# South Park Landfill

# Remedial Investigation/ Feasibility Study

**Prepared for**

City of Seattle
South Park Property Development, LLC

**February 2021**

**REVISED FINAL**

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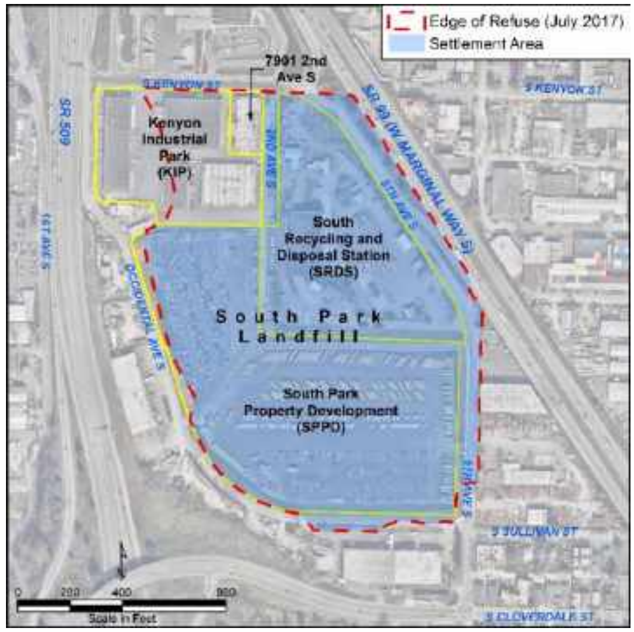
# Executive Summary




The South Park Landfill Site (Site) is a closed solid waste landfill in the South Park neighborhood of Seattle, Washington. It is located in the Lower Duwamish Valley near the western valley wall between State Routes 509 and 99. The landfill operated from the 1930s until 1966 when it was closed. By 1970, the City of Seattle (City) South Recycling and Disposal Station (SRDS), Kenyon Industrial Park (KIP), and several other facilities had been built on top of the Landfill and were operating.

In February 2007, the Site was added to Washington State's Hazardous Sites List. Soil, groundwater, surface water, and landfill gas (LFG) monitoring began in the late 1980s and has continued to the present day.

This Remedial Investigation/Feasibility Study (RI/FS) of the Site has been conducted under Washington State Model Toxics Control Act (MTCA) Agreed Order No. 6706 (Agreed Order) with the Washington State Department of Ecology (Ecology). The RI/FS has sufficiently characterized the nature and extent of contamination associated with the Landfill and evaluated the necessary remedial actions for the Settlement Area. This RI/FS was conducted in accordance with MTCA, as established in Chapter 173-340 of the Washington Administrative Code (WAC).

Sections 1.0 through 6.0 of this document present the RI findings for the Site. Sections 7.0 through 15.0 present alternatives for the different actions that make up remedial action for the Settlement Area, and Section 16.0 presents the preferred Remedial Alternative for the Settlement Area. An overview of the RI/FS findings is discussed below.

**SOUTH PARK LANDFILL CONCEPTUAL SITE MODEL**

The native soils beneath the Landfill, and across the entire Lower Duwamish Valley, consist of river- and estuarine-deposited silts and sands. Beginning in the 1890s and intensifying in the 1930s, human activities further raised the land surface throughout the valley by the placement of fill. At the Landfill, the fill consisted of solid wastes, much of which was burned to reduce its volume and promote more rapid settling and compaction. When the Landfill was closed in 1966, additional general-purpose (unclassified) fill was brought in, and the surface was regraded to allow the development of the KIP parcel, the SRDS parcel, and land for other industrial operations. Since 2013, the largest remaining parcel, the South Park Property Development (SPPD) parcel, has been undergoing cleanup and redevelopment according to an Ecology-approved Interim Action Work Plan that was prepared and approved in 2013 under the Agreed Order.

Solid waste landfills, which have been extensively studied across the country and are well understood, can be classified into five main stages on the basis of the aging, or breakdown, of wastes within the landfill. Active landfill cells begin in Stage 1, in which the refuse/waste is largely intact, and progress through Stage 4 as the refuse decomposes and the cell is closed. An old, Stage 5 landfill, on the other hand, is one in which the wastes are so degraded that the landfill processes are negligible.

According to the data collected at the Landfill, it is in late Stage 4 to early Stage 5, depending on the location within the Landfill. The specific findings of the RI are the following:

- Solid waste was disposed of in the Landfill from the 1930s through the mid-1960s. Much of the solid waste was burned to reduce its volume. The Landfill is now old, and the contents are heavily degraded.
- The Landfill was, and is, unlined. Much of the solid waste lies above a silt deposit, and deeper sections of the solid waste have breached the silt deposit and are in direct contact with regional groundwater.
- The entire Landfill is developed as either operating facilities or roadways. Approximately 90 percent is covered with buildings, pavement, roadways, sidewalks, and low-permeability geomembranes. The remaining 10 percent is primarily landscaped areas or graveled roadway shoulders.
- Ongoing monitoring of LFG and groundwater confirms that the Landfill is in late Stage 4/early Stage 5, depending on the location, as evidenced by the following characteristics:
    - The Landfill is still producing low concentrations of methane (LFG), but the rate of LFG production is so low that there is no measurable pressure buildup (late Stage 4). In some areas, the methane production is so low that normal air is entering the Landfill, and the air within the Landfill contains low but measurable concentrations of oxygen (early Stage 5).
    - The leachate has a neutral pH, with a salt content that is trending downward and less than the naturally occurring salinity found deeper in the groundwater system.
- Methane, which is the primary concern related to LFG, was not detected in the structures on top of the Landfill, but it is still measurable within subsurface of the Landfill. Buildings on the Landfill and adjacent to the Landfill on KIP and in properties along 5$^{th}$ Avenue South were monitored for methane in four events during the RI; no methane was detected in these buildings with a detection limit of 100 parts per million.
- Vinyl chloride, iron, and manganese are the only chemicals of concern (COCs) for groundwater that exceed cleanup levels at the conditional point of compliance at the edge-of-refuse.
- The vinyl chloride concentrations in on-site wells ranged from no detection at a detection limit of 0.02 micrograms per liter (µg/L) to a detected concentration of 1.4 µg/L. Ecology has established a preliminary cleanup level (CUL) of 0.29 µg/L for

vinyl chloride in groundwater. This value was selected to protect potential drinking water uses, but it is also protective of surface water quality. There are no current or anticipated drinking water wells between the Landfill and the Lower Duwamish Waterway, which is located approximately 1,600 feet downgradient.

  - Iron exceeds the preliminary CUL based on A-Zone background concentrations determined for the site (27 mg/L). Manganese exceeds the preliminary CUL determined for the site (2.2 mg/L).
  - Three other COCs are being monitored to confirm that their concentrations remain less than their respective groundwater CULs at the conditional point of compliance (CPOC): *cis*-1,2-DCE, benzene, and arsenic.

- Contaminated soil and groundwater traceable to auto wrecking yard activities from 1953 to around 1965 in the northwestern portion of the Landfill (Kenyon Industrial Park and 7901 parcels) have commingled with landfill waste.

The potential exposure pathways at the Landfill are (1) incidental direct contact with contaminated soil or solid waste that is not under a controlled landfill cap, (2) incidental direct contact with contaminated groundwater during construction activities or from withdrawal of groundwater, and (3) direct contact with/inhalation of indoor air that may be contaminated as a result of LFG entry into structures.

**MTCA REQUIREMENTS FOR LANDFILLS**

Under MTCA, closed landfills are considered to be sites that have used "containment of hazardous substances" as the preferred remedy. To meet the requirements of MTCA, the selected remedy must be protective of human health and the environment under specified exposure conditions. WAC 173-340-360(2)(a) specifies four threshold criteria that must be satisfied by all cleanup actions:

1. Protect human health and the environment.
2. Comply with cleanup standards (WAC 173-340-700 through 173-340-760).
3. Comply with applicable local, state, and federal laws (WAC 173-340-710).
4. Provide for compliance monitoring (WAC 173-340-410 and WAC 173-340-720 through 173-340-760).

In addition, WAC 173-340-360(2)(b) specifies three other criteria that cleanup actions must achieve:

1. Use permanent solutions to the maximum extent practicable.
2. Provide for a reasonable restoration time frame.
3. Consider public concerns (WAC 173-340-600).

**PREFERRED REMEDIAL ALTERNATIVE**

The FS establishes the remedial action goals for the Settlement Area and describes how the landfill containment requirements will be met in accordance with the MTCA regulatory requirements. The study relied on a large volume of experience with the successful closure and/or cleanup of solid waste landfills. The preferred alternative for the Settlement Area which will require Landfill closure consists of the following elements:

- A **landfill cap/cover** to prevent people, animals, and stormwater from coming into direct contact with the solid waste. The landfill cap will also decrease the amount of stormwater infiltration relative to conditions before the remedial action is implemented.
- **Stormwater controls** to prevent solid waste from coming in contact with stormwater and to protect the landfill cap/cover. Stormwater controls will also need to meet regulatory requirements, including the City's stormwater code and any applicable regulations related to the National Pollutant Discharge Elimination System.
- **LFG controls** to prevent subsurface migration of LFG off-site and/or into on-site or nearby buildings and structures. Because of the low rate of methane production, either active or passive systems or ongoing monitoring are appropriate LFG controls, depending on the parcel.
- **Monitoring** of groundwater to confirm that the residual vinyl chloride in the groundwater system continues to degrade over time.
- **Long-term monitoring** of the cap/cover, the LFG controls, and groundwater to ensure that the remedy is effective and provides long-term protection of human health and the environment. Additional details of the monitoring are presented in the Cleanup Action Plan (CAP).
- **Environmental (Restrictive) Covenants** to ensure long-term compliance with regulations and maintenance of the remedy. Draft Environmental (Restrictive) Covenants will be included in the CAP.

**REGULATORY PROCESS**

Ecology has approved this RI/FS and prepared a Final CAP identifying its preferred remedy for the Settlement Area. The Settlement Area consists of the two largest parcels within the "Edge of Refuse" (defined in Section 1.2) and certain adjacent City of Seattle and Washington State right-of-ways.

An Interim Action at the SRDS parcel will continue to be completed under the terms of the Interim Action Work Plan and Agreed Order. As detailed in the CAP, after completion of the Interim Action, Ecology will review the Interim Action Report and determine whether the actions completed for the Interim Action on the SRDS parcel are equivalent to the required final remedial action; if they are, the Interim Action will become the final action for that parcel.

An Interim Action has been completed at the SPPD parcel. Ecology will determine in the CAP whether the actions completed at the SPPD parcel are equivalent to the final remedial action.

# South Park Landfill Remedial Investigation/Feasibility Study

## CERTIFICATION

This document has been prepared for the City of Seattle under the direction of:

**Name:** Dr. Teri A. Floyd, Ph.D.

**Date:** February 2021

## AUTHOR RECOGNITION

The following individuals have contributed to the preparation of this Remedial Investigation/Feasibility Study:

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## Table of Contents

## List of Tables

## List of Figures

## **List of Appendices** (Provided separately)

## List of Acronyms and Abbreviations

| Acronym/ Abbreviation | Definition |
|---|---|
| 7901 | 7901 2nd Avenue S., LLC |
| AESI | Associated Earth Sciences |
| Agreed Order | Agreed Order No. 6706 |
| ARAR | Applicable or Relevant and Appropriate Requirement |
| bgs | Below ground surface |
| BMP | Best Management Practice |
| BTEX | Benzene, toluene, ethylbenzene, and xylenes |
| CAP | Cleanup Action Plan |
| CDD | Chlorinated dibenzo-p-dioxin congeners |
| CDF | Chlorinated dibenzofuran congeners |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| City | City of Seattle |
| CKD | Cement kiln dust |
| cm/sec | Centimeters per second |
| COC | Chemical of concern |
| COPC | Chemical of potential concern |
| County | King County |
| cPAH | Carcinogenic polycyclic aromatic hydrocarbon |
| CPOC | Conditional point of compliance |
| CSCS | Confirmed or Suspected Contaminated Site |
| CUL | Cleanup level |
| DCA | Disproportionate cost analysis |
| DCE | Dichloroethene |
| DU | Decision Unit |
| Ecology | Washington State Department of Ecology |
| FS | Feasibility Study |
| ft/day | Feet per day |
| GIS | Geographic Information System |
| Glitsa | Glitsa American, Inc. |
| HDPE | High density polyethylene |
| Herrera | Herrera Environmental Consultants, Inc. |
| IA | Interim Action |
| IAWP | Interim Action Work Plan |
| IB | Industrial Buffer |
| IG2 | General Industrial 2 |

| Acronym/ Abbreviation | Definition |
|---|---|
| JEM | Johnson and Ettinger Model |
| KCA | King County Archives |
| KIP | Kenyon Industrial Park |
| L3 | Lowrise 3 |
| LEL | Lower explosive limit |
| LFG | Landfill gas |
| LUST | Leaking underground storage tank |
| µg/kg | Micrograms per kilogram |
| µg/L | Micrograms per liter |
| $\mu g/m^3$ | Micrograms per cubic meter |
| µS/cm | Microsiemens per centimeter |
| MCL | Maximum Contaminant Level |
| MFS | Minimum Functional Standards |
| mg/kg | Milligrams per kilogram |
| mg/L | Milligrams per liter |
| MI | Multi-Increment |
| MSL | Mean sea level |
| MTCA | Model Toxics Control Act |
| NAVD 88 | North American Vertical Datum of 1988 |
| ng/kg | Nanograms per kilogram |
| NMOC | Non-methane organic compound |
| NPDES | National Pollutant Discharge Elimination System |
| NRDS | North Recycling and Disposal Station |
| OMM | Operation, maintenance, and monitoring |
| OMMP | Operations, Maintenance, and Monitoring Plan |
| OSHA | Occupational Safety and Health Administration |
| PAH | Polycyclic aromatic hydrocarbon |
| PCB | Polychlorinated biphenyl |
| PEL | Permissible exposure limit |
| PID | Photoionization detector |
| PLP | Potentially liable person |
| POC | Point of compliance |
| ppm | Parts per million |
| ppmv | Parts per million by volume |
| PQL | Practical Quantification Limit |
| PSCAA | Puget Sound Clean Air Agency |
| PVC | Polyvinyl chloride |

| Acronym/ Abbreviation | Definition |
|---|---|
| RCW | Revised Code of Washington |
| RETS | Renton Effluent Transfer System |
| RI | Remedial Investigation |
| RI/FS | Remedial Investigation/Feasibility Study |
| ROW | Right-of-way |
| SDOT | Seattle Department of Transportation |
| Site | South Park Landfill Site |
| SMA | Seattle Municipal Archives |
| SMC | Seattle Municipal Code |
| SPPD | South Park Property Development, LLC |
| SPU | Seattle Public Utilities |
| SR | State Route |
| SRDS | South Recycling and Disposal Station |
| STS | South Transfer Station |
| STSII | South Transfer Station Phase II |
| SVOC | Semivolatile organic compound |
| SWPPP | Stormwater Pollution Prevention Plan |
| TCDD | 2,3,7,8-tetrachloro-dibenzo-p-dioxin |
| TCE | Trichloroethene |
| TCLP | Toxicity Characteristic Leaching Procedure |
| TDS | Total dissolved solids |
| TEQ | Toxicity equivalency quotient |
| TOC | Total Organic Carbon |
| TPH | Total petroleum hydrocarbons |
| TSCA | Toxic Substances Control Act |
| UCL | Upper confidence limit |
| UECA | Uniform Environmental Covenants Act |
| USACE | U.S. Army Corps of Engineers |
| USEPA | U.S. Environmental Protection Agency |
| UST | Underground storage tank |
| VOC | Volatile organic compound |
| WAC | Washington Administrative Code |
| Work Plan | Remedial Investigation/Feasibility Study Work Plan |
| WSDOT | Washington State Department of Transportation |

# 1.0 Introduction

The South Park Landfill Site (Site) is a former municipal solid waste landfill located in the South Park neighborhood of Seattle, Washington. It received solid wastes from the 1930s until 1966, when it was closed under existing landfill closure laws. In February 2007 the Landfill was added to Washington State's Hazardous Sites List, based on concerns related to groundwater contamination, and the presence of potentially flammable and explosive landfill gas (LFG). Groundwater, surface water, soil, and LFG investigations began in the late 1980s and have continued to the present day. When referring to the Model Toxics Control Act (MTCA) Site that contains the Landfill, the term "Site" will be used in this document. The term "Landfill" refers to the actual property where landfill activities occurred between the 1930s and 1966. The Landfill is a portion of the Site. The Consent Decree and Cleanup Action Plan address a portion of the Site referred to as the "Settlement Area" which encompasses two parcels and adjacent City of Seattle and Washington State right-of-ways (ROWs). The Settlement Area overlaps part of the Landfill.

This Remedial Investigation/Feasibility Study (RI/FS) of the Site has been conducted under Washington State MTCA Agreed Order No. 6706 (Agreed Order) with the Washington State Department of Ecology (Ecology) in order to sufficiently characterize the nature and extent of contamination associated with the Landfill and evaluate any remedial actions necessary for the Settlement Area portion of the Site. The City of Seattle (City), King County (County), and South Park Property Development, LLC (SPPD) were originally identified by Ecology as the potentially liable persons (PLPs) for the Landfill. The City and SPPD were signatories of the Agreed Order and have expanded the scope of work to include implementation of two Interim Actions (IAs): one on the SPPD parcel completed in 2015 and one on-going at the City's parcel. The scope of work for completing the RI/FS can be found in the RI/FS Work Plan (Work Plan; Farallon 2010a). This RI/FS has been conducted in accordance with MTCA, as established in Chapter 173-340 of the Washington Administrative Code (WAC).

## 1.1 MTCA REQUIREMENTS FOR LANDFILLS

The Landfill is a historical municipal landfill that was originally closed in 1966 under the County's Title 10 provisions for landfills—the only applicable regulations at the time. Washington State's first Minimum Functional Standards (MFS) for solid waste landfills, Chapter 173-301 WAC, became effective in 1972. In November 1985, Chapter 173-301 was replaced by Chapter 173-304 as Washington State's MFS for solid waste landfills. MTCA allows for containment to be the preferred remedy for historical landfill sites and uses MFS (WAC 173-304) as a relevant and appropriate requirement.[1] Closed landfills are considered under MTCA to be sites that have used "containment of hazardous substances" as the preferred remedy. Under WAC 173-340-740(6)(f),

[1] Refer to WAC 173-340-370(3), where Ecology recognizes the need to use engineering controls such as containment for sites that contain large volumes of materials with relatively low levels of hazardous substances and WAC 173-340-350(8)(c), which allows for the FS to be focused appropriate for the site. WAC 173-340-710(7)(c) indicates that MFS (WAC 173-304) is an Applicable or Relevant and Appropriate Requirement (ARAR) for closed solid waste landfills.

MTCA states that containment sites will comply with cleanup standards if they meet the following requirements:

> *"WAC 173-340-740(6)(f) The department recognizes that, for those cleanup actions selected under this chapter that involve containment of hazardous substances, the soil cleanup levels will typically not be met at the points of compliance specified in (b) through (e) of this subsection. In these cases, the cleanup action may be determined to comply with cleanup standards, provided:*
>
> *(i) The selected remedy is permanent to the maximum extent practicable using the procedures in WAC 173-340-360;*
>
> *(ii) The cleanup action is protective of human health. The department may require a site-specific human health risk assessment conforming to the requirements of this chapter to demonstrate that the cleanup action is protective of human health;*
>
> *(iii) The cleanup action is demonstrated to be protective of terrestrial ecological receptors under WAC 173-340-7490 through 173-340-7494;*
>
> *(iv) Institutional controls are put in place under WAC 173-340-440 that prohibit or limit activities that could interfere with the long-term integrity of the containment system;*
>
> *(v) Compliance monitoring under WAC 173-340-410 and periodic reviews under WAC 173-340-430 are designed to ensure the long-term integrity of the containment system; and*
>
> *(vi) The types, levels, and amount of hazardous substances remaining on-site and the measures that will be used to prevent migration and contact with those substances are specified in the draft cleanup action plan."*

For closed solid waste landfills, Ecology allows for containment to be the remedial action with MFS as an ARAR. It is not necessary to evaluate removal actions or perform a disproportionate cost analysis; however, the specific remedy selected for the Settlement Area portion of the Site must demonstrate that the other elements of containment are met as defined by sections WAC 173-340-740(6)(ii) through (iv) above.

MFS (WAC 173-304) then acts as a starting point and a relevant and appropriate requirement for defining the MTCA remedy for the Site. In September 1993, approximately 10 years after MFS was developed, the U.S. Environmental Protection Agency (USEPA) published their *Presumptive Remedy for CERCLA Municipal Landfill Sites Directive* (USEPA 1981). This document was based on their experiences on multiple solid waste landfill sites and reflected a growing body of knowledge regarding the key components that were necessary to build long-term containment remedies at solid waste landfills. This RI/FS uses ideas from USEPA's presumptive remedy to refine the MTCA remedial action for the Settlement Area portion of the Site, while continuing to treat MFS as a key ARAR. The remedy described in the FS follows the concepts in MTCA, MFS, and USEPA's guidance and uses the term "presumptive remedy" to remind the reader of the large body of knowledge that exists regarding solid waste landfills and their long-term care.

## 1.2 TERMINOLOGY

The following terms are used throughout the document and it is helpful to distinguish them from the beginning:

- **Site (capitalized)**, or occasionally for clarity **MTCA Site**, is intended to be used consistent with the MTCA definition of the site and includes the Landfill, Settlement Area, and other areas where contamination has come to be located. The use of the uncapitalized site refers to sites in general, rather than the South Park Landfill Site in particular.
- **Landfill,** or occasionally for clarity **Edge of Refuse,** refers to the extent of refuse or solid waste that was placed during the operation of the South Park Landfill from the 1930s until it was closed in 1966. The use of the uncapitalized landfill refers to landfills in general, rather than South Park Landfill in particular. The Landfill is a portion of the Site.
- **Settlement Area** refers to two parcels (South Recycling and Disposal Station [SRDS] and SPPD) and adjacent City of Seattle and Washington State ROWs. The Settlement Area is the portion of the Site for which remedial actions are detailed in the Cleanup Action Plan.
- **Parcel** is used to refer to tax parcels with specific ownership. The Landfill is located on several parcels that are owned by different parties. Several parcels contain areas where the Landfill is present and other areas where it is not. Likewise, several parcels, such as the Kenyon Industrial Park (KIP), include areas that are within the Edge of Refuse and other areas that are not. Many of the figures within the report include both parcel boundaries and the Landfill boundary to help the reader understand the relationship between the two when both are discussed. Adjacent tax parcels are also identified in several sections when discussing data collected outside of the Edge of Refuse.
- **Right-of-way or ROW** refers to transportation corridors used by either the City or Washington State as identified on the County's parcel viewer (King County 2016). They are distinct from the tax parcels and do not have tax parcel numbers associated with them**. Roadway** will be used to refer to the portion of the ROW that is ordinarily used for vehicular travel, exclusive of the sidewalk or shoulder, consistent with Revised Code of Washington (RCW) 46.04.500. In general, the ROWs include the roadways, shoulders, sidewalks, and, in the case of state highways, a buffer area and median.

The MTCA Site definition is also intended to include the former West Ditch component of the stormwater system. This former ditch was located outside of refuse and is not part of the Landfill (as defined by the extent of solid waste), but has been redeveloped as the West Bioswale, a component of the stormwater system at the Landfill (Section 2.6.1.2), and is considered part of the MTCA Site.

## 1.3 REMEDIAL INVESTIGATION/FEASIBILITY STUDY OBJECTIVE

The purpose of the RI is to collect, evaluate, and document the data necessary to adequately characterize the environmental conditions associated with the Site in support of the FS. The purpose of the FS is to develop and evaluate cleanup alternatives and recommend a cleanup action for the Site, or a portion of the Site, in accordance with WAC 173-340-350 through 173-340-390. Based on the results documented in the RI/FS, a Final Cleanup Action Plan (CAP) was produced by Ecology in order to satisfy the requirements of the Agreed Order.

The specific objectives of this RI include the following:

- Identify the extent of refuse that is to be "contained" as part of the Landfill cleanup.
- Identify the nature and extent of soil contamination outside of area of refuse, but either present on the Landfill or related to a release from the Landfill.
- Identify the nature and extent of LFG present within and surrounding the Landfill.
- Identify the potential for ongoing leachate production and the need for leachate controls.
- Identify the nature and extent of landfill-related groundwater contamination at the edge-of-refuse and extending downgradient as far as the point of compliance (POC) wells across State Route (SR) 99.
- Develop preliminary cleanup levels (CULs).

All of the RI objectives have been met for this Settlement Area, as will be discussed in Sections 2.0 through 6.0 of this document.

The specific objectives of the FS include the following:

- Identify remedial action objectives appropriate for closed solid waste landfills, including identification of landfill-related ARARs.
- Evaluate alternatives and select the preferred alternative for the Settlement Area where the presumptive remedy components are consistent with solid waste landfill closure and the redevelopment of the site.
- Identify the mechanism that will ensure that the preferred alternative will function effectively and will be operated and maintained in a manner that will ensure protection of human health and the environment in a long-term manner.
- Provide a schedule for the implementation of the preferred alternative.

The objectives of the FS have also been met for the Settlement Area, as will be discussed in Sections 7.0 through 16.0.

## 1.4 REPORT ORGANIZATION

The RI is presented in Sections 2.0 through 6.0. Sections 2.0 and 3.0 define the physical, historical, and geographical setting of the Landfill and Settlement Area. Section 4.0 identifies the extent of refuse and the nature and extent of soil contamination that is outside of the extent of refuse, but is still considered part of the Site. Preliminary soil CULs developed under MTCA provisions are then used to identify areas of soil contamination that require remedial action. Section 5.0 describes the groundwater system, develops preliminary CULs for detected chemicals, and identifies the nature, extent, and fate of groundwater contamination associated with the Landfill and Settlement Area. Section 6.0 describes the current condition of LFG formation and migration, and identifies any toxic chemicals (volatile organic compounds [VOCs]) present in the LFG.

Sections 7.0 through 15.0 present the requirements for the MTCA cleanup action for the Settlement Area. Each section evaluates a different component of the cleanup action with respect to technologies, and then screens alternatives that are appropriate. Section 16.0 then combines all of the cleanup action components into a single preferred alternative for the Settlement Area and discusses how this alternative meets the MTCA cleanup requirements.

The appendices provide additional information supplemental to the RI and FS sections and include the following:

- Appendix A – A historical review of the evolution of the Landfill and surrounding parcels including historical aerial photographs, a few key documents, and a tabulated summary.
- Appendix B – A collection of supporting field and sampling documentation including lithologic descriptions (boring logs) and indoor air monitoring details.
- Appendix C – A summary of analytical data including frequency of detections, chemicals tested, and sample counts for soil, solids, groundwater, soil vapor, and indoor air.
- Appendix D – A summary of deviations from the Work Plan.
- Appendix E – Analytical laboratory data reports for samples collected during the RI for soil, solids, groundwater, soil vapor, and indoor air.
- Appendix F – Analytical laboratory data validation reports for RI chemical analyses.
- Appendix G – Field documentation for the former West Ditch sampling and grain size analyses.
- Appendix H – Dioxin/furan sample photographs and multi-increment (MI) sample composite process.
- Appendix I – Hydrogeological data, including slug tests and groundwater elevation contour maps.
- Appendix J – Groundwater quality trend plots and maps and data tables of results from specific groundwater sampling events from 2011 through March 2014.

- Appendix K – Bioscreen Modeling Results for Groundwater to address the probable contribution of vinyl chloride concentrations at MW-31.
- Appendix L – Supplemental Investigations, including LFG investigations at KIP and soil and groundwater sampling at the Lenci Parcel.
- Appendix M – Pavement at KIP and 7901 Parcels.

# 2.0 Site Setting

The following sections provide general information about the Site, including: the physical setting, the location and description of the various parcels that constitute the Site, a discussion of current conditions and redevelopment plans, stormwater controls and utilities, and a description of previous environmental investigations and cleanup actions conducted in the vicinity of the Site. Section 3.0 describes the Site's physical setting in further detail.

## 2.1 DUWAMISH VALLEY HISTORY

The Site is located within the glacially-carved Duwamish Valley, which extends from Elliott Bay to the confluence of the Green River, and contains floodplains, freshwater wetlands, and tidal marshes. Figure 2.1 shows the location of the Landfill within the Duwamish Valley. The valley was originally inhabited by Native American tribal communities before becoming settled by Euro-Americans in the 1850s. These settlers drained and filled the wetlands with various fill materials and cleared the lowland forests for agricultural and logging purposes. The subsequent channelization of the river, in the early 1900s, lead to an increase in commercial, industrial, and residential developments within the valley (Windward Environmental 2010). Two mixed industrial, commercial, and residential communities, Georgetown and South Park, were later developed within the valley. In the mid-1960s, the South Park neighborhood was rezoned as industrial with some low-density residential areas. Industrial operations in the area include cargo handling and storage, marine construction, boat manufacturing, marina operations, paper and metals fabrications, food processing, and airplane parts manufacturing. Approximately 3,700 people reside in the South Park neighborhood and work in the wholesale trade, transportation and utilities, construction/resources, manufacturing, and service industries (Ecology 2009a).

## 2.2 SITE AND SURROUNDING AREA DESCRIPTION

The Landfill consists of several parcels situated in the South Park neighborhood, located in Section 32 of Township 24 North, Range 4 East. Several of the parcels were initially added to the County Tax Rolls via foreclosure in the 1920s and were later purchased by the City and the County in the 1950s. The Landfill was operated by the City until it closed in 1966 and included disposal and burning of municipal, commercial, and industrial waste (SPU 1997; Ecology and Environment, Inc. 1988). Since that time, the Landfill has undergone filling and grading activities and has been redeveloped; nearly half of the Landfill is currently covered with existing structures. A detailed description of the history of the Landfill and its owners is provided in Table 2.1 and Appendix A. Appendix A also includes historical aerial photographs illustrating changes to the Landfill boundary and land use over time.

The Landfill covers approximately 39 acres and is roughly bounded to the north by South Kenyon Street, to the east by SR 99 and 5$^{th}$ Avenue South, to the south by South Sullivan Street, and to the west by Occidental Avenue South, as illustrated on Figure 2.2. The County tax assessor parcels and relevant parcel information are included on Figure 2.2. The blue dashed line shown on Figure 2.2 depicts the approximate demarcation of the solid waste boundary as identified in the Work Plan (Farallon 2010b). A summary of parcel information is provided in Table 2.1, and a discussion of the individual parcels is provided below. Information presented in Section 4.0 will be used to define the final "extent of landfill solid waste;" therefore, the blue dashed line shown on Figure 2.2 should be considered a preliminary demarcation of the Landfill boundary.

## 2.3 ZONING AND LAND USE

The Landfill, with the exception of the southeastern corner in the vicinity of the intersection of 5th Avenue South and South Sullivan Street, is zoned by the City as General Industrial 2 (IG2; Figure 2.3). This zoning designation includes general and heavy manufacturing, commercial uses subject to certain limitations, transportation and utility services, and salvage and recycling uses. The areas to the west, north, and northeast of the Landfill are also designated as IG2. The southeastern corner of the Landfill is designated as Industrial Buffer (IB), which is intended to provide buffering between industrial areas and adjacent residential areas. Further to the east, southeast, and south of the Landfill, the area is designated as either Lowrise 3 (L3) or Residential Single Family 5000 (SF 5000). The nearest residential property to the Landfill is an L3 apartment building located at the southeastern corner of 5th Avenue South and South Sullivan Street, which is approximately 100 feet southeast of the Landfill (Figure 2.3).

Major roadways surrounding the Landfill are shown on Figure 2.3 and include the following:

- SR 99, adjacent to the northeastern portion of the Landfill
- SR 509, approximately 200 feet west of the Landfill

Based on zoning characteristics and review of the available aerial photographs, both the IG2- and IB-zoned areas of the Landfill can be reasonably considered as industrial properties.

## 2.4 THE LANDFILL PARCELS

Today the closed landfill lies beneath four separately owned tax parcels and two ROWs maintained by the City's Department of Transportation (SDOT) and one ROW maintained by Washington State Department of Transportation (WSDOT). They are described in the following sections.

### 2.4.1 South Park Property Development Parcel

The SPPD parcel (County Tax Parcel No. 3224049005) includes 21.0 acres of undeveloped land purchased from the County in 2006. The property was purchased by the County out of tax title in 1957 and leased to the City from 1958 to 1978 for rubbish disposal. After disposal operations ended in 1966, additional unclassified fill was added and the parcel was graded (but not paved) as part of landfill closure. The County later leased portions of the property to a variety of tenants from the mid-1980s through the late 1990s, primarily for truck and equipment storage. In 2008, the property was largely cleared of vegetation and, in some areas, a layer of crushed concrete was added as ballast and the parcel was regraded. In 2014 and 2015, SPPD performed an IA cleanup at the parcel per the 2013 Ecology-approved Interim Action Work Plan (IAWP) under Agreed Order No. DE 6706 for the Site (Farallon 2013). The IA was performed simultaneously with the redevelopment of the property. The property redevelopment includes a modular building for employees and paved parking for employees and visitors. The parcel was paved and equipped with an engineered stormwater system appropriate for general parking and storage of closed containers. The parcel is served by municipal water, sewer, electricity, or other utilities and is zoned for industrial use.

The IA work included regrading and capping the Landfill surface, installing an engineered stormwater collection system, installing and operating a LFG control system, implementing institutional controls, and conducting monitoring. Refer to Figure 2.4 for the current configuration of the SPPD parcel, including the recent upgrades.

### 2.4.2 South Recycling and Disposal Station Parcel

The SRDS, a 10.3-acre parcel, is located at 8100 2$^{nd}$ Avenue South on County Tax Parcel Nos. 7328400005 and 3224049110. Parcel No. 7328400005 was sold out of tax title status to the City in 1951. The SRDS was constructed in 1966 on top of the closed landfill and includes the main waste disposal building, a small maintenance facility, a scale house, two vehicle-fueling systems, and several additional small buildings used for offices and household hazardous waste collection. Several of these structures, including the original and relocated scale pits and the main waste disposal building, are pile-supported. These piles extend to depths of more than 96 feet below ground surface (bgs; City of Seattle DOE 1965). The facility is paved except for some perimeter landscaping and small areas in the interior of the property. Parcel No. 3224049110, a ROW was added to this parcel in 2003 through the ordinance provided in Appendix A. Even though the SRDS facility is made up of two parcels, it will be referred to as one parcel throughout the document.

The current truck fueling systems at the SRDS consist of 2,000- and 3,000-gallon aboveground storage tanks (ASTs) used to store diesel fuel, and a dispenser island. In 1999, an earlier fueling system was decommissioned. It had consisted of two underground storage tanks (USTs; one 10,000-gallon diesel tank and one 3,000-gallon gasoline tank), dispensers, and underground piping. In a 1999 report, Herrera Environmental Consultants, Inc. (Herrera) indicated that a release of petroleum hydrocarbons had occurred and that about 250 cubic yards of petroleum-contaminated soil was removed from an excavation beneath the former fuel dispensers during the decommissioning activities (Herrera 1999). Some residual petroleum hydrocarbons, attributed to the former fueling system, remained in the soil/refuse layer. Heavy oil-range petroleum hydrocarbons were also detected in soil and attributed to disposal practices when the property was operated as a landfill.

The property also contains a localized French drain system beneath the compactor structure on the east side of the tipping building, which discharges to the municipal sanitary sewer. The system is designed to capture the seasonal build-up of groundwater beneath the foundation, but operates infrequently. The utilities serving the SRDS are located along 2nd Avenue South and 5th Avenue South.

The SRDS parcel has been in operation since 1966 as a transfer station for municipal solid waste and other recyclable materials. In spring 2013, the City opened a new solid waste transfer station across the street on South Kenyon Street. Both the SRDS and the new transfer station are accepting the City's solid waste while the City is rebuilding its North Recycling and Disposal Station (NRDS) in Fremont/Wallingford. When construction of the NRDS is complete in 2016, the City will conduct an interim remedial action and redevelop the SRDS to support the new South Transfer Station (STS) and other Utility functions. The cleanup will happen as an IA under Agreed Order No. DE 6706 to meet the City's capital plan schedule. The cleanup will be consistent with the 2015 Ecology-approved IAWP (Herrera and Aspect 2015). The IA includes: installation of asphalt, concrete, or membrane caps, and LFG and surface water controls; implementation of institutional controls; and compliance monitoring. The LFG collection system will include horizontal (trench) collectors, conveyance piping, and vents to address areas covered by cap materials as well as new buildings planned for construction. The design of the IA is in early stages at the time of the preparation of this RI/FS and further detail will not be available until the Engineering Design Report is ready for submittal to Ecology as part of the IA.

Both LFG and groundwater will be monitored to assess effectiveness of the IA on the SRDS portion of the Landfill. After approval of a final CAP, monitoring of the SRDS portion of the Landfill will be completed as part of the long-term monitoring plan, as described in the CAP. Refer to Figure 2.5 for the current site plan and the proposed future site plan of the SRDS parcel.

#### 2.4.3 The Kenyon Industrial Park and the 7901 2nd Avenue South Parcels

The northwest quadrant of the Landfill is occupied by two parcels with privately owned buildings leased for uses consistent with industrial zoning. The larger is the KIP parcel, a 6.5-acre parcel (County Tax Parcel No. 3224049007) owned by Harsch Investment Properties, LLC. The smaller is the 7901 2nd Avenue South parcel, a 0.72-acre parcel (County Tax Parcel No. 3224049077) owned by 7901 2nd Ave S., LLC (7901), and hereafter referred to as the 7901 parcel. The buildings at the KIP have addresses ranging from 111 to 129 South Kenyon Street and from 7900 to 8100 Occidental Avenue South.

The KIP and 7901 parcels were originally Parcel B and Parcel A, respectively, of Short Subdivision No. 6606850 (Seattle Engineering Department 1934). Parcel B (KIP) contained a historical drainage channel that drained surface water from the valley wall toward wetlands closer to the Lower Duwamish Waterway. This can be seen in the first frame (1946 aerial) of Figure 2.6. Where the channel crossed the KIP parcel is referred to in this RI/FS as the historical KIP swale depending on the timeframe.

East of the historical KIP swale, landfilling began in the 1930s and continued until the late 1940s; west of the swale were farmed fields, a house, a barn, and small farm structures. By 1951, landfilling at the KIP and 7901 parcels had ceased and the parcels were sold out of tax title status to the City. It is not clear if the City owned all of the KIP and 7901 parcels in 1951 or only the section east of the swale where landfilling had occurred. The 1951 aerial shows that the section of the KIP and 7901 parcels where landfilling had occurred had been regraded and were leased as an auto-wrecking or used vehicle sales lot.

In 1953, the Ripley Family sold the section of the KIP parcel west of the historical KIP swale (where there was no landfilling) to John Farrell who converted the farm to an auto-wrecking business. In 1955, John Farrell purchased the rest of the KIP parcel (and potentially 7901) from the City. By the mid-1950s, auto-wrecking and sales were occurring at the KIP and 7901 parcels on both sides of the swale and Farrell had begun filling in the swale to acquire more useable land for his auto yard. This can be seen in the second frame (1960 aerial) of Figure 2.6.

Sometime between 1965 and 1967, the 7901 building and the first building at KIP had been constructed and occupied (refer to the 1969 frame of Figure 2.6). In 1972, the main stormwater line for KIP was placed in the historical KIP swale and the swale was filled as part of the construction of the third building on KIP. By 1974, the swale had been completely filled, the KIP and 7901 parcels had been paved and equipped with a stormwater collection system, and all five buildings had been constructed and occupied.

The KIP and 7901 parcels were, most likely, owned by the Farrells until 1986 when all or part became bank-owned through a foreclosure. In 2008, Harsch Investment Properties, LLC, the current owner of KIP, purchased it from the bank; the 7901 parcel was purchased by John Hill from Janice Farrell and then converted to an LLC—the 7901 2nd Ave S., LLC.

Currently, the KIP parcel houses light industrial operations, which consist of a total of four buildings (three within the Landfill boundary) with paved areas covering the remaining surfaces outside of the building footprints. The buildings are slab-on-grade and contain a mixture of office and manufacturing, commercial, and warehouse space. The offices generally have either carpet or tile floorings, while the warehouse areas have exposed concrete floors. The following buildings are located on the KIP parcel (Koll-Dove Venture I 1996):

- A 32,000-square-foot building built in 1966, located at 7951–7953 2nd Avenue South
- A 15,624-square-foot building built in 1973, located at 7929–7937 2nd Avenue South
- A 36,000-square-foot building built in 1973, located at 7910–7936 Occidental Avenue South
- A 44,000-square-foot building built in 1970, located at 121–129 South Kenyon Street

On the 7901 parcel, an approximately 17,000-square-foot building was constructed in the late 1960s (refer to Figure 2.6 for its location).

