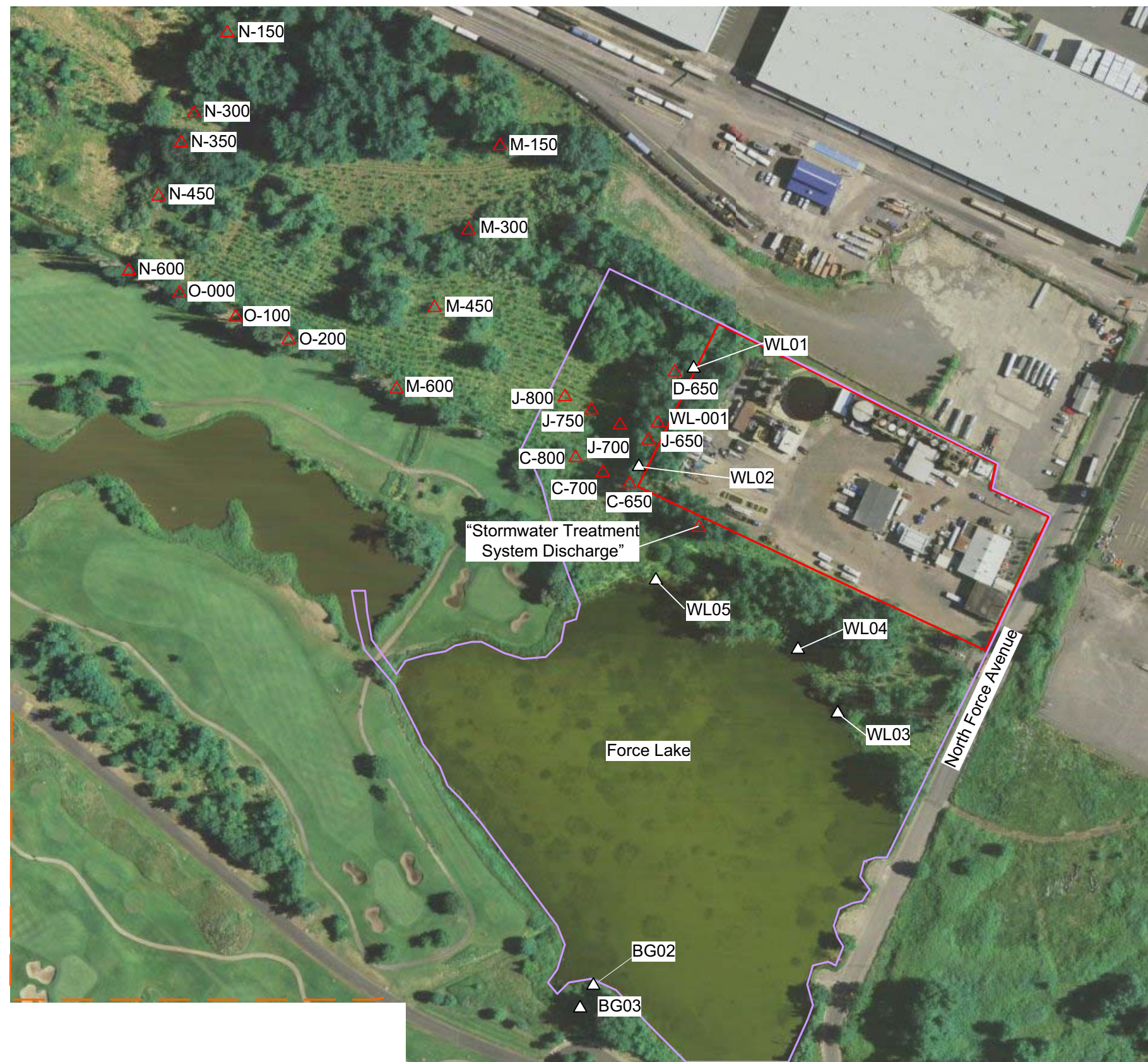
Figure 8
Historical On-Facility Soil and Surface
Water Sample Locations
 Harbor Oil Site

BRIDGEWATER GROUP, INC.



50 ft
 Approximate Scale

Source: Coles Environmental Consulting, Inc., Energy & Materials Recovery, Inc. Site Diagram (Formerly Harbor Oil, Inc.), March 2005.



Note: Force Lake sediment sample (S-1) and water sample (W-1) collected in 1997 are not shown because sampling locations were not identified by the COP.



200 Feet
Approximate Scale

Legend:
 Offsite Sampling Locations
 △ Golder (1990)
 △ E&E (2001)
 — Harbor Oil Facility Boundary
 — Phase 1 RI Study Area Boundary

Figure 9
Historical Off-Facility Soil and Surface Water Sample Locations
 Harbor Oil Site

