Prepared for:
Alaska Railroad Corporation
Anchorage, Alaska

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Remedial Investigation
Alaska Railroad Corporation
Anchorage Terminal Reserve
U.S. EPA Docket No. CERCLA 10-2004-0065

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List of Acronyms

ADEC	Alaska Department of Environmental Conservation
ADFG	Alaska Department of Fish and Game
ADOT	Alaska Department of Transportation & Public Facilities
AMSL	above mean sea level
ANPR	Advance Notice of Proposed Rulemaking
ARAR	Applicable or Relevant and Appropriate Requirement
ARRC	Alaska Railroad Corporation
AOC	Administrative Settlement Agreement and Order on Consent No. 10-2004-0065
AWQC	Ambient Water Quality Criteria
BEHP	bis((2-ethylhexyl)phthalate
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, xylene
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	cubic feet per second
COIs	chemicals of interest
COPCs	constituents of potential concern
CSM	Conceptual Site Model
CVOCs	chlorinated volatile organic compounds
DEM	Digital Elevation Model
DFSPA	Defense Fuel Support Point-Anchorage
DQO	Data Quality Objective
DO	dissolved oxygen
DRO	diesel range organics
DTSC	California Department of Toxic Substances Control
EAFB	Elmendorf Air Force Base
EC	specific conductance or electric conductivity
EDB	ethylene dibromide
EPH	extractable petroleum hydrocarbon
ERA	Ecological Risk Assessment
EROS	Earth Resources Observation Systems
FC	fraction of media that is available for contact
FS	Feasibility Study

ft	feet
ft/day	feet per day
ft/ft	feet per foot
ft/yr	feet per year
GC	gas chromatography
GRO	gasoline range organics
GW	groundwater
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
IQR	interquartile range
January 2007 WP	Remedial Investigation Additional Scope of Work – January 2007 Memorandum
KAPP	Knik Arm Power Plant
LIDAR	Light Detection and Ranging
LNAPL	light non-aqueous phase liquid
LP	leased property
March 2007 WP	Response to EPA Comments Regarding Additional Scope of Work and Scope of Work for Final Proposed Field Activities Memorandum
MDC	maximum detected concentration
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
ML&P	Municipal Light and Power
MNA	monitored natural attenuation
MOA	Municipality of Anchorage
mph	miles per hour
MSGP	Multi-Sector General Permit for Industrial Activities
mV	millivolt
NCDC	National Climatic Data Center
ND	non-detect
NOAA	National Oceanic and Atmospheric Administration
North Boundary Survey	North Boundary Assessment Groundwater and Soil Results
NOV	Notice of Violation
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
Oil Companies	Flint Hills Resources, Chevron, and Tesoro

ORP	oxidation-reduction potential
OU5	Operable Unit 5
%	percent
PAH	polynuclear aromatic hydrocarbon
PC	Planned Community
PCE	tetrachloroethene or perchloroethylene
PCBs	polychlorinated biphenyls
ppbv	parts per billion (volumetric)
PSDDA	Puget Sound Dredge Disposal Analysis
QA/QC	quality assurance/quality control
POA	Port of Anchorage
RA	Risk Assessment
RA Scoping Memo	Risk Assessment Scoping Memorandum
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RETEC	ENSR Corporation (dba The RETEC Group, Inc.)
RFA	RCRA Facility Assessment
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RI/FS WP	Remedial Investigation and Feasibility Study Work Plan
RL	reporting limit
ROST	Rapid Optical Screening Technique
RRO	residual range organics
RSLERA	Refined Screening Level Ecological Risk Assessment
SBR	Site Background Report
SE	sediment area
SED	sediment
Site	Anchorage Terminal Reserve, Anchorage, Alaska
SLs	screening levels
SLERA	Screening Level Ecological Risk Assessment
SOW	Statement of Work
SVOC	semi-volatile organic compound
SWMU	solid waste management unit
TCE	trichloroethene
TDS	total dissolved solids

TMDL	total maximum daily load
TOC	total organic carbon
TRL	target risk level
USACOE	United States Army Corps of Engineers
USGS	United States Geological Survey
U.S. EPA	United States Environmental Protection Agency
UST	underground storage tank
UTL	upper tolerance limit
VPH	volatile petroleum hydrocarbon
UV	ultraviolet
VOCs	volatile organic compounds
WPA	Remedial Investigation/Feasibility Study Work Plan Addendum
µg/L	micrograms per liter
µS/cm	microSiemens per centimeter

Executive Summary

This Executive Summary presents the conclusions of the Remedial Investigation (RI) and associated Risk Assessment (RA). The RI report was developed under the Comprehensive Environmental Responsibility, Compensation, and Liability Act (CERCLA) and the Resource Conservation and Recovery Act (RCRA) Administrative Settlement Agreement and Order on Consent No. 10-2004-0065 (AOC) dated June 29, 2004 (U.S. EPA, 2004a) and associated Statement of Work (SOW) (U.S. EPA, 2004b) dated May 17, 2004 between the United States Environmental Protection Agency (U.S. EPA) Region 10 and ARRC. Under the AOC, ARRC agreed to conduct a joint CERCLA/RCRA Remedial Investigation/Feasibility Study (RI/FS) at the Site. The RI therefore is designed to satisfy both.

To ensure full characterization of both on-site and upgradient properties, DQOs were developed and guided the investigation of potential Site impacts.

The AOC outlined three specific goals to be satisfied by the RI/FS:

1. Investigate the nature and extent of contamination presenting risk at the Site (the RI)

2. Assess the potential risk to human health and the environment caused by Site contamination (the RA, included in this RI as Appendices B and C)

3. Based on the findings of the RI and RA, assess the need for remedial and corrective action at the Site, identify and evaluate alternatives for any such required action, and select a recommended alternative (in the FS, to be prepared and submitted subsequent to this RI)

A key focus of the AOC is the protection of Ship Creek, as explicitly stated in Section 2 of the SOW*: "The objectives of the work required under this AOC have been determined preliminarily, based on available information, to include the following: (1) Human health protection with respect to exposure to Site contaminants at or from the Site in soils, groundwater, surface water, and sediments, including exposures occurring from expected use of Ship Creek and its banks for recreation, occupational activities, and consumption of resident fish; (2) Protection of benthic invertebrates, resident fish and wildlife receptors of such aquatic life that may be affected by potential water or sediment contamination in Ship Creek."*

In order to meet the requirements of the AOC, the RI/FS WP defined the purpose of the RI as follows:

- Assessment of contaminant transport, receptors, and pathways for protection of Ship Creek and its resources
- Protection of human health and ecological receptors
- Identification of relevant sources of chemicals present that may pose a risk

The following sections provide conclusions from the RI and RA regarding nature, extent, and sources of risk from soil, groundwater, surface water, and sediment.

Remedial Investigation conclusions

A fundamental objective for the RI was to develop a strategy to fully meet the goals of the AOC, while efficiently utilizing ARRC and agency resources. This objective was developed early in the planning process. U.S. EPA and ADEC were actively involved in establishing the RI approach and sampling and analysis

program. ARRC met on numerous occasions with U.S. EPA and ADEC throughout the RI process, and proposed investigation plans and the rationale for those plans.

Several key concepts were agreed upon with U.S. EPA and ADEC to guide the RI/FS process. These included the following:

- Conducting the RI/FS under a site-wide approach.
- Focusing the Site investigation on the potential impact to Ship Creek from Site sources of risk. This was achieved through systematic sampling of the media that could affect the creek and the establishment of perimeter sampling by means of monitoring well transects.
- Using the extensive set of historical information and analytical chemical data to define focused, authoritative sampling in areas where Site impacts have been previously documented, and to direct other Site sampling based on the historical record of Site activities and to pathways by which contaminants could reach Ship Creek or Cook Inlet.
- Addressing specific RCRA concerns related to SWMUs and Areas of Concern, independent of the site-wide approach, reflecting the joint CERCLA/RCRA nature of the RI/FS.
- Adopting a perimeter approach to evaluating the Terminals Area due to the significant and extensive data set available for this area as well as the active involvement by ADEC and the Terminal lessees within the boundaries of the oil company leaseholds.
  - The perimeter area evaluated sediment data from Cook Inlet, surface water data from the storm water system draining the northern part of the Terminals, and groundwater data from monitoring wells between the industrial areas and Cook Inlet to define potential sources of risk to Cook Inlet.
  - The perimeter area also evaluated soil data from areas of the Terminals outside the leased properties, e.g., public roadways and other land managed directly by ARRC. Evaluating soil impacts in these areas was directed towards determining whether migration was occurring form sources of risk within the oil company leased properties.
  - The oil company leased properties are currently under ADEC environmental supervision and are subject to semi-annual or annual monitoring requirements, as well as other ADEC requirements. This RI has incorporated the available data into the Site database, to reflect the past and ongoing environmental monitoring and evaluations conducted by the oil company lessees that address their individual leased properties. The risk assessments for these areas was handled differently, however: the RA associated with the RI contains a site-specific risk assessment for the Tesoro leased property. The RAs for Chevron and Flint Hills leased properties are under separate development and will be submitted following this RI.
- A perimeter approach was also utilized for the ARRC operating railyard. Sampling was conducted within the railyard, but the focus of the investigation was to ensure migration from the railyard into the lease properties was not occurring.

The following summarizes the Site conceptual model, the RI findings regarding the nature and extent of Site impacts, and the information collected during the RI regarding the RCRA SWMUs and Areas of Concern.

Summary of Site Conceptual Model

The data collected during the RI have been added to the extensive pre-RI dataset to refine and confirm the preliminary CSM presented originally in the Site Background Report (SBR) and refined in the RI Work Plan. The Site was under the control of the federal government until 1985 at which time it was transferred to the State of Alaska. Much of the Site contamination originated from pre-1985 releases. As a result of long-term contamination residence time and hydrogeologic conditions at the Site, the extent of contamination from these past releases may extend substantially beyond the original source areas.

The preliminary CSM portrayed the relationship between the COPCs and their sources, transport mechanisms, and ultimately, human and ecological receptors. The SBR presented the following three preliminary CSMs:

1. Hydrogeological CSM, which describes the Site hydrology, geology, hydrogeology, and potential source areas and migration pathways;

2. Human health CSM, which characterizes exposure pathways and identifies human receptors; and

3. Ecological CSM, which characterizes exposure pathways and identifies ecological receptors.

The human health and ecological CSMs build on the risk assessment scoping process and are presented in Appendices B and C with the detailed risk assessments. Preliminary human health and ecological CSMs presented in the SBR were developed and refined through collection of site data.

The RI data validated the characteristics of the Site used in developing the preliminary hydrogeological CSM. The hydrogeological CSM can be outlined as follows:

- Ship Creek is a gaining stream along its full reach through the Site. With development in the Railyard area beginning in 1919, Ship Creek has evolved from a meander stream lined with saltwater mashes and ponds to its current highly channelized configuration.
- Ship Creek is a relatively high-energy stream due to spring snowmelt and episodic precipitation events. As a result, the creek has few areas of active sediment accumulation within the Site.
- There are numerous outfalls to Ship Creek at the Site that constitute point source discharges to the creek. These outfalls discharge water from multiple sources, including ARRC storm water, Municipality of Anchorage (MOA) storm water, and Elmendorf Air Force Base (EAFB) treatment effluent.
- The groundwater aquifer at the Site consists of alluvial material in the Ship Creek Area and graded fill material in the Terminals Area. Across the entire Site, the base of the alluvial aquifer material rests on fine-grained, very low conductivity sediment of the Bootlegger Cove formation, which impedes downward vertical migration of groundwater and dissolved-phase contaminants.
- Groundwater recharge at the Site occurs from infiltration of precipitation, groundwater flow from off-site areas to the east, and re-infiltration of seep water coming from the bluffs to the north and south. As a result, there are numerous potential off-site (upgradient) sources of contamination, as well as the potential for contamination to leach from soil to groundwater.
- Groundwater flow beneath the Site is generally from east to west, with convergence toward Ship Creek on both the north and south sides. Ship Creek creates a groundwater divide through the Site.
- The groundwater flow velocity ranges from about 40 to 350 feet per year (ft/yr) on the north side of the creek, and from 20 to 210 ft/yr on the south side.
- The permeable nature of the alluvial and fill material, combined with the shallow groundwater conditions (5 to 15 bgs) at the Site, create the potential for vapor migration to indoor air.

Summary of data collection

The RI included a sample collection effort from September 2004 to August 2007, aimed to evaluate the nature and extent of contamination at the Site. Sample design, collection, and evaluation followed DQOs and evaluation flowcharts developed in the RI/FS WP. It was determined that the sampling effort was adequate to define the nature and extent of contamination in accordance with the requirements of the AOC. The effort included the following field activities:

- Surface and subsurface soil samples were collected from more than 86 borings, in addition to a number of surface soil collection locations, for a total of 106 surface soils and 86 subsurface soils sampling locations. This does not include soil samples collected under ADEC oversight at specific leased properties (LP019 and LP022).
- A total of 61 monitoring wells, 52 permanent direct push wells, and 60 temporary direct push groundwater sampling points were installed. Most permanent locations were sampled two to four times over the course of the RI, for a total of more than 300 groundwater samples. This total does not include groundwater sampling and monitoring conducted under ADEC oversight at leased properties (LP019, LP003/004, LP025, LP127, and LP022). In addition, 20 water seeps along the North Bluff were sampled.
- A total of 27 surface water samples were collected from Ship Creek and off-channel areas. This total does not include 9 surface water samples collected by Tesoro in the storm water drainage system adjacent to its leased property.
- A total of 45 sediment samples were collected from Ship Creek and off-channel areas. This total does not include sediment samples collected in Cook Inlet by the Port of Anchorage (POA) that have been evaluated in this RI.
- A total of 17 soil gas samples were collected from 11 locations.
- Seven water samples were collected from water supply wells located on the Site.
- LNAPL was collected, but not analyzed, from two groundwater locations with detectable NAPL.

More than 100,000 total laboratory analyses are included in the RI and pre-RI data set. The pre-RI data set contains all environmental data collected at the Site prior to September 2004. Most of the RI samples were analyzed for the entire target analyte list: inorganics, VOCs, SVOCs, PCBs, EPH/VPH, and field parameters. Some of the step-out groundwater sampling focused on only key constituents identified in the targeted plume, such as CVOCs.

To define the nature and extent of contamination, relevant screening levels were developed for the protection of human health and ecological receptors and to evaluate media transfer. These screening levels were used to evaluate the complete RI data set and to select the COIs for discussion in the RI results section. Non-detect COPCs are included in tables, but were not considered in the nature and extent evaluation. However, the RA does incorporate non-detect data in the risk COPC selection process. These COPCs were used to define the nature and extent of contamination.

Additional studies related to hydrogeology, tidal influence, geology, and groundwater flow at high and low river stages (highest water conditions in Ship Creek occur after snow melt in June and July, and low water conditions occur in February and March), visual Site inspections, history of lease use, and review of pre-RI data provided a framework to understand the source, fate, and transport of contaminants found at the Site.

The evaluation of nature and extent of contamination (Section 4.0) and the evaluation of sources, fate, and transport of the contaminants (Section 5.0) provide the basis for the following media-specific conclusions related to the nature and extent of contamination.

Summary of nature and extent of Site impacts to surface water

Nature and extent of surface water contamination were evaluated separately for Ship Creek and for the off-channel aquatic areas along the north side of the creek. Surface water data were collected only within the creek and where standing water was present in the off-channel areas.

For Ship Creek proper, no significant exceedances of surface water screening levels were noted. A few slight exceedances for inorganics were noted, but none for organics. For the off-channel areas, organics were absent in surface water except in samples associated with the ditch area at sediment area SE-3 (see next section). In this area PCBs, PAHs, and some inorganics exceeded screening levels, consistent with what was observed in the underlying sediment.

In addition to the Ship Creek Area, ARRC evaluated surface water samples collected from the storm drain located in the northwestern part of the Terminals Area. Benzene concentrations in some of these samples exceeded screening levels, although high mixing and dilution that occur when the discharge enters Cook Inlet indicate this is not a source of risk to aquatic habitats or receptors.

Summary of nature and extent of Site impacts to sediment

Nature and extent of sediment contamination were evaluated separately for Ship Creek proper and for the off-channel aquatic areas along the north side of the creek.

For Ship Creek proper, only minimal exceedances of conservative (i.e. protective) sediment screening levels were noted in some samples for some PAHs and two inorganics, specifically antimony and nickel. The magnitude and frequency of exceedances were low, and no sources of risk were noted in Ship Creek. This includes the areas where known groundwater plumes may intersect with Ship Creek.

For the off-channel areas, elevated detected concentrations exceeding sediment screening levels were noted for PCBs, PAHs, and some inorganics. Many of the exceedances can be grouped into distinct geographic units, as follows:

- **SE-1, the pond located behind Kapp Dam.** This pond had exceedances for PCBs, several PAHs, and some inorganics. This pond may be affected by past activities at LP120, the former KAPP facility, which used the pond for cooling water recirculation.
- **SE-2, the storm water pond, located south of Whitney Road near the ARRC Operations building.** This pond receives discharges from a storm drain originating in the Railyard and in MOA residential areas on the North Bluff, in addition to runoff from adjacent leased properties. In this pond, elevated PAHs and some inorganics (specifically, lead, zinc, and cadmium) exceeding screening levels were present in an area of sediment accumulation. The remainder of the pond, with associated marshy areas, does not exceed screening levels and does not appear affected by Site discharges.
- **SE-3, the Railroad Avenue marsh, located south of Post Road in the eastern part of the Site.** This marsh area and a ditch feeding the marsh, contain elevated PAHs, phthalates, inorganics (specifically cadmium, lead, mercury, and zinc), and PCBs. Only part of the marsh and associated ditch areas specifically are impacted. The source may be related to adjacent leased properties and past waste disposal in this area.
- **SE-4, the Standard Steel ditch, located west of the former Standard Steel CERCLA site.** This consists of a ditch with PCBs and some PAHs in excess of sediment screening levels. The PCBs are likely residuals from the prior operations at Standard Steel, as the ditch was not remediated in the Standard Steel CERCLA process.

Several other off-channel sediment areas sampled for the RI had occasional low-level exceedances of individual PAH screening levels and a few inorganics, but the exceedances were minor and are not considered a source of risk.

In the Terminals Area, sediment data collected off-shore for the POA by the USACOE did not show any exceedances of screening levels.

Summary of nature and extent of Site impacts to Groundwater

Nature and extent of groundwater contamination were evaluated based on the transect evaluation strategy, followed as appropriate by step-out sampling to further define nature and extent. Screening levels were based on MCLs or ADEC groundwater screening guidance. The totals below are based on detected concentrations and do not include the Terminals Area, which was evaluated separately using a perimeter-based strategy. In addition to the direct contact and ingestion evaluation summarized below, groundwater data were also screened against indoor air vapor intrusion potential. Groundwater data from the Ship Creek bank area (primarily from the A and B transects) were also screened against surface water criteria to evaluate if groundwater discharge may represent a source of risk to Ship Creek.

Ship Creek area

- **SVOCs:** No SVOCs were detected above human health contact and ingestion screening levels.
- **PCBs:** One sample of 45 samples had PCB detections and exceeded human health screening levels. This sample was located at LP022, a lease under active ADEC oversight. Note that LP022, ML&P, includes extensive areas outside the boundaries of the Site which where PCBs, have been found. These areas fall outside of the Site, however,
- **VOCs:** VOC screening level exceedances were detected for PCE (11 of 341 samples), TCE (35 of 341 samples), vinyl chloride (34 of 341 samples), and benzene (12 of 354 samples). In addition, the 1,1,2-trichloroethane (112TCA) screening level was exceeded in 3 of 325 samples, and the 1,2-dibromo-3-chloropropane (DBCP) screening level was exceeded in 1 of 246 samples. All the CVOC exceedances can be grouped into distinct groundwater plumes. These plumes were designated as GW-1, GW-2/3, GW-4, GW-5, GW-6, GW-7, GW-8, and GW-9.
  - GW-1, a TCE plume following groundwater flow paths south of Ship Creek with a suspected but not confirmed off-site source east-southeast of LP072 but west of LP094.
  - GW-2/3, a vinyl chloride plume following groundwater flow paths south of Ship Creek with a likely off-site source, possibly associated with a waste oil tank located on ML&P property outside of the Site. One arsenic exceedance also occurred in this area.
  - GW-4, a vinyl chloride plume following groundwater flow paths south of Ship Creek originating off-site southeast of 1st Avenue.
  - GW-5, in the area of LP991 where there is apparently stable and immobile benzene and other hydrocarbon contamination Several inorganics (specifically, arsenic, lead and cadmium) also were elevated here, as was 112TCA. Small amounts of LNAPL have been noted in this area.
  - GW-6, a TCE and PCE plume on the north side of Ship Creek originating in the Railyard, following the alignment of the connector bridge, and reaching Ship Creek downstream of Kapp Dam.
  - GW-7, an apparently stable and immobile fuel hydrocarbon contamination area associated with a former fueling rack location on the Railyard. Arsenic, DBCP, and 112TCA also exceeded screening levels here. Small amounts of LNAPL have been noted in this area.
  - GW-8, a TCE and vinyl chloride plume at LP127 north of Ship Creek. This is under continuing ADEC oversight and was related to a previous paint shop at this leased property. The CVOCs do not appear to reach Ship Creek, and the plume appears stable.
  - GW-9, a TCE and PCE plume at LP085 associated with a leaking used oil tank removed in 1992. The plume does not appear to reach Ship Creek and appears stable. Tesoro perimeter, a VOC and hydrocarbon plume originating within LP019 in the extreme northwest of the Site and migrating across the boundary towards Cook Inlet.

Additionally, individual sample exceedances include 112TCA (at MWA07), and 2 exceedances of PCE at MWE02

- **Inorganics.** Note that background levels of metals were not considered in the groundwater evaluation due to the difficulty in developing representative background values. Arsenic exceeded MCLs in 28 of 233 samples (8 of which were in GW-2/3, GW-5, GW-7, or GW-8), cadmium in 12 of 236 samples (1 in GW-5), and lead in 3 of 238 samples (1 in GW-5). In addition, screening levels were exceeded for iron (40 of 229 samples), manganese (97 of 229 samples) and nickel (11 of 214 samples). Other exceedances of drinking water screening levels were scattered throughout the Site. Few samples were highly elevated relative to the screening levels.

North Bluff area

A number of exceedances were noted in groundwater and seeps in the North Bluff area (specifically, benzene, TCE, arsenic, cadmium, and nickel). These exceedances are not Site-related, and are assumed to represent groundwater entering from the north along the bluff, most likely from sources at EAFB.

Terminals area

The perimeter of the Terminals Area was evaluated to determine if migration of contaminants from the Terminals leases towards Cook Inlet may be occurring. Groundwater from the perimeter area west of LP019 (Tesoro) exceeded screening criteria for benzene and several other organics. This area was defined as an area for further evaluation. It was concluded that migration of contaminants exceeding screening levels (MCLs) towards Cook Inlet (or the adjacent storm drain) could not be ruled out, although the low flux in relation to the mixing and dilution in Cook Inlet indicate that such migration almost certainly is not a source of risk.

Groundwater within the Terminals Area leases associated with hydrocarbon storage (LP019 Tesoro, LP003/004 Flint Hills, and LP025 Chevron) exceeded screening values for benzene and to a lesser extent other BTEX components at multiple locations. NAPL was present in some areas. This condition is widespread, and currently managed under ADEC supervision by the affected lessees.

Summary of Nature and Extent of Site impacts to soil

Nature and extent of soil contamination was very limited. The RA further evaluated these exceedances. As part of the soil evaluation, contaminant levels were also screened for leaching potential to groundwater and for potential impacts to indoor air through vapor intrusion. In addition, contaminant levels in soils (and in intermittently dry sediment) in the Ship Creek riparian zone were compared to ecological screening levels to evaluate potential sources of risk to wildlife. Detected exceedances of soil screening levels were as follows:

- **SVOCs.** Only benzo(a)pyrene exceeded human health screening levels in any sample. Three of 81 surface soil samples and one sample of 73 subsurface soil samples had exceedances of screening levels for benzo(a)pyrene. No other exceedances of any SVOC were detected anywhere on the Site. Detected exceedances were minor (less than twice the screening level) and widely scattered.
- **PCBs.** No surface soil samples (of 22 samples) exceeded screening levels and one subsurface sample of 12 samples exceeded human health screening levels. The exceedance was noted at the LP127 lease, where PCBs have been addressed in remedial efforts under ADEC oversight. Concentrations were well below the Toxic Substances Control Act remedial action level of 50 mg/kg total PCBs.
- **Fuel hydrocarbons.** No surface soil sample and only one subsurface soil sample, exceeded screening levels for EPHs. This subsurface soil sample was located at area GW-7, where groundwater contamination also was found.

- **VOCs:** No exceedances of screening levels were noted in surface or subsurface soils.
- **Inorganics.** The following inorganics exceeded screening levels, and, where applicable, background levels: arsenic (5 of 85 surface soil samples and 2 of 72 subsurface soil samples); chromium (2 of 85 surface soil samples); iron (2 of 85 surface soil and 2 of 65 subsurface soil samples); and mercury (1 of 85 surface soil samples). Exceedances were at individual sample locations that are not co-located, and in only one case (iron at MWA12) exceeded the screening level (or background) more than twice.

Additional sampling beyond that described above also was conducted and evaluated for the RI, for example soil gas sampling near occupied buildings in areas of known or suspected groundwater impact, and sampling of water supply wells that are in use at the Site.

In conclusion, the RI used pre-RI data and Site knowledge to develop an appropriate sampling strategy to meet the DQOs and other requirements of the AOC. Sampling was conducted in accordance with 1) the established DQOs, 2) the strategy for RI completion and 3) EPA protocols and methods. The AOC and SOW objectives for the RI have been met. The HHRA and ERA (summarized below and presented in Appendices B and C, respectively, of this RI report) further evaluated the site data to determine the potential risk associated with the contaminant levels that have been found. The RI data and the RA evaluation will be the basis for the upcoming FS.

Summary of RCRA SWMU and Area of Concern evaluation

Railyard and leased property sites were originally evaluated for the presence of SWMUs and Areas of Concern as described in U.S. EPA RFA Reports for the Site in 1996 and 2002. These reports identified SWMUs and Areas of Concern that U.S. EPA determined required further evaluation. According to U.S. EPA RFA Guidance, SWMUs and Areas of Concern should be evaluated to determine if releases have occurred and to determine the need for further action. The guidance also states that SWMUs and Areas of Concern should be screened from further investigation if they do not pose a threat to human health or the environment (U.S. EPA, 1996). All the SWMUs and Areas of Concern identified in the RFA reports were evaluated as part of the RI.

As detailed in Section 6.0, ARRC determined that the vast majority of SWMUs and Areas of Concern were no longer present, not in use, closed, or in good operational condition. These findings were consistent with the findings of the 1996 and 2002 RFA reports. A survey conducted to determine current status revealed that many of the SWMUs and Areas of Concern have undergone closure/cleanup activities under ADEC oversight. A summary of the information on ADEC oversight is included in Table 6-3.

SWMUs and AOCs identified as involving a potential environmental concern that required further investigation and/or additional evaluation consisted of the following small subset of areas in the Railyard, and include:

- SWMU 64
- SWMU 65
- SWMU 69
- AOC 1
- AOC 2
- AOC 3

All of these areas were sampled as shown in Table 6-1 and any contaminants at these locations were included in the risk assessment. Additionally, as shown in Tables 6-1 and 6-2, focused RI sampling was conducted at

/or downgradient of other SWMUs and AOCs based on historical knowledge. Of the above SWMUs and AOCs, only AOC2 was identified as an area of potential source of risk, referred to as GW-7.

Risk Assessment conclusions

Section 7.0 provides a summary of the Human Health and Ecological Risk Assessment Reports presented in Appendices B and C of the RI. Those risk assessments were a substantial element in determining whether impacted areas did not require further action or whether they needed to be forwarded to the FS for evaluation of remedial alternatives.

Human Health Risk Assessment

The HHRA draws the following risk conclusions for the evaluated Site receptors and environmental data using ADEC's cancer TRL of $1x10^{-5}$ and noncancer HI of 1.0:

- **Soil.** Seven leased properties in the Ship Creek Area of the Site have reported unacceptable surface soil risks for outdoor workers. Risk at LP022, LP127 and LP131 is due to elevated concentrations of PCBs while at LP024 risk is due to summing the individual risk from arsenic, benzo(a)pyrene, and PCBs. Risk at LP137 is due to TCE. Risk at LP991 and RY065 is due to summing several carcinogenic PAHs (benzo(a)pyrene, dibenz(a,h)anthracene and indeno(1,2,3-cd)pyrene). An exceedance of TCE is also noted for one sample in the Railyard. When the contribution of background for arsenic is accounted for, and an area-wide EPC is calculated, noncancer risks drop below a HI of 1 at two leased properties (LP127 and LP131) although cancer risks remain above the TRL of 10^{-5} on an area-wide basis. Therefore, the potential for unacceptable risk may exist to outdoor workers exposed to surface soil in these areas and will be evaluated further in the FS.

  Cumulative cancer risks for construction workers exposed to surface and/or subsurface soil at the Site are below the TRL of 10^{-5}, indicating no unacceptable cancer risk exists. However, as discussed above, concentrations of total PCBs in surface soil at LP022, LP031, LP127 and LP131 are above a noncancer HI of 1 for construction workers. In addition, noncancer risks for subsurface soil at LP991 are above a HI of 1 due to concentrations of benzene, naphthalene and xylene**.** When an EPC is calculated for construction workers in these areas, noncancer risk drops below a HI of 1 at LP127 and LP991, indicating there is no potential for unacceptable risk. **Therefore, further consideration in the FS is only warranted for PCBs at LP022, LP031, and LP131 and only for potential exposures to construction workers**.

  Surface and subsurface soil concentrations in the PC District are below the acceptable cancer TRL of 10^{-5} for future residents (adult and child). All noncancer risk reported above a HI of 1 for future child residents is due to background levels. **Therefore, no further evaluation of the PC District is warranted.**

  In the Riparian area, cumulative cancer risk is below a TRL of 10^{-5} and the noncancer HI of 1.0, indicating that exposure to bank soil/sediment does not pose an unacceptable risk to recreational users (adult and child). **Therefore, no further evaluation of the Riparian area is warranted.**

  No surface soil locations in the Railyard exceed the cumulative cancer TRL of 10^{-5} or noncancer HI of 1, indicating that no unacceptable risk exists to trespassers (adolescent) in this area. **Therefore, no further evaluation of the Railyard is warranted.**

  Risks from exposure to surface and/or subsurface soil in the Perimeter Terminals Area are below both the cancer TRL of 10^{-5} and noncancer HI of 1. These results indicate that no potential for unacceptable risks exists to construction workers or maintenance workers in this area. **Therefore, no further evaluation of the Perimeter Terminals Area is warranted.**

Risk levels at one surface soil sample (LP019-KPG1) exceeded a cumulative cancer TRL of 10^{-5} (along with U.S. EPA's upper-bound risk level of 10^{-4}) and noncancer HI of 1 for outdoor workers at the Tesoro facility located within the Interior Terminals Area. This risk is due to elevated historical concentrations of benzene and xylene in surface soil. However, this sample is located below the secondary containment liner and exposure does not occur under current conditions. Therefore, the risk is likely to be over estimated based on the conservative nature of the assumptions applied. **Therefore, no further evaluation in the FS is warranted.** For construction/excavation workers at the Tesoro facility, cancer and noncancer risks are below acceptable levels on an area-wide basis, indicating no potential for unacceptable risk exists to construction workers exposed to subsurface soil at Tesoro. **No further evaluation is necessary with respect to construction/excavation workers at the Tesoro facility.**

- **Groundwater.** Concentrations reported for the consumption wells in use in the Ship Creek Area of the Site are below MCLs. An initial analysis showed that, bis(2-ethylhexyl)phthalate (BEHP)exceeded its MCL, but this was not confirmed in a second analysis using the drinking water method (EPA Method 525.2). Therefore, no further evaluation is necessary with respect to human consumption of groundwater from the wells at the Site that are currently used for this purpose. In addition, arsenic concentrations at the one Perimeter Area well (LP060-SUP02) were slightly above the MCL. However, further evaluation is not proposed at this location as the well is 290 feet (ft) deep and used only for industrial purposes.

  Use of monitoring well groundwater as a drinking water source was conservatively included in the HHRA to determine whether future use could occur or if institutional controls are necessary. Numerous exceedances of drinking water standards are reported in the shallow aquifer across the Site. **Further evaluation of Site groundwater in the shallow aquifer above MCLs or background within the leased properties of the Ship Creek Area is warranted in the FS**. It is important to note, that no one is currently using this groundwater from the shallow aquifer for potable purposes.

  Benzene exceedances of the MCL were noted in groundwater at the Tesoro facility. In addition, two wells (LP019-MW1 and LP019-MW23) located on the Tesoro property boundary in the Perimeter Terminals Area have exceedances of ADEC cleanup levels for fuel hydrocarbons (C12-16 and C16-21 aliphatics). **Further evaluation in the FS is warranted with respect to groundwater at the Tesoro facility and at the Tesoro property boundary in the Perimeter Terminals Area.** It is important to note, that no one is currently using the groundwater from the Tesoro leasehold or the Perimeter Terminals Area for potable purposes.

  For construction workers in the Ship Creek Area of the Site, groundwater risks are below the cancer TRL of 10^{-5} at all locations. Noncancer risks are below a HI of 1 at all locations except LP022-B3 due to PCBs, RY065-MWE05 and RY065-MWE06 due to naphthalene and 1,2-dibromo-3-chloropropane, and at LP137CHMWE2 and LP137CHMWE5 due to benzene and naphthalene. Because noncancer risk in the Railyard is essentially equal to a HI 1, only **PCBs and VOCS in groundwater at LP-022 and LP-137 respectively, warrant further evaluation in the FS.**

  For construction workers in the Perimeter Terminals Area, cumulative cancer risks are below the acceptable TRL of 10^{-5}, while noncancer risks exceed the HI of 1 at AR001-MWE17 due primarily to concentrations of naphthalene. These results indicate the potential for unacceptable risk may exist to construction workers in this area. **Therefore, evaluation in the FS is warranted with respect to construction worker exposure to groundwater in the Perimeter Terminals Area.**

  At the Tesoro facility, cumulative risks exceed the cancer TRL of 10^{-5} and noncancer HI of 1 for construction workers potentially exposed to benzene in groundwater at LP019-PW19B. Noncancer risk is also above a HI of 1 at LP019-PW24 due to xylene. **FS evaluation may be warranted with respect to construction worker exposure to groundwater at the Tesoro facility.**

- **Surface water and Sediment**. No risks exist to receptors exposed to sediment in Cook Inlet, Ship Creek or off-channel areas. **No further evaluation is necessary with respect to exposures to sediment**. Further, no surface water risk exists to receptors in Ship Creek or near the storm water drainage ditch in the Perimeter Terminals Area. **Thus no further evaluation is necessary with respect to exposures to surface water in Ship Creek or in the storm water drainage ditch in the Perimeter Terminals Area**. However, surface water risks in off-channel areas are above acceptable risk levels at SC002-SCD06 where the cancer risk is above 10^{-5} due primarily to concentrations of indeno(1,2,3-cd)pyrene. **Surface water exposures at SC002-SCD06 will be evaluated further in the FS for potential risks to recreational users.**

  Consumption of fish caught from Ship Creek does not pose unacceptable risk to receptors, as the recreationally valuable fish are predominately a migratory species. This limits amount of time they are in contact with potentially bioaccumulative compounds in the creek. In addition, Ship Creek itself contains relatively low (or non-detect) concentrations of COPC. The highest concentrations are observed in the off-channel areas to which fish are not exposed. **Therefore, no further evaluation is warranted with respect to consumption of fish caught from Ship Creek**.

- **Lead.** Lead was not determined to be a COPC in any surface water body at the Site; therefore, no further evaluation is warranted. While two off-channel sediment locations (SC002-CSD04 and SC002-CSD07) have concentrations above the lead RBC, exposure to the lead EPC in sediment on an area-wide basis does not pose unacceptable risk to recreational users in the Riparian Area and no further evaluation is warranted with respect to lead in surface water or sediments at the Site.

  No surface soil concentrations of lead exceed the RBCs for outdoor workers and trespassers. **Therefore, no further evaluation is necessary with respect to lead in surface soils.** In addition, concentrations of lead in surface and/or subsurface soil in the PC District are below the residential child RBC and no **further evaluation is necessary with respect to potential residential exposures to lead in surface or subsurface soils at the PC District area.** However, the subsurface soil EPC for lead at LP065 is above the construction worker RBC due to the isolated elevated occurrence at LP065-5MW (all other lead concentrations from samples taken at this leased property are below the RBC). **Therefore, further evaluation of lead in subsurface soil at LP065-5MW will be conducted in the FS.**

  In groundwater, lead concentrations above background levels and the MCL have been identified at two locations (AR001-MWA05 and LP991-MWE23) in the Ship Creek Area and one location (LP084-DPA03) in the Perimeter Terminals Area. **These lead exceedances in the groundwater at these three locations will be further evaluated further in the FS.**

- **Vapor Intrusion**. Vapor intrusion risks for indoor commercial/industrial workers are below acceptable levels for both groundwater and soil gas under all building scenarios evaluated within the Areas of Concern determined for the Site and no further evaluation is necessary with respect to potential vapor intrusion risk to indoor commercial/industrial workers. An exception to this occurs at LP-137 where the cancer risk is above the TRL of $1x10^{-5}$. This risk is attributable to concentrations of benzene and TCE reported in historical groundwater data (which were included to address a potential data gap) and indicates further consideration in the FS is warranted. In addition, vapor intrusion risks for future residents in the PC District are below acceptable levels and no further evaluation is necessary with respect to vapor intrusion risks to potential future residents in the PC District area. However, vapor intrusion risks from exposure to BTEX in groundwater at the Tesoro facility are above the cancer TRL of 10^{-5} while the noncancer risk is below the acceptable HI of 1.0. This risk is likely to be overestimated based on the conservative nature of the assumptions applied. **However, further evaluation of the vapor intrusion pathway for commercial/industrial workers at the Tesoro property may be warranted in the FS**.

- **Leaching.** Site-specific SSL leaching exceedances found in groundwater pertain to CVOCs and BTEX in areas identified as groundwater sources in the RI, specifically GW-5, GW-6, GW-7, GW-8 and GW-9. Results of the SPLP data collected from within these areas to further characterize the leaching potential of soil contaminants at the Site indicate the following:
  - Chlorinated VOCs in soil are not leaching to groundwater at concentrations exceeding RBCs. **No further evaluation is necessary with respect to possible leaching of chlorinated VOCs to groundwater**.
  - Arsenic leachate concentrations at LP024 are elevated above the background range for groundwater and may be considered a potential source in soil at that location, and thus the arsenic at LP024 will be evaluated further in the FS.
  - Ethylbenzene, toluene, and xylene are not leaching to groundwater at concentrations exceeding RBCs, while benzene is a potential source to groundwater in the Perimeter Terminals Area at AR001-MWE17. **Benzene in this part of the Terminals Area will be evaluated further in the FS.**
  - Naphthalene leachate results exceed the U.S. EPA Region 6 tap-water value at LP991 and **will be considered further in the FS.**
  - In addition, bank groundwater exceedances identified in the RI that are likely associated with a groundwater plume migrating toward Ship Creek at concentrations above surface water quality criteria **will be addressed further in the FS to evaluate impact on Ship Creek habitat.**

Ecological Risk Assessment

The ERA draws the following risk conclusions from the evaluated environmental and biological data:

- **Ship Creek.** Sediment and surface water in Ship Creek do not present significant or widespread risk to aquatic or benthic organisms, birds or mammals. Therefore, no significant adverse community-level ecological risk is anticipated for Ship Creek.
- **Off-channel Areas.** Potential ecological risk to higher trophic level receptors is limited to PCBs and phthalates and in sediment in the Railroad Avenue marsh area (sediment area SE-3). Birds such as the spotted sandpiper and mallard could be adversely affected if their main source of food and water was from this area. No aquatic community impacts are expected in ponds and marshes based on surface water concentrations. Sediment concentrations likely do not result in unacceptable risk to benthic communities in any area, with the exception of portions of sediment areas SE-2 (PAHs and lead), SE-3 (PAHs, PCBs, phthalates, and metals) and SE-4 (PCBs). **These areas will be further evaluated in the FS**.
- **Riparian Area**. The areas associated with risk are localized and small relative to the home ranges of (mobile terrestrial receptors, even those with small home ranges such as the robin and shrew. Mobile receptors (birds and mammals) are not likely to be exposed to levels of COPCs in soil that would result in adverse impacts, with the possible exception of PCBs and phthalates in the same localized intermittently dry sediment locations from areas SE-3 and PCBs in SE-4 as described for off-channel area sediment. Weight-of-evidence indicates no significant adverse impact is occurring to other riparian biota, including plants and invertebrates.
- **Cook Inlet Drainage Ditch.** No significant adverse community-level ecological risk is anticipated for Cook Inlet from discharges of storm water exceeding marine chronic benchmarks for xylene due to the rapid dilution in the inlet.

The results of the RSLERA showed, with the exception of off-channel areas SE-2, SE-3 and SE-4, that no adverse impacts to ecological organisms are likely to occur. The ERA concludes that, with the stated exception, current conditions at the Site do not result in significant ecological risk.

Overall RI and RA conclusions

The RI and RA evaluation strategy at the Site has been successful in efficiently collecting data of sufficient quantity and quality to satisfy the investigation Data Quality Objectives (DQOs) and AOC. The RI data were used to evaluate the nature and extent of contamination in sediment, surface water, groundwater, and soil; quantify human health and ecological risk; and identify environmental media and areas at the Site to be considered in the FS for potential remedial alternatives. The strategy applied at the Site was successful in characterizing previously known areas of contamination, and identifying additional areas where contaminant concentrations exceeded SLs.

In addition, evaluation of known and suspected sources, including RCRA SWMUs and Areas of Concern, and identification of additional areas where SLs were exceeded provided the basis for a human health and ecological risk assessment that met all AOC requirements. The RI and RA evaluation thus met both the CERCLA and RCRA objectives of the AOC.

The following is a summary of the RI and RA conclusions:

Surface water and sediment

- Surface water and sediment contamination in the main channel of Ship Creek is minimal and not a source of risk to human health or the environment
- Sediment in portions of three off-channel aquatic areas on the north side of Ship Creek contain contaminant concentrations that may result in significant ecological risk to benthic biota (SE-2, the storm water pond; SE-3 the Railyard Avenue Marsh; and SE-4, the Standard Steel ditch). One area additionally presents adverse risk to mammal and bird receptors (SE-3). In area SE-2 the presence of PAHs and to a lesser extent lead in deep portions of the pond is a potential risk to benthic biota. In area SE-4 the presence of PCBs in portions of the ditch also is an ecological risk to benthic biota. In area SE-3, PAHs, phthalates, PCBs, and several metals occur in the ditch and adjoining portion of the area occur at concentrations that may present a risk to aquatic life and benthic fauna, and to mammals and birds exposed to PCB containing sediment.

Groundwater

- Groundwater contamination was identified at nine discrete areas, seven associated with occurrences of CVOCs (TCE, PCE and/or vinyl chloride, 7 areas) and two associated with the occurrence of fuel hydrocarbons. Four of these occurrences reach Ship Creek, but at low concentrations not considered to pose a risk.
- Three of the nine groundwater areas delineated during the RI were previously identified; one was suspected and confirmed; and four were previously not suspected.
- Water well use surveys conducted as part of the RI confirmed that shallow groundwater in the areas identified with contamination was not being used; all water supply wells at the Site were tested and did not contain any contaminants exceeding drinking water standards; deep water supply wells are not impacted by Site-related contamination.
- The only scenario indicating unacceptable risk would be that of a construction worker contacting groundwater during trenching, but this risk is present at very few areas at the Site.
- Evaluation of volatiles in soil gas and groundwater via modeling of vapor intrusion shows no unacceptable risk at existing buildings except possibly LP-137.

- Although no future shallow groundwater use is envisioned for the Site, the groundwater is being considered potentially potable, and as a result contaminant concentrations exceeding MCLs will be considered in the FS.
- Localized contaminant concentrations in groundwater exceeding MCLs or RI SLs were found in various areas of the Site. These occurrences do not appear to represent sources of risk to human health or the environment.
- LNAPL was detected on the water table in monitoring wells only in two areas (GW-5 and GW-7) of the Site, both with historical information documenting likely past sources.

Soil

- Soil contamination at the Site that represents direct contact risk to human health from soil exposure is limited in extent and occurs as localized point exceedances on the Railyard and in some leased properties. No additional significant areas of soil contamination were identified at the Site during the RI.
- A few additional surface and subsurface soil contamination areas were identified based on potential for leaching to groundwater. Only localized areas of exceedances for some organic contaminants (e.g. TCE and benzene) were noted), generally associated with known groundwater plumes. In addition scattered exceedances of leaching screening levels were noted for arsenic. No major soil source areas for groundwater impacts were identified at the Site during the RI.
- Terrestrial ecological receptors were evaluated based on a weight-of-evidence approach due to the limited soil data set available. The dataset also included intermittently dry sediment areas. Quantitative dose estimates were evaluated for birds (robin and red-tailed hawk), and mammals (hare, shrew, and fox) of several trophic levels and data were compared to screening levels for terrestrial plants and invertebrates Potential quantitative ecological risk to terrestrial community and higher tropic order biota largely coincides with the areas of risk already observed for intermittently dry sediment exposure (SE-3 and SE-4) to aquatic biota, for PCBs, phthalates, and some metals. No elevated adverse ecological risk to riparian biota is likely in other, upland areas of the riparian corridor.

Terminals Area

- The Terminals area was evaluated separately, as the area is geologically and operationally distinct from the rest of the Site. In this area a perimeter approach concentrated on detecting and characterizing any migration of contaminants toward Cook Inlet. Potential migration was limited to an area along the LP019 Tesoro boundary to Cook Inlet. There is no evidence of Site-related contaminants in the off-shore sediment in Cook Inlet adjacent to this area.
- The three main leased properties in the Terminals area, Tesoro, Chevron and Flint Hills all have ongoing monitoring and interim response programs in place with ADEC. The risk assessment for Tesoro is included in this report, and indicates that the contaminants found in the perimeter area are associated with sources within the Tesoro leased property. The other two leased properties, Chevron and Flint Hills, have elected to do their own risk assessments. ARRC will submit those two risk assessments to U.S. EPA in an addendum to this RI/RA report when they have been completed.

Issues to be considered in feasibility study

The outcome of the RI and RA is identification of a subset of locations and contaminants in select media that require further evaluation in the FS to determine if they need to be addressed through remedial and corrective action.

The conclusions of the RI and RA yield the following key areas for evaluation and definition of RAOs in the FS. Additional locations and issues identified as potential issues in the RI and RA will also be discussed further in the FS.

1. Groundwater in separate, defined areas of the site includes concentrations of chemicals at levels above the MCL for some analytes. These include the following identified source areas described in Section 5 of the RI and detailed further in the RA.

   - **Groundwater area GW-1**, located on south side in eastern portion of Site – COC is TCE. The RI concluded the TCE at these locations may have an off-site source. The plume reaches Ship Creek.
   - **Groundwater area GW-2 /3** – located on south bank west of ML&P (LP022) – COC is vinyl chloride Source is off-site. The plume may reach Ship Creek.
   - **Groundwater area GW-4** – located on south bank in western portion of Site, plume flows in a northwesterly direction and reaches Ship Creek east of the ARRC administration building – COC is vinyl chloride. The RI concluded the vinyl chloride at these locations is from an off-site source. The plume may reach Ship Creek.
   - **Groundwater area GW-5** – COCs are hydrocarbons (benzene), and metals (arsenic, cadmium, and lead). This area contains NAPL. This area is confined, and does not appear to be moving. The source is associated with past activities at LP991 (the former Arctic Cooperage).
   - **Groundwater area GW-6** – COC is PCE and TCE. This plume appears to originate on the Railyard and flows south towards Ship Creek downstream of the Kapp Dam. The plume has an unusual flow pattern possibly associated with preferential pathways present in fill under the foundations of the overhead bridge.
   - **Groundwater area GW-7** –COCs are 1,1,2-trichloroethane, 1,2,-dibromo-3-chloropropane, arsenic, and benzene. This area on the Railyard contains NAPL, and appears to be non-motile and associated with the former fueling rack discontinued in the 1970's.
   - **Groundwater area GW-8** – COCs are vinyl chloride and TCE, with locally elevated arsenic. This plume is the result of spills at a paint facility on LP127. The plume does not appear to reach Ship Creek. This issue is currently under ADEC review.
   - **Groundwater area GW-9** – COCs are TCE and PCE. Plume is located at CBS Equipment (LP085) and is the result of a leaking waste oil tank removed in the 1990s. The plume does not appear to reach Ship Creek.
   - **Terminal Perimeter adjacent to LP019 (Tesoro)** – COCs are naphthalene, 1,2-dibromoethane, benzene, and ethylbenzene. This plume originates from sources within the Tesoro leased property (LP019) and reaches Cook Inlet.
   - **Other exceedances noted in the RI and RA not associated with specific groundwater or sediment areas and include**
     - PCBs at LP022B3 (ML&P); PCE at MWE02 (Railyard), and 1,1,2-trichloroethane at MWA07 (Railyard)
     - Lead at DPA03 and MWA05 along north bank of Ship Creek
     - Arsenic at 12 locations scattered in the Railyard and leased properties north and south of Ship Creek
     - Cadmium at MWA05, MWC07, MWC10, scattered locations on or near the Railyard
   - **Terminals leased properties.** Benzene, ethylbenzene and toluene were detected at multiple locations in exceedance of the MCL. The oil terminal leased properties are actively managing

environmental issues through ADEC monitoring and interim action programs. The FS portions dealing with these areas will be addressed independently of the main FS

- Additional exceedances of groundwater standards were noted in the North Bluff groundwater or seeps located along the north boundary of the Site with Elmendorf Air Force Base. These are noted in the RA, but will not be addressed in the FS as they are the results of upgradient sources and not Site activities.

2. Several discrete areas of sediment contamination were identified for further evaluation in the FS. These were identified as potential sources of risk in Section 5 and further discussed in the ERA and also evaluated in the HHRA. All sediment areas were located in off-channel aquatic areas.

   - **Sediment area SE-2**, the storm water pond located on the north bank of Ship Creek. PAHs and to a lesser extent lead in deeper areas of the pond exceed ecological protection levels. The source of the contamination is likely associated with a storm sewer operated by ARRC and the Municipality of Anchorage.

   - **Sediment area SE-3.** A small portion in the northeast corner of the Railyard Avenue marsh on the north bank in the eastern portion of the Site contains a ditch affected by PAHs, phthalates, PCBs and metals (lead and mercury) that represent ecological risk. Nearby low lying areas contain PCBs. The source of the PAHs and other organics may be associated with activities at nearby leases. The origin of the localized PCBs is not known. The lead and PAHs found in the ditch are also a potential human health risk.

   - **Sediment area SE-**4. The former drainage ditch from the Standard Steel CERCLA site contains PCBs that may be an ecological risk. The CERCLA site was listed for PCBs. The ditch was outside the area addressed under the Standard Steel CERCLA order.

3. No discrete and extensive sources of risk related to soil were identified in the RI/RA. However, the HHRA identified localized soil issues to consider in the FS as follows:

   - **PCBs** were noted at LP022 and LP127. LP127 (the Post Road Co tenancy) were addressed in a removal action in the 1990s, but residual PCBs were found. PCBs at LP022 (ML&P) are associated with several known sources at this location, most of which are located outside the Site boundaries.
   - ***Lead*** was noted in a pre-RI subsurface soil sample at LP065, the Princess Tours facility on the Railyard
   - ***Xylene*** has been reported in pre-RI data in subsurface soil at one location along the western perimeter of LP003 (Flint Hills).

An evaluation of soil leaching potential to groundwater was conducted and verified through SPLP (Synthetic Leaching Procedure) data collection, as reported in the Human Health Risk Assessment.

1.0 Introduction

The RI report has been developed under the Comprehensive Environmental Responsibility, Compensation, and Liability Act (CERCLA) and the Resource Conservation and Recovery Act (RCRA) Administrative Settlement Agreement and Order on Consent No. 10-2004-0065 (AOC) dated June 29, 2004 (U.S. EPA, 2004a) and associated Statement of Work (SOW) (U.S. EPA, 2004b) between the United States Environmental Protection Agency (U.S. EPA) Region 10 and ARRC. Under the AOC, ARRC agreed to conduct a joint CERCLA/RCRA Remedial Investigation/Feasibility Study (RI/FS) at the Site (Figure 1-1).

The RI reports on the implementation of the following documents:

- *Remedial Investigation and Feasibility Study Work Plan* (RI/FS WP), *Revision 1*, August 15, 2005 (ENSR Corporation (dba The RETEC Group, Inc. [RETEC], 2005a)
- *Remedial Investigation/Feasibility Study Work Plan Addendum* (WPA), June 16 *Revision 1*, July 28, 2006 (RETEC, 2006a)
- *Remedial Investigation Additional Scope of Work – January 2007 Memorandum* (January 2007 WP) (RETEC, 2007a)
- Response to EPA Comments Regarding Additional Scope of Work and Scope of Work for Final Proposed Field Activities Memorandum (March 2007 WP) (RETEC, 2007b).

These documents jointly describe the sampling and analysis conducted at the Site to satisfy the requirements of the AOC.

The Risk Assessment (RA), included as Appendix B (Human Health Risk Assessment [HHRA]) and Appendix C (Ecological Risk Assessment [ERA]), resulted from the implementation of the *Risk Assessment Scoping Memorandum (*RA Scoping Memo) (RETEC, 2006b).

The Alaska Railroad, which began operations in 1914, was owned by various departments of the federal government, including the former War Department, Department of Interior, and, most recently, the Department of Transportation. It is only since 1985 that the State of Alaska has owned the Alaska Railroad. The Site consists of approximately 600 acres of property in the lower Ship Creek valley. The Railyard and leased properties are depicted on Figure 1-2 along with the number of SWMUs and Areas of Concern at each leased property. The Railyard facility occupies approximately 313 of the 600 acres and includes a railroad track system, maintenance and repair buildings, shops, a refueling area, a tank car cleaning area, warehouses, and administrative offices. Note that, of the common railroad practices at the Site, railroad tie treating and its commonly associated practices and chemicals have not been conducted on the ARRC property. Approximately 287 of the 600 acres consist of parcels that are leased to a variety of Anchorage commercial and industrial businesses. The acreage associated with both the Railyard and the leased properties includes public streets and rights-of-way and undeveloped areas. Leasing of most of the 287 acres began during the federal ownership.