There are currently no known redevelopment plans for the KIP and 7901 parcels.

### 2.4.4 The Lenci Parcel

A review of aerial photographs and historical maps indicated that a lobe of solid waste may extend south of the current location of South Sullivan Street to the historical location of South Sullivan Street (shown on Figure 2.2). City records indicate that the material may have included sawdust fill, but several borings also indicated the presence of brick, glass, and a piece of ceramic. The relocation of South Sullivan Street created the parcel that became the Lenci parcel. County Tax Parcel No. 3224049045 is owned by Lenci Frank Corporation and occupied by Emerson Power Products.

Between 1963 and 1967, the southernmost section of the Landfill was reconfigured as part of landfill closure. South Sullivan Street (historical location) was relocated to its current location leaving part of the historical landfill under and across South Sullivan Street from the rest of the closed landfill. This can best be seen by reviewing the 1963 and 1967 aerials in Appendix A.

From 1967 until 1980, the parcel was used as an auto-wrecking yard. In 1980 the current Lenci parcel was redeveloped into its current configuration. It comprises 2.8 acres of developed land with a 50,417-square-foot building constructed in 1980 that is surrounded by an asphalt parking lot and perimeter landscaping. Utilities located on South Cloverdale Street service this facility.

There are currently no known redevelopment plans for this parcel.

The adjacent undeveloped 0.6-acre parcel owned by Gordian Development has been used as an auto-wrecking yard and a used auto sales lot. No permanent structures occupy this fenced, gravel-surfaced property. It was across the historical South Sullivan Street, and was not part of the Landfill.

### 2.4.5 Public Roads and Rights-of-Way

Sections of Occidental Avenue South, South Sullivan Street, 2$^{nd}$ Avenue South, and 5$^{th}$ Avenue South are within the footprint of or adjacent to the Landfill. The roadways are paved City streets, but the shoulders in many places were unpaved graveled strips, often with stormwater ditches.

Those sections that border the SPPD parcel were upgraded as part of the IA and now include curbs, gutters, and walkways as described in the IAWP. In sections where a parcel is higher in elevation than the road, retaining walls have been installed that are underlain by a geomembrane layer to further prevent contain with refuse.

The 5$^{th}$ Avenue South ROW along the SRDS parcel will undergo upgrades as discussed in the approved SRDS IAWP as part the IA. South Kenyon Street and Occidental Avenue South along the KIP parcel already have paved shoulders. The only unpaved area along the KIP parcel is an area of landscaping along Occidental Avenue South and this area is well outside of the footprint of the landfill.

SR 99 (also known as West Marginal Way South near the Site) was constructed along the northeastern edge-of-refuse, adjacent to the SRDS parcel, as illustrated on Figure 2.2. SR 99 is a multi-lane, limited access "highway" in this area and acts as the Landfill's boundary with refuse abutting the nearside of SR 99 (the landfill underlies part of the ROW, but [based on georeferenced aerial photographs] does not extend beneath the SR 99 roadway). As discussed in later sections, groundwater monitoring wells along this boundary are, by necessity, either installed in solid waste on the landfill side of the ROW or on the east side of the ROW.

## 2.5 ADJACENT PARCELS

The parcels described below are adjacent to the Landfill and within the study area of this RI/FS.

### 2.5.1 Occidental Avenue South Properties

There are several properties located along Occidental Avenue South that are immediately adjacent to the western boundary of the landfill. These properties were not part of the landfill when it operated. As will be discussed in later sections of this report, these properties are located upgradient of the landfill; that is, groundwater flows from these properties toward and under the landfill.

These properties include the following tax parcels, which are identified on Figure 2.2:

- County Tax Parcel No. 3224049068 is a 0.4-acre parcel owned by W.G. Clark Construction Company. This parcel was used as farmland until sometime after 1946. A structure was built on the property in 1983 and is currently being used as a service building. The property has both stormwater and sanitary sewer lines. Similar to the western half of the KIP parcel, this parcel was not part of the landfill and is not part of the Site.
- County Tax Parcel No. 3224049008 is a 0.5-acre property currently owned by International Construction Equipment that was developed in 1986 and used for light industrial purposes. The property is connected to the sanitary line along Occidental Avenue South for interior plumbing. In addition, the property has a stormwater collection system along the northern and eastern perimeters of the property that drains into a detention system and through a sand filter before discharging into a 24-inch-diameter collector storm drain pipe that parallels the West Bioswale on the SPPD parcel and tight-lines to a 30-inch-diameter concrete pipe installed in the public ROW along Occidental Avenue South (formerly discharging to the former West Ditch via a culvert, which passed underneath Occidental Avenue South).
- County Tax Parcel No. 3224049102 is a 0.6-acre property currently owned by John McFarland. This parcel was a farm until sometime after 1946 when several additional structures were built on the property. This property, zoned for industrial use, is currently vacant. The property does not have any known stormwater or sanitary sewer lines.

- County Tax Parcel No. 3224049010 is a 2.5-acre property owned by Rainier Northwest JFK, LLC. This property is not within the landfill footprint. This parcel was farmland until sometime after 1953, when it was developed into a log sort yard. A structure was built on the property in 1974 and is currently being used by North Star Ice Equipment as a warehouse. The property is an Ecology-regulated UST site that had one unleaded gasoline UST closed in place in 1964. The property has one confirmed and another suspected, but unconfirmed, stormwater line that formerly discharged to the former West Ditch and now discharge into a 24-inch-diameter collector storm drain pipe that parallels the West Bioswale and tight-lines to a 30-inch-diameter concrete pipe installed in the public ROW along Occidental Avenue South.

### 2.5.2 5th Avenue South Properties

There are also several properties to the east of 5th Avenue South that are immediately adjacent to the landfill. These properties were not part of the Landfill based on aerial photographs and historical property ownership records reviewed at Seattle Municipal Archives (SMA) and King County Archives (KCA). Refer to the 5th Avenue Properties Ownership History Memorandum and Figure 1 in Appendix A for more details. These 5th Avenue properties are immediately downgradient of the landfill. They also have their own fill history that begins in the late 1960s, as discussed in Section 4.2.1.2. These properties, which are identified on Figure 2.2, include the following:

- **8230 5th Avenue South:** County Tax Parcel No. 7883600005 is a 1.3-acre property owned by JYS4, LLC. According to historical property ownership records from SMA and KCA, the northern portion of the property (River Park Block 5, Lots 21 through 24) has been privately owned since 1955. The City has owned a portion of Block 5 for street use since 1940. The southern portion of the property (South Park Block 1, Lots 1 through 6) has been privately owned since 1953. This property was undeveloped prior to 1969 when grading, and possibly filling, activities occurred. In 1990, a structure was built on the property and is currently used as a warehouse. The property is served by both stormwater and sanitary sewer lines.
- **8250 5th Avenue South:** County Tax Parcel No. 7883600350 is a 2.4-acre property owned by Ness Manitowoc Property, LLC. According to historical property ownership records from SMA and KCA, the northern portion of the property (South Park Block 2, Lots 1 through 11; presented in the Summary Memorandum in Appendix A) has been privately owned since 1965. The southern portion of the property (South Park Block 2, Lots 34 through 48) has been privately owned since 1955. The property was undeveloped until 1969, when cement kiln dust (CKD) was used as fill on the property. Additional information about the subsurface materials for this parcel can be found on the Renton Effluent Transfer System (RETS) Line boring logs in Appendix B. A structure was built on the property in 1973 and is currently being used as a garage and service building. The property is an Ecology-regulated Confirmed or Suspected Contaminated Site (CSCS) that had two gasoline (unleaded and leaded) USTs removed in 1996. The property is serviced by the sanitary sewer.

- **500 South Sullivan Street:** County Tax Parcel No. 7883600600 is a 1.9-acre property zoned as IB and owned by White Sands, LLC. According to historical property ownership records from SMA and KCA, the northern portion of the property (South Park Block 3, Lots 1 through 16) has been privately owned since 1968. Lots 17 through 19 appear to have been privately owned since 1954. However, a portion was conveyed to the State of Washington, presumably for roadway use in 1958 and 1965. The southern portion of the property (South Park Block 3, Lots 27 through 48) has been privately owned since 1951. This property was undeveloped until 1969. An easement on portions of both blocks were conveyed to King County Metro for a sewer interceptor in 1973, 1985, and 1986. CKD fill was also discovered on this property and additional information is presented in the RETS Line boring logs found in Appendix B. A structure was built on the property in 1974 and is currently being used as a service building. This property is an Ecology-regulated UST site that had four USTs removed in 1964. The USTs contained diesel, oil, and used/waste oil. This property is served by stormwater and sanitary sewer lines.

### 2.5.3 Former Glitsa Property

The Former Glitsa American, Inc. (Glitsa) property is immediately northeast of the landfill on the far side (east) of SR 99. This 1.2-acre property, County Tax Parcel No. 7328400740, is owned by Tenor Company, LLC. The Former Glitsa property is currently listed as a MTCA Site (Facility Identification No. 63168342) with confirmed petroleum- and solvent-impacted soil and groundwater. Investigations in 2008 and 2009 found soil impacted with Stoddard-solvent, ethylbenzene, and total xylene concentrations greater than the MTCA Method A CULs. There were also detected concentrations of toluene, arsenic, chromium, and lead. Impacted groundwater had Stoddard-solvent, vinyl chloride, and benzene concentrations greater than the MTCA Method A CULs. In addition, there were detected concentrations of toluene, ethylbenzene, total xylenes, trichloroethene (TCE), and *cis*-1,2-dichloroethene (DCE; Environmental Associates 2010).

Because the Former Glitsa property is downgradient of the Landfill and contains some of the same chemicals of concern (COC), a more detailed history of the Former Glitsa property was prepared and is contained in Appendix A.

#### *2.5.3.1 Early Years to Mid-1950s*

The Former Glitsa property has historically consisted of Lots 1 through 18 and 56 through 62 of Block 18 (shown on Figure 2.7) and the vacated street end of South Monroe Street between 5$^{th}$ Avenue South and SR 99.

Between 1925 and 1948, the lots were unused and sat on the County's delinquent tax rolls. In 1948, the City acquired Lots 12 through 18 and 56 through 62. By 1953 (when the property is first shown with disturbed soil), the lot is in use as a commercial facility operated by a private party (variously, as Auto Top and Trim Company, M.B. Barker, and Austin's Welding). High-quality photographs of the business show the soil disturbance to correspond to unpaved parking and driveways (Figure 2.7 and the Summary Memorandum in Appendix A). The property was sold in approximately 1958, while it was occupied by Austin's Welding.

In 1951, Lots 1 through 11 were sold off the delinquent tax rolls, to a private party, who would become Farwest Paint Manufacturing Company (Farwest Paint) by 1959. They continued to operate there until 1977, when they move to a larger facility.

The Former Glitsa property has been in private hands since the 1950s. The only aerials with visible soil disturbance clearly show this disturbance to be consistent with the construction and operation of a small private facility (Auto Top and Trim Company) beginning in 1953.

#### *2.5.3.2 Late 1950s to 1977*

In the late 1950s, Farwest Paint developed Lots 1 through 11 into a paint manufacturing facility with the street address of 327 South Kenyon Street. Farwest Paint manufactured water and oil-based paints until 1977 when they moved to a larger facility. In 1959 they installed a 7,500-gallon UST for petroleum solvents and their yard operations expanded onto Lots 61 and 62.

Austin Welding operated on Lots 12 through 16 at 257 South Kenyon Street, and was joined by a small auto-wrecking operation (T&S Auto Wrecking Company) with an address of 225 South Kenyon Street. According to the Polk Directories, in 1960 T&S Auto Wrecking became F&S Auto Wrecking. Austin Welding was listed as vacant from 1963 through 1965.

In 1966, Farwest Paint expanded onto 225 and 257 South Kenyon Street as Farwest Wrecking Company. A new entity, Samac Trucking appeared along the SR 99 ROW with an address of 266 South Kenyon Street. This configuration remained constant until 1970, when Farwest Wrecking Company was no longer there and the property was shared by Samac Trucking and Farwest Paint Manufacturing. During the 1970s, Samac Trucking became Samac Truck Repair.

#### *2.5.3.3 Late 1970s to 2016*

In 1978, when Farwest Paint Manufacturing vacated and sold the property, 329 South Kenyon Street was occupied by an electrical construction company. The property was later occupied by a floor finishing products manufacturer (Glitsa; Eco Compliance Corporation 2007), before being bought by the Tenor Company, LLC.

Remedial measures at this property have been implemented, including removal of the leaking underground storage tank (LUST) and approximately 180 tons of Stoddard solvent-contaminated soil as of March 2009 (Environmental Associates 2009a). Because of the relatively close proximity of the contamination to the existing warehouse, not all of the impacted soil could be removed. An active remediation system initially consisting of three soil vapor extraction wells and one groundwater extraction well began operation in July 2009. The remediation system was later expanded to include 10 additional dual-purpose vapor and groundwater extraction wells, which began operation in February 2010. By the end of April 2010, approximately 17.82 million cubic feet of air and approximately 118,500 gallons of water had been treated, with reportedly over a 97 percent contaminant mass removal from the groundwater (Environmental Associates 2010).

During the cleanup work on the site, an area on Lots 1 through 3 and adjacent Lots 61 and 62 were found to contain buried paint manufacturing wastes including drums of paint wastes, apparently disposed by Farwest Paint (Ecology 2014a).

As of 2016, the parcel is still owned by Tenor Company, LLC, but is now occupied by Alaska Logistics.

## 2.6 STORMWATER CONTROLS AND UTILITIES

### 2.6.1 Stormwater Controls at the Landfill

The existing stormwater drainage infrastructure at the landfill includes elements for stormwater control on the different parcels. The systems discharge into the City system, but, in general, each parcel's system is separate until it discharges in the publically owned system. The primary features are shown on Figure 2.8.

#### *2.6.1.1 The Kenyon Industrial Park Parcel Stormwater System*

The KIP parcel is completely covered in paved surfaces (i.e., buildings, asphalt, and concrete). Stormwater within the parcel is collected in catch basins and conveyed to the 30-inch-diameter KIP main stormwater line that runs north through the property. Historically, the KIP main stormwater line connected the former West Ditch on the SPPD parcel to the City's storm drain system located in 2$^{nd}$ Avenue South. However, this connection was terminated during the SPPD parcel IA. Today, stormwater entering the KIP main stormwater line comes from KIP only.

The KIP stormwater system ties in to the storm drain system on SR 509 that flows into the wetlands on the west side of SR 509.

#### *2.6.1.2 The SPPD Parcel Stormwater System*

The current stormwater conveyance system serving the SPPD parcel consists of two bioswales, the North Bioswale and the West Bioswale (refer to Figure 2.8 for locations). These features were constructed or redeveloped in 2015, and replace stormwater conveyance features formerly present at the site.

*Former Configuration*

A former conveyance feature, the East-West Channel, was eliminated in 2013 as part of the IA. The East-West Channel was a steep-sloped, unlined channel that traversed the middle of the SPPD parcel. The channel was built directly into the Landfill's solid waste sometime prior to 1963. Stormwater upgrades to this channel were made in 1995, which most likely eliminated stormwater contributions from along 5$^{th}$ Avenue South and the properties to the east of 5$^{th}$ Avenue South. Prior to these stormwater redevelopments, the East-West Channel may have discharged into the former West Ditch (R.W. Beck 1999). The ditch was filled with soil fill and capped as part of the IA.

The former West Ditch ran along the western SPPD-owned portion of the Landfill paralleling Occidental Avenue South. It formerly received runoff from several small (not more than 12-inch-diameter) culverts originating from the North Star Ice Equipment facility and Occidental Avenue South; it also received stormwater runoff from International Construction Equipment through a corrugated acrylonitrile butadiene styrene (ABS) pipe draining an unknown area, and sheet flow from Occidental Avenue South. During the wet season, the former West Ditch also received contributions from groundwater.

*Current (Post-Interim Action) Configuration*

Former industrial and roadway stormwater inputs to the former West Ditch are now captured in a 24-inch-diameter collector storm drain pipe that parallels the West Bioswale and tight-lines to a 30-inch-diameter concrete pipe in the public ROW along Occidental Avenue South just north of South Kenyon Street joining the SR 509/South Kenyon Street storm system. Therefore, the historical off-site inputs now by-pass the former West Ditch.

During the IA, the former West Ditch was reconfigured as the West Bioswale. The former West Ditch was outside of the edge-of-refuse and the base of the ditch contained contaminants typical of stormwater runoff at concentrations less than their CULs (discussed in Section 4.0); therefore, no removal action was required. Organic-rich material present in the former West Ditch prior to its redevelopment were solidified in place; drain rock sufficient to provide adequate groundwater conveyance capacity over the solidified material was placed underneath the West Bioswale, eliminating groundwater inputs to the bioswale. The bottom of the West Bioswale and its side slopes are covered in backfill of sufficient thickness to maintain its hydraulic and treatment functions. The eastern slope, which is adjacent to the Landfill, is covered with a low-permeability membrane cap to separate stormwater from the landfill contents.

The West Bioswale now receives and treats stormwater from catch basins and subsurface stormwater infrastructure serving the recently paved and redeveloped SPPD parcel via a 24-inch-diameter underground stormwater conveyance pipe installed in the former East-West Channel. The pipe enters the West Bioswale at its southern end. The West Bioswale maintains the original flow direction of the former West Ditch, from south to north. A flow splitter directs flows that exceed the West Bioswale's design capacity to the previously described 30-inch-diameter concrete storm drain.

Treated stormwater discharges from the West Bioswale from a new 12-inch-diameter storm drain line that is connected to the previously mentioned 30-inch-diameter storm drain line along the western edge of the West Bioswale. At the point where stormwater from this line joins the SR 509/South Kenyon Street storm system, treated stormwater from the newly constructed North Bioswale also joins the system. The North Bioswale is located along the northern boundary of the SPPD parcel, and receives sheet flow stormwater runoff from the northern portion of the property. Stormwater from the SPPD parcel no longer enters the KIP stormwater mainline.

#### *2.6.1.3 The South Recycling and Disposal Station Stormwater System*

The SRDS has been operating as a solid waste transfer station for the City since 1966. The SRDS was developed to receive commercial waste and residential vehicles. The property is almost entirely covered in impervious surfacing (i.e., buildings, asphalt, and concrete). Stormwater is collected into two systems. One system collects stormwater and liquids that may have come into contact with solid waste, and directs them to the sanitary sewer. The other system collects stormwater from around the parcel, and then connects to the City's storm drain system in 2$^{nd}$ Avenue South. This system ties in to the storm drain system on SR 509 that flows into the wetlands on the west side of SR 509.

A series of roadside ditches and catch basins collect stormwater runoff from South Kenyon Street and 5$^{th}$ Avenue South in front of the property. These stormwater systems also connect to the City's storm drain system in 2$^{nd}$ Avenue South. The SRDS stormwater system is illustrated on Figure 2.8.

The SRDS is currently undergoing redevelopment as discussed in Section 2.4.2. The IA and redevelopment will likely modify the stormwater system. Modifications and upgrade will be designed to maintain a separation between stormwater and landfill contents.

#### *2.6.1.4 Stormwater Quality*

Because of the work done during the SPPD IA, stormwater at the Settlement Area enters engineered stormwater systems designed to keep stormwater separate from refuse. Current stormwater water quality reflects the use of the individual parcels, not the landfill.

### 2.6.2 Other Utilities at the Landfill

The SRDS, KIP, and 7901 parcels are connected to the public sanitary sewer systems within 2$^{nd}$ Avenue South and South Kenyon Street. Seattle Public Utilities (SPU) Geographic Information System (GIS) mapping data show that the parcels appear to have been built to current stormwater/sewer separation standards.

During the SPPD parcel IA, the former East-West Channel was lined, filled with clean materials, and converted to the utility corridor for the site (details are contained in the SPPD IA Construction Completion Report [Farallon 2016a]). Natural gas, water, sewer, and stormwater lines are located in this corridor. Natural gas, water, and sewer connections exist in both Occidental Avenue South and 5$^{th}$ Avenue South at either end of the former channel.

### 2.6.3 Other Major Utilities in the Vicinity of the Landfill

Additional major utilities constructed in the vicinity of the landfill include the RETS Line, which borders the northeastern boundary of the landfill along the SR 99 ROW (refer to Figure 2.8). This 96-inch-diameter force main sewer line carries treated effluent from the County's South Treatment Plant in Renton, Washington, to an outfall in Elliott Bay. The RETS Line sits in concrete cradles and is surrounded by backfill that is similar to surrounding areas (mixed sands, silts, and fill).

## 2.7 PREVIOUS INVESTIGATIONS

Several regional studies and adjacent investigations have been conducted in the vicinity of the landfill, and numerous previous investigations have been performed at the landfill prior to this RI/FS. The following sections provide a summary of the relevant regional studies and previous investigations. Table 2.2 summarizes the regional studies, while Tables 2.3 and 2.4 summarize the adjacent property investigations and previous investigations at the Site, respectively.

### 2.7.1 Regional Studies

Several regional studies have been conducted in the Duwamish Valley to better understand groundwater flow patterns and determine contaminant contributions to the Lower Duwamish Waterway. A summary of relevant reports is presented in Table 2.2. Information from these studies was used in the RI/FS process to improve the understanding of regional hydrogeology and potential environmental impacts on the Lower Duwamish Waterway.

### 2.7.2 Adjacent Property Investigations

Ecology's Integrated Site Information System (ISIS) and the USEPA Envirofacts databases were queried for information about environmentally impacted properties in the vicinity of the Site. These databases currently list a number of properties with known/suspected hazardous substance releases or properties with the potential for hazardous substance releases in the vicinity of the Site. The databases queried included the following:

- Comprehensive Environmental Response, Compensation and Liability Information System (CERCLIS)
- CSCSs
- LUSTs
- USTs
- Toxic Chemical Release Inventory System (TRIS)
- Resource Conservation and Recovery Information System (RCRIS) Large and Small Quantity Generators (LQG and SQG)

The properties in the vicinity of the Site with known/suspected hazardous substance releases or the potential for hazardous substance releases are shown on Figure 2.9. The figure shows the most significant designation for each of the properties. Previous environmental investigations of hazardous substance releases completed on properties immediately adjacent to the Site are summarized in Table 2.3 and a brief description of these investigations is provided in the following sections.

#### *2.7.2.1 Former Glitsa Property*

The Former Glitsa property is located adjacent to the landfill immediately east of SR 99 and south of South Kenyon Street. The property was historically used as an auto-wrecking facility and welding facility, and was occupied by a paint company (Farwest Paint Manufacturing Company) and a floor finishers/floor finishing products manufacturing company (Glitsa; Eco Compliance Corporation 2007). The property is currently owned by Tenor Company, LLC. A summary of investigative and remedial activities is presented in Table 2.3.

#### *2.7.2.2 Former South Kenyon Street Bus Yard*

The former South Kenyon Street Bus Yard is located immediately to the north of South Kenyon Street and the landfill. The property was historically used for receiving dredge fill and as an auto-wrecking yard before being used by First Student, Starline, and Curtis Transportation for storage and maintenance of school buses and chartered motor coaches (AMEC 2009a). SPU purchased the property and redeveloped it into a state of the art transfer facility, which opened in spring of 2013. A summary of investigative and remedial activities is presented in Table 2.3.

### 2.7.3 On-Site Investigations

Numerous previous investigations have been conducted at the landfill since 1984. A summary of the most relevant investigations can be found in Table 2.4 and the explorations from these environmental and geotechnical investigations are shown on Figure 2.10. Data from previous investigations have been used where appropriate; for example, historical groundwater data have been used to establish trends in concentrations over time, but are not used to describe current conditions. The following sections provide a brief summary of the previous soil vapor (including LFGs and VOCs), indoor air, surface water (water collected in depressions at the landfill), soil, and groundwater investigations conducted to date.

#### *2.7.3.1 Soil Vapor and Indoor Air Investigations*

Due to the nature of the Landfill, both LFG (various gases produced at landfills as solid waste materials decompose, including methane) and VOCs in soil vapor and indoor air have been an environmental and health and safety concern. Investigations have targeted monitoring the levels of methane to assess the environmental impact and public health risk of the closed Landfill. As the Landfill has been redeveloped and has aged, monitoring of LFGs has continued in an effort to characterize LFG generation (to describe evolution of the Landfill decomposition), monitor for explosive hazards, and monitor for health and safety concerns including the migration of LFG and VOCs into indoor air within the buildings constructed over and adjacent to the Landfill. A more detailed review of historical and current soil vapor investigations will be discussed in Section 6.0 and soil vapor probe construction logs, sampling locations, and other location descriptions for soil vapor and indoor air sampling activities can be found in Appendix B.

### *2.7.3.2 Surface Water Investigations*

As part of assessment work related to the closed Landfill, seasonally ponded water on the surface of the Landfill within topographic lows, like the former West Ditch and former East-West Channel, was investigated to determine the impact from underlying solid waste and/or leachate. The results were used to assess if this material posed a risk to the environment and human health. It should be noted that ponded water is intermittent and may also derive from groundwater that may infiltrate upward and intersect the ground surface during higher levels of precipitation. This water can be impacted by both the industrial nature of the Landfill and the surrounding area, and any solid waste that may be present in the subsurface potentially elevating concentrations of chemicals to levels greater than background.

The grading and new pavement components of the IA on the SPPD parcel eliminated the ponding and the concerns related to it.

### *2.7.3.3 Soil and Solid Waste Investigations*

Various investigations (to investigate fill, native materials, and landfill cover) have been initiated at the Landfill since 1986 in order to assess the extent of the solid waste within the Landfill and determine if its contents posed a significant threat to public health and the environment. Most of the investigations have focused on location/extent of solid waste, LFG, and groundwater. Occasionally, prior investigations have compared solid waste and soil concentrations to preliminary CULs, but not in a consistent manner. The investigations indicated that the soil and solid wastes within the Landfill contain hazardous substances, such as petroleum hydrocarbons, polycyclic aromatic hydrocarbons (PAHs), other semivolatile organic compounds [SVOCs]), common solvent-derived VOCs, and metals that are common in urban soils and/or in solid waste. Findings from these studies will be discussed briefly in Section 4.0.

### *2.7.3.4 Groundwater Investigations*

The earliest groundwater quality investigations were initiated in 1989. The quality of groundwater at the Site has been investigated to determine if groundwater quality poses a significant threat to public health and the environment. Groundwater investigations have primarily focused on the Landfill boundary and areas with specific known or suspected concerns. The groundwater monitoring network at the Landfill has been used to establish groundwater conditions at the Landfill boundary and downgradient. Some of the groundwater wells have been monitored periodically since the late 1980s and others from the mid-1990s, allowing for trends to be tracked over time through seasons and as the Landfill continues to age.

# 3.0 Physical Setting

## 3.1 REGIONAL GEOLOGY AND HYDROLOGY

### 3.1.1 Descriptive Geologic Overview

#### *3.1.1.1 Regional Geology*

The Duwamish Valley is a branch of Puget Sound that was created during the Vashon Stade (a recent, short period of regional glacial advance) of the Fraser Glaciation (a major period, approximately 10,000 years, of regional glacier coverage). The glaciation associated with the Vashon Stade occurred between about 13,000 and 15,000 years ago (Palmer 1997). The combined scouring action of the flowing ice and running glacial melt water flowing from underneath the glacier caused the erosion that created the Duwamish Valley, and the glacial outflow river covered this new valley with glacial deposits.

As the ice sheet retreated, the exposed valley became inundated with seawater, which until approximately 5,700 years ago extended to the city of Auburn, Washington. As the glacier continued to retreat, large mudflows from the flanks of Mount Rainier (the Osceola Mudflow) and erosion of the newly exposed Cascade Mountain Range deposited a tremendous volume of fine-grained sediments into the local marine waters of Puget Sound. Over geologic time, these sediments migrated downstream, filling in the submarine valley with the fine-grained sand and silt estuarine and alluvial deposits, and advancing the shoreline at the mouth of the Green/Duwamish River system from Auburn toward Elliott Bay (Hart Crowser 1998). Because Puget Sound is saline, the estuarine deposits were laid down in a saline or brackish environment and are often distinguished by abundant shell fragments, whereas the more shallow alluvial deposits tended to be laid down in a system influenced by the freshwater in the river.

With settlement of the area, the tidal flats and floodplains were filled and the meandering Duwamish River was dredged and straightened to form the present-day Duwamish Waterway. Dredged materials were used to fill old channels and lowlands above flood levels, including the old dredge fill site at the former South Kenyon Street Bus Yard immediately north of the Landfill.

As the area was settled, especially after the 1930s, additional filling occurred throughout the valley to raise the land above the seasonal water table and level the land for development. This has resulted in a surficial fill layer over most of the Duwamish Valley (Hart Crowser 1998).

#### *3.1.1.2 Geologic Units*

The types of geologic units found at the Site include the following: imported fill; alluvial deposits including overbank flood deposits; estuarine deposits; and glacial deposits. A plan view of the geologic units present in the vicinity of the landfill is illustrated on Figure 3.1 and described in Table 3.1. The structure of the Duwamish Valley and the stratigraphy of these units are illustrated in the regional geologic cross section presented on Figure 3.2. As illustrated on Figure 3.2, the alluvial and glacial deposits can be more than 200 feet thick in the center of the Duwamish Valley (Hart Crowser 1998).

### 3.1.2 Topography

The topography in the area of the Site is controlled by the Duwamish Valley, which trends from the northwest to the southeast. The valley has steep-sided hills seen to the east in the Beacon Hill neighborhood and to the west in the Highland Park neighborhood with elevations ranging from approximately 214 to 420 feet elevation North American Vertical Datum of 1988 (NAVD 88), respectively. The area surrounding the Site is relatively flat, with a slight downward slope to the northeast, toward the Lower Duwamish Waterway. The topography in the vicinity of the Site, based on the 1981 U.S. Geological Survey map of the Seattle South quadrangle, is included on the Site Location Map (Figure 2.1).

The topography of the Site varies due to the fill and grading history, with elevations generally ranging between 14 and 44 feet elevation NAVD 88. The KIP, 7901, and SRDS portions of the Landfill are generally lower, with elevations ranging between 14 and 29 feet elevation NAVD 88. In comparison; the SPPD parcel of the Landfill is slightly higher with elevations typically ranging between 29 and 44 feet elevation NAVD 88.

### 3.1.3 Regional Hydrology

#### *3.1.3.1 Surface Water Occurrence*

The Lower Duwamish Waterway, at its closest point, is located approximately 1,600 feet northeast of the Landfill, as illustrated on Figure 2.2. The channelization and realignment moved the Lower Duwamish Waterway from the present-day King County International Airport/Boeing Field to its current location closer to the Landfill. Between 1928 and 1931, the federally authorized navigation channel was dredged, removing native alluvial deposits and creating a tidally influenced channel approximately 400 to 500 feet wide with bottom elevations of approximately -20 feet Mean Lower Low Water (David Evans and Associates 2006)

The dredging of the Lower Duwamish Waterway allowed saline waters from Elliott Bay to intrude up channel, creating a tidally influenced estuary as far upstream as the upper turning basin of the channel (to approximately River Mile 4.7). The Lower Duwamish Waterway receives most of its freshwater discharge from the Green River and its tributaries, with less than 1 percent of the flow coming from surface water runoff within the Duwamish Valley (Windward Environmental 2010). Locally, the Lower Duwamish Waterway receives tidally controlled recharge from both groundwater and a slough to the north of the Site (west of SR 509; shown on Figure 2.8) that was once likely a part of a natural surface water drainage feature, which was fed from the valley uplands to the south of the Site.

#### *3.1.3.2 Regional Groundwater Flow*

Groundwater within the Duwamish Valley generally occurs within the coarse-grained alluvial channel deposits (Alluvial Aquifer). The Alluvial Aquifer identified at the Site is part of the larger valley-wide Alluvial Aquifer. For the purposes of this RI/FS, the Alluvial Aquifer is further subdivided into an A-Zone and B-Zone (refer to Figure 3.2). Within the Alluvial Aquifer, in the uppermost portion of the Alluvial Aquifer, discontinuous Silt Overbank Deposits are present at elevations generally between 0 and 10 feet elevation NAVD 88, and groundwater that persists above this unit is within the Perched Zone. Although groundwater also occurs in the underlying estuarine deposits, it generally consists of a brackish water of lower quality (Hart Crowser 1998). Regional groundwater flow in the Alluvial Aquifer in the central portion of the Duwamish Valley generally moves from the higher elevations of the uplands (recharge area) to the lower elevations of the Lower Duwamish Waterway (discharge area). Groundwater flow in the vicinity of the Site is generally to the northeast, toward the Lower Duwamish Waterway; however, in localized areas where fine-grained alluvial deposits or bedrock knobs are present, groundwater flow directions may be more variable. Also in the vicinity of the Site, the fine-grained overbank flood deposits may trap infiltrating rainwater and strand groundwater when the water table is high, resulting in perched groundwater conditions that can also cause variable groundwater flow directions when compared to the underlying Alluvial Aquifer. A more detailed discussion of the groundwater conditions at the Site is presented in Section 5.4.

#### *3.1.3.3 Groundwater and Surface Water Interactions*

In general, groundwater in the Alluvial Aquifer discharges into the Lower Duwamish Waterway (as illustrated on Figure 3.2); however, high tides within Elliott Bay can cause an apparent groundwater flow reversal, with surface water from the Lower Duwamish Waterway intermittently infiltrating inland. This area of tide-related temporal groundwater flow reversal generally occurs within about 500 feet of the Lower Duwamish Waterway (Hart Crowser 1998). Recent tidal studies near the Boeing Isaacson property (River mile 3.6 on Figure 3.1) and the Great Western International property (River Mile 2.4) have noted tidal influences on groundwater levels in wells approximately 400 feet from the Lower Duwamish Waterway. Similar studies conducted at the Boeing Plant 2 facility (River Miles 2.9 to 3.6), which is located slightly upstream and across the Lower Duwamish Waterway from the Site, noted tidal influences between 300 and 600 feet from the Lower Duwamish Waterway (Windward Environmental 2010), with measurable tidal fluctuations as much as 1,000 feet from the Lower Duwamish Waterway.

The Lower Duwamish Waterway contains a saltwater wedge that typically influences and extends upstream to approximately River Mile 7.5 (Dawson and Tilley 1972). This is approximately 4 miles upstream of the Site. The saltwater wedge is driven by the differences in density of fresh water and saltwater and consists of a dense lower layer of predominantly unmixed seawater overlain by a layer of less dense brackish water that progressively becomes fresher water upstream (or increases in salinity further downstream). The existence of the saltwater wedge within the Lower Duwamish Waterway has a significant impact on the groundwater quality of the Alluvial Aquifer, with the greatest impact occurring adjacent to the Lower Duwamish Waterway.

Specific conductivity measurements made within the Alluvial Aquifer at depths of less than 50 feet range from 2,000 to 3,000 microsiemens per centimeter (µS/cm) near the Lower Duwamish Waterway and decrease to 500 to 1,500 µS/cm with distance away from the waterway. These relatively high specific conductivity values are indicative of groundwater mixing with the saltwater from in the Lower Duwamish Waterway. Specific conductivity measurements taken within the lower alluvial aquifer (estuarine deposits) range from 820 to 24,000 µS/cm (Hart Crowser 1998). These specific conductivity measurements are equivalent to total dissolved solids (TDS) concentrations of 550 to 16,100 milligrams per liter (mg/L). For example, at Boeing Plant 2, where there are approximately 10 wells completed in the lower alluvial aquifer (the C-level monitoring wells at Boeing Plant 2), all of the wells have TDS greater than 10,000 mg/L, irrespective of distance from the waterway (Environmental Partners, Inc. and Golder Associates, Inc. 2009). It is likely that the high TDS and specific conductance in these wells are due to connate (from the time of formation) water deposited with the sediments in an estuarine environment several thousand years ago.

## 3.2 LOCALIZED CONDITIONS

### 3.2.1 Hydrogeologic Conditions

The alluvial deposits that form the Alluvial Aquifer are relatively thick, ranging from about 20 feet thick along the western edge to more than 50 feet thick along the eastern edge of the Landfill. In general, the alluvial deposits become thicker closer to the center of the Duwamish Valley. The alluvial deposits that form the Alluvial Aquifer are generally composed of dark gray or black silty sand or sand. Under much of the Site, the Silt Overbank Deposits are fairly continuous within the uppermost portion of the alluvial deposits, which act as low permeability aquitards that separate infiltrating precipitation and overland flow into a Perched Zone within the Alluvial Aquifer. The estuarine deposits are encountered at approximately sea level along the western edge of the Landfill and dip to the northeast, toward the center of the valley, where they are encountered at greater depths (deeper than -25 feet elevation NAVD 88). Beneath the southwestern edge of the Landfill, glacial deposits were encountered at approximately -5 feet elevation NAVD 88. These glacial deposits consisted primarily of hard silt and are representative of glacially consolidated lacustrine deposits. The maximum depth of the glacial deposits is unknown in the vicinity of the Landfill.

### 3.2.2 Groundwater Use

Groundwater in the vicinity of the Site is not used as a drinking water source. Potable water is instead provided by the City's municipal water supply, which is primarily derived from the Cedar River watershed. In order to confirm that groundwater is not currently being used as a potable water source, groundwater well logs from the Ecology Well Log database were examined for the areas downgradient of the Site and between the Site and the Lower Duwamish Waterway, including the southwest quarter section of Section 29 and the northwest and northeast quarter sections of Section 32 in Township 24 North, Range 4 East. Review of these records indicated that all of the wells were either resource protection monitoring wells—used to collect subsurface information or to determine the existence or migration of pollutants—or dewatering wells. Because no groundwater supply wells are located downgradient of the Site, groundwater beneath the Site does not serve as a current source of municipal or domestic potable water.

Groundwater in the area is not forecast to be used as a source of potable water for the following reasons:

- As stated in Washington State's well regulations (WAC 173-160-171), a water supply well shall not be located within a minimum specified distance from known or potential sources of contamination, including landfills and areas affected by seawater intrusion.
  - This distance is 1,000 feet from a landfill.
  - Ecology has determined that groundwater near the Lower Duwamish Waterway has been or has the potential to be affected by seawater intrusion. This distance, based on decisions on other sites, is at least 500 feet from the waterway.
  - Groundwater beneath the B-Zone in the marine and estuarine deposits is saline with TDS concentrations that exceed 10,000 mg/L causing the deeper groundwater to qualify as not potable under WAC 173-340-720(2)(b)(ii).[2]
  - Groundwater in the A- and B-Zones of the Alluvial Aquifer has naturally high concentrations of iron and manganese.
- WAC 173-160-171 also states that the well shall not be located where it is subject to surface water ponding, and is not located in a floodway, except as provided in RCW 86.16.041(3)(g), Floodplain Management, which states that new and replacement water supply systems must be designed to eliminate or minimize infiltration of flood waters into the system, specifically:
  - No groundwater drinking water supply wells should be located within the Federal Emergency Management Agency 100-year floodplain unless they are protected from surface or subsurface water drainage capable of impairing the quality of the groundwater supply (WAC 173-160-171).

Waivers or variances are allowed under WAC 173-160; however, the most common variance is to allow installation in a deeper uncontaminated aquifer. In the case of the Site area, deeper groundwater within the Alluvial Aquifer is naturally saline due to the nature of the deposits and is not appropriate for drinking (refer to Section 5.0).

Figure 3.3 illustrates where these restrictions would apply; the iron and manganese quality issue is aquifer-wide and not shown on the figure. Based on these restrictions and the availability of a high-quality public water supply, no future groundwater wells are currently anticipated in the area.

### 3.2.3 Climate

The maritime climate of the Seattle area is characterized by short, cool summers and mild winters without significant variation in temperatures or precipitation, which minimize strong seasonal effects on groundwater or surface water. Average annual monthly temperatures and average annual monthly precipitation from October through March from the National Climatic Data

[2] Boeing Plant 2 contains the largest collection of wells in this zone. All 10 of the wells at Boeing Plant 2 constructed in this lower zone have measured TDS concentrations greater than 10,000 mg/L.

Center weather observation station located at Seattle-Tacoma International Airport (Station No. 457473) from 1948 through 2010 are illustrated on Figure 3.4.