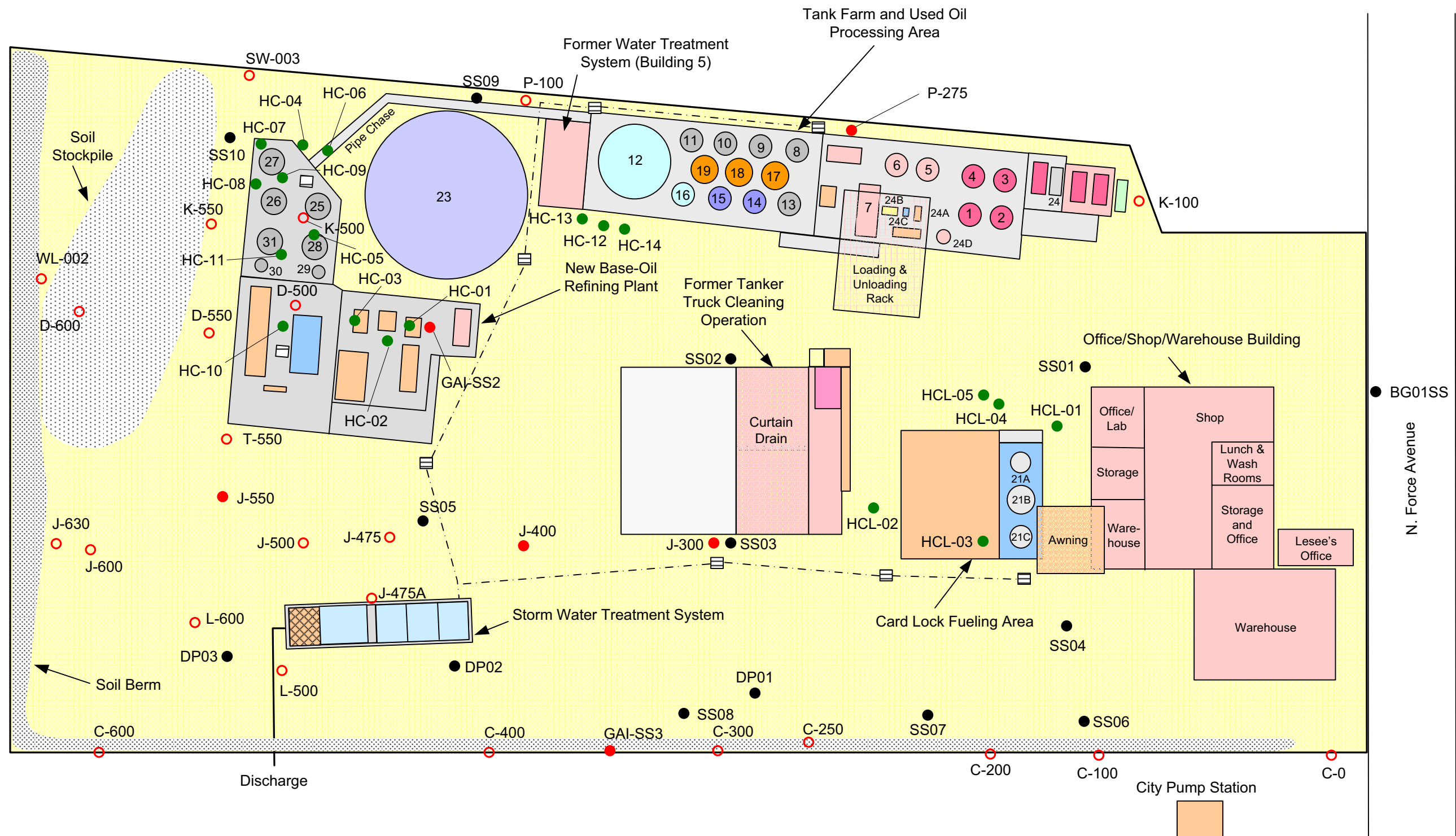
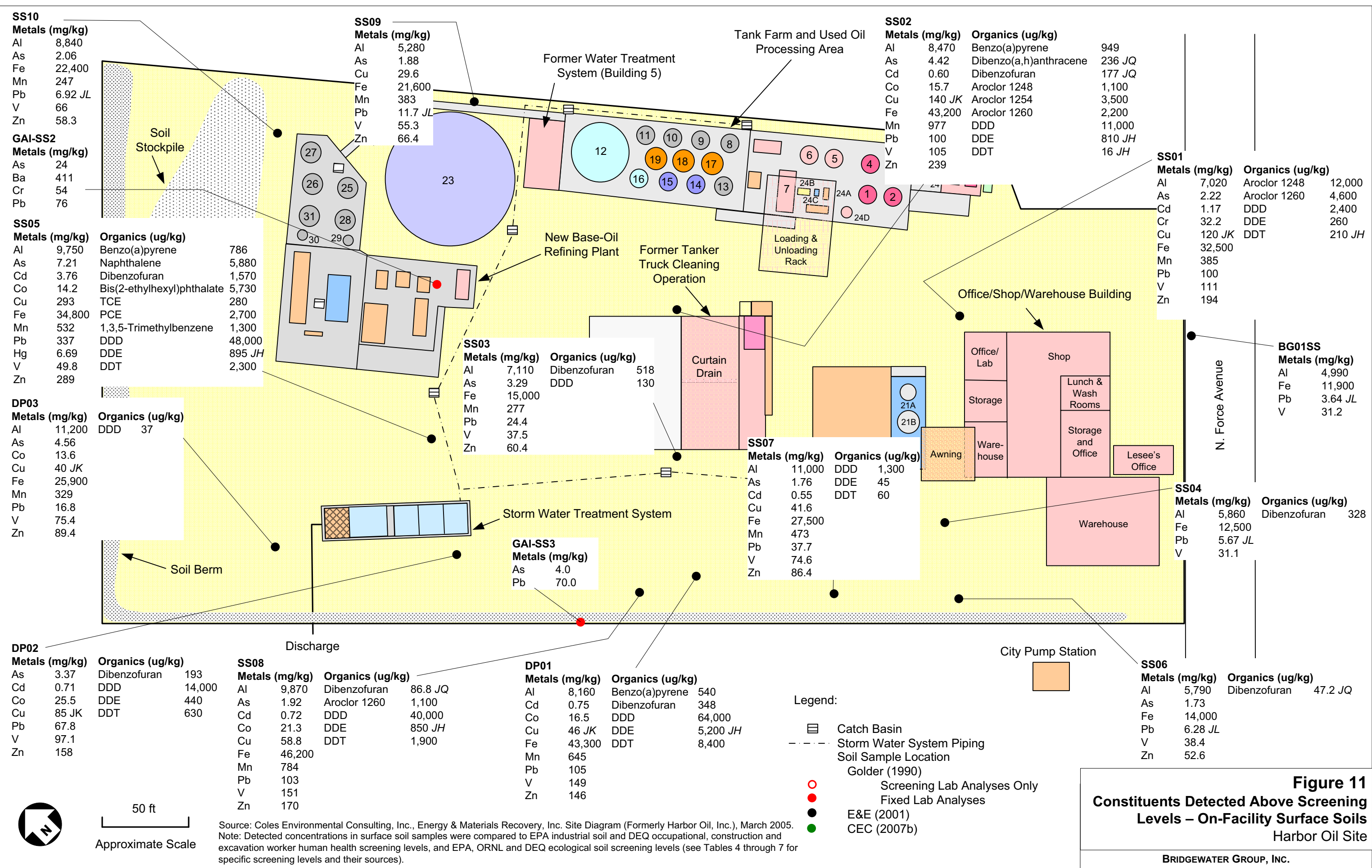