1.1 Objectives of the Administrative Settlement Agreement and Order on Consent

In accordance with the AOC and SOW the RI/FS includes:

1. Investigation of the nature and extent of contamination at the Site (the RI)
2. Assessment of the potential risk to human health and the environment caused by Site contamination (the RA, included in this RI)

3. Development of site-specific remedial action and corrective measures objectives (the Feasibility Study [FS], to be prepared and submitted subsequent to this RI)A key focus of the AOC is the protection of Ship Creek, as explicitly stated in Section 2 of the SOW (U.S. EPA, 2004b):

> *"The objectives of the work required under this AOC have been determined preliminarily, based on available information, to include the following: (1) Human health protection with respect to exposure to Site contaminants at or from the Site in soils, groundwater, surface water, and sediments, including exposures occurring from expected use of Ship Creek and its banks for recreation, occupational activities, and consumption of resident fish; (2) Protection of benthic invertebrates, resident fish, and wildlife receptors of such aquatic life that may be affected by potential water or sediment contamination in Ship Creek."*

In order to meet the requirements of the AOC, the RI/FS WP defined the purpose of the RI as follows:

- Assessment of contaminant transport, receptors, and pathways for protection of Ship Creek and its resources
- Protection of human health and ecological receptors
- Identification of relevant sources of chemicals present that may pose a risk

Section 4.4 of the SOW states: *"Respondent will identify source areas that are contributing to contamination at or from the Site that may cause human or ecological exposures above acceptable risk levels."* This concept is referred to in this document as "sources of risk." The overall strategy implemented for the RI, therefore, is focused on identifying such sources of risk, and not on concentrations below risk based screening levels or nondetect levels.

The following requirements will be addressed as part of the FS. However, data collected to address these issues are presented in the RI.

- Identify the need for and the range of potential remedial alternatives, and evaluate those that would meet both CERCLA remedial actions and RCRA corrective measures requirements
- Screen potential remedial actions
- Recommend preferred remedial alternative

This RI fulfills Section 4 ("Work to be Performed") of the SOW, attached to and referenced by the AOC. A summary of the activities completed in compliance with the SOW is presented in Table 1-1.

1.2 Preliminary Conceptual Site Models

The RI/FS WP presented preliminary Conceptual Site Models (CSMs) summarizing what was known or suspected about the Site, based on data evaluated for the *Site Background Report* (SBR) (RETEC, 2005b).

Figures 1-3a, 1-3b, and 1-3c show the preliminary CSMs for Site hydrogeology, human health exposure, and ecological exposures, respectively. These CSMs were used to develop the rationale for the RI and to define the necessary scope in order to meet the Data Quality Objectives (DQOs). The CSMs are iterative and have been refined in response to new Site data and comments from U.S. EPA. In the sections that follow, this report will present refined CSMs, based on the data acquired during implementation of the RI.

The hydrogeologic CSM (Figure 1-3a) shows the initial understanding of the interactions between geology, groundwater, surface water, and tides on fluid flow and migration pathways. The CSM illustrated the preliminary understanding of (and the need to develop further information regarding) (1) temporal and spatial shallow groundwater flow patterns, (2) the effects of tidal flux on groundwater flow and levels, (3) the thickness

of the saturated zone in the valley alluvium and hydrogeologic characteristics of the Bootlegger Cove formation underlying the alluvium, and (4) the relationship between the outwash aquifer on the North Bluff and the shallow alluvial groundwater.

The human health CSM (Figure 1-3b) summarizes the initial understanding of release mechanisms, contaminant transport pathways, and human exposure pathways and routes that were considered complete for the receptors likely to be affected at the Site. Current and likely future Site receptors are limited to industrial and commercial workers, except for the limited areas where residential exposure is a potential future pathway. In addition, recreational users of the Ship Creek Area and trespassers in other areas are considered. Exposure media included contact with groundwater in seeps and ditches, inhalation of dust and particulates, inhalation of volatiles in seeps, groundwater, or soil (including indoor air exposures in existing buildings), ingestion of groundwater in specific cases, and direct contact with soil and groundwater by construction and/or industrial workers at the Site. ARRC scoped the RI so that it would generate the data needed to evaluate these pathways.

The ecological CSM (Figure 1-3c) summarizes the initial understanding of potential ecological exposures at the Site, based in large part on the results of the *Ship Creek Preliminary Habitat Survey* (RETEC, 2005ca) conducted in October 2004. The key points of the ecological CSM were that ecological exposure pathways were not expected to be complete throughout the developed portions of the Site, or along the North Bluff, as exposures in those areas are upgradient of Site influence. Exposures were of potential concern in Ship Creek and the riparian zone adjacent to the creek and thus there was a need to identify representative receptors in those areas. The resulting data gaps were addressed in the subsequent RI data collection effort. The ecological CSM also took into account potential exposures in Cook Inlet, the ultimate receiving water for any discharges from the Site.

1.3 Approach for achieving investigation objectives

A fundamental objective for the RI was to develop a strategy to meet the goals of the AOC, while maintaining an expedited schedule and efficient use of resources. This rationale was developed early in the planning process. U.S. EPA and Alaska Department of Environmental Conservation (ADEC) were actively involved in the development of the RI approach and sampling scope requirements. ARRC met on numerous occasions with U.S. EPA and ADEC throughout the initial phases of the RI process, proposed investigation plans, and presented the basis for the plans. Agency suggestions and questions were taken into account and were reflected in the RI/FS WP, the WPA, and subsequent work plans. Site sampling work plans were submitted as drafts to U.S. EPA and were reviewed, discussed, and revised as agreed upon.

Several key concepts were agreed upon with U.S. EPA and ADEC to guide the RI/FS process. These include the following:

- Taking a site-wide approach to the Site investigation, addressing the entire 600-acre Site as a single entity, rather than a property-by-property evaluation.
- Focusing the RI/FS on the potential impact to Ship Creek from discharges from Site sources of risk. This was evaluated through systematic sampling of the media potentially affecting the creek.
- Using the extensive set of historical information and analytical chemical data to define focused, authoritative sampling in areas where potential Site impacts have been previously documented, and to direct other Site sampling based on the historical record of Site activities and events.
- Recognizing that the joint CERCLA/RCRA nature of the RI/FS would require addressing specific RCRA concerns related to solid waste management units (SWMUs), independent of the site-wide approach. Sampling locations were selected specifically to address RCRA SWMUs and Areas of Concern where possible.

- Adopting a perimeter approach to evaluating the Terminals Area in the northwest portion of the Site, due to the extensive data set available for this area, and the active involvement of petroleum company lessees and ADEC with respect to contaminants within the boundaries of those leased properties.
- Adopting a perimeter approach for the Railyard Area of the Site. The Railyard is an active area where site sampling is restricted through the presence of numerous railroad tracks and structures to support the railroad operations. EPA and ADEC agreed that a perimeter approach for sampling in this area was appropriate to ensure that impacts were not migrating off the Railyard into the leased properties and ultimately Ship Creek. Sampling within the Railyard boundaries was conducted as well with the above constraints accounted for in sample placement.

It is important to reiterate the site-wide evaluation strategy agreed upon and adopted for this RI. The Site summaries were utilized to guide sample collection in areas where, as described in the RI Work Plan, previous environmental impacts were documented or where historical site land use indicated an area of potential impact. Authoritative sampling was conducted only in such areas. Areas without information suggesting environmental concerns were not specifically targeted for sampling. Potential sources of risk originating in areas not selected for authoritative sampling were evaluated through sampling at downgradient systematic transect locations. These locations were established and sampled to determine whether unsuspected sources of risk existed upgradient from those transects.

Areas that were evaluated in a different manner are discussed in the subsections below.

1.3.1 Areas not specifically addressed in the RI/FS

The following areas were expressly excluded from evaluation in the RI/FS or were not included in the investigation design:

- **Standard Steel Former CERCLA site.** The Standard Steel site, a 6.2-acre former salvage site located in the eastern portion of the Site along Ship Creek, was previously on the National Priorities List (NPL) (Superfund Site ID 1000073) because of elevated polychlorinated biphenyls (PCBs) and lead in soil. Remediation and restrictive covenants have been implemented and this site was removed from the NPL in September 2002. Therefore, as agreed to with U.S. EPA the area occupied by the former Standard Steel facility was not investigated further. or included among the sample collection scope. However, a small area near Ship Creek, along a ditch that formerly drained the Standard Steel area and is outside the footprint of the former CERCLA site, was included in the RI in order to evaluate downgradient residual impacts.
- **Elmendorf Air Force Base (EAFB) Operable Unit 5 (OU5).** EAFB currently operates a recovery system for CVOCs along the North Bluff in the eastern portion of the Site as part of its CERCLA OU5. The recovery system includes groundwater and seepage recovery systems, treatment ponds, a discharge pipe to Ship Creek, and monitoring wells. The area where the system is installed is addressed by an agreement between ARRC and EAFB, for which EAFB is responsible. Therefore, no systematic evaluation of this area was conducted, except for monitoring samples from a few seeps along the bluff to evaluate any ongoing migration onto the remainder of the Site.
- **Government Hill and Other Leases.** A small part of the Site is located on Government Hill, north of the North Bluff. One lease, LP029, is a multi-family residential unit unaffected by potential environmental issues related to industrial activities at the Site and was, therefore, not included in the RCRA Facility Assessment (RFA) (U.S. EPA, 2002a) and not targeted for systematic investigation. Also, four other commercial leased properties along Loop Road in this area (LP097, LP081, LP047, and LP054) were not considered to be significant potential sources of risk and were, therefore, not targeted for investigation.

1.3.2 RI approaches for protection of Ship Creek

The strategy to meet the requirements of the AOC, as described in prior sections, was developed based on the following objectives. These influenced the sampling design described in the RI/FS WP and subsequent Site investigations.

1. Evaluate Ship Creek media (surface water and sediment) based on identifying likely depositional areas where current or past releases from the Site would be likely to accumulate. These included low energy depositional areas in Ship Creek and off-channel aquatic areas identified in the *Ship Creek Preliminary Habitat Survey* (RETEC, 2005c).
2. Evaluate sources of risk to Ship Creek by defining "transects" of sentinel groundwater wells parallel to Ship Creek (e.g., Transect A north of the creek and Transect B south of the creek). Figure 1-4 shows the general layout of the transects[1] . These sentinel wells were located based on a systematic approach, whereby wells were spaced roughly equidistantly along the transect, but exact locations were modified in some cases so a well could be placed downgradient of a likely or suspected source of risk. The detailed rationale was described in the RI/FS WP.
3. Differentiate between sources of risk on the Railyard and leased properties by defining Transect C along the boundary between the Railyard and the leased properties on the north side (Figure 1-4).
4. Evaluate contribution (if any) of suspected sources from off-site, upgradient sources by defining Transect D, including groundwater seeps and monitoring locations along the North Bluff (Figure 1-4).
5. Collect concurrent soil samples with selected groundwater well installation based on the pre-RI data or identified data gaps.

The RI/FS WP defined a decision matrix (or flow charts) for the evaluation of RI results (Figures 1-5a, 1-5b, and 1-5c). The WPA and subsequent work plans used the decision matrix to define step-out sampling necessary to define the nature and extent of sources of risk in accordance with the AOC. This RI report presents the final outcome of these evaluation steps, including:

- Initial groundwater sampling at locations described in the RI/FS WP that was conducted in 2005.
- Additional evaluation of sources of risk based on evaluation of 2005 data and described fully in the WPA (see Figure 1-5a for the decision process). Data collection was conducted in 2006.
- Additional step-out sampling to further delineate sources of risk as described in the January 2007 WP and the March 2007 WP that were implemented in the spring of 2007.

No boundary transect was defined along the south boundary of the Site (south of Ship Creek), as the property is fairly narrow on the south side. Groundwater impacts detected along a transect triggered step-out sampling, which either defined the nature and extent of those impacts as being confined within the Site or as extending to the Site boundary based on impacts from off-site sources. Sources of risk were not further evaluated beyond the Site boundary, consistent with the AOC, and only those portions of the contamination located within the Site are evaluated in the RI and FS.

The systematic emplacement of sampling locations and subsequent step-out sampling, in accordance with the decision matrix flowchart, allowed the identification and definition of the nature and extent of potential sources

[1] The exact layout and complete list of locations that were considered part of a transect differ slightly from the conceptual transect system shown on the figures. In some cases, subsequent sampling points were defined closer to Ship Creek and, therefore, the Ship Creek protection transects could be shifted while still fulfilling the needs of the decision matrix. More detail will be provided in subsequent sections.

of risk to Ship Creek, as well as locating the sources of risk within the leased properties, the Railyard, or off-site sources.

1.3.3 Authoritative groundwater, soil, and soil gas evaluation

The RI also included an authoritative (sample collection focused on suspected or potential sources of risk) sampling plan. This assured that, in addition to the systematic collection of data to define impacts to Ship Creek, there was also a sampling plan for defining any potential impacts from known or suspected sources based on historical records review or visual inspection, as described further in the following sections.

1.3.3.1 Soil and groundwater

Historical data from the Site indicated the potential existence of various sources of risk at the Railyard or the leased properties. Identification of such potential sources was based on review of prior environmental sampling and monitoring reports, previously identified SWMUs or Areas of Concern, or visual inspections of leased properties where inadequate data existed. At areas where sources of risk might be present, authoritative soil and/or groundwater sampling was conducted. Locations where such sampling was conducted were initially identified with the prefix "E" in the location name (e.g., MWE01), although later phases of the investigation for step-out sampling did not strictly adhere to this convention.

Figures 1-5b and 1-5c present the process approved by U.S. EPA for RI data evaluation of soil in terms of human health protection and potential for leaching to groundwater[2]. Surface soil and subsurface soil were considered similarly, although only subsurface soil was considered for purposes of leaching to groundwater, in accordance with the following general process:

- Was the analyte present above the project-agreed reporting limit (RL)? If not, the analyte was of no further concern and no data gap exists.
- Was the analyte detected above the project-agreed SL? If not, the analyte was of no further interest and no data gap exists.
- For subsurface soil data evaluated for leaching potential to groundwater, if an analyte was present above the designated SL, then underlying groundwater was evaluated to determine if co-occurring compounds exceeding SLs were present in groundwater. For all soils exceeding SLs, the evaluation of whether a source of risk was present was based on evaluating additional data available for the location, including:
  - Historical soil data, indicating if the detections are from part of a known source area
  - Land use and soil cover, indicating if potential receptors may be exposed to analytes exceeding SLs and, thus, represent a source of risk

The "weight-of-evidence" evaluation using the factors described above was applied to determine if data were adequate to describe the nature and extent of the source of risk and to complete the risk assessment.

1.3.3.2 Soil gas and indoor air

To address potential concerns for subsurface sources of risk (soil or groundwater) to enclosed spaces (i.e., current on-site commercial or industrial buildings), soil and groundwater data were evaluated in the RI. The initial sample event for groundwater data, together with the location of buildings on the Railyard and leased

[2] In addition to the evaluation described here, soils located in the riparian zone adjacent to Ship Creek were also considered in terms of potential ecological exposures.

properties, was used to define appropriate locations for site-specific soil gas sampling associated with occupied buildings, following current U.S. EPA guidance on vapor intrusion evaluations (U.S. EPA, 2002b). This Tier 1 data set, reported in this RI, was evaluated in Tier 2 risk screening, fate and transport modeling and risk evaluation, as included in Section 7.0 and in the HHRA (Appendix B)[3].

1.3.4 Terminals Area

The northwestern portion of the Site, adjacent to Cook Inlet and the Port of Anchorage (POA), is a shoreline area primarily consisting of fill. The area is physically and hydrogeologically distinct from the rest of the Site, which occupies alluvial flats along Ship Creek (Figure 1-1). The area is primarily occupied by storage facilities for petroleum products and would, therefore, be expected to have a different nature and extent of contamination than areas of historical railroad use. These leased properties include Chevron (LP025/LP027), Flint Hills (LP003, LP004, and LP005), and Tesoro (LP019)[4] (Figure 1-2). Extensive data sets and ongoing monitoring mandated by ADEC exist for these leases and, per agreement with U.S. EPA, these data sets were included in this RI to evaluate those portions of the Site. As agreed to with U.S. EPA, the RI includes the sampling and monitoring data from these areas that ADEC or the lessees have made available to ARRC. The RI also evaluates potential migration from these areas to adjacent portions of the Site, to Ship Creek, or to Cook Inlet. For these reasons, the RI addresses this area, hereafter referred to as the "Terminals," separately from the remainder of the Site.

The RI evaluation of the Terminals is based primarily on the conditions at the perimeter of the Terminals leased properties, to determine the potential for migration of contaminants originating within these leased properties with respect to the SWMUs they contain, and to reflect the monitoring and other data ARRC has received from the Terminals lessees and ADEC. The perimeter evaluation includes:

- Sediment data from Cook Inlet, surface water data from the storm water system draining the northern part of the Terminals, and groundwater data from monitoring wells between the industrial areas and Cook Inlet to define potential sources of risk to Cook Inlet.
- Soil data from areas outside the Terminals leased properties, e.g., public roadways and other property managed directly by ARRC. The evaluation of soil impacts in these areas was directed toward determining if migration has occurred from sources of risk within the Terminals leases to areas outside those properties.

The Terminals leased properties are currently under ADEC environmental supervision and are subject to semi-annual or annual monitoring requirements, as well as other State-led environmental programs. This RI has incorporated the available data into the Site database and into the existing information in tables and figures. Ongoing ADEC environmental programs are intended to address concerns within the individual leased properties in the Terminals Area.

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[3] A vapor intrusion evaluation was conducted on an expedited basis at one area, LP072, where elevated trichloroethylene concentrations were reported in groundwater, as well as in soil gas. This evaluation, results of which were presented at a May 15, 2007 meeting with U.S. EPA, was intended to determine if an immediate hazard to occupants existed. It was determined that no immediate hazard was present. This evaluation is, therefore, presented as part of the overall vapor intrusion evaluation in this document.

[4] Municipal Light and Power (ML&P), LP022, is also under active ADEC oversight. ML&P is located along Ship Creek (Figure 1-4), and part of the facility is located on ARRC property (highlighted on map). Data collected at ML&P under ADEC responsibility were included in the RI evaluation, particularly as it related to potential migration to Ship Creek.

Note that the "perimeter" area has been defined to include most of the leases in the southern portion of the Terminals, i.e., LP060, LP101, LP068, and LP084, which are storage and harbor facilities that were deemed unlikely to contain sources of risk (based on historical uses and data), as noted in the RFA (U.S. EPA, 2002a) and reported in the SBR (RETEC, 2005b) and RI/FS WP (RETEC, 2005a) (Figure 1-2). However, these leased properties have monitoring wells designed to evaluate potential for migration from or to other areas.

1.3.5 Sources of Site information

Prior to the AOC, there were a large number of environmental investigations, monitoring events, and interim responses across the Site. These studies provided invaluable data for purposes of focusing the RI/FS and interpreting the results from the RI data collection. Figure 1-4 gives an overview of the distribution of all data collection at the Site, pre-RI as well as during the RI.

"Pre-RI data" includes all environmental data collected by interested parties prior to September 13, 2004, the date when the AOC studies commenced. These data were summarized and evaluated in the SBR. All Site environmental data collected after that date are considered to be part of the "RI data set," even though these data may include investigations and monitoring events conducted by lessees or other entities under state environmental programs or other Federal programs.

Pre-RI data have been used in the RI/FS for three distinct purposes:

a. To define and guide the location and scope of RI sampling, as described in the RI/FS WP (RETEC, 2005a). Evaluation of the prior data allowed the definition of sampling needs, including authoritative sampling at locations of known or suspected contamination, to define the nature and extent of contamination. This process was described in detail in the RI/FS WP.

b. To interpret the results of the RI data collection in terms of evaluating the nature and extent of sources of risk to human health and the environment. In this process, as defined in the data interpretation flowcharts (Section 1.3.2) historical data were considered when determining if a RI sample may represent or point to a source of risk.

c. To provide information regarding when sources of risk originated.

It should be noted that the pre-RI data set is of varying quality and scope, depending on the purpose of the original data collection. In addition, older data may be of less utility for media like surface water and groundwater, where temporal change may be swift and concentration and extent vary over time. However, pre-RI data were utilized to guide sample collection in areas where, as described in the RI Work Plan, previous environmental impacts were documented or where historical site land use indicated an area of potential impact. Authoritative sampling was conducted in such areas. Areas without information suggesting environmental concerns were not specifically targeted for sampling. Potential sources of risk originating in areas not selected for authoritative sampling were evaluated through sampling at downgradient systematic transect locations. These locations were established and sampled to determine whether unsuspected sources of risk existed upgradient from those transects.

For this reason, pre-RI data are not directly considered in the risk assessment for groundwater and surface water, as the data set collected for the RI incorporated areas of previously identified impacts. Spatial and seasonal coverage is adequate using the RI data set, as this data encompasses all areas identified with any potential environmental impacts (authoritatively placed wells) as well as areas that had not previously been sampled (systematic sampling). However, contaminant persistence in soil and sediment indicated that pre-RI data should be considered fully in the risk assessment.

The "current RI" data include all data collected in the various phases of the RI investigation, in addition to data collected by lessees under ADEC oversight. In addition, the current RI data include Cook Inlet monitoring results generated by the United States Army Corps of Engineers (USACOE) as part of evaluations associated

with the Port of Anchorage Expansion Project that are pertinent to the evaluation of contaminants that may have migrated from the Terminals.

1.3.6 Leased property review for remedial investigation

The SBR included a summary of all leased properties that were designated by U.S. EPA in the RFA as "site requiring further action" (Figure 1-2). The leased property site summaries include the following information:

- Site designation
- ARRC contract number
- Site name
- Address
- Site overview
- RFA SWMUs or Areas of Concern as identified by U.S. EPA and description
- ARRC comments regarding RFA description
- Documented releases
- Summary of analytical data results
- Investigation and/or cleanup action conducted
- Agency lead and closure status
- Leased property history and Site use

1.3.7 RCRA SWMU/Area of Concern review for remedial investigation

Based on the overall strategy to meet CERCLA requirements for a site-wide approach, individual RCRA SWMUs or Areas of Concern were not specifically targeted for sampling in the RI. However, samples were placed in the leased area where historical; data indicated a potential concern. RCRA SWMUs and Areas of Concern were identified as part of the RFA (U.S. EPA, 2002a). To address RCRA-specific concerns related to SWMUs and Areas of Concern, pre-RI data associated with such units were evaluated in the RI/FS WP to guide authoritative and systematic sampling. Specific sample locations that address SWMUs and Areas of Concern are noted in Section 6 Tables.

Additional review was conducted through lease-specific surveys to determine current conditions and the current status of all SWMUs and Areas of Concern. The results of these surveys are reported in the RI to address SWMU and Area of Concern specific reporting and evaluation needs.

1.4 Current and likely future land use

Current land use at the Site is dedicated to transportation uses in the active Railyard areas. Most of the rest of the Site, except for a small area on Government Hill that is residential, is used for commercial and industrial purposes. As the property owner, ARRC has full control over land uses within the Site and will continue operating the Site under the current land uses. Municipality of Anchorage (MOA) zoning for the Site is consistent with the current uses. The RI and RA are based on the expectation that the current transportation, commercial, and industrial uses at the Site will continue for the foreseeable future.

The southwestern portion of the Site south of Ship Creek, currently occupied by commercial establishments and railroad facilities, is zoned by the MOA as Planned Community (PC), a designation that can allow future residential development. This area is, and will remain, the only portion of the Site where limited residential development may occur in the foreseeable future. Preliminary proposals for such development exist. This use

is considered in the risk assessment for this area. However, as the owner of the land in question, ARRC will ultimately determine its future land use, including whether any residential development will be allowed.

1.5 Prior documents, studies, and interim reports

Two separate RFA reports conducted by the U.S. EPA (SAIC, 1996; Booz-Allen Hamilton, 2002) preceded the AOC. The SBR discussed the RCRA SWMUs and Areas of Concern identified in these reports and also presented information from past Site environmental investigations. These data (through September 13, 2004) were summarized in the SBR and were used to define RI data needs and the RI scope outlined in the RI/FS WP. The past environmental investigations included:

- Monitoring reports and investigations generated under ADEC direction or oversight or by ADEC itself. Data from active ADEC monitoring programs for some leased properties (Tesoro Petroleum, Chevron, Flint Hills, and ML&P) have been continually updated and are included as part of the RI data set.
- Environmental Site assessments conducted as part of property or lease transfers
- Brownfield investigations, such as that conducted at the Knik Arm Power Plant (KAPP) property
- Investigation reports regarding the Standard Steel facility, which formerly was a CERCLA site
- Other environmental investigations commissioned by ARRC, including UST removals and Phase I and II site assessments
- Environmental evaluations by city, state, or federal agencies, including those done to develop total maximum daily loads (TMDLs) to address non-attainment of fecal coliform standards in Ship Creek

Interim actions conducted as part of the AOC included:

- *Ship Creek Preliminary Habitat Survey* ("Habitat Survey"), December 3, 2004, revised July 1, 2005 (RETEC, 2005c)
- *North Boundary Assessment Groundwater and Soil Results* (North Boundary Survey), December 3, 2004 (RETEC, 2004a)
- Groundwater Use Survey, 2006

To allow a complete data evaluation, this RI also presents data from other recent environmental investigations conducted at and near the Site; in particular, the following:

- Annual or semi-annual groundwater monitoring programs conducted by Tesoro, Chevron, Flint Hills, and ML&P under ADEC oversight
- Physical, biological, and chemical data collected in Cook Inlet in support of the planned expansion of the POA. These data include the *Marine Terminal Redevelopment Environmental Assessment* (Port of Anchorage, 2005), the *Draft 2004 Marine Fish and Benthos Studies* (Pentec, 2005), and the *Draft Chemical Data Report, Anchorage Harbor Rapid Optical Screening Technique* (ROST) *Study* (USACOE, 2006).
- Tesoro 2006 investigation – Port of Anchorage Terminal No. 1 Pipeline C 2006 Response Action Report (Oasis, 2006)
- EAFB groundwater annual monitoring program data related to the OU5 northeast of the Site
- Maps provided by the Watershed Program of the Municipality on the existing storm sewer system (MOA, 2003)

1.6 Report organization

This document is organized as follows:

Section 1.0 Introduction. This section presents the objectives and strategy for the RI/FS, to meet the requirements of the joint CERCLA/RCRA AOC, it defines the overall scope of the RI and reviews the CSM that informed the design of the RI.

Section 2.0 Scope of remedial investigation. This section describes the scope, extent, and completion of field studies and other data collection tasks conducted as part of the RI, in accordance with the RI/FS WP. The appendices to this report present appropriate documentation regarding the field tasks. In addition, Section 2.1 demonstrates that the DQOs defined for the RI, as outlined in the RI/FS WP, have been achieved.

Section 3.0 Site physical characteristics. This section presents the evaluation of studies into the physical, hydrologic, hydrogeologic, and demographic conditions at the Site. A refined CSM is presented summarizing the current understanding of the Site.

Section 4.0 Nature and extent of contamination. This section presents the nature and extent of contamination from chemicals evaluated by the RI, including data from other reports and sources that complement the RI data collection. This evaluation has been done by comparing the data against the SLs designated in the RI/FS WP and refined through subsequent ARRC responses to U.S. EPA and ADEC comments. The section presents a summary of the nature and extent of areas of potential remedial concern.

Section 5.0 Source and migration investigation. This section presents the evaluation to identify potential sources of risk to human health and the environment. This evaluation considers the outcome of the data evaluation flowcharts defined in the RI/FS WP to evaluate sources of risk to human health and the environment. The section also evaluates the areas of potential remedial concern in terms of the flowcharts and in relation to additional lines of evidence, including historical data to determine if they are sources of risk to human health or the environment.

Section 6.0 Evaluation of RCRA SWMUs and Areas of Concern. This section presents an evaluation of RCRA SWMUs and Areas of Concern identified by U.S. EPA at the Site during the RFA. This section also provides information regarding the current status of these areas as of the completion date of this RI report.

Section 7.0 Summary of Human Health and Ecological Risk Assessments. The human health and ecological risk assessments are included as Appendix B and C, respectively. Section 7 provides a summary of these reports.

Section 8.0 References.

2.0 Scope of remedial investigation

This section describes the scope of work completed to fulfill the RI requirement of the AOC. All RI data were collected in accordance with the RI/FS WP (RETEC, 2005a), WPA (RETEC, 2006a), January 2007 WP (RETEC, 2007a), and the March 2007 WP) (RETEC, 2007b). Appendix A includes all site field activity forms. Variances to proposed scopes of work are discussed relative to specific data collection activities. Table 2-1 includes a summary of the field activities. To ensure that the data collected during the RI were of adequate quality and quantity, media-specific DQOs were developed in accordance with *U.S. EPA Guidance on Systematic Planning using the Data Quality Objective Process* (U.S. EPA, 2006) as part of the RI/FS WP. In order to evaluate analytical results and determine if additional samples were required, a data evaluation process was developed with specific criteria for each environmental medium. The data evaluation process was defined in Section 1.3.2 through use of detailed flowcharts. The flowcharts are shown as Figures 1-5a, 1-5b, and 1-5c. The objective of data evaluation was to determine (1) if data were adequate to meet the DQOs, complete the risk assessment, and delineate sources of risk; or (2) if additional data collection was necessary to meet these objectives.

2.1 Data adequacy review

In accordance with the *Advance Notice of Proposed Rulemaking* (ANPR) (U.S. EPA, 1996a), data-gathering strategies should be tailored to reflect site-specific DQOs. The DQO process is a seven-step, iterative planning approach used to guide environmental data collection. DQOs were developed for the RI to define the decision to which the data would contribute and specify the overall degree of data quality or uncertainty that the decision maker is willing to accept during the decision making process. DQOs are intended to provide "…a systematic approach for defining criteria that a data collection design should satisfy, including: when, where, and how to collect samples or measurements…" (U.S. EPA, 2006).

The seven steps in the DQO process are as follows:

1. State the Problem
2. Identify the Decision
3. Identify Inputs to the Decision
4. Define Boundaries for the Study
5. Develop Decision Rules
6. Specify Tolerable Limits of Decision Error
7. Optimize the Design for Obtaining Data

The *Guidance for the Data Quality Objectives Process* (U.S. EPA, 2006) was used to develop RI/FS WP DQOs for surface water and sediment, groundwater and LNAPL, and soil investigations. The respective RI/FS DQOs are presented in Tables 2-2a through 2-2c.

In addition to the DQOs, a process for evaluating analytical results was developed for each environmental medium to determine if additional samples were needed to complete the RI, RA, or FS. The process for each medium was illustrated in a series of flow charts in the RI/FS WP (RETEC, 2005a). Each analytical result was evaluated by comparing analyte concentrations to RI SLs and determining if adequate data (e.g., current or pre-RI analytical data or land use information) were available to delineate sources of risk and evaluate remedial alternatives. If sufficient data were available, then additional sampling was not required. If sufficient data were not available, step-out sampling from the original sampling point was completed. The evaluation flow charts used for determining additional RI sampling are presented on Figures 1-5a, 1-5b, and 1-5c.

2.1.1 Ship Creek media data quality objectives

The following section describes the data for Ship Creek media (i.e., surface water and sediment) relative to the decision rules for the Surface Water and Sediment DQOs (Table 2-2a) and data evaluation process flow chart (Figure 1-5a). Each DQO decision rule is discussed below:

1. Are analytical data adequate to develop a list of COIs for Site characterization? YES.

Twenty-seven surface water and 66 sediment samples were collected from the full reach of Ship Creek across the Site. This included samples from both the main channel of Ship Creek and adjacent off-channel areas. All samples were collected in accordance with the RI/FS WP (RETEC, 2005a) unless otherwise specified below. Sample collection completion was greater than 90 percent (%), as specified in the Quality Assurance Project Plan (QAPP) (RETEC, 2005d). Each surface water or sediment sample was analyzed for the project analyte list, which included the current hazardous substances list of target analytes for Superfund Sites (RETEC, 2005 a). The project analyte list also included all known or potential analytes found at the Site, based on previous sampling and/or operational history. The project analyte list is shown in Table 2-3. Each sediment or surface water sample was evaluated using the criteria provided on Figure 1-5a. If the project criteria were not satisfied, additional sampling was proposed. Additional sampling recommendations were documented in the WPA, the January 2007 WP, and the March 2007 WP. All WP-proposed and U.S. EPA-recommended samples, except as noted in comments of Table 2-1, were collected and, as a result, the database is considered adequate for developing a list of COI. All surface water and sediment locations are shown on Figure 1-4. Analysis of COIs will be completed in the HHRA and ERA (Appendices B and C, respectively).

2. Are the data adequate to evaluate the nature and extent of the COI that exceed relevant SLs in riparian zone wetlands and ponds? YES.

Each surface water or sediment result was compared to RI SLs (Table 2-3), in accordance with the project evaluation flow charts (Figure 1-5a). Analytes exceeding relevant RI SLs were assumed to be potential COIs. Non-detect analytes were assumed not to be COI if the method detection limits were below the SL concentrations. If RI SL concentrations were exceeded, then additional sampling was proposed in the WPA and/or the January 2007 WP and the March 2007 WP. Results from each were compared to RI SLs until sufficient data were available to determine nature and extent of all analytes exceeding RI SL concentrations. All WP-proposed and U.S. EPA-recommended samples, except as noted in comments of Table 2-1, were collected and, as a result, the database is considered adequate for determining nature and extent of COIs in surface water and sediment.

3. Are the data adequate to evaluate COIs that exceed relevant screening in surface water and sediment accumulations and surface water in Ship Creek adjacent to and downstream of the Site? YES.

Surface water data were collected from off-channel aquatic areas to represent worst-case conditions near the creek. These data are adequate to evaluate the Ship Creek Area and Cook Inlet, located downstream of the Site. As explained in Section 3.1.6, the high current and tides in the inlet result in rapid dispersion of any contaminants, so data collection was not attempted. Sediment data were collected in (a) all off-channel areas along Ship Creek and (b) significant sediment accumulation (depositional) areas in Ship Creek (Figure 1-4). Site-related sediment contamination would be expected to accumulate in such areas and, therefore, point-by-point risk estimates can be derived, representing worst-case exposure.

4. If COIs exceed relevant SLs in surface water or sediment, are the data adequate to identify potential upgradient sources? YES.

Each surface water or sediment sample concentration that exceeded the SL was compared with groundwater and soil results from Transects A and B (Figure 1-4) to evaluate whether that analyte was entering Ship Creek media via groundwater transport. If an analyte exceeded SLs and was not present in Transect A or B, then

other sources, such as upgradient outfalls, areas of surface water runoff, or off-site sources, were evaluated. Samples were collected until enough data were available to determine potential source areas. All WP-proposed and U.S. EPA-recommended samples, except as noted in comments of Table 2-1, were collected and, as a result, the database is considered adequate for determining potential sources of COIs in surface water and sediment.

5. If COIs exceed relevant SLs in surface water or sediment, are the data sufficient to complete human health and ecological risk? YES.

Three sample events of surface water and sediment sampling were conducted in accordance with RI data evaluation criteria (Figure 1-5a). Data from each sample event were evaluated relative to the RA Scoping Memo criteria until sufficient data were available to meet risk assessment needs. All WP-proposed and U.S. EPA-recommended samples, except as noted in comments of Table 2-1, were collected and, as a result, the database is considered adequate for risk assessment.

6. If an unacceptable human health or ecological risk is identified, are the data adequate to evaluate potential remedial action alternatives? YES.

As part of the RI, data were collected to evaluate the lateral and vertical extent of sediment accumulation in areas where sediment contaminant pose an unacceptable risk. These data will be evaluated in the FS.

2.1.2 Groundwater data quality objectives

The following section describes the data for groundwater relative to the RI groundwater DQO decision rules (Table 2-2b) and data evaluation process flow chart (Figure 1-5b). Each groundwater DQO decision rule is discussed below.

1. Are the analytical data adequate to develop a list of COIs? YES.

Greater than 300 groundwater samples were collected across the Site as part of the RI. Sample collection completion was greater than 90%, as specified in the QAPP. Samples were collected in accordance with the RI/FS WP, unless otherwise noted below. Each groundwater sample was analyzed for the project analyte list, which included the current hazardous substances list of target analytes for Superfund Sites (RETEC, 2005a). The project analyte list included all known or potential analytes found at the Site based on previous sampling and/or operational history. The project analyte list is provided in Table 2-3. Each groundwater sample was evaluated using the criteria provided on Figure 1-5b. If the project criteria were not satisfied, additional sampling was proposed. Additional sampling recommendations were documented in the WPA, the January 2007 WP, and the March 2007 WP. All WP-proposed and U.S. EPA-recommended samples, except as noted in comments of Table 2-1, were collected and, as a result, the database is considered adequate for developing a list of COIs. COI analysis was conducted in the HHRA and ERA (Appendices B and C, respectively).

2. Are the nature and extent of dissolved phase COIs at the Site that could migrate to Ship Creek or other receptors adequately delineated? YES.

Groundwater samples were collected along four east-west trending transects (A through D) (Figure 1-4), along the perimeter of the Terminals Area, and at additional locations between the transects based on Site history. Transects A and B were oriented roughly parallel to the north and south banks of Ship Creek, respectively. Transects C and D were located respectively along the south and north boundary of the ARRC Railyard. Transect sample locations were selected to evaluate potential migration of contaminants to Ship Creek from the north and south, as well as to determine migration onto and off of the ARRC Railyard. The Terminals Area groundwater sampling locations were situated so that they would detect and allow evaluation of any contaminant migration to Cook Inlet. The rationale for the sampling locations is presented more fully in Section 1.3.

Each groundwater sample result was compared to RI SLs (Table 2-3), in accordance with the project evaluation flow charts (Figure 1-5b). Analytes exceeding relevant RI SLs were assumed to be potential COIs. If RI screening level concentrations were exceeded, then additional step-out sampling was proposed in the WPA, and/or the January 2007 WP and the March 2007 WP. Results from each step-out sampling event were compared to RI SLs until sufficient data were available to determine the nature and extent of all analytes exceeding RI SL concentrations, or until the ARRC property boundary was reached. No sampling was conducted outside ARRC property boundaries. All COI plumes were delineated to the fullest extent possible.

3. Are background concentrations and the relative contribution of upgradient sources to dissolved phase COIs beneath the Site adequately characterized? YES.

Thirty nine (23 in initial RI sampling with 16 additional locations to further characterize background) groundwater and seep samples were collected to evaluate background conditions. Background sample locations are discussed further in Section 2.6.5. However, the background groundwater data showed large variations among sampling events and between nearby wells. As a result, temporal and spatial variances in "background" groundwater concentrations complicate the groundwater background evaluation. Therefore, it is not possible to get one set of background data for the whole Site, as groundwater is clearly influenced by a complex mix of inputs and hydrogeologic factors. Although the data collected during the RI do not support a simple background calculation, other methods have been applied to evaluate background conditions across the Site. Groundwater background is discussed in detail in Section 4.1.3.

4. Are hydrogeologic data adequate to develop CSMs? YES.

Approximately 80 soil borings were completed and soil cores logged to evaluate material type and hydrogeologic conditions. Eight cores were analyzed in the laboratory for porosity, permeability, bulk density, and grain size to further characterize the physical conditions of the aquifer. Three site-wide fluid level gauging events were completed during the RI to evaluate groundwater flow. Two wells along Ship Creek were monitored continuously, using transducers, from March 2006 to October 2006, to evaluate seasonal groundwater fluctuation. Ten slug tests were completed across the Site to estimate hydraulic conductivity. Finally, a tidal study was completed to evaluate the influence of daily tides on groundwater flow and contaminant distribution. All these data were collected in accordance with the RI/FS WP and WPA, or upon the recommendation of U.S. EPA. Based on these results, sufficient data are available to develop a hydrogeologic CSM.

5. If completed exposure pathways (including vapor intrusion) to Ship Creek or other receptors are identified for groundwater with dissolved phase COIs, can the human health and ecological risk be calculated based on the existing data set? YES.

Ecological and human health risk in Ship Creek was evaluated using (a) concentrations in Ship Creek media potentially affected by migration from on-site sources of risk, and (b) bank groundwater (Transects A and B) compared against surface water criteria to define potential exposures. The number of locations included in these transects allowed evaluation of potential risk to Ship Creek. The data were adequate to determine risk from this pathway. In locations where groundwater concentrations indicated the potential for human exposure via vapor intrusion within 100 feet of buildings, soil gas was sampled to evaluate risk based on actual measurements of contaminants in that medium. The data were adequate to determine risk from this pathway.

6. Is the distribution of LNAPL that may be a source to dissolved phase COIs sufficiently delineated? YES.

Three site-wide fluid gauging events were completed using an oil/water interface probe, in accordance with the RI/FS WP (RETEC, 2005a). All RI wells were gauged. Two wells were found to contain LNAPL. The LNAPL

thickness was measured at each well. Based on these data, the extent of LNAPL is known and can be assessed as potential sources of COIs.

7. If groundwater or LNAPL present an unacceptable human health or ecological risk, are the groundwater and LNAPL data adequate to evaluate potential remedial action alternatives? YES.

Groundwater analytical data collected through several sample events have been used to delineate the distribution of contaminants at the Site. Additionally, MNA data were collected from each potential COI plume (Figure 2-1). These analytical data, along with groundwater flow measurements and aquifer physical properties data, will be evaluated in the FS.

2.1.3 Soil data quality objectives

The following section describes the data for soil relative to the RI soil DQO decision rules (Table 2-2c) and data evaluation process flow chart (Figure 1-5c). Each soil DQO decision rule is discussed below.

1. Are the analytical data adequate to develop a list of COIs? YES.

Approximately 180 soil samples were collected across the Site as part of the RI. Samples were collected in accordance with the RI/FS WP. Each soil sample was analyzed for the project analyte list, which included the current hazardous substances list of target analytes for Superfund Sites (RETEC, 2005a). The project analyte list also included all known or potential analytes found at the Site, based on previous sampling and/or operational history. Each soil sample was evaluated using the criteria provided on Figure 1-5c. If the project criteria were not satisfied, additional sampling was proposed. Additional sampling recommendations were documented in the WPA, the January 2007 WP, and the March 2007 WP. All proposed and U.S. EPA-recommended samples were collected and, as a result, the database is considered adequate for developing a list of COIs. COI analysis was conducted in the HHRA and ERA (Appendices B and C, respectively).

2. Is the nature and extent of COIs sufficiently delineated at known or suspected sources? YES.

Soil samples were collected from monitoring well boreholes across the Site. Soil samples were collected from a minimum of two depths at each location. One sample was always collected from the interval 0 to 0.5 feet below ground surface (bgs) and one from the interval with the highest total VOC concentration as measured in headspace vapors. Additional sample collection was at the discretion of the on-site geologist, based on visual or olfactory observations. In all cases, attempts were made to sample the soil showing the greatest potential contamination. Sample results that exceeded RI SLs were evaluated using the project criteria flow chart (Figure 1-5c) to determine the need for additional sampling. Any analyte that exceeded its RI SL concentration was considered a COI for the RI and was delineated. All proposed and U.S. EPA-recommended soil samples were collected and, as a result, the database is considered adequate for delineating the nature and extent of COIs.

3. Are soil data adequate to develop a CSM? YES.

Approximately 80 soil borings were completed and soil cores logged to evaluate material type and hydrogeologic conditions. Eight cores were analyzed for soil properties, which included porosity, permeability, bulk density, and grain size. Additionally, eleven soil vapor monitoring wells were installed and sampled at three depths each, in order to evaluate a potential soil vapor pathway. Based on these results, sufficient data are available to develop a CSM.

4. Are the data sufficient to evaluate human health and ecological risk? YES.

Soil samples were collected in areas where suspected sources of risk were located. Point-by-point risk evaluation of these locations provides "worst-case" risk estimates for potential receptors. In combination with pre-RI data and other pertinent information, the data are sufficient to evaluate risk.

Ecological risk from soil exposures was evaluated for the riparian zone, based on a weight-of-evidence approach incorporating risk estimates from riparian soil data and other information. These data were adequate to estimate riparian risk when combined with sediment data collected in areas that are subject to seasonal or intermittent terrestrial conditions.

5. If an unacceptable human health and ecological risk is identified, are the data adequate to evaluate remedial action alternatives? YES.

Based on the pre-RI data, and the results of the soil sampling completed during the RI, sufficient data are available to evaluate remedial action alternatives following risk assessment, in the FS.

2.2 Data validation summary

To support the site-specific DQOs, all current RI laboratory data for samples collected by RETEC from September 2004 to present were validated according to the directives specified in the *Quality Assurance Project Plan* (QAPP) (RETEC, 2005d). The data validation process ensured technical data quality and method compliance, provided precision, accuracy, and completeness assessments, verified that adequate analytical documentation was performed and reported, determined whether the analytical data were usable, and helped the data user to determine whether project DQOs were met.

The analytical data were reviewed in accordance with directives set forth in the *Quality Assurance Project Plan* (QAPP), *Alaska Railroad Corporation, Anchorage Terminal Reserve, USEPA Docket No. CERCLA 10-2004-0065, June 2005 (revised April 4, 2006),* authored by RETEC and approved by EPA on July 7, 2005 (RETEC, 2005d). Data were also evaluated based on validation criteria set forth in the *USEPA Contract Laboratory Program* (CLP) *National Functional Guidelines for Organic/Inorganic Data Review*, (Organic) (U.S., 1999b) and (Inorganic) (U.S. EPA, 2004c), and the *USEPA CLP National Functional Guidelines for Superfund Organic Methods Data Review*, (US EPA, 2005 (Draft), as they applied to the reported methodology and specified QAPP requirements. Washington State Department of Ecology (WDOE) methods were reviewed as per *WDOE Analytical Methods for Petroleum Hydrocarbons* (WDOE, 1997). Field duplicate control limits were taken from the *USEPA Region I Laboratory Data Validation Functional Guidelines for Evaluating Organics Analyses*, (U.S. EPA, 1996b), using specified QAPP control limits.

The Data Validation Reports from 2004 through 2007 are presented in Appendix E, L and M. Each report identifies the sample set, sample matrix, analytical laboratory, and analytical method(s) evaluated. The reports provide basic summaries of data set precision, accuracy, method compliance, and completeness. Additionally, each report details specific quality control outliers or concerns related to the data set and the resulting data qualification that was assigned to individual data points. These assigned qualifiers were utilized when applying data results to project DQOs and subsequent actions.

Data points that did not meet project DQOs due to over-dilution or severe QA/QC failure were clearly identified as rejected or not-reportable in the Data Validation Reports and in the project database and were subsequently not utilized in the RI/FS. All remaining data were suitable for their intended use with any qualifications and/or clarifications noted. The overall precision, accuracy, method compliance, and completeness evaluations for all data sets were acceptable.

2.3 Studies to evaluate physical conditions

The following sections describe the data collection activities completed to characterize the physical conditions of the Site. These data are subsequently used to revise the preliminary CSM, shown as Figures 1-3a, 1-3b, and 1-3c.

2.3.1 Physiography

The Site base map, including topography, was created by compiling various historical information in the ARRC files, as well as information from various local and federal agencies. Over the course of the RI, the base map was refined using ground surface elevation data collected at each boring and monitoring well installed. Additional surface elevation data from recent MOA surveys were also incorporated into the most recent elevation map of the Site (Figure 1-1). Finally, a recent aerial photograph of the Site (true color aerial photo taken on May 22, 2003) has been incorporated into the Site base map for presentation of RI data.

2.3.2 Hydrology and hydrogeology

To satisfy the DQOs, hydrologic and hydrogeologic Site conditions were characterized by conducting the following field activities (Figure 2-1):

- Groundwater fluid level gauging
- Tidal study
- Long-term gauging using transducers
- Ship Creek surface water gauging using installed staff gauges
- Light non-aqueous phase liquid (LNAPL) gauging
- Aquifer slug tests

Two fluid level gauging events were proposed in the RI/FS WP. The first gauging event was completed in November 2005 and a second gauging event was completed in April 2006. Both gauging events were completed in accordance with the RI/FS WP. A third fluid level gauging event was completed in September 2006 after the installation of river staff gauges. It was determined that to adequately evaluate groundwater flow, at least one groundwater event needed to coincide with stream gauging. The stream elevation data were necessary to evaluate convergence of groundwater on Ship Creek and verify that Ship Creek was a gaining stream through the Site. At the request of U.S. EPA, ARRC concurrently coordinated a special groundwater sampling event in September 2006 at the Terminals Area, in which Flint Hills Resources, Chevron, and Tesoro (Oil Companies) gauged monitoring on their respective facilities. The purpose of this gauging was to produce a Terminals Area groundwater elevation map.

A tidal influence study was completed in October 2005 in accordance with the RI/FS WP. This study involved setting pressure transducers at five well locations west of the Kapp Dam (Figure 2-1) for a period of one month. The data from this study were used to characterize tidal influences on groundwater flow and contaminant distribution, as well as to evaluate the connectivity of the shallow groundwater aquifer to Ship Creek and Cook Inlet.

Long-term gauging along Ship Creek was conducted with transducers in two monitoring wells adjacent to the creek (Figure 2-1). These data were collected at the recommendation of U.S. EPA to determine seasonal groundwater elevation fluctuations associated with snow melt and precipitation. The data collection occurred from March 2006 to October 2006.

Based on the initial attempts to create a site-wide groundwater flow map, it was determined that surface water elevations in Ship Creek were necessary to fully evaluate groundwater flow. To collect surface water data, five

staff gauges were installed along Ship Creek during 2006 (Figure 2-1). Surface water and streambed elevations were measured in Ship Creek in September 2006, using the newly installed stream level gauges. With the exception of SG03 and SG05, all surface water elevations were surveyed in accordance with the WPA. Gauges SG03 and SG05 streambed elevations were not measured due to very unstable streambed and rapid bed load transport.

Ultra violet (UV) light screening during soil logging to determine the distribution of LNAPL was done in accordance with the RI/FS WP for borings completed in 2005. Subsequent borings were not screened using UV light because very little LNAPL was observed at the Site, and because fluorescence from UV light was found to have a close correlation with headspace screening for total volatile organic compounds (VOCs). Based on this correlation, soil borings completed after 2005 were only screened for total VOC vapor in headspace analyses. LNAPL data generated by these two methods were determined to be sufficient for RI evaluation.

With the exception of monitoring well MWC10, ten slug tests were completed in accordance with the WPA (Figure 2-1). The data were evaluated and eight of ten slug tests were considered sufficient for estimating hydraulic conductivity and to be representative of the alluvial aquifer conditions.

2.3.3 Land use, land cover, and demographics

Land use and surface cover were evaluated using pre-RI information, current leaseholder records, aerial photographs, and field inspections. As recommended by U.S. EPA, ARRC agreed to complete a land surface cover map as part of the *RA Scoping Memo* (RETEC, 2006b) to distinguish between areas of industrialized development, areas of natural vegetative cover, and areas of exposed soil. Results are presented and discussed in Section 3.4.

2.3.4 Leased property reviews

As part of the SBR, leased property files related to issues raised in the RFA were reviewed. In an effort to ensure that all available data were gathered and summarized, ARRC sent a letter to all the Site lessees requesting that they review the list of documents that were obtained from ADEC, U.S. EPA, or other sources, and supply ARRC with any documents that might be helpful to the RI/FS. All responsive information was then included in the SBR. Any relevant new information that ARRC obtained after submission of the SBR has been incorporated into this RI report.

All available and appropriate leased property information was used for the RI and RA.

2.4 Evaluation and use of pre-RI data

In compliance with the AOC, ARRC was required to "…gather, evaluate, and present the existing Site information and data…to assist in planning the scope of the RI/FS" (U.S. EPA, 2004a). ARRC completed this task and reported all available pre-RI Site information in the SBR (RETEC, 2005b). Sources for Site data included existing ARRC files and database, numerous environmental investigation reports, routine environmental monitoring as required by state and federal regulatory agencies, U.S. EPA RFA reports, as well as reports documenting spills, tank removals, and remedial actions.

In addition, historical research of Site history and specific locations of activities and events included sources such as railroad archives, former employee interviews, aerial and historical photograph analysis, as well as research in local museum and university archives.

Data in the database consist of historical data (designated as "pre-RI") and current data collected from September 2004 to present. The "pre-RI" data that were received from various sources and in various formats

were entered into the project database and identified with five different data quality codes. These codes are defined below and indicate the level of supporting documentation received along with the analytical results.

NV-A – These data were obtained from report summary tables with no supporting analytical information or QA/QC documentation. The NV prefix indicates that the data were not validated by RETEC.

NV-B – These data were obtained from laboratory report pages listing method references, reporting limits, and dates of analysis. The NV prefix indicates that the data were not validated by RETEC.

NV-C – These data were obtained from laboratory reports that included the analytical information listed under NV-B with the addition of surrogate recovery data for organics. The NV prefix indicates that the data were not validated by RETEC.

NV-D – These data were obtained from laboratory reports that included analytical information and QA/QC listed under NV-C with the addition of method blanks, spike, and laboratory duplicate data. The NV prefix indicates that the data were not validated by RETEC.

NV-E – These data were obtained from laboratory reports that included analytical information and QA/QC listed under NV-D with the addition of instrument calibration data and organic sample chromatograms. The NV prefix indicates that the data were not validated by RETEC.

All pre-RI analytical data for the Site were entered into a project database that was submitted to the U.S. EPA as part of the SBR. The database was revised as the result of on-going quality assurance/quality control (QA/QC) activities, or as new data were entered into the database and updates were provided to the U.S. EPA. The pre-RI data provided an overview of existing Site conditions, although with some limitations:

1. The pre-RI data set reflected data collected at different times and for different specific purposes and lacked temporal and spatial continuity.
2. Pre-RI investigations typically focused on a narrow analyte list of known or suspected contaminants associated with specific purposes of individual investigations.
3. Pre-RI data tended to be clustered in the areas targeted by specific past investigations.

These limitations were considered and addressed in the RI/FS WP. In contrast to the sampling results brought together in the SBR, the RI sampling was conducted across the entire 600-acre Site (i.e., not just in areas of suspected contamination), at approximately the same time (i.e., groundwater and surface water sampling events were completed during a specified time period corresponding with seasonal changes), and using a single comprehensive analyte list (i.e., all media were analyzed for the same list of constituents).

Pre-RI data provided the basis for RI sampling by identifying areas where insufficient data existed to satisfy the primary objectives of the RI as required under the AOC (U.S. EPA, 2004a):

1. Determination of human health protection with respect to exposure to Site contaminants at or from the Site in soils, groundwater, surface water, and sediments, including exposures occurring from expected use of Ship Creek and its banks for recreation, occupational activities, and consumption of resident fish.

2. Determination of potential adverse effects on benthic invertebrates, resident fish, and wildlife receptors of such aquatic life that may be affected by potential water or sediment contamination in Ship Creek (including off-channel and riparian areas).

To evaluate the distribution of contaminants and identify potential sources of risk, the pre-RI analytical data for sediment, surface water, groundwater, and soil were compared to preliminary RI SLs and plotted on Site maps (Figures 2-2 through 2-6). Because the RI approach was different in Ship Creek than in the Terminals Area, as discussed in Section 1.3, the pre-RI data are presented and discussed separately for the two areas.

Sediment

Pre-RI analytical results for analyte concentrations detected in sediment samples that exceeded the current RI SLs are as follows:

- Ship Creek Area organic analyte concentrations that exceeded SLs for sediments are shown on Figure 2-2a.
- Ship Creek Area inorganic analyte concentrations that exceeded SLs for sediments are shown on Figure 2-2b.