### 3.2.4 Ecological Resources

#### *3.2.4.1 Terrestrial Conditions*

A description of the current and future terrestrial conditions of the various parcels of the Landfill was reviewed in order to determine if the Landfill could be excluded from a terrestrial ecological evaluation per WAC 173-340-7491. The Landfill is covered in pavement or buildings throughout with the exception of minor landscape planting areas on the SRDS, most of which will be eliminated as part of redevelopment.

Closure requirements for landfills require that landfill contents remain contained. The final remedial action for the Landfill will define capping requirements in more detail, but it will continue to use some form of containment by pavement, buildings, or other physical barriers (such as low permeability geomembranes), which will continue to prevent plants or wildlife from being exposed to contaminated soils and debris.

The Landfill is exempt from assessment of terrestrial ecological evaluation consistent with WAC 173-340-7491(1)(b) because all contaminated soil "will be below existing buildings, paved roads, pavement, or other physical barriers that will prevent plants or wildlife from being exposed to soil contamination." To qualify for this exemption, an institutional control is required under WAC 173-340-440. This institutional control is already required as part of landfill closure and will be confirmed to be in place as part of the MTCA process (refer to Section 15.0).

#### *3.2.4.2 Wetlands in the Landfill Vicinity*

Based on several consultant studies and a U.S. Army Corps of Engineers (USACE) evaluation, there are no wetlands in the immediate vicinity of the Site. A wetland evaluation was previously conducted by Associated Earth Sciences, Inc. (AESI) in order to determine if regulated wetlands occurred at the Site, as defined in the USACE Wetland Delineation Manual or the Ecology Wetlands Identification and Delineation Manual (R.W. Beck 1999). Based on the evaluation, it was determined that the former East-West Channel did not appear to have flowing water and there appeared to be little to no infiltration. Because the feature was a non-vegetated, isolated, channel-like impoundment of surface water without significant infiltration, it was not identified as wetland habitat.

The former West Ditch consisted primarily of relatively sparse, non-native plant species. A letter from the USACE supported the determination that neither the former East-West Channel nor the former West Ditch was considered to be wetlands or other waters of the United States (R.W. Beck 1999).

In 2007, the USACE again confirmed that the former East-West Channel and the former West Ditch were not waters of the United States, and review by Ecology (Ecology 2009b) and the City

(City of Seattle 2008) determined that the former East-West Channel and the former West Ditch were not regulated as wetlands under Washington State or Seattle Municipal Code (SMC), respectively (Farallon 2010b).

#### *3.2.4.3 Wetlands North of the Landfill*

An existing slough, located west of SR 509 and approximately 1,000 feet north of the KIP parcel, is a tidally influenced, constructed wetland that drains directly to the Lower Duwamish Waterway. Stormwater runoff from the SPPD parcel, KIP parcel, 7901 parcel, SRDS parcel, and other parcels not associated with the Landfill ultimately drain to this wetland and the Lower Duwamish Waterway through a piped storm drain system. Tidal records for the Seattle waterfront in Elliott Bay indicate that Mean High Water inundates the base of the wetland all the way to its southern (upstream) end, and extends partially up the side slopes of the wetland. As a result, much of the wetland is inundated with tidal backwater on a daily basis, and thus its hydro-period—the length of time and portion of year the wetland holds ponded water—is strongly influenced by tides. Therefore, stormwater runoff from the Landfill has little impact on the hydro-period of this wetland. Because this is the ultimate receiving water body downstream of the Landfill, stormwater management requirements at the Settlement Area will be dictated by water quality restrictions for discharge to the wetland.

A stormwater pond east of SR 509 and north of South Holden Street is shown as a wetland on National Wetland Inventory maps. This pond was constructed to treat and control runoff as part of the First Avenue South Bridge improvement project in the 1990s, and is owned and operated as a stormwater control facility by WSDOT. Outflow from the pond is piped under SR 509 to the tidally influenced wetland west of SR 509. Because this pond was constructed and is maintained as a stormwater control facility, it is not considered to be a jurisdictional wetland. Stormwater runoff from the Landfill does not currently drain to this pond and is not planned to drain to this pond; therefore, development of the Landfill will not affect the pond.

# 4.0 The Extent of Solid Waste and Soil Contamination

## 4.1 CLOSED LANDFILLS AND MTCA CLEANUP LEVELS

Closed landfills are considered under MTCA to be sites that have used "containment of hazardous substances" as the preferred remedy, as discussed in Section 1.1. The waste and associated soil at the Site is presumed to be contaminated with one or more hazardous substances. Due to the heterogeneous nature of waste at municipal landfills and its containment within a closed landfill, the Landfill contents were not fully characterized for specific hazardous substances during the RI, although leachate, groundwater, and LFG have been and are discussed in the following sections. Soil used as daily cover during operations and during closure and post-closure activities is also considered part of the Landfill contents (because it is beneath the cap) and has not been fully characterized. As with the refuse, the soil fill is presumed to contain one or more hazardous substances. Soil and refuse within the contained area of the Landfill are considered to be compliant with MTCA CULs as long as the requirements for containment under WAC 173-340-740(6)(f) are met.

Soil at the Landfill that is above the contained area, such as in landscaping, must meet MTCA CULs for soil down to either the standard POC of 15 feet bgs or where the containment of the Landfill begins (typically a geomembrane layer beneath landscaping).

Properties within the Landfill are primarily zoned as IG2 with a small portion of the southeastern SPPD property zoned as IB (as discussed in Section 2.3, and shown on Figure 2.3). Therefore, soil CULs were identified for the Landfill based on direct contact industrial exposure levels defined in WAC 173-340-745. Because default values for MTCA Method C Industrial CULs are used, with the exception of petroleum hydrocarbons, the CULs can be found in the Cleanup Levels and Risk Calculation (CLARC) database on the Ecology website (https://fortress.wa.gov/ecy/clarc/CLARCHome.aspx). Landfill-specific CULs for petroleum hydrocarbons have been calculated using Ecology's Workbook Tools for Calculating Soil and Ground Water Cleanup Levels under the MTCA Cleanup Regulation (Ecology 2007).

Soil CULs were not developed for the cross-media protection of indoor air or groundwater because both MFS and the presumptive remedy include long-term monitoring of LFG and groundwater to demonstrate that containment is effective at the Landfill and that indoor air and groundwater CULs are met. This allows for empirical demonstration that CULs for cross-media pathways are met. Finally, the presumptive remedy for landfills is designed to bring a landfill into compliance with MTCA in a reasonable restoration time frame—the time needed to implement the presumptive remedy.

## 4.2 REFINEMENT OF THE EXTENT OF SOLID WASTE

In order to establish the location of the containment remedy, the extent of solid waste must be delineated. A thorough understanding of the extent of solid waste is necessary in order to specify the location and scope of groundwater and LFG monitoring requirements. The extent of solid waste resulting from the City's operations was determined by examining historical information, aerial photographs, and results of field investigations, as described in the following sections.

### 4.2.1 Historical Operations

Historical operations at the Landfill are based primarily on information available in the City and King County Solid Waste Division (KCSWD) files and aerial photographs taken from 1936 to 2004. The aerial photographs and key records are provided in Appendix A. Table 4.1 provides a summary of the historical owners and operations. Figure 4.1 provides the historical footprint of operations and shows fill activities at the landfill.

#### *4.2.1.1 Historical Operations at the Landfill*

Aerial photographs and historical information relating to this section are provided in Appendix A. The information regarding the location of the historical operations and fill is summarized on Figure 4.1.

The historical Landfill operations primarily occurred on the following three tax parcels:

- **First Addition River Park:** This parcel included the SRDS parcel.
- **Tax Lot 5:** This parcel consisted of the present-day SPPD parcel, the Lenci Frank Corporation property, and the Gordian Development property, and extended to the centerline of 5th Avenue South and the old South Sullivan Street alignment.
- **Tax Lot 7:** This parcel included the KIP and 7901 parcels.

The original disposal location, which became active sometime before 1936, was on the southeast portion of the landfill, a large area located north of South Sullivan Street, east of Occidental Avenue South, and west of 5th Avenue South on Tax Lot 5 (Figure A.1 of Appendix A). A smaller disposal site was bounded by South Kenyon Street to the north, and was located east of 1st Avenue South on Tax Lot 7 (present-day KIP and 7901 parcels; Figure A.2 of Appendix A). Materials disposed of in the Landfill primarily consisted of municipal, commercial, and industrial waste (SPU 1997; Ecology and Environment, Inc. 1988) from south and west Seattle. Waste from some parts of nearby unincorporated King County may also have been disposed of, as allowed under the County's 1958 lease with the City. Much of the waste was burned before disposal and the site was known as the South Park Burn Dump. The ash and non-combustibles (such as glass, bricks, and metal fragments) were placed in low-lying areas on the Landfill as fill.

By 1946, active disposal in the northwestern corner of the Landfill expanded to the south and then east into the parcel occupied by the present-day SRDS (formerly the First Addition River Park), and was bound to the east by West Marginal Way South. At this time, active burning of solid waste was occurring at the Landfill. In 1951, First Addition River Park and Tax Lot 7 were purchased by the City. In the 1951 aerial in Appendix A (Figure A.5), the area that would become the sections of KIP and 7901 parcels overlying the Landfill appear to have been closed to landfilling and regraded, and are being used for auto-storage and wrecking. Active disposal had moved to the southeast into present-day SRDS and SPPD parcels, adjacent to West Marginal Way South. Smoke from the burning is visible in the aerial.

In 1953, the northwest corner of Tax Lot 7 was purchased by a private owner, John Farrell (as discussed in Section 2.4.3 and Appendix A), and the lot was converted to an auto-wrecking yard this same year (refer to Appendix A and Figure A.6). The County purchased Tax Lot 5 in 1957 and began leasing the property to the City for rubbish disposal in 1958. Burning of rubbish ended in 1961.

After the landfill was closed in 1966, changing use of the southern portion of Tax Lot 5 resulted in the realignment of South Sullivan Street approximately 150 feet northward from its original location, which is shown on Figure 4.1 and Figures A.1 through A.6 in Appendix A. As a result, the extent of waste extends south of the modern day South Sullivan Street.

By 1977, the KIP, 7901, and SRDS parcels were established facilities, closely resembling their current configuration and use today. In 2008, the SPPD parcel was largely cleared of vegetation and, in some areas, a layer of crushed concrete was added as ballast and the parcel was regraded. In 2014 and 2015, SPPD performed an IA for cleanup at the parcel that was performed simultaneously with the redevelopment of the property. The property redevelopment includes a modular building for employees and paved parking for employees and visitors. The IA work included regrading and capping the landfill surface, installing and operating a LFG control system, implementing institutional controls, and conducting monitoring.

More detailed descriptions of the Landfill's development can be found in the text of Appendix A and on Figures A.1 through A.24.

#### *4.2.1.2 Historical Operations in the Vicinity of the Landfill*

In 1936, the parcels surrounding the landfill consisted primarily of agricultural parcels and undeveloped land; however, by 1941 residential properties began to be developed to the east and the southeast of the landfill (refer to Appendix A). By the mid-1950s, several additional agricultural properties surrounding the landfill were developed (refer to Appendix A), including the following:

- Auto-wrecking yards to the south of South Kenyon Street and to the north of South Cloverdale Street extended onto the northwestern and southern portions of the landfill.
- Gas stations with repair bays and pump islands developed on the southeast corner of Occidental Avenue South and 1$^{st}$ Avenue South and on the southeast corner of South Kenyon Street and 1$^{st}$ Avenue South.
- A log sort yard developed on one of the parcels to the west of Occidental Avenue South.

- A commercial business developed a portion of the Former Glitsa property across SR 99 to the east of the Landfill, constructing a building, unpaved parking lots, and driveways. Appendix A contains a detailed review of property records and aerials for the Former Glitsa property. In 1959, an industrial warehouse building was developed on the property, which would become the location of Farwest Paint Manufacturing by 1970.

By 1967, the auto-wrecking yard to the north of South Cloverdale Street shifted eastward coinciding with the relocation of a portion of South Sullivan Street approximately 150 feet north of its original position onto the southern portion of the Landfill. In addition, the SR 509 and South Cloverdale Street interchange was completed by that time and the two gas stations located along 1st Avenue South were abandoned (refer to Appendix A).

In 1969, filling activities were occurring to the east of 5th Avenue South (as shown on Figure 4.1 and in Appendix A); however, these filling activities occurred after the Landfill had been closed, and there is no indication that the City or the County either leased or owned this parcel or were involved in the filling. Therefore, the filling is believed to be unrelated to activities at the landfill. In addition, CKD was likely being used as fill on the parcels east of 5th Avenue South, as indicated by the materials observed in the RETS Line borings (additional discussion can be found in Section 4.2.3 and illustrated on Figure 4.2, where the RETS Line borings follow West Marginal Way South and begin with the designation "7-"). In 2015, Ecology published a compilation of known and suspected CKD sites in the Duwamish Valley and identified an additional seven borings with CKD on the properties between 5th Avenue South and West Marginal Way South.

With the development of the KIP and 7901 parcels (by Farrell), the KIP main stormwater line was completed in the historical KIP swale west of the Landfill. The portions of the swale on the KIP and 7901 parcels were partially backfilled using CKD (additional information is presented in Section 4.2.3) and other unclassified fill materials. At this time, the former West Ditch, which had historically discharged through the swale, was connected to the KIP main stormwater line. By 1974, development of the present-day KIP and 7901 parcels was completed. Figure 2.6 provides a time-lapse series of aerial photographs taken during the development of the KIP and 7901 parcels. This figure shows the sequence over time of the development of the auto-wrecking yard both on and off of the Landfill, and the backfilling of the swale.

By 1977, the former log sort yard developed into the Northstar Ice Equipment Corporation property and by 1982 the auto-wrecking yard north of South Cloverdale Street was abandoned and developed into the Emerson Power Products facility (aerial photographs from this period can be found in Appendix A). From 1985 to 1997, parcels surrounding the landfill remained relatively unchanged; however, sometime between 1997 and 2002 the parcel to the north of South Kenyon Street had started being used as a bus yard (shown in Appendix A). No other significant changes appear to have occurred on the surrounding parcels through 2004.

The parcel to the north of South Kenyon Street was used as an auto-wrecking yard and container storage area. It is likely that CKD was also used as fill in this area, as it had been observed in some boring locations to be as thick as 12 feet (AMEC 2009a). This property was redeveloped for the reconstruction of the SRDS. As part of the construction of the new facility, the CKD fill from this property was removed as the preferred method outlined in the *Focused Feasibility Study South Kenyon Street Bus Yard Site* (AMEC 2009b).

### 4.2.2 Extent of Solid Waste Investigations

From the 1930s until the last decade, much of the lower Duwamish Valley has been filled to raise the elevation above the potential for flooding and to provide a stable base for building construction. A wide range of materials have been used including hydraulic fill from the Lower Duwamish Waterway, unclassified soil fill, construction debris, and CKD. The purpose of establishing the Landfill boundary is not to locate and characterize fill in the valley, but to determine the edge-of-refuse associated with the historical South Park Burn Dump. The edge-of-refuse is a critical compliance point throughout landfill regulations and will be used to define the conditional POC (CPOC) for the Landfill in MTCA.

Refinement of the boundary was performed in two investigations: the RI field work in 2012 and a supplemental investigation in 2015. These investigations are described in the following sections.

#### *4.2.2.1 2012 Remedial Investigation*

One of the data gaps identified during development of the Work Plan (Farallon 2010a) was the refinement of the western and southern Landfill boundaries based on the extent of solid waste. To address this data gap, a series of direct push soil borings were advanced at 12 locations (RP-01 to RP-12) along Occidental Avenue South and South Sullivan Street to assess whether solid waste extends across the roadways.

The locations where the borings were advanced are illustrated on Figure 4.2. Boring locations were completed at the following times: RP-01 through RP-05 were completed on January 13, 2011; RP-06 to RP-11 were completed on December 29, 2010; and RP-12 was completed on January 17, 2011. With the exception of RP-12, boring locations were consistent with the proposed locations from the Work Plan (Farallon 2010a). The proposed location for RP-12 was beneath an immovable stack of semi-trailers on the Lenci Frank Corporation (Emerson Power Products) parcel (Parcel No. 3224049045; refer to Figure 2.2). Therefore, the location for RP-12 was relocated along the southern edge of South Sullivan Street, approximately 20 feet north of its proposed location. All borings were completed in accordance with the RI Sampling and Analysis Plan, presented in Appendix D of the Work Plan (Farallon 2010a).

Borings RP-01 through RP-12 were each advanced to a total depth of 15 feet bgs, and were continuously sampled to determine soil composition and to monitor field indicators for contamination. The soil samples collected from the borings were characterized by interbedded sands and silts with an occasional presence of gravels. Brick, wood debris, wood fibers, and plant roots were encountered periodically in core samples retrieved for soil logging. Saturated groundwater conditions were encountered from approximately 1.3 feet bgs to 6.5 feet bgs. Handheld field instruments were used to screen and monitor levels of methane, oxygen, carbon dioxide, hydrogen sulfide, and VOCs. Concentrations of methane encountered during drilling activities ranged from 0.1 to 3.1 percent. Based on field screening, VOCs were generally not detected; however, a single detection of 25 parts per million (ppm) was noted in Boring RP-11, at a depth of approximately 6 feet bgs, and was associated with petroleum odor. Soil boring locations were backfilled with hydrated bentonite chips and finished to match surface conditions.

In addition to the extent of solid waste borings, two of the reconnaissance groundwater sampling probes (FB-12 and FB-13), installed as part of the reconnaissance groundwater investigation, and seven of the new soil vapor probes (GP-24, GP-25, and GP-27 to GP-32), installed as part of the LFG investigation, contained useful information for determining the edge of solid waste and exposing subsurface fill materials. Both GP-24 and GP-25 are located to the west of the western Landfill boundary within the KIP parcel, while GP-27 to GP-32, FB-12, and FB-13 are located to the east of the eastern Landfill boundary along 5$^{th}$ Avenue South. Additional information about groundwater conditions can be found in Section 5.0, and information about soil vapor conditions can be found in Section 6.0. The following sections provide a summary of the modifications to the Landfill boundary and a description of the fill materials along the boundary.

#### *4.2.2.2 2015 Landfill Gas Investigation in the Historical KIP Swale*

As will be discussed in Section 6.3.3.2, the greatest LFG concentrations found in the study area were found in the historical KIP swale on the KIP parcel adjacent to the Landfill. A field investigation was performed in 2015 to determine the source of LFG in the swale, and its pattern of occurrence and potential for intrusion into buildings. Soil borings were advanced along transects that started within the landfill and continued across the filled swale. Information gathered from the soil borings, and from a very detailed analysis of aerial photographs and historical plan sheets (for the installation of the stormwater system in the swale), were used to refine the edge-of-refuse along the swale.

#### *4.2.2.3 2017 Lenci Property Investigation*

In 2017 the owners of the Lenci Property performed a Preliminary Phase II Subsurface Sampling and Testing Investigation and submitted the April 28, 2017, Report by Environmental Associates to Ecology for their consideration (Environmental Associates 2017). Three direct-push soil borings were advanced, logged, and sampled. The report is included as Attachment L.3 in Appendix L. Locations are shown as B1 through B3 on the Lenci Property on Figure 4.2. The borings encountered wood chips, minor glass and brick debris, and native organic-rich silts. This is consistent with historical records and with other borings in the area south of the SPPD parcel as shown in Figure 4.2.

### 4.2.3 Revised Landfill Boundary

The Landfill boundary, as shown on Figure 4.2, defines the extent of solid waste for the Landfill. This figure presents both the approximate Landfill boundary (blue dashed line) from the Work Plan (Farallon 2010a) and the revised Landfill boundary (red dashed line). The Landfill boundary was modified based on a careful review of aerial photographs and historical documents as discussed in Section 4.2.1, combined with a review of the boring logs of all soil borings, soil vapor probes, and groundwater monitoring wells located around the Landfill.

For the purposes of this RI/FS, solid waste is defined as materials that were historically disposed of in the Landfill, and includes: general paper-type waste materials; ash from historical burning; non-combustibles such as fragments of glass, ceramic, wood, and metal; and general construction debris such as concrete chunks, dry wall, and bricks. The occasional piece of construction debris, such as bricks, was not considered definitive since it can be found throughout the Duwamish Valley.

In addition to the subsurface explorations to determine the extent of solid waste along Occidental Avenue South and South Sullivan Street, the lithologic descriptions from previous subsurface explorations surrounding the revised Landfill boundary were evaluated to assess the presence of historical disposal of unclassified fill and/or fill activities outside of the Landfill boundary. This evaluation focused on three areas: (1) potential CKD fill around the KIP main stormwater line completed in the historical KIP to the west of the Landfill; (2) potential disposal of unclassified fill to the east of 5th Avenue South; and (3) potential disposal of CKD fill on adjacent properties to the east of 5th Avenue South (refer to Figure 4.1). A summary of the changes to the approximate Landfill boundary from the Work Plan (Farallon 2010a) are provided in the subsequent sections. The two deposits of CKD were placed by the property owners outside of the Landfill after the Landfill was closed, with potential impacts to groundwater quality and LFG migration.

#### *4.2.3.1 Southwestern Extent along Occidental Avenue South*

Soil borings were completed at 7 locations (RP-01 to RP-07) to better delineate the extent of solid waste along Occidental Avenue South. In addition, the lithologic descriptions from one of the LFG probes (GP-32) and monitoring wells (MW-29), installed as part of this RI, were also used to evaluate the presence of solid waste. Figure 4.2 illustrates the extent of the solid waste along the Landfill boundary and provides a description of the solid waste (brown highlighted descriptions) encountered in the various explorations.

As depicted on Figure 4.2, unclassified fill was encountered in all of the extent of solid waste borings, as well as at GP-32 and MW-29; however, definitive solid waste was encountered only in GP-32 and MW-29. In MW-29, glass was encountered at a depth of 6 feet bgs, while in GP-32 ceramic debris and glass shards were encountered between 3.5 and 7 feet bgs and white and black layered unknown fill material with a sulfur smell was encountered between 7.5 and 8.5 feet bgs. With the exception of MW-29, no solid waste was encountered outside of the approximate Landfill boundary presented in the Work Plan. Because the solid waste encountered in MW-29 was a relatively thin layer at a depth of 6 feet bgs and no other solid waste was encountered in the adjacent explorations, the approximate Landfill boundary from the Work Plan along Occidental Avenue South and South Sullivan Street was modified to no longer include RP-01 to RP-07 and MW-29 (shown on Figure 4.2 as a blue dashed line). Instead the Landfill boundary was moved in slightly toward the SPPD parcel boundary to where there is an upward change in the slope, which is representative of historical disposal and filling activities (refer to Figure 4.2).

This indicates that the Landfill extends to the edge of the SPPD parcel where it is slightly elevated above the roadway, but does not extend into the Occidental Avenue South ROW.

#### *4.2.3.2 Southern Extent along South Sullivan Street*

Soil borings were completed at eight locations (RP-08 to RP-12 and B1 to B3 on the Lenci Property) to better delineate the extent of solid waste along South Sullivan Street. City records indicate that sawdust fill was placed on the southern portion of the Landfill, to the south of the present-day South Sullivan Street alignment, in the early 1930s (refer to Appendix A). The aerial photographs also confirm that the ground was disturbed in this area during that time, and that disposal may have occurred (refer to Appendix A).

The majority of borings in this area encountered only wood and brick debris with the occasional piece of glass or metal. A black material was detected in a single boring, GP-32, at 7.5 to 8.5 bgs. To better determine whether this wood and brick debris and the black material at GP-32 represented solid waste containing hazard substances, Lenci tested representative soil samples from B1 and B2 (B3 was advanced through native soils) and a groundwater sample from an existing well (MW-NW) in the vicinity of GP-32. Results are discussed in Attachment L.3 in Appendix L. Groundwater was clean and soil results were consistent with old wood debris and bricks with no exceedances of cleanup levels.

These findings indicate that although landfilling extended south of the SPPD parcel onto the Sullivan Street ROW and the Lenci Property, the material was limited to wood debris and brick debris with the occasional piece of glass or metal. Groundwater is clean and soil results are less than cleanup levels. For this reason, Ecology has determined that the Southern Boundary of the Settlement Area will coincide with the southern boundary of the SPPD parcel.

#### *4.2.3.3 Eastern Extent along 5th Avenue South*

Review of aerial photographs and property records indicate that the Landfill did not extend east of 5th Avenue South onto the JYS4, Ness Manitowoc, or White Sands parcels. These sites were developed between 1969 and 1974 (refer to aerials in Appendix A) and contain CKD as fill as discussed in Section 2.5.2. However, it was not clear whether the Landfill extended into the ROW, especially since 5th Avenue South was undeveloped during many of the years when the Landfill operated.

Several reconnaissance groundwater probes (FB-12 and FB-13) and soil vapor probes (GP-27 to GP-31) were installed along 5th Avenue South as part of this RI. Both of the reconnaissance groundwater probes had indications of solid waste. At the location of FB-12, abundant brick, charred wood, glass, concrete, and metal fragments were observed from 6 to 11 feet bgs; while at location FB-13, scattered glass, brick, metal, and wood fragments were observed from 1 to 11 feet bgs (refer to Appendix B and Figure 4.2). In addition, several soil vapor probes (GP-27, GP-28, and GP-29) located in close proximity to FB-12 and FB-13 also contained solid waste. Solid waste was found in the following locations: GP-27 had glass, concrete, and brick fragments (6.5 to 11 feet bgs); GP-28 had fragments of ceramic, wood, and brick (7 to 9 feet bgs);

and GP-29 had glass and brick fragments (2 to 3 feet bgs), brick and glass fragments and a piece of a sneaker (3 to 8.5 feet bgs), and a window/door screen (8.5 to 9 feet bgs).

As discussed in Section 4.2.1.2 above, although the construction debris fill looks similar to the materials deposited at the Landfill, aerials and records indicate that the filling occurred after the Landfill closed while the properties were privately owned and the filling is unrelated to activities at the Landfill.

Slightly elevated methane concentrations were observed in both GP-28 (between 0 and 2.8 percent) and GP-29 (between 2.4 and 8.5 percent), as will be further discussed in Section 6.0. Therefore, the eastern edge of the Landfill boundary was extended to the far side of 5$^{th}$ Avenue South to include these boring locations (the locations of these borings are shown on Figure 4.2). The extension of the Landfill boundary is limited to the east by the geotechnical borings along the RETS Line, which did not encounter solid waste, and further to the south by the observed native materials in both GP-30 and GP-31, near the intersection of 5$^{th}$ Avenue South and South Sullivan Street.

Based on these findings, the 5$^{th}$ Avenue South ROW from the northern property line of the White Sands parcel to South Kenyon Street to the Landfill was added to the Settlement Area definition and the edge-of-refuse was moved (as shown on Figure 4.2).

#### *4.2.3.4 Northeastern Extent along State Route 99*

Based on review of the historical aerial photographs and the extent of disposal activities (Figure 4.1), the Landfill boundary was extended slightly onto the SR 99 ROW along the northeastern edge of the SRDS property. Solid waste thicknesses were determined along this boundary based on lithologic descriptions from geotechnical borings installed prior to the installation of the RETS Line along SR 99 (Boring Locations 7-3700 through 7-3803 and 7-3900 through 7-4641; refer to Figure 2.10). Based on these borings, the solid waste had a thickness that ranged between 1.5 and 10.5 feet (AESI 1998). Based on the borings and the aerial photographs, the edge-of-refuse boundary was extended into the ROW, but solid waste does not appear to occur beneath the roadway, because the roadway was already in use as an unpaved road when the Landfill began.

#### *4.2.3.5 Historical KIP Swale Area*

As part of the historical KIP swale investigation in 2015 (discussed above and in Section 6.0), aerials were reviewed along with property records, available fill permits, and the construction drawing for the KIP stormwater mainline (the project that included the filling of the swale and the construction of the buildings at KIP). Then four transects of soil borings were advanced across the historical swale location to determine the edge-of-refuse, the location and thickness of the CKD deposit, and the subsurface concentrations of LFG. These results were used to refine the edge-of-refuse and to delineate the CKD deposit.

#### *4.2.3.6 5th Avenue South Post-Closure Unclassified Fill*

As previously discussed in Section 4.2.1 and presented in Appendix A, aerial photographs indicate that filling was occurring on a triangular property (Parcel No. 7883600005) to the east of 5th Avenue South in 1969 (refer to Figure 4.1). At this time, the Landfill was no longer accepting municipal solid waste and the SRDS had opened. As summarized above in Section 2.5.2, SMA and KCA historical property ownership records were reviewed for the parcel. There is no indication of ownership and/or leasing of this property by the City or County after 1955 for the northern portion of the property and after 1953 for the southern portion of the property, with the exception of a portion of one lot conveyed to the City for a storm drain easement in 1988. Therefore, the filling on this parcel is not related to activities at the Landfill.

Geotechnical borings installed prior to the installation of the RETS Line confirmed the presence of unclassified fill in several borings along the eastern boundary of this property (7-3450, 7-3550, 7-3597, 7-3600, 7-3647, and 7-3650), which suggests that the triangular property to the east of 5th Avenue South was at one time used for the disposal of unclassified fill. This debris had thicknesses of between approximately 5 and 16.5 feet. This unclassified fill placement occurred after the closure of the landfill and is not related to the solid waste placed within the Landfill boundary. Figure 4.2 illustrates the occurrence of the unclassified fill in the various RETS Line borings.

#### *4.2.3.7 5th Avenue South Cement Kiln Dust Fill*

The geotechnical borings installed prior to the installation of the RETS Line indicate a consistent presence of CKD, with thicknesses ranging between 2 and 13 feet along the RETS Line on the parcels to the east of 5th Avenue South.

A review of historical aerial photographs (presented in Appendix A) indicates that the fill was likely placed on the two parcels to the east of 5th Avenue South (Parcel Nos. 7883600350 and 7883600600) during 1969. As summarized in Section 2.5.2, the northern portion of Parcel No. 7883600350 had been privately owned since 1965 and the southern portion of the parcel had been privately owned since 1968. The northern and southern portions of Parcel No. 7883600600 had been privately owned since 1951.

In the late 1960s, filling of the historical KIP swale with CKD also occurred on the KIP parcel and to the north of South Kenyon Street. One soil vapor monitoring probe (GP-28), which was installed as part of this RI, confirmed the presence of CKD from approximately 3.5 to 7 feet bgs. As with the triangular parcel to the north (discussed in Section 4.2.3.6), these parcels were filled after the Landfill closed and were under private ownership.

## 4.3 CHEMICAL CHARACTERIZATION OF SURFACE SOILS AND LANDFILL CONTENTS

### 4.3.1 Waste and Soil within the Landfill

It is not customary to analyze samples within a closed landfill, as these samples would be considered samples of solid waste, not soil, and to be very heterogeneous because solid waste is heterogeneous. Numerous studies have described the general characteristics of solid waste, especially municipal solid waste. USEPA studies beginning in the 1960s indicated that the municipal solid waste stream from 1960 to 1970 contained the following materials (USEPA 1988):

| Materials | Percentage of Total (average of 1960, 1965, and 1970) | Combustible |
|---|---|---|
| Paper and cardboard | 33.4 | Yes |
| Yard wastes | 19.5 | Plant materials yes, residual soil no |
| Food wastes | 13.1 | Food yes, packaging varies |
| Metals | 12.5 | No |
| Glass | 9.6 | No |
| Plastics, textiles, rubber | 6.6 | Mixed |
| Wood | 3.8 | Partially |
| Misc. inorganic wastes | 1.7 | No |

Source: USEPA 1988

At South Park Landfill, the customary procedure was to burn the waste and then bury the remaining non-combustible materials along with the ash. To control ash dispersal, cover was added as needed and generally consisted of imported soil fill or existing soils at the Landfill.

The materials disposed at the Landfill were commonly used materials; however, they do contain hazardous substances regulated under MTCA. Hazardous substances likely to be present within the waste include: (1) PAHs, plasticizers, and other SVOCs; (2) low levels of volatile organics from household cleaners and products, especially benzene, toluene, ethylbenzene, and xylenes (BTEX) and chlorinated solvents; and (3) metals.

In addition to these materials, sections of the Landfill before and immediately after its original closure in 1966 were used for auto-wrecking facilities. USEPA lists petroleum products, heavy metals, and chlorinated solvents (parts cleaning) as common contaminants of concern at automobile salvage yards (USEPA 2006).

The waste/fill at the Landfill is presumed to be contaminated with one or more hazardous substances. Due to the heterogeneous nature of waste at municipal landfills and its planned containment within a closed landfill, the landfill contents were not fully characterized for specific hazardous substances during the RI, although leachate and groundwater were. Soil used as daily cover during operations and as fill during closure and post-closure activities is also considered part of the landfill contents and was not fully characterized. As with the refuse, the soil fill is presumed to contain one or more hazardous substances. As seen in the data presented in subsequent sections, the most likely hazardous substances to be present in the contained waste at the Landfill (including soil cover and contaminated soil associated with auto salvage operations that occurred at the property after the Landfill was closed and before it was redeveloped) include the following:

- Diesel-range and oil-range total petroleum hydrocarbons (TPH), including constituent PAHs
- SVOCs, including phthalates from plastics and carcinogenic PAHs (cPAHs) from combustion
- TCE and BTEX at low concentrations
- Metals

#### *4.3.1.1 Previous Findings at the KIP Parcel*

Three historical investigations at the KIP parcel included an analysis of "soil," most of which was actually either refuse or a thin layer of cover soil placed during closure. In 1995, Blasland, Bouck, and Lee, Inc. (BBL 1995) conducted an expanded Phase II investigation at the Site that included soil, groundwater, soil vapor, and LFG sampling. In soil they found diesel- and oil-range TPH in seven of the eight samples, with a maximum concentration of 890 milligrams per kilogram (mg/kg; less than the current MTCA Method A CUL of 2,000 mg/kg). Soil was also tested for VOCs: toluene was detected the most frequently (four of the eight samples) followed by TCE detected in two of eight samples. Their maximum concentrations were low at 0.26 mg/kg for toluene and 0.055 mg/kg for TCE; these concentrations are less than their respective MTCA Method C CULs.

#### *4.3.1.2 Previous Findings at the SPPD Parcel*

Historically, there have been between 70 and 80 soil samples collected on the SPPD parcel, which were analyzed for the following parameter groups.

| Parameter Groups | Number of Samples |
|---|---|
| Volatile Organic Compounds | 78 |
| Semivolatile Organic Compounds | 78 |
| Pesticides | 71 |
| Polychlorinated Biphenyls | 71 + 9 |
| Total Petroleum Hydrocarbons | Over 80 |
| Metals | 73 |

Table C.1 of Appendix C, Analytical Data Summaries, lists the analytes that were never detected in the soil samples. Table 4.2 lists those chemicals that were detected in the soil samples and compares them to standard MTCA Method C Industrial CULs, as discussed in Section 4.1.

Lead and arsenic exceeded the industrial-based CULs in some of the samples collected from test pits in the late 1990s. Several of the samples were screened for leachable metals using the toxicity characteristics leaching procedure (TCLP) to determine whether the material was a hazardous waste based on leaching characteristic. All TCLP results were less than the criteria for classification as a Characteristic Waste, indicating that the soils could remain on-site as long as they were placed below the Landfill cap/cover. Since the time when these samples were collected, the Landfill has been regraded and new surface fill has been placed, making it difficult to know the exact location of the soil with CUL exceedances. The whole SPPD parcel is underlain by refuse; therefore, it is assumed that the whole parcel will be capped in such a way as to contain both the solid waste and the contaminated soil.

One of the 71 soil samples analyzed for polychlorinated biphenyls (PCBs), at TP-39, had a concentration of 18,000 micrograms per kilogram (µg/kg)—this value is less than the MTCA Method C Industrial CUL for PCBs, but greater than the Toxic Substances Control Act (TSCA) criterion of 10,000 µg/kg for unpaved industrial areas[3]—a relevant, but not applicable requirement. Farallon performed an investigation in 2007 with the intent of bounding the location (Farallon 2007). Nine samples forming a 10-foot by 10-foot grid around the location were analyzed for PCBs. The results for eight of the nine samples were no detections with a detection limit of 50 µg/kg; the ninth sample had a PCB concentration of 90 µg/kg. An additional 25 test pit samples were collected in this area to delineate the area of concern. No other elevated concentrations were found. These results are consistent with the otherwise low concentrations of PCBs in the rest of the Landfill samples and indicate that PCBs are not a contaminant in the surface fill of the SPPD parcel. The most likely source of PCBs to the single sample with elevated concentrations was a fleck of PCB-containing paint or caulk, or a unit transcription error.

#### *4.3.1.3 South Recycling and Disposal Station Surface Soil Sampling by Seattle Public Utilities*

Based on previous exceedances of the MTCA Method A Industrial CULs for arsenic, cadmium, lead, and mercury, SPU decided to investigate the surface soil quality in the landscaped areas within the SRDS parcel. This work was completed at the same time as the 2011 RI data gaps investigations were being completed, but was not performed under the Work Plan. The additional surface soil sampling was completed on June 17, 2011, by Camp Dresser and McKee, Inc. (CDM 2011). These data were used to evaluate the soil quality in the landscaped areas.

A total of 28 sample increments were collected from Decision Unit (DU) 2 at approximately the same locations as the dioxin/furan sampling, as later described in Section 4.3.4 and as indicated on Figure 4.3. Approximately the top 2 inches of soil were collected from each of the sample increments. No sample increments were collected from DU2-4 and DU2-5. The sample increments from DU2 were submitted to Analytical Resources, Inc. and composited, dried, and split similar to the dioxin/furan sampling. The MI sample composite was then analyzed for the MTCA 5 Metals (arsenic, cadmium, lead, chromium, and mercury) by USEPA Method 6010/7000.

[3] Ecology makes the same distinction in the MTCA Method A Table, where they default to the TSCA limit of 10,000 µg/kg as a relevant, but not necessarily applicable, requirement.

The following table presents the DU2 surface soil sampling results.

| Analyte | Concentration (mg/kg) |
|---|---|
| Arsenic | 20 |
| Cadmium | 2.1 |
| Lead | 273 |
| Mercury | 0.23 |
| Total Chromium | 43 |
| Hexavalent Chromium | <0.400 |

#### 4.3.2 Landscape Soil Present at SRDS and in ROWs

Landscaping soil was placed on top of the Landfill cover. For example, it is present in landscaped areas on the SRDS parcel and in landscaped areas and shoulders along the roadways (Figure 2.5). The soil used for landscaping must comply with the MTCA Method C Industrial CULs.

Two soil data gaps were identified during the Work Plan development:

- No dioxin/furan data were available for surface soils at the site (landscaped areas, former West Ditch, and the SPPD parcel, which was unpaved until 2015)
- No data were available for soil in the former West Ditch and roadway shoulders, with results in the former West Ditch expected to be "worst case"
- The results of RI studies to fill these two data gaps are discussed in the next sections.

#### 4.3.3 Former West Ditch Investigation and Modifications during the SPPD Parcel Interim Action

Soil samples were collected along the base of the former West Ditch to assess whether the soils in the ditch were contaminated with hazardous substances that would influence cleanup decisions at the Landfill. The following sections provide a summary of the procedures and findings of the investigation. A summary of chemicals analyzed for, but not detected, in soils encountered at the Site and a summary of the frequency of detections and exceedances of chemicals analyzed can be found in Tables C.1 through C.4 in Appendix C. A summary of field modifications and deviations from the Work Plan, as was necessary to characterize the soil conditions and adapt to changing field conditions at the Site, is summarized in Appendix D. None of the modifications adversely affected the quality or usability of the data. Analytical laboratory reports and data validation reports can be found in Appendices E and F, respectively.

Finally, these findings were used in the 2013 to 2015 IA on the SPPD parcel. Part of the cleanup and redevelopment of the parcel involved installation of new stormwater features that included revisions to the former West Ditch. These are also discussed in the following sections.