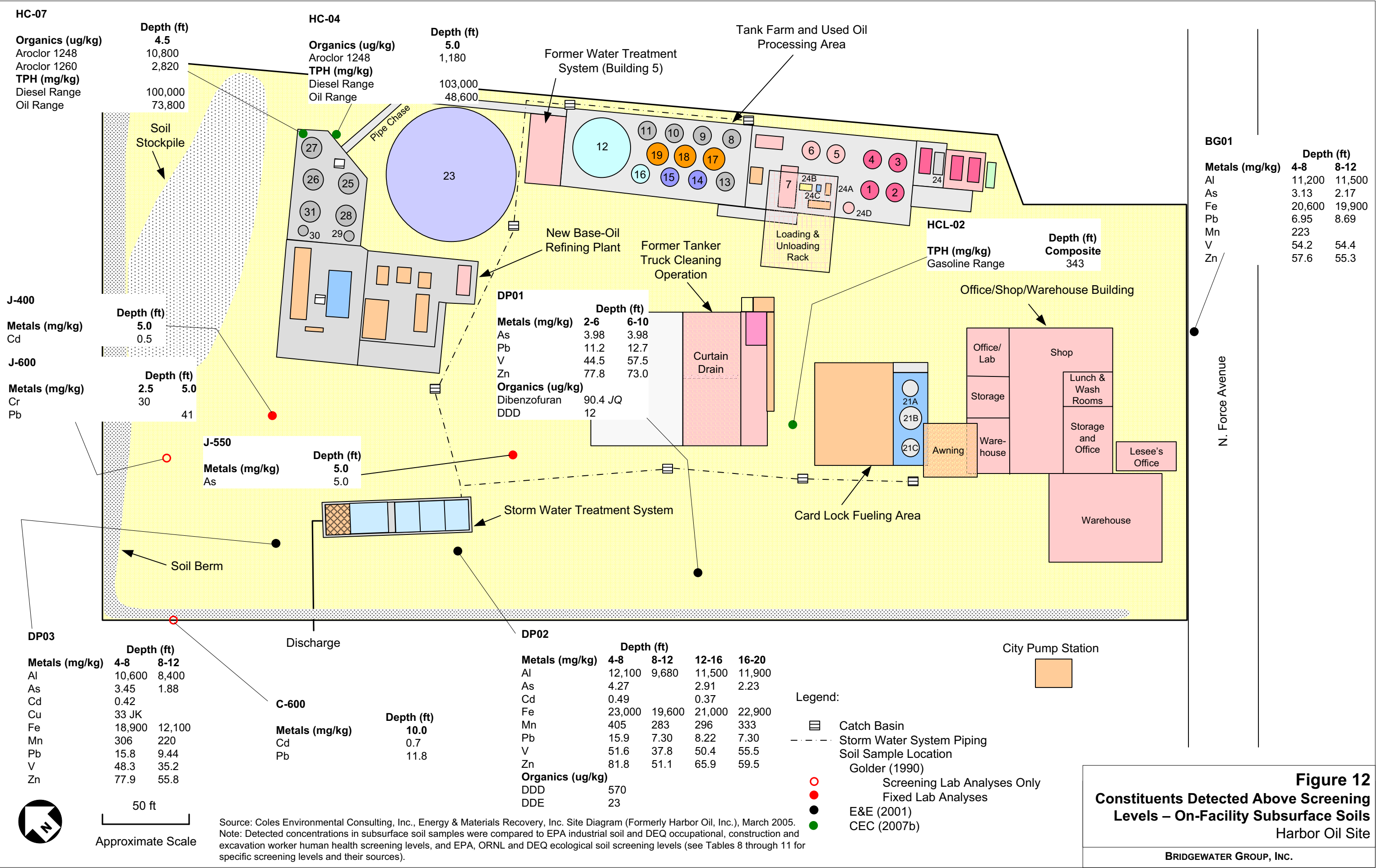
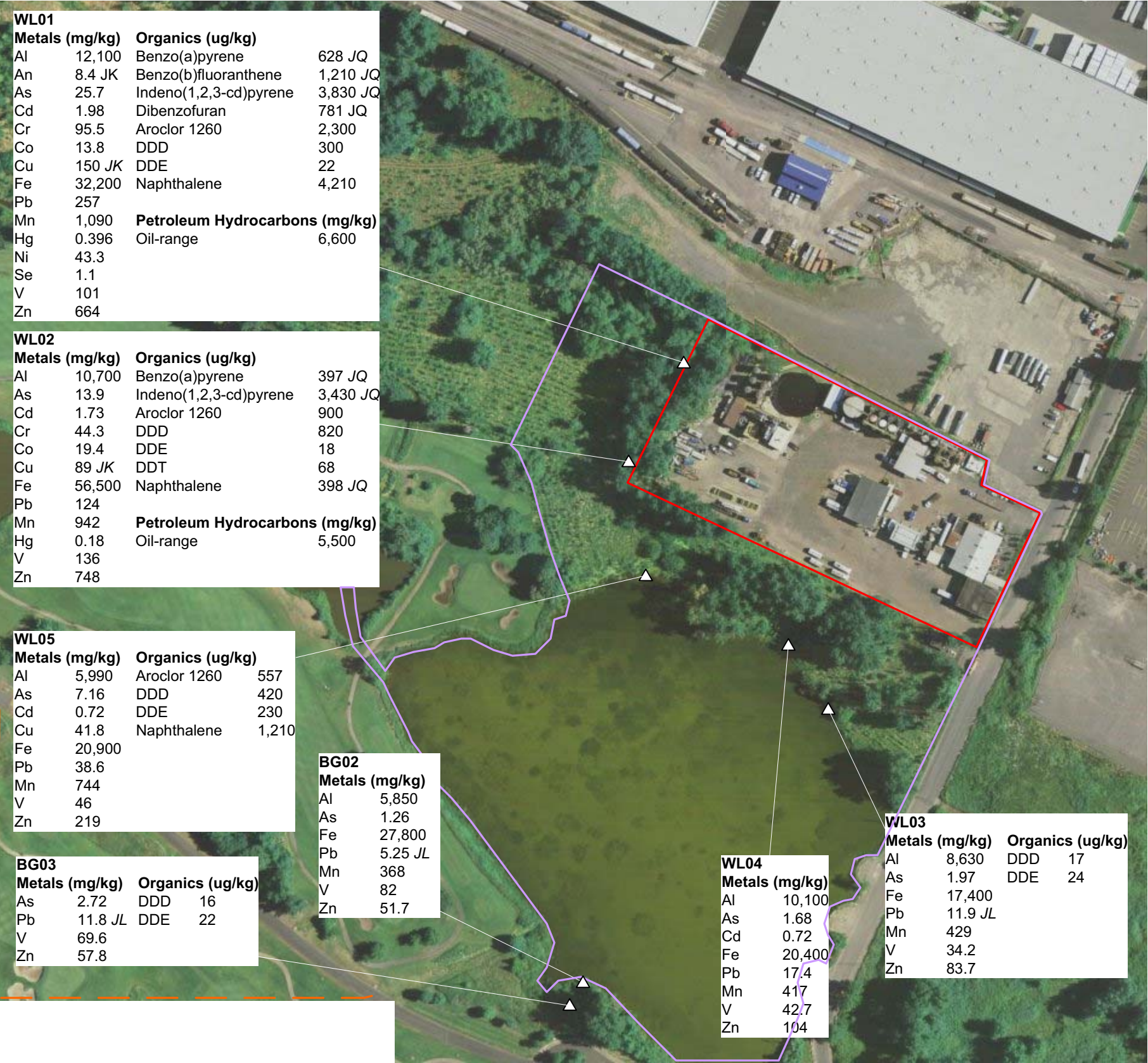