Surface water

Pre-RI analytical results for analyte concentrations detected in surface water samples that exceeded the current RI SLs are as follows:

- Ship Creek Area organic analyte concentrations that exceeded SLs for surface water are shown on Figure 2-2a.
- Ship Creek Area inorganic analyte concentrations that exceeded SLs for surface water are shown on Figure 2-2b.
- Terminals Area benzene concentrations that exceeded SLs for surface water are shown on Figure 2-3a.
- Terminals Area fuel hydrocarbons (i.e., diesel range organics [DRO], gasoline range organics [GRO], residual range organics [RRO]) concentrations that exceeded SLs for surface water are shown on Figure 2-3b.

Groundwater

Pre-RI analytical results for analyte concentrations detected in groundwater samples that exceeded the current RI SLs are as follows:

- Ship Creek Area VOC concentrations that exceeded SLs for groundwater are shown on Figure 2-4a.
- Ship Creek Area semi-volatile organic compounds (SVOC) concentrations that exceeded SLs for groundwater are shown on Figure 2-4b.
- Ship Creek Area fuel hydrocarbons (i.e., GRO, DRO, RRO) concentrations that exceeded SLs for groundwater are shown on Figure 2-4c.
- Ship Creek Area inorganic analyte concentrations that exceeded SLs for groundwater are shown on Figure 2-4d.
- Terminals Area benzene and metals concentrations that exceeded SLs for groundwater are shown on Figure 2-3a.
- Terminals Area fuel hydrocarbons (i.e., DRO, GRO, RRO) concentrations that exceeded SLs for groundwater are shown on Figure 2-3b.

Soil

Pre-RI analytical results for analyte concentrations detected in soil samples that exceeded the current RI SLs are as follows:

- Ship Creek Area organic concentrations that exceeded SLs for soil are shown on Figure 2-5a for surface soil and Figure 2-5b for subsurface soil.
- Ship Creek Area fuel hydrocarbon (i.e., GRO, DRO, RRO) concentrations that exceeded SLs for soil are shown on Figure 2-5c for surface soil and Figure 2-5d for subsurface soil.
- Ship Creek Area inorganic analyte concentrations that exceeded SLs for soil are shown on Figure 2-5e.
- Terminals Area benzene, toluene, ethylbenzene, xylene (BTEX) analyte concentrations that exceeded SLs for soil are shown on Figure 2-6a.
- Terminals Area fuel hydrocarbon (i.e., DRO, GRO, RRO) concentrations that exceeded SLs for soil are shown on Figure 2-6b.

All pre-RI data were used to identify potential groundwater plumes at the Site prior to selecting sample locations. Based on the pre-RI data, nine areas along Ship Creek (LP024, LP035, LP049, LP085, LP120, LP122, LP127, and LP991) were identified where dissolved phase compound concentrations exceeded the RI groundwater screening levels. Locations where compounds exceeded the screening level are shown as red dots on Figures 2-2 through 2-6. In addition to the Ship Creek area, several areas in the Railyard, as well as the Terminals Area, were identified as locations where compounds exceeded screening levels. In order to develop a current understanding of groundwater conditions at the Site (i.e., update the pre-RI date set) and to delineate and determine risk from previously identified exceedances, ARRC collected groundwater data from across the Site (Figure 2-7), including locations with existing pre-RI data. The rationale for all RI groundwater sampling, including sampling at the locations listed above, is provided in Tables 2-4 and 2-5. The complete RI data set will be carried forward to the FS.

2.5 RI sampling summary

The section provides a summary of RI sampling completed between September 2004 and August 2007. Sample collection completion was greater than 90%, which exceeds the completeness goal established in the QAPP (RETEC, 2005d).

Multiple field sampling events were completed to meet RI objectives:

- The initial RI/FS field event occurred in September 2004 and included the *North Boundary Assessment Groundwater and Soil Results* (RETEC, 2004a) and the *Ship Creek Preliminary Habitat Survey* (RETEC, 2005c).
- The majority of the RI/FS field activities were completed between August and November 2005, in accordance with the scope of work described in the RI/FS WP (RETEC, 2005a).
- Based on the results from 2005, additional RI/FS field work was completed between March and November 2006, in accordance with the scope of work described in the WPA (RETEC, 2006a).
- To satisfy any remaining data gaps, field activities were completed in January, March, May, June, and August of 2007.

Table 2-1 provides a summary of RI field activities completed during each sampling event from 2004 through 2007. A comparison of completed work relative to proposed activities, as described in the RI/FS WP, and subsequent work plans, also is presented in Table 2-1. If a location was not accessible to sample collection or proper sample volume could not be obtained, then ARRC made every effort to collect a sample at the next

nearest location. Site-specific DQOs were used to determine if the data collected were adequate to satisfy AOC requirements. The data collected are compared to media-specific DQOs in Section 2.1 above.

All data analyzed specifically for the RI included the highest level (i.e., U.S. EPA Level IV) of QA/QC documentation. The identified QA/QC levels and level definitions for all pre-RI data are summarized in the SBR (RETEC, 2005b). Quality assurance data validation reports (electronic only) for all RI data are provided in Appendix E, and an electronic database (including all pre-RI and RI data) is provided in Appendix F (as an electronic MS Access® file).

2.5.1 Ship Creek media sampling

Ship Creek media sampling included surface water and sediment sampling within Ship Creek and associated off-channel ponds. Before sampling was initiated, a habitat survey was completed (RETEC, 2005c). This was done in September 2004 as a preliminary study of Ship Creek and the associated riparian zone and to aid in identifying potential sample locations. The Ship Creek sampling activities that followed occurred in 2005, 2006, and 2007 and were driven by the RI/FS WP and the WPA, as well as the January 2007 WP and the March 2007 WP. The Ship Creek media sampling activities are presented by year completed, with references to the specific work plan for which the scope of work was defined. A detailed summary of the work completed is provided in Table 2-1. Sample locations are shown on Figure 2-7.

2005

Ship Creek riparian zone surface water and sediment sampling activities completed in 2005, in accordance with the RI/FS WP, were as follows:

- With the exception of the SVOC analytical results, all surface water and sediment data collected were deemed acceptable for data evaluation.
- In 2005, a high percentage of sediment samples were diluted during SVOC and PCB analyses, resulting in higher- than-acceptable detection limits and non-detect (ND) results for those analytes. As a result, SVOC and PCB data were not adequate for evaluation and data from these locations was collected again in 2006 to develop an adequate data set.[5]

2006

Ship Creek riparian zone surface water and sediment sampling activities completed in 2006, in accordance with the WPA, were as follows:

- The 2005 sediment sample results showed elevated detection limits and no target SVOC or PCB detections making the data quality suspect. The data were rejected in the data validation and sampling was conducted at the same location in May 2006. This second data set were deemed acceptable for data evaluation and determination of COIs. All additional analytical sediment samples proposed in the WPA were collected.
- All surface water samples were collected in accordance with the WPA, with the exception of CSD05 and CSD08, dry locations where no sample was available.

[5] A large proportion of the sediment and soil sampling conducted for SVOCs in 2005 were inappropriately diluted during analysis due to a laboratory error. The elevated detection limits rendered these data unusable. As a result, during the 2006 sampling event, data were collected at all affected locations and analyzed using appropriate techniques.

2007

Ship Creek riparian zone surface water and sediment sampling activities completed in 2007, in accordance with the January 2007 WP and March 2007 WP, were as follows:

- Impacted sediment at the pond located south of Whitney Road was delineated using 15 sediment cores and completed in accordance with the January 2007 WP.
- Sediment and surface water samples per the March 2007 WP were collected partly in March 2007 and partly in late July 2007. The delay was due to the unsafe conditions in Ship Creek until water levels declined in summer. The late July samples included 6 sediment samples.

2.5.2 Groundwater sampling

Initial groundwater sampling activities were performed by RETEC in September 2004 when 20 seep samples were collected for preliminary groundwater data as part of the *North Boundary Assessment Groundwater and Soil Results* (RETEC, 2004a). Subsequent groundwater sampling activities occurred in 2005, 2006, and 2007 and were conducted in accordance with the RI/FS WP, WPA, the January 2007 WP, and the March 2007 WP. Groundwater sampling activities are described by the year that the work was completed. In addition to the text, a detailed sampling summary is provided in Table 2-1 and sample locations are shown on Figure 2-7.

2005

Groundwater sampling activities completed in 2005, in accordance with the RI/FS WP, were as follows:

- The initial groundwater sample event and analysis event was completed in accordance with the RI/FS WP. Analytical data are determined to be acceptable for evaluating COIs.
- With the exception of wells DPB01, MWA13, and MWA17, all groundwater monitoring wells were installed as specified in the RI/FS WP and are adequate for evaluation of nature and extent of contamination. Of the three wells not installed as specified in the RI/FS WP, DPB01 was installed as part of the 2006 scope, MWA13 was not installed due to access problems, and MWA17 was not installed because there is an existing well at that location.
- Seep sampling along the bluff area and at one location along Ship Creek was completed in accordance with the RI/FS WP.

2006

Groundwater sampling activities completed in 2006, in accordance with the WPA and the *Groundwater Data Collection Plan for Fall 2006* (RETEC, 2006c), were as follows:

- Groundwater gauging and sampling was completed in April 2006, in accordance with the RI/FS WP and WPA. Analytical data from this sampling event were determined to be acceptable for evaluating COIs.
- With the exception of dry wells DPB03B1 and DPB03B2, all step-out wells were sampled and completed in accordance with the WPA. Step-out wells DPB03B1 and DPB03B2 were not sampled due to lack of water.
- With the exception of monitoring wells MWB05, MWB25, MWB30, MWE23, and MWE05, additional sampling and fluid level gauging was completed in September 2006, in accordance with the WPA. Monitoring wells MWB05, MWB25, and MWB30 would not produce a reasonable volume of groundwater to collect samples. Well MWE23 was destroyed as part of ARRC redevelopment in this area. Monitoring well MWE05 was not sampled due to product present in the well. Wells with LNAPL were not sampled due to the potential for product to enter the sample and result in a misrepresentation of dissolved phase concentrations.

- All permanent direct push and temporary direct push step-out wells were installed as specified in the WPA, with the exception of MWE26, which was not installed.

2007

Groundwater sampling activities completed in 2007, in accordance with the January 2007 WP and March 2007 WP, were as follows:

- Additional delineation of CVOCs was needed on the south side of Ship Creek after analyzing the 2006 groundwater data. In January 2007, 15 additional step-out direct push wells were sampled, in accordance with the January 2007 WP to delineate CVOCs. Five additional step-out wells were installed and sampled in March 2007, in accordance with the March 2007 WP, to complete the delineation of the CVOCs.
- All 15 natural attenuation samples were collected in January 2007 in accordance with the RI/FS WP and January 2007 WP. With the exception of DPD06 and MWE32, all additional March 2007 groundwater samples, including natural attenuation samples, were collected in accordance with the March 2007 WP. Proposed natural attenuation sampling wells MWE05-E1 and DPD06 and monitoring well MWE32 were not sampled due to low water production.

2.5.3 Soil and soil gas sampling

Initial soil sampling activities occurred in September 2004, when 20 surface soil samples were collected for preliminary data along the north boundary of the ARRC Railyard. Subsequent soil sampling activities occurred in 2005 through 2007 and soil gas sampling occurred in 2006. Soil and soil gas sampling activities are presented by year the work was completed, with reference to the work plan for which the scope of work was defined. In addition to the text, a detailed summary is provided in Table 2-1 and shown on Figure 2-8.

2005

Soil sampling activities completed in 2005, in accordance with the RI/FS WP, were as follows:

- With the exception of the SVOC analytical results, soil data were deemed acceptable for evaluation and determination of COIs.
- A high percentage of samples were diluted during SVOC analyses, resulting in higher than acceptable detection limits and ND results for all target analytes. As a result, these data were not adequate for characterization. All locations where samples had elevated detection limits and no target SVOC detected were resampled.
- With the exception of borings MWA02, MWA12, and MWA13, all soil borings generated soil samples, in accordance with the RI/FS WP, that are adequate for evaluation. MWA02 and MWA12 were completed using direct push rather than hollow stem auger and, therefore, no soil samples were collected. MWA13 was not drilled due to Site conditions (area was covered with standing water). Based on groundwater results, no soil samples are needed at well MWA02 and no further work was proposed.

2006

Soil and soil gas sampling activities completed in 2006 under the WPA were as follows:

- With the exception of SS03 and SS04 surface samples, all 2005 surface and subsurface samples with elevated detection limits and no target SVOC detections were recollected in May 2006 and were deemed acceptable for data evaluation and determination of COI. Surface soil locations SS03 and SS04 were not re-sampled due to construction in the area that modified these locations (i.e., ground had been excavated and the original sample could not be reproduced). All proposed soil borings were

completed. With the exception of DPD13 subsurface sample, MWB31 surface and subsurface VOC samples, and MWA12 surface and subsurface samples only (including 8270C), all surface and subsurface soil samples have been collected in accordance with the WPA.

- All soil vapor monitoring point installations and associated soil gas sampling were completed in accordance with the WPA.

2007

Soil sampling activities completed in 2007 under the March 2007 WP were as follows:

- A direct push soil boring and well DPE35 was completed at an historical fueling area in the Railyard in use prior to the 1960s. One surface and one subsurface soil sample were collected in accordance with the March 2007 WP.

2.5.4 Other Site sampling

2.5.4.1 LNAPL sampling

Although LNAPL samples were collected at each location where LNAPL was noted (MWE21 at LP991 and MWE05 on the Railyard), in accordance with the RI/FS WP, they were not submitted for gas chromatography (GC) or physical properties analysis. Because these LNAPL occurrences were associated with previously known LNAPL sources (storage tanks), GC and physical properties data were not considered necessary for determining nature and extent.

2.5.4.2 Water supply well sampling

To confirm that the groundwater contamination present in the shallow alluvial aquifer is not impacting the deeper aquifer, ARRC identified and sampled all the water supply wells at the Site. Based on a water supply well inventory, eight supply wells were identified and confirmed to be in use. These wells are located at LP127, LP 060, LP044, LP049, LP020, LP017, LP015, and LP056 (Figure 1-4). Seven of the eight wells identified were sampled (Figure 2-8). No sample was taken at LP 056 because access to this location could not be secured. Because the water wells sampled were in use, and the well-heads were sealed, actual well depths could not be measured or sampled directly. Instead, samples from each location were collected at spigots as close to the well as possible. The water from these wells was not filtered or chlorinated prior to the sampling point. Each well was analyzed for the full suite of RI/FS constituents of potential concern (COPC). Well construction details were not available for most of these wells and, thus, are not presented in this report.

2.5.5 Background sampling

The RI/FS WP presented preliminary background values for soil and for “natural” groundwater. The RI/FS WP further detailed a process to determine background for “anthropogenic” groundwater (meaning groundwater entering the Site that has been impacted by upgradient sources) through proposed sampling along the North Bluff and background for “anthropogenic” sediment and surface water. ARRC proposed to do this based on combining available pre-RI data and sampling proposed for the 2005 field season. The background data approach and values presented in the RI/FS WP were preliminary, based on the best information available at the time, and were subject to modification as additional information and comments from U.S. EPA were received.

Data collected during the 2005 field season provided additional information on background conditions and recognition of data gaps for background evaluation. Additional sampling in 2006 and 2007, under U.S. EPA-approved work plans, adequately addressed data gaps to accurately evaluate the Site background conditions. The following subsections discuss the sources and usefulness of preliminary background data and additional background sampling activities for each media. Background sampling locations for all media are shown on Figure 2-9.

Surface water

Some limited pre-RI surface water data generated by EAFB, Fort Richardson, and others in portions of Ship Creek upstream of the Site, are available to evaluate background surface water quality. Because most of these data are more than ten years old, and Ship Creek, like most streams, is temporally variable, these data were rejected for use as relevant background.

Preliminary background data for Ship Creek were developed from sample SC11 (Figure 2-9) collected in September 2005 at the Reeve Boulevard Bridge and from Hart Crowser (2004a) HC-05 and were used in the initial analysis. Both dissolved and total inorganics data were available. These data alone were not sufficient to show temporal/seasonal background variability. To address this data gap, surface water samples were collected at the SC11 station in April 2006 and July 2006. Sampling was completed in accordance with the WPA. Four additional surface water samples also were collected concurrently, at upstream locations SC12, SC13, SC14, and SC15, in accordance with the WPA, for a more robust data set.

The 2005 sampling effort revealed that the water chemistry of the main channel of Ship Creek differed from off-channel areas (ponds and marshes) and is not representative of natural background in the off-channel areas. The absence of background data for off-channel aquatic features required identification and sampling of appropriate off-channel areas upstream of Reeve Boulevard. To accomplish this, four locations (CSE08, CSE09, CSE10, and CSE11) (Figure 2-9) were sampled in 2006, in accordance with WPA.

Sediments

Limited pre-RI background sediment data were available for Ship Creek, but only two samples were deemed adequate for use in the RI. These are Station HC-05 (Hart Crowser, 2004a) and Station SC-I 1 (Boden, 1997)[6]. Combined with sample SC11 collected in 2005, a total of three background samples were available for the Ship Creek main channel. Additional samples were required to apply the proposed ADEC soil background calculation method (ADEC, 2003). Therefore, four additional sediment samples were collected, in accordance with the WPA, from representative reaches of the Ship Creek channel upstream of Reeve Boulevard (SC12, SC13, SC14, and SC15) (Figure 2-9). Note that the pre-RI samples were not included in the evaluation of background.

As in the case of surface water, the 2005 sampling showed that the physical-chemical characteristics of Ship Creek main channel sediment differ from those of off-channel features. To address this data gap, identification and sampling of appropriate off-channel areas upstream of Reeve Boulevard (CSE08, CSE09, CSE10, and CSE11) (Figure 2-9) was completed in 2006, in accordance with the WPA.

Groundwater

In 2004 and 2005, background groundwater sampling was completed by taking seep samples along the North Bluff. Additional background groundwater samples were collected in 2005 along Transect D, in accordance with the WPA (Figure 2-9). These data did not appear to be globally representative of Site (alluvial) conditions.

A probability plot method (Department of Toxic Substances Control [DTSC], 1997) was used to determine if representative background levels could be estimated from available Site groundwater data. Background levels could be estimated for major constituents, but failed for trace inorganics since the data set contained many censored (non-detect) values and, therefore, skewed the probability plot method.

[6] Note that although the sample identification is similar, this is not the same sample location or event as "SC-11," which was collected as part of the RI.

To further evaluate representative background groundwater conditions, additional data were needed from alluvial background locations upgradient (i.e., east) of the Site on EAFB property in the Ship Creek valley, and south and southeast of the Site. As a result, additional groundwater background data were collected, as described in the WPA:

- Installation and sampling of three alluvial groundwater collection locations (DPB28, DPB29, and DPB30) (Figure 2-9), immediately east and southeast of the Site (i.e., just west of Reeve Boulevard)
- Samples were collected from EAFB wells OU5 MW-09, MW-10, MW-12, and MW-31 and NS3-02, located in the alluvial zone near Ship Creek upstream of the Site (Figure 2-9).
- All, except one sample location (MWD11) along the "D" transect, were installed and sampled as proposed in the Work Plan.

Soil

Background soil concentration values are set forth in the *EAFB OU5 RI/FS* (USAF, 1993). The EAFB data included both morainal and alluvial soils, from which final natural background levels were established. These values are not necessarily fully applicable to the Site because all soil is alluvial, including areas of marine influence. Additionally, the area has long-term anthropogenic influence, for which development of an anthropogenic background is desirable. Because the alluvial soil area upgradient of the Site is influenced by EAFB, no reasonable dedicated soil background data set could be identified, and no further data collection was proposed or needed. Background was estimated from the soil data collected as part of the RI/FS. This data set amounted to at least 65 samples for subsurface soils and 83 samples for surface soils, representing a large data set adequate for the statistical evaluation. For these reasons, a statistical evaluation of Site soil data applying the probability plot method of California DTSC (DTSC, 1997) was conducted in order to establish a "local background."

2.6 Studies to provide data for the feasibility study

The AOC requires ARRC to complete an evaluation of potential remedial alternatives for any Site contamination that constitutes a human health or ecological risk or exceeds Applicable or Relevant and Appropriate Requirements (ARARs). AARC will conduct this evaluation in the FS. In addition to the sampling described above, ARRC collected the following data to support the FS evaluation:

- Twenty-three groundwater samples were collected and analyzed for monitored natural attenuation (MNA) parameters in areas of VOC- and CVOC-impacted groundwater.
- Eight soil cores were submitted for analysis of geotechnical properties, such as grain size distribution, bulk density, total organic carbon, and permeability.
- Fifteen sediment cores were collected in the pond adjacent to LP069 to evaluate the lateral and vertical extent of impacted sediment.
- Fluid level measurements were completed at all RI monitoring wells and aquifer slug testing was completed at ten locations to evaluate groundwater flow direction, gradient, and hydraulic conductivity of the alluvial aquifer.
- Tidal influence at five monitoring wells (Figure 2-1) screened in the shallow alluvial aquifer was evaluated to determine effects on potential contaminant migration.

3.0 Site physical characteristics

This section provides a summary of Site physical characteristics, organized geographically around Ship Creek, the central focus of the RI. Attributes of the Terminals Area are also described in subsections separate from the Ship Creek discussion. Analytical data for each environmental medium, as well as background concentrations, will be discussed in Section 4.0.

Description of Site physical characteristics is based, to a large extent, on data available prior to initiation of the RI. However, these preliminary data have been augmented and refined with site-specific information and observations obtained during completion of the various phases of RI field work. The combination of pre-existing (pre-RI) data and new information is key for verifying and appropriately revising assumptions used in developing conceptual models that describe the Site conditions, and potential risks to human and/or ecological receptors. The Site physical characteristics described here include those features that fundamentally influence or control the distribution and possible migration potential for individual environmental contaminants and/or general sources of risk.

3.1 Ship Creek and Cook Inlet

The primary aquatic feature of the Site is Ship Creek. Ship Creek bisects the Site from east to west and is the ultimate recipient of surface water and shallow aquifer flows at the Site, except for the Terminals and northwestern area, which drain directly to Cook Inlet.

As noted in Section 1.0, the central objectives of the RI/FS are to determine whether human health and ecological receptors at the Site, particularly the valuable recreational fishery in Ship Creek, are adequately protected and, if not, evaluate potential remedial alternatives. This section provides some physical and pre-RI background information regarding the creek. Additional information can be found in the *Ship Creek Preliminary Habitat Survey* (RETEC, 2005c).

3.1.1 Ship Creek history

The current course of Ship Creek is channelized and controlled[7]. Prior to settlement of Anchorage and construction of the railroad, Ship Creek, with associated salt marshes, occupied the entire valley bottom, as is commonly seen in undeveloped tidal estuaries in this region. One of the first acts by the Federal government, when constructing the railroad in 1919, was the diversion and channelization of Ship Creek along the south end of the valley to allow construction of railroad track on fill on the north side.

Figure 3-1 shows changes in the channel of Ship Creek over time, based on aerial photographs from 1920, 1950, 1961, 1989, and the 2003 base map. Several marshy areas and meanders on the south side persisted until the 1960s, when development accelerated on the south bank and the creek was routed to its current, channelized configuration, with armored banks in many areas (MOA, 2003; RETEC, 2005c). The green area on Figure 3-1 represents the remainder of the riparian portion of the creek, where fill is limited and relatively

[7] The MOA defines the entire length of Ship Creek within the Site as “channelized,” with a “stream developed buffer” (MOA, 2003).

natural conditions exist[8]. It is this area that was identified in the Ship Creek Habitat Survey as the only significant site-related ecological exposure area on the Site.

Two significant features have been constructed in the Ship Creek Area over the years, as described below and shown on Figure 3-1.

- Two ponds were excavated on the north bank downstream of the railroad bridge near the current LP069 (Dean's Auto). Constructed sometime in the 1940s, there were originally two ponds probably associated with water intakes for a power plant. The southerly pond, still present in 1950, had by 1961 been allowed to fill in, and is now a marshy area. The other pond has been maintained open, and currently receives effluent from storm drain ARRC A-2. It drains to Ship Creek via a pipe installed in recent years, as beaver activities block the natural outfall. Both the currently persisting pond and the filled-in pond were extensively sampled for the RI.
- The KAPP was built in 1952-1953. A dam (variously called the "Kapp Dam" or the "Chugach dam") was constructed across Ship Creek, creating a pond to provide cooling water for the power plant. The dam effectively blocked tidal action further upstream, and areas upstream of the dam today are purely freshwater environments. The dam is built to a spillway height such that high tides will not rise above it. To allow continued fish migration, a fish ladder has been installed on the northern side of the dam. The power plant is now closed. Sedimentation above the dam (gravel and sand bars) has essentially eliminated any pool or storage capacity.

3.1.2 Ship Creek hydrology

Ship Creek (United States Geological Survey [USGS] hydrologic unit code 19020401) heads at Shrimp Lake near Indian Creek Pass at the 2,700-foot level of the Chugach Mountains, 15 miles southeast of Anchorage. The North Fork of Ship Creek, the major tributary, heads near Moraine Pass. Although a very small glacier is close to the North Fork, Ship Creek, as a whole, is not glacial, as evidenced by its generally clear water. The length of Ship Creek from its source to the mouth is 25 miles, draining a watershed totaling 123 square miles, of which the upper 83% is essentially undeveloped (MOA, 2003). The drainage includes alpine meadows, perennial snowfields, forests, wetlands, and industrial, recreational, and residential areas of the Anchorage area. The first 15 miles of the creek flow through pristine and undeveloped areas. The next 8 miles flow through Fort Richardson and EAFB. The final 2 miles flow through the Site from Reeve Boulevard on the east to Cook Inlet on the west (Figure 1-1). Stream bed elevations were surveyed at each staff gauge location ranging from approximately 70 feet above mean sea level (MSL) at Reeve Boulevard to approximately 4 feet above MSL at the C Street Bridge. This represents a grade of approximately 0.6%. The staff gauge installation report is provided in (Appendix D).

Figure 3-2 presents a hydrograph for Ship Creek derived from three USGS gauges on Ship Creek upstream of the Site. The graph shows a hydrograph pattern typical for south-central Alaska, with peaks from snowmelt in June and low flows in March and April. Reportedly, Ship Creek has, in years past, gone dry in early spring, possibly due to upstream withdrawals of surface and groundwater. The average annual flow rates have ranged from 62.5 cfs in 1996 to 226 cfs in 1980. The "period of record" maximum flow is 2,100 cfs, which occurred in 1989.

Flow control structures are absent in the uppermost reaches. The Ship Creek Dam, upstream of the Glenn Highway Bridge, was constructed in 1952 as a diversion point for Anchorage water supply. Below the Glenn

[8] The Watershed Management Services of MOA (MOA, 2003) notes that an ideal riparian setback for Ship Creek would be 183 feet on both sides. Within the Site, only 18% of this ideal area can be characterized as "undeveloped," while the rest is fill or impervious surfaces (79%) and maintained lawns (3%).

Highway, several dams, reservoirs, and erosion control structures are present, effectively limiting sediment transport.

Studies over the years (Weeks, 1970; Barnwell et al., 1972) indicate that Ship Creek is a generally gaining stream in its lower reaches (below Davis Highway), and Weeks (1970) indicated that below EAFB, i.e., on the Site, the creek gains roughly 22 cubic feet per second (cfs) during non-peak flow periods. This was confirmed by RI groundwater elevation and stream gauging data. Potentiometric maps (Figure 3-3, Figure 3-4a and Figure 3-4b) created from RI water level data illustrate the convergence of groundwater elevation contours at Ship Creek, indicating that it is a gaining stream within the Site.

Upstream portions of Ship Creek act as a water source for Anchorage for withdrawal points above Ship Creek dam in the upper reaches of the creek. Other major water users with senior water rights include the Department of Defense, Alaska Department of Fish and Game (ADFG), and Chugach Electric (currently inactive). Ship Creek supports annual runs of natural and hatchery salmon and is heavily fished by recreational fishermen. Annual catch is approximately 5,000 king salmon and 11,000 silver salmon per year (MOA, 2003).

3.1.3 Sediments

Table 3-1 presents data for the physical characteristics of sediment samples collected in Ship Creek and surrounding, off-channel habitat (chemical constituents are described in Section 4.0).

Off-channel areas, including ponds, marshes, drainage ditches, and relict channels, tend to have high content of fines (average 46%) and sand (47%), with little gravel (7%). Organic carbon content is generally high (average 4.2%, ranging up to 10% in the organic rich material in the upper reaches of the Railroad Avenue Marsh and Ditch). Plant debris (leaves, twigs) and duckweed were common in the samples in many of the sampled locations. The background area upstream of the Site, in the pond near the EAFB Eagle Glen Golf Course, was also high in total organic carbon (TOC) (6.0%), but had somewhat less fines (20%) and more gravel (34%) relative to the on-site locations.

Ship Creek itself is a high energy environment with few significant eddies or backwaters that result in depositional areas for fines. Bedload sediment consists of sand and gravel. Finer-grained sand and gravel accumulates in the trailing end of point bars that are frequent in the stream, although the more channelized sections lack these features. The data reveal that, based on sediment data through 2006, Ship Creek sediments average 17% fines, 72% sand, and 12% gravel. Sampling protocol accounted for this condition via maximized fines content during sampling, as contaminants tend to persist primarily in finer fractions of sediment. The organic carbon content is also much lower than the off-channel ponds, averaging 0.5% TOC. Background samples in Ship Creek upstream of the Site were similar to on-site samples.

Only two samples had elevated content of fines, CR04, located in the eddy captured behind (i.e., upstream) the Kapp Dam, presumably a good location to integrate any contamination arriving from upstream; and CR09 in a small backwater area. Sediment sample locations are shown on Figure 1-4.

The Kapp Dam limits marine influence to the lower reaches of Ship Creek. Below the dam, the creek is tidal and subject to daily inundation. The upper reaches are dominated by sand and gravel beds, but lower down, the admixture, with marine clays deposited by Cook Inlet tides, becomes dominant (e.g., CR-02) (Figure 1-4). One sample, CR13, was collected high on the bank at the location of a groundwater seep as SP60 (see Figure 1-4). Marine clay was dominant in this area, which is only inundated at the higher tides.

The general absence of extensive deposits of fine-grained sediments in the main channel of Ship Creek suggests that contaminants migrating from upstream or entering via storm water, runoff or groundwater flux are not likely to persist and will rapidly disperse downstream. Conversely, the low energy aquatic off-channel

environments lack significant drainage and are likely to accumulate fine-grained sediment with associated contaminants.

3.1.4 Classification

Ship Creek is on the State Section 303(d) list of impaired water bodies for fecal coliform (1992) and petroleum hydrocarbons (1992). ADEC states that *"Petroleum products floating on ground water are moving from the site towards Ship Creek that threatens the waterbody"* (ADEC 2004a), justifying the listing for petroleum hydrocarbons. Ship creek remains listed as impaired under 303(d) listed for petroleum hydrocarbons. The results of the current RI/FS will provide input to ADEC for determining any recovery actions for Ship Creek (ADEC 2004a). As this RI shows, current point or non-point sources of petroleum hydrocarbons from the Site that would contribute to any Ship Creek impairment are absent.

A TMDL assigning Waste Load Allocations for point source discharges and Load Allocations for non-point sources was established to address Total Fecal Coliforms in 2004 (ADEC 2004b). Fecal Coliform data indicate that Ship Creek does not meet the applicable water quality standards. The largest and most frequent exceedances of the water quality criteria occur during summer months, likely due to increased storm water runoff and source activity (e.g., pets and wildlife). Therefore, site activities are not implicated.

3.1.5 Discharges, outfalls, and storm drainage system

Multiple point source discharges to Ship Creek occur within the Site. A survey of outfalls along Ship Creek was conducted as part of the *Ship Creek Habitat Preliminary Survey* (RETEC, 2005c), and the outfalls located along the creek were ground-truthed against MOA and EAFB information (Figure 3-1).

A consensus on the approach to be used for evaluating storm water discharges and outfalls was reached during the July 18, 2006 meeting between ARRC, U.S. EPA, and ADEC. The approach was as follows:

- Exclude MOA outfalls from further evaluation.
- Determine if contaminant concentrations in Ship Creek sediments exceed risk-based action levels (following completion of the risk assessment).
- Correlate the locations of sediment that exceed the action levels with outfall locations.
- Determine who owns the outfall and if the source of flow is on or off the Anchorage Terminal Site.
- If the source of flow is from the Anchorage Terminal Site and not from an MOA outfall, evaluate and propose actions to identify and control the source.

The active point source outfalls and discharge points identified along Ship Creek can be subdivided into the following categories:

1. MOA and Alaska Department of Transportation & Public Facilities (ADOT) storm water outfalls. This includes ten major outfalls (> 1 foot diameter) identified on MOA subdrainage maps and three minor outfalls (< 1 foot diameter) not identified on the MOA subdrainage maps

2. The EAFB outfall for the OU5 treatment system (one outfall)

3. ARRC storm water outfalls draining the Railyard. Some of these are also used for drainage from off-site residential and commercial areas under MOA jurisdiction, and are identified on MOA subdrainage maps (5 outfalls)

4. Drainage pipes from off-channel ponds to Ship Creek (2 outfalls)

For storm water management, the Site is located within the lower Ship Creek subwatershed, as defined by MOA Watershed Management Services, covering 2,020 acres (MOA, 2003). However, only part of the area occupied by the Site falls under MOA jurisdiction. The jurisdictional boundary was determined in negotiations for the 1992 National Pollutant Discharge Elimination System (NPDES) permit, whereby MOA was responsible for areas south of Ship Creek and small areas north of the creek, while ARRC or the Department of Defense had jurisdiction over the remainder.

Figure 3-1 shows the location of outfalls to Ship Creek, the MOA jurisdiction, and ARRC jurisdiction subdrainages, and the approximate layout of the storm drain system on the north side of Ship Creek. Outfalls in the Terminals Area subdrainages are not shown on the map and were not surveyed for the *Ship Creek Preliminary Habitat Survey* (RETEC, 2005c).

ARRC storm water system

There are five point outfalls to Ship Creek along the north bank draining storm water from the Railyard. These locations, described below, represent areas where extensive aquatic habitat existed adjacent to the outfall:

- **ARRC C-1.** This outfall, adjacent to the C Street Bridge, drains Railyard subdrainage 1093, covering the westernmost part of the Railyard. It is intermittent, as it does not flow in dry weather. However, during rain storms, it is fully operational.
- **ARRC A-1.** This outfall drains Railyard subdrainage 1092, comprising a part of the western Railyard (including LP049, Wrightway Auto), but is connected with storm drains along the north boundary of the Railyard to other areas of the Railyard. It has active flow at most times.
- **ARRC B-1.** This active outfall is an isolated system draining the central parts of the Railyard (sub-drainage 1091), including most of the maintenance facilities. It also drains LP120, the KAPP. Samples were taken of surface water (SC001-SS12) and sediment (SC001-CR13) immediately adjacent to this outfall.
- **ARRC A-2.** This active outfall drains via a short ditch to a pond identified as a sediment area of potential concern. The outfall drains portions of the central and eastern Railyard, but also is connected to the primary storm drain from MOA subdrainage 829, encompassing the eastern portion of the Government Hill neighborhood, including runoff from the snow disposal site for Government Hill. It is, therefore, a combined drainage shared by MOA and ARRC. Conditions in the adjacent pond may be related to this drain. Samples were collected in the pond.
- **ARRC B-2.** This active outfall is located near the intersection of Whitney Road and Post Road. The storm water then flows in a ditch along the railroad tracks to Ship Creek. This outfall drains the eastern Railyard, including the seep collection system along the north boundary. Surface water and sediment samples were collected in the ditch.

MOA and ADOT storm water system

Figure 3-1 shows the approximate extent of the MOA storm water subdrainages at and near the Site. Some subdrainages do not have installed storm drains and drainage is presumably from overland runoff. Where point outfalls are present along Ship Creek, these are shown on Figure 3-1 and given the name of the corresponding subdrainage.

Along the south side of the creek, nine major outfalls and two minor outfalls are present. The two minor outfalls, subdrainages 812A and 833A, drain localized areas and appear to be active only during precipitation events. The remainder is continually flowing storm drains, capturing runoff from nearby industrial and commercial areas of Anchorage. The *Ship Creek Preliminary Habitat Survey* (RETEC, 2005c) provided detailed descriptions of conditions seen at the outfalls. However, no specific sampling was conducted at any outfalls managed by MOA as agreed in the RI/FS WP.

On the north side of the creek, the MOA storm water subdrainages administered by MOA are small and seem to lack specific storm drains and presumably drain via surface runoff and infiltration.

A major outfall ("ADOT" on Figure 3-1) is managed by the ADOT and collects all runoff from the East Loop Road Overpass and portions of Government Hill (subdrainage 820). This outfall was not sampled as it is unrelated to the ARRC Site.

Other outfalls

The effluent from the EAFB OU5 treatment system (Figure 3-1) in the northeast corner of the Site drains to Ship Creek via an outfall on the north bank at Yakutat Street in the east end of the Site. This outfall was not sampled as it is related to an area excluded from consideration in the RI.

At the pond where ARRC A-2 outfall (Figure 3-1) is located, an additional gravity fed pipe has been installed to drain the pond to Ship Creek. This was installed because beaver activity frequently blocked the natural outfall of the pond, with consequent flooding of nearby properties. The pond surface water and sediment were sampled.

Finally, the cooling water pond for the KAPP has a separate drain via an outfall under the dam immediately adjacent to ARRC B-1. The flood gates controlling the level in the pond are closed and drainage from the pond appears to occur via this drain. The pond surface water was sampled.

A canal (not shown on map) draining the Elmendorf fish hatchery ponds is present immediately east of the Site, adjacent to Reeve Boulevard (Figure 3-1).

Permits

Storm water drainage by MOA to Ship Creek occurs under a NPDES general permit effective January 5, 1999[9]. The Municipality's NPDES storm water permit is a 5-year-term permit to discharge storm water to United States' receiving waters issued jointly to the MOA and the ADOT by U.S. EPA Region 10. The MOA and ADOT are operating under an extension of the first-term permit issued in 1997. This permit authorizes discharge of storm water from the storm water system under MOA jurisdiction or within State rights of way, including storm water associated with industrial activity.

ARRC discharges storm water under the NPDES Storm Water Multi-Sector General Permit for Industrial Activities (MSGP), effective October 30, 2000 through October 30, 2005 and continuing in effect until its reissuance. Railroads qualify for this general permit. The MOA NPDES Permit and the ARRC MSGP authorize discharges of pollutants to Ship Creek, as long as all permit requirements are met. In ARRC's case, compliance with ARRC's Storm Water Pollution Prevention Plan is required and monitoring conducted as specified by the MSGP. Therefore, and as long as the permit requirements are met, the discharges from storm water drains are "federally permitted" and exempt from CERCLA. As a result, and combined with the fact that many of the areas that drain to these outfalls are located outside the Site, storm water outfalls were not specifically sampled or evaluated in this RI. However, the investigation of Ship Creek media (i.e., sampling of downstream sediment depositional locations) was designed to evaluate the cumulative effect of contaminants from all sources potentially affecting Ship Creek, which may include pollutants discharged under permits via the MOA or ARRC storm water systems.

[9] The permit expired in 2003, but its terms are binding while the parties continue to negotiate terms for a successor permit. A draft version of the second-term permit was due in summer 2007.

3.1.6 Cook Inlet

Cook Inlet (more specifically, the Knik Arm of Cook Inlet) is the receiving water body of Ship Creek and runoff from Terminals Area located in the northwest portion of the Site (Figure 1-1). It is reasonable to assume that any persistent contaminants in Ship Creek eventually reach the inlet. Cook Inlet is characterized by a highly dynamic hydrology that includes a very large tidal variation (up to 42 feet, which is the second largest tidal amplitude in the world) and tidal currents regularly exceed 4.6 knots. Several large glacial outwash rivers flow into the inlet, resulting in suspended solids exceeding 1460 micrograms per liter (µg/L). Large areas of the inlet are continually scoured by current and tide. In areas where lower energies allow sedimentation, extensive marine mud flats are present. Such mudflats occur at the mouth of Ship Creek and along the shorelines north and south of the mouth (APET, 2005).

Conditions in the Knik Arm are so dynamic that any contaminants originating in Ship Creek would be rapidly dispersed, and accumulations with a potential for adverse effects to water quality are unlikely. This is consistent with the assumptions underlying the MOA NPDES permit for municipal storm water discharge to Cook Inlet (MOA, 2002) and the secondary treatment waiver under another MOA NPDES permit.

The shoreline north of the mouth of the creek is in a depositional eddy formed by Cairn Point, north of the POA. Slower shoreline currents result in accumulation of marine clays. However, large portions of the original mudflats have been filled in for the construction of the Terminals Area of the Site and the adjoining POA. The generally accumulative conditions near the Terminals and the Port require the USACOE to continually dredge the area to maintain navigation. The POA is currently implementing a major expansion of the Port facilities, which will further fill in previous mudflats adjacent to the Site (POA, 2005 – *Marine Terminal Redevelopment Final Environmental Assessment*, March 7, 2005) and expand the dredging footprint. This particularly applies to the portion of Cook Inlet adjacent to the Tesoro lease (LP019), where potential migration to Cook Inlet is possible (Section 4.8).

The marine clay mudflats are a potential receiving medium for any discharges from the Terminals Area and, therefore, were evaluated for the RI using data collected by the *Port of Anchorage for the Final Environmental Assessment for the Anchorage Marine Terminal* (APET, 2005) and subsequent monitoring (USACOE, 2006). These documents provide further detail about Cook Inlet.

As part of the *Draft Chemical Data Report*, *Anchorage Harbor* ROST *Study* (USACOE, 2006), a task associated with the Environmental Assessment for the Port Expansion Project, sediment samples were collected in 26 borings in the near-shore environment. Eight of these cores were collected immediately west of Tesoro (LP019) and Flint Hills (LP003/004), and show that the sediment consists almost entirely of marine clay and silt to a depth of at least 3 feet. In boring AHTH-26, located just offshore from the south boundary of Flint Hills, the 0- to 4-foot sediment interval consisted of 97% clay and silt, with increasing sand and gravel (14%) in the 6- to 10-foot interval. Elsewhere off the Site, sediment in the 0- to 4-foot interval consisted of 87% to 98% silt and clay. It is likely that the surficial sediment material consists entirely of marine clays typical of Cook Inlet conditions.

3.2 Environmental setting

The following section describes the environmental conditions at the Site with a focus on the Ship Creek Area. A separate discussion for highlighting conditions specific to the Terminals Area of the Site is provided below in Section 3.6.

3.2.1 Climate and meteorology

The Anchorage Terminal Reserve is located in south central Alaska, northeast of the Alaska Peninsula and Cook Inlet. The climate in this area is sub-arctic, with an average annual precipitation of 16.1 inches, based on 30 years of data compiled by the National Climatic Data Center (NCDC). The wettest months are August,

September, and October, with August having the highest average precipitation of 2.9 inches. March and April are the driest months, with an average of 0.59 inch of precipitation. The greatest average daily temperature is 65 degrees Fahrenheit and occurs in July, while the lowest average daily temperature is 9 degrees Fahrenheit and occurs in January.

The average monthly wind speed is 7 miles per hour (mph), with average high gusts over 50 mph, according to National Oceanic and Atmospheric Administration (NOAA) November 1998 Climatic Wind Data Report (NOAA, 1998). The prevailing wind direction is from the north during the period October through March, and from the south to southeast from April through September.

3.2.2 Physiography

The Site is located in the Cook Inlet-Susitna lowland physiographic province within a subsection referred to as the Anchorage Lowland (Warhaftag, 1970). Specifically, the Site lies in the Ship Creek valley, incised within the Anchorage lowlands adjacent to the Knik Arm of the Cook Inlet. Site topography was evaluated using multiple datasets compiled over the course of the RI. These included the following data sources:

- USGS 5-meter elevation contours (see Figure 1-1 for the contours used in the map)
- Light Detection and Ranging (LIDAR) elevation model from the MOA
- National Elevation Dataset Digital Elevation Model (DEM), 1999, obtained from the USGS Earth Resources Observation Systems (EROS) data center
- Site-specific elevations surveyed at well locations

The resulting RI topographic map (Figure 1-1) was used for developing topographic profiles, geologic cross sections, and structure contour maps. Based on pre-RI and current data, the topography of the Ship Creek Area consists of four primary topographic zones:

1. The relatively flat floodplain of Ship Creek that contains most of the Railyard and many leased properties

2. The tidal flats area on the western portion of the Site (i.e., the Terminals Area discussed further in Section 3.6) that has been covered with fill and is the location of the POA and several petroleum terminals

3. The steep slopes north and south of the Ship Creek floodplain and east of the tidal flats that rise approximately 50 to 100 feet above the floodplain and tidal flats, and are largely forested where development has not occurred

4. The relatively flat outwash plain at the top of the North Bluff (i.e., topographically above the Railyard and leased properties), where the Government Hill community and EAFB are located. A few ARRC leased properties are located on the outwash plain

3.2.3 Geology and soils

Regionally, the Site is located on the eastern margin of the tectonic Cook Inlet Forearc Basin, bounded by the Alaska Range to the north and west, and the Chugach Mountains to the east. Several major fault zones bound and cut across the basin (e.g., Bruin Bay-Castle Mountain fault system to the west and Denali fault system to the north). South-central Alaska lies above a subduction zone where the Pacific tectonic plate is being subducted beneath the North American plate. As a result of all these tectonic factors, the area experiences significant seismic activity, with shallow and intermediate events emanating from near-surface fault systems while deeper events originate in the Benioff Zone associated with the subduction.

The Site is covered by Quaternary-age unconsolidated deposits (Figure 3-5). The geology of the Anchorage Railyard area has been described in several reports, including early mapping efforts by Cederstrom, Trainer, and Waller (1964), and Schmoll and Dobrovolny (1972), and later mapping efforts by Updike and Carpenter (1986) and Schmoll, et al. (1996). In addition, engineering studies following the 1964 earthquake, such as that by Hansen (1965), and geotechnical data collected in association with construction of the POA access bridge, also known as the A-C Copulet, have helped document the Site geology. The information from these various reports, along with data collected as part of the RI, have been compiled and are illustrated on Figures 3-8a to 3-8c.

RI activities refined the literature description in the Ship Creek Area by providing site-specific verification of material type, thickness, and distribution. Data from 86 soil borings (Figure 2-7) completed during the RI were used for this report. All boring logs are provided in Appendix I.

A description of the Site geologic units and their stratigraphic relationships, as interpreted from historical information and RI field activities, is provided below:

Glacial outwash deposits. The relatively flat plain north and south of the Ship Creek Area (and upon which EAFB and the downtown portion of Anchorage are constructed) is composed of glacio-fluvial outwash laid down south of the Naptowne age (late Wisconsin) Elmendorf moraine. The outwash consists of sands and gravels displaying cross bedding and graded beds. The outwash appears to be about 50 to 60 feet thick immediately north of the Railyard and has a relatively high hydraulic conductivity. The outwash overlies the silts and clays of the Bootlegger Cove formation. RI drilling was confined to the Ship Creek valley and no new data were collected in the outwash deposits.

Ship Creek alluvium. Ship Creek alluvium occupies the bottom of the Ship Creek valley and within the study area overlies and is incised into the silts and clays of the Bootlegger Cove formation. The lithology within the Ship Creek alluvium, as supported by grain size data and visual logging, consists of interbedded clay, silt, peat, well-graded sand, and gravel. Depositional environment controls the variability in texture and includes sands and gravels transported and deposited in the fast-flowing waters of the Ship Creek channel; medium to coarse sands deposited on point bars in the stream; fine sands and silts deposited as overbank floodplain sediments and abandoned channel fill; and peat that accumulated in abandoned channels and on low-lying areas of the floodplain. The base of the alluvium generally consists of well-graded sand and gravel in fining upward sequences. The middle and upper portions of the alluvium generally consist of finer-grained, unconsolidated materials, including silts and clays. Based on grain size analyses completed at selected wells (MWA04, MWC12, and MWD01) from across the Site, the Ship Creek alluvium ranged from a silty sand with gravel to a well graded sand with silt to a poorly graded sand. Grain size data are provided in Table 3-3.

Although it is difficult to distinguish from the overlying fill material in certain places, the Ship Creek alluvium was identified across the entire Ship Creek Area, with variable thickness ranging from less than 1 foot to about 25 feet. Beneath the Railyard and leased properties to the south, the Ship Creek alluvium ranges from approximately 5 to 25 feet thick, with the greatest thickness in the eastern portion of the Site. The Ship Creek alluvium is typically saturated within a few feet of its upper contact and forms the shallow aquifer that is present across the Site.

Fill material overlying Ship Creek alluvium. Within the developed portions of the Ship Creek Area (i.e., the Railyard and leased properties) fill has been placed over the Ship Creek alluvium (to level and raise the ground surface elevation and to provide a high bearing capacity surface). As shown on Figure 3-5, much of the Ship Creek Area is capped by a veneer of fill consisting of re-worked silt, sand, and gravel up to about 4 feet thick.

In some locations, the fill material has been placed on top of peat and silt soils, which was helpful during the investigation to identify the contact between the fill and the *in situ* alluvium. However, in many locations, the fill

overlies Ship Creek sands and gravels and the transition from fill material to Ship Creek alluvium is difficult to discern. Because most of the fill material was placed on the floodplain alluvium above the high groundwater level, the fill material is above the water table at most locations and does not control groundwater flow.

Tidal/estuarine sediments. In the western Ship Creek Area, between the Railyard and the terminal facilities, the Ship Creek alluvium inter-fingers with fine-grained marine/tidal/estuarine deposits. These deposits continue along the Knik Arm shoreline and are exposed at low tide as mudflats consisting of silt and clay-sized particles, but also may include some sands and gravel near the high tide line and peat soils above the high tide line. The tidal/estuarine sediments overlie the Bootlegger Cove formation and have a low permeability. During RI drilling in the western Ship Creek Area, it was difficult to distinguish between the Bootlegger Cove and the fine-grain tidal sediments.

Bootlegger Cove formation. The Bootlegger Cove formation consists predominately of silts and clays deposited in a glacio-marine or glacio-lacustrine environment, although Updike and Carpenter (1986) have identified sandy and sandy gravelly facies within the Bootlegger Cove formation. The silts and clays are typically gray and massive, and have a low permeability. The Bootlegger is the oldest sediment layer present within the study area – that is, it extends beneath the entire study area (underlying the outwash, Ship Creek alluvium, and tidal/estuarine sediments). All soil borings completed as part of the RI field activities were drilled so that the Bootlegger Cove formation was encountered in order to confirm its presence beneath the entire Ship Creek Area. In the western Ship Creek Area (e.g., MWA01, MWA04, MWA05, MWA06), soil borings were advanced into fine grain sediments that may have been tidal sediments rather than Bootlegger Cove formation. Site-specific visual logging indicates that the Bootlegger Cove formation within the investigation area consists predominately of blue-gray clay with moderate to high plasticity.

The Bootlegger Cove formation is exposed along the base of the west facing bluff above the tank farms in the Terminals Area and along portions of the bluff north of Ship Creek (Figure 3-6). For example, in the North Bluff area, the Bootlegger Cove formation is clearly visible in the recent excavations west of the “knob area,” where it crops out about 8 to 12 feet above the level of the adjacent road and railroad tracks. Although the eastward extent of the Bootlegger Cove formation in the bluffs north of Ship Creek is not precisely known, Schmoll, et al. (1996) suggest that the Bootlegger Cove formation may be present above the level of the Ship Creek floodplain upstream to about the EAFB power plant location. Note that along the base of the westward-facing bluff, the North Bluff, and the bluff south of the ARRC property, the Bootlegger Cove formation is covered by colluvium, including landslide debris.

Hansen (1965) described slope failures that occurred during the 1964 Good Friday Earthquake. His report shows that Bootlegger Cove clays and silts are present above the Ship Creek valley floor in the Government Hill slide, Alaska Native Hospital slide, and slides along East Bluff Road. The soil stratigraphy of the North Bluff is shown in cross sections through the Government Hill and Alaska Native Hospital slide areas, and also in the slide areas along East Bluff Road.

Updike and Carpenter (1986) show that, within the study area, the Bootlegger Cove formation reaches a maximum thickness of about 200 feet beneath the southwestern tip of Government Hill and a minimum thickness of less than about 120 feet beneath the ARRC heavy equipment shop. Drilling logs show that within the study area, the Bootlegger Cove formation overlies a sequence of sands, gravels, and till several hundred feet thick, which, in turn, overlies bedrock. The sands and gravels underlying the Bootlegger Cove formation are saturated and constitute a confined aquifer (which has been tapped by many wells throughout the Anchorage lowland). The Bootlegger Cove formation thins to the east of the Railyard and pinches out completely beneath the alluvial fan formed where Ship Creek debouches from the mountains onto the lowlands. Where the Bootlegger Cove formation pinches out, the Ship Creek alluvium and Naptowne age outwash directly overlie this thick, older sequence of sand and gravels, allowing recharge of the confined aquifer. In the project area, RI soil borings indicate that the surface of the Bootlegger slopes downward from

the northeast to the southwest, having an elevation of about 60 feet above mean sea level (AMSL) (12 feet bgs at MWA26) near Reeve Boulevard and 5 feet AMSL at C Street (MWA05 10 feet bgs) (Figure 3-6).

Colluvium. Substantial portions of the valley walls and bluffs north and south of Ship Creek are covered with colluvium (soils that have been transported down slope by gravity). The colluvial materials include slope wash materials and landslide debris, and tend to cover and obscure the *in situ* Bootlegger Cove and outwash soils. In some places, the colluvium may look like its parent material (which is the outwash and Bootlegger Cove silts and clays), while at other locations it may be a mixture of sands, gravels, silts, and clays and include organic material from plants growing on the slopes. It has been identified as a separate map unit in this report because the colluvium is likely disturbed enough by transport to change its properties. In addition, the colluvium may provide a conduit between the outwash and the Ship Creek alluvium, allowing groundwater to flow from the outwash into the alluvium without surfacing as a seep or spring.

Landslide debris. The 1964 earthquake caused several large landslides on the slide slopes above the Ship Creek valley floor and tidal flats that have been studied by the USGS (Hansen, 1965) and others (Shannon and Wilson, 1964). The slides in the study area include the Government Hill slide and four slides along East Bluff Road. Landslides just outside the study area include the 4th Avenue slide, the Native Hospital slide, and a slide north of the Terminals Area tank farms. The Government Hill landslide was described as a "translational slide" in that soil blocks moved primarily horizontally to the south and grabens (down-dropped blocks) developed under the Government Hill School. A cross section through the Government Hill slide is shown as cross section A-A' on Figure 3-8a. The four landslides along East Bluff Road were described as rotational slides because failed soil blocks moved/rotated about a point along a curved plane. A cross section through one of the East Bluff slides is shown as cross section C-C' on Figure 3-8c. Note that Hansen (1965) shows the Bootlegger Cove formation above the Ship Creek valley floor on both the north and south sides of the valley in the Government Hill, East Bluff Road slides, 4th Avenue slide, and Native Hospital slide. The juxtaposition of outwash and silt and clays in the slide blocks likely influence groundwater flow pathways in and near the slide blocks.