#### *4.3.3.1 Investigative Approach*

The former West Ditch was part of an existing stormwater conveyance system for the Landfill. Over time, materials, primarily consisting of soil and vegetative matter, accumulated on the bottom of the ditch. As part of the SPPD IA and redevelopment, the ditch was filled with soil fill and capped. To better characterize the lithology and chemical constituents of this material, samples were collected from the former West Ditch. As indicated by the Work Plan and illustrated on Figure 4.4, samples were collected at three locations (SS-01, SS-02, and SS-03) along the former West Ditch: (1) SS-01 is located at the upstream end, near the confluence with the former East-West Channel; (2) SS-03 is located at the downstream end, where the drainage enters the storm drain system located on the KIP parcel; and (3) SS-02 is located at the midpoint between the first and second sampling locations. The sampling program targeted both recently deposited material and the underlying native soil. Each location was sampled with an 8-foot-long, 3-inch-diameter piston-core sampler. Each core was divided into up to four representative sections, and each section was containerized for laboratory analysis. As outlined in the Work Plan (Farallon 2010a), at least one native soil sample was collected 1 foot below the base of the recently deposited material at each location, with the exception of SS-02. At SS-02, the boring could not be advanced (refusal) 6 feet below the mud-line and was halted prior to reaching the underlying native material. The samples were analyzed for metals, SVOCs, PCBs, petroleum hydrocarbons, pesticides/herbicides, and grain size. Appendix G provides a summary of the sampling procedures, photographs, and grain size analyses; the analytical data summaries are presented in Appendix C and the laboratory reports are in Appendix E.

In addition, a single sample (SS-P) was collected from a culvert discharging into the former West Ditch, and analyzed for the same constituents.

#### *4.3.3.2 Investigation Findings: Lithology and Hydraulic Connectivity*

The former West Ditch lithology consisted solely of organic muck (SS-02) or organic muck overlying native soil consisting of either sand (SS-03) or organic silt (SS-01), as illustrated with depth on Figure 4.4. Based on the grain size analyses, the recently deposited material (organic muck) in all three of the former West Ditch samples generally consisted of between 45 and 80 percent silt or clay. The underlying native material in SS-01 consisted of organic silt with almost 95 percent silt or clay. The underlying native material in SS-03 consisted of sand with less than 25 percent silt or clay.

The organic silt observed at SS-01 is indicative of the Silt Overbank Deposit and indicates that the former West Ditch in this area was likely perched on the Silt Overbank Deposit. This is further supported by the boring log from nearby piezometer PZ-1 (piezometers PZ-2 and PZ-3 had poor recovery), which indicated the presence of a relatively thick Silt Overbank Deposit (about 8 feet thick). Somewhere between SS-01 and SS-03, however, the Silt Overbank Deposit either pinches out, or has been eroded. Therefore, at SS-03 the former West Ditch was instead likely in hydraulic continuity with the A-Zone of the Alluvial Aquifer.

#### 4.3.3.3 *Investigation Findings: Chemical Results*

The former West Ditch samples represent soils, including depositional soils, which have been exposed to stormwater coming from adjacent facilities and roadways, from sheet flow off the landfill surface, and from seasonal groundwater discharge into the ditch. All were potential sources of contamination. Data were needed to assess the potential need for environmental cleanup and to evaluate appropriate cleanup alternatives.

A summary of analytical results for each location is presented in Table 4.3. Table 4.4 presents the frequency of detections and exceedances for each chemical. A list of all chemicals analyzed, but not detected, and their detection limits is presented in Appendix C, Table C.3. Table 4.4 also compares the results to the MTCA Method C Industrial CULs and urban background soil values where appropriate.

None of the samples contained hazardous substances that exceeded the MTCA Method C Industrial CULs. The samples with the greatest lead and chromium results were also analyzed for TCLP metals. These results were less than the hazardous waste criteria.

Specific findings are as follows:

- **cPAHs:** With the exception of the sample collected at boring location SS-01 from 4 to 6 feet bgs, cPAHs were detected at all locations and all depths. Generally, concentrations were similar to Seattle background urban concentrations in soils (Ecology 2011a) and much less than MTCA Method C Industrial CULs.
- **SVOCs:** Non-carcinogenic PAHs were detected in all samples, although concentrations were very low in the samples collected from Boring SS-01 from 4 to 6 feet bgs. Dibenzofuran (a PAH-like chemical) was detected in 3 of the 11 samples. Phthalates were detected in approximately half the samples, with bis(2-ethylhexyl)phthalate being the most commonly detected. Pentachlorophenol was detected in one sample. Concentrations for all detected SVOCs were low and orders of magnitude less than MTCA Method C Industrial CULs.
- **PCBs:** PCBs were detected in all samples and at all depths. Total PCB concentrations ranged from 426 to 5,200 µg/kg. Concentrations did not show any specific trend with depth, but did vary with location. Concentrations of the Aroclors 1254 and 1260 were greatest in samples collected from boring SS-02, while concentrations of Aroclor 1242 were greatest in samples collected from boring SS-03. PCB concentrations were generally lowest in samples collected from boring SS-01. The culvert sample (SS-P) had a PCB concentration of 630 µg/kg, which was less than all but one other sample. PCB concentrations in all samples were less than the MTCA Method C Industrial CULs and the TSCA CULs for paved industrial areas.
- **Herbicides:** There were no detections of herbicides in any of the former West Ditch or culvert samples.

- **Pesticides:** Chlordane and dichlorodiphenyltrichloroethane (DDT) isomers were detected in all former West Ditch samples; however, concentrations in several samples were so low that confirmation or confirmation and quantification were difficult (as reflected in the “J” and “JN” qualifiers in Table 4.3). Samples from SS-02 were the most consistently contaminated samples. Concentrations were much less than MTCA Method C Industrial CULs.
- **Petroleum hydrocarbons:** Diesel- and motor oil-range TPH were detected in all samples; gasoline-range TPH were not detected. The sum of the diesel- and motor oil-range petroleum hydrocarbons ranged from 125 to 3,980 mg/kg. A review of the chromatograms (included in Appendix C) indicates the sample collected from SS-01 at 4 to 6 feet bgs (125 mg/kg total TPHs) is in native materials. It also indicates that the measured residual TPH concentration does not resemble petroleum-derived hydrocarbons and is most likely the quantification of biologically derived organic molecules that are extracted and quantified during the analytical procedure. The lowest samples in the other two borings are located in an area with residual, recognizable petroleum contamination, and may not represent underlying native materials. Concentrations are much less than MTCA petroleum-specific CULs (refer to Section 4.1 for additional discussion).
- **Metals:** Metals were detected in both the former West Ditch and the culvert samples. All metal concentrations were less than MTCA Method C Industrial CULs. Generally, the lowest metal concentrations were detected in the deepest sample (4 to 6 feet) at either SS-01 or SS-03, while the greatest metal concentrations were detected in the shallowest sample (0 to 2 feet) at SS-03 or in the middle sample (2 to 4 feet) at SS-02.
- **TCLP Metals:** Because material from the former West Ditch is considered for placement within the Landfill, metal concentrations that are regulated in characteristic hazardous waste are compared to the “20 times” criterion. When the criterion is exceeded, the samples are tested using the TCLP test to determine if the materials are hazardous wastes.[4] The samples passed the TCLP test; therefore, the former West Ditch soils, if removed from the ditch, are appropriate for reconsolidation on-site as part of the cleanup.

In summary, the soils from the former West Ditch have concentrations that are less than the MTCA Method C Industrial CULs and may remain on-site in the ditch, or in landscaped areas outside the capped Landfill or within the capped Landfill.

[4] The criterion for lead is 100 mg/kg, which is less than the MTCA Method B residential CUL, but greater than background. In the former West Ditch samples, the chromium concentration from the sample collected at SS-03 from 0 to 2 feet bgs exceeded the 20:1 dangerous waste standard; and 7 of the 11 samples had lead concentrations that exceeded the 20:1 dangerous waste standard. Therefore, the TCLP was used to re-analyze the sample with the greatest lead concentration (SS-02-6-8) and the sample with a chromium concentration (SS-03-0-2) that exceeded the 20:1 dangerous waste standard. Based on the TCLP results, both samples had chromium and lead concentrations that were less than the Maximum Concentration of Contaminants for the TCLP (Chapter 173-303-090 WAC) and would not be classified as a dangerous waste.

#### *4.3.3.4 Current Conditions*

The former West Ditch was modified during the SPPD IA to accommodate an upgrade to the stormwater system on the SPPD parcel. The modifications were discussed in Section 2.6.1.2. While the soils concentrations in the former West Ditch did not trigger remedial action, the upgrade of the former West Ditch into an engineered bioswale afforded the opportunity to reduce the mobility of the contaminants present in the bioswale via solidification, and reduce inputs from three potential sources: run-off from offsite properties, groundwater discharge, and direct contact with refuse.

### 4.3.4 Dioxin/Furan Testing of Surface Soils

Site-wide surface soil sampling for three DUs was performed to evaluate the presence of dioxins/furans that could be encountered by workers, visitors, or ecological receptors. A summary of the investigative procedures and findings is provided in the subsequent sections.

#### *4.3.4.1 Investigative Approach*

The RI field program included soil sampling across the Landfill to assess concentrations of dioxins/furans that may be present in the upper 6 inches of surface soil, including soil deposited in the former West Ditch. For this, Ecology recommended the use of MI sampling. In this technique, a site is divided into DUs. A large number of individual samples are collected in each DU and combined to form a single sample that is representative of the specific DU. The sample represents the “average” exposure concentration for the DU.

Figure 4.3 shows the DUs (DU1, DU2, and DU3) for the Landfill and the location of the individual samples that were collected to form the MI sample for each DU. Each DU has a depth interval of 0 to 6 inches below current grade. Each sample increment was collected with a handheld, stainless steel split-tube sampler. Thirty sample increments (sub-samples) were collected from within DU1 and DU3, and 60 sample increments were collected from DU2, due to the larger area.

For the purposes of MI sampling, the Landfill was divided into three DUs to evaluate potential deposition of dioxins/furans in the following areas:

- **DU1:** The former West Ditch was selected as DU1 to represent the quality of runoff from the Landfill and the properties immediately to the west of the Landfill (also discussed in Section 2.6.1). Because dioxins/furans are strongly hydrophobic and partition onto fine particles, the depositional nature of the former West Ditch was considered ideal to evaluate whether there was any indication that the Landfill could have acted as a historical source through stormwater. A total of 30 sample increments were collected at even intervals along the former West Ditch, starting to the north, near the boundary of the KIP and 7901 parcels, and ending to the south, near the confluence with the East-West Channel. Sample increment locations were cycled laterally by collecting samples in the center and to the right and left sides of the ditch (while facing downstream, to the north), as indicated on Figure 4.3 by a “C,” “R,” or “L,” respectively.

- **DU2:** This DU was identified to represent the unpaved areas at the SRDS. About 20 percent of the area within the SRDS is unpaved. Each of the 12 unpaved areas was assigned a number of sample increments that were proportional to the size of the unpaved area. Within each of the unpaved areas, the sample increment locations were evenly distributed to provide consistent sampling coverage and density (Figure 4.3). A total of 30 sample increments were collected within DU2, most of which were collected from landscaped areas.
- **DU3:** This DU was identified to represent the SPPD parcel, the only unpaved section of the Landfill. Due to the large area of DU3, 60 sample increments were collected, with 30 sample increments to the north of the former East-West Channel and 30 sample increments to the south of the former East-West Channel. The sample increment locations were laid out on a systematic rectangular grid, aligned with the landfill boundaries and a random starting point. Slight adjustments to individual sample increment locations were necessary during sample collection due to patches of thick blackberry bushes and the temporary storage of large construction waste containers to the south of the former East-West Channel.

The individual samples (a total of 120 sample increments) were delivered to Analytical Resources, Inc. in 4-ounce glass jars. The sample increments from each DU were composited and passed through a 2-millimeter sieve to remove large particles. For DU1, a large quantity of leaves, twigs, and roots was removed, but this represented a small fraction of the mass of the overall sample increments in the ditch. For DU3, the sieved quantity removed about half of the sample mass and was composed largely of coarse sand and fine gravel.

Next, the samples were dried at room temperature on trays in a dedicated room. The drying trays were protected by aluminum foil tents, and the soil was turned 2 to 3 times per day for approximately 3 days. After the samples had dried, sample splitting was first attempted using a Jones-type, or chute, riffle splitter;[5] however, significant fines were present in the DU1 sample and easily became airborne while being placed in and falling from the riffle splitter. This loss of fines would have continued with each of multiple passes. Dioxins/furans are known to be preferentially present on very fine particles; therefore, this loss of fines was judged to be unacceptable and an alternate splitting method was selected.

Instead, the samples were split using the USACE MI sample splitting protocol. Each MI sample was placed in a tray, and a 30-section grid was overlaid on each tray. Samples were procured by taking approximately a 0.3 ± 0.1-gram subsample from each grid section to yield a final 10-gram sample for analysis. A laboratory technician used a stainless steel V-spatula to remove soil from a random location in each grid section for each sample. After a 10-gram sample aliquot was generated, the soil was smoothed before taking another round of 0.3-gram subsamples. For each MI sample, five 10-gram sample aliquots were combined for a single dioxin/furan analysis, and three 5-gram sample aliquots were combined for a single total organic carbon (TOC) analysis. Appendix H provides a summary of the USACE MI sampling procedures and photographs.

[5] The purpose of the riffle splitter is to ensure that the combined sample is thoroughly homogenized.

For the dioxin/furan analysis, and per WAC 173-340-708(8)(D), 7 chlorinated dibenzo-p-dioxin congeners (CDDs) and 10 chlorinated dibenzofuran congeners (CDFs) were analyzed per MI sample increment. These congener concentrations were used to calculate a toxicity equivalency quotient (TEQ) concentration of 2,3,7,8-tetrachloro-dibenzo-p-dioxin (TCDD), based on the toxicity equivalency factors (TEFs) recommended by the World Health Organization (Van den Berg et al. 2006). The reference chemical is TCDD because it is the most toxic and best studied of the 210 CDDs and CDFs.

#### *4.3.4.2 Investigation Findings: Chemical Results*

The results of the three DU samples are summarized in Table 4.5. As seen in Table 4.5, the TEQs for the MI samples ranged from 28 nanograms per kilogram (ng/kg) in DU1 to 333 ng/kg in DU2 with the greatest TEQ occurring in the landscaped areas at the SRDS and the lowest TEQ occurring in the former West Ditch. The TEQs in each of the DUs are summarized below.

| Decision Unit | Description | Dioxin/Furan TEQ Result (ng/kg dry wt) | MTCA Method C Cleanup Level (ng/kg dry wt) |
|---|---|---|---|
| DU1 | Former West Ditch | 27.9 | 1,500 |
| DU2 | SRDS | 333 | |
| DU3 | SPPD parcel | 66.3 | |

Abbreviations
wt Weight

Extensive soil sampling was recently conducted by Ecology (Ecology 2011b) in several urban residential neighborhoods in Seattle to determine urban background dioxin/furan concentrations. Samples were collected from City ROWs (generally the grassy area between curbs and sidewalks) and five adjacent sub-samples at each location were homogenized for analysis. As discussed in the report, the samples were selected to be representative of adjacent properties, many of which were residential. Results of the study are presented in the following table.

| Area | Number of Samples | Dioxin/Furan TEQ (ng/kg) | | | |
|---|---|---|---|---|---|
| | | Range | Average | Median | 90th Percentile |
| Georgetown | 20 | 5–110 | 36 | 23 | 66 |
| Ballard | 20 | 2–62 | 26 | 22 | 47 |
| Capitol Hill | 20 | 3–96 | 18 | 8 | 53 |
| Ravenna | 20 | 5–50 | 15 | 10 | 30 |
| South Park | 20 | 4–23 | 12 | 12 | 19 |
| West Seattle | 20 | 2–33 | 8 | 4 | 13 |
| All Areas (2011 study) | 120 | 2–110 | 19 | 12 | 46 |

The reported TEQ concentrations at the Landfill for samples from DU1 (the former West Ditch), DU2 (SRDS), and DU3 (SPPD) are an order of magnitude less than the MTCA Method C Industrial CUL and similar to background concentrations. Therefore, dioxins/furans are not a COC for soils at the Landfill. Since the majority of the site drained through the West Ditch, and the sediments in the West Ditch had the lowest TEQ concentrations, which were in the background range, there is no indication that stormwater leaving the site would be any different than stormwater leaving residential properties in the region, with respect to dioxins/furans.

#### 4.3.5 Phase II Subsurface Sampling and Testing at the Lenci Parcel

In March 2017, Environmental Associates, working for the owner of the Lenci Parcel, performed a focused Phase II Investigation (Environmental Associates 2017) that included advancement of three soil borings in a transect across the estimated location of the southern lobe of the landfill.

Their observations indicated:

> "The near surface soils consisted of 3 to 6 feet of fine to medium sand, interpreted to represent fill likely used during development of the current property building in the late 1960s. Under this more recent fill, a layer of wood chips with minor amounts of glass and brick debris was encountered. At B1 this lower fill layer was approximately 2.5 feet thick, whereas at B2 it was approximately 7 feet thick and was somewhat intermixed with organic silts. At B3 the layer of wood chips was less than one (1) foot in thickness . . . At all three (3) boring locations, soils below the wood-chip layer appeared to be native tideland deposits consisting of organic silt and peat, which extended to the maximum depths of exploration that varied between 12 and 22 feet below the ground surface."

Two samples were collected for analysis: one from the sawdust and brick fill layer and one in the native layer immediately below the fill layer. The samples were tested for TPH, VOC, SVOCs, and RCRA 8 metals. All results were less than MTCA CULs for industrial sites, except for arsenic from the native silt/peat layer which was 21 mg/kg versus a background-based cleanup standard of 20 mg/kg. The Environmental Associates full report is provided in Appendix L, Attachment L.3.

#### 4.3.6 Ecology's 7901 Investigation

In May 2017, Ecology conducted soil sampling using push probes at four locations on the 7901 parcel. As documented in an email exchange between Floyd|Snider and Ecology in 2017 (refer to Appendix L, Attachment L.5) 4 Geoprobes were advanced to depths of 18 to 20 feet and 11 samples were analyzed for PCBs, VOCs, SVOCs, PAHs, metals, and TPH. Soil testing at the 7901 parcel by Ecology demonstrates that there are hazardous substances in the soil/waste. The following hazardous substances exceeded MTCA CULs for an industrial facility in at least one location: lead, TPH, and total CPAHs.

## 4.4 SOIL CHEMICALS OF CONCERN

Consistent with standard protocols at solid waste landfills, the heterogeneous contents of the landfill (waste, ash, and soil) were not characterized in detail. The contents are expected to contain hazardous substances and to be contained. Contamination from subsequent uses of the Landfill, such as an auto wrecking yard, would also be contained in areas of overlap. The presence of the Landfill requires the placement of an environmental covenant on the property stating that the Landfill is present and incurring other obligations discussed in the FS.

Landscaping soil at the Settlement Area above the cap was tested and hazardous substances were identified at concentrations typical for urban soils, less than the MTCA Method C Industrial CULs (CDM 2011). The Environmental (Restrictive) Covenants will also state that the site is limited to Industrial uses.

## 4.5 THE FIVE STAGE MODEL OF SOLID WASTE LANDFILLS

Solid waste landfills have been extensively studied across the country and are well understood by today's solid waste engineers. Solid waste engineers routinely use the concept that municipal solid waste landfills undergo well-defined stages as they age, and that understanding these stages allows the engineer to predict the characteristics of LFG and leachate production. The following section describes the five stages of solid waste landfills, and then discusses where the Landfill is within this scheme and what that means for future LFG and leachate production.

### 4.5.1 The Five Stage Model

Municipal solid waste landfills contain a high proportion of organic material that can be degraded by the range of micro-organisms found in landfills, including food and garden waste, paper and board, and wood and some textiles (Williams 2005). The processes of degradation of organic bioreactive wastes in landfills involve not only biological processes but also interrelated physical and chemical processes. Five main stages of degradation of biodegradable wastes have been identified and are routinely used by landfill engineers to understand performance and improve designs. The Five Stage Model is shown on Figure 4.5. The Landfill is in late Stage 4 (where methane is still present, but at low pressure) to Stage 5 (areas with little or no methane) of the Five Stage Model.

As shown in the figure, the stage of the landfill controls the composition of the LFG, the rate at which the LFG is produced, and the composition of the leachate coming from the landfill. Stage 4 conditions typically last the longest and involve the most pronounced changes. During Stage 4, LFG is dominated by methane and carbon dioxide, with little to no oxygen present. The leachate becomes anaerobic. Initially it is acidic due to the formation of organic acids from food decomposition, but later the pH returns to neutral and the carbon dioxide acts to buffer the pH. The anaerobic conditions within the landfill favor the reductive dechlorination of the solvents such as TCE to vinyl chloride and then further reduction occurs to the non-toxic ethene. If the anaerobic leachate enters groundwater, the groundwater will also become anaerobic and this will cause the dissolution of iron and manganese from the native soils. It is during this time that many unlined solid waste landfills develop groundwater contamination from vinyl chloride, iron, and manganese.

During late Stage 4, methane concentrations drop to levels less than 20 percent and, most importantly, the rate of methane production slows sufficiently enough that there is little or no buildup of pressure. Without a buildup of pressure, there is no mechanism to "push" LFG migration; rather the gas is emitted slowly from the landfill through a combination of diffusion and barometric pumping.[6] At Stage 5, methane production is so low, that the gas within the landfill begins to resemble atmospheric conditions, and both oxygen and nitrogen concentrations rise. The leachate has a neutral pH and is only slightly elevated in salts. The underlying groundwater system also starts to recover during this period.

### 4.5.2 South Park Landfill Stage

The Landfill was opened in the 1930s and closed in 1966. It primarily accepted solid waste and much of the waste was burned to reduce volume. In the following sections on groundwater and LFG measurements at the Landfill will be used to confirm that the Landfill is in late Stage 4 or Early Stage 5 depending on location and measurement used (e.g., salinity vs. LFG). The consistency of the groundwater and LFG data over the last two decades as discussed in the next section, in combination with an understanding of normal aging processes at these landfills will support the decisions made at the Landfill.

[6] Barometric pumping refers to the natural airflow in the unsaturated zone included in landfills without active gas control systems, in response to natural atmospheric pressure variations.

# 5.0 Groundwater Occurrence and Quality

## 5.1 INVESTIGATION OF GROUNDWATER

Investigations to characterize groundwater conditions at the Landfill were primarily conducted through the installation of groundwater monitoring wells and temporary groundwater monitoring probes and the sampling and monitoring of groundwater. Monitoring wells were installed within the Alluvial Aquifer to investigate the potential distribution of chemicals in a shallow perched water zone (Perched Zone) and two zones that underlie the Perched Zone (A-Zone and B-Zone).[7] The Perched Zone rests on the Silt Overbank Deposit, which generally acts locally as an aquitard either trapping groundwater that becomes perched or slowing the downward migration of rainwater infiltrating from the surface. Based on review of the boring logs, the Perched Zone is rarely more than 2 feet in thickness, and appears to be pools of infiltrating rainwater trapped on the hummocky surface of the Silt Overbank Deposit in places where the Silt Overbank Deposit is present.

Beneath the Silt Overbank Deposit, the Alluvial Aquifer has been divided into two zones for investigative purposes. The A-Zone extends from the base of the Silt Overbank Deposit for approximately 15 to 20 feet (generally to -15 feet elevation NAVD 88). The B-Zone extends from approximately -15 feet elevation NAVD 88 to either the top of the estuarine/marine deposits or approximately -35 feet elevation NAVD 88, whichever is first.

Most of the Landfill rests on the Silt Overbank Deposit in contact with the Perched Zone; however, the silt unit is not continuous beneath the Landfill, and solid wastes extend approximately 5 feet into the A-Zone, at least on the KIP parcel. Where the Landfill is present, the Perched Zone water is more accurately described as leachate rather than groundwater, because it lies within the waste.

Groundwater wells have been installed into all three zones, and monitoring wells on the KIP parcel (where the Landfill extends into the A-Zone) are screened across both the Perched Zone and upper part of the A-Zone. Because the Silt Overbank Deposit is discontinuous in this area, screening across both the Perched Zone and A-Zone is appropriate to characterize groundwater conditions.

## 5.2 PREVIOUS FINDINGS

Groundwater monitoring has occurred at the KIP parcel since 1989, and in the perimeter monitoring well network surrounding the Landfill since 1998. A summary of previous investigations at the Landfill can be found in Section 2.7 and Table 2.4.

[7] The A-Zone and B-Zone designations are based on depth within the Alluvial Aquifer and do not represent different aquifer stratigraphy. Similar designations (A-level and B-level) are used across the Lower Duwamish Waterway at Boeing Plant 2 for the same purpose in the same valley-wide aquifer.

The historical data from the monitoring of groundwater at the Landfill indicate the following:

- Low parts per billion (ppb) concentrations of TCE (a common degreasing solvent) and its degradation compounds *cis*-1,2-DCE isomers and vinyl chloride were present in groundwater at the Landfill. In addition to the TCE at the Landfill, there was another low-level source detected in upgradient monitoring well MW-12, in the vicinity of a historical gas station.
- Petroleum hydrocarbons and BTEX had been detected in a few of the monitoring wells at the Landfill. The highest concentrations were upgradient of the Landfill and there were also measurable concentrations beneath the Landfill and in one of the downgradient perimeter monitoring wells.
- Several metals (arsenic, chromium, lead, manganese, and mercury) had also been detected in groundwater at the Landfill and in groundwater upgradient of the Landfill.

Based on these findings, critical data gaps were identified in the historical data that needed to be addressed for the completion of this RI/FS.

## 5.3 SCOPE OF INVESTIGATION

The scope of the RI field investigation was presented in Section 4.0 of the Work Plan (Farallon 2010a) and included the following:

- Collection of reconnaissance groundwater quality samples using temporary direct-push well points to address data gaps identified in the Work Plan associated with upgradient contamination in MW-12 and downgradient contamination at MW-27 and MW-25.
- Installation of additional groundwater monitoring wells to give better downgradient and edge-of-refuse coverage of groundwater quality.
- Collection of site-wide groundwater quality samples that were analyzed for chemicals of potential concern (COPCs), including ones that were reported as not detected at Practical Quantification Limits (PQLs) that exceeded the preliminary screening levels established by Ecology for the Work Plan.
- Collection of downgradient groundwater water quality samples that were analyzed for natural attenuation parameters to better understand the downgradient fate of chemical contamination.
- Performance of slug tests in downgradient A-Zone Alluvial Aquifer monitoring wells to determine hydraulic properties and evaluate fate and transport of chemicals along the downgradient edge of the Landfill.

## 5.4 GROUNDWATER INVESTIGATIONS

### 5.4.1 Reconnaissance Groundwater Sampling

Reconnaissance groundwater sampling was completed at eight locations (FB-07 to FB-14), including five upgradient and three downgradient locations, to address data gaps discussed in the Work Plan. The locations where reconnaissance groundwater samples were collected are illustrated on Figure 5.1. Analytical results are presented in Table 5.1.

#### *5.4.1.1 Area 1: Vicinity of MW-12*

Groundwater quality at monitoring well MW-12, located upgradient of the Landfill, is impacted by chlorinated VOCs (TCE, *cis*-1,2-DCE, and vinyl chloride) and arsenic. The source of these constituents is unknown, and could act as a source to the Landfill. Five temporary push-probes (FB-07 to FB-11) were installed in this area during the RI, as described in the Sampling and Analysis Plan presented in Appendix D of the Work Plan (Farallon 2010a), to assess whether there is a potential source of TCE and its degradation products or of arsenic in the area that could impact cleanup at the Landfill.

Sampling locations FB-07 to FB-11 were completed upgradient of the Landfill in the A-Zone of the Alluvial Aquifer and were analyzed for TCE and its degradation products and dissolved arsenic. Results are shown in Table 5.1. Arsenic concentrations are low in all samples and likely represent background conditions. The degradation products of TCE (*cis*-1,2-DCE and vinyl chloride) were detected in four of the five locations, showing that there was a historical source of TCE in the area, and that it was degrading to *cis*-1,2-DCE and vinyl chloride, which would migrate in groundwater to beneath the Landfill. Although this may have been important historically, concentrations now are too low to be of concern as an on-going source to the Landfill.

**This data gap has been addressed by the data collected;** upgradient contamination at MW-12 is no longer a significant source of TCE and its degradation products to the Landfill.

#### *5.4.1.2 Area 2: 5$^{th}$ Avenue South between the Landfill and Off-Site CKD Deposits*

Fifth Avenue South was not an active roadway during early years of the Landfill operations and a layer of waste exists under 5$^{th}$ Avenue South today. For this reason, Ecology approved installation of two downgradient compliance monitoring wells, MW-27 and MW-08, on the far side of SR 99, rather than through waste in the 5$^{th}$ Avenue South ROW. Later it was discovered that CKD was used as construction fill by the property owners of the intervening properties (refer to Section 2.0) and that MW-27 (but not the deeper MW-08) was contaminated with arsenic. Two reconnaissance groundwater probes (FB-12 and FB-13) were advanced in the 5$^{th}$ Avenue South ROW to determine if the arsenic was present in the groundwater as it migrated from the Landfill and to also determine the concentrations of TCE and its degradation products. The probe water samples were collected from beneath the waste layer.

Results of the reconnaissance groundwater probe analysis are shown in Table 5.1. Arsenic concentrations are low in the probe samples, likely reflecting background conditions. Results are a factor of 10 less than concentrations at MW-27 (2 versus 20 µg/L). Based on these results, the arsenic results in MW-27 are believed to be impacts of the intervening CKD deposits and to not represent Landfill conditions.

**This data gap has been addressed by the data collected;** arsenic concentrations at the Landfill are less than 5 µg/L (background) and are not contributing to the arsenic concentrations in MW-27.

TCE and its degradation products were also analyzed in FB-12 and FB-13; results are presented in Table 5.1. At FB-13, only vinyl chloride was detected (0.34 µg/L vs a CUL of 0.29 µg/L). At FB-12, all three compounds (TCE, *cis*-1,2-DCE, and vinyl chloride) were detected. At MW-27, approximately 300 feet downgradient of FB-12, TCE and *cis*-1,2-DCE have degraded and are not detected, and the vinyl chloride concentration has decreased to 0.11 µg/L. The results in FB-12 and MW-27 may be useful in calibrating groundwater attenuation between the locations.

#### *5.4.1.3 Area 3: Downgradient of the Northeast Corner of the Landfill*

A reconnaissance probe (FB-14) was advanced in the South Kenyon Street ROW next to the Former Glitsa property to assess how much attenuation was occurring between the edge-of-refuse and the east side of SR 99 (approximately 200 feet downgradient of the Landfill) and to evaluate the distribution of VOCs downgradient of the Landfill at three different depths. The three depths evaluated were located within the Silt Overbank Deposit (8 to 13 feet bgs), immediately below the Silt Overbank Deposit in the A-Zone of the Alluvial Aquifer (17 to 22 feet bgs), and above the estuarine deposit in the B-Zone of the Alluvial Aquifer (36 to 40 feet bgs). Ecology representatives provided oversight during the drilling and sampling of FB-14 and collected a set of split samples that were analyzed at Ecology's laboratory. Results are presented in Table 5.1; sample labels ending in "ES" are Ecology's split samples collected during the event. The locations are shown in Figure 5.1.

Conditions similar to those at MW-08 and MW-27 were expected—that is, the concentrations represented by the historical monitoring well pair MW-10 and MW-25, would have degraded sufficiently to be in compliance with the CULs by the time groundwater reached FB-14. However, those expectations were not met. TCE and *cis*-1,2-DCE were detected in the upper sample representing water within the Silt Overbank Deposit and a very thin layer (inches) of perched water above it. This result at FB-14 was the greatest TCE concentration detected in the South Park study area since 1998. Vinyl chloride concentrations, but not TCE and *cis*-1,2-DCE, were also detected in the next deeper zone, A-Zone. The vinyl chloride concentrations in the A-Zone sample at FB-14 were also the greatest seen since sampling began in 1998.

**Results at FB-14 did not resolve the data gap;** rather, they indicated that a new source of TCE and/or its degradation products had been found and required further investigation. This would result in the installation of a pair of monitoring wells in the vicinity of FB-14 and two additional monitoring wells at the Landfill upgradient of FB-14. These additional investigations are discussed below.

### 5.4.2 Monitoring Well Installation

To address groundwater data gaps outlined in the Work Plan, five new monitoring wells were installed during the RI field program. The locations of the new monitoring wells are illustrated on Figure 5.1, and the boring and construction logs are provided in Appendix B. The new monitoring wells were completed as follows:

- Monitoring well MW-29 was installed within the SDOT ROW along South Sullivan Street in the vicinity of MW-4 in the A-Zone of the Alluvial Aquifer to evaluate the occurrence of petroleum hydrocarbons previously noted in the MW-4 monitoring well log. Monitoring well MW-29 was installed using a direct-push drill rig with oversized tooling and was screened across the A-Zone of the Alluvial Aquifer to a depth of 30 feet bgs.
- Monitoring wells MW-30 and MW-31 were installed in the vicinity of FB-14 as a Perched Zone/A-Zone monitoring well pair completed above and below the Silt Overbank Deposit. The Perched Zone completion was installed to better understand local conditions, while the A-Zone completion was installed to represent groundwater quality downgradient of the Landfill footprint. This monitoring well pair was installed using standard hollow stem auger drilling methods to depths of 13 and 23 feet bgs, respectively.
- Monitoring well MW-32 was installed as close to the edge-of-refuse as possible and upgradient of MW-30 and MW-31. The purpose of this monitoring well is to evaluate potential contaminants migrating downgradient from the Landfill in the A-Zone of the Alluvial Aquifer. Because MW-32 was completed within the Landfill's solid waste footprint, a temporary conductor casing with a 10¼-inch inner diameter was extended approximately 1 foot into the Silt Overbank Deposit and sealed with an approximately 1-foot bentonite seal. The remainder of the boring was drilled using 4¼-inch inner diameter hollow stem auger drilling methods. The monitoring well was installed to a depth of 24 feet bgs and completed in the A-Zone of the Alluvial Aquifer.
- Monitoring well MW-33 was installed as close to the edge-of-refuse as possible and upgradient of the former Glitsa property. This monitoring well was completed immediately below the Silt Overbank Deposit in the A-Zone of the Alluvial Aquifer, at a similar elevation to MW-31. MW-33 was also completed within the Landfill's solid waste footprint and was installed to a depth of 25 feet bgs with a 10¼-inch inner diameter temporary conductor casing and sealed approximately 1 foot into the Silt Overbank Deposit.

### 5.4.3 Site-Wide Groundwater Sampling

A complete round of groundwater quality samples was collected from the Site-wide monitoring well network to test for COPCs, including those that were originally not detected at PQLs that exceeded the preliminary screening levels. Figure 5.1 illustrates monitoring well locations included in the Site-wide groundwater sampling event, which was conducted from January 26 to 28, 2011. Groundwater water quality samples were collected according to the Sampling and Analysis Plan presented in Appendix D of the Work Plan (Farallon 2010a). Based on the Work Plan, the groundwater quality samples were analyzed for TPHs, total and dissolved metals, pesticides/herbicides, SVOCs, and VOCs. The laboratory analytical method PQLs used for the analyses were either less than the preliminary screening levels in the Work Plan, or, if not achievable, the lowest achievable PQL, in which case the lowest achievable PQL became the preliminary screening level.

In addition, groundwater quality samples were collected on July 8, 2011, from the new monitoring wells (MW-30 to MW-33) installed to address data gaps identified during this RI. These groundwater water quality samples were only analyzed for TCE and its degradation products. They were sampled again during IA monitoring as discussed in Section 5.4.6.

### 5.4.4 Water Quality Sampling

A number of water quality parameters were measured at the Landfill to assess the overall condition of groundwater upgradient and downgradient of the Landfill. Conventional measures included pH, specific conductance, ORP, dissolved oxygen, alkalinity, chloride, sulfate, sulfide, ammonia, nitrate, nitrite, dissolved iron, and dissolved manganese. All of the data are listed in Appendix C, and key parameters are discussed in Section 5.6.

### 5.4.5 Slug Testing

The hydraulic conductivities of the A-Zone and B-Zone of the Alluvial Aquifer were evaluated by conducting slug tests in the following monitoring wells on January 19 and 20, 2011: MW-8, MW-10, MW-24, MW-25, MW-26, and MW-27. Each slug test was conducted using a solid displacement slug, and included rising and falling tests at two different initial displacements. Groundwater level responses to the slug tests were monitored at a resolution of 100 milliseconds, using a vented Instrumentation Northwest PT2X pressure transducer. The results of these slug tests are summarized in Table 5.2 and Appendix I.

### 5.4.6 Interim Groundwater Monitoring Events

An Interim Site-wide Groundwater Monitoring program was implemented to provide groundwater quality monitoring prior to the completion and submittal of the CAP and development of a Long-Term Groundwater Monitoring Plan. The program was implemented in accordance with the Interim Site-wide Groundwater Monitoring Plan (Floyd|Snider and Aspect 2012). Three complete rounds of groundwater quality and natural attenuation parameter samples were collected from the Site-wide monitoring network from April 1 to 4, 2013, July 15 to 18, 2013, and March 17 to 19, 2014. The locations of the monitoring wells are shown on Figure 5.1.

Groundwater samples were analyzed for the following analytes:

- Vinyl chloride and its precursors: *cis*-1,2-DCE and TCE
- Dissolved and total fractions of iron and manganese
- Benzene (MW-25, KMW-05, and KMW-08 only)

In addition, groundwater samples were analyzed for the following geochemical indicators and natural attenuation parameters that were not included in the Interim Site-wide Groundwater Monitoring Plan:

- Major cations, including sodium, potassium, calcium, and magnesium
- Major anions, including chloride, sulfate, nitrate, nitrite, and alkalinity (carbonate, bicarbonate, and hydroxide)
- Ammonia and sulfide

Detailed descriptions of the Interim Site-wide Groundwater Monitoring program and results are presented in three Interim Site-wide Groundwater Monitoring Reports (Floyd|Snider and Aspect 2013a, 2013b, and 2014).

### 5.4.7 Phase II Subsurface Sampling and Testing at the Lenci Parcel

In March 2017, Environmental Associates, working for the owner of the Lenci parcel, performed a focused Phase II Investigation that included sampling an existing groundwater monitoring well, which they designated as MW-NW. Based on its screened interval and depth, it would have sampled A-Zone groundwater. The groundwater was sampled for petroleum hydrocarbons, VOCs, SVOCs, and selected metals. No organics were detected in groundwater, and metals, including arsenic, were at concentrations less than MTCA levels for drinking water (background for arsenic). The Environmental Associates report is provided in Appendix L, Attachment L.3.

### 5.4.8 Ecology's 7901 Investigation

In May 2017, Ecology conducted groundwater sampling using push probes at three locations on the 7901 parcel. As documented in an email exchange between Floyd|Snider and Ecology in 2017, soil (refer to Appendix L, Attachment L.5) three samples were analyzed for PCBs, VOCs, SVOCs, metals, and TPH. Groundwater testing at the 7901 parcel by Ecology demonstrates that there are hazardous substances in the groundwater. Because the groundwater samples were collected from push probes and not from monitoring wells, the results were compared to screening levels that were equal to the preliminary CULs. Although there were exceedances in the groundwater push probe samples (antimony, lead, and TPH), these constituents were in compliance in CPOC wells near the parcel.

### 5.4.9 Supplement Groundwater Investigation (2019)

A supplemental groundwater investigation was completed by SPU in 2019 at the request of Ecology. The investigation consisted of the installation of six new monitoring wells and two rounds of groundwater sampling. The results are documented in the Supplemental Groundwater Investigation Report dated April 7, 2020 by Aspect Consulting, submitted under separate cover.

## 5.5 GROUNDWATER CONDITIONS

### 5.5.1 Groundwater Occurrence

At the Landfill, there are three groundwater zones of interest; all are part of the Alluvial Aquifer system:

- The Perched Zone is a thin discontinuous layer of groundwater (mostly infiltrating rainwater) that exists above the Silt Overbank Deposit. In many places, the Perched Zone groundwater is in contact with solid waste and is conceptually equivalent to Landfill leachate in those locations. The thickness of the Perched Zone may vary seasonally, but is often only a few inches of water sitting on the hummocky surface of the Silt Overbank Deposit.
- The A-Zone of the Alluvial Aquifer is immediately beneath the Silt Overbank Deposit and is the critical zone where leachate (and perched water) can enter the groundwater system and move off-site. The A-Zone extends from the base of the Silt Overbank Deposit for approximately 15 to 20 feet (generally to -15 feet elevation NAVD 88).
- The B-Zone of the Alluvial Aquifer (B-Zone) is the next deeper zone of the Alluvial Aquifer extending from approximately -15 feet elevation NAVD 88 to either the top of the estuarine/marine deposits or approximately -35 feet elevation NAVD 88, whichever is more shallow.

The majority of the monitoring wells and direct-push groundwater sample locations at the Landfill are installed in the Alluvial Aquifer below the Perched Zone, except at the KIP parcel, where the monitoring wells are screened across both the Perched Zone and the upper 5 to 10 feet of the A-Zone of the Alluvial Aquifer. Monitoring wells with the designation of “KMW” should be considered to represent a combination of Perched Zone and A-Zone Alluvial Aquifer groundwater conditions.