Figure 10
Soil Sampling Locations in Relation to
Former Facility Features
 Harbor Oil Site







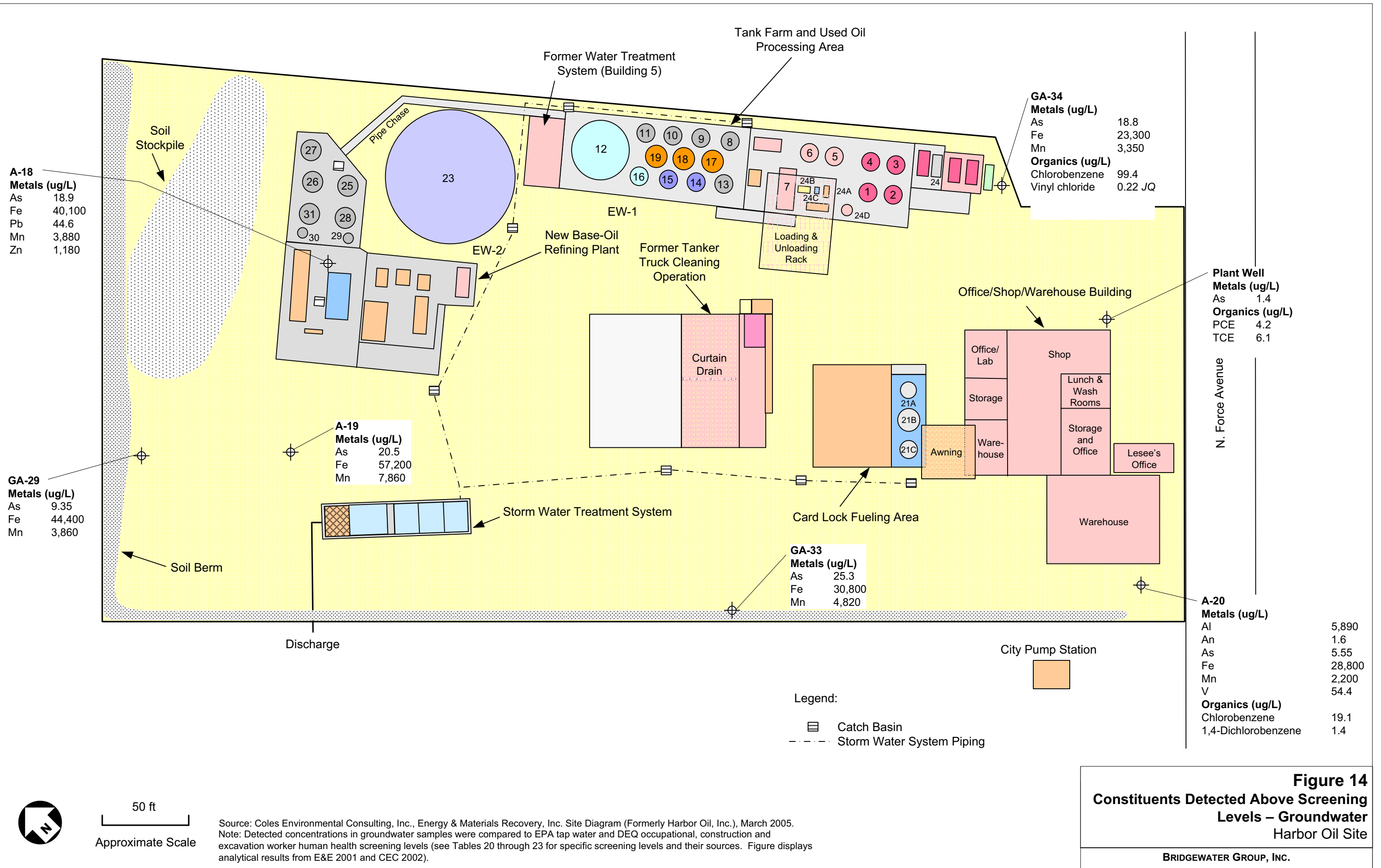
Note: Detected concentrations in soil samples were compared to EPA and DEQ residential soil human health screening levels, and EPA, ORNL and DEQ ecological soil screening levels (see Tables 13 through 15 for specific screening levels and their sources).