3.3 Hydrogeology

This section describes the groundwater and surface water hydrogeology of the Ship Creek Area, including the North Bluff. A separate section describing the hydrogeology of the Terminals Area of the Site is presented in Section 3.6. Water quality data, including background conditions, will be discussed in Section 4.0.

A shallow unconfined aquifer lies within the Ship Creek alluvium beneath the Ship Creek valley. A second shallow aquifer also exists above the Ship Creek valley in the outwash material of the Elmendorf moraine. A third, deeper (50 to 200 feet bgs) confined aquifer occurs in the sand and gravel beneath the Bootlegger Cove formation. The Bootlegger Cove formation itself has a low hydraulic conductivity relative to the outwash material or the Ship Creek alluvium and typically does not produce water. As a result, the Bootlegger Cove formation serves as an aquitard separating the deep and shallow aquifers (RETEC, 2007b).

Groundwater within the outwash primarily originates as precipitation infiltration on the outwash plain and Elmendorf moraine. The groundwater flow direction is generally southward from the Elmendorf moraine toward Ship Creek, although near the westward facing bluffs above the Terminals Area tank farms, the groundwater flow direction is to the west. This stratigraphy of the North Bluff results in the emergence of groundwater as seeps along the face of the bluff, at the contact between the permeable outwash material and the impermeable Bootlegger Cove. The water from seeps collects in drainage ditches at the base of the bluffs and may re-infiltrate into the Ship Creek alluvial aquifer. In places where the colluvium or landslide debris has accumulated, the groundwater may not come to the surface, but instead moves through these materials and into the underlying alluvial aquifer.

Recharge to the Ship Creek aquifer is derived from three sources: (1) precipitation infiltration on the Ship Creek floodplain, (2) groundwater entering the Ship Creek alluvium from the outwash north and south of Ship

Creek, and (3) water that has infiltrated through the Ship Creek channel in upstream reaches where Ship Creek may be a losing stream that flows westward downgradient through the alluvium (RETEC, 2005a). Results of long-term RI groundwater monitoring (March 2006 to October 2006) using pressure transducers at MWB06 and MWB17 (Figure 2-1) indicate groundwater level changes occur in response to long-term seasonal changes as well as short-term precipitation events.

Hydrographs from MWB06 and MWB17 show an overall increase in groundwater levels of approximately 1 foot (Figures 3-9a and 3-9b) between March and June 2006. Because this is a time of relatively low precipitation, the observed increases in groundwater level are the result of seasonal snow melt and ground thawing, which allows for greater recharge. Short-term episodic groundwater elevation changes are observed at elevation spikes on the hydrographs and graphically correlate with measurable precipitation events (Figures 3-9a and 3-9b). The hydrograph illustrates that peaks in precipitation are generally followed by increases in groundwater levels. At MWB17, an increase in groundwater level elevation in the period between August 10, 2006 and August 23, 2006 of approximately 1.5 feet represents the largest groundwater elevation change observed during the gauging period. This elevation gain corresponds with the heaviest precipitation (5.28 inches total cumulative precipitation) recorded during the observation period. Groundwater elevation peaks and precipitation peaks are offset by approximately 24 to 72 hours. These lag times are reflective of infiltration rates.

Prior to the RI, no area-wide monitoring of groundwater elevations had been completed at the Site. However, based on the limited pre-RI data, flow was interpreted to be generally westward with convergence toward Ship Creek (i.e., flow north of Ship Creek is toward the southwest and flow south of Ship Creek is toward the northwest). As part of the RI, three site-wide groundwater gauging events were completed in September/October 2005, April 2006, and September 2006. The September 2006 event also included simultaneous gauging by Flint Hills Resources, Chevron, and Tesoro in the Terminals Area.

Based on site-wide gauging, groundwater was determined to range from approximately 5 to 20 feet bgs, with a saturated thickness of approximately 5 to 15 feet. Depth to groundwater was found to be the shallowest, often less than 5 feet bgs, at the base of the bluff on the north side of the Railyard. Groundwater elevation gauging results from within the Ship Creek Area confirmed west-southwest flow on the north side of the creek, with an average gradient of approximately 0.012 feet per foot (ft/ft), and west-northwest flow on the south side of the creek, with an average gradient of about 0.006 ft/ft (Figures 3-3 and 3-4a and 3-4b). To the north of the Ship Creek Area, groundwater flow is interpreted to be roughly parallel to the bluff in most places, as the alluvium butts up against the impermeable Bootlegger Cove (Figures 3-8b). Ship Creek staff gauge measurements generally confirm groundwater convergence to Ship Creek.

Slug tests performed in wells screened within the alluvial aquifer yielded hydraulic conductivity estimates ranging from approximately 10 to 95 feet per day (ft/day). Slug test results are provided in Table 3-2. Based on the estimated hydraulic conductivity and groundwater gradients, Darcy velocity on the north side of the creek ranges from between about 0.1 and 1 ft/day and on the south side of the creek from less than 0.1 to 0.5 ft/day.

Along the western boundary of the Site, the Ship Creek alluvium contacts the low permeability tidal and estuarine sediments, and the shape of this contact may influence the groundwater flow pattern and groundwater discharge quantity to both Ship Creek and the inter-tidal zone. Because the Ship Creek alluvium is not found in the Terminals Area, it is suspected that it pinches out to the west (Figure 3-7) and, as a result, the low permeability of the tidal and estuarine soils forces groundwater to enter Ship Creek rather than discharge as seeps on the tidal flats.

Pre-RI drilling through the Bootlegger Cove formation and into the confined aquifer in the vicinity of the Railyard encountered artesian water with a static head above the elevation of the Ship Creek floodplain (when active pumping of the confined aquifer was not occurring). The combination of the upward hydraulic gradient

between the shallow and deep aquifers and the low hydraulic conductivity of the Bootlegger Cove aquitard suggest that the deep aquifer is isolated from contaminants that might be present in the shallow aquifer. As a result, RI activities focused on the shallow alluvial aquifer.

To assess the tidal effect on groundwater on the north side of Ship Creek, transducers were placed in five wells (MWA01, MWA04, MWA05, MWE01, and MWC01) spaced at various locations west of the Kapp Dam for a 30-day period from October 1 to October 30, 2005 (Figure 3-3). Hydrographs of the groundwater data versus the tidal data for Cook Inlet indicate that groundwater levels were not influenced by tidal fluctuations. The transducer elevations showed no correlation with the diurnal tidal cycle. Groundwater levels were influenced by barometric pressure changes, as seen in the barometric pressure and water level elevation plot (inset on Figure 3-5). During the tidal study, comparisons of horizontal gradients between wells also were evaluated and it was determined that gradients remained unaffected by the changing tides. The lack of tidal influence is the result of the shallow aquifer being higher in elevation than the high tide water elevation, as well as being isolated from any deeper groundwater by the Bootlegger Cove formation and/or tidal deposits (Figures 3-8a through 3-8c).

To assess the potential long-term groundwater fluctuations north of Ship Creek, a transducer was placed in monitoring well MWB06 (Figure 2-1) between March 10 and October 15, 2006. The transducer data from this location demonstrate a very distinct tidal influence (Figure 3-9a).

Groundwater elevations at MWB06, located on the south side of the creek, are affected by the tides. The RI transducer data showed that when the high tide elevation exceeds 11.5 feet AMSL, groundwater elevation in well MWB06 rises as well. A graphical correlation between tide elevation and groundwater levels are shown on Figure 3-9a). As illustrated in Figure 3-9a, only the highest of the high tides affect groundwater on the south side of Ship Creek.

As previously discussed, no tidal influence was observed on the north side of the creek because water levels and the top of the Bootlegger Cove and/or tidal sediments (i.e., the base of the alluvial aquifer) are higher than the high tide elevation (Figure 3-8b). However, on the south side of Ship Creek in the vicinity of MWB06, the top of the Bootlegger Cove formation, as well as groundwater elevations (Figures 3-8b), are lower relative to the north side. These results are consistent with the Bootlegger Cove structure contour map (Figure 3-6), which shows the formation dipping to the southeast. At MWB06, the permeable alluvial aquifer material extends to a depth below the highest high tide level. As a result, when the tide extends to the east and fills the Ship Creek channel below the Kapp Dam, groundwater elevations on the south side of the creek rise. In these instances, Cook Inlet water flows from the creek basin to the aquifer.

3.4 Land use and demography

3.4.1 Site property distribution and land use

The ARRC executive and general offices are located at 327 West Ship Creek Avenue on the south bank of Ship Creek (Figure 1-1). The area immediately surrounding the Site is primarily industrial/commercial. The marine waters of Knik Arm (an extension of Cook Inlet) are located approximately 0.4 miles to the west but still within the boundaries of the Site. The Railyard facility itself occupies approximately 313 of the 600 acres and includes a railroad track system, maintenance and repair buildings, shops, a refueling area, a tank car cleaning area, warehouses, and administrative offices. About 287 of the 600 acres consist of parcels that are leased to a variety of Anchorage commercial and industrial businesses. The Site also includes public streets and rights-of-way. Leasing of most of the 287 acres began during the federal ownership.

Currently, ARRC maintains a rail system for freight and passengers from Seward, Alaska to Fairbanks, Alaska, with spur lines to North Pole and Whittier. The railroad system is operated year-round. The central business district of Anchorage is located on the bluff above Ship Creek to the south of the Site. The Government Hill

residential, commercial, and light industrial district is located on the bluff due north of the Site. EAFB lies on the bluff north and northeast of the Site and east of the Site along Ocean Dock Road.

The current and historical use of the Site for commercial/industrial purposes is unlikely to change in the foreseeable future. ARRC controls and will continue to control land uses at the Site since ARRC owns all the Site property. The public understanding and assumption that industrial and commercial land use will continue at the Site was validated in the public interviews conducted by U.S. EPA (August 23 and 24, 2004), where several members from the public stated that, "the most common concern expressed is that U.S. EPA's investigation could slow or stop development of the Ship Creek Area."

3.4.2 Site zoning

Figure 3-10 presents the current zoning configuration for the Site vicinity, which, coupled with ARRC property management policies, provides the framework for the current industrial and commercial use of essentially the entire Site. Most of the Site is zoned for heavy or light industrial uses, as shown on Figure 3-10. Neither ARRC, nor the State, nor the MOA has any short- or long-range plans for different land uses at the Site or in the immediately surrounding area. The only potential exception to this is the area in the southwestern portion of the Site, which is currently zoned as a PC district and includes residential within its permitted uses. This area is and will remain the only area of the Site where a limited amount of future residential housing could possibly be located. Ultimately, as the owner of the property, ARRC will determine the land use in this area, including whether to lease any land for residential purposes as the PC district designation allows. This PC district is in the southwestern portion of the Site, as shown on Figure 3-10.

3.4.3 Site surface cover

The presence of surface cover at much of the Site limits the potential for soil exposure via direct contact. Therefore, as agreed to with U.S. EPA in the RA scoping meeting held in July 2005, an evaluation of the surface cover at the Site (e.g., parking lots, buildings, soil cover, and vegetative cover) has been conducted to distinguish between areas of industrialized development (with little potential for exposure), areas of natural vegetative cover, and areas of exposed soil, shown on Figure 3-11. To estimate the size and distribution of these areas, a review of existing aerial photographs of the Site was completed and a Site walk-through was conducted by field personnel.

The type and extent of land cover is important for risk assessment purposes primarily for above ground storage tanks evaluating exposure to soil. Key types of cover present at the Site can be grouped into the following categories:

- **Impermeable.** Includes buildings, dams, pavement, and tanks with associated secondary containment areas. Little to no opportunity for soil exposure potential exists within these areas.
- **Permeable.** Includes maintained gravel and open gravel/dirt lots. Potential for exposure to soil exists within these areas.
- **Natural.** Includes landscaped areas, weedy lots, and natural green areas (i.e., vegetative), as well as aquatic habitats including ponds, creek channel, tidal flats, and water. Natural cover limits direct exposure to soil in these areas, and a low frequency of human use occurs in these areas as well. However, some soil exposure is still possible.

The results of the surface cover evaluation are depicted on Figure 3-11, which provides a breakdown of cover types and percentages for the preliminary exposure areas discussed.

This information will be used in the risk assessment to account for the fraction of media that is available for contact (FC), which ultimately affects the potential for exposure to constituents.

3.4.4 Site groundwater use

A review of all water supply well records was completed for the Site and surrounding area to determine domestic and/or commercial use of groundwater (i.e., the shallow or deep aquifer) at or near the Anchorage Terminal Reserve. In addition, a groundwater well survey was conducted at the Site as part of the RI to identify properties with existing groundwater wells and, where possible, determine their use (e.g., drinking water or other purposes such as irrigation or dust control). In addition, the groundwater well survey identified wells that go through the Bootlegger Cove formation and, thus, theoretically could create potential conduits for contaminant migration to the deep aquifer below that formation. The survey questionnaire and results are included in Appendix J.

To ensure a complete inventory of groundwater wells present at the Site, survey questionnaires were distributed to leased properties by mail. The survey was completed in March 2006 and over 100 responses were received. Nine groundwater wells have been reported for the Site. The approximate locations of the nine wells are presented on Figure 1-4. These wells were sampled and results are reported in Section 4.0. The following table contains information on the nine wells identified by the tenant survey.

In addition to groundwater wells on site, State records were consulted to identify nearby water supply wells. No nearby (1/2 mile) water supply wells are present.

LP #	Use of Well Water	Well Depth	Well Water Sampling Notes and Sample ID
LP044	Used daily for coffee and other – toilets, hand washing. Bottled water used for drinking	Unknown	Yes, SUP03
LP056	Daily for drinking and sanitary purposes	Screened in deeper aquifer	Not sampled, access denied.
LP127	Daily for sanitary purposes	Unknown	Incorrect location in original reporting (LP066). SUP01
LP015	Daily for drinking, washing hands, sanitary	Estimated to be 200 ft	Yes, SUP07
LP049	Daily for drinking and industrial use	Deeper than 150 ft	Yes, SUP04
LP060	Daily for industrial use	290 ft	Yes, SUP02
LP017	Daily for sanitary purposes	11 ft	Yes, SUP06
LP020	Daily for personal use including drinking	77 ft	Yes, SUP05
LP111	No use as well	Unknown	On inspection this turned out not to be completed well.

3.5 Ecological habitat

3.5.1 North Bluff

The North Bluff borders the entire northern boundary of the Ship Creek Area and consists of a 50- to 90-foot, relatively steep bluff separating the Railyard from EAFB . The width of the vegetated area varies with the bluff slope, ranging from less than 100 feet to 360 feet at its widest. The North Bluff area is dominated by second- and third-growth native vegetation, except in the central portion where the bluff has been excavated and is

currently devoid of vegetation (the "cut"), and portions of the far eastern section where the EAFB OU5 treatment system is located (including a large treatment pond).

Along the foot of the bluff, there are multiple groundwater seeps. Small linear marshes and bogs exist where small natural or artificial berms capture some of the seepage along the base of the bluff. Most of the flow is intercepted by the storm water drainage system at the base of the bluff (Figure 3-1).

The *Ship Creek Preliminary Habitat Survey* (RETEC, 2005c) concluded that:

- The North Bluff area was the only portion of the upland portions of the Site with significant ecological habitat.
- The central and eastern portions of the bluff contain healthy second-growth woodland habitat of value as a shelter belt and habitat for small animals. Abundant water sources in the form of seeps are present.
- The entire area is located upgradient of railroad or lessees activities and would not be expected to be affected by Site discharges. Off-site activities and industry (i.e., EAFB) would be the source of any contamination issues found in this area. There are known sources north and east of the Site (e.g., as documented in the OU5 treatment area) that could affect the North Bluff area.

Based on the above factors, the North Bluff was not considered for further ecological evaluation in this RI/FS. However, groundwater and seeps (the "D" transect) in the North Bluff area were extensively sampled to provide baseline data regarding potential impacts from EAFB and other sources located above the bluff. These data are discussed in Section 4.1.

3.5.2 Ship Creek riparian zone

As reported in the *Ship Creek Preliminary Habitat Survey* (RETEC, 2005c), Ship Creek riparian habitat is dominated by riparian woodland and scrub-shrub communities. Most of the riparian habitat consists of wooded areas on historic meanders within the remaining active floodplain of the creek. The riparian community spans the floodplain and is bounded by artificial berms marking the edge of the fill for developed land. The berms define the boundary between the riparian community and developed/commercial areas. Vegetated riparian areas are generally wider on the north side of the creek than the south; however, the riparian strip decreases to less than 30 feet on both sides in some areas. Vegetated areas extend up to 300 feet on the north side, but not greater than 150 feet to the south. A recently constructed bike path has resulted in the disappearance of parts of the remaining riparian strip on the south. Where industrial development reaches the Ship Creek channel itself, constructed rip-rap barriers to constrain stream migration are present, and riparian habitat is absent.

The most prevalent riparian community consists of a canopy of willows (*Salix* sp.), quaking aspen (*Populus tremuloides*), and alder (*Alnus viridis* ssp*. sinuata*). Along the channel's edge, dense thickets are often formed by Sitka willow (*Salix sitchensis*) and Pacific willow (*Salix lasiandra*). The understory is dominated by common horsetail (*Equisetum arvense*), coltsfoot (*Petasites palmatus*), purple-leaved willowherb (*Epilobium ciliatum*), and colonial bentgrass (*Agrostis capillaris*). The Kapp Dam normally prevents saltwater from passing upstream of the dam, though, saltmeadow cordgrass (*Spartina patens)*, a brackish tolerant species, occurs along the creek channel in some areas upstream from the dam. Below the dam, little or no vegetated riparian areas are present. Each bank is composed of rip-rap or concrete between the dam and the mudflat area that begins about ½ mile downstream from the dam.

Ship Creek and its riparian area are typical of a modified and urban-influenced stream. However, most sections have good-to-excellent habitat conditions for aquatic life. The Ship Creek channel is fairly stable, as it has been channelized, but the riparian floodplain has been much reduced over the last half century. As a high energy stream, there are few areas of sediment deposition present.

The riparian zone is reduced to those areas of the floodplain not developed for industrial or commercial purposes. Some of these areas are large enough to represent fair-to-good habitat for wildlife. Several areas of marshes, backwaters, and ponds are present; they were designated as "off-channel areas" for the purposes of designing and executing the RI/FS. These generally are the result of berms, pond excavation, and other construction activities. They are fairly undisturbed but have, in some cases, developed a significant biological community.

Ship Creek and its riparian zone were evaluated in the RI/FS as follows, reflecting the different habitats present:

- Ship Creek sediment and surface water (differentiating between the tidal area below the dam and the freshwater remainder), evaluated with respect to impacts to the aquatic communities.
- Ship Creek off-channel aquatic areas, including permanent ponds and marshes, and various intermittent channels and ditches. Sediment and surface water from these areas were evaluated with respect to impacts to the aquatic communities.
- Ship Creek riparian areas, evaluated with respect to terrestrial biota (including root uptake from shallow groundwater). This area was not subjected to focused investigations, aside from the aquatic areas, so little soil data are available. However, all available soil (and groundwater) data in the area combined with sediment data representing intermittent or seasonally dry aquatic areas, were considered for this evaluation.

3.6 Terminals Area focused study

The Terminals Area is bounded by Cook Inlet to the west, the POA to the north, EAFB and Government Hill neighborhood to the east, and Ship Creek to the south. The Terminals Area is an active industrial site consisting of multiple operations including barge freight transfer, container cargo storage, cement receiving and storage, and petroleum product storage and transfer (i.e., fuel terminals). The fuel terminals have operated within the Terminals Area since the 1950s, with the majority of construction occurring in the 1960s and 1970s (POA, 2005). Currently, Tesoro (LP019), Chevron (LP025 and 027), and Flint Hills Resources (LP003, 004, and 005) operate fuel terminal facilities on ARRC leased property in this area.

In addition to the Terminals Area, petroleum storage and transfer facilities currently operate on the POA property located immediately to the north and east of the Site. These facilities are operated by Tesoro and Aircraft Services International Group on property leased from the POA. Between 1942 and 1996, the U.S. Army operated the Defense Fuel Support Point-Anchorage (DFSPA) in an area immediately to the north and east of the current Terminals Area.

Petroleum pipelines connect the Terminals Area to the POA, the Ted Stevens Anchorage International Airport, and the Tesoro Refinery in Nikiski, Alaska. In addition to the pipelines, petroleum products are also moved to and from the Terminals Area via railcar and truck.

Based on available release reports, the primary potential sources for hydrocarbon contamination in this area are the former DFSPA, and the historical and current bulk storage tanks and the associated conveyance network (i.e., pipelines, railcars, and trucks) (Shannon and Wilson, 1992) that extends within and outside these leased properties.

ADEC has exercised and continues to exercise environmental regulatory oversight at the fuel terminals operated by Tesoro, Chevron, and Flint Hills. ADEC was also the regulatory agency responsible for the closure and Record of Decision at the former DFSPA.

The fuel terminal facilities continue to be regulated by ADEC, and U.S. EPA approved a perimeter approach for the RI/FS at the Terminals Area, as discussed in Section 1.3.4. The perimeter approach involved ARRC

installation of groundwater monitoring wells outside the oil terminal leased property boundaries and monitoring for dissolved phase hydrocarbon compounds and LNAPL at the water table (RETEC, 2005a).

The RI monitoring network was designed using existing data collected at the leased properties in the Terminals Area. This included more than 500 soil sample analyses and more than 600 groundwater sample analyses, and over a decade of groundwater elevation and flow data. These data were summarized in the SBR and provided to U.S. EPA in an electronic database format. These data allowed ARRC to target completion of new monitoring wells and collect soil samples in areas where additional data were deemed most useful for completing the RI, FS, and RA. The monitoring network was specifically designed to evaluate groundwater flow, contaminants migration, and sources of risk to Cook Inlet and Ship Creek that emanated from the fuel terminal leased properties.

The environmental setting for the Terminals Area is very similar to that of the Ship Creek Area discussed in Section 3.2. As a result, this section will describe those features of the Terminals Areas that are distinct from the rest of the Site.

Terminals Area physiography

The Terminals Area is located on the east bank of the Knik Arm of the Cook Inlet. The topography consists of relatively flat tidal mud to the west with increasing elevation to the east eventually forming a steep bluff that rises approximately 100 feet (Figure 1-1). At the top of the bluff, the topography becomes a relatively flat glacial outwash plain where the Government Hill neighborhood and EAFB are located.

The western developed portion of the Terminals Area is characterized by relatively flat topography. This area, located between Ocean Dock Road and Cook Inlet (Figure 1-1), was built primarily on fill material, most of which was placed between 1950 and 1988 (Shannon and Wilson, 1992). The barge freight areas, LP060 and LP101, as well as the Tesoro and Flint Hills fuel terminals, are built on fill material (Figure 3-5). The Chevron Terminal is located on slightly higher ground in the eastern portion the Terminals Area. From west to east the topography rises approximately 20 to 40 feet in elevation across the Chevron facility (Figure 1-1). The Chevron Terminal is built right up to the steep bluffs on the east side of the area. The former DFSPA was located to the east and topographically higher than Chevron and the other portions of the Terminals Area. The Chevron facility and the former DFSPA were constructed on glacial outwash material.

Terminals Area geology and soils

There are no outcrops of bedrock in the Terminals Area. Instead, several hundred feet of unconsolidated Tertiary sediments overlie bedrock, which, if present, would consist of Mesozoic metamorphic rocks of the Chugach Mountain (Updike and Carpenter, 1986). The various reports for the area (see references cited above) describe the following primary units in the Terminals Area:

- Fill materials
- Glacial outwash deposits
- The Bootlegger Cove formation
- Landslide debris from the 1964 earthquake
- Colluvium

Tidal/estuarine sediments

The generalized stratigraphy of the area is illustrated in a series of geologic cross sections (Figure 3-12). In contrast to the Ship Creek Area, no Ship Creek alluvium is mapped in the Terminals Area. Instead, fill material directly overlies tidal and estuarine sediments (Figure 3-12).

The tidal/estuarine sediments along the Knik Arm shoreline are marine/tidal/estuarine sediments that are dominated by silt and clay-sized particles, but also may include some sands and gravel near the high tide line and peat soils above the high tide line. Within the Terminals Area and the adjacent POA, development has been facilitated by placing fill materials on tidal/estuarine sediments. The fill material varies in texture but primarily consists of reworked outwash type soil excavated from nearby borrow pits and landslide debris (Shannon and Wilson, 1992). The fill material in the Terminals Area and POA is up to 40 feet thick in some areas (POA, 2005). Much of the fill material placed on the tidal sediments is below the high tide line and, hence, the water table is within the fill material, unlike Ship Creek where the fill material is mostly above the water table.

Like the Ship Creek Area, the Bootlegger Cove formation underlies the entire Terminals Area. Geotechnical studies completed by the POA in support of port expansion indicate that the natural Bootlegger Cove clays found beneath the POA, immediately adjacent to the Terminals Area, do not appear to be susceptible to liquefaction during earthquakes (POA, 2005). However, the POA report cautions that zones of loose sand and silty sand could liquefy during a large earthquake.

Terminals Area hydrology

The distribution of natural sediments and placed material described above controls the distribution and flow of groundwater through the Terminals Area. In the vicinity of the Terminals Area, the hydrology consists of two shallow water table aquifers, a deep confined aquifer and surface water drainage.

One of the shallow water table aquifers exists in the outwash deposits on the bluff above the Terminals Area. In places, the aquifer in outwash material daylights as seeps along the bluffs on the eastern boundary of the Terminals Area. This outwash aquifer occurs beneath the former DFSPA and the Chevron facility. Further to the west, the shallow water table aquifer occurs in the fill material beneath the Tesoro and Flint Hills Resources facilities. Groundwater beneath the Terminals Area occurs about 3 to 10 ft bgs. The saturated thickness of the aquifer increases from about 5 to 10 ft in the west, to 30 to 40 ft in the glacial outwash material to the east. The water-bearing units and saturated thickness are illustrated on Figure 3-12.

The sands and gravels beneath the Bootlegger Cove formation constitute the deep confined aquifer. The predominately fine grained soils of the Bootlegger Cove formation have a low hydraulic conductivity and consequently the Bootlegger Cove formation serves as an aquitard separating the deep aquifer from the shallow aquifer.

Groundwater recharge for the shallow aquifer is primarily from precipitation infiltration in outwash and fill material. Groundwater flow is generally to the west–northwest in the Terminals Area shallow water table aquifer. Groundwater gradients generally increase to the east (Figure 3-4b). Hydraulic conductivity values for the fill material in this area were derived from a slug test completed for the RI. The estimated hydraulic conductivity values were between approximately 12 and 37 ft/day (Table 3-2). Based on groundwater gradients from the Terminals Area groundwater elevation map (Figure 3-4b), groundwater velocities were estimated to range from 0.28 to 0.86 ft/day.

Tidal studies have previously been completed at both the Flint Hills and Tesoro facilities. Tidal effects were observed at Flint Hill, but no tidal effects have been observed at Tesoro. As described earlier, ARRC also completed a tidal study along Ship Creek near C Street and found no tidal influence. The lack of tidal influence is likely the result of the shallow aquifer being higher in elevation than the high tide water elevation as well as being isolated from any deeper groundwater by the impermeable Bootlegger Cove formation. However, tidal influences may be observed locally due to heterogeneity in the Bootlegger Cove formation (i.e., more permeable zones may allow connection between the aquifer and inter-tidal zone) or may be the result of changes in water levels of surface water features such as drainage ditches.

In the Terminals Area, glacial outwash and fill material are in contact with the low permeability tidal and estuarine sediments. As a result the low permeability of the tidal and estuarine soils may force groundwater to discharge as seeps on the tidal flats. These are observed along the western edge of some of the fill material.

Surface water in the Terminals Area is controlled by constructed drainage ditches and storm sewers. The drainage and storm sewers in the Terminals Area discharge to Cook Inlet. At Tesoro, storm water that accumulates in containment areas is checked for sheens before being discharged into the Municipality of Anchorage's drainage ditch and storm sewer that runs along the western boundary of the Tesoro facility (Oasis, 2006).

3.7 Refined hydrogeologic Conceptual Site Model

The data collected during the RI have been incorporated with the extensive pre-RI dataset. Although the RI data did not result in any significant changes, these data confirm and quantify the preliminary CSM presented in the SBR. For example, although groundwater flow was generally understood prior to the RI, RI gauging was useful for determining gradient and, ultimately, flow velocities, as presented above. The preliminary CSM portrayed the relationship between the COPCs and their sources, transport mechanisms, and ultimately, human and ecological receptors. The human health and ecological CSMs build on the hydrogeological CSM and are presented in detail in Appendices B and C, respectively.

The RI data validated the hydrogeologic characteristic of the Site used in developing the preliminary CSM. The details of the hydrogeologic CSM were presented in the previous sections and are summarized below:

- Ship Creek is a gaining stream along its full reach at the Site. With development in the Ship Creek Area beginning in 1919, Ship Creek has evolved from a meander stream lined with saltwater mashes and ponds to its current highly channelized configuration.
- Ship Creek is a relatively high energy stream as the result of spring snowmelt and episodic precipitation events. As a result, there are few areas of active sediment accumulation within the Site.
- Numerous storm water outfalls along Ship Creek at the Site serve as point source discharges to the creek. The water discharged from these outfalls originates from multiple sources, including ARRC storm water, MOA storm water, and EAFB treatment effluent.
- The groundwater aquifer at the Site consists of alluvial material in the Ship Creek Area and graded fill material in the Terminals Area. Across the entire Site, the base of the aquifer consists of fine-grained impermeable sediment that impedes the downward vertical migration of groundwater and dissolved-phase contaminants.
  - The alluvial aquifer is relatively thin with a saturated thickness ranging from about 5 to 15 ft
  - The alluvial aquifer lies stratagraphically above Bootlegger Cove formation
  - The Bootlegger Cove formation was encountered across the entire Site
  - Bootlegger Cove formation effectively isolates the alluvial hydrostrategraphic unit from the deeper sand and gravel aquifer that serves as a regional water supply resource due to (1) low hydraulic conductivity properties, and (2) confined and artesian (upward vertical hydraulic gradient) configuration of the aquifer (RETEC, 2005a).
- Groundwater recharge at the Site occurs from infiltration of precipitation, groundwater flow from off-site areas to the east, and re-infiltration of seep water coming from the North Bluff and bluffs south of Ship Creek. As a result, there are numerous potential off-site sources of contamination, as well as the potential for contamination to leach from soil to groundwater.

- Groundwater flow beneath the Site is generally from east to west with convergence toward Ship Creek on both the north and south sides. In most places, Ship Creek creates a groundwater divide through the Site.
- The groundwater flow velocity to the creek ranges from between about 40 to 350 feet per year (ft/yr) on the north side and from 20 to 210 ft/yr on the south side of the creek.

4.0 Nature and extent of contamination

The nature and extent of all analyzed contaminants in the Site environmental media (sediment, surface water, groundwater, and soil are described in this section. This data summary and interpretation satisfies a fundamental objective of the RI/FS process and is the basis for risk assessment and feasibility study efforts described in subsequent sections. In particular, the nature and extent of contamination described in this section will be the basis for detailed evaluation of specific areas of the Site identified as potential sources of risk. The data are presented as a series of summary tables indicating compounds that were detected and which of the compounds exceeded RI SLs. The RI SLs were used as benchmarks for evaluation purposes and are not intended as criteria of potential concern or risk. The RI data are evaluated with respect to risk in the HHRA (Appendix B) and ERA (Appendix C).

The distribution of data is shown on maps for each environmental medium and compound class. Summary tables (indicated by the suffix "a" in the numbering) indicate all exceedances of SLs, including exceedances based on reporting limits for censored (non-detect) data. Although non-detect exceedances are not shown on the maps, these data are considered in the COPC selection process in the risk assessments. Detailed tables (indicated by the suffix "b" in the numbering) show specific concentrations for selected constituents of interest in the media of concern. Data for constituents that do not exceed SLs are not included in tables referenced in this section. Complete data sets are presented in electronic format in Appendix H.

4.1 Background investigation

Guidance for Comparing Background and Chemical Concentrations in Soil at CERCLA Sites (U.S. EPA, 2002c) states that there is no CERCLA requirement to remediate Site contaminants below their background levels. This is particularly true for naturally occurring inorganics, such as metals. In this RI/FS, three kinds of background are discussed:

- Natural background, which represents the concentrations expected in the absence of human impact. Such background data are typically collected at locations similar to the Site in undeveloped or otherwise natural areas. In urban areas, it is frequently impossible to define an unaffected background concentration. For study of the Site, no natural background is identifiable, as surrounding areas are developed and presumably impacted by anthropogenic activities, or else not representative of the geology and hydrology at the Site.
- Anthropogenic background, which represents the concentrations found in adjacent or upgradient areas unaffected by the Site. This may be considered representative of typical conditions in the area. Anthropogenic background is also relevant when defining the nature of the influx from upstream or upgradient, to differentiate between contaminants from on-site and off-site sources. Background for sediment and surface water in this RI/FS is defined on the basis of the anthropogenic background prevalent in Ship Creek upstream of the Site. Background for groundwater is, in part, developed from concentrations observed in groundwater flow entering the Site from upgradient sources. Anthropogenic background may be defined for organics as well as inorganics..
- Local background, which refers to estimated background for a site derived from the statistical analysis of on-site data without reference to surrounding areas. Local background defines what the Site conditions would be like in the absence of site-related sources. This method, which, in this RI/FS is applied to soil, is frequently used when surrounding land use, contamination history, or geological conditions do not allow definition of a "background" data set.

Background data evaluated, as described in Section 2.6.5, from the locations shown on Figure 2-9 are used as follows in the RI/FS:

- In the RI, the "RI SLs" are used to determine the nature and extent of contamination. They incorporate the background values derived for sediment, surface water, and soil that are discussed later in this RI report[10]. If the background is higher than toxicity-based SLs, then the background becomes the RI SSL. Note that if no toxicity-based SL exists, then the background also becomes the SL. This is the case, for example, for calcium, magnesium, sodium, and potassium.
- In accordance with ADEC and U.S. EPA guidance, the initial phases of the risk assessment are done without reference to background conditions. Risk is calculated based on the absolute concentrations found in the different media. Only in the risk characterization is background incorporated to describe the relative contribution of site-related contamination to total risk.
- Natural background levels are most pertinent with respect to metals and other naturally occurring inorganics, since these occur irrespective of human activity at the Site. Anthropogenic background also is relevant, for example, with respect to organic contaminants to the extent those are entering the Site groundwater from upgradient sources (as is the case with Transect D locations and associated North Bluff seeps).

4.1.1 Surface water

Table 4-1 shows the estimated background concentrations of constituents in surface water in Ship Creek and the off-channel aquatic areas in the riparian zone adjacent to Ship Creek. The background was calculated from a background data set collected upstream of the Site that consisted of the following:

- Seven samples of Ship Creek surface water, including three sample events at the upstream boundary of the Site and four additional samples collected in the reach of Ship Creek above the dam at EAFB
- Four samples of off-channel surface water, collected concurrently from a pond on the south side of Ship Creek upstream of the dam at EAFB

Background was calculated separately for dissolved and total inorganics. As noted in the RI/FS WP, it was initially hypothesized that there could be significant differences between off-channel aquatic areas (dominated by local runoff and groundwater recharge) and Ship Creek itself (dominated by stream flow). As the table shows, however, concentrations were broadly similar for Ship Creek and the off-channel areas (though there were some significant differences for inorganics, as discussed below). Background values were calculated for each zone separately, as well as for the combined data. In this report, the combined background is used to screen data.

The background value was defined as equal to the mean plus the interquartile range (IQR) of the data set. If the IQR was higher than the maximum detected concentration (MDC), the background defaulted to the MDC. For analytes that were not detected in the background data set, any detection would be considered higher than background. Note that estimated ("J" flagged) data were included in the evaluation.

Six inorganics showed significant differences between the off-channel areas and Ship Creek: barium, calcium, magnesium, manganese, potassium, and iron. In all cases, the off-channel areas had significantly higher

[10] Groundwater background is, at the moment, not incorporated into the RI screening levels due to the difficulty in defining a widely applicable background level for the heterogeneous groundwater conditions at the Site. As a result, locations may be identified as exceeding screening levels, although they may be within naturally occurring ranges (for example, arsenic).

concentrations, as would be expected for these inorganics in a groundwater-influenced system. These differences will be considered in the risk assessment.

4.1.2 Sediment

Table 4-2 shows the estimated background concentrations for sediment in Ship Creek and the off-channel aquatic areas in the riparian zone adjacent to Ship Creek. The background was calculated from a background data set collected upstream of the Site that consisted of the following:

- Five samples of Ship Creek sediment from five locations: one at the upstream boundary of the Site and four additional samples collected in the reach of Ship Creek above the dam at EAFB
- Four samples of off-channel sediment, collected concurrently from a pond on the south side of Ship Creek upstream of the dam at EAFB

As noted in the RI/FS WP, Section 3.5, it was initially hypothesized that there could be significant differences between the off-channel aquatic areas, which are quiescent areas dominated by local runoff, intermittency, and accumulation of fines, and Ship Creek itself, a high energy environment dominated by sand and gravel (Section 3.1). As the table shows, however, concentrations were broadly similar for Ship Creek and off-channel areas (with the exception of some inorganics, as discussed below). A background value was calculated for each area separately and combing the areas. In this report, the combined background is used to screen data.

The background value was calculated using the recommended ADEC method for soil, equal to the mean plus the IQR of the data set (ADEC, 2003). Where this value was higher than the MDC, the background defaulted to the MDC. For analytes that were not detected in the background data set, any detection would be considered higher than background. Note that estimated ("J" flagged) data were included in the evaluation.

Three inorganics showed significant differences between the off-channel areas and Ship Creek: calcium, lead, and manganese. For calcium and lead, the off-channel areas had the higher concentration. However, for manganese, the Ship Creek sediments had the higher concentrations. The difference for lead is interesting in light of the elevated surface soil background for the Site (130 mg/kg), which may account for lead-enriched sediments accumulating in the off-channel areas. Finally, as noted in Section 3.1.3, the organic carbon content was found to be much higher in the quiescent sediments in the off-channel areas than in Ship Creek. The amount of organic carbon affects the bioavailability of organic contaminants. These differences will be considered in the risk assessment.

4.1.3 Groundwater

To determine a "background" for Site groundwater in accordance with the AOC, several different approaches were attempted, as noted in the RI/FS WP and the WPA. Data considered as representative of Site background[11] include the following:

- Transect D and North Bluff seep groundwater, which represents groundwater influx along the North Bluff (presented and discussed in the WPA).
- Alluvial groundwater from five existing wells located on EAFB upgradient of the Site, as proposed in the WPA (OU5-MW-09, MW-10, MW-12, NS3-02, and OU5-MW-31). These wells are shown on Figure 2-9. Since they are upgradient and off site, they represent groundwater that has not been affected by Site conditions (i.e., they represent "local background").

[11] Groundwater background was evaluated jointly for the entire Site, including the Terminals Area.

- Groundwater entering the Site from the southeast side, measured in three wells installed as proposed in the WPA.
- Calculated local background for widely detected inorganics (and only for these inorganics because the method does not work well for inorganics with high censoring rates), using all RI Site data.

Review of data from these sources indicates high spatial and temporal variability in inorganic constituents and the frequent presence of trace organics in groundwater influx from the north and southeast. In addition, areas near Cook Inlet appear to be influenced by marine conditions. Therefore, it is not realistic to define a single "background" for groundwater with site-wide applicability. However, understanding the natural concentrations of inorganics as much as possible is important for those inorganics such as arsenic, where risk-based criteria are lower than naturally occurring concentrations.

To further assess this issue, and based on discussions with U.S. EPA, Site data were reevaluated with a view to subdividing the Site into groundwater "zones" for which separate background values might be calculated. The field parameter of EC was chosen as an indicator of potential water source and the Site was subdivided into zones based on observed EC ranges. Figure 4-1 shows the outcome of this evaluation. The Site was subdivided into three zones as follows:

- **"Riverine" groundwater.** Areas where minimum (if more than one measurement was available) groundwater EC was less than 350 µS/cm were considered riverine. Ship Creek water has EC of less than 200 µS/cm. Areas where Ship Creek influence is present, at least seasonally, are likely to have inorganic concentrations similar to those of the creek. However, rain water also has low EC and, as Figure 4-1 shows, seepage areas along the North Bluff, at times, appear to be rain water dominated. This results in "islands" of low EC within areas that have a higher EC matrix.
- **"Standard" groundwater.** Areas with EC greater than 350 µS/cm, but less than 1000 µS/cm, were considered typical groundwater for alluvial areas unaffected by the creek or the inlet. Off-site surface water areas also have higher EC, which indicate they are the result of groundwater discharge.
- **"Tidal" groundwater.** Areas with minimum EC greater than 1,000 µS/cm were defined as "tidal." These areas are concentrated in the near-shore environment, including portions of the Terminals. The elevated conductivity indicates the presence of salinity, most likely from tidal influx or from dissolution of salts entrained in the marine clays that underlie the recent fill in some of these areas. Note that Figure 4-1 also shows several isolated areas with elevated EC. These tend to occur where elevated contaminant levels have been noted and are likely related to the contaminant source.

Based on this division, three separate groundwater zones were delineated and background levels were established for each. The data on Figure 4-1 show that there appear to be seasonal variations in some areas. This can cause some uncertainty as to definition of zones for the groundwater. In such cases, the zone classification is based on the lowest EC reported for that location. The zone classifications reflect best professional judgment in cases where extensive seasonal variation is present. Along the bluffs and in portions of the Terminals Area, there were frequent records of very low EC, probably associated with times dominated by rainwater runoff. These areas, nevertheless, were assigned to standard groundwater (North Bluff) and tidal groundwater (Terminals) based on professional judgment.

As an interim measure, to further evaluate the natural concentrations of some inorganics in the Site alluvial groundwater, an alternate approach was used to identify preliminary local background for four inorganics whose measured Site concentrations frequently exceed SLs (arsenic, nickel, iron, and manganese) and which were ubiquitously detected. The method is based on the probability plot method (DTSC, 1997) for soil. This is described further in the soil background discussion below. Although this method is not typically used for groundwater due to the lack of statistical independence associated with multiple samples from a given location, it can help identify if the observed concentrations are clearly not associated with the "typical"

groundwater. The method works only where data censoring is limited and, therefore, cannot be used for trace level inorganics that are commonly reported as NDs.

This method was applied to the aggregate RI data for groundwater through 2006 for arsenic, nickel, manganese, and iron. In the case of arsenic, a subset of "hot spot" samples above the inflection point was identified. When these high values were removed, a background concentration of 32 µg/L was calculated (based on the lower of the maximum or twice the mean). For manganese and iron, inspection of the probability plot showed no apparent inflection point separating normally distributed data from "hot spots." It appears that all the data for manganese and iron belong to the same underlying population, suggesting that no anthropogenic hot spots exist[12]. The resulting background values for arsenic, manganese, and iron (but not nickel) are much higher than those based on North Bluff data, which may be related to geochemical factors. The concentrations of all three of these inorganics in groundwater are strongly associated with redox conditions. In reducing conditions, the dominant chemical form of these inorganics is more soluble. Thus, the higher background levels for these inorganics in the Site groundwater compared the groundwater at the North Bluff may be due to reducing conditions on Site.

Table 4-3 presents estimates for groundwater background derived from North Bluff seepage, upstream riparian groundwater, as well as estimates from the local background described above. As can be seen the range of background is large, and none of the estimated values are representative for the Site as a whole. Preliminary review of groundwater data from the various zones shown on Figure 4-1 suggest that zone-by-zone comparisons still do not provide a representative basis for comparison. Development of a representative background does not appear feasible for this Site. However, Table 4-3 values do provide reasonable ranges for what may be considered "natural' for the area, and will be qualitatively considered in nature and extent and risk characterization.

4.1.4 Soil

Table 4-4 shows the estimated background concentrations for Site soils. Appendix K presents calculations and probability plots for the RI soil data set, as well as a summary table of the data that were used to define background. Background was estimated from the soil data collected as part of the RI/FS. This data set amounted to at least 66 samples for subsurface soils and 87 samples for surface soils, representing a large data set adequate for the statistical evaluation. As noted in Section 2.6.5, the previously determined background for EAFB was not considered representative of the alluvial Ship Creek valley at the Site. Also, there are no suitable upgradient sites from which samples unaffected by anthropogenic activities could be collected. For these reasons, a statistical evaluation of Site soil data using the graphical probability plot method of California DTSC (DTSC, 1997) was used to divide the sample population into an "impacted" and a "background" population based on visual identification of an inflection point in the probability plot. The lower, presumptively unimpacted, population was then used to establish the "local background." Table 4-4 also presents the accepted natural background values for the area occupied by EAFB.

The probability plot method is subject to uncertainties, as the identification of the inflection point separating populations is based on professional judgment. In some cases the inflection point is unclear or weak, and in others there may be multiple inflection points. The premise is that the lower "background" population is normally or lognormally distributed to decide that it represents background. However, lognormal populations may have significant skewness, and even if apparently parametric may not necessarily represent true background. Therefore, local background estimates based on the graphical evaluation may be subject to significant uncertainties..

[12] For iron, the estimated background based on the probability plot method is 29,000 µg/L, and for manganese 4,300 µg/L. Nickel is somewhat more complex, suggesting anything below 52 µg/L may be natural.

Probability plots

The probability plot method found that, based on Site data distribution, inorganics either were normally or lognormally distributed site-wide, suggesting no elevated concentrations; or else were normally/lognormally distributed when data above the inflection point were removed, indicating the remainder of Site data were consistent with background. In many cases, the calculated background values for inorganics are lower than, or consistent with, values reported for EAFB, suggesting that the probability plot method adequately describes the area. For these inorganics, there is no reason to suspect that widespread contamination is present on the Site.

For a few inorganics (e.g. selenium, barium, zinc, and zinc) the probability plot was more complex and interpretation indicates that two separate populations, but presumably within naturally occurring ranges, are present, possibly related to different concentrations in native outwash alluvium and in fill material used for construction.

As seen in Table 4-4 the method identified some inorganics for which one or more locations appear to represent unusually elevated concentrations. These locations have been plotted on Figure 4-2. Background concentrations were calculated after removing the samples from these locations that were "above the break" in the probability plots.

The analytical methods employed in the RI resulted in very low censoring rates and, for most inorganics, the frequency of detection was 100%. Therefore, the data set is not distorted at the low end due to NDs. The inorganics for which data censoring was an issue were thallium (37% ND data), selenium (25-26% ND data), silver (32-34% ND data) and, to a lesser extent, antimony (5% ND data). For cyanide, considered as an inorganic for background purposes, the ND frequency approaches 60%, and the reliability of the background evaluation, therefore, is lower. The distortion produced by data censoring is substantial, and it is difficult to fit a distribution in such cases. Consistent with the DTSC background method, the ND data at the lower end of the distribution were removed and the remaining data were tested to determine if they could be considered background based on fitting a normal or lognormal distribution.

The lower, presumably local, background populations for the inorganics fit either a lognormal or normal distribution, suggesting their suitability as background estimates. The following are exceptions to this conclusion:

- **Barium, surface soil**. There appear to be several natural populations, as well as a few unusually low values present, and the data set does not conform to a parametric distribution. Visually, however, the data appear reasonably linear (R^2=0.923) and the parametric background value is used as it is more statistically powerful than the non-parametric upper tolerance limit (UTL).
- **Cyanide, surface and subsurface soil.** As noted above, the high censoring level for cyanide resulted in non-parametric data. The non-parametric UTL will be used as background.
- **Thallium, subsurface soil.** High censoring and data scatter results in poorly correlated data. However, there are no clear inflection points in the data and, therefore, all site data are likely local background. The non-parametric UTL was used to derive background.
- **Potassium, surface soil.** Even though there was no censoring, and only two samples clearly are above the probability plot break; the natural background does not fit a parametric distribution. The non-parametric UTL was used.
- **Selenium, subsurface soil.** As for thallium above, all Site data are likely local background. The non-parametric UTL was used as background.

- **Lead, subsurface soil.** There appear to be two local background populations present, in addition to a few locations "above the break." The mixture of two populations results in a non-parametric distribution, and the non-parametric UTL was used for background.

Background Calculations

Apart from these exceptions, the data set was determined to represent local background and the background was determined using the ADEC-recommended method, i.e., the 95%/95% UTL for the data set (ADEC, 2003). Parametric or non-parametric UTLs were calculated in accordance with the underlying distribution, except as noted above. The resulting values established background for purposes of this RI/FS.

Table 4-4 also compares the calculated background to the background levels calculated for EAFB (USAF, 1993). As can be seen, the Site background is generally comparable to the EAFB data, with a few significant exceptions that reflect the uncertainty involved in the probability plot method:

- **Cadmium and silver.** Local background is significantly lower than at EAFB in both surface and subsurface soils.
- **Selenium.** Local background for selenium is significantly higher than at EAFB in both surface and subsurface soils
- **Lead.** Local background is significantly higher than at EAFB. This is especially noticeable for surface soil, for which the local background is 130 mg/kg. This is an unusually high value, although review of the probability plot indicates that the data are fully consistent with a background population. It is likely that this value represents widespread and diffuse anthropogenic influence in the area, as it is higher than typical true natural background levels. However, as the reported value is still considerably lower than the lowest human health lead clean-up level (400 mg/kg), the uncertainty about the background level does not affect risk-based conclusions about upland portions of the Site. It is acknowledged that in this RI, ecological exposures add uncertainty due to screening levels that are lower than this background value. However the ERA (Appendix C) evaluates these areas using the proper screening levels accordingly.
- **Zinc.** The zinc data for surface soil show two separate populations that are both consistent with background. The lower of these is consistent with EAFB data. The higher population may be related to surface fill from a source with higher zinc than the local native soil, especially as the elevated value is not evident in subsurface soil.

"Hot spots"

Figure 4-2 shows the locations where inorganics data were "above the inflection point" in the probability plot. These locations have concentrations not statistically correlated with the "natural background" of the Site. The figure shows data points exceeding background by a small margin (less then twice the calculated background) and by a larger margin (more than twice the calculated background). Such locations may represent anomalous data of natural origin or, "hot spots," resulting from releases or discharges.

Figure 4-2 also shows more generally the RI sampling locations where exceedances of the calculated soil background levels were observed. Most exceedances of calculated background were minor (less than twice the background) and are not likely to point to potential sources. The background calculation method is inherently conservative in that, on average, 10% of true background concentrations will be incorrectly identified as above background.

There are some locations where multiple inorganics significantly exceed background, suggesting anthropogenic enrichment. These include several locations along Ship Creek: MWA12, near the abandoned water pump house; MWA27, MWA28, SS09, and SS10, adjacent to LP056 (Steel Fabricators), but also DPB28. This last location was originally thought to represent background but, due to the elevated inorganics

and also organics in groundwater, the location was rejected for this purpose (DPB28 is situated on fill used for construction of the Reeve Boulevard causeway).

Elevated inorganics at these and other locations were discussed previously in the soil section and are considered in the ecological and human health risk assessment.

4.2 Ship Creek media investigation

This section presents the results of the evaluation of surface water and sediment in Ship Creek and its riparian zone, including the off-channel aquatic areas found in the riparian zone. As noted in Section 1.0, this evaluation of nature and extent of contamination for surface water is based on recent data only, i.e., data collected as part of the RI or by other parties since September 2004. The physical conditions for these areas were described in Section 3.1.

4.2.1 Ship Creek main channel surface water

Surface water samples from the main stem of Ship Creek were collected once, during low flow conditions, in September 2005. Two stations were sampled during low tide in the tidal segment of the creek below Kapp Dam. One of these samples, SS12, was collected immediately outside the outfall of storm sewer ARRC B-1 and may be influenced by it. Three stations along the creek, in addition to one station immediately upstream of the Site (SC11), were also sampled at this time. Figures 4-3a and 4-3b present the results for inorganics and organics, respectively. Results are reported in Tables 4-5a and 4-5b for the tidal area, and Tables 4-6a and 4-6b for the freshwater portion of Ship Creek.

Field parameters (pH, specific conductance or electric conductivity [EC], turbidity, dissolved oxygen [DO], temperature, total dissolved solids [TDS], and oxidation reduction potential [ORP] were evaluated during the Habitat Survey in September 2004, and were reported in Table 5 of the *Ship Creek Preliminary Habitat Survey* (RETEC, 2005c):

- In the tidal area below the Kapp Dam, EC varied from 210 µS/cm at low tide, when all the flow is Ship Creek fresh water, to 1,910 µS/cm at high tide, when the water is a brackish mixture of marine inflow and Ship Creek water. DO was high (11.8 to 14.8 mg/L), which is at or above saturation. The pH was somewhat acidic (5.5 at low tide, 6.6 at high tide). ORP was positive (+245 to +803 millivolts [mV]).
- In the main stem of Ship Creek, EC was constant (around 190 µS/cm upstream of the Site, 206 µS/cm at Post Road, and 210 µS/cm just above the Kapp Dam), indicating that the creek flow is dominated by upstream flow and not from local influx of elevated EC groundwater. DO was uniformly high (>10 mg/L), and pH was somewhat acidic (5.1 to 6.6). The low pH was somewhat unusual, but other characteristics do not indicate any environmental concerns.

No target analyte organics were detected in any surface water sample. The lack of any such detections is expected given the high flow of Ship Creek.

Evaluation of inorganics showed no exceedances of RI SLs at any of the four main-channel locations. Note that reporting limits for some analytes were well above their screening criteria set forth in the RI Work Plan. This is a source of some uncertainty primarily associated with the low surface water screening levels in comparison to standard analytical method reporting limits. In sample SS12 collected at the mouth of storm sewer ARRC B-1, total arsenic was detected at 3.3 µg/L, but no dissolved arsenic was noted. In sample SP60, which measures the discharge from a bank seep and is not a true surface water sample (data for this sample are presented in the groundwater section), arsenic has been noted at 7 and 13 µg/L, and nickel at 8 to 9 µg/L. These levels exceed their SLs for surface water but are consistent with groundwater background levels. See Section 4.8.3 for a discussion of background in groundwater. In addition, manganese exceeds the

marine SL in SS12. This sample includes water from the storm sewer and is elevated in manganese due to the high background levels of manganese seen at the Site (Table 4-3).

Although additional sample events were not conducted, the creek conditions of high scouring flows suggest that Ship Creek surface water is not impacted by contaminants. However, analysis of the surface water in off-channel areas (Section 4.2.2) and the hyporheic influx from groundwater (Section 4.3) provides additional information regarding Ship Creek water quality.

4.2.2 Off-channel surface water

Eleven surface water samples (CSA02, CSB01, CSB04, CSB06, CSD02, CSD04, CSD06, CSD07, CSC03, and CSE02) (Figure 2-7) were collected from five off-channel aquatic habitats where standing water was present at the time of sampling (September 2005 and follow-up sampling in September 2006). One sample was collected from each aquatic feature, although several features are intermittent or seasonal in nature and at the time of sampling lacked standing water. Results are presented in Tables 4-7a and 4-7b, and are shown on Figures 4-3a and 4-3b. As part of the Ship Creek Habitat Survey, a number of the off-channel areas and storm sewers were evaluated for field parameters. In general, EC was higher in off-channel areas than in Ship Creek, which would be expected as the off-channel areas receive a substantial part of their water from groundwater influx or from storm water dominated by groundwater seepage.