A series of geologic cross sections were developed in the vicinity of the Site to clarify the relationships between solid waste, the Silt Overbank Deposit, and the various groundwater zones within the Alluvial Aquifer. The locations of these cross sections are illustrated on Figure 5.2, and include two cross sections extending from west to east (Figures 5.3 and 5.4) and two cross sections extending from north to south (Figures 5.5 and 5.6) across the Landfill. Cross sections produced as part of the RI corroborate the stratigraphic understanding from earlier regional studies. The correlation between the local and regional lithology is illustrated on Figure 5.7.

The solid waste at the Landfill is estimated (based on boring logs) to have a thickness that ranges from less than 5 to 25 feet, with the solid waste generally thinning near the Landfill boundary. In the Landfill portion of the KIP parcel, the solid waste appears to penetrate the underlying Silt Overbank Deposit and be in direct contact with the underlying alluvial soils (Figures 5.3 and 5.5).

Generally, the Silt Overbank Deposit is continuous across the Site except where the solid waste appears to penetrate it (illustrated on Figures 5.3 and 5.5), and along the northwestern edge (illustrated on Figure 5.3) and the southeastern edge (illustrated on Figure 5.4) of the Landfill where it appears to pinch out. Contaminants can move from the Perched Zone into the deeper zone through two different processes. Where the Silt Overbank Deposit is absent, groundwater is able to flow (convection) following the potentiometric pressure differences in the two zones. Contaminants in the groundwater can follow this flow path, although they will be retarded in their flow depending on how strongly they interact with the aquifer soils. Where the Silt Overbank Deposit is present, groundwater flow is restricted between the Perched Zone and deeper groundwater. Contaminants are able to move by diffusion into the Silt Overbank Deposit, and will slowly diffuse through the deposit, where they may enter the deeper groundwater system. This is a much slower process than convection.

The alluvial deposits that form the Alluvial Aquifer are relatively thick, ranging from about 20 feet thick along the western edge of the Site to more than 50 feet thick along the eastern edge of the Site. In general, the alluvial deposits become thicker closer to the center of the Duwamish Valley. The alluvial deposits that form the Alluvial Aquifer are generally composed of dark gray or black silty sand or sand. Underlying the Alluvial Aquifer are estuarine deposits, which consist of fine sand and silt, and are characterized by the presence of shell fragments. The estuarine deposits are encountered at approximately mean sea level (MSL) along the western edge of the Site and dip to the northeast, toward the center of the Duwamish Valley, where they are encountered at greater depths (more than 35 feet below MSL) and are better described as marine deposits. Beneath the southwestern edge of the Site, near the edge of the alluvial valley, glacial deposits were encountered at approximately 9 feet below MSL, in monitoring well MW-14 (Figure 5.1 and Figure 5.4). The glacial deposits are representative of the Duwamish Valley walls and deep Duwamish Valley floor.

As is shown in Figures 5.3 and 5.4, upgradient of the Landfill, only the A-Zone of the Alluvial Aquifer is present. By the downgradient edge of the Landfill, the aquifer is now deeper and the B-Zone is also present.

Figure 5.7 overlays the A-A’ cross section of the Landfill on the regional cross section of the Duwamish Valley Aquifer from the 1998 Duwamish Basin Groundwater Pathways Conceptual Site Model (Hart Crowser 1998). The findings at the Landfill are very consistent with the larger conceptual model of the Duwamish Valley Aquifer.

Groundwater hydrographs were plotted for monitoring wells completed within the Perched Zone and both the A- and B-Zones within the Alluvial Aquifer (refer to Figure 5.8). The hydrographs indicate seasonal fluctuations in groundwater levels of between 0.5 and 2.5 feet in the vicinity of the Landfill; however, fluctuations up to 5 feet have been observed during dewatering activities associated with construction at the SRDS. Groundwater level monitoring conducted by AESI also indicated that groundwater levels below the Silt Overbank Deposit are influenced by changes in barometric pressure, indicative of confined aquifer conditions (AESI 2000).

### 5.5.2 Vertical Gradients

Within the Alluvial Aquifer, there is generally no vertical gradient apparent from the water level data based on measurements along the downgradient edge of the landfill. Vertical groundwater gradients (the change of hydraulic head per unit distance) were calculated based on water level measurements collected during the RI and interim site-wide groundwater monitoring in the downgradient Perched Zone/A-Zone pairs of the Alluvial Aquifer (MW-30/MW-31) and the A- and B-Zones of the Alluvial Aquifer (MW-27/MW-8, MW-25/MW-10, and MW-26/MW-24). These data are presented in Table 5.3. During the four monitoring events, only two instances of vertical gradients were observed in the Alluvial Aquifer: a slight upward gradient observed only in the MW-27/MW-8 monitoring well pair in January 2011 (0.006), and a slight downward gradient measured only in the MW-10/MW-25 monitoring well pair in March 2014 (0.008).

The MW-30/MW-31 monitoring well pair was specifically installed to distinguish between the Perched Zone and Alluvial Aquifer systems. Downward vertical gradients were consistently observed in monitoring well pair MW-30/MW-31 during the RI and interim site-wide groundwater monitoring, and ranged between 0.06 and 0.1. This confirms that the Silt Overbank Deposit is likely acting as a low permeability aquitard; however, in areas where the silt is not present, diffusion-driven migration of contaminants into the A-Zone would occur even in the absence of downward gradients.

### 5.5.3 Aquifer Characteristics

Slug tests, as described in Section 5.4.5, were performed in the A-Zone/B-Zone monitoring well pairs downgradient of the Landfill to determine the hydraulic conductivity—the quantitative measure of an aquifer's ability to transfer water. A summary of the slug test results is provided in Table 5.2 and the slug test analyses, performed using AQTESOLV Professional, are provided in Appendix I. The horizontal hydraulic conductivity of the Alluvial Aquifer was estimated based on the geometric mean of individual slug test results, which gives greater relative contribution to numerically higher hydraulic conductivity values, as recommended in *Groundwater Hydrology*. (Bouwer 1978). The mean (geometric) hydraulic conductivity of the Alluvial Aquifer was approximately 60 feet per day (ft/day; $2 \times 10^{-2}$ centimeters per second [cm/sec]), with a range of values between 26 and 150 ft/day ($0.9 \times 10^{-2}$ to $5 \times 10^{-2}$ cm/sec). These results are within the expected range of hydraulic conductivity values for clean sand and greater than expected for silty sands (Freeze and Cherry 1979); this is consistent with the aquifer soil characteristics.

A comparison of the slug test results with hydraulic conductivity values estimated from 1-hour pumping tests conducted in 2000 (AESI 2000) on the monitoring wells completed in the B-Zone of the Alluvial Aquifer (MW-8, MW-10, and MW-24) can be found in Table 5.2. The pumping test results yielded hydraulic conductivity values that were about 1.5 times greater than the slug test results; however, it should be noted that the ranges in values for the slug test and pumping test results indicate considerable overlap. The slug test results are likely indicative of localized hydraulic characteristics of the aquifer material surrounding the monitoring well screen, while the pumping test results are more indicative of the hydraulic characteristics of a larger section of the Alluvial Aquifer.

### 5.5.4 Groundwater Flow

Groundwater surface elevation contour maps from the dry and wet season are shown on Figures 5.9A (July 2013) and 5.9B (March 2014). Additional contours from other events are contained in Appendix I. These contours, representing both dry and wet season conditions indicate little seasonal variation in the general groundwater flow direction beneath the Landfill, with a general groundwater flow direction to the northeast, toward the Lower Duwamish Waterway beneath much of the Landfill (Figures 5.9A and 5.9B and Figures I.1 through I.7 in Appendix I). This is consistent with findings from previous investigations at the Landfill (as described in the Work Plan) and with findings from other MTCA sites within the Duwamish Valley (such as those discussed in Section 5.5.5), all of which have indicated that the regional groundwater flow direction in the Alluvial Aquifer is from the Duwamish Valley walls toward the Lower Duwamish Waterway.

In creating the groundwater elevation contour maps, it was concluded that groundwater levels measured in the former West Ditch to the north of SS-02 (shown on Figure 2.10 and located in the former West Ditch) are representative of groundwater in the A-Zone of the Alluvial Aquifer. This is because the former West Ditch is likely in hydraulic continuity with the A-Zone of the Alluvial Aquifer due to the absence of the Silt Overbank Deposit (refer to Figure 5.4). To the south of SS-2, however, the Silt Overbank Deposit appears to be present beneath the former West Ditch, as inferred from lithologic material observed at PZ-01, PZ-02, and SS-01. In this area, the Silt Overbank Deposit likely acts as a low permeability aquitard between the former West Ditch and the underlying A-Zone of the Alluvial Aquifer. Therefore, water levels in the former West Ditch between SS-01 and SS-02 were not included in the creation of the groundwater elevation contour map.

### 5.5.5 Groundwater Velocity

Groundwater flow velocities and travel times in the vicinity of the Landfill are estimated from the most recent groundwater elevation contour map information (refer to Figures 5.9A and 5.9B) and hydraulic conductivity estimates of the A-Zone of the Alluvial Aquifer (refer to Table 5.2). Using these data, a horizontal groundwater flow velocity can be calculated from the following equation (Fetter 1994):

$$v = \frac{1}{n_{eff}} K \frac{\Delta H}{\Delta L}$$

Where:

v = Groundwater velocity [L/t]
K = Hydraulic conductivity [L/t]
$\Delta H/\Delta L$ = Hydraulic gradient [L/L]
$n_{eff}$ = Effective porosity [dimensionless]

Due to differences in groundwater flow directions, soil descriptions, and hydraulic conductivity estimates, groundwater flow velocities were calculated for two areas of the Landfill: (1) the northern region of the Landfill (SRDS property), in the vicinity of MW-10/MW-25, with a northeasterly groundwater flow direction and slightly higher hydraulic conductivity estimate; and (2) the southern region of the Landfill (SPPD property), in the vicinity of MW-8/MW-27, with a easterly groundwater flow direction and slightly lower hydraulic conductivity estimate.

The following table summarizes the average groundwater flow velocity in the two areas of the Landfill:

| **Horizontal Hydraulic Conductivity[1] (ft/day)** | **Horizontal Hydraulic Gradient[2] (ft/ft)** | **Effective Porosity[3] (%)** | **Horizontal Groundwater Velocity (ft/day)** | **Average Groundwater Velocity** | |
|---|---|---|---|---|---|
| | | | | **(ft/yr)** | **(ft/day)** |
| **Northern Region** | | | | | |
| Slug Test MW-25 | 0.0029 | 21 to 26 | 2.0 to 1.7 | 150 | |
| Pumping Test MW-10 | 0.0029 | 21 to 26 | 2.3 to 1.9 | 170 | |
| **Average** | 0.0029 | 21 to 26 | 2.2 to 1.8 | 160 | 2.0 |
| **Southern Region** | | | | | |
| Slug Test MW-27 | 0.0026 | 21 to 26 | 0.52 to 0.42 | 42 | |
| Pumping Test MW-8 | 0.0026 | 21 to 26 | 0.88 to 0.71 | 71 | |
| **Average** | 0.0026 | 21 to 26 | 0.70 to 0.56 | 57 | 0.63 |

Notes:

1 Horizontal hydraulic conductivity values based on the January 19, 2011, slug test in MW-25 and MW-27 and historical pumping test data from MW-8 and MW-10 (AESI 2000).

2 Hydraulic gradient calculated in the vicinity of MW-32 and upgradient of MW-25, based on the June 2011 groundwater elevation contour map.

3 Effective porosity values for fine to medium sand (21 to 26 percent, respectively) from Fetter (1994) based on the MW-25 and MW-31 monitoring well log soil descriptions.

Abbreviations:

ft/day Feet per day
ft/ft Feet per foot
ft/yr Feet per year

The groundwater velocity in the northern region of the Landfill is approximately 2 ft/day, while the groundwater velocity in the southern region is approximately 0.63 ft/day. The groundwater velocity in the southern region of the Landfill is slightly lower due to the higher silt content observed in the area. Given the average groundwater velocities, it is estimated that the travel time for groundwater to move across the Landfill is between 1.5 and 5 years. Similarly, the boundary of the Landfill and the Lower Duwamish Waterway are separated by approximately 1,600 feet and, with these groundwater velocities, it would take 2 to 7 years for groundwater from the Landfill to reach the Lower Duwamish Waterway. Other projects in the Duwamish Valley have calculated similar average groundwater velocities in the Alluvial Aquifer.

Reported values are tabulated below and are consistent with those found at the Landfill:

| Site Name | Typical Reported Groundwater Velocity | Comment | Citation |
|---|---|---|---|
| Boeing Plant 2 | 2.4 ft/day | Alluvial Aquifer, A- and B-Zones; across the Lower Duwamish Waterway from the Landfill | Environmental Partners, Inc. and Golder Associates Inc. 2009 |
| Fox Avenue Site | 2.0 ft/day | Alluvial Aquifer, A- and B-Zones; across the Lower Duwamish Waterway and slightly downstream of the Landfill | Calibre and Floyd\|Snider 2009 |
| Electronics Manufacturing Facility (EMF) Plume | 2.0 ft/day | Alluvial Aquifer, B-Zone; across the Lower Duwamish Waterway, behind Plant 2, and near the eastern valley wall | Calibre 2008 |

## 5.6 NATURE AND EXTENT OF GROUNDWATER CONTAMINATION

### 5.6.1 Data Availability

The Site exists within an urban area of Seattle with a long history of filling and industrial operations. As such, it was not surprising to find groundwater contamination upgradient of the Site, as well as beneath and downgradient of the Landfill.

The Landfill locations for which groundwater data are available are shown on Figure 5.1. As is appropriate for landfills, the majority of the monitoring wells are along the perimeter (edge-of-refuse). Table 5.4 summarizes monitoring well completion details for the monitoring wells, along with information describing how data from the monitoring well are used in groundwater evaluations.

Groundwater at the Landfill has been tested for chemical contamination for over a decade. Analytes have included metals, VOCs, SVOCs, PCBs, pesticides and herbicides, and conventional landfill parameters. Many chemicals have never been detected in groundwater at the Site. Tables C.5 and C.7 in Appendix C list those chemicals tested for but not detected in groundwater samples along with their associated detection limits.

A summary of chemicals detected in on-Site and downgradient groundwater is presented in Table 5.5. The table includes the maximum detections and the location and date of the maximum detection. The table includes data from 1998 forward and may not represent current conditions. Figures later in this section display current conditions for key chemicals. Data validation reports are provided in Appendix F.

This data compilation includes the results of the three additional rounds of groundwater sampling that occurred after the 2012 Draft RI/FS was published. These additional rounds were collected under an Interim Site-wide Groundwater Monitoring Plan that was approved by Ecology in 2013 (Floyd|Snider and Aspect 2012).

### 5.6.2 Development of Cleanup Levels for Detected Chemicals

In order to facilitate discussion of the chemicals detected in groundwater, preliminary CULs were developed for all the chemicals presented in Table 5.5. These include all chemicals detected in on-site and downgradient groundwater.

CULs for groundwater COCs are MTCA standards based on protection of groundwater for drinking water use. Although the affected aquifer is not used for drinking water, these standards were incorporated based on discussions with Ecology. The MTCA CULs provide protection for potential future use of the aquifer for drinking water. These MTCA CULs are also protective of surface water use where groundwater from the aquifer discharges to the Lower Duwamish Waterway.

Although MTCA CULs are based on protection of drinking water, there is no current or anticipated future use of the groundwater for drinking water and no exposure; this assessment of exposure is based on the following:

- No drinking water wells currently exist between the Landfill and the Lower Duwamish Waterway.
- High-quality public water is available from the City throughout the area.
- King County Board of Health Code, Title 12, Section 12.24.010(C)(4) prohibits installation of new public drinking water wells within 1,000 feet of a sanitary or abandoned landfill. Waivers are allowed but require engineering studies to justify a reduced setback; no such waivers were found in the Duwamish Valley.
- WAC 173-160-171 prohibits installation of a drinking water well within 1,000 feet of an existing landfill.
- WAC 173-160-171 prohibits installation of a drinking water well within a 100-year floodplain, and most of the area between the Landfill and the Lower Duwamish Waterway is within the floodplain, as shown on Figure 3.3.
- Groundwater within approximately 500 feet of the Lower Duwamish Waterway is brackish to saline even at shallow depths due to the extent of the saltwater wedge that intrudes upstream and infiltrates into groundwater.
- Groundwater throughout the aquifer contains high concentrations of naturally occurring iron and manganese, making the groundwater unpalatable.
- Groundwater at depth within the aquifer (estuarine deposits) is saline, reflecting its origin as a marine embayment.

After discussions with Ecology, the decision was made to use MTCA CULs based on the drinking water scenario because the edge-of-refuse (the POC for landfills) is located approximately 1,600 feet from the Lower Duwamish Waterway, and a private, shallow drinking water well is technically feasible, although it would not produce palatable water due to naturally occurring iron and manganese.

The following additional considerations affect the development of preliminary groundwater CULs for the Settlement Area:

- The CUL for arsenic is based on the state-wide natural background concentration as defined in the MTCA Method A table for groundwater (Table 720-1 in WAC 173-340).
- Background-based screening levels were developed for iron and manganese using the iron and manganese concentrations in the upgradient monitoring wells. Background concentrations were set at the 90 percent upper confidence limit (UCL) of the 90$^{th}$ percentile. Upgradient monitoring wells were available only in the more shallow A-Zone because the B-Zone does not exist upgradient of the Landfill (the aquifer is thin near the Duwamish Valley wall). The screening levels for the deeper B-Zone were developed from a larger aquifer-wide data set.
- Several COPCs have drinking water Maximum Contaminant Levels (MCLs). If the groundwater is considered a potential drinking water source, then these drinking water MCLs are applicable requirements. Consistent with MTCA (WAC 173-340-720(5)(B)), those CULs have been adjusted downward to reach $1.0 \times 10^{-5}$ risk. The adjusted MCL was then chosen as the applicable standard (Ecology 2005).

Table 5.5 lists the preliminary CULs based on a drinking water scenario for the chemicals detected in the solid waste, edge-of-refuse, and downgradient monitoring wells.

Groundwater monitoring at landfills under both state and federal regulations requires monitoring upgradient and downgradient of the Landfill, with the downgradient monitoring wells located as near to the edge-of-refuse as possible. This effectively makes the edge-of-refuse the POC for groundwater (Ecology 2012). Monitoring wells are not required nor expected in the middle of the Landfill. Under MTCA, this POC is considered a CPOC and is generally placed as close to the edge-of-refuse as practicable. Because refuse extends into the SR 99 ROW and it was not possible to get permission to place monitoring wells within the ROW due to safety concerns, some of the CPOC monitoring wells are located on the Landfill side of SR 99 where a thin layer of solid waste is present, and the monitoring wells are screened in the aquifer below the waste, while other CPOC monitoring wells are located on the far side of SR 99, just outside of the ROW.

### 5.6.3 Chemicals of Concern for Groundwater

Table 5.5 identifies the chemicals that have been detected in groundwater at the Site since monitoring began in 1998. It also presents the groundwater CUL for each particular chemical and whether the CUL is a MTCA Method B calculation or a MTCA-modified drinking water MCL. The table summarizes the number of groundwater samples analyzed for that chemical, the percentage of the time it was detected, and the location and date of the maximum detection. If the maximum detection since 2005 is greater than the preliminary CUL, then the chemical is discussed below:

- **Benzene.** Benzene is detected in two locations: KMW-05 upgradient of the Landfill, and CPOC well MW-25. The maximum detection in KMW-05 is 8.2 µg/L versus a preliminary CUL of 5.0 µg/L. In CPOC monitoring well MW-25, benzene concentrations have exceeded the preliminary CUL once in the last 10 years. Current concentrations at MW-25 are non-detections at 0.2 µg/L versus a preliminary CUL of 5.0 µg/L. Using the compliance test provided in MTCA (WAC 173-340-720), this well is in compliance. Figure 5.10 shows benzene and TPH concentrations in 2011, the last year for a full round of data; only monitoring wells with detected benzene have been monitored since then.
- ***cis*-1,2-DCE.** This precursor of vinyl chloride is in compliance in all groundwater monitoring wells at the Landfill (Figures 5.11A and 5.11B).
- **Vinyl chloride.** Vinyl chloride is detected at least occasionally in all CPOC monitoring wells, and exceeds its preliminary CUL, at least occasionally, in five of them (Figure 5.12).Concentrations range from non-detect at 0.02 µg/L to 1.4 µg/L. Vinyl chloride also exceeds the preliminary CUL in MW-31, which is not a CPOC well. Its concentration in MW-31 is the highest in the study area. Vinyl chloride will be discussed in more detail later in this section.
- **Arsenic.** Arsenic concentrations were measured in the 2011 RI event. Upgradient concentrations are greater than downgradient, as shown in Table 5.6 and Figure 5.13, and slightly greater in total than in dissolved. Concentrations in upgradient well KMW-05 are exceptionally high (1,200 µg/L, Figure 5.13); the well is screened across the CKD deposit placed upgradient of the Landfill in the late 1960s and it is believed that the CKD is the source of the arsenic (GeoSyntec 2005, Leidos 2015). The nearest downgradient well to KMW-05 is interior well KMW-03A and its concentration is only slightly elevated at 8 to 9 µg/L versus a preliminary CUL of 5.0 µg/L; other nearby wells have concentrations less than the preliminary CUL. Arsenic concentrations at MW-25, which is generally downgradient from KMW-03A and a CPOC well, are less than the preliminary CUL. Arsenic concentrations were in compliance at all other CPOC wells in 2011 except for MW-27. As discussed in Section 5.4.1.2, arsenic in MW-27 is due to another CKD deposit unrelated to the Landfill. Arsenic exceedances in groundwater are not related to the Landfill. Because of the effect of the CKD deposits on arsenic concentrations, the known CKD deposits have been added to Figure 5.13 for clarity.

  After the 2011 data were collected, two additional CPOC wells were installed, MW-32 and MW-33, and have not been tested for arsenic. Arsenic will be retained as a COC and these wells will be tested, as discussed Section 14.0.
- **Barium.** Total barium concentrations exceed the preliminary CUL in two interior monitoring wells at the KIP parcel, KMW-03A and KMW-04; there are no exceedances for dissolved barium. No CPOC monitoring wells have barium exceedances.

- **Lead.** There has been a single exceedance for lead. It occurred in monitoring well KMW-01A, an interior monitoring well on the KIP parcel. There have been no exceedances in the in CPOC monitoring wells.

Based on the information above, vinyl chloride is retained as a COC for groundwater. Benzene and arsenic will continued to be monitored for a period of time, as discussed in Section 16.0. Iron and manganese are also COCs for groundwater, but are discussed below, along with the development of their preliminary CULs.

### 5.6.4 Iron and Manganese

Iron and manganese concentrations are routinely measured at landfills because they are often leached from soils by the anaerobic groundwater produced during landfill refuse decay. Their presence can limit groundwater use due to taste, odor, staining, and fouling of pipes (through precipitation). Iron and manganese concentrations are naturally present in the Alluvial Aquifer at concentrations that already limit water quality (Ecology 2014b).

To understand if the Landfill was contributing to the high concentrations, dissolved iron and manganese concentrations in the A-Zone were compared upgradient and downgradient of the Landfill. Results, where available, were included from the late 1990s to 2014, and are shown in Figure 5.14. Although the data are relatively constant at each well, they do differ from location to location. To better understand the variability in the aquifer, the larger data set collected for revision of the Conceptual Site Model of the Duwamish Valley Aquifer was also reviewed. This dataset was collected from Ecology and USEPA databases and trimmed to remove locations that had been impacted by contaminant releases as determined by the presence of organic contaminants. Figure 5.15 shows the data for the Alluvial Aquifer, and for upgradient wells at the Landfill. The variation in the upgradient Landfill locations is well within the background range for the Duwamish Valley dataset. Because the Alluvial Aquifer becomes more saline with depth, the depth in the aquifer affects the background range. The downgradient A-Zone wells at the Landfill should be compared to the upgradient A-Zone wells; whereas the downgradient B-Zone wells at the Landfill have no upgradient wells for comparison and should be compared to the B-Zone wells from the valley-wide dataset.

The following table presents the estimates of area background concentrations of iron and manganese from the different data sets that were calculated in accordance with WAC 173-340-709. The values shown are the 90/90 UTL (upper tolerance limit), which is the upper 90 percent confidence level (UCL) on the 90th percentile of the distribution. The bottom rows list the proposed background values for use at the Landfill.

| Estimates of Background Concentrations (mg/L) | Iron (dissolved) | Iron (total) | Manganese (dissolved) | Manganese (total) |
|---|---|---|---|---|
| Upgradient Landfill (0 to 45 feet bgs) | 26 | 27 | 2.0 | 2.1 |
| Aquifer-wide 0 to 45 feet bgs | | 43 | | 2.9 |
| Aquifer-wide 45 to 65 feet bgs | | 39 | | 2.5 |
| **Proposed Background Concentrations** | | | | |
| A-Zone monitoring wells | | 27 | | 2.1 |
| B-Zone monitoring wells | | 31 | | 1.1 |
| **Preliminary Cleanup Levels (the greater of MTCA Method B and Background Concentrations)** | | | | |
| A-Zone monitoring wells | | 27 | | 2.2 |
| B-Zone monitoring wells | | 31 | | 2.2 |

For the A-Zone, there are sufficient site-specific data to recommend the site-specific background. For the B-Zone, which does not exist upgradient of the Landfill, the Duwamish Valley-wide background is proposed. Background is proposed based on total, rather than dissolved concentrations, because the data are from groundwater monitoring wells, rather than reconnaissance probes.

Figures 5.16A and 5.16B present the most recent concentrations of iron and manganese in dry and wet seasons, respectively. Table 5.7 presents the ranges of iron and manganese that have been measured in groundwater since 2011. Locations that are on the far side of SR 99 (and thus slightly beyond the actual CPOC) are within background concentrations. Wells that are within the Landfill, but as close as practicable to the CPOC, have concentrations that are occasionally greater than background concentrations. For example, MW-32 has iron concentrations of 26 mg/L (dry season) to 29 mg/L (wet season) compared to a background concentration of 27 mg/L; the adjacent well MW-33 is within background during both seasons.

For the B-Zone background concentrations, data from other MTCA sites within the valley were used to estimate a background concentration. The B-zone does not exist upgradient of the landfill; therefore, no site-specific data were available. If more and/or better data become available in the future, the B-zone background estimate may be updated.

For manganese, the proposed background concentrations are less than MTCA Method B; therefore, the CUL in groundwater for manganese is based on the MTCA Method B value.

### 5.6.5 Current Groundwater Conditions at the Landfill

Tables 5.6 and 5.7 present the minimum and maximum COC concentrations from January 2011 to March 2014. These chemicals are discussed further below.

#### *5.6.5.1 Benzene and Petroleum Hydrocarbons*

The most likely source of benzene in groundwater in the area is petroleum products. Benzene and TPH continue to be measured in upgradient monitoring well KMW-05; only benzene exceeds its preliminary CUL level, and by less than a factor of 2. Benzene is not detected in the surrounding monitoring wells, indicating that this is small, localized exceedance.

The only downgradient monitoring well with a benzene exceedance was MW-25; the exceedance occurred once in 2011; since 2011, benzene concentrations have been between not detected at 0.2 µg/L and 0.40 µg/L. Benzene was not detected in the Perched Zone, A-Zone, or B-Zone of the Alluvial Aquifer at reconnaissance probe FB-14, which is located downgradient of MW-25.

Benzene will continue to be measured in KMW-05, KMW-03, and in two CPOC wells (MW-10 and MW-25) as discussed in the long-term monitoring program in the Operations, Maintenance, and Monitoring Plan (OMMP) attachment to the CAP.

#### *5.6.5.2 Trichloroethene and Its Degradation Products, Including Vinyl Chloride*

TCE is a common solvent used for degreasing in household, commercial, and industrial products, since the 1940s, and is a common contaminant at landfills. In the landfill environment it rapidly degrades to a mixture of the DCE isomers, with *cis*-1,2-DCE dominating; in turn, the DCE isomers degrade to vinyl chloride; and vinyl chloride degrades to non-hazardous constituents.

While TCE was likely present at the Landfill historically, TCE is no longer detected at the Landfill. There are low level detections below the preliminary CUL in MW-12 (an upgradient monitoring well discussed in Section 5.4.1), in the perched off-Landfill monitoring well near the former Glitsa Property (MW-30), and in MW-26, located downgradient of the Landfill, across SR 99. The highest TCE concentration in MW-26 since 2011 was 0.42 µg/L versus a preliminary CUL of 4.0 µg/L; these concentrations in MW-26 may represent residual TCE coming from the Landfill.

The degradation product of TCE, *cis*-1,2,-DCE, is still detected in the majority of groundwater monitoring wells; it is also detected in upgradient monitoring well MW-12 and perched off-Landfill monitoring well MW-30. The *cis*-1,2,-DCE concentrations are summarized in Table 5.6, and the most recent dry season and wet season results are shown in Figures 5.11A and 5.11B, respectively. All concentrations are below the preliminary CUL, but concentrations at several wells are high enough to be of interest in tracking vinyl chloride concentrations.

If conditions remain anaerobic at the Landfill (late Stage 4), the *cis*-1,2-DCE will continue to degrade to vinyl chloride, acting as a low level reservoir of vinyl chloride. If conditions become less anaerobic, the degradation of *cis*-1,2-DCE to vinyl chloride may slow. This could happen either because the Landfill continues to age into Stage 5 or because remedial actions such as active LFG systems affect shallow groundwater where the Silt Overbank Deposit is absent. Although *cis*-1,2-DCE is not a COC (concentrations are well below its CUL), it will continue to be monitored for as long as needed to understand the source of vinyl chloride to the system.

Vinyl chloride is detected in all interior and most downgradient and CPOC monitoring wells. Refer to Table 5.6 for a data summary and Figures 5.11A and 5.11B for current dry and wet season conditions. In the central and southern parts of the Landfill, vinyl chloride concentrations at the edge of solid waste range from 0.02 to 1.4 µg/L (refer to monitoring well MW-18 and direct push probes FB-12 and FB-13 on Figure 5.1 with results in Table 5.1. Downgradient vinyl chloride concentrations immediately on the other side of SR 99 are 0.04 to 0.31 µg/L versus a preliminary CUL of 0.29 µg/L (refer to monitoring wells MW-08, MW-24, MW-26, and MW-27 on Figures 5.11A and 5.11B). Concentrations in the downgradient monitoring wells have been at these low levels since at least 2006 (refer to the trend plots in Appendix J).

In the northeast corner of the Site, vinyl chloride concentrations leaving the edge-of-refuse are defined by MW-25, MW-32, and MW-33 where concentrations over the last 5 years have ranged from 0.2 to 1.4 µg/L. As discussed in Section 5.4.1, during the RI new monitoring wells were placed across SR 99 from the northeast corner of the site. Concentrations were expected to resemble those discussed above: 0.02 to 0.3 µg/L.

Bioscreen, a model used to estimate volatile organic concentrations in groundwater as they degrade and attenuate, was calibrated using measured aquifer characteristics (in Section 3.0) and measured concentrations at FB-12 and FB-13 as compared to concentrations at MW-24 and MW-27. This calibrated version of Bioscreen was then used to estimate what concentrations at the new monitoring wells were expected to be based on concentrations leaving MW-25, MW-32, and MW-33. Estimated concentrations were expected to be no higher than 0.5 µg/L. Calculations are included in Appendix K.

TCE was detected in MW-30 in the Perched Zone (a zone that is seasonal and not contiguous with the Landfill). A second monitoring well was installed in the A-Zone of the Alluvial Aquifer (MW-31), and this monitoring well has *cis*-1,2-DCE at concentrations between 3.9 and 6.3 µg/L and vinyl chloride at concentrations between 4.3 and 9.0 µg/L. These concentrations appear to be greater than those seen at the Landfill in decades (since 1999), based on the existing well lateral and vertical coverage, and data set. Vinyl chloride is quite mobile in groundwater, and its travel time from MW-25, MW-32, or MW-33 to MW-31 is expected to be on the order of two to four years based on measured groundwater gradients and literature retardation factors. If these concentrations were due to the Landfill based on the current well coverage and screen depths, it is believed that they would be less than concentrations that left the Landfill 2 to 4 years ago; on the order of the Bioscreen modeled concentrations of less than 0.5 µg/L for vinyl chloride.

It is possible that conditions at MW-30 are influenced by a local source of TCE that infiltrated the unpaved ground around MW-30 and was entrained in infiltrating rainwater that perched on the relatively thick Silt Overbank Deposit seen in the monitoring well logs (also shown on cross section A-A' in Figure 5.3). Concentrations in the deeper MW-31 at the same location would be influenced by groundwater from the Landfill and from degradation of the same TCE source. Given that groundwater *cis*-1,2-DCE and vinyl chloride travel reasonably quickly through the groundwater system and the low concentrations coming from the Landfill, the majority of the *cis*-1,2-DCE and vinyl chloride likely originated from a non-landfill source.

Finally, two historical studies were also considered to understand possible chlorinated solvent concentrations in groundwater farther downgradient of the landfill. Monitoring well ALN-493 was installed in the A-Zone of the Alluvial Aquifer along Riverside Drive as part of an environmental investigation related to a planned pump station and water quality facility. This location is where groundwater, especially groundwater from the northwest corner of the Landfill, would discharge into the Lower Duwamish Waterway. Monitoring well ALN-493 is screened in the top (A-Zone) of the Alluvial Aquifer and represents groundwater quality near the discharge point. It was sampled for TCE, DCE isomers, and vinyl chloride in 2008 and 2009 (PGG 2008, 2009). The chlorinated ethenes, including vinyl chloride, were not detected. The vinyl chloride detection limits were 0.1 and 0.2 µg/L for the two events, which is less than the vinyl chloride CUL of 0.29 µg/L. Assuming migration from the presently known vinyl chloride concentrations at the site, these data support the degradation of TCE and its degradation products, including vinyl chloride, prior to reaching the Lower Duwamish Waterway.

Multiple monitoring wells were installed during the RI at the historical bus barn property located immediately north of the Landfill; most were abandoned during the redevelopment. Two monitoring wells, BYMW-5 and BYMW-1, are located near the northwest corner of the Landfill and allow for further delineation of groundwater quality in that corner. BYMW-5 was sampled in February 2008 and BYMW-11 in July of 2008 (AMEC 2009a). The results indicated that TCE, the DCE isomers, and vinyl chloride were not detected at the detection limit of 0.2 µg/L. These data are further confirmation of groundwater quality at the Landfill.

#### *5.6.5.3 Restoration Timeframe*

Vinyl chloride is present at concentrations between not detected at 0.02 µg/L and 1.4 µg/L/ along the downgradient side of the Landfill and is a groundwater COC that remains out of compliance at the CPOC. When determining the remedial action for a COC that is out-of-compliance at a POC or CPOC, it is necessary to also set a restoration timeframe- the length of time needed to bring the COC into compliance at the CPOC. To do this for vinyl chloride, it is necessary to have a conceptual model of where the reservoir of vinyl chloride is in the system and how it is likely to behave in the future. Based on the following observations, the remaining source of vinyl chloride is unlikely to be present in the unsaturated waste layer where leachate would be produced by infiltrating rainwater (the saturated layer is in contact with groundwater and is less influenced by infiltrating rainwater and more likely to be tied to residual *cis*-1,2-DCE concentrations that are likely present in silts in the aquifer):

- Vinyl chloride is a gaseous degradation product of TCE, a common degreasing solvent. The TCE degrades to DCE isomers that in turn degrade to vinyl chloride. The presence of vinyl chloride indicates that conditions are (or were) appropriate for anaerobic dechlorination reactions to occur; otherwise, there would be no vinyl chloride.
- No TCE is detected in the KMW interior wells which contain the largest amount of leachate (KMW-01A, -03A, -04, and -06). The only wells that still contain detectable TCE are an upgradient well (MW-12) and two wells across SR 99 (MW-30 and MW-26). Additionally, five of the six LFG probes tested for TCE in soil vapor contained no

detectable TCE at detection limits of approximately 10 micrograms per cubic meter (μg/m$^3$) (refer to Section 6.5). The TCE concentration at the sixth probe was 80 μg/m$^3$; if 100% of the TCE in the air sample dissolved in rainwater, it would result in a concentration of 0.08 μg/L—a concentration too low to be the source of vinyl chloride exceedances of the preliminary CUL of 0.29 μg/L. Therefore, TCE is no longer acting as a source of vinyl chloride at the Landfill.

- No *cis*-1,2-DCE is detected in the KMW interior wells which contain the largest amount of leachate (KMW-01A, -03A, -04, and -06). Additionally, five of the six LFG probes tested for *cis*-1,2-DCE in soil vapor contained no detectable *cis*-1,2-DCE at detection limits of approximately 10 μg/m$^3$ (refer to Section 6.5). The *cis*-1,2-DCE concentration at the sixth probe was 99 μg/m$^3$; if 100 percent of the *cis*-1,2-DCE in the air sample dissolved in rainwater, it would result in a concentration of 0.1 μg/L. *cis*-1,2-DCE is detected at low concentrations in the A-zone wells and is likely continuing to degrade to produce vinyl chloride; however, its maximum concentration in the A-Zone is 2.0 μg/L (MW-32). Concentrations of *cis*-1,2-DCE in the unsaturated refuse are too low to contribute significant vinyl chloride to groundwater. *cis*-1,2-DCE already in the A-Zone of the aquifer is likely contributing vinyl chloride to the A-Zone, at concentrations up to 1.3 μg/L.[8] This value is very close to the maximum vinyl chloride concentrations of 1.4 μg/L seen in groundwater.
- Vinyl chloride is detected in the KMW interior wells at concentrations lower than at the downgradient CPOC wells. The maximum was 0.39 μg/L in KMW-03A and the mean vinyl chloride concentration in the interior KMW wells since 2011 is 0.24 μg/L; whereas three downgradient CPOC wells (MW-10, MW-25, and MW-33) have had vinyl chloride concentrations between 0.26 and 1.4 μg/L during that same period.
- The Landfill in most locations is underlain by the Silt Overbank Deposit, a fine-grained silt unit that on other sites in the Duwamish Valley contains relatively high, naturally occurring TOC (Ecology 2014b). This unit would be expected to be capable of retarding the migration of organic contaminants due to both the TOC and the higher surface area of silt. Over time, it would slowly release these organic contaminants back into the aquifer. If the residual source of vinyl chloride to the system is controlled by slow release by diffusion of *cis*-1,2-DCE and vinyl chloride from the silt units within the aquifer, then restoration timeframes will be slow and best predicted by the trend plots shown in Figure 5.12.

Given this conceptual site model, the results of the Bioscreen model, and a review of the trend plots, the probable restoration timeframe is 10 years.

[8] DCE at 2.0 μg/L would degrade to produce vinyl chloride at 1.3 μg/L due to the stoichiometry of the chemical reaction.

### 5.6.6 Upgradient and Downgradient Water Quality and the Potential for a Measurable Leachate Impact

As discussed in Sections 5.6.3 through 5.6.5 and shown in Tables 5.6 and 5.7, groundwater quality downgradient of the Landfill is very similar to conditions upgradient of the Landfill with the exception of vinyl chloride, iron, and manganese. There are periodic exceedances of iron and manganese background by less than a factor of 2 in two A-Zone wells (MW-25 and MW-32) and two B-Zone wells (MW-10 and MW-18). In comparing upgradient and downgradient conditions there is little measurable impact of leachate entering the system, consistent with the age of the Landfill.

At the Landfill, leachate is present in the Perched Zone as that is the portion of groundwater that is in contact with waste. Because the Perched Zone ranges in thickness (by location and likely by season) from 0 feet to 2 feet, there are no Perched Zone or leachate wells, *per se*. The older KMW wells, however, are screened across the Perched Zone, the Silt Overbank Deposit, and the top few feet of the A-Zone of the Aquifer and, therefore, contain the greatest concentrations of leachate.