200 Feet
Approximate Scale

- Legend:
- △ Offsite Sampling Locations
 - △ Golder (1990)
 - △ E&E (2001)
 - Harbor Oil Facility Boundary
 - Phase 1 RI Study Area Boundary

Figure 13
Constituents Detected Above Screening Levels – Wetland Soils
Harbor Oil Site



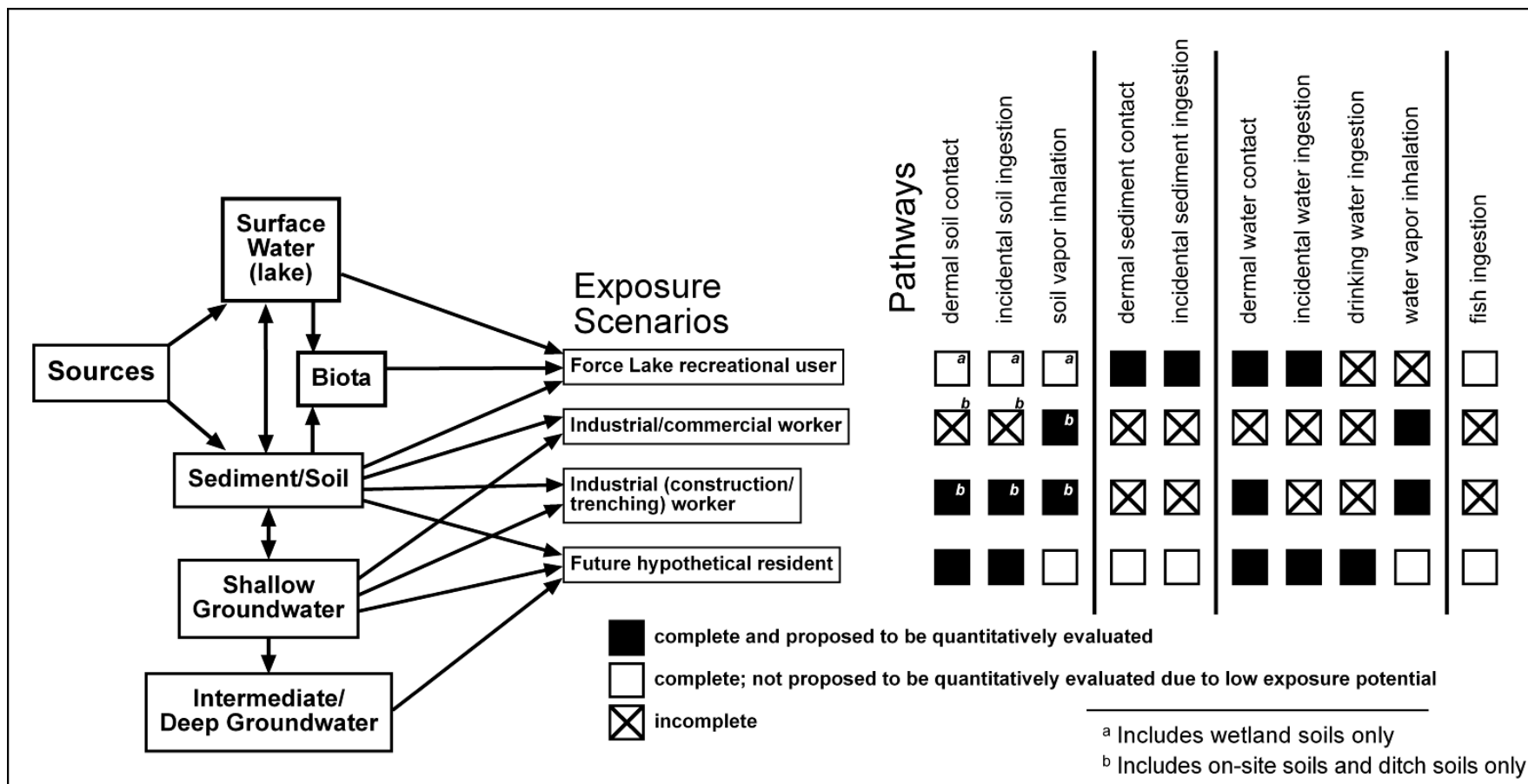


Figure 15
Preliminary Human Health CSM
 Harbor Oil Site

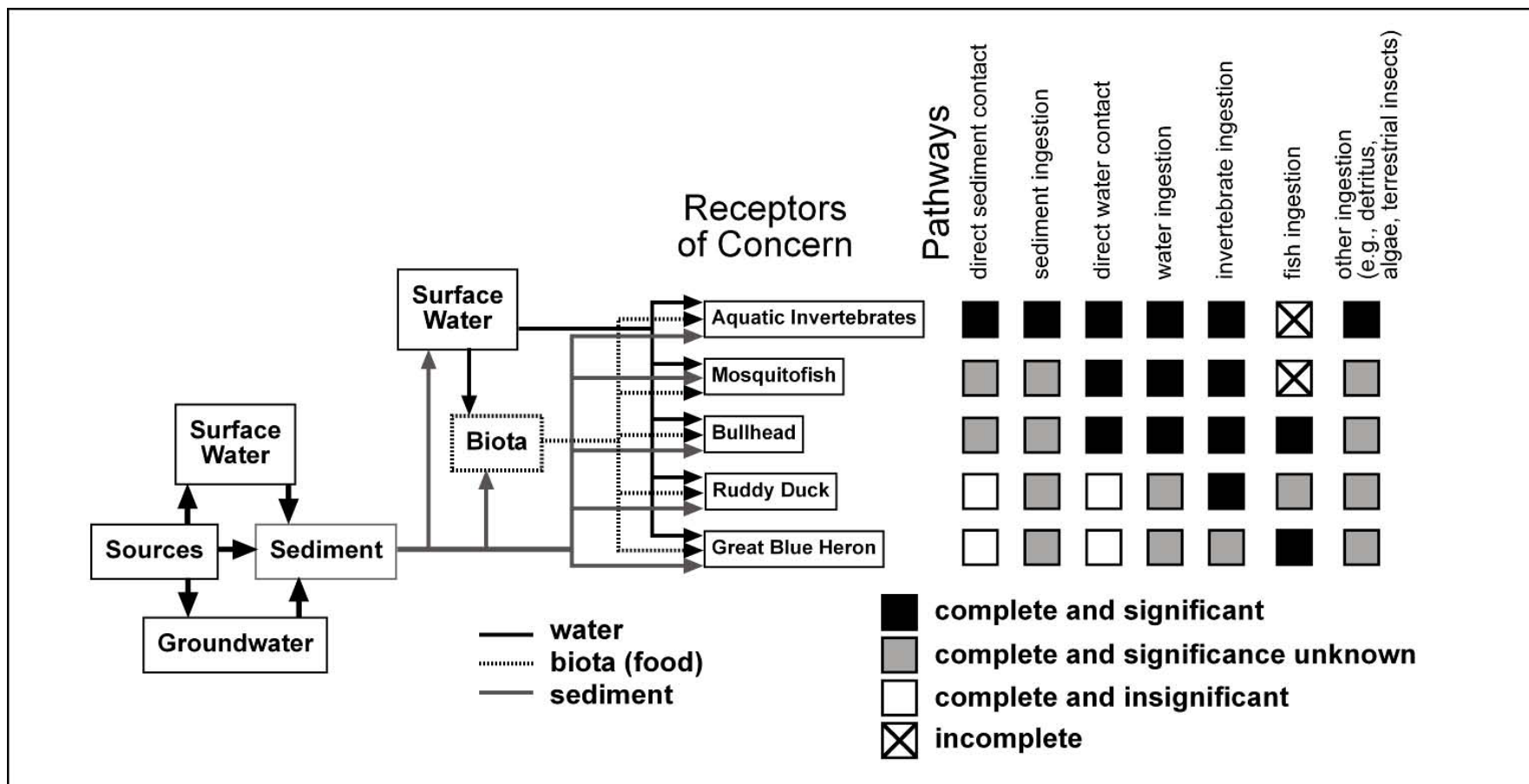