- **Kapp Dam cooling pond.** A sample (CSA02) from this pond did not contain any organics.
- **Storm water pond area.** Samples were collected from the main pond (CSB-01), near the outfall of storm sewer ARRC A-2 to the pond (CSB-06), and the marshy remains of the second pond, east of the main pond (CSB-04). Organic target analyte detections were limited to a single estimated detection of toluene at 0.4 µg/L at CSB-04, well below SLs.
- **Storm water drainage ditch along railroad tracks.** This ditch drains storm sewer ARRC B-2. One sample (CSC03) at the mouth of the ditch did not detect any organic target analytes.
- **Relict channel below LP127**. A sample (CSE02) from a relict channel located immediately below LP127 did not show any organic target analytes.
- **Railroad Avenue Marsh.** The *Ship Creek Habitat Survey* identified a ditch with apparent sediment contamination feeding this large marshy area at the eastern side of the Site. One sample from the main body of the marsh (CSD-02) did not show any target analyte organics. A sample from the visually impacted ditch (CSD-04) showed an estimated detection of 1,4-Dichlorobenzene at 0.37 µg/L. A second sample event was conducted in August 2006. A surface water sample (CSD-07) from the upper part of the ditch collected at this time showed exceedances of RI screening criteria for PCBs (entirely from Aroclor 1260), polynuclear aromatic hydrocarbons (PAHs) (Benzo(b)fluroanthene and Indeno(1,2,3,c,d)pyrene), and bis((2-ethylhexyl)phthalate (BEHP). This area is discussed more extensively in Section 4.2.4, as sediment impacts appear to be present and are the likely source of the observed surface water analytes.
- **Standard Steel ditch.** This area was extensively sampled for sediment, but the ditch lacked water during both sampling events and, consequently, no surface water samples were collected.

Inorganics content of these 10 samples, listed above, showed some exceedances: arsenic, 4 of 11 samples (CSD-02, CSD-06, and CSD-07 in the Railroad Avenue Marsh); barium, 10 of 11 samples (all off-channel stations except CSB-04); iron, 3 of 11samples (samples CSD-06 and CSD-07 in the Railyard Avenue Marsh); and manganese, 7 of 11 samples, all areas.

In the Railroad Avenue Marsh (CSD-02, CSD-04, CSD-06, and CSD-07), dissolved barium exceeds the RI SL at concentrations consistent with other off-channel areas. Dissolved arsenic (0.9 to 3 µg/L), iron, and manganese also show exceedances in this area. These inorganics are likely associated with the elevated

concentrations seen in the underlying sediment (Section 4.2.4), as the marsh is relatively stagnant and water flux is low.

Note, due to the low SLs for some surface water analytes, standard method detection limits are greater than some of the SLs. This provides some uncertainty in evaluating the monitoring results.

4.2.3 Ship Creek sediment

Exceedances of RI SLs in Ship Creek sediments are relatively few (two tidal samples and three main channel samples of 18 samples show any exceedances for organics). Figure 4-4a and 4-4b show the exceedances of inorganics and detections of organics.

Tidal area

Four samples (CR02, CR03, CR12, and CR13) (Figure 4-4a and 4-4b) were collected in the tidal area below the Kapp Dam, as summarized in Tables 4-8a and 4-8b. PAHs were detected at low levels in all samples although not all PAHs were detected in every sample. Only in sample CR12, collected at the outfall of storm sewer ARRC A-1, were exceedances (2-methylnaphthalene, fluorene, and naphthalene) noted. In this sample, BTEX compounds were also detected, in addition to the observation of sheens when the sediment was disturbed during sampling. This location forms a very limited area of deposition immediately outside the outfall of the storm sewer, covering less than 10 square feet of gravelly sand.

In the tidal area sample CR02, collected in a marine clay depositional bank area, trace levels of PAHs and toluene were observed. Sample CR03, in an area of sand and gravel, had trace levels of PAHs but also 0.8 milligrams per kilogram (mg/kg) of 4-methylphenol, which exceeds the SL. Finally, sample CR13, consisting of marine clay and silty sand at the location of seep SP60 (see Section 4.2.1 for associated water data), reported trace levels of PAHs and acetone, but no SL exceedances.

Sample CR13, located on the creek bank where groundwater seep SP60 emerges, had elevated arsenic (8.3 times the marine sediment SL) and, to a lesser extent, chromium (1.2 times the SL). Other samples in the marine clays also showed minor exceedances for arsenic (1.2 to 2.1 times the SL).

The Ship Creek tidal area does receive some influence from urban discharges and sources. However, the sediment is not significantly impacted by Site sources, except immediately adjacent to the storm sewer and possibly at the location of the groundwater seep, although these metal exceedances appear consistent with soil and groundwater conditions[13].

Main channel area

Thirteen samples (CR04 through CR10 and CR20 through CR25) (Figure 4-4a and 4-4b) (plus one sample at the upstream boundary) were collected from Ship Creek between Reeve Boulevard bridge (upstream) and the Kapp Dam, as summarized in Tables 4-9a and 4-9b. Sampling focused on identifying depositional areas with sediment with elevated TOC and fines (clay and silt) content. Section 3.1.3 described the physical characteristics of the sediment. Only one relatively stable depositional area is present in this reach of Ship Creek. This consists of an eddy behind the northern side of the Kapp Dam. Sample CR04 was collected here. All other samples were from the depositional end of point bars or other sand bars, where fines content was low and expected residence time low due to the dynamic nature of the creek.

[13] Anecdotal reports note the recurring presence of sheens in lower Ship Creek after breakup each year. Such sheens are most likely related to spring melt runoff from the many storm sewers along Ship Creek. However, as the RI sediment sampling confirms, such transient sheens do not significantly accumulate in the Ship Creek sediments.

CR20 through CR25 were collected separately in late June 2007. These samples specifically targeted areas of potential groundwater migration from known or suspected sources near Ship Creek, and were collected, to the extent possible, in depositional areas associated with suspected source areas.

All sediment samples had trace levels of various PAHs, although all were below the RI SL, with the exception of sample CR04 (see below). In two samples, CR06 and CR23, a trace amount of acetone was observed. This widespread but very low level presence of PAHs (also seen below the Kapp Dam) is typical for a stream in an urban setting.

Sample CR04, which would be expected to describe the combined impact from all upstream sources accumulating in a relatively quiescent area, had exceedances of four individual PAHs (benzo(a)pyrene, benzo(k)fluoranthene, indeno(1,2,3,c,d)pyrene, and pyrene), all high molecular weight, recalcitrant PAHs strongly adsorbed to fine sediment. Other PAHs and 4-methylphenol were detected at trace levels. The magnitude of the exceedances was minimal, however. Section 7.0 (risk assessment) addresses the potential ecological risk from these PAHs.

Inorganics exceedances are minimal, except for antimony (1 to 2 times the SL of 0.2 mg/kg at 2 locations) and nickel (less than 1.1 times the SL of 37 mg/kg at 3 locations). In addition, copper exceeds the SL by 1.1 times in one sample.

The samples CR20 through CR25 are indicators of potential migration via groundwater to Ship Creek. Trace levels below screening levels of PAHs were noted in two samples, similar to those seen in other samples in the creek. Sample CR23 had trace levels (0.008 mg/kg of carbon disulfide, just reaching the SL of 0.008 mg/kg. This sample also had trace levels (below levels of concern) of 2-butanone, acetone, phenol, toluene, and 4-methylphenol.

Sample CR24 had trace levels (below SLs) of several tri- and dichlorobenzenes. This sample, located immediately downgradient of the groundwater area affected by TCE labeled GW-1 (see Section 5.1.1) also showed low levels of cis-1,2-dichloroethene (0.0062 mg/kg) and TCE (0.049 mg/kg). These concentrations are well below the TCE screening level of 1.6 mg/kg and are of no further concern as a source of risk. However, their presence suggests that the GW-1 area does reach Ship Creek.

4.2.4 Off-channel areas sediment

Indications of contamination were found in some of the off-channel sediment locations selected for evaluation, as described below. Tables 4-10a and 4-10b present summary results for the evaluation, which are graphically shown on Figures 4-4a and 4-4b.

KAPP pond

This pond is occasionally flushed by Ship Creek flows and contains from a few inches to about a foot of silty depositional sediment overlying the alluvial gravel. Three samples (CSA01, CSA02, and CSA03) showed exceedances of PAHs. Up to 11 separate PAHs exceeded the RI SL (in sample CSA02). In addition, PCBs exceeded the SL at one station (CSA03), at 0.18 mg/kg of Aroclor 1248. The SLs were not significantly exceeded. Nevertheless, these results will be evaluated in the risk assessment.

Several inorganics slightly exceeded the RI SLs. Concentrations of antimony (1 to 2.5 times the SL) and nickel (less than 1.1 times the SL) were similar to those seen in Ship Creek sediment and consistent with naturally occurring concentrations. Other inorganics with exceedances of SLs included arsenic (1 to 1.3 times), chromium (1.1 times), copper (1.6 to 1.8 times), lead (1.2 to 1.7 times), mercury (1.1 times), and cadmium (1.3 times). It appears that these exceedances are minimal and consistent with naturally occurring concentrations. See Section 4.1.2 for a discussion of sediment background levels.

Due to the magnitude and nature of exceedances, this area was designated as sediment area SE-1, and will be evaluated further in Section 5.0 and Section 7.0 as a potential source of risk.

Relict channels east of KAPP

A sample (CSE03) from a relict channel east of the Kapp Dam taken at a representative location in that channel had traces of PAHs that were below SLs and exceedances of antimony, arsenic, chromium, copper, and nickel exceeding their respective SLs by a multiple of less than 1.5. Inorganics present at levels consistent with naturally occurring concentrations occur at this location.

Storm water pond

This pond was sampled extensively as it was suspected to contain site-related contamination. One sample (CSB01) was taken in the center of the deep part of the pond. Three additional samples were collected elsewhere in the pond (CSB02, CSB03, and CSB06). In addition, two samples (CSB04 and CSB05) were collected in marshy areas east of the current pond, where previously a pond had existed but which currently has been filled in to form a marshy area.

The main lobe of the pond is deep (over 11 feet), and 1 to 2 feet of greenish silt are present overlying the Ship Creek alluvial gravel. This silt was visibly impacted, with presence of hydrocarbon odors, heavy sheening, staining, and inclusions of free product. In February 2007, this layer of impacted sediment was further evaluated (i.e., sediment cores were collected and visually inspected in the field) to determine the extent of contamination, as described in Section 5.2.2.

Samples from two depth intervals at CSB-01 (0 to 1 foot and 1 to 2 feet) contained elevated concentrations of most (12 of the 16 evaluated) PAHs (although no other organics were detected). Some of these PAHs, such as phenanthrene, were noted as exceeding the SL by over 200 times (8.9 mg/kg in CSB01, the most impacted sample, compared to a SL of 0.04 mg/kg). Sample CSB-06 also showed exceedances, up to 4 times the SL, for PAHs such as pyrene. Sample CSB06 was collected in sandy silt in 2 feet of water, near the edge of the pond at the mouth of a ditch draining storm sewer ARRC A-2. This sample also had exceedances for four PAHs, and also had 4-methylphenol and acetone at concentrations below SLs. Samples CSB02 and CSB03 were collected from the shallower (less than 3 feet) eastern and southern lobes of the pond and were sandy and gravelly. Traces of PAHs were present, similar to other areas of the Ship Creek system These PAHs did not exceed SLs, suggesting the impacts reported at CSB-01 and CSB-06 are confined to the deep sediment in the main lobe of the pond.

Samples CSB04 and CSB05 were from the marshy areas to the east of the main pond, which has limited hydrologic connection to the main pond. Sample CSB04 had the usual traces of PAHs that were below the SLs. Sample CSB05 had PAHs consisting of anthracene at the SL and phenanthrene at 1.2 times the SL. Sample CSB05 is at the eastern edge of this area, and immediately downgradient of the Arctic Cooperage site (LP991). The absence of elevated high concentrations of PAHs, inorganics, or PCBs (i.e., less than 2 times the SL) here is evidence that Arctic Cooperage is not an ongoing or recent source of organic or inorganic contaminants to the pond or to Ship Creek.

Samples CSB01 and CSB06 also had elevated concentrations for several inorganics: lead at 6.2 to 6.6 times the SL, zinc at 3.1 to 4.5 times the SL, and cadmium at 2.9 to 3.0 times the SL. In addition, several other inorganics (e.g. antimony, arsenic, chromium ,copper, mercury, and nickel) have lower levels of exceedances, presumably related to storm water influx. The other samples in the area show low levels of exceedances for several inorganics (antimony and nickel), at concentrations similar to what is seen elsewhere in the area.

Due to the magnitude and nature of exceedances, this area was designated as sediment area SE-2, and will be evaluated further in Section 5.0 and Section 7.0 as a potential source of risk.

Railroad ditch

This ditch drains storm sewer ARRC B-2 and flows to Ship Creek parallel to the railroad track. Three samples along this ditch showed exceedances of up to 9 PAHs at the upper end (CSC01), near the outfall of the sewer, but only minimal exceedances elsewhere (anthracene at 1.0 times the SL at CSC03 at the outfall of the ditch). PAHs were otherwise present at trace levels, as was (BEHP). The presence of PAHs at the outfall of the storm sewer is not unexpected, as road runoff and other anthropogenic sources typically result in PAHs present in storm sewer discharges.

Inorganics exceedances were noted for antimony, nickel, arsenic, chromium, copper, and zinc but, in all cases, at less than 2 times the SL, which is consistent with other areas.

The low level of exceedances for inorganics and PAHs indicate that the ditch is not a significant source. Nevertheless, this area is further evaluated in the ERA (Appendix C).

Relict channel below LP127

Lease LP127 has known environmental issues, including CVOCs in soil and groundwater and PCBs in soil. These have been addressed during remedial actions in the 1990s and early 2000s. A sample (CSE02) was collected in a relict channel along the shoreline immediately adjacent to this lease. As in other areas, trace levels of PAHs and 4-methylphenol, as well as minimal exceedances of sediment SLs of aluminum, antimony, and copper were noted. No indications of sources for this contamination were observed in the area. Contaminants present at LP127 were not found in the channel and, therefore, LP127 has not had an impact on the channel.

Railroad Avenue Marsh

The *Ship Creek Preliminary Habitat Survey* (RETEC, 2005c) identified a short ditch in this marshy area as being visibly impacted by hydrocarbons. Extensive sampling was conducted in this area, including additional step-out sampling based on initial results. The ditch originates adjacent to leased property LP029. Five samples (CSD04, CSD05, CSD06, CSD07, and CSD08) were collected in the ditch and in adjacent wet areas. The ditch drains into a natural marsh adjacent to Ship Creek. This marsh lacks active surface drainage to the creek, from which it is separated by a vegetated gravel bank, but there is evidence of seeps that could allow the marsh to affect the creek. Three samples were collected in the marsh proper. These consisted of CSD01 at the west downgradient end, CSD02 near where the ditch reaches the marsh, and CSD03 at the southeast upgradient end of the marsh.

Sample CSD03 on the “upgradient” side of the marsh, towards the southeast, showed traces of PAHs and acetone, and of antimony and nickel at the levels seen elsewhere in Ship Creek. As a result, it was concluded that this area is not adversely affected (i.e., no elevated concentrations) by site-related contamination. All other samples, however, showed exceedances for PAHs, PCBs, and detections for other organic contaminants. Sample locations are shown on Figures 4-4a (inorganics) and 4-4b (organics).

The area affected by the ditch (i.e., the ditch, nearby areas, and portions of the marsh downgradient of the ditch) contained elevated PAHs, PCBs, and several inorganics, particularly lead and mercury. Exceedances of the SL in the ditch area exceed 100 times for some COPCs (PCBs, BEHP, some PAHs), and by over 10 times for others (lead, cadmium, mercury, some PAHs). PCBs, here as elsewhere at the Site, are limited to the Aroclor 1260. Other detections include several phthalates, 4-methylphenol, and 3,3’-diethylorobenzidine.. No VOCs were detected. Bis-2(ethylhexylphthalate) and dicthylphthalate exceed screening levels.

Other inorganics were noted above the SLs, but at minimal exceedances (less than 2 times the SL), similar to the situation in other off-channel areas. Such small exceedances of the conservative SLs are unlikely to be a source of risk. Nevertheless, these data are evaluated in the risk assessment to confirm this.

Due to the widespread and significant magnitude of exceedances for inorganic and/or organic contaminants, this area was designated as sediment area SE-3, and will be evaluated further in Section 5.0 and Section 7.0 as a potential source of risk.

Standard Steel ditch (termed area SE-4 going forward)

The former Standard Steel CERCLA site has been remediated under CERCLA and was excluded from this RI/FS (see Section 1.3.1). However, an old ditch running through a riparian zone in a westerly direction to Ship Creek from the old location of Standard Steel that was outside the remediation area was sampled for this RI. The ditch appears to carry occasional local runoff and melt-water, is frequently dry, and is not an active drainage, although it appears to have been active in the past. An initial sediment sample (CSE01) collected in the ditch led to additional evaluation needs. Four additional samples (CSE04, CSE05, CSE06, and CSE07) were collected. CSE04 is near the mouth of the ditch to Ship Creek and CSE07 is at the head of the ditch located at the former Standard Steel boundary (Figure 4-4a and 4-4b).

PCBs (Aroclor 1260) were noted above SLs in all the samples, ranging from 0.05 to 2.5 mg/kg (1.4 to 73 times the SL), suggesting that residual PCBs from the old Standard Steel site are present. In addition, PAHs exceeding SLs were noted in three of the five samples (CSE01, CSE04, and, barely, at CSE07). PAHs were detected in all samples, as seen elsewhere at the Site. In addition, 4-methylphenol and dibutylphthalate were detected at trace levels at two locations.

In the case of inorganics, low level exceedances (less than 2 times the SL), similar to those seen elsewhere, were noted for antimony, arsenic, copper, and chromium. Note that inorganics data were collected only at three locations (CSE01, CSE04, and CSE06). Zinc and lead both exceeded by approximately 2.9 times their respective SLs in CSE01. Finally, cadmium was reported at 3.9 mg/kg at this location, or 6.5 times the SL.

Due to the widespread and significant magnitude of exceedances for inorganic and/or organic contaminants, this area was designated as sediment area SE-4, and will be evaluated further in Section 5.0 and Section 7.0 as a potential source of risk.

4.3 Groundwater and LNAPL nature and extent investigation

The RI groundwater sampling was conducted iteratively until sufficient data were collected to evaluate the nature and extent of contamination, and complete human health and ecological risk assessments. Two sampling events were completed in October 2005 and April 2006 in accordance with the RI/FS Work Plan. A third site-wide sampling event was completed in September 2006 to provide additional data at selected locations where contaminant concentrations exceeded RI SLs. In addition to the site-wide sampling events, step-out sampling was completed at selected locations where additional data were needed to adequately define the nature and extent of potential contamination and sources of risk. This section will discuss the nature and extent of potential contamination and sources of risk of groundwater in the Ship Creek Area. Groundwater conditions at the Terminals Area will be discussed in Section 4.8.

4.3.1 Groundwater sampling summary

Between October 2005 and May 2007, greater than 300 groundwater samples from the water table aquifer were collected at more than 150 locations across the Ship Creek Area. Of these locations, 59 were along Transects A and B representing Ship Creek bank sampling, 12 were along Transect C representing the southern boundary of the Railyard, 11 were along Transect D representing the northern boundary of the Railyard, and five samples were collected from seeps along the North Bluff (Figure 2-7). In addition to the transect wells, 28 infill locations (designated as “E wells”) were sampled in areas where pre-RI data indicated data gaps. Finally, 57 temporary step-out well locations were sampled to delineate the nature and extent at potential sources of risk based on the RI sampling results (Figure 2-7). Samples were analyzed for

compounds from the RI analyte list (Table 2-3) and compared with RI screening values to determine if additional data were required to meet the goals of the AOC.

4.3.2 Groundwater sampling results

The groundwater sampling results are presented on Figures 4-5a through Figure 4-5f and in Tables 4-11a through 4-13. The groundwater discussion for the Ship Creek Area will be divided into three parts and will address the results for each transect as well as the overall groundwater quality characteristics as follows:

1. Bank samples from Transect A and B representing potential sources of risk to Ship Creek and including step-out locations used to delineate nature and extent of potential contamination and sources of risk (Section 4.3.2.1)

2. Railyard Boundary Transects C and D (Section 4.3.2.2)

3. Ship Creek Area all wells (Section 4.3.2.3)

Background groundwater results along with background surface water, sediment, and soil were presented in Section 4.1. The results for the Terminals Area are presented as a separate discussion in Section 4.8.

4.3.2.1 Bank groundwater (Transects A and B)

The sample locations defined as "bank groundwater" for this evaluation are those located closest to the creek and are conservatively representative of the hyporheic conditions in the groundwater/surface water interface where ecological exposure may occur directly to organisms in the sediment interface, or the influx may ultimately affect surface water concentrations in the receiving water. Analytical results for bank groundwater analyses are shown on Figures 4-3a and 4-3b along with surface water results. The concentrations of compounds detected in bank groundwater samples are presented in Table 4-11a and 4-11b. "Bank groundwater" includes Transect A (north side of Ship Creek) and Transect B (south side of Ship Creek) sample locations. However, during the course of the RI, the nomenclature was not strictly adhered to, and subsequent step-out sampling, in some cases, provided a bank groundwater location closer to Ship Creek than previous samples. Therefore, not all "A" and "B" samples are considered "bank groundwater," and some "E" locations have been included as bank groundwater due to their location adjacent to Ship Creek.

For the purposes of this evaluation, groundwater data were compared to surface water RI screening criteria. For simplicity, Table 4-11a shows a comparison to both freshwater and to marine criteria for all bank groundwater, irrespective of the receiving water was tidal. Table 4-11b highlights only exceedances of the freshwater screening level, however. The screening criteria incorporate ecological and human health Ambient Water Quality Criteria (AWQC), as well as surface water background, as defined in Section 4.1.1.

The table also shows exceedances of RI groundwater screening levels and of RI vapor intrusion screening levels for reference. The evaluation of these locations as groundwater samples is presented in Section 4.3.2.3.

Table 4-11a shows the results for the joint evaluation for north and south banks. Table 4-11b is organized to show the north and south banks separately. Sample locations are ordered from west to east (upstream) along the creek. Figures 4-3a and 4-3b show locations of bank groundwater exceedances of surface water SLs.

<u>Inorganics</u>

In more than 100 groundwater samples collected (the range is from 89 to 117 samples, depending on the analyte), exceedances of surface water inorganics SLs in the Transect A and B sentinel wells were common. Bank groundwater had 20 inorganics that exceeded surface water SL concentrations in one or more wells (Table 4-11a). It should be noted, however, that there are no available site-specific background levels for

inorganics in groundwater and, as a result, the inorganics data are compared to surface water background levels only without reference to area groundwater background. Of the 20 inorganics in groundwater with one or more exceedances of surface water SLs in bank groundwater, 10 (arsenic, barium, cadmium, chromium, cobalt, copper, cyanide, lead, manganese, and mercury) also had at least one corresponding exceedance (or near exceedances) in the receiving surface water (Figure 4-1a). Bank groundwater exceedances are discussed below.

- **Aluminum**. 18 of 104 bank groundwater samples exceeded the surface water screening level of 300 µg/L with a magnitude of exceedance reaching 43.
- **Arsenic.** 62 of 106 bank groundwater samples exceeded the very low surface water screening level of 0.7 µg/L with a magnitude of exceedance reaching 89**.** Exceedance details are shown in Table 4-11b. Only 15 of these samples also exceeded the groundwater SL (10 µg/L). Concentrations ranged from 0.25 to 62 µg/L. Concentrations exceeding the SL were distributed along the full reach of Ship Creek, with the highest concentration occurring at DPB02 (Figure 4-3a and Table 4-11b). Note that corresponding surface water samples containing arsenic concentrations exceeding the SL came from 2 areas (SS12 at the mouth of a storm water outfall in the tidal area, and CSD02, CSD06, and CSD07from the Railyard Avenue marsh off-channel and intermittent area.
- **Barium.** 67 of 104 bank groundwater samples exceeded the surface water screening level of 34 µg/L with a magnitude of exceedance reaching 6. Exceedance details are shown in Table 4-11b.No samples exceeded the groundwater SL (2,000 µg/L). Concentrations ranged from 3.7 to 220 µg/L. Concentrations exceeding the SL were distributed along the full reach of Ship Creek, primarily but not exclusively along the north bank, with the highest concentration occurring at MWA05 in the tidal zone (Figure 4-3a and Table 4-11b). Ten corresponding surface water samples CS contained barium concentrations exceeding a SL (Figure 4-3a). All these surface water exceedances are in the off-channel areas.
- **Cadmium.** 29 of 107 bank groundwater samples exceeded the surface water screening level of 0.27 µg/L with a magnitude of exceedance reaching 39. Exceedance details are shown in Table 4-11b. Only two samples exceeded the groundwater SL (10.6 µg/L). Concentrations ranged from 0.04 to 10.6 µg/L. Concentrations exceeding a SL were distributed along the full reach of Ship Creek and both banks, with the highest concentration occurring at MWA05 (Figure 4-3a and Table 4-11b). Two surface water samples CSD06, and CSD07, contained corresponding cadmium concentrations exceeding a SL (Figure 4-3a). Both surface water exceedances are in intermittent off-channel areas at the Railroad Avenue Marsh and not associate with the wells with highest cadmium.
- **Chromium.** 6 of 104 bank groundwater samples, or less than 6%, exceeded the surface water screening level of 11 µg/L (for hexavelent chromium) with a magnitude of exceedance reaching 3. Exceedance details are shown in Table 4-11b. No samples exceeded the groundwater SL (100 µg/L). Concentrations ranged from 0.35 to 30 µg/L. Exceedances are scattered and noncontiguous (Figure 4-3a and Table 4-11b). Two corresponding surface water samples in the Railroad Avenue Marsh area, CSD02 and CSD04 in the intermittent Railyard Avenue marsh , contained chromium concentrations exceeding a SL (Figure 4-3a) but are not associated with bank groundwater locations exceeding the SL.
- **Cobalt**. 20 of 104 bank groundwater samples exceeded the surface water screening level of 3 µg/L with a magnitude of exceedance reaching 5
- **Copper.** 8 of 104 bank groundwater samples exceeded the surface water screening level of 9.3 µg/L with a magnitude of exceedance reaching 8. Concentrations exceeding SL were distributed along the full reach of Ship Creek, with the highest concentration occurring at the most western well on the south side of the creek, an upgradient location relative to the Site (Figure 4-3a).
- **Cyanide.** 3 of 101 bank groundwater samples exceeded the surface water screening level of 5.2 µg/L with a magnitude of exceedance reaching 20Concentrations ranged from 2.4 to 20 µg/L.

Concentrations exceeding the SL were found at 2 locations: MWA19 on the north bank, with and DPB02 on the south bank in the tidal area (Figure 4-3a). Cyanide was detected in one surface water sample only in the Railroad Avenue Marsh, but at a concentration below the freshwater SL (Figure 4-3a).

- **Iron.** 67 of 117 bank groundwater samples exceeded the surface water screening level of 3.2 µg/L with a magnitude of exceedance reaching 7. Iron exceedances are based on the surface water background level and do not take into account the much higher background concentrations seen in groundwater.
- **Lead.** 5 of 109 bank groundwater samples exceeded the surface water screening level of 300 µg/L with a magnitude of exceedance reaching 43. Exceedance details are shown in Table 4-11b. Concentrations ranged from 0.11 to 22.4 µg/L. Concentrations exceeding the SL were only found at 4 locations on the north side of Ship Creek between MWA03 and MWA12. IN all cases subsequent sampling at these same locations did not show elevated lead levels. (Figure 4-3a and Table 4-11b). Four corresponding surface water samples, all from the intermittent Railroad Avenue Marsh had lead concentrations exceeding SLs (Figure 4-3a and are not associated with the locations.
- **Magnesium,** 99 of 117 bank groundwater samples exceeded the surface water screening level of 7800 µg/L with a magnitude of exceedance reaching 11. Magnesium is a common ion of no toxicological consequence except for amphibians. Exceedances are based on the surface water background level and do not take into account the much higher background concentrations seen in groundwater.
- **Manganese.** 79 of 117 bank groundwater samples exceeded the surface water screening level of 100 µg/L with a magnitude of exceedance reaching 210. Exceedance details are shown in Table 4-11b.. Concentrations ranged from 0.67 to 21,000 µg/L. Concentrations exceeding SL were found along the full reach of both banks of Ship Creek, with the highest concentration occurring at DPA06 (Table 4-11b). Corresponding manganese concentrations in surface water exceeded the freshwater SL in 21 of 56 samples collected for the RI in both the Ship Creek main channel and off-channel areas. Exceedances do not take into account the much higher background concentrations seen in groundwater.
- **Mercury.** 3 of 104 bank groundwater samples exceeded the low surface water screening level of 0.051 µg/L with a magnitude of exceedance reaching 2.5. Exceedance details are shown in Table 4-11b. No samples exceeded the groundwater SL (2 µg/L). Concentrations ranged from 0.03 to 0.13 µg/L. Concentrations exceeding SL were found scattered on both sides of Ship Creek, with the highest concentration occurring at MWA14 (Figure 4-3a and Table 4-11b). However, note that most detection limits were higher than the screening level. Only one corresponding surface water sample, CSD07, from the Railroad Avenue Marsh had detected mercury but below the SL
- **Nickel.** 7 of 107 bank groundwater samples exceeded the surface water screening level of 52 µg/L with a magnitude of exceedance reaching 10. Exceedance details are shown in Table 4-11b. Exceedances are concentrated on the north side of the creek in the tidal area, except for an unusually high detection at DPA11.
- **Potassium.** 95 of 117 bank groundwater samples exceeded the surface water screening level of 1300 µg/L with a magnitude of exceedance reaching 31. Potassium exceedances are based on the surface water background level and do not take into account the much higher background concentrations seen in groundwater. Magnesium is a common ion of no toxicological consequence.
- **Selenium.** 9 of 104 bank groundwater samples exceeded the surface water screening level of 5 µg/L with a magnitude of exceedance reaching 2.8. Exceedances are few and minor.

- **Sodium.** 10 of 117 bank groundwater samples exceeded the surface water screening level of 4600 µg/L with a magnitude of exceedance reaching 140. Sodium is a common ion of no toxicological consequence.
- **Vanadium.** 7 of 104 bank groundwater samples exceeded the surface water screening level of 19 µg/L with a magnitude of exceedance reaching 4. Exceedances are few and minor.
- **Zinc.** 1 of 104 bank groundwater samples exceeded the surface water screening level of 120 µg/L with a magnitude of exceedance reaching 1.7. The exceedance is trivial.

Transect A and B inorganics summary

Inorganics concentrations in groundwater exceeding their respective freshwater SLs were generally distributed on both side of Ship Creek and along the full reach of the creek at the Site. Matching inorganic exceedances in surface water are limited to specific off-channel areas (Figure 4-3a), with the exception of arsenic, which was also found at a storm water outfall location in the main channel of the creek. Therefore, it does not appear that inorganics exceedances in bank water result in exceedances in Ship Creek. However, the potential risk to the biota directly affected in the sediment interface is evaluated in the ERA (Appendix C). Surface water results were discussed in detail in Section 4.2 above.

Organic constituents

Table 4-11a shows very limited surface water SL exceedances for detected organic compounds in bank groundwater:

- The maximum reported value for bis(2-ethylhexyl)phthalate is 4.6 µg/L and exceeds the surface water screening level of 2.2 µg/L in 6 of 104 samples. However, the reporting limit exceeds the screening level in 98 samples. The detected exceedances are discussed further below.
- Carbon disulfide has 1 detect and 144 non-detected exceedances in 146 samples; and xylenes had 1 detect and 49 non-detected exceedances in 147 samples. The single exceedance of carbon disulfide barely exceeds the screening level by 1.3 times. The xylenes exceedance exceeds the low screening level of 1.8 µg/L by 2.8 times. These exceedances are trivial.
- CVOCs (trichloroethylene, tetrachlorethene and vinyl chloride) exceed the surface water SLs in 7 of 154, 4 of 154 and 19 of 154 samples, respectively. These exceedances are discussed further below. Note, none of the CVOC reporting limits exceed the screening level.

On the north side of the creek (Transect A), exceedances of surface water criteria in the transect sentinel wells can be summarized as follows (Table 4-11b, Figures 4-3a and 4-3b):

- The area around DPA30 shows exceedances for trichloroethene (TCE) and tetrachloroethene (PCE) near the shoreline. This area, identified also based on site-wide groundwater concerns, is termed GW-6 and is discussed in detail in Section 5.0.
- The area around MWA16 shows persistent exceedances for vinyl chloride (VC). This area is termed GW8 and is discussed in detail in Section 5.0. The absence of elevated concentrations in downgradient locations DPA-33 suggests that these elevated concentrations do not reach Ship Creek.
- The area around MWA19 shows exceedances for TCE. This area is termed GW9 and is discussed in detail in Section 5.0. The absence of elevated concentrations at sentinel well DPE30 installed downgradient of the suspected source area, or at MWA18 that also is located downgradient, suggests these elevated concentrations do not reach Ship Creek.
- Low level exceedances for BEHP were noted in three locations and are discussed further in Section 5.2: MWA05 (4.1 µg/L), SP60 (4.1 µg/L), and MWA08 (4.6 µg/L), at 1.9 to 2.1 times the surface water

SL. These are all located in the eastern part of the Site. In addition, MWA08 exceeds for carbon disulfide (1.2 µg/L or 1.3 times the surface water SL).

On the south side of Ship Creek (Transect B), exceedances exactly coincide with areas otherwise identified as groundwater concerns:

- Areas near DPB03 and DPB04 were identified based on concentration of VC exceeding the surface water SL in wells near the creek. This area is designated as GW-4 and is discussed in detail in Section 5.0.
- Areas near DPB07 and DPB08 were identified based on concentration of VC exceeding the surface water SL in wells near the creek. This area is designated as GW-2/3 and is discussed in detail in Section 5.0.
- Areas near MWB17 and DPB18 were identified based on concentration of TCE exceeding the surface water SL. This area is designated GW1 and is discussed in detail in Section 5.0. Sediment sampling conduced in June 2007 in the discharge area for this plume show the presence of TCE.

Transect A and B organic constituent summary

The nature and extent of organic contaminant occurrence in bank groundwater identified based on surface water impact concerns coincides with those areas with elevated CVOCs identified based on Site wide groundwater evaluations (see below). The only additional issue related to bank groundwater is low level exceedances for BEHP and carbon disulfide in the lower, tidal portion of the creek. These minimal exceedances are not likely to result in impacts to Ship Creek, nor are they associated with widespread elevated concentrations. The ecological risk assessment will address Ship Creek risk-related concerns.

4.3.2.2 Railyard boundaries (Transects C and D)

The sample locations in the Railyard include all Transect C and D locations. Because no areas of groundwater concern (e.g. GW-1, GW-2/3, GW-4, etc. as discussed above) were identified for Transects C and D, the discussion of these transects will be different than for Transects A and B. Instead of identifying areas of concern and delineating the extent of contamination, the discussion of Transects C and D will focus on compounds that potentially could migrate across them. Each groundwater sample along Transects C and D was analyzed for the list of constituents on the project analyte list (Table 2-3) and included the following compound categories: 1) organic constituents, which consist of fuel hydrocarbons (EPH and VPH), VOCs (including CVOCs), and SVOCs; and 2) inorganics, which consist of the 20 inorganics on the RI analyte list (Table 2-3) . Pesticides, PCBs, and herbicides were analyzed if pre-RI data or Site operational history indicated their potential presence in an area. Results for these compounds will be discussed only if detections occurred. Analytical results for Transects C and D are shown on Figures 4-5a and 4-5f. A summary of the analytical data is provided in Table 4-12a and concentrations of specific compounds of interest are presented in Table 4-12b. The results for each transect and group of infill wells are discussed below.

Transect C

The purpose of Transect C (Figure 1-5) was to evaluate if contaminants dissolved in groundwater at concentrations exceeding the RI SLs were migrating from the Railyard to ARRC leased properties located to the south. Twelve monitoring wells (MWC01 to MWC12) (Figure 2-7) were located along the length of Transect C. Groundwater data were compared to groundwater RI screening criteria (Table 2-3). The results of groundwater monitoring for each compound category are as follows:

Inorganics

The results for inorganics compounds are shown on Figures 4-5a and 4-5b and Table 4-12a and 4-12b.

- **Arsenic** exceeded its RI SL of 10 µg/L at least one time, at MWC02 and MWC07, with maximum concentration values of 24.7 and 11.5, respectively. Arsenic concentrations at MWC07 decreased to below SLs to 2.6 µg/L during the April 2006 sampling event (Figure 4-5a and Table 4-12b).
- **Cadmium** exceeded its RI SL of 5 µg/L at MWC10, with a maximum concentration value of 180 µg/L. Cadmium concentration at MWC10 decreased to 6.6 µg/L during the September 2006 sampling event (Figure 4-5a and Table 4-12b).

Organic constituents

The results for organic compounds are shown on Figures 4-5c through 4-5f and Table 4-12a and 4-12b.

- **Fuel Hydrocarbons** were detected at two (MWC02 and MWC04) of the 12 Transect C wells (Figure 4-5f). However, no detected EPH or VPH concentrations exceeded an RI SL (Table 4-12b).
- **VOCs,** not including CVOCs, were detected at one (MWC02) of the 12 Transect C wells (Figure 4-5d). However, no detected VOC concentration exceeded an RI SL (Table 4-12b).
- **CVOCs**, consisting of TCE, PCE, VC, and daughter products, were detected at two (MWC01 and MWC02) of the 12 Transect C wells (Figure 4-5c). However, no detected CVOC concentrations exceeded an RI SL (Table 4-12b).
- **SVOCs** were detected at one (MWC07) of the 12 Transect C wells (Figure 4-5e). However, no detected SVOC concentrations exceeded an RI SL anywhere in the Ship Creek Area (Table 4-12b).

Transect C summary

With the exception of arsenic and cadmium, no compound in any category exceeded an RI SL. Based on these results, no compound exceeding RI SLs was observed to be migrating from the Railyard and impacting adjacent leased properties.

Transect D

The purpose of Transect D (Figure 1-4) was to evaluate if contaminants in groundwater migrate from upgradient sources and impact the groundwater quality beneath the Railyard. The sample locations (wells and seeps) along Transect D are considered representative of anthopogenic background entering the Site and were included in the data set used to estimate background. Eleven monitoring wells (Figure 2-7) were located along the length of Transect D. In addition to the monitoring wells, five seep locations along the North Bluff (SP01, SP24, SP35, SP40, and SP48) were regularly sampled as part of the RI groundwater program in of 21 seeps along the bluff which were sampled in 2004. Groundwater and seep data were compared to groundwater RI screening criteria (Table 2-3). The results of groundwater monitoring for each compound category are as follows:

Inorganics

The results for selected inorganics compounds are shown on Figures 4-5a and 4-5b and Table 4-12b. These inorganics from upgradient sources may contribute to concentrations at the Site.

- **Arsenic** exceeded its RI SL of 10 µg/L at MWD08, with a concentration 19.4 µg/L in October 2005 (Table 4-12b and Figure 4-5a). Arsenic concentrations at MWD08 decreased during subsequent sampling events to below RI SLs (Figure 4-5a and Table 4-12b).
- **Cadmium** exceeded its RI SL of 5 µg/L at SP12, MWD06 and MWD08, with maximum concentration values of 230 µg/L. Cadmium concentrations decreased to 16 µg/L during the April 2006 sampling event at MWD06 but remained relatively constant at MWD08 (Figure 4-5a and Table 4-12b).

- **Nickel** concentrations exceeded the RI SL of 100 µg/L at three wells, DPD04, DPD10, and DPD12 with maximum concentration values of 190 µg/L, 250 µg/L, and 1800 µg/L, respectively (Figure 4-5a and Table 4-12b). Nickel concentrations decreased to below the RI SL at DPD10 during the April and September 2006 sampling event. At DPD12, the nickel concentration dropped to 580 µg/L DPD12 (Figure 4-5a and Table 4-12b).

- **Manganese**. Manganese exceedances have been noted in DPD13, MWD01, SP24, SP35, and SP48.

Organic constituents

The results for organic compounds are shown on Figures 4-5c through 4-5f and Table 4-12a and 4-12b. These detections are indications of upgradient contributions to Site groundwater.

- **Fuel Hydrocarbons** were detected at one (DPD13) of the 12 Transect D wells (Figure 4-5f). Both EPH (2,270 µg/L) and VPH (3,960 µg/L) concentrations exceeded their RI SLs of 1,500 µg/L and 1,300 µg/L, respectively (Table 4-12b). Additionally, water from seep SP35, adjacent to DPD13, had a VPH concentration of as high as 2,450 µg/L (Figure 4-5f). The fuel hydrocarbons in this area were identified prior to the RI and are believed to be associated with a previously noted release from an EAFB fuel pipeline at the top of the bluff. Seep SP12 (Figure 4-5f), sampled in September 2004, contained dissolved phase DRO in groundwater at a concentration of 4,200 µg/L.
- **VOCs** (except CVOCs), were detected at many Transect D locations (Figure 4-5d). One seep location, SP35, which is located adjacent to DPD13, did have concentrations of benzene ranging from 8.3 µg/L to 16 µg/L, which exceed the RI SL concentration of 5 µg/L (Table 4-12b).
- **CVOCs** (TCE, PCE, vinyl chloride) were detected at several Transect D locations (Figure 4-5c). On the railyard TCE was detected but at concentrations below the RI SL of 5 µg/L (Table 4-12b and Figure 4-5c). In the eastern end of the Site several seeps have elevated TCE. These seeps are located within the EAFB OU5 area, derive from known sources at EAFB, and are actively managed by recovery system operated by EAFB (RETEC, 2004a).
- **SVOCs.** No detected SVOCs in the D transect exceeded screening levels. A few locations, such as SP35, had detections of naphthalene (Table 4-12b and Figure 4-5e).

Transect D summary

The results along Transect D were consistent with pre-RI data. Fuel hydrocarbons and benzene are present in one area (SP35/DPD13) associated with a known fuel spill at EAFB. The elevated TCE concentrations at the eastern end of the Site are associated with the EAFB OU5 TCE plume. Both of these of-site sources to Site groundwater were known. (Figures 3-4a, 3-4b, and 3-4c). It is likely that TCE from this source may be the source of the low concentrations (below RI SLs) at downgradient MWC12 and MWE16 (Figure 4-5c).

Several metals show elevated concentrations entering the railyard at several locations along the bluff. These scattered but elevated concentrations may affect Site concentrations and are indicative of the complex groundwater background conditions at the Site.

4.3.2.3 Ship Creek Area all wells

This section will describe the overall groundwater quality conditions and plume delineation for the Ship Creek Area. The data presented are from all four transects as well as infill wells (i.e., those wells identified with an "E" in the location nomenclature). Summary statistics are shown in Table 4-13 and detailed RI analytical results are provided for Transects A and B in Tables 4-11a and 4-11b and for Transect C and D, and E wells, in Tables 4-12a, and 4-12b. The distribution of compounds are all shown on Figures 4-5a through 4-5f.

Organic constituents

The results for organic compounds are summarized in Table 4-13, and shown on Figures 4-5c through 4-5f. Tables 4-11b and 4-12b show detailed results for key constituents.

- **Fuel Hydrocarbons**. EPH and VPH were analyzed throughout the Ship Creek Area as part of the RI. Of the over 200 analyses completed, EPH was detected in 31 samples and VPH in 24 samples (Tables 4-11a and 4-12a). Six sample concentrations exceeded the total EPH and VPH RI SLs of 1,500 µg/L and 1,300 µg/L, respectively. Although EPH and VPH samples were collected from across the entire Ship Creek Area, exceedances were limited to wells located in three areas of previously identified contamination and known sources. Detailed observations for these areas are summarized below.
  - **Former fueling area and storage tank also identified as GW-7 (Figure 5-1).** Two wells (MWE05 and MWE06) had maximum EPH concentrations of 3,670 µ/L and 3,500 µg/L, respectively during the October 2005 RI sampling event (Figure 4-5f). EPH concentrations decreased to below the RI SL during subsequent sample events. Maximum VPH concentrations of 1,890 µg/L and 2,340 µg/L, respectively, occurred during the October 2005 RI sampling event. VPH concentrations have decreased to below the RI SL at MWE05 but have remained relatively constant at MWE06 (Figure 4-5f). This occurrence of fuel hydrocarbons is limited in extent as no EPH or VPH exceedance occurs either upgradient at MWD06 or downgradient at sampling points MWC01 through MWC04 (Figure 4-5f).
  - **LP991 Arctic Cooperage area also identified as GW-5 (Figure 5-1).** Two wells (MWE22 and MWE25) had maximum EPH concentrations of 10,300 µg/L and 1,790 µg/L, respectively (Figure 4-5f). Although total VPH was detected at both wells, concentrations were below the RI SL. EPH concentrations decreased to below the RI SL during the April 2006 sampling event at MWE25, but increased at MWE22 (Figure 4-5f). This occurrence of fuel hydrocarbons is limited in extent, as neither EPH nor VPH were detected at upgradient or downgradient locations (Figure 4-5f). Groundwater contamination at this leased property is related to historical oil recycling operations and releases, and was well documented in the SBR (RETEC, 2005b).
  - **North Bluff at west end of Transect D (Figure 2-7).** One well (DPD13) and one seep (SP35) had fuel hydrocarbon concentrations exceeding SLs. Well DPDC13 had EPH and VPH concentrations of 2,270 µ/L and 3,960 µ/L, respectively, both of which exceeded RI SLs. VPH was detected in both well DPDC-13 and seep SP35. However, the concentrations exceeded the SL of 1,300 µg/L only at SP35. Hydrocarbons in this area are likely related to releases associated with an EAFB fuel line. These were discussed in Section 4.3.2.2 above.

At two wells, MWE04 and MWA07, the C12-C16 range of aliphatics exceeded the RI SL. However, the total EPH and VPH at both locations were below the RI SLs (Figure 4-5f). MWE03, located in the center of the western area of the ARRC Railyard near the fueling and maintenance areas, showed no hydrocarbon exceedances. Well MWA07, at LP049, was identified as area GW-6 and discussed in Section 4.3.2.1. It will be discussed further in Section 5.2.

- **VOCs** were analyzed and generally detected at concentrations below the groundwater RI SL across the Ship Creek Area (Figure 4-5d). However, six VOC compounds located in four areas exceeded the groundwater RI SLs (Tables 4-11a and 4-12a). The compounds that exceeded SLs were 1,1,2-Trichloroethane (three exceedances), 1,2-Dibromo-3-chloropropane (one exceedance), benzene (12 exceedances), PCE (11 exceedances), TCE (35 exceedances), and VC (34 exceedances) (Tables 4-11a and 4-12a). PCE, TCE, and VC are discussed below. These areas are co-located with those areas identified as having fuel hydrocarbon concentrations exceeding RI SLs.
  - **LP049 GW-6 (Figure 5-1).** One well at this location had a concentration of 1,1,2-Trichloroethane (6 µg/L) that exceeded the groundwater RI screening of 5 µg/L (Figure 4-5d). Although other VOCs were detected upgradient and downgradient of this location, none exceeded the

groundwater RI SL. Fuel hydrocarbons also exceeded RI SLs at this location as discussed above.

- **Former fueling area and storage tank GW-7 (Figure 5-1).** Two wells located in the northwest area of the Railyard had VOC exceedances (Figure 4-5d). Wells MWE05 and MWE06 had maximum benzene concentrations of 25 µg/L and 9 µg/L, respectively, which were above the groundwater RI SL of 5 µg/L. MWE05 also exceeded the groundwater RI SL of 0.048 µg/L for 1,2-dibromo-3-chloropropane (4.09 µg/L) during the October 2005 sampling event. However, it was not detected during subsequent sampling events. Well MWE05 also exceeded the groundwater RI SL for 1,1,2-Trichloroethane (7.7 µg/L). Hydrocarbon contamination in this area is limited in extent and related to fuel dispensing and storage in the area as discussed above. This area will be discussed further in Section 5.0.
- **LP991 Arctic Cooperage area also identified as GW-5 (Figure 5-1).** Two wells (MWE22 and MWE25) had maximum benzene concentrations of 21 µg/L and 9.19 µg/L, respectively, which exceed the groundwater SL (Figure 4-5d). Additionally, 1,1,2-Trichloroethane (5.1 µg/L) occurred at a concentration exceeding the groundwater RI SL. This area also had fuel hydrocarbon exceedances. As discussed above, this contamination is limited in extent as no upgradient or downgradient wells had concentrations of fuel hydrocarbons or VOCs exceeding the groundwater SLs (Figure 4-5f and Figure 4-5d). Groundwater contamination at this leased property is related to past oil recycling operations and releases. These were well documented in the SBR (RETEC, 2005b).
- **North Bluff at the west end of Transect C (Figure 2-7).** One seep, SP35, had benzene concentrations exceeding the groundwater SL (Figure 4-5d). Seep SP35 had benzene concentrations ranging from 8.3 to 16 µg/L. Adjacent well DPD13 did not exceed for any VOC, although low level VOC concentrations were observed. Again, like the other areas discussed for VOCs, fuel hydrocarbons also were detected in this area (Figure 4-5f and Figure 4-5d).

- **CVOC** concentrations exceeded groundwater RI SLs in 73 samples. These exceedances were located in six areas across the Ship Creek Area. Three of the occurrences were located on the south side of Ship and are identified as GW-1, GW-2/3, and GW-4. The other three areas were located on the north side of Ship Creek and are identified as GW-6, GW-8, and GW-9 (Figure 5-1 shows all groundwater areas on single map). These areas will be described below and discussed further in Section 5.0.
  - **GW-1** is located on the south side of Ship Creek on the southeastern boundary of the Site (Figure 5-1). TCE was initially detected above the groundwater RI SL of 5 µg/L at MWB17 (16.4 µg/L) and DPB18 (51 µg/L) (Figure 4-5c). As a result of these exceedances, three additional monitoring wells were installed (DPB21, DPB22, and DPB23) (Figure 4-5c). TCE concentrations at DPB21 exceeded the groundwater RI SL but were below the SL at DPB22 and DPB23. In order to delineate the extent of TCE at this location, an additional six temporary groundwater wells were installed and sampled (DPB18A1, DPB18A2, DPB18D1, DBP17A1, DBP17A2, and DBP17B1) (Figure 4-5c). Finally, existing upgradient wells B18E1 and B18E2 and downgradient well DPB16 were sampled to determine the full extent of CVOCs.

    TCE concentrations exceeding the groundwater RI screening levels were detected in wells MWB17B1 (31 µg/L), MWB17A2 (15 µg/L), MWB17 (1 µg/L), MWB17A1 (70 µg/L), MWB18A2 (56 µg/L), MWB18 (50 µg/L), MWB18A1 (190 µg/L), and MWB21 (270 µg/L) (Figure 4-5c, and Tables 4-11b and 4-12b). TCE concentrations decreased to the west becoming less than the screening levels at MWB17-B1 and non-detect at DPB13. TCE concentrations increased to the east with the highest concentration of TCE (270 µg/L) occurring at DPB21, on the east boundary of the Site. TCE was non-detect approximately 1000 feet to the east, in groundwater samples from wells B18-E1 and B18-E2. On the north bank of Ship Creek, opposite GW-1, wells DPE30 and MWA20 through MWA25 were all non-detect for TCE (Figure 4-5c).

The on-site area of TCE exceedances at GW-1 is delineated, on the north by Ship Creek, to the west by well DPB16 (0.18 µg/L), and to the south by DPB22 (ND), DPB23 (1.2 µg/L), and DPB18-B1 (ND) (Figure 4-5c). Based on these data and the fact that groundwater flow at GW-1 is from east to west (Figure 3-4c), an upgradient and off-site source within 1000 feet of the property is indicated.

Additional soil and groundwater data were collected by ADEC and ARRC in June and August 2007, respectively. These data indicated that while TCE concentrations in groundwater do exceed screening levels upgradient of the ARRC boundary, concentrations are lower than observed at DPB21and decrease to the east and southeast. Five soil samples collected by ADEC at locations within 1000 feet upgradient of GW-1 had TCE concentrations that exceeded the ADEC soil to groundwater leaching screening level. Although no source was determined at the time of sampling, these soil impacts indicate previous releases of TCE at concentrations that could impact groundwater upgradient of the ARRC boundary and GW-1. The result of ADEC and ARRC 2007 sampling are provided in Appendix L. GW-1 will be discussed further in Section 5.0.

- **GW-2/3** is located on the south side of Ship Creek (Figure 5-1). Based on detections of VC, it extends along Ship Creek Avenue for approximately 1,000 feet from east of MWB07 to the intersection of Ship Creek Avenue and Ingra Street. VC was initially detected above the groundwater RI SL of 2 µg/L at MWB08 (3.3 µg/L) and MWB09 (6.5 µg/L) (Figure 4-5c). As a result, one additional monitoring well (DPB24) and 16 temporary step-out monitoring wells (DPB08A1, DPB08A2 DPB08B1 DPB08B2 DPB08B3 DPB08C1 DPB08C4, MWB09-A1, MWB09-A1, MWB09-A2, MWB09-B1, MWB09-B2, MWB09-C1, MWB09-D1, MWB09-D2, MWB09-D3, MWB09-E3) (Figure 4-5c) were installed to delineate the extent of VC and other associated CVOCs in the area.

  The limit of CVOCs at GW-2/3 is shown on Figure 4-5c. VC exceedance concentrations ranged from 3.7 to 25 µg/L, with the highest concentration occurring at MWB09-B2 (Figure 4-5c) in the eastern portion of the area. Although TCE concentrations were below SLs, low level TCE occurred in all samples east of MWB09-B2 (Figure 4-5c). TCE was the only CVOC occurring on the far east side in the vicinity of Ingra Street at wells MWB09-B1, and MWB09-D1 to D3. Pre-RI data indicated that TCE (21.7 µg/L) and PCE (14 µg/L) exceeded screening levels east of GW-2/3 at off-site well B2A (Figure 2-4a). A review of potential CVOC sources of contamination in the vicinity of GW-2/3 was completed by U.S. EPA in October 2007 and noted a documented source approximately 1,300 feet upgradient of GW-2/3 (Appendix N). The TCE and PCE source noted by U.S. EPA was commingled with a petroleum hydrocarbon plume. U.S. EPA speculated that the mixing of the CVOC and petroleum hydrocarbon could have enhanced the reductive dechlorination process resulting in the vinyl chloride observed downgradient at GW 2/3.

  To the north, on the opposite bank of Ship Creek, low level TCE and cis-1,2-dichloroethene were detected in wells MWA08 through MWA10. Wells MWA11 through MWA14 were non-detect for all CVOCs. The nearest CVOC exceedances on the north bank occurred at MWA16 (VC - 3.5 µg/L) and MW6 (TCE – 16.9 µg/L) at LP127 (Figure 4-5c).