The A-Zone is the critical zone where leachate (and perched water) can enter the groundwater system and move off-site. Consequently, a comparison of the Perched Zone water that is in contact with waste with downgradient A-Zone groundwater is a good evaluation of whether leachate is migrating off-site via the A-Zone aquifer. The interior Landfill monitoring wells screened in the perched zone are KMW-01A, KMW-03A, KMW-04, and KMW-06. Downgradient wells screened in the A-Zone are MW-25, MW-26, MW-27, MW-32, and MW-33. As discussed in Section 5.6.5.2 and shown in Table 5.8, groundwater quality downgradient of the Landfill in the A-Zone is not significantly different from Perched Zone groundwater. Common water quality measures including pH, specific conductance, alkalinity, chloride, dissolved iron, dissolved manganese, benzene, and arsenic are generally similar in the upgradient wells (not including KMW-05) and the downgradient A-Zone wells (Table 5.8). In some cases, the leachate is different than the downgradient groundwater (pH, chloride, and manganese). For other parameters, the leachate is similar to the downgradient A-Zone groundwater (specific conductance, alkalinity, dissolved iron). However, downgradient groundwater appears similar to upgradient groundwater for all parameters. Based on these results it can be inferred that leachate is not significantly affecting the A-Zone groundwater.

## 5.7 SUMMARY OF GROUNDWATER NATURE AND EXTENT

Vinyl chloride, iron, and manganese are the only groundwater COCs that exceed preliminary CULs at the CPOC. The preliminary CUL for vinyl chloride is 0.29 µg/L and is based on consumption of drinking water. Vinyl chloride concentrations at the Landfill near the downgradient edge-of-refuse range from non-detect at 0.02 µg/L to detections ranging from 0.051 µg/L to 1.4 µg/L. The source of vinyl chloride at the Landfill is believed to have been small amounts of the degreasing solvent TCE that were likely disposed of at the Landfill and have since degraded to vinyl chloride. Vinyl chloride is still present today because residual contamination is likely trapped in the fine-grained Silt Overbank Deposit; this residual contamination would slowly diffuse into the A-Zone of the Alluvial Aquifer. Concentrations in groundwater downgradient of the Landfill at monitoring wells across SR 99 are between non-detect at 0.02 and 0.31 µg/L (MW-08, MW-24, MW-26, and MW-27), except at MW-31 where a second non-Landfill source is also contributing contamination.

Groundwater throughout the aquifer contains high concentrations of naturally occurring iron and manganese. In the A-Zone, background concentrations for iron and manganese were calculated from upgradient monitoring data by Ecology. For the B-Zone background concentrations, data from other MTCA sites within the valley were used to estimate a background concentration by Ecology. The off-site data were used because the B-Zone does not occur upgradient of the landfill. If more and/or better data become available in the future, the B-Zone background estimate may be updated. Background was based on the upper $90^{th}$ percent confidence level of the $90^{th}$ percentile of the data, consistent with procedures in WAC 173-340-709 and current guidance from Ecology.

Iron and manganese exceed the A-Zone background concentrations determined for the site (27 mg/L and 2.1 mg/L, respectively). Manganese also exceeds the B-Zone background concentration determined for the site (1.1 mg/L). Therefore, iron and manganese are also groundwater COCs that will be monitored at the CPOC.

Three other COCs are being monitored to confirm that their concentrations remain less than their respective groundwater preliminary CULs at the CPOC:

- *cis*-1,2-DCE is in compliance in all wells, but is the precursor of vinyl chloride and will be monitored in all wells in which vinyl chloride is monitored.
- Benzene is greater than its preliminary CUL in upgradient well KMW-05 and is detected in MW-25; it will be monitored in CPOC well MW-25.
- Arsenic is greater than its preliminary CUL in upgradient well KMW-05 and interior well KMW-03A. It will be monitored as discussed in Section 16.0.

Groundwater COCs and their preliminary CULs are shown in Table 5.9.

**Table 5.9**
**Groundwater COCs, Their Preliminary CULs, and Compliance Status**

| Chemical | Preliminary Cleanup Levels | Compliance Status | Range in CPOC Monitoring Wells (March 2014) |
|---|---|---|---|
| Vinyl Chloride | 0.29 µg/L | Out of compliance | < 0.02 to 0.99 µg/L |
| Iron (Total) | 27 mg/L (A-Zone)<br>31 mg/L (B-Zone) | Out of compliance | A-Zone: 4 to 29 mg/L<br>B-Zone: 21 to 33 mg/L |
| Manganese (Total) | 2.2 mg/L (A-Zone)<br>2.2 mg/L (B-Zone) | Out of compliance | A-Zone: 0.15 to 2.9 mg/L<br>B-Zone: 1.1 to 1.5 mg/L |
| *cis*-1,2-DCE | 16 µg/L | No exceedances | < 0.2 to 1.9 µg/L |
| Benzene | 5.0 µg/L | No exceedances | < 0.2 µg/L |
| Arsenic | 5.0 µg/L (background) | No exceedances[1] | Dissolved: 0.2 to 0.9 µg/L |

Note:
1 MW-27, a downgradient, A-Zone well across SR 99 consistently has arsenic at concentrations greater than the preliminary CULs due to a CKD deposit that is across the street from the Landfill and unassociated with the Landfill; this well is not a CPOC for arsenic. Arsenic concentrations at the CPOC upgradient of MW-27 are in compliance, as shown in Figure 5.13 of the RI.

# 6.0 Landfill Gas and VOCs in Soil Vapor

The following section provides information about LFG at the Site, including information on LFG generation, concentrations in subsurface probes, and results of building monitoring. The occurrence of VOCs in LFG and their potential for vapor intrusion is also discussed.

## 6.1 OVERVIEW: LANDFILL GAS PRODUCTION AT LANDFILLS

LFG is a complex mixture of gases produced by the microbial decomposition of putrescible wastes, primarily food waste, in a landfill. The two largest components of LFG at municipal landfills are methane and carbon dioxide, both produced as microbial by-products of waste degradation. Methane concentrations are typically between 40 and 60 percent by volume, with carbon dioxide making up the rest. LFG also contains the following components (Tchobanoglous, Theisen, and Vigil 1993):

- Varying amounts of nitrogen and oxygen gas from the atmosphere; the amount depends on how easy it is for atmospheric air to enter the landfill mass and how quickly the microbes consume the oxygen.
- Water vapor, hydrogen sulfide, and other organic degradation products, such as carbon monoxide, ethane, and ethene produced by the microbial decomposition of the waste. Most of these other contaminants are known as "non-methane organic compounds" (NMOCs). The non-methane organic compounds usually make up less than 1 percent of LFG.
- VOCs such as vinyl chloride, benzene, and TCE that were present as trace contaminants of the waste and have volatilized into the LFG mixture. These are typically present at parts per million by volume (ppmv) concentrations.

From a regulatory standpoint, LFG is most notable because of the presence of a large amount of methane combined with its flammability and potential explosiveness (lower explosive limit [LEL] at 5 percent volume in air). Out of concern related to this hazard, methane is monitored at landfills and adjoining areas. Methane is not regulated as a hazardous substance, but LFG is closely regulated at landfills.

As discussed in Section 4.5, solid waste landfills have predictable stages in the evolution of their behavior. During the early years (Stages 1 through 3) when the waste is fresh and still contains putrescible components (primarily food wastes and plant debris), methane is produced at a faster rate than a landfill can naturally vent to the atmosphere, and significant LFG pressure builds up within the landfill. This pressure acts to push the LFG out of the landfill and into surrounding areas. During this stage, the LFG is approximately 50 percent methane and 50 percent carbon dioxide, with 1 percent NMOC and no measurable oxygen.

As the landfill ages, the rate of methane production decreases sharply. The concentration of methane and carbon dioxide remains virtually unchanged, but there is no pressure build up and LFG leaves the landfill through diffusion. Effectively, during Stages 2 and 3, the landfill has LFG that is approximately 50 percent methane and has sufficient pressure to push the LFG out of the landfill mass. By Stage 4, the rate of LFG production has decreased and the composition is still approximately 50 percent methane, but there is no measurable pressure. At this stage, as confirmed by measurements at the Landfill, there is too little pressure for convective gas migration, and diffusion and barometric pumping drive LFG distribution.

In Stage 5, the LFG generation is so low that atmospheric gases (nitrogen and oxygen) can now diffuse into a landfill. There is no measurable pressure, the methane content is less than 50 percent, and oxygen is returning, with measured concentrations of up to 22 percent (atmospheric concentrations).

As discussed in the following sections, data from South Park Landfill indicate that the Landfill is in late Stage 4 or early Stage 5 depending on location. For LFG, that means that (1) there is no buildup of pressure, (2) methane concentrations are below 50% and often below 10%, (3) as the LFG continues to drop, atmospheric air enters and is detected as an increase in oxygen, with oxygen concentrations as high as atmospheric concentrations.

## 6.2 REQUIREMENTS FOR LFG AT A CLOSED LANDFILL

LFG mitigation criteria under the MFS are defined in WAC 173-304-460 and King County Board of Health Title 10 regulations. The principal criteria relevant to the Landfill are the following:

- Methane concentrations in soil at the Edge of Refuse must not exceed 5 percent by volume, the LEL for methane. These concentrations are typically monitored at permanent LFG probes using calibrated field monitors.
- Methane concentrations inside buildings and structures within the Edge of Refuse must not exceed 1.25 percent by volume, or 25 percent of the LEL. These concentrations are typically measured by either calibrated hand-held monitors or installed building monitors/alarms.
- Methane concentrations inside buildings and structures beyond the Edge of Refuse must not exceed 100 ppmv. These concentrations are typically measured by either calibrated hand-held monitors or installed building monitors/alarms.

## 6.3 SUBSURFACE LANDFILL GAS

The Landfill has been closed since 1966, and is therefore more than 50 years old, with some sections more than 70 years old.

### 6.3.1 Historical Landfill Gas Findings

LFG has been monitored periodically at the Landfill for at least the last 25 years. LFG was investigated in 1995 at the KIP parcel as part of the property transfer (BBL 1995). Twenty-five subsurface locations were tested for LFG and are shown in Figure 6.1 (these temporary probes were labeled BH-1 through BH-26 on the figure; BH-10 was not installed) and results are tabulated in Table 6.1. Of the 25 locations tested, 6 had no detectable methane; another 7 were less than 5 percent; only 3 locations were above 20 percent: BH-17, BH-2, and BH-11. The majority of the samples with no detected methane were on the far side of the western building, outside of the Landfill footprint. The two highest concentrations were located in the historical KIP swale. These results from more than a decade ago are consistent with late Stage 4 to early Stage 5 LFG conditions, except in the historical KIP swale.

The County installed 16 LFG probes within and near the perimeter of the Landfill, (GP-01 to GP-03, GP-05, GP-07, GP-09, GP-11, GP-13, GP-15 to GP-17, GP-19 to GP-23), which were monitored approximately quarterly for over 5 years starting in 1997 and ending in 2004. The location of the probes are shown on Figure 6.1 and a summary of the data is presented in Table 6.2. None of the probes had measurable pressure; 9 of the 15 did not exceed the LEL and contained oxygen most of the time, indicating Stage 5 conditions as early as 1998. The greatest LFG concentrations were in GP-2, GP-21, and GP-17, but the greatest was 43 percent and they all periodically contained oxygen with little or no LFG, indicating late Stage 4. None of these probes were in the historical KIP swale. The full dataset for these probes was contained in the RI/FS Work Plan.

Very limited data is available for the SRDS parcel, primarily because the buildings onsite were constructed with LFG mitigation and all enclosed buildings are monitored routinely for methane. No methane has been detected in the structures based on City records.

The data gap identified in the RI/FS Work Plan for subsurface methane was the absence of current data in the existing LFG probes and the need for additional probes along the perimeter. Data gaps for monitoring of LFG in buildings were also identified and are discussed in Section 6.4.

### 6.3.2 Scope of RI and Interim Action Investigations

Four investigations of subsurface LFG occurred in the 2011-2015 time period and are used to form the RI data set. They are described below:

- The scope of the RI field investigations was presented in Section 4.0 of the Work Plan (Farallon 2010a) and included the following:
  - Installation of up to nine additional LFG probes near the perimeter of the Landfill (and outside the Landfill footprint).
  - Monitoring of existing and newly installed soil vapor probes for methane and carbon dioxide.
- The scope of the LFG monitoring during the SPPD IA was presented in Section 4.2.1 of Compliance Monitoring Plan, Appendix C of the SPPD IA Work Plan (Farallon 2013) and included the following:
  - Installation of four new LFG monitoring probes (two between the SPPD and KIP parcels and two between the SPPD and SRDS parcels). These are not perimeter probes, but are part of internal controls of the LFG control system installed as part of the SPPD IA.

  - Monitoring of interior and perimeter probes in March 2016 for methane, carbon dioxide, oxygen, temperature, and pressure; at this time, the SPPD LFG system was operational, but not optimized.
- The scope of the Supplemental Subsurface LFG Investigation on the KIP parcel was presented in the September/October 2015 LFG Sampling Results at Kenyon Industrial Park Technical Memorandum (Herrera 2016) and included the following:
  - Installation of two near perimeter probes across South Kenyon Street to monitor the northern boundary of the Landfill;
  - Installation of 25 temporary probes to collect LFG along the western boundary between the Landfill and a historical filled swale outside the Landfill.
  - Collection of a round of LFG measurements at new, temporary, and existing locations within the study area of the supplemental investigation.
- Opportunistic collection of LFG samples along South Kenyon Street as part of the City's redevelopment of the South Kenyon Bus Yard facility also occurred.

### 6.3.3 Remedial Investigation and Interim Action Findings

#### *6.3.3.1 Landfill Gas Monitoring Probe Installation during the Remedial Investigation*

Nine LFG probes, GP-24 through GP-32, were installed by Cascade Drilling near the Landfill perimeter, between December 2010 and March 2011, with oversight provided by Herrera Environmental Consultants, Inc. or Aspect Consulting. Four new probes (GP-33 through GP-36) were installed with oversight provided by Farallon on May 15, 2013, and a final two perimeter probes along South Kenyon Street (GP-37 and GP-38) were installed with oversight from Herrera on September 29 and October 14, 2015.

The LFG probe locations can be found on Figure 6.2; new probes are in sequence beginning with GP-24 and ending with GP-38. The LFG probes were installed to supplement the existing LFG monitoring system and provide additional data to supplement the identified data gaps and to address potential locations where the risk of methane accumulation is considered most likely. Construction details for the LFG probes are provided in Appendix B.

As the LFG probes were installed, subsurface materials were observed and lithologic descriptions recorded at each location. The LFG probes were constructed of $^{3}/_{4}$-inch-diameter Schedule 40 polyvinyl chloride (PVC) casing. The casing is screened with 0.010-inch machined slots and is installed within a $^{2}/_{12}$-sized sand filter pack that extends 2 feet above the top of the screened-interval. The remaining annular space is filled with hydrated bentonite chips and a concrete surface seal. Construction details and lithologic descriptions for each soil vapor monitoring probe location can be found in Table B.3 in Appendix B.

LFG probes were constructed in landfill solid waste, unclassified fill, and in native material:

- Seven (GP-27, GP-29, GP-32, GP-33, GP-34, GP-35, and GP-36) of the nine are screened in solid waste material.
- Two (GP-24, GP-25) are screened in a unit containing CKD.
- Four (GP-28, GP-31, GP-37 and GP-38) are screened in unclassified fill material.
- Two (GP-26 and GP-30) are screened in native materials.

The LFG probes are appropriate for monitoring for LFG and for the collection of samples that can be analyzed for the specific constituents of LFG and/or VOCs.

#### *6.3.3.2 Landfill Gas Monitoring*

*Landfill Gas Monitoring Approach*

Soil vapor monitoring for LFG was conducted according to procedures outlined in the Sampling and Analysis Plan (Farallon 2010b) and the South Park Custodial Landfill Monitoring Procedures (Aspect 2011). The monitoring events occurred during periods of falling barometric pressure on the following dates:

- Main RI Events: February, May, June, September, and November 2011
- March 2016, Site-wide event co-occurred with the first quarter post-construction event for the SPPD IA. Additional measurements were made during the SPPD IA in probes at the SPPD parcel, but many of the measurements occur during construction, startup, and optimization of the LFG system at the SPPD parcel and are not relevant for the either the RI or the FS; they are presented in the Construction Completion Report for the SPPD IA (Farallon 2015).

For the RI events, methane, carbon dioxide, and oxygen were measured using a LANDTEC GEM 2000 Gas Analyzer and values were recorded in percentages. Total VOCs were measured with a MiniRAE 2000 photoionization detector (PID; 10.6 electron Volt [eV] lamp). Prior to the monitoring events, the field instruments were zeroed or calibrated. The gas standards used for calibration include a 4 percent oxygen span gas and a 50 percent methane calibration gas. The PID was calibrated using a 100 ppm isobutylene standard gas.

LFG and total VOCs were measured in the field by connecting the two hand-held instruments in-parallel using silicone and polyethylene tubing. A minimum of one probe volume was evacuated before recording final instrument readings. An SKC, Inc.-branded universal pump was used to evacuate the 2-inch diameter PVC monitoring probes at a flow rate of 3 liters per minute (L/min) and the GEM™ 2000 Gas Analyzer and Extraction Monitor was used to evacuate the 0.75-inch-diameter probes at a purge rate of 300 milliliters per minute (ml/min). The LFG probes were purged until methane, carbon dioxide, and oxygen percentages stabilized (varied by less than 10 percent for three consecutive measurements), to ensure that representative measurements were collected (Farallon 2010a; Aspect 2011).

Barometric and static pressures were measured at each probe prior to purging. Methane, carbon dioxide, oxygen, and VOC concentrations were monitored for every quarter casing volume purged from the respective soil vapor monitoring probe. In cases where groundwater level elevations extended above the soil vapor monitoring probe screened interval, barhole testing was done adjacent to the location. Barhole testing was performed by driving a 1-inch-diameter steel casing with a 6-inch steel mesh screen to a depth of 1.5 to 2 feet bgs with a slide hammer. A length of polyethylene tubing was extended from the screened interval to the surface and connected to the screening instruments. A minimum of one casing volume was evacuated prior to recording measurements. The suite of measurements during barhole testing includes methane, carbon dioxide, oxygen, total VOC concentrations, static pressure, and barometric pressure.

*Landfill Gas Monitoring Results Pre-SPPD Interim Action*

The location of the LFG probes that were used during the RI are shown on Figure 6.2; the KMW groundwater monitoring wells are also shown on the figure because LFG measurements were occasionally taken in these wells since they are screened across the unsaturated zone. Table 6.2 contains a list of the results for each location in each event. Table 6.3 provides a summary of subsurface LFG measurements.

Methane concentrations ranged from not detected (zero) to 85 percent. Wellhead pressures were measured at all locations. The reproducibility of the meter is approximately +/- 0.25 inches of water. The only well with a measurable pressure was GP-15 in a single event, and it had no measurable methane. The lack of pressure confirms that the Landfill is at least in late Stage 4.

Field measurements of methane concentrations at LFG probe locations GP-01, GP-02, GP-19, GP-20, GP-21, and GP-22 (within the Landfill boundary) show methane concentrations ranging from 3.3 to 21 percent. During the installation of these LFG probes, solid waste was encountered and ranged in thickness from 13 to 18 feet. The low concentrations of methane in these locations indicate that the Landfill is in late Stage 4/early Stage 5, due to the age and decomposition of the wastes.

The North and South Piezometers located within the SRDS were monitored for methane in May 2011. No methane was detected in the North Piezometer (TB-16), located near the Landfill perimeter, and 21 percent methane was detected in the South Piezometer (TB-20) located in an area with greater thickness of solid waste. Again, this is consistent with the waste in this area also being old and heavily aged. No pressure was detected.

LFG was not monitored at LFG probe locations GP-13 or GP-32, only once at GP-30, and twice at GP-15 due to flooded well screens. These probes are all located in low-lying areas where the water table is near the ground surface at least seasonally. To get measurements in these areas, barhole punches were used and could be screened above the water table at the time of sampling. Barhole measurements were taken adjacent to GP-30 and near GP-32 and are reported in Table 6.1 as BH-30 and BH-32, respectively. No methane was detected in the barhole monitoring completed adjacent to GP-30 and 0.1 percent methane was detected in the barhole monitoring completed adjacent to GP-32. Barhole monitoring was not completed adjacent to GP-13 (located in the former West Ditch) or GP-15 (drainage ditch), as surface elevations at these locations were significantly lower than elsewhere at the Landfill. A barhole measurement taken from a location within a topographic low and several feet bgs would not provide meaningful data. LFG migrating to the west from the Landfill in these areas would be short-circuited by the topographic lows and high water level, escaping to the atmosphere. Based on results of soil vapor monitoring probe and barhole monitoring to the south and east of the Landfill, negligible methane concentrations were detected migrating off-Site in these areas. Again, this is consistent with the advanced age of the Landfill.

The maximum methane concentrations detected at LFG probe locations GP-27, GP-28, and GP-29 along the eastern perimeter of the Landfill were 6.5, 2.8, and 8.5 percent methane, respectively. LFG probes GP-27 and GP-29 along the eastern perimeter of the Landfill are screened within solid waste, and methane concentrations periodically exceeded the LEL of 5 percent. Bringing LFG concentrations in these probes to less than 5 percent became a goal of the SPDD IA, and is discussed further in the next section.

The greatest methane concentrations were observed in LFG probes GP-24 and GP-25, and monitoring well KMW-05, located in the western portion of the KIP parcel and outside of the Landfill boundary. These are the highest concentrations of methane detected in the study area, and are outside of the Landfill in a historical KIP swale. This area will be discussed in more detail below.

Methane readings at the Landfill perimeter and within the Landfill consistently indicate that the Landfill has aged into late Stage 4 (where the methane concentration is greater than the LEL, but there is no measurable pressure) and early Stage 5 (where the methane concentrations are less than the LEL and oxygen is beginning to be measurable). The Landfill continues to produce low levels of methane but with no measurable pressure. Because the methane concentrations are still greater than 5 percent (the LEL for methane in air), in buildings without LFG mitigation, monitoring will still be warranted as discussed in Sections 6.4 and 11.0 to confirm that methane is not seeping into the buildings at a concentration of concern.

*Focused LFG Investigation in the Area of the Historical KIP Swale*

As work continued at the Landfill (the preparation of the FS and the IA at the SPPD parcel), it became clear that the LFG concentrations observed in LFG probes GP-24 and GP-25, and monitoring well KMW-05, located in the historical KIP swale outside of the Landfill boundary were anomalous.

In contrast, monitoring well KMW-04, located on the KIP parcel and within the Landfill boundary, was monitored for LFG parameters on May 12 and 26, 2011, and no methane was detected.

This triggered an investigation of the history of the area, as discussed in Section 4.0. The historical swale area with the elevated methane readings had been a surface water feature through the operation of the Landfill, with its eastern edge representing the extent of the Landfill. After the

KIP and 7901 parcels were sold to John Farrell in 1955, the historical KIP swale was filled over a number of years (as shown in aerials), and paved over by 1972. Boring logs documented in the area found a relatively thick unit of CKD (less than 1 foot to 8.5 feet) that was underlain by soft sediments with organics and plant debris noted consistent with the swale's history as a drainage swale. The methane appeared to be beneath the CKD unit. Petroleum contamination was also seen in the area, especially in the boring for KMW-05.

The field investigation was conducted September 29 through October 15, 2015. Herrera provided oversight for installation of 25 temporary vibratory probes (TGP-1 through TGP-25) and monitored two permanent LFG probes (GP-24 and GP-25) and seven monitoring wells (KMW-01A, -03A, -04, -05, -06, -07, and -08; all screened across the water table) for LFG. Probe boring records are provided in Appendix B. Table 6.4 presents the percent methane results for the temporary probes; Table 6.5 presents LFG and other gas measurements at the TGP probes, the KMW wells, and the two GP probes. Locations of temporary and permanent LFG probes in the vicinity of the KIP swale are shown on Figure 6.3. A memorandum outlining the findings is presented in Appendix L, Attachment L.1.

Subsurface conditions were evaluated by first installing a vibratory probe for the purpose of logging the soil sequence down to either Silt Overbank Deposits or to groundwater (approximately 10 feet for most locations). A second, adjacent, probe was then installed to the specific depth of interest for characterizing LFG concentrations within the vertical profile. The exploratory borings were advanced using a probe-drive sampler attached to a driven probe rod. During drilling, discrete soil samples for soil classification and field screening were collected continuously at 5-foot intervals using 5-foot-long by 2-inch-outside-diameter probe-drive samplers with dedicated clear Lexan® liners. The samplers were sealed with piston stop pins while being pushed or driven to the desired sampling depth. The piston stop pins were retracted into the samplers while being pushed or driven to obtain a soil sample. Following retrieval, the soil-filled Lexan® liners were removed from the samplers and cut open to expose the soil cores. Soil encountered during drilling was visually inspected and classified according to the Unified Soil Classification System (USCS; American Society for Testing and Materials [ASTM] D2488-09). Depth to groundwater, if encountered, was recorded on the borehole log.

The initial boreholes were monitored following probe removal for the presence of LFG (including methane, carbon dioxide, oxygen, and hydrogen sulfide), with a LANDTEC GEM 2000 Plus. A PID also was used to monitor each borehole and each soil sample for VOCs. Following completion, the boreholes were plugged with bentonite pellets.

To target specific strata adjacent to each initial borehole location, a Post-Run Tubing System, with a 1.5-inch-diameter probe rod was driven to the selected monitoring depth, followed by insertion of 1/4-inch-diameter polyethylene tubing. The GEM was connected directly to the tubing and LFG was monitored after removal of three casing volumes.

*LFG Sampling Results at KIP*

Twenty-four of the LFG probes were completed through asphalt, with thicknesses ranging from 1 to 3.5 inches; aggregate thickness beneath asphalt ranged from 2 to 9 inches and varied from crushed rock to sandy gravel. Fill (soil fill and/or CKD) material was encountered beneath the aggregate. It ranged in thickness from 6 to 14.5 feet and was underlain by a Silt Overbank Deposit. CKD was encountered within the fill material, generally as a single layer, at depths ranging from 0.5 to 9 feet bgs, with thicknesses ranging from 2.5 inches to 8.5 feet (CKD area is presented on Figure 6.3). In addition to CKD, fill material typically contained sand and gravel, with occasional brick fragments, broken glass, and charred wood.

Groundwater was measured in the temporary probes at depths ranging from 3 to 12 feet bgs across the site. Stained soil with a sheen and petroleum hydrocarbon odor was observed in temporary borings TGP-6, -8, -11, -14, -16, and -23 at depths ranging from 5.5 to 14.5 feet bgs.

Methane measured in open boreholes during initial temporary probe installations reflected concentrations associated with all strata combined at each of the 25 locations (Table 6.2). Methane concentrations within targeted strata ranged from 0 to 64.8 percent by volume (Table 6.2). Targeted strata depths ranged from 2 to 9.5 feet bgs, such that they were above groundwater and in permeable fill material (CKD was avoided, when possible).

Table 6.5 provides a synoptic round of LFG measurements at locations at KIP where subsurface measurements could be taken. It includes the TGP probes, monitoring wells KMW-01A, -03A, -04, -05, -06, -07, and -08, and LFG probes GP-24 and GP-25. Methane concentrations ranged from 0 to 65 percent by volume. The table also includes historical measurements for the GP probes; as shown the 2015 values are consistent with the historical data.

Typically, CKD is a dense, low permeability material that limits migration of methane. An attempt was made to set the probes below the CKD but above groundwater in order to get worst case conditions; however, eight probes were completed within CKD, because the CKD was thick enough that groundwater was encountered before the base of the CKD. Methane concentrations were extremely low, ranging from 0.0 to 1.4 percent at six of the eight locations. At locations TGP-16 and -20, CKD was less than 2 feet thick, overlain and underlain by more permeable soil fill material; methane concentrations were 26 and 16 percent at TGP-16 and -20, respectively.

Methane measurements presented in Table 6.5 are plotted on Figure 6.3. They indicate consistently low concentrations along the entire western side of the historical KIP swale, consistently high concentrations along the north-south centerline of the swale, and mixed results along the eastern side of the swale.

Methane concentrations from locations within the Landfill on KIP ranged from not detected to 13 percent. This included the three temporary probes (TGP-23 through -25) and wells KMW-01A, KMW-03A, and KMW-04. This is consistent with overall findings at the Landfill. Methane concentrations within the swale area were the highest in the study area, but they were variable by location, ranging from not detected to 65 percent. This pattern of moderate concentrations in the Landfill can be seen in Figures 6.1 (historical), 6.2 (RI) and 6.3 (supplemental).

The variable nature within the historical KIP swale is likely due to more complex stratigraphy in the swale. Attachment L.1 of Appendix L contains cross sections showing the stratigraphy of the Silt Overbank Deposit, fill, and CKD, and the location of the water table at the time of drilling. For example, methane concentrations are consistently high in GP-25 where there is sufficient CKD to trap methane allowing for a buildup of concentrations, but where the gap between the water table and the bottom of the CKD is always large enough for the methane to reach the probe. In GP-24, where the reading are variable, the gap between the base of the CKD and the water table is much smaller and, when the water table is high, methane has to travel through water or CKD, or both, to reach the probe.

*Landfill Gas Monitoring Results Post-SPPD Interim Action*

A round of LFG measurements were conducted in the perimeter probes planned for long-term monitoring in March 2016. The March 2016 Event was planned as a Post-construction Long Term Monitoring Event for the SPPD IA that would have included about half of the perimeter probes for the Landfill plus a series of probes that are interior Landfill probes located along the boundaries between SPPD and SRDS and SPPD and KIP. The remainder of the perimeter probes were measured at the same time to have a current, synoptic round of data. The measurements were collected using the same procedures as used for the RI data; details are presented in the *Draft Landfill Gas Collection and Control System Interim Action Progress Report Technical Memorandum* (Farallon 2016b). Results are tabulated in Table 6.6.

Several more rounds of LFG measurements were collected throughout 2016 in the probes surrounding the SPPD parcel as the LFG system was optimized and operated. The data were presented in the Construction Completion Report (Farallon 2017) and are summarized in Table 6.7. Operational changes in the system were able to bring all LFG compliance probes at the SPPD parcel into compliance. It should be noted that probes between the SPPD parcel and the KIP and SRDS parcels are “perimeter” probes for SPPD, but are completed in refuse and are not compliance perimeter probes for the Settlement Area.

*KIP Swale Monitoring*

Following probe installation, Herrera performed monthly monitoring beginning in September 2016. LFG monitoring was also conducted at two gas probes, GP-24 and GP-25, and four monitoring wells, KMW-01A, KMW-03A, KMW-04, and KMW-06, previously installed on the KIP property. The additional monitoring was conducted to determine distribution of LFG throughout the KIP parcel. Two perimeter probes, including GP-22 and GP-33 located on the SPPD parcel, the adjacent property to the south, also were monitored to determine effectiveness of the active LFG collection system constructed on SPPD. The measurements were collected using the same procedures as used for the RI data; details are presented in the *LFG Monitoring Results at Kenyon Industrial Park Technical Memorandum* (Herrera 2017) that is included as

Attachment L.2 in Appendix L. Results are tabulated in Table 6.8 and LFG probe locations in the vicinity of the KIP swale are shown in Figure 6.4.

During the 12-month monitoring period, September 2016 through August 2017, results were as follows:

- No methane was detected in probe GP-39 with the exception of 0.1 percent during the initial monitoring period. The screen in this probe is open to fill material located above and below the CKD. Typically CKD is a dense, low permeable layer that impedes the flow of LFG.
- Methane concentrations ranged from 0 to 7.5 percent in probe GP-40. During the November 2016 and April 2017 monitoring periods, high water levels prevented purging more than one probe volume. The probe screen straddles two fill zones and CKD, but during all 12 monitoring periods, the water level was above the lower fill zone and CKD.
- No methane was detected in probe GP-41. The screen in this probe is open to the lower fill zone and CKD, which extends to the asphalt/aggregate, within 1 foot of ground surface. The water level extended above the top of the screen during monitoring performed in February, March, April, and June 2017.
- No methane was detected in probe GP-42. The screen in this probe straddles two fill zones and CKD.
- Methane concentrations ranged from 0.5 to 16.4 percent in probe GP-43, which is located at the southern portion of the KIP swale LFG network. During seven of the last 12 monitoring periods, high water levels prevented measurements from equilibrating. The probe screen straddles two fill zones and CKD. Due to elevated methane concentrations in GP-43, indoor air was monitored at the buildings located on the W.G. Clark property, which had not previously been monitored during the RI. Methane was not detected in indoor air in this building. Indoor air monitoring at the W.G. Clark property is discussed in Attachment L.4 in Appendix L.
- No methane was detected in a manhole located north of KIP and the swale in the center of South Kenyon Street.

Methane concentrations in the other probes and wells measured across KIP are typical of historical readings taken prior to the 12-month monitoring period results discussed in the memorandum. The two LEL exceedances measured in probes GP-22 and GP-33 during December 2016, were attributed to an unscheduled shutdown of the LFG extraction system on SPPD. The methane concentrations dropped below the LEL during subsequent monitoring when the extraction system was operational.

*Summary for LFG*

The compliance probes around the Landfill, except those in the KIP swale, are in compliance. The probes in the KIP swale are continuing to be investigated to determine whether any corrective action is needed, and will be discussed further in the CAP.

## 6.4 INDOOR LANDFILL GAS MONITORING

### 6.4.1 Historical Indoor Landfill Gas Monitoring Results

Indoor air was investigated at the KIP parcel from 1989 through the 1990s where the majority of the buildings are located throughout the 1990s. An explosive gas and organic vapor survey was conducted in the buildings on the KIP parcel by Golder Associates, Inc. on October 24 and 25, 1989. Elevated results were found in three locations and resulted in the replacement of a defective gas-fired heating element (PSI 1993).

On August 23, 1993, Professional Service Industries, Inc. conducted a second Air Quality Investigation at the KIP parcel. The results of the 1993 investigation indicated that the concentration of total organic vapors inside the buildings were near background levels. Areas found to be slightly above background levels could be explained by poor air circulation combined with smoking in the areas, the operation of warehouse and office equipment, or any combination of the above. Elevated concentrations of explosive gas (below the methane LEL) were found associated with leaky natural gas meters that were recommended for repair.

Another indoor air investigation was performed in 1995 as part of a Phase II Investigation (BBL 1995). According to the report, the buildings were screened with portable equipment and appropriate locations within the suites were selected to ensure that methane gas would be detected if present. Twenty-six samples at critical locations were sampled and analyzed for LFG. Twenty-five were non-detect at the detection limit. One had methane at 27 ppmv (vs. a standard of 12,500 ppmv); this sample, although part of the building inspection scope, was just outside the western-most building in the location of the historical KIP swale.

As part of the RI/FS Work Plan, the following data gaps were identified:

1. The current methane levels in buildings that could be affected by LFG were considered to be a data gap, including:
    a. On-site buildings on the KIP and 7901 parcels.
    b. Adjacent buildings to the Landfill <u>if</u> subsurface LFG probes along the Landfill perimeter indicated methane concentrations greater than 5 percent in the following areas:
        a. Areas south of the Landfill boundary along South Sullivan Street; data discussed in Section 6.3 indicated that perimeter probes were in compliance along this boundary.

b. Properties immediately east of 5th Avenue South and west of SR 99 (West Marginal Way South); perimeter probes exceeded 5 percent methane in this area, and building monitoring was triggered and is discussed in the sections below;

c. Areas east of the SRDS and across SR 99; perimeter probes indicated no methane in the area, and buildings were not monitored.

### 6.4.2 Scope of Landfill Gas Monitoring in Buildings

Air monitoring for LFG was performed in and around four buildings located in the KIP parcel, the building at the 7901 parcel, and five buildings located east of 5th Avenue South and the SPPD (refer to Figures 6.5A and 6.5B). Tables B.4 and B.5 in Appendix B provide the monitoring locations within each building. The buildings were monitored February 18 through 22, 2011, based on elevated methane measurements detected in LFG probes located near the buildings. A LANDTEC GEM™ 2000 Gas Analyzer and Extraction Monitor was used to measure air quality in the buildings.

The monitoring of LFG in indoor air continued quarterly for 1 year at the five buildings located along 5th Avenue South in conjunction with the monitoring of LFG in LFG probes to develop baseline data. Decision trees were developed to determine conditions that would trigger the monitoring of additional buildings (Figure 6.6) and to determine what actions would occur if elevated methane concentrations were detected inside the buildings (Figure 6.7).

Indoor air monitoring was performed in the five buildings on 5th Avenue South on May 25, June 29, and September 23, 2011. The May and September monitoring periods were performed in conjunction with quarterly LFG probe monitoring and the June monitoring was initiated due to the detection of methane concentrations greater than the LEL in a LFG monitoring probe adjacent to the buildings. The methane for these two events was measured with a Photovac flame ionization detector (FID) with a detection limit of 0.5 ppm methane.

As part of indoor LFG monitoring at buildings supplied with natural gas, a request was made for Puget Sound Energy to confirm that there were no leaks from their system. They did not identify added manufactured natural gas constituents (such as odor agents) within either of the LFG probe locations at the KIP parcel (GP-24 or GP-25) and no leaks were identified along their infrastructure. Puget Sound Energy also indicated that a natural gas pipeline survey had been completed in the area within the last 4 months and no leaks were detected. This standard work simply confirms that the methane is not coming from leaks in the supplied gas lines.

Elevated concentrations of methane were detected in perimeter probe GP-43 on September 26 and October 3, 2016. The concentrations ranged from 32.5 to 32.7 percent by volume methane, exceeding the LEL of methane. This triggered indoor air monitoring for buildings located within 100 feet of the probe. Buildings 1, 2, and 3 on the W.G. Clark property are within 100 feet of the probe (refer to Figure 1 in Attachment L.4 of Appendix L). All three buildings at W.G. Clark were constructed with a concrete slab on grade. A methane mitigation system was constructed in

Building 2, including a series of perforated pipes installed in gravel beneath the concrete slab and vented to the roof on the north side of the building. An additional, large open air building is located in the southern part of the property, and is constructed on gravel with a steel roof, but no walls. No methane or VOCs were observed at concentrations greater than the detection limits during the air monitoring on October 17, 2016.

#### 6.4.3 RI Indoor Landfill Gas Monitoring Results

More than 200 indoor and outdoor locations were monitored for methane between February 17 and February 22, 2011 at the KIP, 7901, and 5$^{th}$ Avenue South parcels as shown on Figures 6.5A and 6.5B. Methane was not detected at any of the building monitoring locations.

Additional methane monitoring in the five buildings located on 5$^{th}$ Avenue South was conducted on May 25, June 29, and September 23, 2011. Again, no methane was detected at any of the building monitoring locations.

Methane monitoring was conducted in the buildings located on the W.G. Clark property on October 17, 2016. No methane was detected at any of the building monitoring locations.

### 6.5 AIR TOXICS IN SOIL VAPOR

#### 6.5.1 Historical Investigations

A single historical investigation was located on air toxics. It was performed at the KIP parcel in indoor air more than a decade ago in buildings with active industrial operations that included petroleum products and solvents. These data were considered too old and of questionable value since it would not be possible to separate Landfill contributions from contributions from industrial activities.

#### 6.5.2 Scope of RI Investigation and Sampling Approach

Because the buildings are in use as industrial operations, indoor air represents both potential inputs from the Landfill via vapor intrusions and inputs from the industrial operations. Therefore, soil vapor measurements were used to assess potential inputs from the Landfill. The soil vapor results will then be compared to the screening tables in the Ecology guidance on vapor intrusion (Ecology in their *Guidance for Evaluating Soil Vapor Intrusion in Washington State: Investigation and Remedial Action* (Ecology 2009c; revised by Ecology in April 2015 to update toxicity factors).

As discussed in Section 6.3.3.2, a hand-held PID monitor was used in the field to screen for the presence of total VOCs during the LFG monitoring. Table 6.2 presents the PID results with the LFG monitoring results.

Soil vapor sampling occurred on May 11 and 12, 2011, to identify potential VOCs of concern for vapor intrusion into nearby buildings. Soil vapor samples were collected at six locations based on the following criteria:

- Locations with the maximum LFG concentrations were sampled because LFG can act as a carrier for VOCs when concentrations are great enough to result in elevated LFG pressures. LFG probe locations GP-25 and GP-27 were sampled for VOCs because GP-25 generally had the greatest LFG (methane) concentrations and GP-27 had elevated methane concentrations occasionally at levels greater than the methane LEL of 5 percent, and was located within 50 feet of a building.
- Areas with historical VOC contamination were sampled. Blasland, Bouck, and Lee, Inc. measured soil vapor at the KIP parcel (refer to Table 2.4) in 1995 using temporary LFG probes. At that time, the greatest concentrations found were near monitoring wells KMW-04 and KMW-05. Although the temporary LFG probes are gone, the monitoring wells remain and are screened across the water table allowing for the intrusion of soil vapor into the well casing. During the current investigation, vapor samples were collected from the two groundwater monitoring wells and the data are considered representative of VOCs entering the well casing from both the surrounding unsaturated soil (soil vapor) and from the groundwater.
- Areas lacking sufficient historical data were also sampled. For this, two piezometer locations were identified for sampling at the SRDS (the North and South Piezometers), where LFG had been detected.