Figure 16
Preliminary Ecological CSM – Aquatic Receptors
 Harbor Oil Site

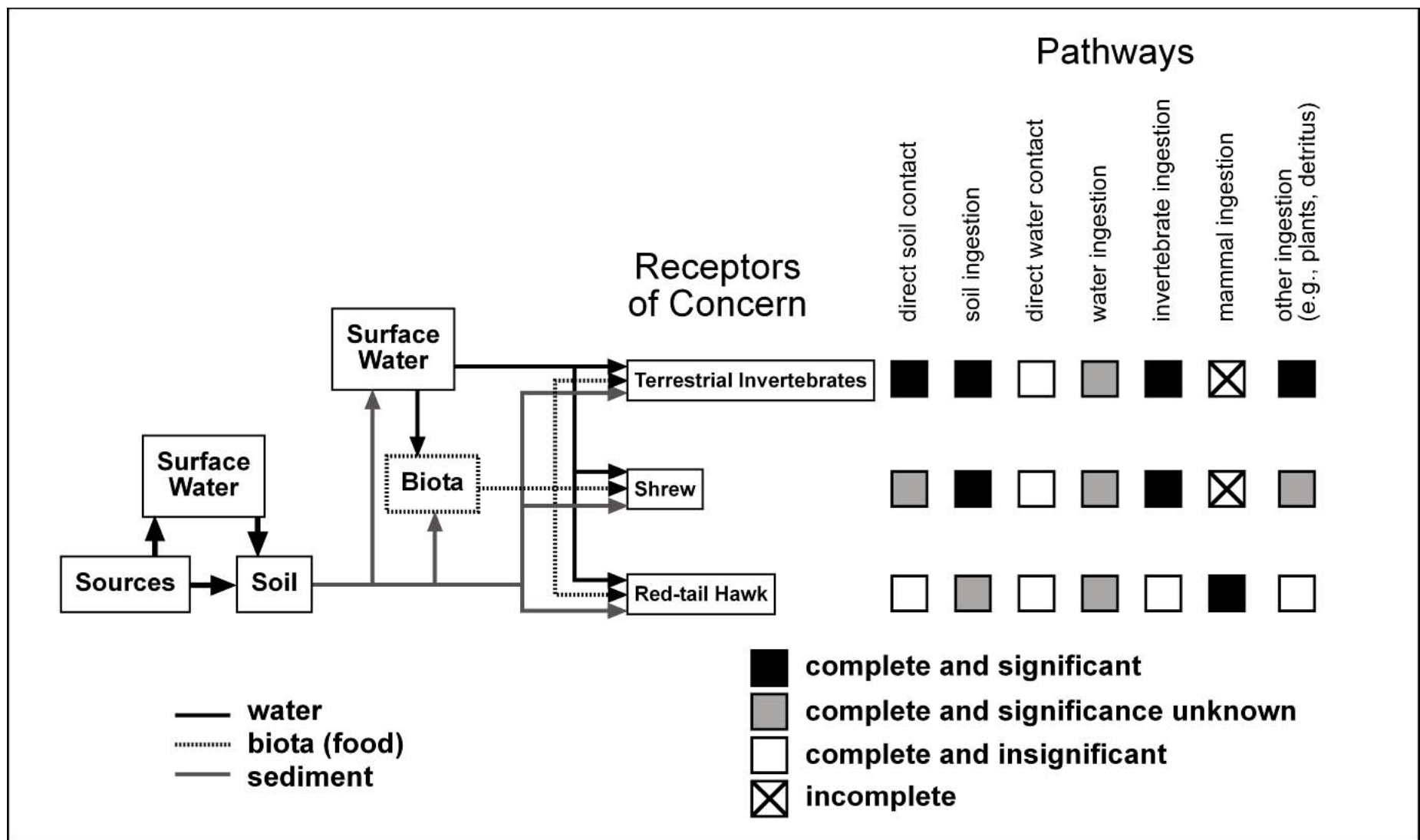


Figure 17
Preliminary Ecological CSM – Terrestrial Receptors
 Harbor Oil Site



50 ft
Approximate Scale

Source: Coles Environmental Consulting, Inc., Energy & Materials Recovery, Inc. Site Diagram (Formerly Harbor Oil, Inc.), March 2005.

Legend:











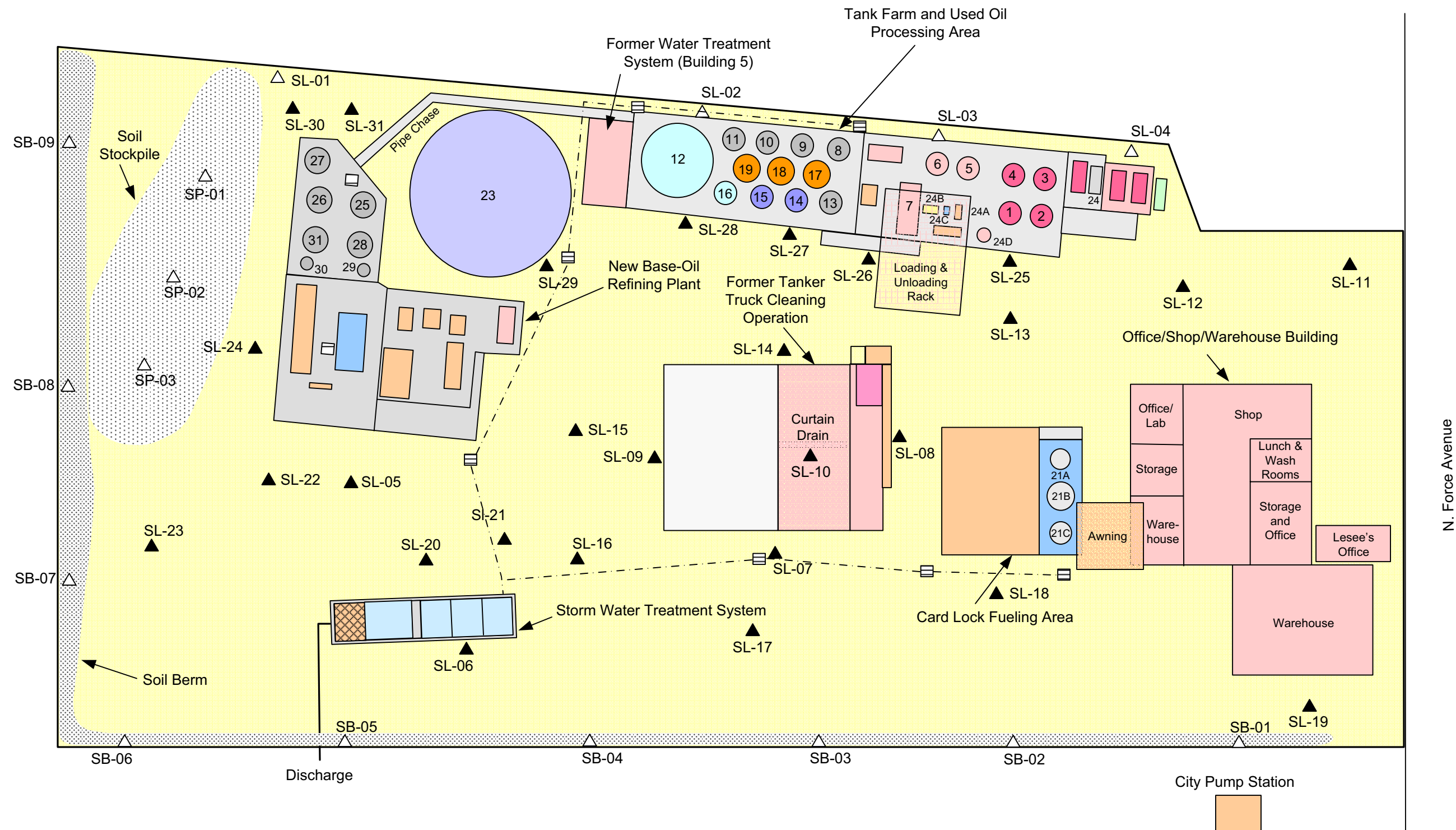
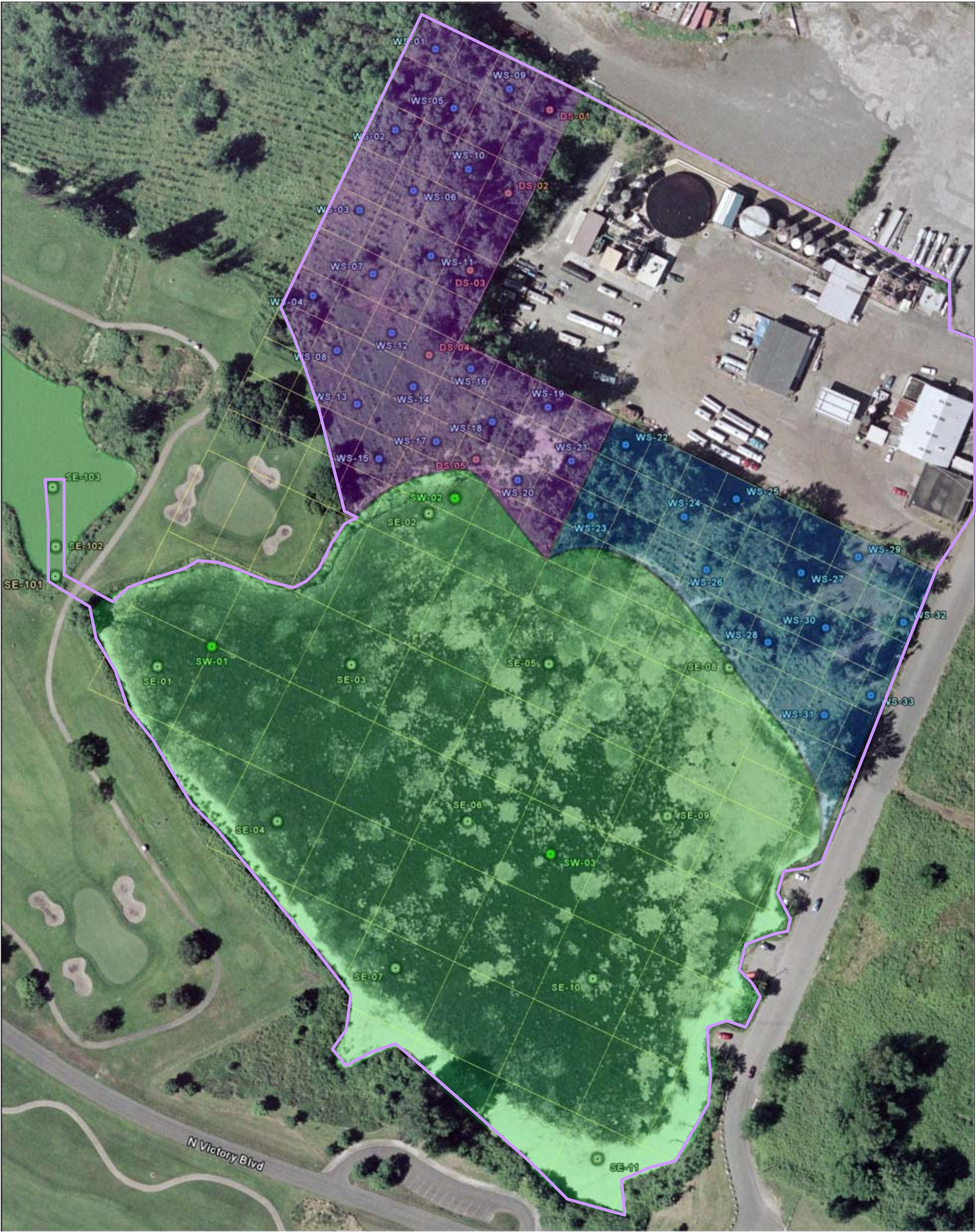
-  Catch Basin
-  Storm Water System Piping
-  Soil Sample Location
-  Golder (1990)
-  Screening Lab Analyses Only
-  Fixed Lab Analyses
-  E&E (2001)
-  CEC (2007b)
-  Hand Auger Boring Locations
-  Push-Probe Boring Locations








Figure 18
Proposed Phase 1 On-Facility Soil
Sample Locations
Harbor Oil Site

BRIDGEWATER GROUP, INC.