  VC exceedances are bounded on the east by step-out wells MWB09-D1, MWB09-D2, and MWB09-D3. However, concentrations at an off-site well, B2A, approximately 1000 feet upgradient did exceed screening levels for both TCE and PCE (Figure 2-4a). To the west, CVOCs are bounded by step-out well DPB08C4 (Figure 4-5c). To the south, CVOC exceedances are bounded by wells DPB24, DPB08C2, and DPB08C2 (Figure 4-5c). The northern extent of GW-2/3 is bounded by Ship Creek. Although CVOCs occur on the north side of Ship Creek, upgradient of GW-2/3 at GW-8, wells MWB10 and MWB11 located between GW-8 and GW-2/3 were non-detect for CVOCs (Figure 4-5c). Additionally, the concentration of VC was lower at the upgradient location, MWA16, than at GW-2/3 (Figure 4-5c). These data indicate that GW-2/3 is not connected to GW1 or sources on the north side of Ship Creek. The source(s) of CVOCs exceedances at GW-2/3 are likely located on the south side of the creek upgradient and potentially off-site from GW-2/3. GW-2/3 will be discussed further in Section 5.0.

- **GW-4** is located on the south side of Ship Creek (Figure 5-1). It extends to the southeast for approximately 1,200 feet between wells DPB03B1 and DPB04E3. It is characterized by VC ranging from 1.6 µg/L to 9.5 µg/L, with the highest concentration occurring at DPB04E3 (Figure 4-5c). VC was initially detected exceeding the groundwater RI screening level of 2 µg/L at DPB03 (7.27 µg/L) and DPB04 (5.07 µg/L) (Figure 4-5c). As a result of these exceedances, two new monitoring wells, DPB26 and DPB27, and 15 temporary step-out monitoring wells (DPB03A1, DPB03A2 DPB03B1 DPB03B2 DPB03C1, DPB04A1, DPB04A2, DPB04D1, DPB042, DPB04D3, DPB04D4, DPB04E1, DPB04E2, DPB04E3, DPB04E4) (Figure 4-5c) were installed to delineate the extent of VC.

  The extent of low concentrations of VC and other CVOCs at GW-4 are shown on Figure 4-5c. VC exceedances at GW-4 extend southeast to the southern boundary of the Site at DPB04E3, where the highest VC concentration (9.5 µg/L) occurred. Non-detect results for VC at wells MWB06, MWB04-E2, MWB07, and DPB08-C3 (Figure 4-5c) delineate the eastern boundary of GW-4. The northwestern extent of GW-4 is delineated by DPB02 and Ship Creek. The full extent of GW-4 to the southwest was not delineated due to drilling limitations. Currently, exceedance concentrations at DPB03-B2 (3µg/L) and DPB04-A1 (3.2 µg/L) remain unbounded. The northern boundary of GW-4 is Ship Creek. CVOCs exceedances occur on the north bank of Ship Creek immediately across from GW-4 in well DPA30 (TCE 62 µg/L and PCE 6.1 µg/L) at GW-6.

  Although the specific source(s) for the low level CVOCs at GW-4 cannot be identified, this area is not likely to be continuous with either GW-2/3 or GW-6 on the north side of Ship Creek. GW-4 is situated cross gradient from GW-2/3 based on groundwater flow directions which are to the north-northwest (Figure 3-4). Further, the distribution of non-detect results at MWB06, MWB07, and DPB08-C3 delineate a boundary roughly parallel to flow between the two occurrences. In the vicinity of GW-4 Ship Creek is deeply incised in the marine sediments and/or Bootlegger Formation as discussed in Sections 3.2 and 3.3. As a result, the alluvial aquifer in this area is not continuous across the creek and thus no hydraulic connection between the GW-4 and GW-6 aquifers is possible. GW-4 will be discussed further in Section 5.0.

- **GW-6** is located on the north side of Ship Creek immediately to the east of LP049 extending north from Ship Creek beneath the A-C Couplet Bridge for approximately 500 feet (Figure 5-1). TCE, PCE, and VC were initially detected at DPA30 at concentrations of 62 µg/L, 6.1 µg/L, and 1.5 µg/L, respectively. TCE and PCE exceeded the groundwater RI SL of 5 µg/L; however,. VC did not exceed its SL. Based on these results, twelve temporary monitoring wells (DPA30D1, DPA30D2, DPA30D3, DPA30-D4, DPA30E1, DPA30E2, DPA30E3, DPA30E4, DPA30F1, DPA30F2, DPA30F3, DPA30F4) were installed and sampled (Figure 4-5c).

  TCE exceedance concentrations ranged from 5 to 62 µg/L, with the highest concentration at DPA30. PCE exceedance concentrations ranged from 6.1 to 20 µg/L, with the highest concentration at DPA30F1. Although detected, VC did not exceed the groundwater RI SL at any sample location. GW-6 extends north across the ARRC Railyard southern boundary. The extent of CVOC at GW-6 is bounded by wells with concentrations below screening levels: These consist of wells MWD01 and DPB02; to the north, wells MWE01, MWA05, DPA06, and DPA30D3; to the west and wells MWA07, MWE20, DPA30F2, and DPA30D1 to the east. To the south, GW-6 is bounded by Ship Creek. As discussed above, GW-6 is not likely related to GW-4 on the south bank of Ship Creek.

  The specific source(s) for GW-6 is not identified. However, the distribution of exceedances beneath the A-C Couplet Bridge suggests a preferential pathway along the footprint of the bridge and a potential source to the north of the creek (Figure 4-5c). GW-6 will be discussed further in Section 5.0.

- **GW-8** is located on the north side of Ship Creek at LP127 (Figure 5-1). TCE and VC were detected in two separate wells at concentrations exceeding groundwater RI SLs. TCE was detected at monitoring well MW-6[14] (16.9 µg/L) and VC was detected at well MWA16 (6.4 µg/L) (Figure 4-5c). Based on these results, well DPA31 was installed upgradient of MWA16 and well DPA33 was installed downgradient of MW-6. No CVOC concentration above the reporting limit was detected at either of these new wells.

  CVOCs were documented at this location based on pre-RI data in the SBR (RETEC, 2005b), and are associated with Kelly-Moore Paint operations (based on the ADEC Contaminated Sites Database). Although no monitoring well could be placed between MWA18 and Ship Creek, no VC has been reported downgradient of this location on the north side of Ship Creek (Figure 4-5c). Although, CVOCs occur on the south side of Ship Creek at GW-2/3, wells MWB10 and MWB11, located between the GW-8 and GW-2/3 are non-detect for all CVOCs (Figure 4-5c). Therefore, GW-8 is not likely to be a source of CVOCs exceedances in GW-1 and GW-2/3 on the south side of Ship Creek. One well, MWA31, located on the south bank, and downgradient of GW-8 had a detection of low level, "J" flagged TCE (0.18 µg/L). This well is in the vicinity of LP022 (ML&P) where similar low levels of TCE have been previously detected (Figure 2-4a). GW-8 will be discussed further in Section 5.0.

- **GW-9** is located on the north side of Ship Creek at LP085 (Figure 5-1). TCE and PCE were initially detected at well MWA19 at concentrations exceeding groundwater RI SLs (Figure 4-5c). Maximum concentration of TCE and PCE were 14 µg/L and 26.3 µg/L, respectively. As a result, of these initial exceedances, two wells DPA32 and DPE30 were installed upgradient of GW-9 respectively (Figure 4-5c). No CVOCs were detected above laboratory detection limits at either of the new wells. Additionally, only low level (less than 1 µg/L) "J" flagged CVOC concentrations were detected at downgradient well MWA18. Further downgradient at GW-8, TCE and VC were detected above screening levels; however, the source of these exceedances has been identified by ADEC as being related to Kelly-Moore Paint (ADEC Contaminated Sites Database File Number 2100.38.036). TCE and PCE exceedances were documented at this location in the SBR (RETEC 2005b). The data from the new wells (DPA30 and DPE32) and MW18 would suggest that the CVOCs are not migrating toward Ship Creek. Also, based on the previous discussion of GW-1 and GW-2/3, it is unlikely that GW-9 is a source of CVOCs on the south side of Ship Creek. GW-9 will be discussed further in Section 5.0.

The CVOC occurrences discussed above all are bounded by Ship Creek (GW-1, GW-2/3, GW-4, GW-6, GW-8) or are immediately upgradient of the creek (GW-9). However, data from the north and south banks indicate that contaminants are not likely to be migrating from one side of the creek to the other. This is consistent with the hydrogeologic data showing a groundwater divide at Ship Creek, as discussed in Sections 3.3 and 3.7. Downgradient and across the creek from GW-1, CVOCs are not detected above laboratory detection limits in wells MWA21 through MWA22 (Figure 4-5c). Likewise, wells that are downgradient and across Ship Creek from GW-2/3 and GW-4 have low level TCE and PCE concentrations, whereas GW-2/3 and GW-4 are VC occurrences, indicating they are not sources for occurrences on the north side of the creek (Figure 4-5c). Wells downgradient and across the creek to the south from GW-9, where TCE and PCE occur, had CVOCs below laboratory detection limits (Figure 4-5c). Finally, the alluvial aquifer between GW-6 and GW-4 has been incised by the creek and is not continuous between the two occurrences. Thus no hydraulic connection between the north and south sides of the creek..

- **SVOCs** in groundwater did not exceed groundwater RI SLs at any RI sample location (Figure 4-5e).

[14] This is not an RI well but it was sampled by a third party during the RI.

Inorganics

Over 200 groundwater samples were collected and analyzed for the 20 inorganics listed in the RI project analyte list (Table 2-3). Each inorganic was detected in at least one sample (Tables 4-11a and 4-12a). However, only arsenic, cadmium, lead, nickel, iron, and manganese exceeded their respective groundwater RI SLs. The distribution of inorganic concentrations exceeding the groundwater RI SL levels are shown on Figures 4-5a and 4-5b. A discussion of each inorganic exceedance is provided below.

- **Arsenic** concentrations exceeded the groundwater RI SL of 10 µg/L in 28 of 154 samples where it was found above the laboratory detection limit (Tables 4-11a and 4-12a). Arsenic concentrations ranged from 0.21 µg/L to 62 µg/L, with the highest concentration occurring at DPB02 (Figure 4-5a and Tables 4-11b and 4-12b). Arsenic exceedances were distributed on both sides of Ship Creek and across the Ship Creek Area west of MWA24 (Figure 4-5a).
- **Cadmium** concentrations exceeded the groundwater RI SL of 5 µg/L in 12 of 123 samples where it was found above the laboratory detection limit (Tables 4-11a and 4-12a). Cadmium concentrations ranged from 0.041µg/L to 230 µg/L, with the highest concentration occurring at MWD06 (Figure 4-5a and Tables 4-11b and 4-12b). However, cadmium concentrations at MWD06 decreased to 6 µg/L during subsequent sampling events (Figure 4-5a; Tables 4-11b and 4-12b). Cadmium exceedances occurred only on the north side of Ship Creek and west of MWA24 (Figure 4-5a).
- **Lead** concentrations exceeded the groundwater RI SL of 18 µg/L in 3 of 96 samples where it was found above the laboratory detection limit (Tables 4-11a and 4-12a). Lead concentrations ranged from 0.09 to 22.4 µg/L, with the highest concentration occurring at DPA03 (Figure 4-5a). However, lead concentrations at the three sample locations where they initially exceeded SLs (DPA03, MWA05, and MWE23) decreased to below the SLs during subsequent sampling events (Figure 4-5a; Tables 4-11b and 4-12b). Decreases in inorganics concentrations during subsequent sampling events may reflect better groundwater flow through the well with time (i.e., since well completion). Lead exceedances were found only on the north side of Ship Creek (Figure 4-5a).
- **Nickel** concentrations exceeded the groundwater RI SL of 100 µg/L in 11 of 189 samples where it was found above the laboratory detection limit (Tables 4-11a and 4-12a). Nickel concentrations ranged from 0.45 to 1800 µg/L, with the highest concentration occurring at DPD12 (Figure 4-5a). However, concentrations generally decreased in subsequent sampling events (Figure 4-5a; Tables 4-11b and 4-12b). Decreases in inorganics concentrations during subsequent sampling events may reflect better groundwater flow through the well with time (i.e., since well completion). With the exception of MWB05, DPA11 and DPB16 all nickel exceedances were found along the northern boundary of the Railyard at Transect D wells (Figure 4-5a).
- **Iron** concentrations exceeded the groundwater RI SL of 10,950 µg/L in 40 of 184 samples where it was found above the laboratory detection limit (Tables 4-11a and 4-12a). Iron concentrations ranged from 22 to 60,600 µg/L, with the highest concentration occurring at MWE22 (Figure 4-5b). Iron concentrations exceeding SLs are distributed on both sides of Ship Creek and extend across the Site (Figure 4-5b; Tables 4-11b and 4-12b).
- **Manganese** concentrations exceeded the groundwater RI SL of 876 µg/L in 97 of 224 samples where it was found above the laboratory detection limit (Tables 4-11a and 4-12a). Manganese concentrations ranged from 0.67 to 21,000 µg/L, with the highest concentration occurring at DPA06 (Figure 4-5b). Manganese concentrations exceeding SLs are distributed on both sides of Ship Creek and extend across the Site (Figure 4-5b; Tables 4-11b and 4-12b).

With the exception of manganese exceedances, which are found across the entire Site, inorganics exceedances are generally located west of well DPE32 (Figures 4-5a and 4-5b). Nickel exceedances appear to have a biased geographic distribution, with 10 of 11 exceedances located along the North Bluff (Figure 4-5a). The distribution of iron and manganese also shows a distribution to reducing environments. In general,

reducing environments will have higher concentrations of iron and manganese, because both inorganics are more soluble in their reduced (oxidation state II) state. As shown on Figure 4-5b, many exceedances for iron and manganese exist either in the clay-rich western estuarine area or in marshy areas close to Ship Creek, both of which would produce reducing conditions. Also, there appears to be a correlation between the distribution of VOC occurrences with that of elevated iron and manganese (e.g., MWE05, MWE06, MWE22, DPB21) (Figure 4-5b). This likely reflects VOC natural attenuation processes, which consume oxygen during the early phases and result in reduced groundwater conditions.

4.3.3 LNAPL summary

As part of each RI groundwater monitoring event, all RI wells were gauged using an oil/water interface probe to determine the presence or absence of LNAPL. Three gauging events were completed in October 2005, April 2006, and September 2006. As shown in the table below measurable LNAPL was encountered in only two wells.

Monitoring Well	Location	Date	Depth to Product (feet)	Depth To Water (feet)	Product Thickness (feet)
LP991-MWE21	Former Arctic Cooperage Site, GW-5	4/5/2006	10.92	12.95	2.03
RY065-MWE05	Former Railyard Fueling Area, GW-7	9/21/2006	3.75	4.83	1.08

LNAPL was detected at the former Arctic Cooperage site (Figure 1-1) in an area with known historical releases of LNAPL. Historical LNAPL investigation and remediation in this area were performed under ADEC regulatory supervision and the site is listed in ADEC's Contaminated Sites Database. LNAPL was first detected at this location in 1997 and was identified as unweathered JP-8/arctic diesel (Booz-Allen Hamilton, 1999). Historically, product was recovered weekly from the area using either passive skimming canisters or hand bailing beginning in December 1997. Product recovery efforts continued through at least May 1999 and then discontinued. The monitoring wells listed above were abandoned and the area was paved in 2006. LNAPL was detected during the April 2006 RI monitoring event at one monitoring well, MWE21 (Figure 2-7), as indicated above. LNAPL was not detected in any of the surrounding monitoring wells either upgradient or downgradient of this location indicating that this is a localized and stable occurrence. Because of previous LNAPL characterization at this location no LNAPL sample was submitted for analysis.

Well MWE05 is located near a former fueling area and storage tank in the northeast area of the Railyard (Figure 2-7). The LNAPL detected in this well is associated with the former fueling area and tank. Based on operational history the LNAPL in this area would be diesel fuel. Because LNAPL was not detected in any of the wells upgradient or downgradient of this location the extent of LNAPL is limited. Because the operational history and potential LNAPL sources on the Railyard are well documented, no LNAPL sample was submitted for analysis.

In September 2006, ARRC requested each of the oil companies in the Terminals Area (Figure 1-1) to gauge groundwater at their facility in order to develop an area-wide groundwater flow map (Figure 3-4b). As part of this gauging event, Tesoro measured LNAPL in three wells along their western boundary as indicated in the table below.

Monitoring Well	Location	Date	Depth to Product (feet)	Depth To Water (feet)	Product Thickness (feet)
LP019-MW1	Main Terminal, Tesoro	9/21/2006	6.79	6.81	0.02
LP019-MW12	Main Terminal, Tesoro	9/21/2006	7.54	8.43	0.89
LP019-MW14	Main Terminal, Tesoro	9/21/2006	7.27	8.38	1.11

In July 2006, LNAPL sheens were discovered on Cook Inlet adjacent to the MOA storm water outfall (Figure 1-1). It was determined that LNAPL had entered the storm drain immediately west of the Tesoro fence line. In response to this release Tesoro undertook an investigation in which LNAPL was observed west of their facility. Upon further investigation Tesoro identified the source of the release as their Pipeline C (Oasis Environmental, 2006).

The Pipeline C release was determined to have occurred sometime between a passing tightness test conducted in August 2005 and a failing tightness test conducted in July 2006 (Oasis Environmental, 2006). Pipeline C primarily carries jet A fuel, but occasionally carries DF2. Tesoro implemented several response actions to address the Pipeline C release including repairing sections of the storm sewer line, installing a LNAPL recovery system in a storm water sewer vault and installing an interceptor trench with LNAPL recovery. Approximately 1,208 gallons of LNAPL were removed from the interceptor trench and storm water sewer vault from September 2, to December 1, 2006.

No LNAPL was observed at the two RI wells, MWE17 and MWE18 (Figure2-7) immediately west of the Tesoro facility. Although Tesoro has implemented several response actions, these have not been able to prevent sheens at the storm drain outfall (Kent & Sullivan, 2007). Therefore, Tesoro plans to realign a portion of the storm sewer, including installation of a new watertight storm sewer pipeline and placement of bentonite seals in the excavation backfill to prevent LNAPL migration in the new sewer pipe bedding. Additionally, Tesoro is evaluating the use of a grout LNAPL barrier wall that prevents LNAPL migration, but allows groundwater to flow beneath the wall. In conjunction with the grout barrier wall, Tesoro is evaluating using a portion of the existing storm sewer line for LNAPL recovery as well as installing product recovery wells with skimmer pumps.

4.4 Soil gas and vapor intrusion investigation

Groundwater, soil, and soil vapor results were compared to vapor intrusion SLs (Tables 4-11a, 4-11b, 4-12a, 4-12b, 4-16a, and 4-16b). The results of this investigation are presented below.

4.4.1 Soil and groundwater indoor air screening

Soil

No analyte in surface soil and only one analyte in subsurface soil, naphthalene, in subsurface soil exceeded the soil vapor intrusion SLs (Tables 4-16a and 4-16b). The naphthalene analysis exceeded the soil vapor intrusion RI SL of 1.5 mg/kg at DPE35, with a concentration of 1.5 mg/kg. However, because this naphthalene exceedance did not occur within 100 feet of a structure (the first order screening of soil vapor compounds of interest), it is not considered a compound of interest for soil vapor intrusion.

Groundwater

Seven compounds (naphthalene, 1,2,4-trimethylbenzene, isopropylbenzene, benzene, PCE, TCE, and VC) were detected in groundwater at concentrations exceeding soil vapor intrusion RI SLs (Tables 4-11a, 4-11b, 4-12a, and 4-12b). Of these, only four (benzene, TCE, PCE, and VC) are considered compounds of interest based on the proximity of their occurrence to Site structures (i.e., within 100 feet). These compounds are discussed below.

- **Benzene** exceeded the soil vapor intrusion RI SL of 14 µg/L in 3 of 133 samples with concentrations above the laboratory detection limit. Exceedances occurred at MWE22, SP35, and MWE05 (Tables 4-11b and 4-12b; Figure 4-6).
- **TCE** exceeded the soil vapor intrusion RI SL of 5 µg/L in 21 of 107 samples with concentrations above the laboratory detection limit. Exceedances occurred at GW-1, GW-6, GW-8, and GW-9 (Tables 4-11b and 4-12b; Figure 4-6).
- **PCE** exceeded the soil vapor intrusion RI SL of 11 µg/L in 3 of 27 samples with concentrations above the laboratory detection limit. Exceedances occurred at DPA30E1, DPA30D4 and MWA19 (Tables 4-11b and 4-12b; Figure 4-6).
- **VC** exceeded the soil vapor intrusion RI SL of 2.5 µg/L in 33 of 49 samples with concentrations above the laboratory detection limit. Exceedances occurred at GW-2/3 and GW-4, (Tables 4-11b and 4-12b; Figure 4-6).

Based on groundwater and soil results, 11 soil vapor intrusion locations were selected for well installation and soil vapor collection (Figure 2-8).

4.4.2 Soil gas results

The results of the soil vapor investigation are presented in Tables 4-16a and 4-16b. Three compounds, TCE, PCE, and 1,1-dichloroethane, had concentrations above their soil vapor RI SLs.

- **TCE** exceeded the soil vapor RI SL of 4.1 parts per billion (volumetric) (ppvb) in eight of nine samples, with concentrations above the laboratory detection limit. Exceedances occurred at SVB-17, SVB-18 (two depths), SVA-19 and SVMW-6 (two depths), SVSP4 (two depths) (Table 4-16b; Figure 4-6). Exceedance concentrations ranged from 22 to 1,100 ppbv, with the highest concentration occurring at SVB-17.
- **PCE** exceeded the soil vapor RI SL of 120 ppvb in one of seven samples, with concentrations above the laboratory detection limit. The exceedances occurred at SVSP4 (8.5 to 9 ft bgs) (Tables 4-16b; Figure 4-6) with a concentration of 140 ppbv.
- **1,1-dichloroethane** exceeded the soil vapor RI SL of 23 ppvb in one sample. The exceedances occurred at SVSP4 (8.5 to 9 ft bgs) (Tables 4-16b; Figure 4-6) with a concentration of 30 ppbv.

The soil vapor data will be used to evaluate the soil vapor intrusion risk using the Johnson and Ettinger model. Results of the modeling are discussed in Section 7.0.

4.5 Soil investigation

This section presents the results of the evaluation of soil analytical data. The site-wide physical soil conditions were described in Section 3.2. As noted in Section 1.0, this evaluation of nature and extent of contamination is based on recent data only (i.e., data collected as part of the RI or by other parties since September 2004), as the sampling design was intended to focus on suspected sources of risk currently present at the Site in order to describe the nature and extent of contamination. Note that the risk assessment (Appendix B) fully evaluates pre-RI data, so no information regarding Site contaminants has been lost or disregarded. In the RI, soil data

were collected from the surface (0 to 6 inches bgs) and the subsurface (greater than 6 inches bgs) in accordance with the RI/FS Work Plan (RETEC, 2005a). Supplemental soil data associated with step-out locations were collected during 2006 and early 2007 in accordance with the WPA.

The full set of site-wide soil data is provided in Appendix H. Soil data are summarized in Tables 4-14a and 4-15a. Soil COIs are presented in Tables 4-14b and 4-15b. Table 4-17a summarizes soil and sediment COI along the Ship Creek riparian area. Soil COIs from the Terminals Areas are summarized in Table 4-24a. COI selection was based on a comparison of soil concentrations to relevant SLs.

The distribution of surface and subsurface soil COIs compared to their SLs is presented on Figures 4-7a and 4-7b.

4.5.1 Soil sampling results

Inorganics

Figure 4-7a shows the combined surface and subsurface inorganics concentrations in soil samples collected during the RI. Note that Figure 4-7a also shows the locations of pre-RI inorganics sampling that guided the additional soil sampling done during the RI. Inorganics concentrations in soils exceeded the RI SLs for arsenic, chromium, and mercury.

- **Arsenic** concentrations in soil were above the RI SLs at scattered locations across the Site. Arsenic concentrations exceeded SLs on the south side of Ship Creek at one subsurface sample location, DPB02 (14 to 16 ft bgs), and two surface soil locations, MWB14 and MWB17 (Figure 4-7a). On the north side of the creek, arsenic exceeded SLs at four locations. Three of the exceedances occurred in surface soil at sample locations SS05, MWA21, and MWA27, and one subsurface soil location, MWD06 (7 to 9.5 ft bgs) (Figure 4-7a). Arsenic concentration exceeding SLs did not occur at multiple depths at any location (i.e., surface and subsurface at the same location) and likely was not related to a local source. If related to a local source, elevated arsenic concentration would be expected to be distributed in surface and subsurface soil as the release would occur at the surface and infiltrate to deeper levels over time. In addition, the arsenic concentrations that exceed SLs are comparable to soil background values defined in Table 4-4.
- **Mercury** concentrations in soil exceeded the RI SLs at one location, MWA17 (Figure 4-7a), in the surface sample only. This exceedance was isolated and may be associated with the elevated concentrations of PCBs at this location.
- **Chromium** concentrations in soil were detected above RI SLs at two adjacent surface soil locations, MWA27 and MWA28, south of LP056 (Figure 4-7a). These samples contained chromium up to ten times the background concentration (Table 4-4).

Organics

Figure 4-7b presents the results of organic analyses from surface soil samples. Figure 4-7d presents the fuel hydrocarbon analytical test results. Of the surface soil samples collected, only four exceeded SLs. Two of these (MWC01, MWC03) were on the west end of the Railyard, and exceeded the SL for benzo(a)pyrene. The surface sample at MWE10 also exceeded the SL for benzo(a)pyrene. All three of these exceedances were low , i.e., less than two times the SL. The surface soil sample taken at MWA17 exceeded the SL for PCBs. This location is on the north side of the Ship Creek bank area.

The results of organic analyses for subsurface soil samples collected as part of the RI are presented on Figure 4-7c. The sample at MWC01 (12.5 to 14.5 ft bgs) had a detection of benzo(a)pyrene that exceeded the human health SL. This exceedance, like the surface exceedances of benzo(a)pyrene, was less than twice the SL. The sample at MWE05 (5 to 7 ft bgs) exceeded the SLl for EPH (Figure 4-7d). The other depth intervals

at this location had detections of EPH, but did not exceed the SL for any analyte. Well MWE05 is located in GW-7, a dissolved hydrocarbon plume associated with the former fueling area at the Railyard. These two locations contained the only exceedances of organic constituents in subsurface soil collected during the RI.

4.5.2 Soil leaching potential to groundwater

Soil concentrations were compared to soil leaching RI SLs to evaluate a soil to groundwater migration pathway. A summary of exceedances for surface soil is provided in Tables 4-14a and 4-14b. Subsurface results are provided in Tables 4-15a and 4-15b. The distribution of exceedances is shown on Figure 4-8.

Surface soils

Nine compounds detected in surface soils had at least one concentration exceeding the soil leaching RI SL (Table 4-14a). The compounds that exceeded and were carried forward as COI (Table 4-14b) are presented below.

- **EPH** exceeded the soil leaching RI SL of 250 mg/kg in 10 of the 51 samples where it was detected. Concentrations ranged from 9.38 to 1,850 mg/kg, with the highest concentration occurring at MWE10. The distribution of exceedances is shown on Figure 4-8.
- **Arsenic** exceeded the soil leaching RI SL of 12.2 mg/kg in 2 of the 85 samples where it was detected. Concentrations ranged from 2.61 to 29.8 mg/kg, with the highest concentration occurring at SS05. The locations of the two exceedances are shown on Figure 4-8.
- **Chromium** exceeded the soil leaching RI SL of 55 mg/kg in 8 of the 85 samples where it was detected. Concentrations ranged from 16 to 627 mg/kg, with the highest concentration occurring at MWA28. The distribution of exceedances is shown on Figure 4-8.
- **Mercury** exceeded the soil leaching RI SL of 1.4 mg/kg in 1 of the 85 samples where it was detected. Concentrations ranged from 0.023 to 19 mg/kg, with the highest concentration and single exceedance occurring at MWA17. The location of the single exceedance is shown on Figure 4-8.
- **Nickel** exceeded the soil leaching RI SL of 87 mg/kg in 3 of the 85 samples where it was detected. Concentrations ranged from 15 to 353 mg/kg, with the highest concentration occurring at MWA17. The distribution of exceedances is shown on Figure 4-8.
- **Benzene** exceeded the soil leaching RI SL of 0.02 mg/kg in 10 of the 51 samples where it was detected. Concentrations ranged from 0.00636 to 0.369 mg/kg, with the highest concentration occurring at SS07. The distribution of exceedances is shown on Figure 4-8.
- **TCE** exceeded the soil leaching RI SL of 0.02 mg/kg in 2 of the 3 samples where it was detected. Concentrations ranged from 0.0008 to 0.08 mg/kg, with the highest concentration occurring at MWB19. The locations of the two exceedances are shown on Figure 4-8.

Subsurface soils

Eleven compounds detected in subsurface soils had at least one concentration exceeding the soil leaching RI SL (Table 4-15a). The compounds that exceeded a SL and were carried forward as COI (Table 4-15b) are presented below:

- **EPH** exceeded the soil leaching RI SL of 250 mg/kg in 10 of the 27 samples where it was detected. Concentrations ranged from 9.63 to 10,700 mg/kg, with the highest concentration occurring at MWE05. The distribution of exceedances is shown on Figure 4-8.
- **VPH** exceeded the soil leaching RI SL of 300 mg/kg in 1 of the 16 samples where it was detected. Concentrations ranged from 1.54 to 848 mg/kg, with the highest concentration and single exceedance occurring at MWA07. The location of this exceedance is shown on Figure 4-8.

- **Arsenic** exceeded the soil leaching RI SL of 12.2 mg/kg in 2 of the 65 where it was detected. Concentrations ranged from 3.18 to 16 mg/kg, with the highest concentration occurring at DPB02. The locations of the two exceedances are shown on Figure 4-8.
- **Chromium** exceeded the soil leaching RI SL of the 35 mg/kg in 5 of the 72 samples where it was detected. Concentrations ranged from 18 to 86.7 mg/kg, with the highest concentration occurring at MWE16. The distribution of exceedances is shown on Figure 4-8.
- **Benzene** exceeded the soil leaching RI SL of 0.02 mg/kg in 2 of the 9 samples where it was detected. Concentrations ranged from 0.0024 to 0.0534 mg/kg, with the highest concentration occurring at MWA07. The locations of the two exceedances are shown on Figure 4-8.
- **TCE** exceeded the soil leaching RI SL of 0.02 mg/kg in 5 of the 13 samples where it was detected. Concentrations ranged from 0.00083 to 0.148 mg/kg, with the highest concentration occurring at MWC02. The distribution of exceedances is shown on Figure 4-8.
- **PCE** exceeded the soil leaching RI SL of 0.03 mg/kg in 1 of the 5 samples where it was detected. Concentrations ranged from 0.00081 to 0.0743 mg/kg, with the highest concentration and the single exceedance occurring at MWA19. The location of this exceedance is shown on Figure 4-8.

Soil to groundwater leaching is evaluated as part of the risk assessment and is summarized in Section 7.0

4.5.3 Riparian soil evaluation

Figure 4-9 and Tables 4-17a and b show the distribution of exceedances of ecological SLs for soil and sediment in the riparian zone adjacent to Ship Creek, the part of the Site where ecological exposures to terrestrial wildlife may occur. This evaluation is intended to provide a conceptual overview of the potential for ecological risk, which is considered in detail in the ecological risk assessment.

The evaluation is based on standard terrestrial ecological SLs (see ecological risk assessment for these). Because the riparian area in general was not considered a significant potential source of risk, little specific sampling to address this pathway was conducted. The data underlying this evaluation are limited to those generated from the soil samples that were collected as part of the Transect A wells within the riparian zone, and from the sediment samples taken at locations that are intermittently or seasonally dry and, thus, may result in terrestrial ecological exposures.

Table 4-17a shows the exceedances noted for riparian soil, based on ecological SLs. For organics, exceedances are limited to PCBs (specifically, Aroclor 1260), in 5 of 16 samples where PCB were detected. PCBs (Aroclor 1260) were also detected in surface soil at MWA17 (7.97 mg/kg, Figure 4-7b), which is on the edge of the riparian area. No other organic exceedances are present. Table 4-17b shows that the Aroclor, while widely detected, exceeds its SL only in CSD-04, CSD-07, CSE01, and CSE07. The first two of these samples are located in the intermittently flooded ditch in the Railroad Avenue Marsh, already identified as SE-3 as part of the sediment evaluation. The latter two samples are located in the Standard Steel ditch, already identified as SE-4 as part of the sediment evaluation. The ecological risk associated with these results is discussed in detail in the risk assessment.

In comparison to organic compounds, inorganics more frequently exceeded the conservative SLs for ecological exposures in soil. These exceedances consist of the nine inorganics presented in detail in Table 4-17b. These include several common elements, such as calcium and magnesium, which are not a toxicity concern, and a few metals (aluminum, barium, cobalt, selenium) that have only minimal exceedances of SLs and background are minimal (less than twice the SL) and likely of no ecological concern. All except common elements are addressed further in the risk assessment.

4.6 Water supply well investigation

Based on a survey of existing water wells in the area, eight water supply wells were identified and confirmed to be in use. These wells are located at LP127, LP 060, LP044, LP049, LP020, LP017, LP015, and LP056 (Figure 4-10). Seven of the eight wells were sampled. Descriptions of each well and the sampling done at them are provided in Section 3.4.4. Although specific depth data (i.e., well logs) were not available, historical reports and user interviews regarding selected wells (located at LP015, LP020, LP 049, and LP060) indicated that well depths range between 75 and 300 ft bgs. This indicates that the wells likely withdraw groundwater from the deep aquifer, below the bottom of the Bootlegger Cove formation.

Because the water wells were in use when they were sampled and the well heads were sealed, actual well depths could neither be determined by gauging, nor sampled directly. Samples from each location were collected at spigots as close to the well as possible. The water from these wells was not filtered or chlorinated prior to sampling. Each well was analyzed for the full suite of RI/FS compounds. Results from the sampling indicated that groundwater concentrations did not exceed drinking water standards or SLs for any compound. Note that in the sample from the well at LP049, BEHP, a common laboratory contaminant, was detected above the drinking water standard. However, this contaminant was not confirmed in the analysis using the drinking water method (EPA Method 524.2). Also, arsenic was found at a concentration equal to the drinking water standard in the well at LP60. Results of sampling are provided in Tables 4-18a and 4-18b and shown on Figure 4-10. Because no compound that exceeded a SL in the shallow water aquifer was found to exceed the SL in the deep water samples (if it was detected at all), it can be concluded that the deep water aquifer (i.e., below the bottom of the Bootlegger Cove formation) is not impacted by contamination in the overlying shallow aquifer and that the wells withdraw water from the deeper aquifer. This observation is consistent with the conceptual site model presented in the RI/FS Work Plan.

4.7 Monitored natural attenuation parameter and soil characteristics sampling

Soil property and groundwater monitored natural attenuation (MNA) data were collected as part of the RI to support FS evaluation of MNA as a potential remedial action. Soil property data are summarized in Table 4-19 and groundwater MNA data are summarized in Table 4-20 and shown on Figure 4-11.

The soil data provided in Table 4-19 were collected during the drilling program in 2005. With the exception of sample AR001-MWB07, collected from near-surface fill material, and sample RY065-MWD01, collected from the Bootlegger Cove formation, the samples reflect physical characteristics of the Ship Creek alluvium. Sample locations were selected to encompass a range of conditions across the Site and assess the range of physical characteristics focused on the various lithologies within the Ship Creek alluvium.

Groundwater MNA data in Table 4-20 were collected from a combination of existing wells and step-out direct push locations associated with the CVOC and hydrocarbon plumes at the Site. These plumes were identified in Section 4.3 and are further discussed in Sections 5.0. The FS will use these to evaluate these plumes and MNA as a potential remedial action.

A review of geochemical data and historical dissolved hydrocarbon and CVOC data has provided evidence that natural attenuation processes are occurring. Several examples of observations and conclusions that have been made and will be discussed further in the FS Report include the following:

- Groundwater conditions in some areas are conducive to CVOC biodegradation, and CVOC monitoring data suggest that CVOC biodegradation is occurring. Specifically, elevated levels of chloride, as well as the presence of cDCE and VC indicate that reductive dechlorination may be occurring. Elevated concentrations of cVOCs in some areas also tend to have low DO concentrations (<0.5 mg/L). Nitrate levels are below those at which nitrate is thought to compete with CVOCs as an electron acceptor. And, TOC levels (12-15 mg/L) appear adequate to support reductive dechlorination of the low levels of CVOCs present in the area.

- Historical monitoring data show that some areas where groundwater exceeds RGs are confined to isolated areas, with concentrations a short distance downgradient falling below RG values or analytical detection limits, in spite of high groundwater flow velocities.
- Groundwater geochemical data indicate a prevalence of low dissolved oxygen and nitrate concentrations in some wells impacted with hydrocarbons and associated contaminants. These wells also have elevated levels of carbon dioxide, ferrous iron and methane indicating that microbial metabolic processes are responsible for the attenuation of COPCs in these areas.

4.8 Terminals focused study

This section describes the results from the Terminals Area evaluation. Data from both the RI perimeter evaluation and the data collected at each facility are considered in the analysis. Additional monitoring data and evaluations characterizing the areas within the Flint Hills and Chevron leaseholds may be presented in the RA addendum that ARRC will submit to U.S. EPA regarding these properties. Additional data and evaluations concerning the areas within the Tesoro, Flint Hills and Chevron leaseholds also may be presented in the FS Report.

4.8.1 Terminals perimeter evaluation

4.8.1.1 Sediments

Figure 4-12b shows the location and results of sediment borings conducted by the USACOE in Cook Inlet west and northwest of the Site. The borings were conducted to support the planned expansion project for the POA, specifically in those areas slated for filling in and in those areas slated for an expanded dredging footprint. Figure 4-12b shows only those locations adjacent to the Terminals Area of the Site. All locations were evaluated using the ROST method in October 2006. In addition to the ROST sampling, the locations nearer the shore were also sampled for TOC, SVOC and VOC analysis in the 0 to 4 foot interval. Please refer to the source report for full details of the study (USACOE, 2006).

Ten ROST borings were conducted off site, of which six (the inboard locations) were sampled for chemical constituents. At one location, AHTH-26 located off the southwestern end of Flint Hills, samples were collected at multiple depths to address a suspect ROST reading.

The USACOE report confirms that there were no anomalous ROST readings in any sample that would indicate possible contamination, except as noted in AHTH-26 where the ROST readings suggested a 1% difference in fluorescence at 10 feet.

Confirmation sampling for SVOCs and VOCs at six locations (and three depth intervals at AHTH-26) indicated no exceedances of the Puget Sound Dredge Disposal Analysis (PSDDA) criteria that the USACOE applies to determine if dredged material is suitable for open water disposal. The USACOE concluded that, based on chemical analysis, ROST results, site history, and general site conditions, it is extremely unlikely that the proposed dredged material contains more than trace amounts of contamination and, consequently, is suitable for in-water disposal. Screening of these data against the RI SLs confirmed the absence of elevated concentrations of PAHs in the sediments (Table 4-21).

The absence of more than trace levels of contamination in sediment samples directly off site, including the off-site area near Tesoro and the impacted storm drain there, confirms that there is no current source of risk to the Cook Inlet environment and that there is no residual contamination in the Inlet.

4.8.1.2 Surface water

No surface water data from Cook Inlet itself were collected or considered necessary, due to the very high flows and mixing present in the open water. The data described below refer to water samples collected from the

drainage ditch, vault, and outfall into Cook Inlet adjacent to Tesoro. Water from this ditch has been monitored at four locations since 1998. More intense sampling was conducted in association with the interim actions by Tesoro in 2006 related to the presence of sheens in storm water from this ditch that reached Cook Inlet.

Storm water flows northward in an open ditch along the western boundary of Tesoro for about 600 feet, where it enters an underground pipe, passing through an open vault and a sedimentation basin before discharging to Cook Inlet. There have been eleven sampling events in this ditch (at SW-1, in the sedimentation vault; SW-2, in the open vault; SW-3, in the catchment basin where the water enters the pipe; and SW-4, at the south [upgradient] end of the open ditch). About a dozen sampling events over the years have shown benzene concentrations throughout this system, ranging from 9 to 170 µg/L at the sedimentation vault before discharge to Cook Inlet, and GRO concentrations ranging from <90 to 170 µg/L. At the beginning of the ditch, at SW-4, benzene concentrations ranged from 8.7 to 92 µg/L and GRO ranged from <100 to 322 µg/L. Surface water data for the Terminals Area are provided on Figures 4-12a, 4-12b, and 4-12c.

Tables 4-22a and 4-22b summarize the data collected in 2006 in the area of the drainage ditch before and after the interim action conducted by Tesoro (Oasis 2007). Samples were analyzed only for BTEX and DRO/GRO, per ADEC standard procedures. These data showed that, in the nine samples from the ditch, only benzene exceeded the marine surface water criterion of 51µg/L. The detailed overview showed that concentrations of benzene are commonly present in the ditch and presumably reach Cook Inlet, but that exceedances occur only in the LNAPL catchment device in the sedimentation basin (Tesoro sample IDs "EWSWE" and "NSSWE").

4.8.1.3 Groundwater

As part of the perimeter investigation completed in the Terminals Area, five monitoring wells were installed adjacent to the Flint Hills and Tesoro leased properties. Three wells (MWA01, DPBA-02, and DPBA-03) (Figures 4-12a, 4-12b, and 4-12c) were installed on the perimeter of the Flint Hills leased property to evaluate contaminant migration to adjacent properties to the south and Cook Inlet to the west. Two wells (MWE17 and MWE18) (Figures 4-12a, 4-12b, and 4-12c) were installed on the western boundary of the Tesoro leased property to evaluate migration of contaminants to Cook Inlet. No RI wells were installed along the perimeter of the Chevron leased property because the groundwater flow patterns beneath the facility indicate that contaminants migrating from its leased property would move in the direction of either Flint Hills or Tesoro (Figure 3-4b). The Terminals groundwater data evaluated in this RI included both the data from the perimeter wells installed as part of the RI and the data the oil terminal companies have generated in the groundwater monitoring that they conduct semi-annually and report to ADEC.

Each of the five RI monitoring wells was gauged and sampled a minimum of two times, once in October 2005 and once in April 2006, in accordance with the RI/FS WP. Monitoring wells MWE17 and DPA03 were sampled a third time, in September 2006, as the result of a detection that exceeded a SL. Groundwater samples from each well were tested for a limited suite of project analytes (BTEX, ethylene dibromide [EDB], lead, PAHs, EPHs, and VPH), in accordance with the RI/FS WP.

Lead was detected in all samples, and was below the RI SL of 15 µg/L in all but DPA03. At DPA03, lead exceeded the SL during the first sampling event in October 2005, but was below the SL during each of the two subsequent events in April and September 2006. These data confirm that lead is not a source of risk to Cook Inlet. Lead concentrations for all wells are provided in Table 4-23a and the distribution of concentrations is shown on Figure 4-12a.

Hydrocarbon-related compounds were detected only at MWE17 adjacent to the Tesoro leased property (Figure 4-12b). Of the compounds detected, EDB, benzene, ethylbenzene, naphthalene, EPH, and VPH exceeded SLs. All groundwater analytical results are provided in Table 4-23b. The distributions of hydrocarbon and fuel compound concentrations are shown on Figures 4-12b and 4-12c, respectively.

The groundwater results from the RI confirm previous sampling results reported to ADEC by each of the terminal operators. These data are shown, along with data generated from RI sampling, on Figures 4-12b and 4-12c. Because the terminals are required to report only BTEX, DRO, GRO, and RRO, these are the only compounds compared. It should be noted that DRO and GRO are roughly equivalent to the RI EPH and VPH analyses, respectively.

Along the southern and western boundaries of the Flint Hills leased property, no BTEX compound was detected in the RI perimeter wells (MWA01 and DPA03). In addition, no BTEX compound was detected above SLs at the on-site wells (MW-B3-1, MW-30, or MW-29). A north-south line of wells in the western area of the facility (MW-29, MW-B29, MW-27, MW-26, MW-32, MW-33, and MW-B33) were also ND for BTEX. This indicates that it is unlikely that BTEX-impacted groundwater, which is observed in the central part of the Flint Hills terminal, has migrated as far as Cook Inlet (Figure 4-12b). This is supported by sediment results from just off-shore, where BTEX was not detected in any samples (Figure 4-12b) (USACOE, 2006).

Although the groundwater samples from the RI perimeter wells (MW-A01 and DPA03) were non-detect for EPH and VPH, wells had detected DRO and RRO in the groundwater. The most recent data shows DRO detections below SLs at all but two of the wells (31-MW and B31-MW) (Figure 4-12c) on the south boundary. Three wells (31-MW, 29-MW, and 27-MW) also exceed SLs for RRO. However, based on groundwater flow conditions (i.e., flow to the west) (Figure 3-4b) and the fact that the perimeter wells (DPA02 and MWA01) are ND for EPH and VPH, it is likely that the extent of fuel-impacted groundwater is limited to the Terminals Area and does not pose a risk to Cook Inlet.

Along the western boundary of the Tesoro leased property, benzene and ethylbenzene were detected above the RI SL in MWE17 (Figure 4-12b). All hydrocarbon compounds were ND at MWE18, located approximately 500 feet to the south of MWE17. At MWE17, benzene ranged from 680 to 922 µg/L and ethylbenzene ranged from 800 to 1,300 µg/L. These concentrations are consistent with nearby well P23, located approximately 100 feet upgradient near a former railcar loading rack. In addition, the most recent groundwater data from wells located along the western boundary fence line (Figure 4-12b) all show benzene concentrations that exceed the RI SL. The RI perimeter data and the Tesoro data indicate that benzene-impacted groundwater has migrated from the Tesoro leased property.

In June 2006, a sheen was reported on Cook Inlet coming from the MOA outfall, approximately 150 feet west of the northwest corner of the Tesoro property. Upon further investigation, Tesoro identified an LNAPL release from its facility and began delineation of the LNAPL and dissolved phase plume (Oasis, 2006). As part of the Tesoro response, five additional monitoring wells (MW-19 to MW-23) were installed to the north and west of MWE17 as close to the fill-tidal flat boundary as possible (Figure 4-12b and Figure 4-12c). Groundwater from each of the wells was collected and analyzed for BTEX, DRO, and GRO. All five wells had detectable concentrations of benzene and DRO. However, only one well, MW-23, located approximately 100 feet north and west of MWE17, had a benzene concentration (66.3 µg/L) that exceeded the RI SL (Figure 4-12b). Groundwater from all five wells also contained DRO concentrations that exceeded the RI SL. DRO concentrations in the five wells ranged from 1,530 to 7,880 µg/L (Figure 4-12c).

Groundwater analytical data from three sample events and the Tesoro release investigation indicate that impacted groundwater has migrated across the Tesoro property boundary and as far west as the fill-tidal flat interface. However, to the south, between MWE17 and MWE18, the most recent groundwater data indicate that benzene concentrations are below the RI screening value (Figure 4-12b). One Tesoro well, PW-20, immediately to the west and across an open drainage ditch from MWE18 (Figure 4-12c), had a benzene concentration of 29.9 µg/L, which exceeds the RI screening value. However, MWE18 has remained ND for benzene through two sample events. This may be the result of the open drainage ditch providing some hydraulic control and preventing migration to the west, or may reflect the groundwater flow regime in this area. Either way, groundwater contamination in this area is located north of MWE18 and has been identified at MWE17.

Fluid levels were gauged using an oil/water interface probe at all of the RI perimeter wells locations concurrent with groundwater sampling. LNAPL was not observed at any location. In addition, none of the monitoring wells installed as part of the Tesoro corrective action had accumulations of LNAPL. LNAPL was observed in several Tesoro test pits completed during July 2006 as part of the release investigation (Oasis, 2006). Most of the LNAPL observed was in test pit locations completed south of the SW-Vault location (Figure 4-12c) and between the Tesoro property fence line and the north-south storm drain. However, one test pit, located between MW-21 and MW-22 (Figure 4-12c), showed hydrocarbon-impacted soil approximately 50 feet from the fill-tidal flat interface (Oasis, 2006).

Although groundwater and soil impacts are observed right up to the fill-tidal flat boundary, the data do not show any risk to Cook Inlet from these contaminants. In fact, sediment data collected in support of the POA expansion immediately off-shore from the Tesoro property showed no compounds exceeding SLs (USACOE, 2006). Off-site sediment results for organic compounds are shown on Figure 4-12b).

4.8.1.4 Soil

Soil samples were collected from three of the five monitoring well boreholes as part of the RI. At each borehole, one soil sample was collected at the surface and one at a depth based on the highest total VOCs in headspace analyses, or at the interval immediately above the water table. A total of seven samples were collected, two from MWA01, two from MWE18, and three from MWE17. Each sample was analyzed for BTEX, EDB, lead, PAH, EPH, and VPH, in accordance with the RI/FS WP. Soil analytical results are provided in Tables 4-24a and b, and 4-25a and b, and shown on Figures 4-13a, 4-13b, and 4-13c.

With the exception of benzo(a)pyrene (1.24 µg/L) at 10 to 12 feet in borehole MWE17, no compound exceeded an RI soil SL. Test pit soil samples collected by Tesoro, as part of its release investigation, exceeded soil SLs for DRO, GRO, and xylenes (Figures 4-13a and 4-13c). However, each of these samples showed signs of LNAPL impacts (Oasis, 2006). With the exception of the Tesoro samples, which are being evaluated by ADEC, there is no source of risk from the perimeter soils in the Terminals Area.

4.8.2 Terminals leased properties

The Terminals Area leased properties consist of Tesoro Terminal #1 POA, Flint Hills Anchorage Terminal, and the Chevron Anchorage Fuel Terminal, as well as freight terminal and storage areas, where no environmental concern can be identified. As previously discussed, these are active bulk fuel storage areas and transfer terminals and were the focus of the Terminals Area perimeter investigation. The three oil terminal companies currently are carrying out monitoring and other environmental work at their leased properties under ADEC direction and oversight. Each company conducts groundwater monitoring and submits annual reports of that monitoring to ADEC. The purpose of these monitoring programs is to evaluate plume boundary stability, determine off-site migration, and evaluate if any new releases have occurred. All significant spills and releases at these Sites are required to be reported to ADEC and are then subject to the supervision of the ADEC Division of Spill Prevention and Response. ADEC also requires each facility to complete pipeline tightness tests at least once a year to determine if any product is being released from these pipelines to the environment.

Overall, the area is well characterized with groundwater and soil samples having been collected from the three terminal facilities for the past 20 years. This section summarizes the pre-RI and current groundwater and soil data at the Terminals Area. The current conditions of individual SWMUs and Areas of Concern identified at each of the oil terminal facilities are discussed in Section 6.0, including a summary in table format of the Site activities performed under ADEC oversight.

4.8.3 Groundwater

Over 800 groundwater analyses have been completed at the three terminal facilities. The majority of data collected has been for hydrocarbon-related contaminants, such as BTEX, DRO, GRO, and RRO. A limited number of inorganics analyses have also been completed. Prior to the RI, groundwater sampling was limited to the areas within the boundaries of the oil terminals. The pre-RI sample locations are shown on Figures 2-3a and 2-3b. Sampling completed since 2004 is shown on Figures 4-12a through 4-12c. Hydrocarbon-impacted groundwater exceeding the RI SL occurs beneath all three oil terminal facilities.

Flint Hills

At the Flint Hills leased property, benzene has exceeded groundwater SL concentrations beneath the East, West, and North Tank Farms, and beneath the railcar loading rack (Figure 2-3a). Before the RI commenced, the highest benzene concentrations at the Flint Hills facility occurred in the northern portion of the East Tank Farm (MW-13A) and at the railcar loading rack (MW-5) (Figure 2-3a). DRO concentrations in groundwater exceeding RI SLs have occurred across the entire Site, with the highest concentration being in the northern portion of the East Tank Farm (MW-13A) and at the railcar loading rack (MW-5) (Figure 2-3b). Concentrations of GRO in groundwater that exceed the RI SL have occurred primarily at the East Tank Farm and railcar loading area (Figure 2-5d). Concentrations of RRO in groundwater also have exceeded the RI SL in several locations in the vicinity of the West and North Tank Farms (Figure 2-3b).

Semi-annual monitoring at the Flint Hills terminal is limited to between 8 and 12 monitoring wells per event. Monitoring well locations and sampling results since 2004 are shown on Figures 4-12a, 4-12b, and 412c. Results from new monitoring wells (B27-MW, B28-MW, B32-MW, and B33-MW), installed in 2004 in the western area of the facility (Figure 4-12b), indicate that concentrations of dissolved phase benzene and GRO exceeding the RI SL have not been encountered in the western and northern area of the facility. However, dissolved DRO and/or RRO exceeding SLs have been reported at MW-26, B27-MW, and B29-MW, and detections of these compounds have been reported at B33-MW to the north.

Groundwater samples were collected and analyzed for inorganics at 12 wells (Figure 2-3a) between 1992 and 1998. Arsenic concentrations exceeded the RI SL in seven wells and chromium concentrations were exceeded in one well. Arsenic exceedances generally are co-located with hydrocarbon impacts. This is a common association and may indicate that a reducing environment caused by the hydrocarbon contamination causes dissolution of naturally occurring arsenic minerals in the soil (Ghosh, 2003).

With the exception of the RI analyses completed in 2005 and 2006, no other inorganics data are available. The RI samples collected, along the southern and western boundaries of the Flint Hills leased property did not contain inorganics concentrations exceeding RI screening values.

Although the absolute concentrations may vary from sampling event to sampling event, the distributions of benzene, DRO, GRO, and RRO generally have remained relatively constant over time (Figures 2-3a and 2-3b). A statistical analysis of contaminant concentrations over time showed no apparent trends in the data and concluded that contaminant concentrations are stable (Shannon and Wilson, 2007). Based on these data, there is currently no off-site migration inferred.

Chevron

At the Chevron leased property, benzene has exceeded SL concentrations beneath the tank farm as well as to the east and west of the tank farm (Figure 2-3a). Before the RI commenced, the highest benzene concentrations occurred west of the tank farm (MW-16) (Figure 2-3a). Similarly, DRO and GRO concentrations in groundwater have exceeded SLs across the entire Site, with the highest concentrations occurring west and north of the tank farm (MW-3, MW-6B, MW-13A, MW-14, and MW-16) (Figure 2-3b). The high concentrations of contaminants on the east side of the leased property and upgradient of the tank farm (MW-15 and MW-6B) suggest a potential off-site source in this area.

Annual monitoring at the Chevron terminal is limited to approximately 10 monitoring wells per event. Monitoring well locations and sampling results since 2004 are shown on Figures 4-12a, 4-12b, and 4-12c. The current groundwater data show a similar distribution and similar concentrations, as have been reported in the past and described above.

Groundwater samples were collected and analyzed for nickel at nine wells in 1998 (Figure 2-3a). Nickel exceeded the RI SL at one location, MW-17 (Figure 2-3a). Inorganics have not been analyzed at the Chevron leased property since that event.

Although the absolute concentrations may vary from sampling event to sampling event, the distributions of benzene, DRO, and GRO generally have remained relatively constant over time (Figures 2-3a and 2-3b).