Following the LFG probe casing purging procedure discussed in the previous section, a specially-prepared 6-liter Summa canister with a flow controller was connected to a pressure fitting at the top of each sampling location. The flow controller allowed collection of a passively integrated sample over a 1-hour period. The canisters were provided by Air Toxics, LTD and the internal gas pressure of each canister was recorded prior to, during, and after soil vapor sample collection. The canisters were shipped to Air Toxics' Laboratory in Folsom, California, where they performed the VOC analyses by gas chromatography mass spectrometry in accordance with USEPA Method TO-15.

### 6.5.3 RI Results for VOCs in Soil Vapor

The results for chemicals that were detected are presented in Table 6.9. Chemicals analyzed for but not detected in soil vapor samples are summarized in Table C.12 in Appendix C. Data validation reports are provided in Appendix F. The soil vapor sampling results were compared to the soil vapor screening levels developed by Ecology in their *Guidance for Evaluating Soil Vapor Intrusion in Washington State: Investigation and Remedial Action* (Ecology 2009c; revised by Ecology in April 2015 to update toxicity factors). Soil vapor samples from LFG probe and monitoring well locations collected at the Landfill are representative of intermediate soil vapor conditions deeper than just below slab and shallower than the 15 feet bgs guideline depth for the MTCA deep soil vapor screening levels.

Ecology recognizes that a number of technically sound approaches to evaluating vapor intrusion to indoor air can be used to assess risk. The 2009 Ecology guidance does not "require that investigators follow the procedures outlined" in the guidance. However, the guidance does describe "a practicable, tiered approach organized around a number of decision points, and is consistent with MTCA rule requirements and may other vapor intrusion guidance documents."

Floyd|Snider has conducted a Tier I assessment for benzene and xylenes. The site is zoned "industrial." The MTCA regulations in WAC 173-340-750 "provide Method B unrestricted (residential) air cleanup levels and Method C industrial air cleanup levels. While Method B can be thought of as the default method for calculating acceptable indoor air levels, industrial air cleanup levels are applicable when the building of concern is located on —industrial‖ property (per WAC 173-340-200 and -745) and receptors are industrial workers."

The groundwater screening levels (using the updated April 2015 Table B-1) for industrial-zoned sites are:

- Benzene = 22.5 µg/L (non-cancer) and 24.0 µg/L (cancer)
- Xylenes = 678 µg/L (non-cancer, meta) and 963 µg/L (noncancer, ortho)

The soil gas screening levels (using the updated April 2015 Table B-1) for industrial-zoned sites are:

- Benzene = 107 µg/$m^3$ (cancer, sub-slab) and 321 µg/$m^3$ (cancer, deep)
- Xylenes = 3,333 µg/$m^3$ (non-cancer, sub-slab) and 10,000 µg/$m^3$ (non-cancer, deep)

Benzene has been detected in groundwater in off-site well KMW-05 ranging from 5.6 to 8.2 µg/L and at a maximum concentration on-site in well MW-25 at 5.8 µg/L. These maximum concentrations are much less than the MTCA Method C screening level of 24 µg/L. Xylenes were non-detect in off-site well KMW-05 and were not detected in on-site wells. Therefore, these analytes are less than their screening levels for industrial sites and benzene and xylenes should not have to be analyzed for in indoor air. This is supported by groundwater analytical data over multiple sampling events.

However, soil gas data were collected in 2011 from four on-site locations and two off-site locations. Benzene was detected in off-site well KMW-05 soil vapor in 2011 at a concentration of 460 µg/$m^3$. This concentration is greater than the sub-slab soil gas screening level of 107 µg/$m^3$ and the deep soil gas screening level of 321 µg/$m^3$. Xylenes were detected in soil vapor in 2011 at concentrations of 690 µg/$m^3$ (meta and para) and 210 µg/$m^3$ (ortho), which do not exceed the soil gas screening levels. On-site, benzene was detected at a maximum concentration of 22 µg/$m^3$ in GP-27, and xylenes were detected at concentrations of 97 µg/$m^3$ (meta and para) and 32 µg/$m^3$ (ortho). On-site benzene and xylene concentrations do not exceed soil gas screening levels.

Because KMW-05 is the location closest to the KIP building where benzene and xylenes were detected in indoor air in 2007 (URS 2009), both shallow groundwater and soil gas concentrations were input to the Johnson and Ettinger Model (JEM) with very conservative assumptions. The predicted indoor air concentrations were then compared to the MTCA Method C indoor air CUL of 3.21 µg/$m^3$. The results and assumptions are below:

- Groundwater JEM Model Results: 1.2 to 1.4 µg/$m^3$ at 55 °F and 1.8 to 2.0 µg/$m^3$ at 70 °F.
- Soil gas JEM Model Results: 1.1 to 1.4 µg/$m^3$ at 55 °F and at 70 °F.
- Assumptions:
  - Soil type is sand – the soil type is reported as silty sand or sandy silt; however, using sand in the model is more conservative.
  - Soil/water temperature is 55 °F – the model still predicts concentrations less than the MTCA Method C indoor air CUL if the temperature is 70 °F.
  - Default building properties – these have a VERY conservative air exchange rate and building size.
  - Default exposure parameters – these are VERY conservative because they are residential.

This vapor intrusion analysis provides a Tier 1 off-ramp to prevent the need for Tier II evaluations (i.e., indoor air sampling). Based on the results obtained with the Tier 1 analysis, no further monitoring or evaluation is needed based on Ecology's 2015 guidance.

## 6.6 SUMMARY OF RI FINDINGS FOR LFG AND VOCS IN SOIL VAPOR

The following are findings of the RI as discussed above:

- Methane intrusion into buildings at or adjacent to the Landfill is not occurring:
  - Buildings at SRDS were either built with methane mitigation or undergo routine monitoring by SPU staff with no detected methane.
  - Screening of buildings at the KIP and 7901 parcels for methane and explosive gases occurred quarterly for 4 quarters. No methane was detected.
  - Screening of buildings along 5th Avenue South across from the Landfill occurred quarterly for 4 quarters. No methane was detected.
  - No buildings existed on the SPPD parcel at the time of the RI; the new building on the parcel is equipped with methane mitigation and an alarm.
- Methane concentrations measured in the subsurface of the Landfill during the RI range from non-detect to approximately 20 percent (the greatest recorded since 2011 within the landfill footprint is 28 percent at GP-17, an area that is now controlled by the LFG system installed as part of the SPPD IA). Typical concentrations are below 10 percent and many areas are below 1 percent. Similar conditions have been observed at the Landfill since the 1990s.
- The historical swale, adjacent to the landfill, has LFG concentrations ranging from non-detect up to 85 percent, depending on location and season. LFG in the swale appears to be influenced by the interaction of the water table and the overlying CKD unit.

- Perimeter probes are in compliance for LFG except in the following locations:
    - The historical KIP swale; this area will be discussed in the FS.
    - The area along 5th Avenue South adjacent to the SPPD parcel; the LFG Control System component of the SPPD IA has brought this area into compliance; but it is still discussed as part of the FS since the system will need to maintain control sufficient to keep the area in compliance.
    - The area around GP-33, which is also under the SPPD LFG system area of control, has just been brought into compliance. On-going work is occurring to confirm that it stays in compliance.
- Consistent with Ecology's 2015 guidance on vapor intrusion, the low levels of VOCs detected in soil vapor and groundwater are insufficient to cause vapor intrusion issues and do not require further evaluation.

# 7.0 Remedial Action Requirements

This section identifies the requirements that must be met for an alternative to comply with MTCA for a remedial action at the Settlement Area, which is a portion of the Site. The Settlement Area does overlap a portion of the Landfill, therefore discussion on remedial actions necessary to address the Landfill will also apply to the Settlement Area.

## 7.1 MTCA CLEANUP REQUIREMENTS

In order to meet the requirements of MTCA, the selected remedy must be protective of human health and the environment under specified exposure conditions. WAC 173-340-360(2)(a) specifies four threshold criteria that all cleanup actions must satisfy. The threshold criteria are:

1. Protect human health and the environment.
2. Comply with cleanup standards (WAC 173-340-700 through WAC 173-340-760).
3. Comply with applicable local, state, and federal laws (WAC 173-340-710).
4. Provide for compliance monitoring (WAC 173-340-410 and WAC 173-340-720 through WAC 173-340-760).

In addition, WAC 173-340-360(2)(b) specifies three other criteria that alternatives must achieve:

1. Use permanent solutions to the maximum extent practicable.
2. Provide for a reasonable restoration time frame.
3. Consider public concerns (WAC 173-340-600).

Because of the typical size and history of landfills, Washington State has determined that it is impracticable to treat or move a closed solid waste landfill and has outlined specific requirements that allow a solid waste landfill to be closed in place in a manner that meets the MTCA criteria identified above. As a starting point, MTCA uses the closure requirements promulgated in 1985 as Minimum Standard Functions for Landfills (WAC 173-304) as the preferred remedy requirements (refer to WAC 173-340-710(7)(c)) and then modifies them as needed to meet MTCA cleanup requirements.

Closed landfills are considered under MTCA to be sites that have used "containment of hazardous substances" as the preferred remedy. Under WAC 173-340-740(6)(f), MTCA defines the expectation for containment sites as follows:

> *"WAC 173-340-740(6)(f) The department recognizes that, for those cleanup actions selected under this chapter that involve containment of hazardous substances, the soil cleanup levels will typically not be met at the points of compliance specified in (b) through (e) of this subsection. In these cases, the cleanup action may be determined to comply with cleanup standards, provided:*
>
> *(i) The selected remedy is permanent to the maximum extent practicable using the procedures in WAC 173-340-360;*

> *(ii) The cleanup action is protective of human health. The department may require a site-specific human health risk assessment conforming to the requirements of this chapter to demonstrate that the cleanup action is protective of human health;*
>
> *(iii) The cleanup action is demonstrated to be protective of terrestrial ecological receptors under WAC 173-340-7490 through 173-340-7494;*
>
> *(iv) Institutional controls are put in place under WAC 173-340-440 that prohibit or limit activities that could interfere with the long-term integrity of the containment system;*
>
> *(v) Compliance monitoring under WAC 173-340-410 and periodic reviews under WAC 173-340-430 are designed to ensure the long-term integrity of the containment system; and*
>
> *(vi) The types, levels, and amount of hazardous substances remaining on-site and the measures that will be used to prevent migration and contact with those substances are specified in the draft cleanup action plan."*

For closed solid waste landfills, Ecology allows for containment to be the remedial action with MFS as an ARAR. It is not necessary to evaluate removal actions or perform a disproportionate cost analysis (as otherwise required under WAC 173-340-360); however, the specific remedy selected for the Landfill must demonstrate that the other elements of containment are met as defined by sections (ii) through (iv) above. This FS focuses on screening alternative approaches consistent with the landfill closure ARAR that would meet the requirements of containment under MTCA as described above—for example, determining site-specific alternatives for LFG controls that would comply with WAC 173-340-740(6)(f).

The approach of this FS is to use MFS (WAC 173-304) as a starting point and a relevant and appropriate requirement for defining the MTCA remedy for the Landfill. Approximately 10 years after MFS was developed, USEPA published their *Presumptive Remedy for CERCLA Municipal Landfill Sites Directive* (USEPA 1981[9]). This document was based on USEPA's experiences on multiple solid waste landfill sites and reflected a growing body of knowledge regarding the key components that were necessary to build long-term containment remedies at solid waste landfills. This FS uses criteria from USEPA's presumptive remedy to refine the MTCA remedial action for the Landfill, while continuing to treat MFS as a key ARAR. The remedy described in the FS follows the concepts in MTCA, MFS, and USEPA's guidance, and uses the term "presumptive remedy" to remind the reader of the large body of knowledge that exists regarding long-term oversight of solid waste landfills.

[9] Subsequent updates to the original Presumptive Remedy Guidance can be found at https://www.epa.gov/superfund/contaminant-media-and-site-type-specific-remedy-guidance#landfill.

### 7.2 LANDFILL CLOSURE REQUIREMENTS

The Landfill is a historical municipal landfill that was originally closed in 1966 under Title 10 of the Seattle-King County Health Code. In 1972, the State of Washington passed the first MFS for Solid Waste Landfills (WAC 173-301). In 1985, this was replaced by WAC 173-304, which is now referred to as the Minimum Functional Standards for Landfills, or simply MFS. Solid waste landfills operating after October 1991 are required to meet another set of the landfill requirements, WAC 173-351. Because the Landfill closed in 1966, none of the closure requirements in WAC 173-301, 173-304, or 173-351 are applicable requirements; however, MTCA (WAC 173-340-710(7)(c)) uses 173-304 to define a preferred remedy for closed, historical solid waste landfills (as discussed above).

The requirements described in MFS are designed to ensure that a landfill is closed in a manner that:

1. Minimizes the need for further maintenance.
2. Controls, minimizes, or eliminates threats to human health and the environment from post-closure escape of municipal solid waste constituents, leachate, LFGs, and contaminated rainfall or waste decomposition products to the ground, groundwater, surface water, and the atmosphere.
3. Prepares the site for the post-closure period. The post-closure period must allow for continued facility maintenance and monitoring of air, land, and water as long as necessary for the facility to stabilize and protect human health and the environment.

After MFS was promulgated at the state level, the USEPA, in 1991, defined in more detail the presumptive remedy for solid waste landfills that were undergoing cleanup under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). USEPA issued a directive (OSWER Directive 9355.3-11) that established containment as the presumptive remedy on CERCLA municipal landfills. The framework for the remedy was then presented in a manual, *Conducting Remedial Investigations/Feasibility Studies for CERCLA Municipal Landfill Sites,* February 1991 (USEPA 540/P-91/001). The framework in the USEPA guidance manual is used to structure the following discussion; individual sections discuss in more detail what considerations derive from the MFS citation in MTCA.

Components of the presumptive remedy for the source area (extent of solid waste) include the following:

- Landfill cap including stormwater controls
- Source area groundwater controls to contain plume including leachate collection and treatment, if needed
- LFG collection and treatment
- Institutional controls to supplement engineering controls

The presumptive remedy guidance does not address remedial actions for a groundwater plume beyond the source control area or long-term monitoring; however, these are required under MFS and under MTCA. This RI/FS, therefore, adds the following as components of the presumptive remedial action:

- Address downgradient groundwater contamination if necessary
- Implement long-term monitoring

The components of the containment presumptive remedy identified above meet both the MTCA requirements for cleanup and the closure and post-closure requirements of MFS. Each component is described in more detail in Section 8.0.

## 7.3 REDEVELOPMENT AND LAND USE GOALS

In order to meet the cleanup requirements identified above, it is important that the selected remedy meets the goals for the Settlement Area in both its present state and in planned future uses, such as the redevelopment of the SRDS parcel. Redevelopment of the Settlement Area will include components of the presumptive remedy as described above, will ensure protectiveness of human health and the environment, and need to be included as constraints throughout the redevelopment of the properties.

### 7.3.1 Redevelopment of the South Park Property Development Parcel

In 2014 and 2015, SPPD performed an IA for cleanup at the parcel per the 2013 Ecology-approved IAWP under Amendment No. 1 of Agreed Order No. DE 6706 for the Site (Farallon 2013). The IA was performed simultaneously with the redevelopment of the property. The property redevelopment includes a modular building for employees and paved parking for employees and visitors. The IA work included regrading and capping the Landfill surface, installing and operating a LFG control system, installing new stormwater facilities, implementing institutional controls, and conducting monitoring. The IA was designed with the expectation of meeting the final cleanup action elements of the CAP. The IA did not address the obligations in the CAP for ongoing operation, maintenance, and monitoring (OMM). Ecology has reviewed the results of the IA in the CAP to determine if the remedial action meets the requirements of the final cleanup action.

### 7.3.2 Redevelopment Goals for the South Recycling and Disposal Station Parcel

The SRDS parcel has been in operation since 1966 as a transfer station for municipal solid waste and other recyclable materials. In spring 2013, the City opened a new solid waste transfer station across the street on South Kenyon Street. Both the SRDS and the new transfer station are accepting the City's solid waste while the City is rebuilding the NRDS in Fremont/Wallingford. When construction of the NRDS is complete (likely in 2016), the City will clean up and redevelop the SRDS as a support arm of the new STS. The cleanup will happen as an IA under Amendment No. 2 of Agreed Order No. DE 6706 to meet the City's capital plan schedule. The cleanup will be consistent with the 2015 Ecology-approved IAWP (Herrera and Aspect 2015). The IA includes installation of asphalt, concrete, or membrane caps, and LFG and surface water controls;

implementation of institutional controls; and compliance monitoring. The LFG collection system will include horizontal (trench) collectors, conveyance piping, and vents to address areas covered by cap materials as well as new buildings planned for construction. Both LFG and groundwater will be monitored to assess the effectiveness of the IA on the SRDS portion of the Landfill. After approval of a final CAP, this monitoring of the SRDS portion of the Landfill will become part of the Settlement Area-wide, long-term monitoring plan

The IA was designed with the expectation of meeting the final cleanup action elements of the CAP. The IA did not address the obligations in the CAP for ongoing OMM. Ecology will review the results of the IA under the CAP to determine if the remedial action meets the requirements of the final cleanup action. Renovation of the existing SRDS parcel would be consistent with requirements for the final cleanup, and operations would be consistent with the Environmental (Restrictive) Covenant for the closed Landfill.

# 8.0 Presumptive Settlement Area Remedy Components

This section describes each component of the presumptive remedy in more detail and identifies its purpose and how it relates to the conditions of landfills.

## 8.1 LANDFILL CAP INCLUDING STORMWATER CONTROLS

Implementing a landfill cap and managing surface water and stormwater at the Landfill is part of the containment remedy, as it (1) blocks human and terrestrial receptor contact with the contained soil and refuse, (2) minimizes infiltration of waters into the Landfill and the potential for contaminant leaching to groundwater, and (3) prevents conveyed stormwater from coming into direct contact with the Landfill contents.

Landfill caps control the amount of infiltration that occurs due to stormwater runoff into any remaining solid waste still located at a site. The design of the cap and its required permeability is dependent on the stage of the landfill and the condition of the groundwater within and downgradient of the landfill. In all cases, the landfill cap must be designed in a manner to reduce the migration of contaminants from the solid waste to the groundwater.

As part of an effective cap design, the management of stormwater and its conveyance must be addressed. Typically, infiltration of stormwater should be minimized to prevent the formation of leachate and stormwater conveyed through a stormwater system to a central discharge point where it can be discharged to a nearby surface water body, infiltrated into an area that is not upgradient of the landfill, or discharged to a municipal sewer system.

A more detailed description of the existing and future landfill cap for the Landfill is provided in Section 9.0. Stormwater controls are described in further detail in Section 12.0. In both sections, the specific conditions at the Landfill are used to define the technologies or characteristics of the remedial component that would be appropriate for the Landfill.

## 8.2 SOURCE AREA GROUNDWATER CONTROL TO CONTAIN PLUME INCLUDING LEACHATE COLLECTION AND TREATMENT

As part of the containment remedy, groundwater at the CPOC must meet the groundwater CULs. If groundwater does not meet the CULs at the CPOC, then the amount of leachate entering groundwater must be limited until the leachate is no longer contributing to the groundwater exceedance at the CPOC. Two methods are typically implemented to prevent leachate intrusion into the groundwater system. The first is control of groundwater by minimizing the amount of groundwater interacting with the solid waste. This can be done by lining stormwater ditches or tight lining stormwater conveyance systems and designing site components to direct groundwater flow to areas outside of solid waste. The second method is done by collecting and treating contaminated leachate. If the groundwater is not contaminated at the CPOC, then leachate control may not be required.

The implementation of either method is dictated by the stage of a landfill and the condition of the groundwater. Leachate within older landfills may not be as impacted as newer landfills and may not require such controls in order to protect groundwater quality. If analytical sampling of groundwater demonstrates downgradient contaminant migration through groundwater is not occurring, then the plume can be considered to be contained, in which case, leachate control may not be required.

More detailed descriptions of the groundwater conditions and leachate controls are provided in Section 10.0.

## 8.3 LANDFILL GAS COLLECTION AND TREATMENT

An additional component of the presumptive remedy is ensuring that the LFG is addressed properly. LFG may be managed via a gas collection and treatment system or monitoring to ensure that the LFG levels are safe. Various gas systems can meet this requirement and, similar to the landfill cap, the final design is based on the stage of a landfill and the conditions of the LFG itself. The LFG system must be designed to capture the gas within a landfill and ensure that the gas does not migrate outside of the Landfill boundary, and that the gas is discharged safely.

In addition to a collection system, the LFG controls may include provisions for the protection of buildings, utility corridors, and other surface and subsurface structures. Controls such as these, including vapor barriers and passive venting systems, ensure that the LFG does not enter these structures and provides safety to human health and the environment.

A more detailed description of the LFG controls is provided in Section 11.0.

## 8.4 INSTITUTIONAL CONTROLS TO SUPPLEMENT ENGINEERING CONTROLS

As part of the containment presumptive remedy, institutional controls are typically implemented at a landfill to ensure the integrity of the containment systems and to ensure the health and safety of the users of the landfill. Typical controls include long-term operation and maintenance plans, and activity restrictions and implementation procedures. The exact nature of the institutional controls is site-specific and is dependent upon the selected remedy for the landfill cap, stormwater controls, and leachate controls. There are numerous methods of implementing the selected institutional controls, one of which is an Environmental (Restrictive) Covenant that outlines the controls on a landfill in a legally binding document.

A more detailed description of the selected institutional controls and their implementation is included in Section 15.0.

## 8.5 DOWNGRADIENT GROUNDWATER

In addition to addressing the contaminated leachate within the Landfill as described in Section 8.2, it is necessary to identify and address any contaminated groundwater that is downgradient that can be attributed to the Landfill. Leachate control, if necessary, will address the future spread of contamination by limiting the contribution of contaminated groundwater to the downgradient area, while the downgradient groundwater cleanup will address any contamination that is already beyond the edge-of-refuse.

Similar to the other components of the presumptive remedy, the scope of the downgradient groundwater cleanup is dependent upon the conditions of the groundwater and the downgradient areas.

A more detailed description of how downgradient groundwater will be addressed is included in Section 13.0.

### 8.6 LONG-TERM MONITORING

To ensure that the selected components of the presumptive remedy of containment are implemented efficiently and are operating properly, long-term OMM of the various components must be implemented to provide long-term protection of human health and the environment, long-term monitoring of the cap and cover, gas, and groundwater. Stormwater monitoring is not required as part of the MTCA process for the Landfill because the conveyed stormwater will not come into contact with the solid waste.

A more detailed description of the planned OMM and its implementation is included in Section 14.0.

# 9.0 Landfill Cap Control Alternatives within the Settlement Area

This section evaluates the landfill cap components of the presumptive remedy, which will be used to minimize infiltration of stormwater and prevent direct contact with the contents of the Landfill within the Settlement Area. This section identifies the design requirements that must be met during redevelopment of all the parcels within the Settlement Area. The landfill cap is also an essential component of the LFG control systems and stormwater systems, which are described in Sections 11.0 and 12.0, respectively.

## 9.1 EXISTING CONDITIONS

Developed parcels that fall within the Settlement Area, either entirely or partially, were primarily developed prior to the establishment of WAC 173-304, which determines the MFS for capping and covering landfills. Because no specific MFS was required, the existing cap and cover conditions of the Landfill are highly dependent on the land use for which each parcel was developed. This is discussed by parcel in the following sections.

### 9.1.1 The SPPD Parcel

The SPPD property includes 21.0 acres that are within the Landfill. SPPD completed an IAWP (Farallon 2013). The IA included grading and capping the Landfill surface in accordance with IAWP. These activities were completed by early 2015. The landfill cap on the SPPD parcel consists of two types of systems, an asphaltic concrete cap and a low-permeability membrane cap.

### 9.1.2 The SRDS Parcel

The SRDS was completed in 1966 and has since been in use accepting solid waste from commercial haulers and local users. The majority of the parcel is paved, except for some landscaped areas along the eastern edge of the property adjacent to 5$^{th}$ Avenue South and a few landscape planter islands along the western side of the parcel. The parcel was partially filled and graded, both during the SRDS construction and during subsequent minor improvements. Other than the evident surface improvements, it is not known if other materials were incorporated into the parcel development for a landfill cap. The SRDS parcel will undergo demolition and redevelopment in accordance with an Ecology-approved IAWP. Redevelopment is likely to begin in 2017 and will include grading and capping the Landfill surface in accordance with minimum requirements of the CAP.

### 9.1.3 Other Areas

Sections of South Sullivan Street, 5$^{th}$ Avenue South, and the SR 99 ROW overlie the Landfill. As part of the SPPD IA, those sections of ROWs between the parcel and the City-maintained roadway were improved and now contain low permeability geomembrane covered with a vegetated layer that transitions to a paved walkway. A similar approach will be used with 5$^{th}$ Avenue South along the SRDS boundary and will be presented in the IAWP for Ecology's approval.

### 9.1.4 Leachate Production from Infiltrating Rainwater

Leachate production from infiltrating rainwater is not a concern at this landfill and does not influence the design requirements of the landfill cap for the following reasons:

- The Landfill was an unlined solid waste facility that operated from the late 1930s to the mid-1960s and was closed in 1966.
  - The landfill wastes are now more than 60 years old.
  - From 1966 to 2015, approximately 50 percent of the Landfill (the SPPD parcel and part of the SRDS parcel) was unpaved and rainwater falling on the unpaved sections infiltrated through the Landfill contents.
  - The base of the waste is in direct contact with groundwater under water table conditions.
- Leachate quality as measured in the KMW wells on the KIP parcel that are screened across the waste layer in a section that was paved since the late 1960s is barely distinguishable from ambient groundwater (this comparison can be found in Section 5.6).
- Reducing infiltrating rainwater by increasing the impermeability of the landfill cap will not significantly decrease the volume of leachate which is primarily controlled by the elevation of the groundwater table.

## 9.2 LANDFILL CAP REQUIREMENTS

Under MTCA (WAC 173-340-710), solid waste landfill closure requirements shall be per the regulations set forth in WAC 173-304. The MFS for a landfill cap, per WAC 173-304, are intended to perform two functions:

1. Minimize infiltration of stormwater into the solid waste, which creates additional leachate.
2. Provide protection to mitigate the direct contact exposure pathway to humans and the environment (disease vector control).

To achieve these functions, two alternatives are prescribed for landfill caps in WAC 173-304-460. The first is placement of at least 2 feet of low permeability soil (permeability of less than $10^{-6}$ cm/sec). The second is a geomembrane layer with a 50-millimeter minimum thickness.

WAC 173-340-710(4)(f) allows for variances or waiver provisions that are included in other applicable regulations to be accessible as part of the MTCA process. Based on this allowance and the conditions in which the Landfill was originally closed and individual associated parcels were developed, a variance from the prescribed landfill cap alternatives in WAC 173-304-460 is being sought to allow cover material with greater permeability than $10^{-6}$ cm/sec.

### 9.2.1 Alternative Landfill Cap Requirement

A variance, as allowed by WAC 173-340-710, from the MFS for the cap material associated with WAC 173-304 is appropriate for the Landfill based on the following information:

1. The Landfill was closed in 1966 in accordance with applicable regulations at the time.
2. Those parcels that have been developed were done so prior to the issuance of the MFS set forth in WAC 173-304, which was adopted in 1985. These properties have operated without any documented incidents concerning the direct contact exposure pathway and have reduced stormwater infiltration into the Landfill.
3. The unlined Landfill extends into the water table and is in permanent contact with groundwater with or without stormwater infiltration, limiting the importance of stormwater in the production of leachate.

Any proposed variance still needs to maintain cleanup actions that protect human health and the environment (WAC 173-340-710). The functions of the landfill cap, listed above in Section 9.2, will need to be met as well.

Specific details of construction requirements for each type of section (road surfacing/hardscapes; landscape areas, vegetative slopes, and gravel road shoulders; stormwater conveyance and treatment, and building foundations) are included in Section 9.3, but are described in general below.

The following cap cross section is proposed to meet the alternative cap requirements for areas of the Landfill that are or will be covered by pavement:

1. A minimum of 12 inches of fill material will be placed over the solid waste. This fill material does not need to meet a low permeability standard. Existing fill that meets this depth requirement will be considered acceptable.
2. Additional fill or fill of specific geotechnical specification will be placed in order to meet the structural section requirements of road base as required by the project geotechnical engineer.
3. A minimum thickness of 3 inches for asphaltic concrete or a minimum thickness of 4 inches for cement concrete will cover the fill. SDOT has also requested that any sidewalks (not intended to include driveways) in the area be allowed to use a City standard sidewalk section of 2 inches instead of 3 inches; the thinner section is expected to be protective, given the significantly lower weight loads of pedestrians. However, the sidewalks will be expected to be maintained to prevent direct contact with refuse.
4. The sections will be designed to support the inclusion of stormwater infrastructure to collect and convey the stormwater away from the Landfill. This will further limit the amount of infiltration. Stormwater controls are discussed in further detail in Section 12.0.

Other areas, such as landscaped buffers and slopes, planter islands, or gravel road shoulders that will not be paved or receive hardscape (i.e., concrete) will require a minimum 24-inch-thick soil layer and a distinct visible barrier between the new improvements and the top of solid waste. On the SRDS parcel, there is an existing area with large, established trees. These cap requirements are not intended to require their removal. The requirement associated with the trees is to ensure that the landscaping at the base of the trees blocks direct contact with refuse.

Stormwater conveyance and treatment facilities located above solid waste such as swales, ditches, or ponds on the Landfill will be required to have cover, as prescribed by WAC 173-304-460, consisting of a low-permeability layer with a minimum 24-inch thickness of soil with permeability of $10^{-6}$ cm/sec or less, or a 50 millimeter or thicker impermeable geomembrane.

### 9.2.2 Selection of Cap Alternative

To support selection of the proposed landfill cap, a limited disproportionate cost analysis (DCA) following MTCA requirements has been conducted to evaluate the proposed alternative landfill cap requirement relative to MFS-compliant options presented in WAC 173-304-460. Section 9.2.1 defined why a variance from the MFS requirements is appropriate. The DCA further supports the decision-making.

The limited DCA was performed on the landfill cap areas that are or will be covered by pavement. The areas evaluated were the portion of the SPPD parcel that were paved as part of their 2015 IA and the SRDS parcel. The SRDS parcel is undergoing an IA and, for this exercise, it was assumed that 95 percent of the parcel will be paved. In combination, the paved portion of the SPPD and the SRDS parcels cover 27.1 acres.

For the DCA, three alternatives were evaluated:

- **Alternative 1 (proposed alternative with MFS variance):** 12 inches of fill (with no low permeability standard), 6 inches of subbase, 4 inches of asphalt
- **Alternative 2 (MFS alternative):** 2 feet of low permeability soil, 6 inches of subbase, 4 inches of asphalt
- **Alternative 3 (MFS alternative):** 50-millimeter welded geomembrane, 12 inches of fill that does not need to meet the low permeability standard, 6 inches of subbase, 4 inches of asphalt

The proposed alternative (Alternative 1), has an estimated cost of $6,090,000. Alternatives 2 and 3 have added costs—above the baseline cost of Alternative 1—of $2,300,000 and $8,950,000, respectively, with no added environmental benefit.

All alternatives evaluated provide an effective barrier to direct contact with solid waste, and also provide equivalent erosion protection. When combined with the required stormwater infrastructure, all alternatives reduce infiltration of stormwater into the solid waste.

As discussed in Section 9.1.4, due to the age of the unlined landfill and leachate quality as compared to ambient groundwater, leachate production from infiltrating rainwater or groundwater movement is not a concern at this landfill and does not influence the design requirements of the landfill cap. The MFS alternatives utilize low permeability soil (permeability of less than $10^{-6}$ cm/sec) or a geomembrane layer with a 50-millimeter minimum thickness to create a low-permeability layer as part of the landfill cap. However, given groundwater conditions, addition of a low-permeability layer within the landfill cap does not improve protectiveness, permanence or effectiveness of the remedial action.

Comparison of alternatives to the DCA evaluation criteria defined in MTCA is summarized below:

- **Protectiveness:** Alternatives 1, 2, and 3 provide equivalent protectiveness of human health and the environment. With all three alternatives, solid waste remains contained below a cap that protects direct contact pathways, and minimizes erosion.
- **Permanence:** Alternatives 1, 2, and 3 have an equivalent degree of permanence; with all three alternatives, solid waste remains contained below the landfill cap.
- **Cost:** Capital costs for implementation of Alternatives 2 and 3 are significantly greater than Alternative 1. Long-term costs for operations, maintenance, and monitoring would also likely be greater for Alternatives 2 and 3, if MFS requirements for monitoring and repair of low-permeability barriers were implemented.
- **Effectiveness Over the Long-Term:** Alternatives 1, 2, and 3 are equivalently effective over the long-term. They are all capping alternatives that will require operations, maintenance, and monitoring to ensure that the cap functions remain in place long-term.
- **Management of Short-Term Risks:** Because Alternatives 2 and 3 require significantly more import of construction materials, there will be a greater number of truck trips required for Alternative 2 and 3 construction, increasing short-term risks related to truck traffic and haul routes.

## 9.3 IMPLEMENTATION OF ALTERNATIVE LANDFILL CAP REQUIREMENT

### 9.3.1 Implementation Schedule

At present, the SPPD parcel and the adjacent ROW are in compliance with the requirements described above. The SRDS is undergoing an IA that will bring it and the adjacent ROW into compliance in the next couple of years (the specific schedule will be in the IA Engineering Design Report).

Environmental (Restrictive) Covenants (refer to Section 15.0) are required as part of closure so that future parcel owners are aware these parcels are underlain by a closed landfill and that special precautions will be needed when performing subsurface work such as utility trenching or redevelopment. The schedule for placement of the Environmental (Restrictive) Covenants will be included in the CAP.

### 9.3.2 Road Surfacing/Hardscape

This section describes minimum cap requirements for areas of the Settlement Area that will be covered by pavement, sidewalk, or buildings. These minimum requirements may be exceeded due to SDOT, WSDOT, or other site development requirements.

The following cap cross section is proposed to meet the alternative cap requirements for areas of the Settlement Area that will be covered by pavement, sidewalk, or buildings:

1. A minimum of 12 inches of fill material will be placed over solid waste. Fill material does not need a low permeability standard. Existing fill that meets this depth will be considered acceptable.
2. Additional structural fill will be placed as needed to meet the structural section of road base as required by the project geotechnical engineer.
3. A minimum thickness of 3 inches for asphaltic concrete or a minimum thickness of 4 inches for cement concrete will be placed on the fill layer. SDOT has also requested that any sidewalks (not intended to include driveways) in the area be allowed to use a standard sidewalk section of 2 inches instead of 3 inches; the thinner section is expected to be protective given the significantly lower weight loads of pedestrians.

### 9.3.3 Landscape Areas, Vegetated Slopes, and Gravel Road Shoulders

Landscape areas, vegetated slopes, gravel road shoulders, or areas not receiving road pavement, sidewalks, or buildings, will require a soil layer with a minimum thickness of 24 inches and a distinct visible barrier between the new improvements and the top of the solid waste.[10] The soil used as fill must not introduce new contaminants or contain contaminant concentrations exceeding MTCA industrial CULs. Proposed variances to these soil thickness specifications and justification may be submitted to Ecology for approval. On the SRDS parcel, there is an existing area with large, established trees. The landfill cap requirements specified above are not intended to require their removal. The requirement associated with the trees is to ensure that the landscaping at the base of the trees blocks direct contact with refuse.

These measures will also act as a barrier to prevent a direct exposure pathway to the solid waste. Normal maintenance of landscaping (i.e., installation of trees or bushes) could bring humans into contact with the solid waste. In these areas of potential human contact, a visible barrier should be installed if a geomembrane is not utilized. The barrier should be a long-lasting material, distinctly colored to denote the transition of the cap material to the solid waste. Environmental (Restrictive) Covenants for the parcels will require that workers are informed of the purpose of the barrier and the procedures to follow if work has to be done below the barrier.

[10] The visible barrier may not be reasonable in the existing landscaped areas without removing existing trees. The barrier should be placed where practicable, and is not intended as a requirement to remove existing trees and large scrubs.

Existing road shoulders and medians have functioned adequately as a protective barrier for the solid waste. No work is required in these areas unless they are included in construction activities.

### 9.3.4 Stormwater Conveyance and Treatment Facilities

Biofiltration ponds, swales, or other engineered stormwater quality treatment facilities may be located within the Landfill boundary; however, the design of these facilities will need to include one of the alternative cross sections listed below to prevent increased stormwater from contacting solid waste and to limit infiltration.

Two alternative cross sections are proposed for these areas:

1. A minimum 50-millimeter geomembrane extended a minimum of 2 feet under the pavement adjacent to the Landfill boundary. The geomembrane must be buried a minimum of 18 inches below finished grade.
2. A minimum 24-inch-depth section of low-permeability soil ($10^{-6}$ cm/sec or less) overlaid with a minimum of 6 inches of topsoil.

#### *9.3.4.1 The North Bioswale on the SPPD Parcel*

The North Bioswale constructed on the SPPD parcel as part of the IA uses a 60-millimeter geomembrane layout equivalent to the first alternative above in accordance with the 2013 Ecology-approved IAWP.

#### *9.3.4.2 The Former West Ditch and New West Bioswale*

The former West Ditch is part of the Settlement Area and the Site. The former West Ditch is not part of the "contained landfill," rather, it historically served as part of the stormwater system for the SPPD parcel. Soil in the ditch was investigated as part of the RI. It was found to contain PAHs, PCBs, metals, petroleum hydrocarbons, and very low concentrations of two common pesticides. All concentrations are less than MTCA CULs for soil at industrial sites.

As part of the SPPD redevelopment, the soils in the bottom of the former West Ditch were solidified by mixing in a Portland cement mixture to limit groundwater upwelling through the base of the ditch. The low-permeability membrane cap system was installed along the eastern slope of the former West Ditch and keyed into the solidified material, effectively capping exposed solid waste in this in the eastern sidewall of the Ditch. Soil on the western side of the former West Ditch was covered with a distinct visible barrier that was overlain with a minimum of 18 inches of clean fill material or top soil. The design and the basis for the design of the former West Ditch sediment solidification aspect of the surface water control component of the SPPD IA were presented in the Ecology-approved IAWP.

### 9.3.5 Building Foundations

Building foundations designed for new and/or future development on the Settlement Area may be relatively shallow spread footings or slab on grade, or may include the use of piles. Regardless of the foundation style, mitigation of methane gas as discussed in Section 11.0 will need to be incorporated into the design. An impermeable vapor barrier will be required under all building foundations and floor slabs.

Since the Landfill is unlined and in direct contact with groundwater, pile foundations may be allowed at the Landfill. The design will need to be approved by Ecology as consistent with landfill conditions and will address the following issues:

- Potential effects on the interaction of solid waste and groundwater, especially as in regard to drag-down of waste deeper into the aquifer.
- Potential creation of new migration pathways for contaminants.
- Disposal of waste if pile installation requires the use of an auger to predrill a hole through soil and waste for installation.

#### *9.3.5.1 Requirements on the Use of Pilings*

Pilings are not a component of the remedial action at the Settlement Area. However, the use of pilings to support buildings at the Landfill has occurred in the past and is expected to continue to occur in the future. Because the Landfill is not lined and is already in contact with groundwater, there is no prohibition against the use of pilings. However, the design and installation of any future pilings must be consistent with the following remedial action goals:

- The pilings must not create new pathways between the “leachate” zone and deeper groundwater that would result in a worsening of groundwater quality. Short-term effects during installation may be allowed, but should be minimized by the types of pilings and the means of installation.
- The type of piling and the means of installation must minimize the potential for drag down of refuse and/or contaminated soil during installation.
- The type of piling and its connection to the building foundation must minimize the potential for LFG intrusion into structures.

The use of pilings would be a major entry into the contained section of the Settlement Area and would require approval from Ecology consistent with requirements for other major redevelopment activities.