Legend

-  Wetland soil sample (WS-01 through WS-33)
-  Wetland ditch soil sample (DS-01 through DS-05)
-  Sediment (surface) sample (SE-01 through SE-11, SE-101 through SE 103)
-  Surface water sample (SW-01 through SW-05)
-  L-shaped wetland sampling area
-  Southern wetland sampling area
-  Lake sampling area

 Phase 1 RI Study Area Boundary



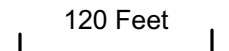
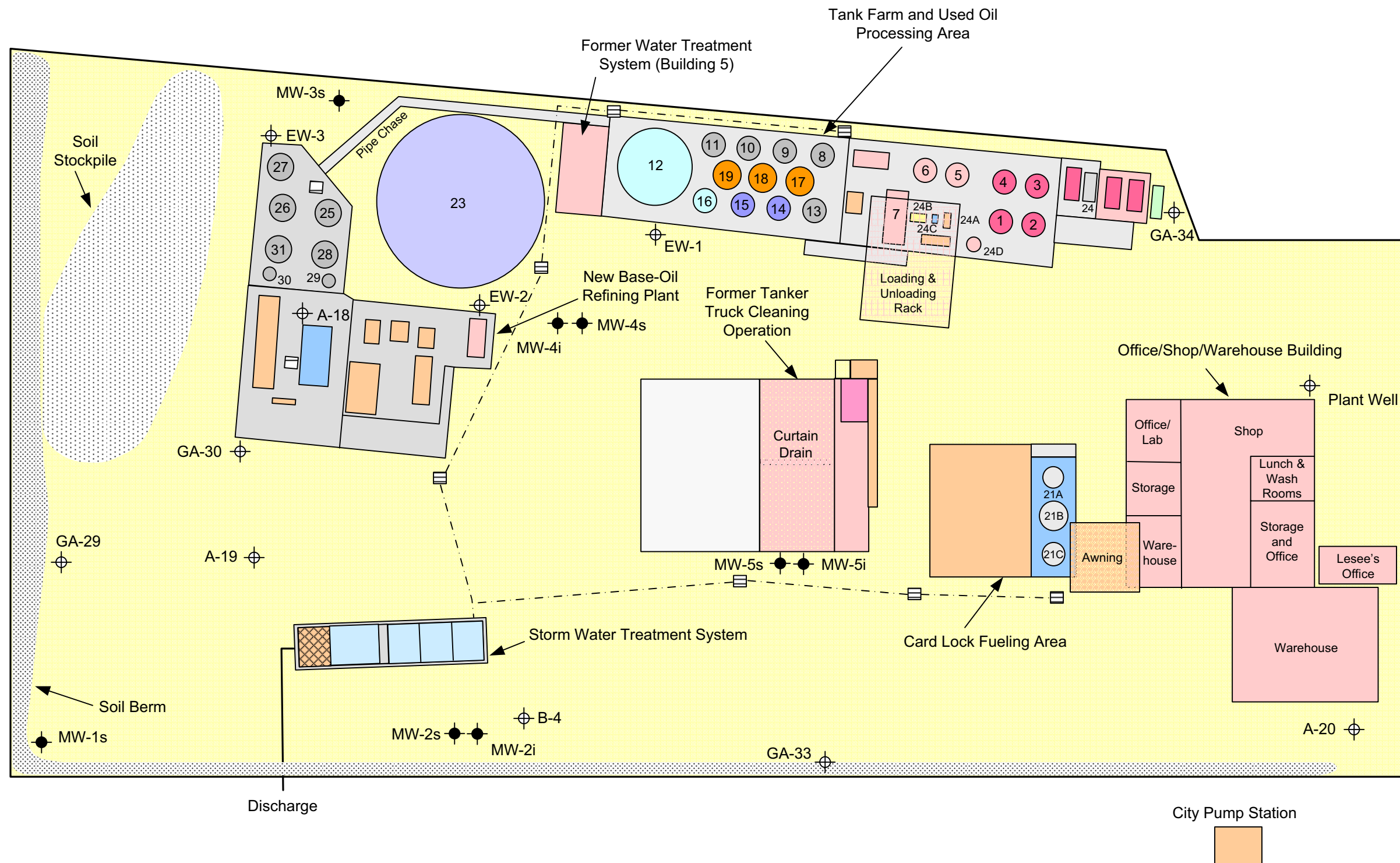

120 Feet
Approximate Scale

Figure 19
Proposed Phase 1 Wetland Soil, Lake
Sediment and Surface Water Sampling
Locations
Harbor Oil Site



Legend:





-  Catch Basin
-  Storm Water System Piping
-  Existing Well Location
-  Proposed Monitoring Well Location

Figure 20
Proposed Phase 1 Groundwater Sample
Locations
 Harbor Oil Site

BRIDGEWATER GROUP, INC.



50 ft
 Approximate Scale

Source: Coles Environmental Consulting, Inc., Energy & Materials Recovery, Inc. Site Diagram (Formerly Harbor Oil, Inc.), March 2005.

APPENDIX A – PROJECT MANAGEMENT PLAN

APPENDIX B – QUALITY ASSURANCE PROJECT PLAN

APPENDIX C – HEALTH AND SAFETY PLAN

APPENDIX D – REMEDIAL ACTION OBJECTIVES TECHNICAL MEMORANDUM

APPENDIX E – SELECTED GOLDER ASSOCIATES (1990) FIGURES

APPENDIX F – OWRD WATER WELL REPORT FOR THE PLANT WELL

APPENDIX G – CEC 2003 SOIL SAMPLING RESULTS

APPENDIX H – PRE-RI LABORATORY ANALYTICAL RESULTS