Based on groundwater flow conditions beneath the Terminals Area (Figure 3-4b), and the fact that the wells located on the Chevron leased property boundary (MW-13A, MW-18, MW-3, MW-20, and MW-4) exceed RI SLs for one or more of benzene, DRO, or GRO, it is likely that contaminants have migrated and continue to migrate from the Chevron leased property.

Tesoro

At the Tesoro leased property, benzene has exceeded SL concentrations beneath the entire leased property (Figure 2-3a). Before the RI commenced, the highest benzene concentrations at the Tesoro facility occurred in the south of the facility at monitoring well PWB-18, and in the northeast corner at PW-66, MW-1, and RW-PL. The high benzene concentrations in the northeast corner were the result of a pipeline leak in 1989. Benzene concentrations in this area were reduced upon soil excavation and LNAPL removal. Benzene concentrations exceeding SLs have occurred along the full length of the western boundary of the facility. DRO and GRO concentrations have exceeded SLs across the Site, with a similar pre-RI distribution to benzene (Figure 2-3b).

Semi-annual monitoring at the Tesoro terminal is limited to approximately 20 monitoring wells per event. Monitoring well locations and sampling results since 2004 are shown on Figures 4-12a, 4-12b, and 4-12c. Results from recent semi-annual sampling are similar to pre-RI results, with the exception of sampling in the northeast corner, where benzene, DRO, and GRO concentrations have been decreasing since the 1989 remediation. However, benzene, DRO, and GRO continue to exceed RI SLs in this area. These same compounds also continue to exceed RI SLs along the western boundary of the facility.

Groundwater has not been sampled for inorganics at the Tesoro facility. Two samples collected from nearby perimeter wells as part of the RI did not exceed SLs for any of the inorganics analyzed.

Although the absolute concentrations may vary from sampling event to sampling event, the distributions of benzene, DRO, and GRO generally have remained relatively constant over time, with the exception of the northeast corner of the facility (Figures 2-3a and 2-3c).

Based on groundwater flow conditions beneath the Terminals Area (Figure 3-4b), and the fact that wells located on the Tesoro leased property western boundary (PW-19B, PW-17, PW-21, PW-15, PW-23, PW-24, and PW-25) continue to exceed RI SLs for one or more of benzene, DRO, or GRO, it is likely that contaminants have migrated and continue to migrate from the Tesoro leased property. This is confirmed by newly installed monitoring wells to the west of the leased property to the boundary. These indicate contaminant migration from the Tesoro leased property, as discussed in Section 4.8. 3.

4.8.3.1 Soils

Over 500 soil samples have been collected at the Tesoro and Flint Hills facilities. The soil analyses consisted primarily of benzene, DRO, and GRO, and, to a very limited extent, inorganics. The distributions of soil

contaminant concentrations exceeding SLs are shown on Figures 2-6a and 2-6b, with the most recent data shown on Figures 4-13a, 4-13b, and 4-13c.

For the most part, the soils at the Tesoro and Flint Hills oil terminal facilities are not impacted with hydrocarbon at concentrations exceeding soil ingestion criteria. In areas where impacts are observed, the distribution coincides with the highest hydrocarbon concentrations in groundwater (e.g., the south and northeast corner of Tesoro, and the East Tank Farm at Flint Hills) (Figures 2-6a and 2-6b). Typically, impacted soil at the facilities are excavated and disposed of under ADEC oversight.

5.0 Source and migration investigation

Section 4.0 presented the analytical results for the RI data collection effort, and related the results to the RI SLs as a tool to define the nature and extent of Site contamination. This section focuses on those areas identified in Section 4.0 as exceeding SLs and, therefore, affected by a potential source of risk. In this section, these areas will be further evaluated in the context of:

- Migration of contaminants to other media or areas, based on specific conditions at the location, and
- Evaluation of sources of risk that may have resulted in the observed contaminants. This evaluation is based on a weight-of-evidence evaluation of pre-RI data and Site knowledge, to place the observed contamination in the context of potential sources.

Section 4 identified eight potential groundwater source areas (GW-1, GW-2/3, GW-4, GW-5, GW-6, GW-7, GW-8, and GW-9), four potential sediment source areas (SE-1, SE-2, SE-3, and SE-4), and one potential soil gas source area (SG-1). In addition to these source areas, there were exceedances for a number of analytes in surface water, sediment, groundwater, or soil. These exceedances were present throughout the Site, but without pointing towards specific sources of risk. All exceedances are noted in tables and figures, but each exceedance in this category was not evaluated in detail for source or fate and transport. To ensure that no sources of risk remain unevaluated, all analytical data (current and pre-RI) were characterized for risk in the risk assessments, as reported in Section 7.

Subsequent sections evaluate the potential source areas in terms of risk (Section 7.0) and in relation to RCRA SWMUs and Areas of Concern (Section 6.0).

5.1 South Bank source areas

Three areas on the south bank of Ship Creek were identified as potential sources of risk to Ship Creek and human health.

5.1.1 Area GW-1

This area (Figure 5-1) encompasses a TCE groundwater contamination area at the southeastern portion of the Site. The associated data for this area are shown in detail on Figure 5-2, including any available pre-RI data. The existence of this impacted area was not suspected until the issue was identified as part of the Transect B (south bank) evaluation in this RI; therefore, prior environmental investigations are largely absent.

Nature and extent

The GW-1 groundwater plume (Figure 5-1) contains TCE at concentrations exceeding the groundwater SL (the ARRC SL was 5 µg/L, corresponding to the drinking water MCL). At sample locations DPB21 and DPA18A1, located at the upgradient Site boundary, concentrations of TCE ranged from 190 to 270 µg/L. Cis-1,2-dichloroethene (c12DCE) was also present, but below the SL, at concentrations ranging from 55 to 57 µg/L. In addition, five other chlorinated VOCs and benzene were detected in the GW-1 plume at concentrations below 1 µg/L. TCE and c12DCE concentrations attenuate along the generally east-to-west flow path in the direction of Ship Creek. This plume likely intersects with Ship Creek at some point, although the distribution of TCE evident in Figure 5-2 shows those TCE concentrations are much lower in the vicinity of the creek, so any flux to the creek would be at low concentrations.

Groundwater samples collected immediately off-site and upgradient (within 100 feet) of GW-1 contained TCE at concentrations exceeding the SL, however, concentrations decreased to below the SL to the east and southeast (Appendix L). Soil samples collected upgradient of GW-1 had TCE concentrations exceeding the

SL for leaching to groundwater. These data indicate historical release of CVOC capable of impacting groundwater (Appendix L). The fact that groundwater concentrations are lower upgradient of GW-1 indicates that the original source is no longer present and only residual TCE remains in the soil.

Because of the elevated TCE concentrations in groundwater under or near the existing buildings used by Karen's RV (LP072) and CPR Automotive (LP125), soil gas samples were collected adjacent to the buildings. TCE and other VOCs were detected in soil gas at concentrations exceeding soil gas SLs, indicating volatilization towards the surface. An imminent threat evaluation was conducted applying the Johnson and Ettinger indoor air volatilization model to determine if current workers are adversely affected. This review, presented to U.S.EPA at the May 15, 2007 meeting, concluded that no imminent threat exists.

The current risk to industrial and construction workers associated with the CVOCs in groundwater in this area, and the risk to Ship Creek biota, is discussed in the human health and ecological risk assessments. In terms of potential ingestion of groundwater in this area, MCLs for TCE are exceeded within the area indicated by the green dashed line on Figure 5-2. However, no current or anticipated future groundwater use occurs in or near this area.

Sources

Based on all available data, the source(s) of the elevated TCE found in this area was suspected to be located off site to the east of the property boundary at Sitka Street. As part of the "step-out" evaluation for this area, additional groundwater sampling was conducted at on-site locations upgradient of the impacted area to evaluate if sources related to the Site were present. These samples included MWB18-E1 and MWB18-E2 at LP093 (Alaska Basic Industries), located on an exclave of Site property southeast of the main portion of the Site and directly upgradient from the observed TCE. In addition, a sample (MWB18-D1) was collected adjacent to LP099, which is northeast of the plume but within a possible flow-path for groundwater (Figure 5-2). None of these locations reported any detections of TCE or related VOCs.

Potential source areas across Ship Creek were also considered. However, as discussed in Section 4.3, CVOC were not detected at concentrations exceeding screening levels on the north bank of Ship Creek across from or hydraulically upgradient of GW-1. Further, north bank wells downgradient of GW-1 (MWA20 through MWA22) were non-detect for CVOCs. These data indicate a source or sources south of Ship Creek.

Review of the history of LP072 (currently subleased by Karen's RV) and LP125 (currently subleased by CPR Automotive), does not show any evidence of activities that would have resulted in use or discharge of chlorinated solvents. Distribution of TCE within the plume shows the maximum concentrations at the fence line between LP072 and Sitka Street (MWB18-A1 and DPB21). The data suggest that the source(s) of the GW-1 plume is located beyond the property boundary, possibly in the off-site areas between Sitka Street and Wrangell Street.

However, subsequent evaluation has been conducted by ADEC east of the property boundary, as well as additional step-out sampling conducted in October 2007. These investigations indicate lower concentrations east of Sitka Street, and indeed, east of the boundary. While the existence of multiple utility corridors in the street suggest potential source areas, the evidence is not clear that the TCE has a specific off-site source. Until such a source is identified, it is conceivable that the source may have been related to activities or spills at or near the fence line. However, no evidence of such sources exists today and, if this is the case, the source is finite and confined. The recent additional investigations associated with this plume are summarized in Appendix L.

Fate and transport

As noted above, the source of the GW-1 groundwater plume appears to be located either very near the Site boundary or off site. TCE concentrations in soil upgradient of GW-1 exceed the soil to groundwater leaching

screening level and indicate possible locations of surface releases that reached groundwater and migrated toward the ARRC boundary. Analysis of groundwater flow directions in the area indicates the plume moves roughly parallel to Ship Creek. It is likely that it intersects with the creek at some point, resulting in TCE reaching surface water. As noted above, however, concentrations nearest the creek are much lower than where it enters the Site. Sediment samples collected in June 2007 indicate that TCE is present in the creek sediment where the plume would be expected to reach the creek. Ecological risk associated with any TCE discharge to Ship Creek is discussed in the ERA (Appendix C).

The presence of c12DCE, a daughter product of the biological transformation of TCE, indicates that intrinsic biodegradation of TCE is occurring in the GW-1 plume. Further analysis will be performed in conjunction with the FS to evaluate the effectiveness of natural attenuation processes in reducing TCE concentrations.

5.1.2 Area GW-2/3

This CVOC groundwater impact area is located along the south bank of Ship Creek along the eastern end of Ship Creek Avenue. This area was identified as a result of the Transect B evaluation. Initially it was thought there were two separate plumes (GW-2 and GW-3) (Figure 5-1), although subsequent step-out sampling following the RI/FS WP and WPA have confirmed that only one distinct plume is present. Based on the discussion presented in Section 4.3, GW-2/3 is bounded and is not continuous with GW-1 or GW-4 located to the east and west, respectively. A detailed view of current and pre-RI data for this area is presented on Figure 5-3.

Nature and extent

Vinyl chloride is the only analyte to exceed groundwater SLs in the Area GW-2/3 plume. TCE and PCE are essentially absent in this area but have been identified approximately 1,300 feet upgradient (Appendix L). Low levels of c12DCE are present, well below SLs and below the concentrations seen for vinyl chloride. In addition, trace levels (less than 2 µg/L) of several other CVOCs, and some BTEX components, have been detected, all of which are well below groundwater SLs.

The specific source of the GW-2/3 plume is uncertain, however, TCE and PCE have been detected upgradient. Sampling in the vicinity of LP077 appears to show a decline in VC concentrations further upgradient. West of LP077, the plume follows the overall northwesterly groundwater flow direction towards Ship Creek (Figure 5-3). Maximum VC concentrations of 23 and 25 µg/L were noted at LP077 (MWB09A1) and just downgradient at MWB09B2. (the ARRC SL for VC was 2 µg/L, the MCL for this constituent). VC concentrations decrease along the downgradient direction, but up to 17 µg/L VC were reported at DBP-08B3 near Ship Creek, a linear distance of about 1,100 feet from the source area. Concentrations decrease to non-detect cross-gradient to groundwater flow. Low level TCE (i.e., less than the screening value) also occurs in the eastern portion of GW-2/3 as was discussed in Section 4.3. The distribution of TCE and daughter products (VC and c12DCE) upgradient suggest attenuation of a potential source area on the east side of the occurrence. U.S. EPA noted a source of TCE and PCE upgradient of GW-2/3 which is commingled with a petroleum hydrocarbon plume (Appendix N).

The current risk to industrial and construction workers associated with the CVOCs in groundwater in this area is discussed in the HHRA (Appendix B) and ERA (Appendix C). MCLs for vinyl chloride are exceeded within the area indicated by the green dashed line on Figure 5-3, although no current or anticipated groundwater use exists in or near this area.

Source

Review of existing data for leased properties within the GW-2/3 plume located no records pointing to a specific source for the GW-2/3 area plume (such as at LP077, which is currently occupied by Tire Centers, LLC). The possibility of sources further upgradient was evaluated as part of the RI and by U.S. EPA (CH2M Hill, 2007), including off-site areas and at LP022 (ML&P) (e.g., well B2A), a facility with extensive history of environmental

releases and environmental investigations (Figure 2-4a). Several sample locations (DPB24, MWB09D3, MWB09D2, and MWB09D1) were placed upgradient of LP077. These samples did not contain elevated concentrations of vinyl chloride or its parent compound. However, several of the samples did show traces of various other CVOCs and BTEX compounds, indicating that contributions of these compounds occur from sources located off site or associated with LP022. U.S. EPA speculated that the co-occurrence of CVOCs and petroleum hydrocarbon would enhance reductive dechlorination resulting in downgradient VC and little or no TCE or PCE remaining immediately upgradient in the vicinity of the hydrocarbon plume (CH2MHill, 2007).

U.S. EPA (CH2M Hill, 2007) provided further information on potential sources. Specifically, historic records from the 1990s from areas located outside the Site boundary and identified a former waste oil tank with elevated concentrations of CVOCs, including TCE, in soil and groundwater. This potential source area is generally upgradient of the GW-2/3 plume. The U.S. EPA documents suggest other potential sources at facilities upgradient of this plume (and also plume GW-4, see below). While no direct evidence exists linking these presumptive sources and the plume, it is a very likely scenario that the residual vinyl chloride would have originated as TCE further upgradient. The USEPA report will be discussed further.

Fate and transport

The vinyl chloride distribution within the GW-2/3 plume follows the groundwater flow path and likely intersects with Ship Creek. As a result, some release to surface water may have occurred. There is relatively little decrease in vinyl chloride concentration along the plume, suggesting that degradation rate is slow relative to the rate of groundwater flow. Sediment samples collected adjacent to GW-2/3 in July 2007 were non-detect for CVOCs. Ecological risk associated with potential discharge to Ship Creek is discussed in the ERA (Appendix C).

North bank groundwater samples immediately across Ship Creek and upgradient of GW-2/3 are non-detect for CVOCs. The nearest CVOCs exceedances on the north side of Ship Creek are upstream at GW-8 (Figure 4-5c). However, wells MWB10 and MWB11, located upstream of GW-2/3 on the south bank across the creek and downgradient from GW-8, are non-detect for CVOCs. The distribution of contaminants and non-detects indicates that GW-8 is not a source for GW-2/3.

The vinyl chloride and c12DCE detected in the GW-2/3 plume are likely daughter products of the biological transformation of PCE and/or TCE, and provide evidence of intrinsic biodegradation of the GW-2/3 plume. The low concentrations of TCE observed indicate that the source materials have been nearly exhausted and that essentially most of the TCE has been transformed to lesser chlorinated VOCs, including c12DCE and vinyl chloride, which is consistent with an older off-site source in the old waste oil tank off-site, as suggested by U.S. EPA (CH2M Hill, 2007). Further analysis will be performed in conjunction with the FS to evaluate the effects of natural attenuation processes on vinyl chloride concentrations in the GW-2/3 plume.

5.1.3 Area GW-4

This CVOC groundwater impact area (GW-4, Figure 5-1) is located along the south bank of Ship Creek along the western end of Ship Creek Avenue and 1st Avenue. This area was identified as a result of the Transect B evaluation. A detailed view of current and pre-RI data for this area is presented on Figure 5-4.

Nature and extent

The only analyte to exceed groundwater SLs in the GW-4 area is vinyl chloride. The samples had significant concentrations of c12DCE, well below the SLs yet considerably higher in absolute terms than the vinyl chloride (typically in the 20 to 30 µg/L range). No TCE or PCE is present. In addition, trace levels (less than 2 µg/L) of several other CVOCs, as well as benzene components, have been noted in these samples at concentrations below SLs.

The vinyl chloride most likely originates off site southeast of LP064, and the plume follows the overall northwesterly groundwater flow direction towards Ship Creek. Affected leases include LP058 (Comfort Inn), LP075 (Ulu Factory), LP071 (BDK), and LP057 (ARRC Headquarters Building). Maximum concentrations of vinyl chloride are less than 10 µg/L, which is lower than concentrations seen in the GW-2/3 plume described previously. Concentrations decline only marginally from where the plume enters the Site (9.5 µg/L at DBP-04E3) to Ship Creek (up to 9 µg/L at DPB03B2), a linear distance of about 1,500 feet, although most concentrations in the intervening distance are lower. Groundwater flow direction on the east side of GW-4 indicates that GW-2/3 (Figure 5-4) is located cross gradient. Concentrations decrease to non-detect to the northeast cross gradient to the groundwater flow.

The distribution of the vinyl chloride points to this plume being clearly distinct from the GW-2/3 plume described in Section 5.4.2. It is notable, however, that the contaminants and concentrations in the two plumes are very similar. But, based on the distribution of vinyl chloride concentrations and on groundwater flow patterns, it is difficult to posit a single source for the two plumes.

Review of the recent investigations conducted by USEPA (CH2M Hill, 2007) point to possible sources upgradient and off-site, including an old dry cleaners operation formerly located on 3rd Avenue that caused extensive PCE groundwater contamination. While no evidence connects the GW-4 plume to this location, its location generally upgradient of the plume illustrates one potential off-site source.

The current risk to industrial and construction workers associated with the CVOCs in groundwater in this area is discussed in the HHRA (Appendix B). MCLs for vinyl chloride are exceeded across the area indicated by the green dashed line on Figure 5-4, but no current or anticipated groundwater use exists in or near this area.

Source

A review of existing data for leased properties in this area discovered no records pointing to a specific source for the GW-4 area plume. The presence of elevated vinyl chloride in samples near the upgradient Site boundary (DPB04E3 and DPB04E4) suggests a potential source is located off site. Additionally, concentrations of VC exceeding screening levels at DPB03-B2 and DPB03-A1 (9 µg/L and 3.2 µg/L, respectively), as well as the prevailing groundwater flow direction to the northwest, suggests another potential source to the south. However, no data are available indicating specific sources for the low level VC exceedances observed at GW-4.

Fate and transport

The vinyl chloride distribution in the GW-4 area follows the groundwater flow path and likely intersects with the creek at some point, with consequent flux to surface water. There is little decrease in concentration along the plume, suggesting that degradation is slow relative to groundwater flow. Ecological risk associated with any discharge to Ship Creek is discussed in the ERA (Appendix C).

Because Ship Creek is deeply incised into the marine sediments and/or Bootlegger Cove formation, the alluvial aquifer is not continuous across the creek in the vicinity of GW-4 and GW-6 (Figure 3-8a and b). As a result, the source areas for these two occurrences are unrelated.

As was noted for the GW-2/3 plume, the vinyl chloride and c12DCE detected in the GW-4 plume are likely daughter products of the biological transformation of PCE and/or TCE, and provide evidence of intrinsic biodegradation. Also, the apparent absence of PCE and TCE suggests that the original source materials have been depleted, and PCE and TCE have been transformed to c12DCE and vinyl chloride. Further analysis will be performed in conjunction with the FS to evaluate the effects of natural attenuation processes on vinyl chloride concentrations in the GW-4 plume.

5.2 North Bank source areas

Four sediment areas and three groundwater areas were identified on or near the north bank of Ship Creek. These areas were discussed in Section 4.0. On the basis of pre-RI evaluations, two of the three groundwater areas were previously known or suspected. The existence of the third groundwater area (GW-6) was not previously suspected, but was identified as part of the Transect A (north bank) evaluation process. The four sediment areas were previously suspected areas of impact based on Site history and observations during the Habitat Survey.

5.2.1 Area SE-1

Area SE-1 (Figure 5-1) encompasses contaminated sediment in the KAPP pond. Figures 5-5a and 5-5b show a detailed map of the area, including current and historic data results for all media in the vicinity.

Nature and extent

As noted in Section 4.0, the KAPP pond had contamination exceeding screening levels in silty sediment throughout the pond area SLs. The accumulation of sediment consists of no more than a foot of silty material, and frequently less, covering alluvial sandy gravel. In the silty material, PAHs and PCBs (Aroclor 1260) were noted in moderate concentrations exceeding the sediment SLs. Some low level exceedances for inorganics were also present (Figures 4-4a and 4-4b).

The limited amount of accumulated silt in the pond is an indication that some flushing occurs, and there also are references to proposals for dredging the pond. The pond was reportedly dredged to ensure sufficient water volume when the KAPP plant was in operation. At that time, the pond also had a recirculation system. Therefore, it is possible that the silt currently in the pond accumulated in recent years.

The KAPP pond covers approximately 1.3 acres (730 feet by 80 feet), for a total volume of silty sediment overlying the alluvial gravel of 58,400 cubic feet (conservatively assuming 1 foot of silt). Note that contaminants appear to be concentrated in the western half of the pond (sample CSA01 has considerably less impacts).

Sources

The KAPP pond is occasionally flushed by Ship Creek flows. At high flows in the creek, water flows into the pond through cracks and holes in the pond berm. Although the flood gates of the pond appear to normally be kept shut, the “leaky” nature of the pond berms indicates that interchange with Ship Creek occurs. The pond does have an active drain that releases water below the Kapp Dam. The elevation difference suggests that water from below the dam would not back up into the pond, except during very high tides.

The pond is located across the street from the inactive KAPP facility (the plant was active 1953 – 1985), and the entire pond is located within the leased property boundaries (LP120). Pond water used for cooling was either returned to the pond or discharged directly below the dam. Today, the pond passively drains to an outlet below the dam.

Previous environmental investigations and actions have occurred at the KAPP power plant. In 1981, concerns were raised about discharges via sewers to Ship Creek. A facility inspection in 1985 noted that this pathway was a continuing concern. A Phase I/II Site Assessment in 1990 noted the presence of PCB-containing transformers, and also identified dry wells and drainage systems whose connections were not ascertained. In 1991, two large underground storage tanks (USTs) were removed. However, no significant environmental contaminant concerns were noted in connection with those removals.

In 1998, two transformers stored on site released up to 2,400 gallons of transformer oil into the storm drains. Emergency response by ADEC and ARRC recovered a large part of this spill, but some reached Ship Creek

below the dam. As described in the response reports, product was recovered from impacted sewers and treated in an oil-water separator. The water phase from the separator was released into the pond, providing another potential source of the contaminants seen in sediment.

In 1998, a Targeted Brownfields Investigation (START, 1999) was conducted at the KAPP and in the pond area. Pond sediment contained traces of PAHs, VOCs, and PCBs at concentrations similar to those observed in the RI (Figure 4-4b). The type of PCB noted in 1999, and again in this RI (Aroclor 1260), was the same as that used in the old transformers, as documented for the 1998 spill. Minor environmental concerns related to SVOCs, fuels, and PCBs were reported at the power plant, but were not considered severe.

There have been proposals in recent years to reactivate the power plant and to dredge the pond area and the Ship Creek pool behind the Kapp Dam, but no action has been taken.

Contaminants present in the pond most likely relate to the power plant. Contaminants may have entered the pond via the cooling water recirculation during the years the plant operated, or via the water discharges to the pond resulting from the 1998 spill. The contaminants seen in pond sediment are consistent with those present at the power plant.

Migration potential

As noted in the previous discussion, sources for the observed contamination likely relate to KAPP cooling water or to the 1998 spill, but may also be related to suspended solids transported by Ship Creek high flows. The pond is fairly quiescent, and large scale scouring of sediments is unlikely. Some dissolution of contaminants in the sediment may occur, and there may be limited movement of suspended sediments downstream. Any migration would primarily occur via the drain to the tidal area below the Kapp Dam, and quickly be flushed by tidal action.

The pond is actively used by aquatic biota, including beavers and birds. Direct exposure is, therefore, possible, as is release of contaminants via bioturbation.

Section 7.0 further evaluates this area in terms of ecological and human health risk, and concludes that no unacceptable risk is present.

5.2.2 Area SE-2

Area SE-2 (Figure 5-1) encompasses the contaminated sediment found in the pond near LP069 (Dean's Auto) and termed "storm water pond" in this report. Figures 5-6a and 5-6b show a detailed map of the area, including current and historic data results for all media in the vicinity.

Nature and extent

Based on a visual survey of the extent of contamination in the pond conducted in February 2007 (Appendix I), the extent of the impacted area has been fully characterized.

Figure 5-7 shows the distribution of silty material and sediment in the pond. The estimated sediment thickness contour indicates that a maximum of 9,172 cubic feet of sediment are present in the pond. Most of this sediment presents some visual evidence of hydrocarbons, although heavily impacted sediment is confined to the deepest portion of the pond. The total volume of heavily impacted sediment is, therefore, less than the total volume.

Samples of the contaminated silty material from the most heavily impacted area (CSB-01 and CSB-06), both located in the deep portion of the pond or near the storm water outflow showed elevated concentrations of hydrocarbon-related constituents, primarily PAHs. No volatile organics, such as BTEX compounds, were

found, suggesting an older source with little on-going contribution from fuel hydrocarbon sources. Some inorganics were moderately elevated, including lead, which is frequently associated with fuel sources.

Sources

The highest concentrations are in the center (and deepest part) of the pond. However, a sample (CSB-06) in shallow water at the mouth of storm sewer ARRC A-2 also had elevated concentrations. Based on this distribution, and the absence of contamination in the shallower eastern and southern portions of the pond, the storm sewer is the probable source of the observed contamination. The storm drain in question drains a large sector of the ARRC Railyard, and is also connected to the municipal storm water drainage from the Government Hill residential area.

Review of data from surrounding areas and leased properties does not point to a significant or single nearby source. Upgradient leased properties include LP069, LP078, LP052, LP123, and LP090. No pre-RI environmental records for LP078 and LP052 are available. A surface soil sample at LP078 (MWE10) found some PAHs, including benzo(a)pyrene, suggesting some contribution to the pond via surface runoff is also possible. North of Whitney Road (i.e., the location of current ARRC Operations Building), pre-RI data indicate the presence primarily of VOCs[15]. Low levels of VOCs are also present in groundwater at LP069.

Review of documentation for the indicated leased properties indicates no obvious sources. USTs used for fuels and/or used oil have previously existed at LP123 (one tank closed in place in 1998); LP069 (three tanks, probably removed some years ago, and confirmed as removed in 2007 [RSE, 2007]); and LP090 (one tank removed in 1998). In addition, LP069 has, in the past, been subject to Notices of Violation (NOV) due to surface releases, contaminated soil, and improper property use as a junkyard. Runoff from these areas has been noted as potentially reaching the pond area via "ditches." Some contribution from these sources is possible.

The RFA identified SWMUs and Areas of Concern at several of the nearby leased properties. These SWMUs and Areas of Concern generally refer to used oil and antifreeze accumulation areas, to drum storage areas, or to the former location of tanks. These SWMUs (Section 6.0) are not likely sources of the observed contamination.

Migration potential

The pond currently lacks a flowing surface drainage outlet, in part due to beaver activity in the pond. In the past, this has led to flooding problems, which were resolved by installing a passive drainage pipe from the southwest corner of the pond to Ship Creek. The drainage pipe drains water from about a depth of 3 feet.

The contaminated silt is limited to the deep portions of the pond. The shallower lobes of the pond lack a silty layer, and also lack elevated concentrations of the contaminants noted in the deeper parts. This indicates that the quiescent nature of the pond, and the presence of a deep "hole" in the middle, serves to contain any contaminants entering the pond. Surface water samples did not have elevated concentrations. The types of contaminants present (PAHs and aliphatic hydrocarbons) are strongly adsorbed to the organic carbon fraction in clays and silts and, therefore, would not be strongly mobile or bioavailable except in particulate form in suspended sediment. As a result, biotransfer and transport in the dissolved phase is expected to be low, as sediment is quiescent and biological activity at this depth is low.

The observed contamination is well-contained and not subject to extensive migration to other parts of Ship Creek. However, the pond, in itself, is a significant aquatic habitat, as are the nearby marshy areas, with

[15] See discussion of soil gas area SG-1 for more on this.

potential exposure of resident biota, such as beavers. Beavers and other aquatic biota may also disturb the impacted sediment. The occasional sheening observed on the pond surface may be the result of such disturbance. Section 7.0 further evaluates this area in terms of ecological and human health risk.

5.2.3 Area SE-3

Sediment area SE-3 (Figure 5-1) consists of a marshy area along the north side of Ship Creek near Railroad Avenue on the eastern side of the Site. Area SE-3 consists of a permanent marshland occupying approximately 550 feet by 200 feet (about 2.8 acres), confined behind the gravel bar defining the Ship Creek main channel. The marshy area is vegetated with macrophytes and duckweed, and typically is covered by 0.5 to 1 foot of standing water. Sediment thickness is about 0.5 to 1 foot over the underlying Ship Creek gravel alluvium. No flowing surface drainage to Ship Creek is present, although seeps along the gravel bank are present, and relict channels at the west end may carry high flows to the creek. The marsh is fed by runoff from surrounding leased properties located north and east of the marsh. In particular, a short ditch (100 feet) at the northeast corner carries runoff from LP029 and was visibly impacted during Site visits. Figures 5-8a and 5-8b show the distribution of contaminants in this area.

Nature and extent

Three samples (CSD04, CSD05, and CSD07) from the 100-foot-long ditch had concentrations exceeding sediment SLs for PCBs (Aroclor 1260), PAHs, phthalates and inorganics (antimony, arsenic, cadmium, copper, lead, mercury, and zinc). Several other organics were detected, but were below the SLs. High concentrations of PCBs were noted in low lying areas to the east of the ditch (CSD08). Concentrations to the west of the ditch were much lower but still significant for PCBs.

In the marsh itself, sediment SL exceedances for PCBs and PAHs were present, most so near the ditch (CSD-02), less so at the downgradient (CSD-01) end. However, concentrations in the marsh were considerably lower than in the ditch. Inorganic concentrations were also lower in the marsh with only arsenic exceeding the SL by more than two times the SL.

The extent of contaminated sediment (and soil) is limited to the 100-foot ditch and adjacent soil piles, and to portions of the 2.8-acre marsh.

Source

The source of the contamination is related to the ditch. The highest concentration of PAHs, phthalates, and metals was present in the silt in the ditch itself, but elevated concentrations were also present in sediment/soil in the area near the ditch, immediately south of the rubble fill that forms a boundary between this area and LP029. The ditch does not appear connected to any discharge point source, outfall, or other obvious conduit from nearby developed areas.

However, the topography of the area surrounding the ditch, and the presence of debris and what appears to be soil piles, suggests that this area contains old dumped soil or debris piles that have been overgrown with riparian vegetation. The highest concentration of PCBs (11 mg/kg, which is the highest concentration found anywhere at the Site) was at CSD08, a low lying area immediately east of the ditch, suggesting that abandoned soil piles here are the source of PCBs. Further sampling to evaluate the content of the soil piles for purposes of evaluating remedial alternatives was conducted in October 2007, and will be reported in the FS.

Lease LP029 (2014 N. Post Road) is currently leased by Mr. Troy Hager, doing business as Commercial Truck Service, a truck repair facility. It is not possible to determine if the source of the PAH contamination in the ditch and nearby areas is due to sources or procedures at this facility or if the material is residual from prior dumping. However, there is no evidence of ongoing discharge from upgradient sources. There are no records in pre-RI sources with environmental data for this or other nearby leased properties.

Fate and transport

Elevated inorganics (especially lead and mercury), PCBs, some SVOCs and PAHs are present primarily in the ditch sediment (CSD04, CSD06, and CSD07). Sediment/soil in adjacent ground depressions to the west (CSD05) has lower levels, but still reported some PAHs and PCBs. However, soil/sediment from the area immediately east of the ditch area (CSD08) have considerably elevated PCB concentrations. PCBs and PAHs were also noted in the surface water overlying the ditch sediment (e.g., CSD04 and CSD07), indicating that sediment contaminants mobilize to surface water. The ditch is intermittent and lacks a clear discharge point to the main body of the marsh, from which it is separated by an elevated area. However, during runoff conditions, the ditch overflows and reaches the marsh, and subsurface migration from the ditch may reach the main body of the marsh. The highest waterborne concentrations in the marsh were noted at CSD02 at the point where flow from the ditch would reach the marsh during runoff conditions.

The section of the marsh furthest away from the likely sources in the upgradient direction (CSD03) lacks COCs above screening levels. However, CSD-01, located at the western, downgradient end of the marsh, does show COCs, but at considerably lower levels than in the ditch area. This indicates that some transport from the ditch area to the marsh has occurred in the past. As the marsh lacks surface drainage to Ship Creek, it is unlikely that contamination reaches the creek.

The contaminants include PCBs (Aroclor 1260), high molecular-weight PAHs, BEHP, and some inorganics. These are refractive substances with slow degradation rates. The absence of VOCs and low molecular-weight PAHs suggests that the material is relatively old.

5.2.4 Area SE-4

Sediment area SE-4 (Figure 5-1) consists of an inactive drainage ditch flowing westwards from the location of the closed Standard Steel CERCLA site towards Ship Creek. This ditch flows for approximately 400 feet through riparian vegetation. It is 4 to 8 feet wide and contains standing water during wet periods. It has been dry during field inspections, except in October 2004 (during the Habitat Survey) when it contained pools of standing water (no active flow however, as the ditch is partially blocked by vegetation debris). Figures 5-6a and 5-6b show the distribution of contaminants in this area.

Nature and extent

Five sediment samples collected along the ditch show that the most impacted location was CSE01, a location sampled in 2005 as representative at the most likely worst-case condition. The sample showed significant exceedances for PCBs, PAHs, and several inorganics (antimony, cadmium, copper, lead, and zinc). However, the elevated concentrations of PAHs appear localized, as subsequent upstream (CSE06 and CSE07) and downstream (CSE05) samples did not have elevated PAHs. Sample CSE04, located near the mouth of the ditch to Ship Creek, did have low level exceedances for PAHs (and PCBs). PCBs (Aroclor 1260 only) were more widespread, with exceedances noted in all samples, particularly at CSE01 and at CSE07 at the head of the ditch adjacent to the former Standard Steel site. Inorganics were detected only at CSE01 and CSE04, (at the mouth of the ditch), where concentrations were not highly elevated (i.e., more than twice the SL)) and were lower than at CSE01. Specifically, arsenic was detected at 3.05 and 7.2 mg/kg at CSE01 and CSE04, respectively. Lead was detected in CSE01 at 99.8 mg/kg. Zinc was detected at 359 mg/kg and 130 mg/kg at CSE01 and CSE04, respectively.

The ditch is 400 feet long, of which the upper 150 feet is affected by elevated concentrations of PCBs. PAHs are more localized to the area around CSE01.

Sources

The ditch once drained the Standard Steel facility. However, it fell outside the footprint of the CERCLA remediation footprint for the Standard Steel facility CERCLA action. No other leased properties or railroad

activities are upgradient. The presence of PCBs in the sediment suggests that residuals from Standard Steel are the most likely source of the observed contaminants, as PCBs (and lead) were listed as COCs for that facility.

Migration potential

The ditch runs to Ship Creek. However, the mouth of the ditch has been partially filled in by creek deposition and streambed course alteration. Active drainage from the ditch into the creek is intermittent and probably occurs only during significant runoff events. Mobilization of some of the impacted sediment contained in the ditch could occur during those events. Accumulation of fine-grained sediment is present in the ditch near the outfall to Ship Creek. However, the absence of PCBs or elevated PAHs in downstream Ship Creek depositional sediment indicates that any silt or contaminants that do end up in the creek are washed downstream to Cook Inlet.

Overall, the PAHs, PCBs, and inorganics noted in the ditch sediments suggest impacts from the time of the Standard Steel operation. These residual contaminants generally have low mobility. Section 7.0 will address ecological and human health risks from the observed sediment contamination.

5.2.5 Area GW-5

Groundwater area GW-5 (Figure 5-1) encompasses the previously known groundwater impact area underlying LP991, the former Arctic Cooperage lease. As part of the RI, additional data were collected to evaluate potential migration to Ship Creek from this source area. Figure 5-9 provides detailed information on current and pre-RI data associated with this area.

Nature and extent

Two wells, MWE22 and MWE25, had benzene concentrations that exceed the groundwater SL (Figure 4-5d). Additionally, 1,1,2-Trichloroethane occurred at a concentration exceeding the groundwater RI SL. However, these VOC exceedances are limited in extent as no upgradient or downgradient wells had concentrations exceeding the groundwater SLs (Figure 4-5d and Figure 4-5e).

Fuel hydrocarbons, EPH and VPH, were detected at this location in two RI wells, MWE22 and MWE25 (Figure 4-5f). Although total VPH was detected at both wells, concentrations were below the RI SL; EPH exceeded the RI SL at least once during RI sampling. These data are consistent with historical groundwater results for this area, which indicated exceedances for both DRO and GRO (Figure 2-4c). However, the RI data clearly show the extent of fuel hydrocarbon exceedances is limited in extent (Figure 2-4c and Figure 4-5f), as neither EPH nor VPH were detected at upgradient or downgradient locations.

LNAPL was detected during the April 2006 RI monitoring event at one monitoring well, MWE21 (Figure 2-7). Similar to the dissolved phase distribution of contaminants, LNAPL was not detected in any of the surrounding monitoring wells either upgradient or downgradient of MWE21 indicating that this is a localized and stable occurrence and does not impact Ship Creek.

Arsenic exceeded RI SLs at MWE22 and MWE25, and cadmium exceeded at MWE23 (Figure 4-5a). These exceedances correspond with VOC and fuel hydrocarbon exceedances discussed above. Because arsenic tends to be more soluble in its reduced state it is not uncommon to find it associated with hydrocarbon occurrences, which are typically oxygen deficient as the result of natural attenuation processes. Arsenic exceedances at GW5 are limited to the area of VOC and hydrocarbon exceedances and does not exceed the RI SL at downgradient well MWA14 and MWA15 (Figure 4-5a). Again, indicating that the contamination at this location is limited in extent and does not impact Ship Creek.

Groundwater contamination at this leased property is limited in extent and related to historical oil recycling operations and releases, and was well documented in the SBR (RETEC, 2005c).

Sources

The source of residual contamination in soil and groundwater at the LP991 location is generally considered to be the former operations of Arctic Cooperage at this location. RI sampling north of Whitney Road and upgradient of LP991, at (DPC05 and DPC06), and MWE12, as well as pre-RI sampling) confirms that there is no contribution to this plume from upgradient sources.

Migration potential

The primary concern related to this groundwater contamination source area is migration towards Ship Creek or its off-channel aquatic areas. The plume is confined to the fill area underlying LP991 and to the boundary area with leased properties to the east and west. To the south (in the riparian zone adjacent to the creek), sentinel wells MWA14 and MWA15 were monitored, showing that no LP991 related contaminants are migrating towards the creek. Detected contaminants barely extend to MWE23, immediately south of the LP991 boundary.

Sediment and surface water samples collected in marshy areas near Ship Creek (CSB-04 and CSB-05), downgradient from this plume and within the SE-2 area, did not contain elevated concentrations of contaminants associated with the groundwater plume.

The absence of LP991 related contaminants in downgradient groundwater, sediment, or surface water shows the absence of migration towards Ship Creek, and that sediment contamination noted in the storm water pond (SE-2) is unrelated to this source. Therefore, this source area is stable and not a continuing source of risk to Ship Creek. Direct current risk to human health from groundwater and soil in this area is evaluated in the risk assessment, as is future risk from groundwater contact. No current or anticipated future groundwater use occurs within this source area.

5.2.6 Area GW-6

Groundwater area GW-6 (Figure 5-1) is located north of Ship Creek along Whitney Road in the western part of the Site. Figure 5-10 provides a detailed map of pre-RI and current data for this area. This area was identified as part of the Transect A evaluation rather than from pre-RI sampling.

Nature and extent

Sample DPA30 contained had 62 µg/L TCE and 6.12 µg/L PCE, in addition to concentrations of benzene and several other CVOCs that were below SLs. Vinyl chloride (1.2 µg/L) and c12DCE (27 µg/L) also were present below SLs. This sample was located close to Ship Creek. Two step-out samples east and west of DPA30 (DPA30D2 and DPA30D3) contained had much lower levels of TCE (1.4 and 5 µg/L, respectively), in addition to very low levels (less than 2 µg/L) of several other CVOCs. The TCE/PCE plume, therefore, is narrow and affects a limited portion of the stream bank.

Stepping out northwards, PCE and TCE were found in lesser concentrations but still above SLs DPA30D4 and A30E1 and A30E2, a linear distance of approximately 400 feet. Only very low levels (less than 1 µg/L TCE) were found in samples to the east, on LP049 (DPA30D1and MWA07). Therefore, the plume appears to follow the footprint of the overhead bridge. The concentrations decline upgradient. The presence of PCE, TCE, and multiple reductive dechlorination byproducts such as c12DCE and vinyl chloride suggests that degradation is ongoing.

As a result of further step-out sampling to identify the source area, conducted in May 2007, five groundwater sampling points further north (DPA30F1 and DPA30F2) show that the TCE and PCE plume remains evident along a north-south axis underneath the East Loop Bypass Bridge. Samples to the east and west had low or negligible concentrations of PCE and TCE. A further sample, DPA30F5 further north, still was dry. The

source area for the TCE and PCE, therefore, appears to be located within the Railyard in an active trackage area (Figure 5-10).

Sources

Step-out sampling to identify the source area for the observed TCE and PCE has confirmed that nearby LP049 (Wrightway Auto) is not the source for most of the CVOCs. As can be seen in Figure 5-10, the flow path for the CVOCs appears to be north to south underneath the highway bridge. The step-out sampling has determined that the source is located within the Railyard, although an exact source has not and cannot be identified. Low levels of various CVOCs (below SLs) are commonly observed in the Railyard area, suggesting the probability of diffuse or multiple sources throughout the area. Recent step-out sampling indicates source areas must be in active trackage parts of the Railyard. However, no structures or known sources are currently present in this area, which is given over to railroad trackage. Other potential sources in the Railyard area are multiple, as CVOC solvents were frequently used as part of repair and maintenance activities.

It is very noteworthy that the flow path of the CVOCs follows the overhead bridge and not the southwest trending groundwater flow pattern. The flow direction, therefore, does not follow the general area groundwater flow pattern. This is suggestive of the existence of a preferential pathway paralleling the overhead bridge, possibly in fill or utility corridors dating from the construction of the bridge. Two storm sewers are present in this area (one is a Railyard storm sewer, the other is a storm sewer draining the overhead highway owned by ADOT). The existence of such a preferential pathway through permeable fill could result in the observed pattern as groundwater flows are directed along the pathway.

Migration potential

Elevated TCE and PCE are present very close to Ship Creek. It is likely some discharge to the tidal portion of Ship Creek is occurring, although the front across which such discharge may occur is narrow, comprising approximately 100 feet of bank width. The HHRA and ERA (Appendices B and C, respectively) further evaluate risk from this area.

5.2.7 Area GW-8

Groundwater area GW-8 (Figure 5-1) is located within the LP127 leased property north of Ship Creek and west of Post Road. Environmental issues related to prior PCB removal action and releases of CVOCs have been documented at this leased property (see "Sources" below)[16]. The RI evaluated residual contamination and migration from the lease towards Ship Creek. Pre-RI and RI data for this area are shown in detail on Figure 5-12.

Nature and extent

Soil data collected in 1999 showed TCE exceedances of soil SLs at several locations within the leased property. Groundwater monitoring data collected in 2003, 2004, and 2005 as part of an independent site investigation indicated exceedances for TCE and 1,4-dichlorobenzene in several monitoring wells (MW-3, MW-4, and MW-6).

[16] An underground storage tank removal in 1990 led to the discovery of elevated PCBs in soil. The responsible party for the PCBs was determined to be Westinghouse, which had operated a transformer storage and repair facility at this leased property. A removal action was implemented by Woodward & Clyde in 1991 (Woodward & Clyde, 1993). ADEC approved No Further Action in 1993, although some residual PCBs (and TPH) were still present in the soil (although not in groundwater). During the RI, some PCBs were noted above screening levels in soil samples from this area, confirming the continued presence of low levels of PCBs. The PCBs are discussed in the risk assessment and are shown on Figures 4-7b and 5-12, but are not an issue related to the TCE groundwater impacts.

RI sampling conducted at two locations on this leased property included MWA17 near the existing monitoring wells, and at MWA16 at the southwest end of the leased property. Well MWA17 had only traces of TCE (less than 1 µg/L), but also had low levels (well below SLs) for several other CVOCs, including 1,1,1-trichloroethane. Well MWA16, further downgradient of the source area, did not have TCE, but showed exceedances for vinyl chloride (6 µg/L in 2005, and 3.5 µg/L in 2006) and traces of c12DCE (less than 2 µg/L).

A sample from the base of the bank to Ship Creek (DPA33) did not contain any CVOCs, nor did sediment and surface water samples from the riparian zone immediately below the lease (CSE02). These areas are somewhat cross gradient of the main plume, but CVOCs were also absent in sediment and surface water CSC03 west (and downgradient) of the source area.

The plume is confined to LP127, and reductive dechlorination of TCE evidently occurs based on the detection of TCE degradation products downgradient of the source area.

Sources

TCE was found in Site soil in a Phase II Site Assessment in 1999 (Shannon and Wilson, 1999). The responsible party for the release was identified as Kelly Moore Paints, then a tenant at this lease. In 2003, excavation took place in one area to address the TCE (Shannon and Wilson, 2003), although prior detections of elevated soil TCE had been noted at various locations of the lease (Figure 5-12). This report noted that there was TCE detected in groundwater to 17µg/L, and recommended that this be addressed via natural attenuation. In 2005, ADEC noted that the 2003 Remedial Action Report had not demonstrated that migration to Ship Creek was absent and that the feasibility of natural attenuation had not been sufficiently demonstrated.

This issue is currently under consideration by ADEC, and discussions of appropriate actions are ongoing. Kelly Moore Paints previously assumed responsibility for the release. The additional data acquired as part of this RI may address some of the concerns expressed by ADEC related to this plume.

Migration potential

As noted in the previous section, additional evidence collected as part of this RI indicates that CVOCs are not migrating to Ship Creek. Reductive dechlorination of TCE also appears to be occurring. Based on these factors, this plume has limited potential for migration and remains confined to LP127.

The risk assessment considers all current data for this area in relation to current exposures by site workers, ecological exposure in Ship Creek, and potential future ingestion of groundwater. Note that a water supply well is present on this leased property, east of the source area. This well is completed in the deeper aquifer and should not be an exposure pathway, as evidenced by analytical data from this well.

5.2.8 Area GW-9

Groundwater area GW-9 (Figure 5-1) encompasses a CVOC groundwater plume underlying portions of LP085, currently leased to CBS Equipment. The presence of the plume had been reported prior to the RI. The RI conducted further additional evaluation of its nature and extent. A detailed map is presented on Figure 5-12.

Nature and extent

Three pre-RI monitoring wells, monitored between 1995 and 1998, show concentrations of TCE in the 5 to 10 µg/L range, and PCE concentrations up to 150 µg/L, in addition to exceedances for 1,2,3-trichloropropane, acrolein, and acrylonitrile. Exceedances were noted throughout the southwestern portion of the leased property, the area within the flow path of groundwater from an old, used oil tank (see below) towards Ship Creek.

As part of the RI, well MWA19 was placed at the downgradient boundary of the leased property. This well has reported exceedances of TCE (14 to 10 µg/L) and PCE (26 to 8 µg/L). In 2007, an additional sampling location placed closer to Ship Creek (DPE30) did not have CVOCs. Well MWA18 southwest of the leased property, across Post Road, had a trace of PCE (less than 1 µg/L). The CVOC plume appears confined to LP085.

Sources

Two USTs were removed in 1992. A leaking gasoline tank at the eastern end of the then-leased property resulted in very high concentrations of BTEX in nearby groundwater. A second tank at the western end of the lease, which stored used oil, had also leaked. At the time of removal, it was noted that PCE and TCE were among several other volatile organics present at high concentrations in groundwater near this tank (Figure 5-12). Additional investigations in 1996 revealed continued high concentrations of TCE and PCE in the southwestern portion of the leased property[17]. In 1997, a plan was approved by the lessee to install horizontal sparge wells to control these VOCs. However, correspondence with ADEC indicates that due to lack of funding this plan has to date not been implemented. Elevated concentrations of PCE and TCE continue to be present, related to the removed used oil tank (Figure 5-12). The data collected for this RI provides additional information for this ongoing ADEC concern.

Migration potential

As noted in the previous discussion, the absence of CVOCs above groundwater SLs in samples nearest Ship creek indicates that migration of the absence of detectable migration to Ship Creek. The plume, therefore, is not a source of risk to Ship Creek. The risk presented to Ship Creek, current Site workers, and to future potential users of groundwater is discussed further in the risk assessment.

5.3 Focused source evaluations

In addition to the impacted areas identified or evaluated based on the transect evaluation process, two additional impacted areas were identified as part of the focused evaluation during the RI. One of these is a groundwater area associated with previously known sources (GW-7) , and the second was the discovery of elevated soil gas concentrations of some VOCs in an area where waste material had been reported in the past (SG-1). These areas are not specifically associated with sources of risk to Ship Creek, but are considered in relation to risk to human health via groundwater or inhalation of vapors.

5.3.1 Area GW-7

Groundwater area GW-7 (Figure 5-1) is located on the north-central part of the Railyard, adjacent to a historical fueling area. A detailed map showing current and pre-RI data from this area is shown on Figure 5-11.

Nature and extent

The former fueling rack is RCRA Area of Concern 2 in the RFA, listed due to the presence of the fueling rack and the likelihood of previous spills. In the SBR, this area was targeted for authoritative sampling to determine if residual contamination remained. To this end, two monitoring wells (with associated soil samples), MWE05 and MWE06, were placed at the former location of the fuel rack, and a Transect D location (MWD06) was positioned immediately upgradient. This impacted area is entirely confined to the Railyard, as shown by the absence of elevated concentrations in downgradient groundwater locations along the C Transect (MWC01,

[17] The BTEX contamination at the location of the eastern tank has decreased rapidly (currently located on LP134). By April 1997, concentrations had dropped to near screening levels. Well MWE24 was placed during the RI at the location of this tank specifically to evaluate attenuation of the BTEX plume. No trace of BTEX or hydrocarbons remains present.

MWC02, and MWC03). Due to the active nature of the Railyard area immediately downgradient of the source and the limited extent of the plume, exact plume delineation was not attempted, as it is not a source of risk to Ship Creek.

Soil and groundwater from MWE05 and MWE06 showed elevated concentrations of fuel hydrocarbons and several specific components of fuel mixtures (BTEX and PAHs). Pre-RI data from this area also noted soil impacts adjacent to the fueling rack.

Two wells located in the northwest area of the Railyard had groundwater VOC exceedances (Figure 4-5d). Wells MWE05 and MWE06 exceeded for benzene,1,2-dibromo-3-chloropropane, and 1,1,2-Trichloroethane.

Fuel hydrocarbons also exceeded in groundwater at MWE05 and MWE06 although EPH decreased to below SLs during subsequent events at both wells and VPH to below SL level in MWE06 (Figure 4-5f). This occurrence of fuel hydrocarbons is limited in extent as no EPH or VPH exceedance occurs either upgradient at MWD06 or downgradient at sampling points MWE03, and MWC01 through MWC04.

Arsenic exceeded RI SLs at MWE05 and MWE06 (Figure 4-5a). These exceedances correspond with VOC and fuel hydrocarbon exceedances discussed above. Because arsenic tends to be more soluble in its reduced state it is not uncommon to find it associated with hydrocarbon occurrences, which are typically oxygen deficient as the result of natural attenuation processes. Arsenic exceedances at GW7 were limited to the area VOC and hydrocarbon exceedances and did not exceed the RI SL at nearby wells MWE05, MWD06, or MWC03 (Figure 4-5a).

Sources

The source of the residual contamination in groundwater and soil is the former fuel rack located east of the Electric Shop. This fuel rack was constructed in the 1950s or 1960s to replace a former fueling area located further east. It was closed in 1978 and replaced by the current fueling area south of the Electric Shop. Spills and discharges during the operations of this fueling rack are the source of the observed soil and groundwater contamination. It should be noted that sample location DPD06/MWD06 immediately upgradient of this source area does not contain elevated concentrations of these contaminants, confirming that the source is local, and upgradient extent is negligible.

Migration potential

As noted above, this plume does not reach the C Transect at the Railyard boundary to the leased properties. It is, therefore, confined to a portion of the active section of the Railyard. The affected area is relatively old, with no contributions expected since the fueling rack was closed. No extensive migration has occurred since, and contaminants are not likely to migrate in the future based on concentration, type and age. Therefore, this plume is not a source of risk to Ship Creek or other areas. The HHRA (Appendix B) addresses any risk to current or future human receptors.

5.3.2 Area SG-1

Area SG-1 (Figure 5-1), located near the new ARRC Operations Building on Whitney Road, was identified based on authoritative soil gas sampling. Soil gas sampling was conducted based on pre-RI data and reports prior to construction of the office building in 2005, indicating the possible presence of elevated soil concentrations of volatiles. The data associated with this area are shown on Figures 5-6a and 5-6b.

Nature and extent

Soil gas data were collected from RI samples collected in a boring within 100 feet of the new ARRC Operations Building. Sample SVSP4 contained a number of VOCs, of which three exceeded surface soil gas SLs at 8.5 to 9 feet bgs: TCE, PCE, and 1,1-dichloroethane. In shallower soil (6 to 6.5 feet bgs), only TCE

exceeded the deep soil gas SL. The extent of elevated soil gas concentrations is not precisely known, except to note that as part of the excavation of the foundation for the Operations Building, the soil known to be impacted from historic disposal was removed.

Migration potential

Downgradient groundwater locations to this area, including MWE08, the storm water pond identified as sediment area SE-2, as well as the cross-gradient locations to the east (DPC05 and DPC06), do not show elevated VOC concentrations. Although no groundwater exactly co-located with the soil gas samples collected, there is no evidence that groundwater impact is present. This area is not a source of risk to Ship Creek or other areas.

The primary exposure medium from residual VOCs in the ground is via volatilization to indoor air, primarily in the ARRC Operations Building. It should be noted that this new building is equipped with vapor barriers, and is unlikely to be exposed to soil vapors. However, the risk assessment does address potential risk to indoor air from this source.

5.3.3 Perimeter Area at LP019 (Tesoro)

The evaluation at the Terminals Area identified one area with potential discharges to Cook Inlet. This area is located at the northwestern corner of the Terminals adjacent to LP019 (Tesoro). Source areas within the Tesoro leased property have resulted in the migration via groundwater of contaminants, including BTEX, petroleum hydrocarbons, PAHs, and other constituents, towards Cook Inlet. A storm water drainage located just west of the fence has intercepted part of the flow and released it to the inlet via the nearby storm water discharge point. In addition, there is evidence that migration of NAPL and dissolved constituents has occurred directly to the mudflats along Cook Inlet via seepage along the fill material seawall next to the storm sewer outfall.

Tesoro implemented interim actions to address this migration in 2006, including recovery trench installation, installation of a product recovery system in the storm sewer sedimentation vault, and repair of breakages in part of the storm sewers. However, in May 2007, there has been evidence of continued discharge of hydrocarbon sheens to the inlet via the storm sewer. Tesoro is currently planning further action to address this discharge under ADEC oversight.

Nature and extent

As noted above, groundwater samples along the fence line and between the fence line and Cook Inlet have reported concentrations of fuel hydrocarbons (DRO and GRO) in excess of SLs (2,500 to 44,000 µg/L DRO), as well as benzene (up to 922 µg/L). The concentrations reported for DRO are such that it is likely that some of it is present as LNAPL. The exceedances are limited to an approximately 200-foot-wide section at the far northwestern corner of the Terminals Area.

Exceedances of benzene SLs are found in the NAPL recovery system installed by Tesoro in the sedimentation vault in 2006 (samples EWSW1 and NSSWE), but these may be representative of the captured contaminants, and not those released into Cook Inlet. Samples from the storm sewer itself show ongoing detections of BTEX compounds and fuel hydrocarbons. Benzene concentrations do not exceed the marine surface water SLs, however, except as noted above.

Hydrocarbon concentrations at MWE17 are consistent with nearby well P23, located approximately 100 feet upgradient near a former railcar loading rack. In addition, the most recent groundwater data from wells located along the western boundary fence line (Figure 4-12b) all show benzene concentrations that exceed the RI SL. The RI perimeter data and the Tesoro data indicate that benzene-impacted groundwater occurs west of the Tesoro leased property. However, to the south, between MWE17 and MWE18, the most recent groundwater data indicate that benzene concentrations are below the RI screening value (Figure 4-12b). One Tesoro well,

PW-20, immediately to the west and across an open drainage ditch from MWE18 (Figure 4-12c), had a benzene concentration of 29.9 µg/L, which exceeds the RI screening value. However, MWE18 has remained ND for benzene through two sample events. This distribution of contaminants suggests that the open drainage ditch may be providing hydraulic control and preventing migration to the west.

In June 2006, a sheen was reported on Cook Inlet coming from the MOA outfall, approximately 150 feet west of the northwest corner of the Tesoro property. Upon further investigation, Tesoro identified an LNAPL release from its facility and began delineation of the LNAPL and dissolved phase plume (Oasis, 2006). As part of the Tesoro response, five additional monitoring wells (MW-19 to MW-23) were installed to the north and west of MWE17 as close to the fill-tidal flat boundary as possible (Figure 4-12b and Figure 4-12c). Groundwater from each of the wells was collected and analyzed for BTEX, DRO, and GRO. All five wells had detectable concentrations of benzene and DRO. However, only one well, MW-23, located approximately 100 feet north and west of MWE17, had a benzene concentration that exceeded the RI SL (Figure 4-12b).

Fluid levels were gauged using an oil/water interface probe at all of the RI perimeter well locations concurrent with groundwater sampling. LNAPL was not observed at any location. In addition, none of the monitoring wells installed as part of the Tesoro corrective action had accumulations of LNAPL. LNAPL was observed in several Tesoro test pits completed during July 2006 as part of the release investigation (Oasis, 2006).

Sources

The source of the contaminants noted in the subsurface west of the fence line, and of the contaminants entering the storm sewer from surrounding groundwater, is acknowledged to be related to subsurface contamination known to exist within the Tesoro leased property. Tesoro implementation of interim actions to control the migration confirms this conclusion. Tesoro is currently carrying out additional interim actions under ADEC direction and oversight, and Tesoro submits annual monitoring reports to ADEC.

Migration potential

There is evidence that migration in the form of discharges and sheens to Cook Inlet has occurred in the past and may continue to occur, although the discharges generally have not exceeded marine surface water SLs. The strong tidal current and high tidal amplitude in Cook Inlet indicates that such discharges cannot result in detected concentrations in Cook Inlet itself. Sediment samples from the off-shore area that have been collected to support the POA expansion also do not contain any detectable VOCs. Exposure in the corridor located adjacent to Tesoro is also minimal, as no public access to this area exists, and no building or occupied facilities are present. However, potential risk in this perimeter area is considered in the risk assessment.

5.4 Summary of key areas of potential concern

In the preceding sections, the RI identified a small number of groundwater and sediment areas of potential remedial concern, based on the presence of groundwater contaminant plumes or impacted sediment areas. Most of the 600-acre Site did not have evidence of environmental impacts to soil, groundwater, or Ship Creek media requiring further attention in the RI/FS. The few areas of extensive impact can be summarized as follows:

- Three groundwater impact areas located under leased properties on the south side of Ship Creek, including:
  - Area GW-1, a TCE plume with possible, but unconfirmed, off-site sources east/southeast of the Site
  - Area GW-2/3, a vinyl chloride plume with likely off-site upgradient sources
  - Area GW-4, a vinyl chloride plume with off-site sources south of the Site

- Four groundwater impact areas along the north bank of Ship Creek
  - Area GW-5, a fuel hydrocarbons (LNAPL, BTEX compounds, and PAHs) and inorganics impacted area under the former LP991, Arctic Cooperage. This area appears confined and static, and is not reaching Ship Creek.
  - Area GW-6, a TCE and PCE plume originating in the Railyard and migrating towards Ship Creek under the A-C Couplet Overpass, and which appears to be related to a preferential flow pathway.
  - Area GW-8, a TCE and vinyl chloride plume with previously acknowledged sources in LP127 (Post Road Co-tenancy). This plume is largely confined to the affected leased property, and is not migrating to Ship Creek.
  - Area GW-9, a TCE and PCE plume with known sources in LP085 (CBS Equipment). This plume has been known for a long time, and is confined to the affected leased property and does not reach Ship Creek.
- Four sediment impact areas in the off-channel aquatic areas of Ship Creek
  - Area SE-1, the former cooling pond of the KAPP facility (LP120), where residual PAHs, inorganics, and PCBs are present
  - Area SE-2, a pond area near LP069 (Deans Auto), where storm water discharges and possible runoff has resulted in accumulation of hydrocarbon and inorganics in the deeper portions
  - Area SE-3, a marshy area near Railyard Avenue at the eastern side of the Site, where dumped soil and oily discharges in a ditch have resulted in elevated concentrations of PAHs, PCBs, other SVOCs, and inorganics in portions of the marsh
  - Area SE-4, a ditch that formerly drained the Standard Steel CERCLA Site, where residuals of PCBs and inorganics are present
- Two isolated areas of subsurface impact
  - Area GW-7, an isolated groundwater plume (LNAPL, BTEX compounds and PAHs) associated with a former fueling rack in the north central part of the Railyard. The groundwater plume appears static and does not migrate to Ship Creek or leased properties south of the Railyard.
  - Area SG-1, an isolated area of elevated soil gas concentrations for several CVOCs, located near the new ARRC Operations Building. The CVOCs, probably associated with waste material formerly buried in the area that was removed at the time of construction of the Operations Building, are localized and do not migrate beyond the immediate area.

The HHRA (Appendix B) and ERA (Appendix C) consider data from these areas and provide further risk-based evaluation of the contaminants noted in the RI. These conclusions are summarized in Section 7.0. The areas identified above, which, on the basis of the risk assessments, may present risk to human health and the environment, will be considered in the FS.

It should be noted that, although the Site as a whole lacked significant areas of soil contamination, impacts to Ship Creek, or groundwater impact, some isolated samples did exceed SLs. In most of these cases, the isolated nature of the exceedances did not point to a source of risk to human health or the environment, and nature and extent were not exhaustively defined. However, the risk assessments fully evaluate all data (RI and pre-RI) from the Site to determine any additional sources of risk, and any such sources of risk will be evaluated further in the FS (Section 7.0).

6.0 Evaluation of RCRA SWMUs and Areas of Concern

Railyard and leased property sites were originally inspected and described in the RFA Reports performed by the U.S. EPA (SAIC, 1996; Booz, et al., 2002). In the RFAs, U.S. EPA identified the leased properties (Appendix A of Booz, et al., 2002) and Railyard SWMUs and Areas of Concern (Section 5 of SAIC, 1996) that it determined would require further evaluation. According to U.S. EPA RFA Guidance, SWMUs and Areas of Concern should be evaluated to determine if releases of concern have occurred and to determine the need for further action. The guidance also states that SWMUs and Areas of Concern should be screened from further investigation if they do not pose a threat to human health or the environment U.S. EPA, 1986). This section provides a summary of the current status of each of these SWMUs and Areas of Concern including those identified by U.S. EPA as requiring no further action. Tables 6-1 and 6-2 include all RFA identified SWMUs and AOCs (SAIC, 1196; Booz et all, 2002). Thus this section addresses all SWMUs/ Areas of Concern as ARRC and the U.S. EPA have agreed.

In order to ensure that SWMUs and Areas of Concerns on individual leased properties and within the Railyard are adequately addressed, ARRC has conducted a progressive, systematic evaluation including:

- Review of the presence and historic use of the SWMUs or Areas of Concern based on review of site documentation and reviews of aerial and other site photos
- Distribution of survey forms to Site lessees asking them to provide information regarding the presence, use, and condition of SWMUs and Areas of Concern. The survey requested specific information on closure and removal activities as well as updating the present use of the area. The completed, returned surveys are included as Appendix G.
- Follow-up visits to leaseholders wherever the responses to the Site survey forms indicated that either further information and confirmation of conditions would be needed to address order requirements or where potential concern is inferred or noted from the lease holder. Photos taken in the Railyard and provided by one lessee are included in Appendix G.
- Review of RI analytical data in the vicinity of the SWMUs and Areas of Concern

The SWMUs and Areas of Concern can be classified into the following categories:

1. Those with active ADEC involvement and progress toward cleanup
2. Those confirmed by the lessee to be no longer present, no longer in use or closed
3. Those that are noted as in good condition in the RFA, and continue to be managed properly as confirmed by the railroad or lessee
4. Those that have a potential environmental concern that required investigation and/ or additional evaluation (further action) during implementation of the RI

Figure 6-1 shows the general location of Railyard SWMUs and Areas of Concern that the 1996 RFA identified. Specific location maps for the SWMUs and Areas of Concern that the RFA designated at the Railyard and within leased properties are not available. No figure is provided for the leased properties SWMUs and Areas of Concern since the RFA did not provide sufficient location information with respect to those properties.

6.1 Railyard SWMUs and Areas of Concern

Table 6-1 provides a summary of information for the Railyard SWMUs and Areas of Concern. The information summarized in Table 6-1 includes the SWMU and Areas of Concern locations, the description of the unit summarized from the RFA, any clarification or response that ARRC provided to U.S. EPA on the RFA description, whether U. S. EPA noted that it was in good condition or had a low potential for releases, its description based on a visual inspection, and a conclusion regarding their current status and condition.

At the start of the RI and based on review of the site-wide data in the SBR, five SWMUs and three Areas of Concern appeared to be candidates for location-specific investigation in the RI. These are shown in the following table. All of these SWMUs and Areas of Concern were investigated as part of the RI.

Railyard SWMU/AOC	Name of Area	Historical Review Indicated Area of Potential Concern
RY SWMU 13	Electric Shop Oil Collection Sump	fueling station drains to this location, reported system overloading
RY SWMU 65	Former Tank Car Steaming Area	potential source contributing to Ship Creek seeps
RY SWMU 66	Former Temporary Tank Car Steaming Area	release of 100 gallons of condensate, 1993
RY SWMU 67	Electric Shop Oil Water Separator	fueling station drains to this location, reported system overloading
RY SWMU 69	Former Tank Car Steaming Area Oil Water Separator	identified as source contributing to Ship Creek seep
RY AOC 1	Refueling Area	fueling rack
RY AOC 2	Former Fueling Area	spills reported
RY AOC 3	Diesel AST	1991 600 gallon release

As presented in Table 6-1, the Railyard SWMUs and Areas of Concern identified by U.S. EPA during the RFA fall into the four categories described in Section 6.0:

Railyard SWMUs with active ADEC involvement and progress towards cleanup

- Many of the SWMUs have undergone Site closure and/or cleanup through ADEC as detailed in Table 6-1.

Railyard SWMUs and Areas of Concern confirmed by the railroad (ARRC) to be no longer present, no longer in use, or closed

- SWMU 2, 10, 12, 16, 24, 25, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 43, 49, 53, 54, 56, 57, 62, 63, 66, 68, 70 71, 72, 73
- AOC 4, 5, 6, 7

Railyard SWMUs noted as in good condition in the RFA, and continue to be managed properly as confirmed by the railroad (ARRC)

- SWMU 1, 3, 4, 5, 6, 7, 8, 9, 11, 13, 14, 15, 17, 18, 19, 20 , 21, 22, 23, 26, 27, 41, 42, 44, 45, 46, 47, 48, 50, 51, 52, 55, 58, 59, 60, 61, 67

Railyard SWMUs and Areas of Concern that have a potential environmental concern that required investigation and/or additional evaluation

- SWMU 64, 65, 69
- AOC 1, 2, 3

The RI included sampling at this last set of three SWMUs and three Areas of Concern. The data from these areas were included in the risk assessment. No source of risk was identified as associated with or determined to be associated with these areas (as detailed in Appendix B and Appendix C).

6.2 Leased properties

Table 6-2 presents a summary of SWMUs and Areas of Concern on the Site leased properties. These are listed numerically by property. The information relevant to determination of their status includes the following:

- The LP (leased property) number, name, RFA status, and SWMU/Area of Concern name
- If noted by U.S. EPA as in good condition with no release – it is marked
- Visual inspection results
- Locations where RI sampling was conducted
- Additional information and conclusion

The RFA listed 124 leased properties at the Site. For 66 of these properties, U.S. EPA did not identify any SWMUs or Areas of Concern. One of the leaseholders listed in the RFA, LP009, is located outside the Site and ARRC accordingly did not pursue an evaluation of that property as part of the RI.

The following lists the leased properties and their SWMUs and Areas of Concern by reference to the four categories described in Section 6.0 above. This information is listed in Table 6-2. Note, the reference "(all)" below indicates that all SWMUs and Areas of Concern in that LP fall into the category.

Those with active ADEC involvement and progress towards cleanup

- LP137 (AOC-1)
- LP022 (AOC 22-2)

Those confirmed by the lessee to be no longer present, no longer in use, or closed

- LP002 (all)
- LP006 (all)
- LP014 (SWMU 14-1, AOC 14-1)
- LP022 (SWMU 22-1)
- LP029 (all)
- LP031 (all)
- LP032 (all)

- LP033 (all)
- LP034 (SWMU 34-1)
- LP035 (all)
- LP043 (SWMU 43-2)
- LP049 (all)
- LP050 (all)
- LP051 (all)
- LP052 (SWMU 52-2, AOC 52-1)
- LP054 (all)
- LP056 (SWMU 56-2)
- LP063 (all)
- LP065 (SWMU 65-4)
- LP069 (SWMU 69-1, SWMU 69-2, SWMU 69-4)
- LP072 (all)
- LP078 (all)
- LP082 (all)
- LP084 (all)
- LP085 (all)
- LP087 (all)
- LP090 (all)
- LP091 (all)
- LP092 (all)
- LP093 (all)
- LP094 (SWMU 94-1, SWMU 94-2, SWMU 94-3)
- LP101
- LP105(SWMU 105-1, SWMU 105-3, SWMU 105-4)
- LP107 (all)
- LP109 (all)
- LP110 (SWMU 110-2)
- LP113 (all)
- LP115 (all)
- LP120 (all)
- LP123 (all)
- LP125 (SWMU 125-3)
- LP127 (all except SWMU 127-1)

- LP128 (all)
- LP130 (AOC 130-1)
- LP131 (SWMU 131-3, AOC 131-1)
- LP134 (AOC134-1)
- LP137 (SWMU 137-2, AOC 137-1)

Those that are noted as in good condition in the RFA, and continue to be managed properly as confirmed by the lessee

- LP008 (all)
- LP011 (all)
- LP018 (all)
- LP022 (AOC22-1)
- LP043 (SWMU 43-1, 43-3)
- LP052 (SWMU 52-1)
- LP56 (SWMU 56-1, SWMU 56-3, SWMU 56-4, SWMU 56-5)
- LP065 (SWMU 65-1, SWMU 65-2, SWMU 65-3)
- LP068 (all)
- LP069 (SWMU 69-3, SWMU 69-5, SWMU 69-6, SWMU 69-7, SWMU 69-8)
- LP075 (all)
- LP083 (all)
- LP094 (SWMU 94-4, SWMU 94-5)
- LP105 (SWMU 105-2)
- LP110 (SWMU 110-1, SWMU 110-3)
- LP111 (all)
- LP122 (all)
- LP125 (SWMU 125-1, SWMU 125-2)
- LP130 (SWMU 130-1)
- LP131 (SWMU 131-1, SWMU 131-2)
- LP133 (all)
- LP134 (SWMU 134-1, SWMU 134-2, SWMU 134-3, SWMU 134-4)
- LP136 (all)
- LP137 (SWMU 137-1)

Those that have a potential environmental concern that required investigation and/or additional evaluation.

- LP034 (AOC34-1) – Site-wide groundwater evaluation has encompassed this location.
- LP026 (AOC26-1) – Site-wide groundwater evaluation has encompassed this location.

Responses were not obtained from LP053, LP095 and LP127. ARRC will continue to pursue this information.

There are some leased properties with SWMUs and Areas of Concern that are currently being addressed through the ADEC contaminated sites program or LUST program. For this subset of leased properties, the ADEC sites summary database was reviewed and is summarized in Table 6-3.

6.3 Terminals

The following leased properties, as identified in the RFA, are located in the Terminals Area:

LP003 & 005	Williams Alaska Petroleum, Inc.
LP004	MAPCO
LP007	Lone Star Northwest
LP016	Chevron (ROW)
LP019	Tesoro Alaska Petroleum
LP025	Chevron USA Products Co.
LP060	North Star Terminal and Stevedore Company
LP068	Premier Industries Inc
LP084	Swan Bay Holdings
LP101	Swan Bay – Barge Docking

Additionally, LP027, LP059, LP103, and LP138 are leased properties with no SWMUs or Areas of Concern identified by U.S. EPA.

Table 6-2 summarizes the SWMUs and Areas of Concern that the RFA listed at the Terminals Area. These fall into the four categories discussed in Section 6.0 as follows:

<u>Those with active ADEC involvement and progress towards cleanup</u>

- LP019 (AOC19-1, AOC19-2)
- Flint Hills, Chevron, and Tesoro are actively conducting monitoring and other actions under ADEC oversight at their leased properties that may encompass some of these SWMUs and Areas of Concern the RFA listed at those properties.

<u>Those confirmed by the lessee to be no longer present, no longer in use or closed</u>

- LP016(all)
- LP019 (SWMU 19-1)
- LP025 (SWMU 25-5)
- LP060 (SWMU 60-3)
- LP101(all)

<u>Those that are noted as in good condition in the RFA, and continue to be managed properly as confirmed by the lessee</u>

- LP003/005(all)
- LP004(all)
- LP007(all)
- LP25 (SWMU 25-1, SWMU25-2, SWMU 25-3, SWMU 25-4, SWMU 25-6, SWMU 25-7)
- LP060 (SWMU 60-1, SWMU 60-2)
- LP068(all)

Those that have a potential environmental concern that required investigation and/ or additional evaluation

- None identified

As the Terminals Area and the leased properties contain a number of SWMUs and Areas of Concern that are currently being addressed through the ADEC contaminated sites program or LUST program, the ADEC sites summary database is summarized in Table 6-3 with respect to Site properties.

6.4 Summary

In summary, the evaluation of RCRA SWMUs and Areas of Concern indicated that the majority of those identified by U.S. EPA during the RFA are neither present nor in use on the Site, or are present but in good condition with no identified environmental concerns. Tables 6-1 and 6-2 document the current SWMU and Area of Concern condition and the conclusion that no additional RCRA concern is valid for this Site. The evaluation of SWMUs and Areas of Concern identified potential environmental concern associated with a very small subset of SWMUs and Areas of Concern including:

Railyard

- SWMU 64
- SWMU 65
- SWMU 69
- AOC 1
- AOC 2
- AOC 3

Leased Properties

- None Identified

Each of these locations was sampled during the RI and the results are evaluated through the Risk Assessment in this document.

7.0 Summary of Human Health and Ecological Risk Assessments

This section provides a summary of the HHRA and ERA that are presented in entirety in Appendices B and C, respectively. The risk assessments were conducted in accordance with the submitted RA Scoping Memo and U.S. EPA federal and regional risk assessment guidance as well as ADEC guidance. The risk assessments include evaluation of Site data for potential current and likely future human health and ecological receptors. The basis of this evaluation is the CSM, which was presented, discussed, and agreed upon with U.S. EPA and ADEC in regulatory meetings. The outcome of the risk assessment is identification of areas, analytes, and media with potential human health or ecological adverse risk that will be evaluated further in the FS.

The human health risk assessment (Appendix B) described the process used to determine human health risk to receptors potentially exposed to COPC associated with media at the Site. The risk to these receptors was calculated in accordance with U.S.EPA and ADEC guidance, and assumptions were developed collaboratively with the agencies during development of the RA Scoping Memo. The assumptions are designed to be conservatively protective of specific receptors and various exposure pathways based on the knowledge of current and anticipated future land use. The primary objective of the HHRA is to identify areas of the Site where risks may exist and to target these locations for remedial and corrective action. To accomplish this objective, the HHRA calculated receptor-specific risk-based concentrations (RBCs) for comparison to Site data for each media. Risk-based concentrations were calculated using a carcinogenic risk level of $1x10^{-6}$ and a non-cancer Hazard Index (HI) of 1. Data from each individual sample location were compared to the RBCs for each Site receptor and the ratio of concentration to RBC was summed to determine the cumulative risk level for each COPC at the sample location. Risks greater than ADEC's target risk level (TRL) of $1x10^{-5}$ and HI of 1 were considered further to determine whether an exposure area could be defined. Cumulative risks were then re-evaluated for receptors on an area-wide basis using EPCs if applicable data were available. Consistent with the RA Scoping Memorandum, risk drivers and exposure areas (or individual sample locations if applicable) above a noncancer HI of 1 or cancer TRL of $1x10^{-5}$ were identified for further evaluation in the FS.

The risk assessment evaluated the following human health receptors, for current and potential future land use scenarios:

- **Current/future on-site outdoor commercial/industrial worker..** This worker conducts typical operational activities in an outdoor setting and is exposed to surface soil via incidental ingestion, dermal contact, particulate inhalation, and inhalation of volatiles in ambient air. Additionally, this receptor is conservatively assumed to use shallow groundwater as a drinking water source or in limited cases deep groundwater where the groundwater well survey determined that the leased property had a well and was using the Site groundwater for commercial or industrial purposes.
- **Current/future on-site maintenance worker - Perimeter Terminals Area**. Maintains grounds that are located in properties that are not leased and at public right-of-ways in the Terminals Area (i.e. the Perimeter area). Exposed to surface soil via incidental ingestion, dermal contact, particulate inhalation, and inhalation of volatiles in ambient air.
- **Current/future on-site indoor commercial/industrial worker**. This receptor represents the typical office worker and is potentially exposed to subsurface soil and soil gas and groundwater volatiles via migration to indoor air. Additionally, this receptor is conservatively assumed to be exposed to shallow groundwater and seeps as a drinking water source or, in limited cases, deep groundwater where the groundwater well survey determined that the leased property had a well and was using the Site groundwater for commercial or industrial purposes.
- **Current/future on-site construction/excavation worker.** The construction/excavation worker may be involved in activities that include installation/maintenance of subsurface utilities (trenching) and

structures, excavation of building foundations, etc. Exposure may be to surface and subsurface soils via ingestion, dermal contact, particulate inhalation, and inhalation of volatiles in ambient air while working in a trench. This receptor may also be exposed to groundwater (as well as seep/ditch water) in areas where depth to groundwater is less than or equal to 15 ft bgs via incidental ingestion, dermal contact, and inhalation of volatiles in ambient air while working in a trench.

Construction/excavation workers may also have direct contact (incidental ingestion and dermal contact) with sediment and surface water in Ship Creek, ditches, and off-channel pond areas. Per agreement for the RA Scoping Memo, these receptors are evaluated qualitatively for such exposures, as contact time is expected to be insignificant and media concentrations are generally low.

- **Current/future on-site trespasser – Railyard.** ARRC prohibits unauthorized entry to the Railyard. Site security, postings, and regular patrols are conducted to prevent trespassing in the main Railyard area and limit (but do not completely eliminate) such activity. For purposes of this risk assessment, trespassers are not a significant receptor, but are considered for the Railyard under current conditions. Surface soil pathways evaluated include ingestion, dermal contact, and inhalation of soil particulates and volatiles in ambient air. Potential exposure to water present at any seeps/ditches in the Railyard along the North Bluff is considered a complete exposure pathway. However, direct contact with seeps by trespassers was not included in the risk assessment as a separate exposure pathway because seep data were compared to drinking water standards and included as part of the cumulative risk evaluation for construction workers, both of which are considered maximum exposure scenarios that would account for receptors with lower exposure potential. In addition, RI data indicate that the seeps are located upgradient of any releases originating at the Site and are considered anthropogenic background sources. Therefore, while potentially contributing to risk the potential contamination there is not site-related.
- **Current/future Ship Creek recreational users (adult and child).** Current and future recreational users of Ship Creek at the Site may be exposed to surface soil along the banks of the creek via incidental ingestion, dermal contact, particulate inhalation and inhalation of volatiles in ambient air. Exposure to littoral (bank) sediment along the corridor and surface water in Ship Creek via incidental ingestion and dermal contact (as well as game fish from the river) may also occur. However, fish consumption will be discussed qualitatively as agreed to during the finalization of the RA Scoping Memo. Exposure assumptions for this receptor account for recreational users temporarily traveling along Ship Creek.
- **Future on-site residents (adult and child) (PC district).** The land use at Site is and will remain industrial/commercial under reasonably anticipated future use scenarios. However, the PC district is zoned for limited potential residential development and it is conceivable that in future ARRC may allow its property there to be used for residential purposes as the PC district designation allows. For this reason, a future on-site residential scenario in the PC district is included in the risk assessment. This future receptor may be exposed to surface and subsurface soil via incidental ingestion, dermal contact, particulate inhalation, and inhalation of volatiles in ambient air. This receptor also may be exposed to subsurface soil and groundwater contaminants via inhalation of soil gas volatiles in indoor air.

  Note that inclusion of this receptor represents a future situation and does not truly represent a potential receptor under current and reasonably anticipated future land use. Exposure to subsurface soil under normal circumstances is absent. Inclusion of subsurface soil is intended to be protective of situations involving future excavation of subsurface soil that brings it to the surface.

HHRA conclusions for specific media are summarized as follows.

7.1.1 Soil summary

The following presents the risk assessment summary and conclusions for receptors potentially exposed to surface (0 to 0.5 ft bgs) and subsurface (0 to 12 ft bgs) soil at the Site.

Ship Creek Area

- Surface soil concentrations across the Ship Creek Area are above the acceptable TRL of 10^{-5} and HI of 1 for the outdoor worker at sample locations within seven lease properties (LP022, LP024, LP127, LP131, LP137, LP991 and RY065). Risk at LP022, LP127 and LP131 is due to elevated concentrations of PCBs while at LP024 risk is due to summing the individual risk from arsenic, benzo(a)pyrene, and PCBs. Risk at LP137 is due to TCE while risk at LP991 and RY065 is due to summing several carcinogenic PAHs (benzo(a)pyrene, dibenz(a,h)anthracene and indeno(1,2,3-cd)pyrene). A sample exceedance of TCE is also noted in the Railyard. When the contribution of background for arsenic is accounted for, and an area-wide EPC is calculated, noncancer risks drop below a HI of 1 at two lease properties (LP127 and LP131), however, cancer risks remain above the TRL of 10^{-5} on an area-wide basis. **Therefore, the potential for unacceptable risk may exist to outdoor workers exposed to surface soil in these areas and will be evaluated further in the FS.**
- Cumulative cancer risks for construction workers exposed to surface and/or subsurface soil at the Site are below the TRL of 10^{-5}, indicating no unacceptable cancer risk exists. However, as discussed above, concentrations of total PCBs in surface soil at LP022, LP127 and LP131, with the addition of LP031, are above a noncancer HI of 1 for construction workers. In addition, noncancer risks for subsurface soil at LP991 are above a HI of 1 due to concentrations of benzene, naphthalene and xylene. When an EPC is calculated for construction workers in these areas, noncancer risk drops below a HI of 1 at LP127 and LP991, **indicating no potential for unacceptable risk exists. Therefore, further consideration in the FS is only warranted for PCBs at LP022, LP031, and LP131 for construction workers.**
- Surface and subsurface soil concentrations in the PC District are below the acceptable cancer TRL of 10^{-5} for future residents (adult and child). However, twelve locations exceed a noncancer HI of 1.0 for child residents due to concentrations of several inorganics that are present at background levels. When the contribution from background is accounted for, the noncancer risk drops below a HI of 1 at all locations, indicating no site-related risk exists to residents exposed to surface and/or subsurface soil within the PC District. In addition, risks for the PC District on an area-wide basis are also below acceptable levels. **Therefore, no further evaluation is warranted.**
- Cumulative cancer risk for recreational users (adult and child) exposed to bank soil and sediment in the Riparian Area is below a TRL of 10^{-5}, while noncancer risk is above a HI of 1.0 at off-channel sediment location SC002-CSD08 due to elevated concentrations of PCBs. However, on an area-wide basis, the noncancer HI drops below 1.0, indicating that exposure to bank soil/sediment COPC does not pose unacceptable risk to recreational users in the Riparian Area. **Therefore, no further evaluation is warranted.**
- No surface soil locations in the Railyard exceed the cumulative cancer TRL of 10^{-5} or noncancer HI of 1, indicating that no unacceptable risk exists to trespassers (adult or adolescent) in this area. **Therefore, no further evaluation is warranted.**

Terminals Area

- For construction workers exposed to surface and/or subsurface soil in the Perimeter Terminals Area, cumulative cancer risk for all locations is below a TRL of 10^{-5} while sample LP003-SDS exceeds the noncancer HI of 1 due to concentrations of benzene and xylene in subsurface soil. However, use of

the area-wide EPC lowers the HI below 1 and indicates no unacceptable risk exists to construction workers in the Perimeter Terminals Area. **Therefore, no further evaluation is warranted.**

- No surface soil locations in the Perimeter Terminals Area exceed the cumulative cancer TRL of 10^{-5} or noncancer HI of 1.0, indicating no potential unacceptable risk exists to maintenance worker exposed to surface soil in this area. **Therefore, no further evaluation is warranted.**
- Risk levels at one surface soil sample (LP019-KPG1) exceeded a cumulative cancer TRL of 10^{-5} (along with U.S. EPA's upper-bound risk level of 10^{-4}) and noncancer HI of 1 for outdoor workers at the Tesoro facility located within the Interior Terminals Area. This risk is due to elevated historical concentrations of benzene and xylene in surface soil. However, this sample is located below the secondary containment liner and exposure does not occur under current conditions. **Therefore, no further evaluation is warranted.**
- In addition to the surface soil sample listed above, one subsurface soil samples (LP019TPS8) at the Tesoro facility was also found to have noncancer risks for construction workers above a HI of 1 (due to benzene and xylene), while cancer risks were below the acceptable cancer TRL of 10^{-5}. However, this sample is also located below the secondary containment liner and exposure does not occur under current conditions. In addition, cancer and noncancer risks are below acceptable levels on an area-wide basis, indicating no potential for risk exists to construction workers exposed to subsurface soil at Tesoro. **No further evaluation is necessary.**

7.1.2 Groundwater summary

The following presents the risk assessment summary and conclusions for receptors potentially exposed to groundwater at the Site.

Groundwater supply

- Eight leased properties have been identified as using local groundwater wells for potable purposes. At a minimum one of these is screened in the shallow groundwater, two are of unknown depth, and the remainder are screened in the deep aquifer below the Bootlegger Cove aquitard. Three COPCs (arsenic, BEHP, and mercury) were identified for the drinking water wells located on these properties. Comparison of data to MCLs for these analytes indicate that all concentrations are below MCLs, with the exception of arsenic at LP060-SUP02 (12 µg/L) and BEHP (10.7 µg/L) at LP049-SUP04. Although the sample from the well at LP049 for BEHP, a common laboratory contaminant, was detected above the drinking water standard it was not confirmed in the sample analyzed via the drinking water method (EPA Method 525.2). Additionally, arsenic was present at a concentration essentially equal to the drinking water standard in the well at LP060. Of the compounds that exceeded a screening level in the shallow water aquifer, none were found to exceed the screening level in the deep water samples (if it was detected at all). Therefore, it can be concluded that the deep water aquifer (i.e., below the bottom of the Bootlegger Cove formation) is isolated from the shallow aquifer and is not impacted by contamination that may occur in the overlying shallow aquifer. **No further evaluation of these two locations is warranted.**
- With the exception of the leased properties discussed above, the MOA supplies drinking water throughout the Site. Therefore, most receptors do not contact Site groundwater directly under current conditions and groundwater that is used comes from deep unimpacted wells. However, use of Site groundwater as a drinking water source was conservatively included in the HHRA to determine whether future use could occur or if institutional controls are necessary. Numerous exceedances of drinking water standards are reported in the shallow aquifer across the Site and institutional controls should be evaluated in the FS to limit potential future use of this aquifer, including prohibition on installation of drinking water wells into this aquifer. **Further evaluation of Site groundwater above background levels within the leased properties of the Ship Creek Area is warranted in the FS**.

- To be consistent with the approach taken for assessing groundwater at the Ship Creek Area of the Site, groundwater from the Tesoro facility located within the Interior Terminals Area was also treated as a future source of drinking water and data were compared to MCLs. Benzene exceedances were noted in 18 wells with concentrations several orders of magnitude above the MCL. In addition, two wells (LP019-MW1 and LP019-MW23) located on the Tesoro property boundary (in the Perimeter Terminals Area) also have exceedances of ADEC cleanup levels for fuel hydrocarbons (C12-16 and C16-21 aliphatics). It is important to note that no one is currently using this groundwater for potable purposes. Tesoro is aware of the groundwater impacts at their facility and has been working with ADEC to monitor and control these impacts**. Further evaluation in the FS is warranted.**

Ship Creek Area

- For the Ship Creek Area of the Site, groundwater risks are below the cancer TRL of 10^{-5} for construction worker exposure at all locations. Noncancer risks are below a HI of 1 at all locations except LP022-B3 due to PCBs, RY065-MWE05 and RY065-MWE06 due to naphthalene and 1,2-dibromo-3-chloropropane, and LP137CHMWE2 and LP137CHMWE5 due to benzene and naphthalene. Because noncancer risk in the Railyard is essentially equal to a HI of 1, **only evaluation of PCBs and VOCs in groundwater at LP022 and LP137, respectively is warranted in the FS.**

Terminals Area

- In the Perimeter Terminals Area, cumulative cancer risks are below the acceptable TRL of 10^{-5}, while noncancer risks exceed the HI of 1 at AR001-MWE17 due primarily to concentrations of naphthalene. These results indicate the potential for unacceptable risk may exist to construction workers in this area. **Therefore, evaluation in the FS is warranted.**
- At the Tesoro facility in the Interior Terminals Area, cumulative risks exceed the cancer TRL of 10^{-5} and noncancer HI of 1 for construction workers potentially exposed to benzene in groundwater at LP019-PW19B. Noncancer risk is also above a HI of 1 at LP019-PW24 due to xylene. **Further evaluation may be warranted in the FS.**

7.1.3 Surface water and sediment summary

The following presents the risk assessment summary and conclusions for receptors potentially exposed to surface water and sediment at the Site.

Ship Creek Area

- No sediment risks in Ship Creek or off-channel areas are above the acceptable TRL of 10^{-5} or HI of 1. This indicates no potential for unacceptable risk exists to recreational users (adult or child). **No further evaluation is necessary**.
- No surface water risks in Ship Creek are above the acceptable TRL of 10^{-5} or HI of 1. This indicates no potential for unacceptable risk exists to recreational users (adult or child). **No further evaluation is necessary**.
- Surface water risks in off-channel areas are below the acceptable TRL of 10^{-5} and HI of 1 for all locations , with the exception of SC002-SCD06 where the cancer risk is above 10^{-5} due primarily to concentrations of indeno(1,2,3-cd)pyrene. **This location will be evaluated further in the FS for potential recreational user risks.**
- Consumption of fish caught from Ship Creek does not pose unacceptable risk to receptors, as the recreationally valuable fish are predominately a migratory species. This limits the amount of time they are in contact with potentially bioaccumulative compounds in the creek. In addition, Ship Creek itself

contains relatively low (or non-detect) concentrations of COPC. The highest concentrations are observed in the off-channel areas to which fish are not exposed. **Therefore, further evaluation of fishing in Ship Creek is not warranted**.

Terminals Area

- Benzene was the only surface water COPC detected in the storm water drainage ditch in the Perimeter Terminals Area. However, concentrations are below the construction worker RBC determined for groundwater, indicating no risk exists to construction workers repairing or installing pipeline in this area. **No further evaluation is necessary.**
- No sediment COPCs were identified for Cook Inlet. Therefore, no risk exists to receptors in this area and **no further evaluation is necessary.**

7.1.4 Lead summary

Lead risks are presented separately due to its unique toxicity characteristics and lack of toxicity values for calculating traditional risk estimates. The risk assessment summary and conclusions for receptors potentially exposed to lead in media at the Site is discussed below.

- Lead was not determined to be a COPC in surface water at Ship Creek or off-channel ponds and ditches. **Therefore, no further evaluation is necessary.**
- Lead concentrations in sediment exceed the recreational user RBC of 400 mg/kg at two locations (SC002-CSD04 [490 mg/kg] and SC002-CSD07 [753 mg/kg]). However, the EPC for lead in the Riparian Area is below the RBC, indicating that exposure to lead in bank soil/sediment does not pose unacceptable risks to recreational users on an area-wide basis. **No further evaluation of these locations in the FS is warranted.**
- Surface soil concentrations of lead are below receptor-specific RBCs for outdoor workers (800 mg/kg) and trespassers (400 mg/kg). **No further evaluation is necessary.**
- Concentrations of lead in surface and/or subsurface soil in the PC District are below the residential child RBC of 400 mg/kg. **No further evaluation is necessary.**
- Concentrations of lead in subsurface soil are greater than the default industrial RBC of 800 mg/kg at LP065-5MW (2,790 mg/kg) and LP991-CHMW1A (830 mg/kg). An EPC was calculated for these two areas and compared to the RBC. The EPC for LP991 is below the industrial lead RBC, indicating that exposure to lead on an area-wide basis does not pose unacceptable risk to construction workers. However, the EPC at LP065 remains above the RBC due to the isolated elevated occurrence at LP065-5MW (as all other sample concentrations at this lease property are below the RBC). **Therefore, further evaluation of lead in subsurface soil at LP065-5MW will be conducted in the FS.**
- In groundwater, lead concentrations above background levels and the MCL have been identified at two locations (AR001-MWA05 and LP991-MWE23) in the Ship Creek Area and one location (LP084-DPA03) in the Perimeter Terminals Area. **These lead exceedances will be evaluated further in the FS as cleanup to MCLs is the goal for groundwater at the Site.** In addition, exposure to lead in groundwater at these locations is unlikely to pose unacceptable risk to construction workers. Using the MCL as a default value (because receptor-specific RBCs for lead in groundwater cannot be calculated due to the lack of toxicity information) for this scenario is a conservative assumption, as construction workers experience only incidental contact with groundwater and exposure potential is low.

7.1.5 Vapor intrusion summary

The following presents the risk assessment summary and conclusions for receptors potentially exposed to volatiles that have migrated from shallow groundwater and soil gas into indoor air.

- Cumulative cancer and noncancer risks for the current/future on-site indoor commercial/industrial worker are below (or equal to) U.S. EPA's acceptable TRL of $1x10^{-5}$ and HI of 1 for both groundwater and soil gas under all building scenarios evaluated within the Areas of Concern determined for the Site with the exception of LP-137 where cancer risk exceeds $1x10^{-5}$ due to concentrations of benzene and TCE in historical groundwater which were included in the risk assessment to address a potential data gap. These results indicate that the potential for adverse risk may exist at LP-137 and further evaluation of groundwater and the indoor air pathway is necessary in the area.
- Cumulative cancer and noncancer risks for the future on-site resident in the PC District are below U.S. EPA's acceptable TRL of $1x10^{-5}$ and HI of 1 for both groundwater and soil gas. These results also account for potential exposure in the proposed mixed-use area because the MDC was used in the evaluation, which represents a worst-case scenario, and the MDC is located greater than 100 feet away from the proposed residential condo development site. Overall, these results indicate that no potential adverse risk exists and no further evaluation of the indoor air pathway is necessary.
- The cumulative noncancer risk for exposure to BTEX in groundwater near the pipeline control room building located on the Tesoro facility is below the acceptable HI of 1 while the cancer risk is above a TRL of $1x10^{-5}$. Note that this risk is likely to be overestimated based on the conservative nature of the assumptions applied. However, Tesoro is currently operating under ADEC monitoring programs and working to address groundwater impacts. **Therefore, further evaluation of the indoor air pathway may be warranted in the FS.**

7.1.6 Leaching evaluation summary

The following presents the risk assessment summary and conclusions for soil contaminants potentially leaching to groundwater at the Site. Exceedances of the site-specific SSLs were noted for:

- Arsenic at AR001-MWB08, AR001-MWB17 and within LP024**.**
- TCE at LP049-DPA30 and within LP127 and TCE and PCE at LP085-MWA19**.**
- Multiple leaching COPC (i.e., arsenic, benzene, cis-1,2-dichloroethene, naphthalene, TCE, PCE, and xylene) at LP991 and LP137.
- Benzene at one location in the Railyard (RY065-MWE05).
- Benzene at AR0001-MWE17 and in boundary samples at LP019 in the Perimeter Terminals Area, while benzene, ethylbenzene and xylene exceedances are noted around the perimeter of LP003.
- The results of the leaching evaluation conducted at the Tesoro facility show a correlation between benzene in soil and underlying groundwater. **Therefore, benzene sources in soil will be evaluated further in the FS to address groundwater impacts**.

The majority of the leaching SSL exceedances found in groundwater pertain to CVOCs and BTEX in areas identified as groundwater sources in the RI, specifically GW-5, GW-6, GW-7, GW-8 and GW-9. Synthetic precipitation leachate procedure (SPLP) data were then collected for these analytes from a subset of locations within these areas to further characterize the leaching potential of soil contaminants at the Site. The results of the SPLP data indicate that:

- Chlorinated VOCs in soil are not leaching to groundwater. **No further evaluation is necessary**.

- Arsenic leachate concentrations at LP024 are elevated above the background range for groundwater and may be considered a potential source in soil. **Arsenic in this area will be evaluated further in the FS.**
- Ethylbenzene, toluene and xylene are not leaching to groundwater while benzene is a potential source to groundwater in the Perimeter Terminals Area at AR001-MWE17. **Benzene in this area will be evaluated further in the FS.**
- Naphthalene leachate results exceed the U.S. EPA Region 6 tap-water value at LP991 and **will be considered further in the FS.**

In addition, the result of the evaluation of bank groundwater used for determining the potential for contaminants to migrate and adversely impact Ship Creek media and receptors concludes:

- Bank groundwater exceedances identified in the RI that are likely associated with a groundwater plume migrating toward Ship Creek at concentrations above surface water quality criteria **will be addressed further in the FS utilizing appropriate fate and transport modeling.**

7.2 Ecological Risk Assessment summary

A SL ERA was completed for the Site. The objective was to ensure *"protection of benthic invertebrates, resident fish and wildlife receptors of such aquatic life that may be affected by potential water or sediment contamination in Ship Creek …[with consideration for] known or suspected sources of soil, groundwater, surface water, and sediment contamination"* (U.S. EPA, 2004a).

7.2.1 Problem Formulation

The ERA identified four key habitats for evaluation:

- Ship Creek – divided into two reaches: (1) above the Kapp Dam (freshwater), and (2) below the dam (tidal)
- Off-Channel ponds and marshes – composed of six sub-areas corresponding with sub-areas in the RI: (1) SE-1, KAPP pond, (2) SE-2, Storm water pond, (3) SE-3, Railroad Avenue marsh, (4) SE-4, Standard Steel ditch, (5) Railroad ditch and (6) other marsh areas
- Riparian (terrestrial) zone – composed of the riparian corridor along Ship Creek
- Cook Inlet - storm water drainage/outfall to the inlet

CSMs were developed for each habitat area showing how contaminants from the Site might reach and impact ecological receptors in the exposure areas of concern. Although there are a number of complete exposure pathways by which ecological receptors may come into contact with site-related chemicals, not all exposure pathways are likely to be of equal concern. Only complete exposure pathways were evaluated in the ERA. Receptors and pathways for evaluation included:

- Aquatic and Benthic Receptors exposed to surface water and sediment – potential risk was evaluated for aquatic life present in Ship Creek freshwater and marine habitats, off-channel (freshwater) ponds and marshes. This group includes fish and amphibians, and was addressed by comparison to screening levels.
- Potential exposure by aquatic receptors to bank groundwater in the transition zone between groundwater and Ship Creek surface water. This endpoint was evaluated by conservatively screening against surface water screening levels.

- Aquatic-feeding birds and mammals - potential risk was evaluated for representative bird and mammalian aquatic life using Ship Creek, and the off-channel ponds and marshes. Risk was calculated based on ingested dose from site media and food.
- Terrestrial (Riparian) evaluation– potential risk was evaluated for terrestrial life that live or obtain resources in the riparian corridor of Ship Creek and are exposed to soil and intermittently dry sediment. This evaluation included evaluation of plants and soil invertebrates (compared to screening levels) and ingested dose by terrestrial representative birds and mammals. In addition, general habitat characteristics were considered, as data for the terrestrial riparian area was limited. No threatened and endangered species (including candidate species for such designations) or species of special concern were identified as potentially inhabiting the Site.

7.2.2 Exposure and Toxicity Parameters

The ecological risk assessment included two levels of evaluation following an initial step of selection of COPCs. The COPC selection process involved comparison of the maximum detected concentrations (or ½ the maximum reporting limit for non-detected analytes) against standard screening benchmarks for environmental media. Those that exceeded were retained as COPCs. In addition, detected analytes known to be bioaccumulative were retained:

1. A screening level ecological risk assessment (SLERA), where the most conservative screening levels or dose estimates were applied to eliminate COPCs that did not occur at concentrations exceeding screening levels or acceptable ingested dose.

2. A refined screening level ecological risk assessment (RSLERA), where risk was evaluated using more realistic screening levels and toxicity and exposure parameters, including consideration of background levels and other site-specific conditions.

The exposure and toxicity parameters applied in the risk assessment were presented in the RA Scoping Memo and are further discussed in Appendix C.

No exposure point concentrations based on average concentrations or upper concentration limits (UCL) of the mean were calculated, as typically called for in risk assessment of mobile species, as the Ship Creek area does not represent a contiguous exposure area. The sub-areas were evaluated separately and the sample density in most cases was not high enough for statistical analysis. Therefore, the RSLERA is presented as a point-by-point evaluation, assuming exposure occurs for a lifetime at every single point. In addition, sampling had focused on worst case conditions. Such unrealistic assumptions result in a large overestimate of risk. This overestimate should be considered when evaluating the risk estimates, particularly for mobile or seasonal receptors.

7.2.3 Risk characterization

Risk estimates for the various assessment endpoints are presented on a point-by-point basis, and expressed as a Magnitude of Exceedance (ME) for endpoints compared directly to media screening levels or benchmarks (sediment biota, aquatic biota, amphibians, plants, and invertebrates), or as a Hazard Quotient (HQ) for endpoints evaluated based on ingested dose from media and food (the representative birds and mammals).

A difference exists between risk assessment for Ship Creek aquatic exposures and riparian zone terrestrial exposures. For the aquatic exposures the data set is substantial, and the quantitative ME or HQ is used as a primary line of evidence. In the riparian (primarily terrestrial) zone the data set available for quantitative assessment was limited. A quantitative evaluation (ME or HQ) was done using the available data, but recognizing the limitations of the data set, other factors were prominently considered in a weight-of-evidence evaluation.

In cases where the ME or HQ is greater than one, additional discussion was included in the risk characterization to evaluate the importance or relevance of the exceedances. All exceedances considered relevant are to be considered further in the FS.

Ship Creek Main Channel

No unacceptable risk to aquatic or benthic fauna, or to mammals or birds feeding in the creek, is expected. Exceedances are limited to a few metals at concentrations barely exceeding background and a HQ=1. For mobile and seasonal sandpipers, for example, such exceedances are trivial. Neither is there any evidence in the previous sections of site-related source areas elevated in nickel, selenium or vanadium. **No further evaluation is anticipated**.

Ship Creek Tidal Area

No unacceptable risk to aquatic or benthic fauna, or to mammals or birds feeding in the tidal areas is expected. Exceedances are limited to a few metals, the highest levels of which occur in one localized area, CR13, a groundwater seep near the high tide line (copper, arsenic, and iron). Background contribution is significant. For mobile and seasonal receptors such exceedances are trivial. The elevated iron noted in sample CR13 is clearly visible as red streaking on the rocks where the seep emerges. **No further evaluation is anticipated**.

Off-channel areas

Four main off-channel areas were identified in the RI. In addition samples from several other off-channel ditches and relict channels exist. Each area was evaluated separately.

Area SE-1 (KAPP Pond)

Minor exceedances for manganese in surface water and for nickel in sediment are minimal or subject to significant background contribution. In addition HQs greater than one were noted for vanadium, copper and selenium for the sandpiper. These point exceedances have significant background contribution, and are small for the mobile and seasonal sandpiper. The area also lacks habitat (beach areas) where sandpipers feed. Therefore, the exceedances are trivial. No adverse risk from the organic COPC found in this area is present. **Area SE-1 does not require further action based on the ecological risk assessment**.

Area SE-2 (Storm Water Pond)

This pond area, which is a receptor for storm water discharges, reported significant adverse risk from two locations, CSB01 in the deep part of the pond, where the RI noted the presence of hydrocarbon residues, and CSB06, at the storm water outfall. In the remainder of the area, only small exceedances for vanadium and nickel were noted. These metals are present near their background levels and, in the case of vanadium, the risk for mobile sandpipers is trivial. Neither are there on-site source areas associated with these metals.

The deep areas of the pond do present unacceptable risk from PAH exposure to sediment dependent biota. Several individual PAHs exceed high screening levels, although the aggregate total PAH screening level is not exceeded. In addition to the PAHs, several metals, e.g. manganese, lead, and zinc, are present at concentrations well above background and high screening levels. However, the reported HQ>1 for the sandpiper is not significant, as the areas with exceedances are deeply submerged and provide no habitat for these birds.

This area will be considered further in the FS for PAHs and co-occurring metals.

Area SE-3 (Railyard Ave Marsh)

This marshy area consists of two units, an area in the northeast corner where a ditch and soil piles are present in a generally terrestrial habitat, and a permanent marshland occupying the remainder of the area.

Exceedances in the main body of the marsh are limited to low level exceedances for metals, in a pattern similar to other off-channel areas. For sediment and surface water, exceedances were noted for arsenic, manganese, and nickel. Background contribution is high, and no on-site source areas for these metals have been identified. For the birds and mammals risk with a HQ>1 was reported for vanadium and selenium, similar to the pattern elsewhere. Exceedances are minimal.

In the northeast part of this off-channel area, there was significant adverse risk reported for PAHs, PCBs, BEHP, and several metals. The ditch area (CSD04, CSD05, and CSD07), which was noted in the RI to be possibly related to nearby leased properties has unacceptable risk for PCBs (ME up to 8 for benthic biota, and elevated HQ for birds). In addition, BEHP is a moderate to high risk for birds and for benthic biota; and di-n-octyl phthalate, for aquatic birds. PAHs are present, and while not a risk to birds and mammals do present potential risk to benthic biota. Several metals (mercury with a ME=10, lead with a ME=8, and cadmium with a ME=4) are notably elevated.

Sample CSD08 is located in a mostly dry area of soil piles just east of the ditch, and has unacceptable risk from PCBs to benthic organisms and aquatic birds. As noted below, this area is periodically dry and, thus, terrestrial animals are also subject to exposure. These areas are also potential risk areas from PCBs, BEHP, di-n-octylphthalate and metals for shrews, robins and other terrestrial organisms.

These exceedances in the ditch and the adjoining area to the east represent adverse ecological risk and will be evaluated further in the FS.

Area SE-4 (Standard Steel Ditch)

The Standard Steel ditch is an inactive drainage ditch from the former Standard Steel CERCLA site. Sediment samples from this ditch (no surface water was present on the occasions when sampling was done) show that PCB concentrations representing potential adverse risk to benthic biota and birds are present in portions of the ditch area. Minor metals exceedances are also present in some locations. However, as these areas do not have a developed benthic habitat due to the frequent absence of aquatic conditions, these exceedances are of minor concern.

The adverse risk from PCBs in ditch sediments will be considered further in the FS.

Other off-channel areas

The localized and minor exceedances of sediment-based benchmarks in some samples from other off-channel areas have significant background contribution and will not be considered further in the FS. There was no risk to birds or mammals.

Riparian (Terrestrial) Area

The riparian evaluation of terrestrial endpoints included sediment samples in areas of intermittent inundation as such areas, at times, may be primarily terrestrial habitat. As noted above, a point-by-point evaluation revealed that unacceptable risk to terrestrial birds and mammals was estimated from exposure to PCBs, BEHP, di-n-octyl phthalate and metals is present in samples from off-channel areas SE-3 and SE-4.

Screening of soil (and some sediment) samples against the conservative screening benchmarks for plants and terrestrial invertebrates indicated that several metals had elevated ME. Many of the exceedances coincide with the already identified exceedances in areas SE-3 and SE-4. Based on the lines of evidence presented in the risk assessment these exceedances are not likely to represent a widespread significant risk to plants or invertebrates.

The riparian evaluation coincides with the off-channel areas in concluding that **areas that require additional attention in the FS are the impacted areas in SE-3 and SE-4**.

Cook Inlet

The storm water drainage in the Terminals Area that discharges to Cook Inlet was evaluated to determine the potential for impacts to surface water. Although benzene, ethylbenzene and xylenes may exceed marine surface water screening criteria at the outfall, impacts to marine life would not be likely because of rapid mixing and dilution in the high tidal flux and currents of the inlet. **Cook Inlet will not be evaluated further in the FS.**

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Groundwater Area 1 Additional Investigation Results

Appendix M

Sediment 2007 Data Results, Data Validation and Field Forms