## 9.4 CONSTRUCTION PRACTICE REQUIREMENTS

This section describes considerations for construction practices on the Settlement Area to mitigate health and safety concerns for workers and maintain environmental controls. Exposure and contact with solid waste are of concern during any construction on a closed landfill site. Additionally, the presence of LFG is a concern during construction activities and needs to be recognized. For construction activities that include disturbance of subsurface materials beneath the landfill cap, all contractors must have a Health and Safety Plan in place during all construction activities that specifically addresses risks associated with construction on landfill sites. This plan should be created by a certified industrial hygienist to ensure that it meets all appropriate occupation and health standards. In addition, requirements and procedures specified in the OMMP, as further described in Section 14.0 and included as Appendix A of the CAP, must also be followed.

Additional construction controls for future site development on any of the parcels associated with the Settlement Area should include the following:

- **Dust and windblown solid waste controls during construction:** In addition to the City's dust control requirements in the City of Seattle Standard Specifications (Section 212; SPU 2014), exposed solid waste may need to be covered daily to prevent odors and material from leaving the parcel. A plan for handling, loading, and reinterring or off-site hauling of solid waste will need to be established and approximate quantities calculated.
- **Erosion control:** Stormwater Best Management Practices (BMPs) should be established to prevent stormwater from entering excavations or stockpiled solid waste. The use of earthen berms or other means should be implemented to control and collect stormwater during construction.
- **Health and safety requirements for construction crews:** Each contractor that works on the Landfill should be made aware that it is a closed landfill, and be made to understand the inherent risks involved. A Health and Safety Plan prepared by a licensed industrial hygienist should be prepared by each prime contractor. The prime contractor is responsible for subcontractor compliance with their Health and Safety Plan.
- **Construction dewatering procedures:** Excavation activities on the Landfill may encounter perched groundwater in solid waste that will need to be removed to facilitate construction. This water will need to be managed according to an approved Stormwater Pollution Prevention Plan (SWPPP) and to the pertinent water quality standards associated with a construction site.

  Testing of the water to meet the County's pretreatment standards or groundwater quality standards will need to be done prior to any discharges.
- **Construction performance monitoring and inspection:** Monitoring of all construction activities within the Landfill should be required. The contractor should have contingency plans in place to respond to odor, erosion, and dewatering activities.

### 9.5 LANDFILL GAS CONTROLS

LFG control systems are usually incorporated into the cover system for closed landfills. The combination of low-permeability materials and a negative (vacuum) pressure system helps to capture and control the gases generated from the solid waste. The LFG control system should be taken into consideration when determining appropriate cover thicknesses and materials. The LFG collection system is described in further detail in Section 11.0.

Utility trenches can become a conduit for LFG migration from a landfill to surrounding areas, because pipe bedding material can be more permeable than the surrounding soils. Where utility trenches cross the Landfill boundary, a low-permeability plug (lower than the surrounding soil) should be installed in place of pipe bedding material.

### 9.6 COMPLIANCE WITH MTCA REQUIREMENTS

The landfill cap component of the remedy described in this section complies with the MTCA requirements for a selected remedy. A description of how the MTCA requirements are met is included in Section 16.0.

# 10.0 Leachate Control Evaluation within the Settlement Area

This section addresses leachate control, and describes why leachate controls are not required for the Landfill.

## 10.1 LANDFILL CONDITIONS

Leachate controls are designed at landfills to prevent contaminants in the waste from leaching and/or migrating into groundwater. Because of the age of the landfill, and other site-specific conditions, leachate no longer has a significant impact on groundwater quality. Key RI observations (presented in Section 5.0) supporting this conclusion include the following:

- The Landfill is old, unlined, and in direct contact with groundwater, and in late Stage 4/early stage 5 conditions. From its closure in 1966 until 2015, 60 percent of the Landfill surface was uncapped and allowed rainfall to the site to infiltrate. Degradation of landfill contents is such that any significant leaching is no longer evident in groundwater leaving the site.
- Several monitoring wells (refer to Section 5.6.6) were installed either through solid waste and are screened below the base of the Landfill or at the downgradient edge of the solid wastes. The groundwater wells represent leachate water quality. The leachate no longer contains organic acids and is near neutral; its salt content is now less than concentrations naturally occurring at the base of the aquifer (approximately 20 to 30 feet below the Landfill).
- Based on the existing well coverage and groundwater sampling results, leachate and groundwater leaving the Landfill are in compliance for all COCs except for vinyl chloride, iron, and manganese.
- Leachate produced by infiltrating rainwater and groundwater is now similar to the surrounding groundwater, with a neutral pH and few contaminants as discussed in Section 5.6. This can be seen by comparing the water quality in the KMW wells that are screened across waste with the water quality of those MW wells that are screened deeper in the A-zone. This comparison was made in Section 5.6.

Given the lack of significant source and leachate impacts left in the Landfill, leachate controls designed to eliminate entrainment of contaminants into leachate and its discharge into groundwater are not warranted at the Settlement Area.

No additional actions would be taken to address leachate at the Settlement Area. The landfill cap discussed in Section 9.0 would be installed and would have the effect of decreasing the amount of infiltrating rainwater. No measurable effect on leachate quality is envisioned.

The leachate control component of the remedy described in this section complies with the MTCA requirements for a selected remedy. A description of how the MTCA requirements are met is included in Section 15.0.

# 11.0 Landfill Gas Control Alternatives within the Settlement Area

This section evaluates the LFG component of the presumptive remedy that will be used to manage LFG, particularly methane, with concentrations at levels greater than the explosive limits. This section identifies the design constraints for the LFG control systems and identifies the options that may be used as part of the selected remedy for the Settlement Area.

## 11.1 LANDFILL GAS COMPOSITION AND CONCERNS

LFG can present a health and safety concern if methane and carbon dioxide are not controlled. Methane, which normally occurs in air at 2 ppm, is an explosion and fire hazard in air at concentrations greater than 5 percent by volume (50,000 ppm). The American Conference of Governmental Industrial Hygienists (ACGIH) has established a permissible exposure limit (PEL) of 1,000 ppm for methane. Also, carbon dioxide, which occurs normally in air at 300 ppm, is a health hazard at concentrations greater than 5,000 ppm (Occupational Safety and Health Administration [OSHA]/Washington Industrial Safety and Health Act [WISHA] time-weighted average PEL). In addition to this, both of these compounds can pose an asphyxiation hazard by displacing air in confined spaces, such as underground vaults or rooms with no air circulation.

In addition to the major LFG constituents, toxic VOCs may be present and if so, their intrusion into ambient air may need to be controlled. Section 6.5 addressed the potential for VOCs in soil vapor to intrude into Landfill structures. Vinyl chloride and benzene were both identified as VOCs that have the potential to intrude into structures. Each exceeded Ecology's vapor intrusion screening level in one of six probes and at concentrations approximately twice their respective screening levels.

## 11.2 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

The following text presents pertinent regulations related to LFG applicable or relevant to: (1) owners of contaminated sites, and (2) owners of landfills. Refer to Table 5.1 in the CAP for the list of ARARs. This discussion pertains to activities on the Landfill.

Chapter 70.105D of the RCW (MTCA) requires Ecology to establish a program to identify sites potentially contaminated with hazardous substances. That program is set forth in WAC 173-340-300. Owners or operators of contaminated sites are required to follow notification, characterization, cleanup, and documentation processes stipulated in the regulation. The Landfill is considered a contaminated site according to MTCA; the cleanup process, including LFG issues, will be negotiated based on MTCA requirements.

Development will need to satisfy building occupant safety and building permit conditions imposed by the City. Public safety (building permits) and King County Board of Health regulations do require mitigating actions.

The King County Board of Health Title 10 regulations requires a permit from the Puget Sound Clean Air Agency (PSCAA) to install a LFG control system at the Landfill that requires discharge into ambient air. PSCAA requirements are negotiable, depending on proposed changes to existing emissions from a site. They will require a permit or Notice of Construction in order to receive an Order of Approval for an active LFG control system, but not for a passive system. If the system is installed as part of the remedial action under a MTCA Consent Decree, Order, or Agreed Order, a permit exemption will be requested; although the system will still be designed to be substantially equivalent to what would have been required under the permit.

Mitigating actions associated with LFG control should take current landfill regulations (WAC Chapter 173-351-200(4)) into account. MTCA cites several references to the WAC 173-304 and 173-351 codes for landfill closure and LFG control; however, because the Landfill was closed prior to adoption of these requirements, the regulations are not applicable, but serve instead as a guide to correct active LFG practices. WAC 173-351-200(4) stipulates requirements for monitoring and compliance with subsurface migration standards, excerpted below:

> *"(4) Explosive gases control*
>
> *(a) Owners or operators of all MSWLF units must ensure that:*
>
> *(i) The concentration of methane gas generated by the facility does not exceed twenty-five percent of the lower explosive limit for methane in facility structures (excluding gas control or recovery system components);*
>
> *(ii) The concentration of methane gas does not exceed the lower explosive limit for methane at the facility property boundary or beyond; and*
>
> *(iii) The concentration of methane gases does not exceed one hundred parts per million by volume of methane in off-site structures.*
>
> *(b) Owners or operators of all MSWLF units must implement a routine methane monitoring program to ensure that the standards of (a)(i) and (ii) of this subsection are met.*
>
> *(c) If methane gas levels exceeding the limits specified in subsection (4)(a)(i) or (ii) of this section are detected, the owner or operator must:*
>
> *(i) Immediately take all necessary steps to ensure protection of human health including:*
>
> *(A) Notifying the jurisdictional health department;*
>
> *(B) Where subsection (4)(a)(ii) of this section is exceeded, monitoring of off-site structures for compliance with subsection (4)(a)(iii) of this section;*
>
> *(C) Daily monitoring of methane gas levels unless otherwise authorized by the jurisdictional health department; and*
>
> *(D) Evacuation of buildings affected by landfill gas shall be determined by the jurisdictional health department and fire department.*

(ii) *Within seven calendar days of detection, place in the operating record, the methane gas levels detected and a description of the steps taken to protect human health; and*

(iii) *Within sixty days of detection, implement a remediation plan for the methane gas releases, place a copy of the plan in the operating record, and notify the jurisdictional health department that the plan has been implemented. The plan shall describe the nature and extent of the problem and the remedy.*

(iv) *The jurisdictional health department may establish alternative schedules for demonstrating compliance with (c)(ii) and (iii) of this subsection."*

The intrusion of VOCs from the subsurface, including from landfills, is regulated under MTCA. Emissions from a landfill must be controlled until indoor air CULs are met.

## 11.3 LANDFILL GAS QUALITY AT THE LANDFILL

LFG quality at the Landfill was assessed with over 1,100 samples collected over the last 20 years. Figures 6.1, 6.2, and 6.4 show the location of permanent and temporary LFG probes that were sampled at the Landfill. Information from those probes is presented in Tables 6.2 through 6.8. LFG will be monitored at the Landfill as discussed in Section 16.0.

The probes shown in Table 11.1 are part of the perimeter gas probe network.

**Table 11.1**
**Perimeter Gas Probe Locations**

| Perimeter Probe | Adjacent LFG System | Adjacent Off-Site Buildings[1] |
|---|---|---|
| GP-37 | SRDS | No |
| GP-09 | SRDS | No |
| GP-26 | SRDS | Yes |
| GP-23 | SRDS | Yes |
| GP-07 | SRDS/SPPD | Yes |
| GP-27 | SPPD | Yes, 5th Avenue South |
| GP-28 | SPPD | Yes, 5th Avenue South |
| GP-29 | SPPD | Yes, 5th Avenue South |
| GP-16[2] | SPPD | No |
| GP-31[2] | SPPD | Yes |
| GP-15 | SPPD | Yes, Lenci/Emerson |
| GP-32[2] | SPPD | Yes |
| GP-03[2] | SPPD | No |
| GP-13 | SPPD | Yes |
| GP-11 | SPPD | Yes |

| Perimeter Probe | Adjacent LFG System | Adjacent Off-Site Buildings[1] |
|---|---|---|
| GP-38 | None | No |
| GP-33 | SPPD | Yes |

Notes:

1 Adjacent off-site buildings within 100 feet are shown on Figure A.2.2.

2 Due to shallow groundwater, these probes are measured only when the water table is low enough for the probes to function.

## 11.4 LANDFILL GAS CONTROL METHODS

Common LFG control technologies include means to collect, convey, and treat LFG to comply with government regulations, odors, or uncontrolled releases that may pose health and safety concerns. LFG control objectives are generally focused on off-site migration, on-site accumulation control, or both. LFG control systems addressing migration and accumulation can be categorized as active, passive, or a combination of both. The control objectives and strategies for this Landfill will focus on both off-site migration and on-site accumulation control, considering both active and passive systems.

Several potential LFG control systems appropriate to the Settlement Area are presented below.

### 11.4.1 Passive Venting

LFG off-site migration is driven by a pressure gradient that develops over time between the gas-producing waste and the atmosphere. Gas can migrate through surrounding soil that is permeable, including a cover above or native material to the side or bottom. The rate of migration is determined by the magnitude of the pressure gradient, the type and permeability of the native soils, the geometry of the solid waste/native soil interface, and barometric pumping. Landfill cover systems can contribute to the gradient by preventing LFG escape and causing lateral migration. If the gradient is interrupted by a vent to the atmosphere, the path of least resistance will be through the vent instead of the surrounding soils. Passive venting of LFG to control off-site migration and on-site accumulation that can infiltrate structures has been successfully demonstrated throughout the United States.

The type of passive vent system used is often dependent on the depth of solid waste and the type of cover system. Shallow landfills less than approximately 20 feet deep can be vented with a horizontal trench and perforated pipe system. A deeper landfill may require the installation of vertical wells, tightly spaced and vented to the atmosphere, to provide the necessary "break" in the LFG pressure gradient. Landfills closed for a long period of time, or low volume and relatively shallow sites, can usually achieve effective on-site gas accumulation control with trenches or wells installed immediately below the landfill cover.

Additionally, effective perimeter LFG migration control can usually be achieved with simple passive ventilation trenches buried within the edge of waste or native soil. Such passive vent systems consist of a slotted or perforated pipe buried within highly permeable backfill materials (e.g., drain rock). Trench depth is dependent on solid waste depth, such that the perforated pipe is placed at approximately one-half the solid waste depth unless deeper permeable strata exist that could cause LFG migration. Burial depth can vary, depending on native soil conditions or if changes in solid waste edge depth are required to accommodate landscaping or a landfill cover system.

Based on soil boring data, depth to groundwater, and solid waste profiles, the average depth of a passive ventilation collector at the Landfill would be approximately 6 feet, with a trench depth averaging between 7 and 8 feet. Vent risers, typically spaced at 100-foot intervals, would be installed to allow LFG an unrestricted escape route. Also, widely spaced cleanout risers would be required for cleaning or flushing equipment access to reduce perforation fouling and debris accumulation. LFG control trench systems can typically be excavated without specialized equipment. Trench spoils must be handled as municipal solid waste, requiring proper collection and disposal and/or reinterment.

At the Landfill, solid waste age, shallow solid waste depth, limited methane generation (i.e., small pressure gradient), and favorable groundwater all favor a passive trench system. Considering on-site accumulation and perimeter LFG control, a passive trench system may provide compliance at lower cost than a vertical well system, slurry walls, or active control systems. For locations where waste extends beyond property lines, passive collection trenches installed at the property boundaries may not provide adequate control for gas accumulations or migration. In these instances, active collection using trenches or wells or off-property controls may be considered. Any proposed passive collection trenches at the perimeter and utility trench locations should be evaluated to ensure that off-site preferential pathways are not created inadvertently, allowing off-site migration. Utility trench plugs or barriers can be installed to prevent migration from occurring within utility bedding.

Passive collection systems can be inexpensively installed as part of new site construction, as well as retrofitted on existing paved or covered sites. Passive venting of new buildings can be quite cost effective when coordinated with the foundation design. Typical passive building systems include an impermeable barrier to control intrusion protection. Passive venting is generally cost prohibitive at existing buildings, due to limited access and the limited radius of influence that can be expected from venting trenches and wells installed beyond the building footprint.

### 11.4.2 Active Control

Active LFG control systems are commonly used in newer landfills to extract LFG for destruction, cogeneration, and/or controlling off-site migration. Such systems typically include vertical wells or deep horizontal trenches installed throughout the solid waste, either while the landfill is being filled or after final closure. The term “active” refers to the application of a vacuum to a gas ventilation system, usually by means of centrifugal blowers (i.e., exhausters) driven by electric motors. Instead of providing a passive “break” in the pressure gradient between the waste and the atmosphere, an active system “pulls” the gas out by applying a negative (vacuum) pressure at the collecting perforated pipelines. The gas is then conveyed to a treatment system for destruction (e.g., flare or thermal oxidizer), adsorption (e.g., granular activated carbon), or beneficial use (e.g., cogeneration), or it is vented to the atmosphere, depending on gas concentrations. These systems most commonly apply to large landfills that continue to receive municipal solid waste, or recently closed sites.

The effectiveness of an active LFG collection system depends greatly on the design and operation of the system, and on the methane generation capability of the landfill waste. An effective collection system should be designed and configured to do the following:

- Handle the maximum LFG generation rate
- Have sufficient radius of influence to effectively collect LFG to protect potential receptors
- Monitor and adjust the operation of individual extraction wells and trenches

Many configurations of wells and trenches, including perimeter systems and in-refuse network-type systems, have proven to be successful at controlling LFG and eliminating off-site migration at a wide variety of landfills. An active system, including a variety of interior collectors, may also be considered if future site development includes underground structures or foundations. Usually, landfill settlement is a concern for in-refuse horizontal collectors, but due to Landfill age and the fact that construction debris was dumped at the Landfill, significant settlement is not anticipated or could be mitigated with preloading, so in-refuse horizontal collectors could be a component of an active LFG collection system at the Landfill, if needed.

Active control systems are balanced by adjusting the vacuum level applied to the perforated piping within the trench or well system. Typically, a radius of influence and appropriate vacuum level are estimated based on soil permeability, site geometry, and collector design. Monitoring probes located within the vicinity of LFG collectors can be used to adjust a control system until a proper radius of influence is achieved, without providing excessive vacuum. Usually, an active system’s applied vacuum is balanced to evacuate LFG within a defined area without pulling in air from above the surface or surrounding soil.

Active LFG collection systems must address air intrusion that may naturally permeate through the landfill cover and at the margins of the waste into the solid waste, which can induce landfill fires if not monitored and controlled. Where excess atmospheric air (oxygen-rich air) is pulled into the solid waste, either inadvertently or by design, the collection system must be monitored and controlled to avoid potential fires.

### 11.4.3 Convertible Control Systems

The Landfill has been closed for 50 years, with relatively low LFG emissions due to its age, but there is the potential for human exposure to LFG-related hazards due to existing and planned developments. Both passive and active systems could therefore be viable strategies. The design of cover installation and the potential development scenarios on each parcel will each play a role in determining the design of the final LFG management system. A convertible system may be appropriate for those parcels that are already developed but currently lack a LFG control system (i.e., the KIP and 7901 parcels), and for parcels yet to be redeveloped the final design decision needs to be made as part of site redevelopment.

A well-designed, integrated landfill control system should ensure that LFG does not migrate beyond the property boundary or accumulate on-site, potentially impacting on-site facilities. This can be achieved by initially providing discrete connections for individual trenches and wells from a non-perforated header, thus allowing subsequent location-specific vacuum or venting control. Impermeable barriers can be installed in perimeter venting trenches (at the edge of waste) to allow them to be converted to active systems without inducing excess amounts of atmospheric air and creating a potential fire hazard. It should be noted, however, that barrier installation costs can be high compared to gas venting trenches alone. The use of a membrane barrier or other low-permeability vertical cut-off trench at the Landfill's waste boundary may be both a technical- and cost-appropriate alternative to barrier-lined trenches, due to shallow solid waste depths and shallow groundwater. An additional benefit of this alternative is that barriers at the waste boundary (such as along the SRDS property) keyed to low permeability soil below groundwater can provide an additional degree of migration protection.

Based on the age and shallow solid waste depth at the Landfill, conversion of the passive collection system described above could readily be accomplished by the addition of a knockout vessel, an exhauster, and header piping to the previously discussed passive system configuration. Addition of an exhauster to the passive system should be triggered by insufficient methane reduction (i.e., to less than the LEL) in perimeter LFG probes.

## 11.5 LANDFILL GAS CONTROL FEATURES

Design features generally used in a variety of passive venting or active collection scenarios are briefly described below, as they would be implemented at the Settlement Area.

### 11.5.1 Passive Collector Trench System

Passive collector trench systems typically include shallow interior trenches, deeper perimeter passive collector trenches, or both. Deeper trench systems may average approximately 6 to 10 feet in depth. A backhoe or small track hoe could excavate the trench to a minimum width of 2 feet. The geotextile, bedding/backfill, pipeline, and appurtenances could then be installed within the trench. It will be necessary to adhere to OSHA guidelines for work in hazardous locations (i.e., protective clothing and ambient air monitoring).

Vents for passive collection systems are typically 4 to 8 inches-diameter high-density polyethylene (HDPE) or galvanized steel pipes. It is not necessary to include valves because the system maintains near-atmospheric pressures. Depending on site conditions, the vents typically extend a minimum of 10 to 15 feet above grade and terminate in a bird screen or rain cap. Cleanouts or access points are typically spaced at 300- to 500-foot intervals, depending on the horizontal trench layout. Cleanouts consist of a 4-inch HDPE angled (45-degree) riser for insertion of a vacuum or flushing wand and hose.

#### 11.5.2 Active Collector Trench System

An active collector trench system would be similar to the passive trench system described above; however, it would likely also include an impermeable barrier to minimize air intrusion at the waste boundary. Active collection trenches not installed at the waste boundary would not include an impermeable barrier. The perimeter perforated piping would be connected to a solid header or manifold with valve stations to allow discrete control of trench segments. Active collection trenches would be installed to a depth of 6 to 10 feet. If an impermeable barrier were installed, the barrier would extend down to seasonal low groundwater elevation.

For an active collector system, a separate HDPE solid pipe header, buried below grade, would be installed to provide vacuum to key points in the perforated collector pipeline, depending on the perimeter collector length. Control valves with flow monitoring ports, installed in hand-holes on a lateral that connects the active header to the perforated collector, would allow adjustment of suction pressure to various points in the system. The active header, control valves, and laterals would also be used to balance the applied vacuum to the entire perimeter system, as required.

An active system requires vacuum pressure supplied by single-stage, explosion-proof centrifugal blowers/exhausters. Typically located on a concrete pad, the exhauster system includes the header piping, a condensate collector (i.e., water knockout), isolation valves, and the blower/vent pipes. A weatherproof control panel and power supply also would be included. To reduce noise and/or screen the exhauster equipment from view, a small, ventilated enclosure may be required.

#### 11.5.3 Extraction Well System

An extraction well system is similar to an active collection trench system, except the trenches are replaced with a well grid. Extraction wells would average approximately 20 feet in depth. Wells would generally be constructed to extend down to seasonal low groundwater. Wells are typically 6-inch HDPE, with a deeper screened zone sized for collection (lower 5 to 10 feet bgs) when combined with a cover system incorporating collector trenches. When a below-cover trench system is not used, wells are either screened throughout the solid waste depth or are partitioned to maximize radius of influence, with a surface plug to minimize short-circuiting. Based on the age of the Landfill and type of waste, wells would be installed on a 100-foot grid, with local deviations as necessary to accommodate the type of cover system, extent of waste, proximity to buildings, and proximity to perimeter trenches.

#### 11.5.4 Venting Well System

A venting well system is the passive counterpart to an extraction well system. Venting wells would average approximately 20 feet in depth (constructed to extend down to seasonal low groundwater). Wells are typically 6-inch HDPE with a screened zone throughout the solid waste depth and vented to a manifold or directly to the atmosphere. Based on the age of the Landfill and type of waste, venting wells would be installed on a 50-foot grid, modified as necessary to accommodate the type of cover system, extent of waste, proximity to buildings, and proximity to perimeter trenches.

## 11.6 LANDFILL GAS CONTROL TECHNOLOGIES

### 11.6.1 Landfill Gas Control Technologies within Buildings

LFG control technologies for buildings and other development features rely on active and passive collection systems similar to landfill systems. Table 11.2 highlights technologies appropriate for buildings at the Landfill, depending on whether the building exists or is planned for development.

### 11.6.2 Landfill Gas Control Technologies

Table 11.3 summarizes LFG control technologies appropriate for the Landfill. Selection and implementation will depend on location of perimeter controls with regard to waste boundaries, existing or planned site development, cost, and site use.

## 11.7 LANDFILL GAS TREATMENT SYSTEMS

Based on LFG composition data as described in Section 6.0, it is unlikely that gas treatment will be necessary for existing or planned site development. If emission estimates or later testing of gases emitted from an active or passive collection system are deemed a threat to public health, then a gas treatment system may be warranted.

LFG treatment systems generally require active gas collection. Vent-mounted flares and odor control canisters have been developed, but these require greater methane concentrations or volumetric flow rates than expected at this site. Treatment options are limited by the low concentration of methane and NMOC; (this term is commonly used in the LFG literature and includes the VOCs discussed in previous sections). Moreover, a perimeter active collection system may cause atmospheric air to be drawn in, further diluting the gas contaminants.

Treatment technologies currently used to reduce NMOC emissions from old landfills and other contaminated sites are selected primarily based on concentrations of the specific COCs and the expected volumetric flow of gas. Suitable technologies under these circumstances include catalytic oxidation and regenerative resin systems. Carbon adsorption systems have also been used for NMOC removal. A gas treatment system appropriate for greater volumetric flows and low NMOC concentrations might utilize large carbon adsorption canisters. Biofiltration, using specialized bacteria grown on enclosed porous media or well-aged compost media, is a new treatment technology with potential for application at the Landfill. None of these technologies remove methane from LFG. Only flaring (or thermal oxidation) has been demonstrated as a proven, economical means of converting the methane to carbon dioxide and water.

Most active LFG control systems that do not recover energy terminate in a combustion flare. Flares have been shown to effectively combust all the methane while destroying at least 98 percent of the NMOCs and odorous sulfur compounds typically found in LFG; however, landfill sites closed for many years and exhibiting low gas generation and declining methane concentrations, frequently do not produce gas with sufficient energy content to sustain combustion. The minimum methane concentration required for continuous flaring is between 15 and 20 percent by volume, depending on atmospheric conditions. The use of an auxiliary fuel, such as natural gas or propane, can ensure continuous combustion with low energy LFG, but this practice is expensive and therefore usually avoided. Typically, older landfills with minimal LFG generation also exhibit very low NMOC and sulfur compound concentrations. In these cases, it is often the practice to vent a LFG exhauster directly to the atmosphere. Periodic exhaust monitoring is then used to ensure that acceptable NMOC and methane emissions levels are maintained. Refer to Table 11.4 for a comparison of the advantages and disadvantages of LFG treatment options and their applicability to the Landfill.

In the event that active collection is necessary, it is unlikely that sufficient methane will be present to support combustion. In fact, methane, NMOC, and sulfur compound levels may be reduced beyond concern for public health or regulatory intervention. In this case, air dispersion modeling may be necessary, based on gas composition and estimated emission rates, to obtain necessary approvals. Direct discharge to the atmosphere may be unacceptable due to low-level odors. A final odor polishing step may be required, such as discharge through compost media or carbon canisters. The need for odor control can usually be assessed once a discharge location of collected gas is established.

Table 11.4 lists potential gas treatment options appropriate for the discharge of collected gases.

## 11.8 LANDFILL GAS CONTROL SYSTEM CONFIGURATION

Landfill development, including on-site structures, foundations, or other enclosed areas, will require gas control measures. Various venting, gas extraction, and structure isolation techniques can be implemented to guard against accumulation of dangerous concentrations of methane and NMOCs. Paved areas (i.e., parking lots, truck ramps, etc.) generally do not require protection, unless gas is forced to migrate toward more susceptible structures or boundaries. New building foundations can be sealed from beneath with bentonite or membranes to minimize gas intrusion. Building foundations or underground structures require more extensive measures, including, in some cases, active gas extraction and interior building monitoring systems. Subsurface structures, such as pilings, utility vaults, and plumbing, must be designed to minimize the potential for LFG intrusion into structures and enclosed spaces. The particular design depends heavily on the type of development, the mix of buildings and pavement, depth of structure, and type of use.

Because of the uncertain timing of development and future use of the Landfill-impacted properties, each proposed development location should be looked at individually, as well as together, to ensure that the systems are compatible. Opportunities should be explored to coordinate venting or collection systems, avoid redundancies, and ensure intended performance. This will be incorporated into the LFG section of the site-wide OMMP. The following sections discuss viable LFG control systems appropriate for each of the properties on or adjacent to the Landfill.

### 11.8.1 South Park Property Development Parcel Landfill Gas Collection System

The SPPD LFG control system has been designed as part of the IA with an asphalt cap covering a majority of the parcel and low-permeability geomembrane overlain with soil on side slopes not paved with asphalt. The asphalt cap or geomembrane terminate at the property boundary, at or just below existing grade.

The collection system is composed of the following:

- Shallow perimeter LFG collection trenches with perforated 6-inch HDPE pipe installed at the geomembrane or asphalt cover limits, along the northwest, west, south, and east perimeters
- Extraction wells along the SRDS property (north and northeast)
- Extraction wells located on an approximate 100-foot grid across the parcel
- Extraction wells and trenches along the west side of 5$^{th}$ Avenue South

The vapor extraction wells and collection trenches are connected to solid HDPE header pipes, with individual valve controls at each well and trench. The HDPE headers convey LFG to a vacuum blower. Blower emissions may be treated prior to discharge if required by Washington State or local regulations. Condensate within the header pipes is collected and pumped via force main to the sanitary sewer.

New buildings on the SPPD parcel will be constructed to be compatible with the LFG control system designed and installed as part of the Ecology-approved IA.

The LFG system is operated by maximizing the collection of LFG generated by the degrading solid waste, controlling methane within specified safe limits in a system of compliance LFG probes and at concentrations less than the LEL, and maintaining safe operating conditions in the subsurface to minimize potential for initiating underground combustion. Methane monitoring occurs at specified intervals in the compliance LFG probes and conventional parameters are monitored in the LFG collectors (oxygen, methane, carbon monoxide, temperature, and vacuum pressure). Residual nitrogen concentration is calculated from conventional parameter values at each LFG collector. Residual nitrogen is an important operational parameter and is maintained at concentrations less than specified safe limits.

Operation of the interim LFG control system is compatible with appropriate control strategies and technologies identified for the adjacent parcels.

### 11.8.2 South Recycling and Disposal Station Parcel

The SRDS parcel is currently paved. The parcel includes the SRDS, Household Hazardous Waste Facility, and several other administrative and operational buildings. The parcel buildings are either naturally ventilated or screened (porous skirting) for methane mitigation. Occupied structures on grade are monitored quarterly for LFG; LFG has not been detected in 20 years of monitoring. Future development of the parcel will likely require fill material overlain by asphalt pavement and new buildings, with the exception of potential reuse of the existing transfer station foundation. Requirements for LFG control will likely be similar to existing conditions. As such, new building LFG control should include passive (convertible to active) venting under buildings, with an impermeable under-slab barrier or vented skirted buildings to meet City Building Code. Based on the current parcel conditions, parcel-wide LFG control could likely be controlled with passive venting trenches under an operable cap, such as asphalt over permeable crushed rock, along with a passive venting perimeter trench at the waste boundary tied to the crushed rock layer under the pavement or cover system that vents to the atmosphere. It is recommended that if a passive system is installed, it be designed to be converted to an active system in the event that LFG migration is detected in perimeter LFG probes (GP-09, GP-26, GP-23, and GP-07), or if odor control is required.

In its passive configuration, the above system would be compatible with the LFG control system on the SPPD property (installed during the 2015 IA) to the south and southwest. Adequate setback from the SPPD parcel boundary should be incorporated to ensure that it would remain compatible in the event of partial or full conversion to an active system.

#### *11.8.2.1 Long-Term Building Monitoring*

This option uses building monitoring or full-time building alarms to confirm the absence of LFG intrusion into the buildings. As long as the monitoring or alarms indicate that methane intrusion is less than levels required in WAC 173-351-200(4) (refer to Section 11.2), then no additional action is needed.

#### *11.8.2.2 Installation of Landfill Gas Controls in Addition to Building Monitoring*

The second option is to augment the building monitoring/alarms with LFG controls. Representative systems that could be installed are described below.

Passive venting of the paved areas and at the solid waste boundaries may provide adequate LFG accumulation control; however, it is recommended that, if passive venting is selected, it be designed to be converted to active control. LFG control for structures and buildings may be necessary because the building foundations do not appear to have not been designed for methane mitigation (e.g., penetration seals, passive venting, and impermeable barriers).

Potential building or structure mitigation alternatives include the following:

- An impressed air curtain under the building slabs within the crushed rock layer, which is vented, accessed at the perimeter footings
- Active vacuum collection using collection trenches at the building footings that are tied in to the crushed rock layer below the concrete slabs
- Perimeter building venting or active extraction wells

For the parcels, including the area to the west beyond the Landfill boundary, similar options and controls would be appropriate for protecting building occupants and minimizing off-site migration.

Utilities passing through waste areas or adjacent to waste areas should be assessed for preferential pathways and off-site LFG migration. This includes both utility bedding and conveyance piping and structures. Sealing of trenches and venting of structures and conveyance piping to prevent LFG accumulations should be included in design of the LFG control systems.

If passive venting is implemented, the system should be designed to be converted to active collection, allowing for adaptive management and potential migration issues associated with on-site or adjacent site development.

For any new development on these parcels, LFG mitigation will need to be addressed and may include under building membranes, passive venting, active venting, and/or monitoring.

In order to avoid interference with the LFG control system on the SPPD property to the south, adequate setback (45–60 feet) from the SPPD boundary should be maintained for any passive venting system and to ensure that it would remain compatible in the event of partial or full conversion to an active system. Building development near the property boundaries would be equipped with independent LFG control systems regardless of any offset.

### 11.8.3 5$^{th}$ Avenue South

For the public roads and ROWs, LFG has not been identified at levels of concern anywhere except for along 5$^{th}$ Avenue South in LFG probes GP-27 and GP-29. The Landfill boundary along this area extends under 5$^{th}$ Avenue South within the ROW. Several utilities are located within this area, notably a 72-inch storm drain bedded through solid waste. LFG control in this area will need to address gas migration, utility corridors, confined spaces (i.e., manholes and vaults), extent of solid waste, and occupied buildings adjacent to the Landfill.

As part of the redevelopment and IA, SPPD installed an active LFG control system in 2014 and 2015. This system also influences the ROW associated with 5$^{th}$ Avenue South adjacent to this parcel. The 5$^{th}$ Avenue South LFG probes will continue to be monitored as part of long-term monitoring of LFG. The probes along 5$^{th}$ Avenue South have been in compliance since the LFG system on the SPPD parcel became operational. If exceedances occur in the future at these probes, the operation of the LFG system at the SPPD parcel will be adjusted to bring the probes back into compliance. If they occur, the out-of-compliance results and the adjustment of the LFG system would be reported to Ecology as part of the long-term compliance monitoring program discussed in Section 6.2.5 of the CAP and presented in Appendix A, Attachment A.3 of the CAP.

### 11.8.4 South Sullivan Street and 426 South Cloverdale Street

LFG has not been detected at levels greater than the LEL within LFG probes GP-03, GP-05, GP-15, GP-31, or GP-32 along South Sullivan Street. The Landfill boundary along this area extends under

South Sullivan Street within the ROW and extends onto the 426 South Cloverdale Street (Lenci/Emerson) parcel to the south. Groundwater is very shallow in this area and likely limits the migration of LFG. No LFG control actions are necessary for this parcel, and the SPPD IA LFG control system makes it unlikely that any will be needed in the future. In that unlikely event, appropriate LFG control strategies could include active collection or passive venting at capping extents. In any case, perimeter LFG probes will continue to be monitored to ensure that migration or gas accumulations are controlled.

### 11.8.5 Landscaped Area Northeast of South Recycling and Disposal Station

This area, located northeast of the SRDS, between 5th Avenue South and SR 99 will be addressed in conjunction with development of the SRDS property. The SRDS is currently paved and LFG control in this area will need to address potential gas migration associated with development modifications to the property. Appropriate LFG control strategies include passive venting, active collection, and convertible passive venting. Continued monitoring or passive venting to prevent migration are options for addressing LFG in the landscaped areas. Passive venting may require construction within the landscaped area and ROW. Active collection systems would be similar to those identified for 5th Avenue South. Continued monitoring of LFG probes GP-09, GP-07, GP-23, and GP-26 following development of the SRDS property will identify changes in LFG migration patterns.

## 11.9 COMPLIANCE WITH MTCA REQUIREMENTS

The LFG control component of the remedy described in this section complies with the MTCA requirements for a selected remedy. A description of how the MTCA requirements are met is included in Section 15.0.

# 12.0 Stormwater Control Alternatives within the Settlement Area

The Landfill contains operating facilities with stormwater requirements based on their business operations. These requirements fall under the jurisdiction of the SMC and the codes and restrictions created under its authority. The City has established several goals for controlling flow and treatment of stormwater runoff designed to maximize the protection of life, property, and the environment as they relate to stormwater and potential pollutants carried within stormwater.

The primary goal of the stormwater controls relative to the Landfill is to maintain a separation between landfill contents and stormwater that is collected and conveyed in the stormwater system.

In conjunction with the City's goals, the stormwater controls located on the Settlement Area will need to be designed in coordination with the closed landfill site requirements. Such design considerations include the following:

- Compatibility with the landfill cap, including preventing stormwater that is collected and conveyed by the system from coming into contact with solid waste
- Minimizing depth of new improvements to limit disturbance of solid waste
- Providing physical barriers between new construction and solid waste
- Collecting and conveying stormwater off-site to limit infiltration into the landfill; elimination of infiltration is not required as discussed in Sections 9.0 and 10.0

This section provides a description of the existing site conditions in order to establish the current conditions of the property and understand how the selected alternatives will affect and be affected by the anticipated development of parcels within the Settlement Area. This section also provides guidance for the end land-user and helps identify feasible BMPs and new construction alternatives to satisfy both the City's requirements and those associated with the Landfill.

## 12.1 EXISTING STORMWATER INFRASTRUCTURE

The existing stormwater conditions were evaluated based on review of previous reports, as-built information, historical photos, the City's GIS database, and site visits. The existing stormwater systems are discussed in Section 2.6 and Figure 2.8 shows existing stormwater infrastructure for the properties associated with the Landfill.

## 12.2 PROPOSED STORMWATER CONTROLS

Stormwater requirements for the Settlement Area are found under SMC Chapters 22.800 to 22.808 and additional practices that address landfill contained in MFS (WAC 173-304-460).

### 12.2.1 Construction Practice Requirements

All construction sites that disturb more than an acre of land are required to submit a Notice of Intent (NOI) for coverage under the general National Pollutant Discharge Elimination System (NPDES) Construction Stormwater Discharge Permit. As part of the permit conditions, a SWPPP needs to be prepared and maintained for review by Ecology. The SWPPP includes selected BMPs necessary to protect downstream waters from silt-laden stormwater runoff during construction.

The installation of underground infrastructure creates the potential of stormwater entering excavations and coming into contact with solid waste. Additional BMPs, such as limiting the amount of open excavations and protecting excavations from stormwater run-on with earth berms or other diversion structures, will need to be included in the SWPPP.

Stormwater that enters any excavations will need to be managed the same as the water generated from the dewatering operations and covered in the BMPs selected for the SWPPP.

### 12.2.2 Stormwater Management Requirements

Design of the stormwater collection and treatment system will need to address the SMC and the limitations associated with building on a closed landfill. Stormwater treatment BMPs that use infiltration as the primary mechanism will not be allowed within the limits of solid waste. Stormwater conveyance and treatment facilities located above solid waste such as swales, ditches, or ponds on the Settlement Area are required to have cover, as prescribed by WAC 173-304-460, consisting of a low-permeability layer with a minimum 24-inch thickness of soil and permeability of $10^{-6}$ cm/sec or less, or an impermeable geomembrane that is at least 50 millimeters thick.

Stormwater infrastructure improvements should also be designed as shallow as possible to limit the amount of solid waste disturbance required for installation. Designing impervious surfaces to convey the stormwater (sheet flow) will help limit the amount of in-ground infrastructure required.

Stormwater infrastructure should be isolated from direct contact with solid waste and should be designed as tightline to prevent stormwater leaking into solid waste and LFG collecting in the stormwater system.

The stormwater controls at the Settlement Area will be designed to capture the bulk of the stormwater before it can make contact with solid waste. Because the Landfill extends into the water table, stormwater controls for the Settlement Area are not intended to limit infiltration; rather, stormwater controls for the Settlement Area are intended to prevent solid waste constituents from contaminating stormwater runoff. The stormwater controls are also intended to minimize the potential for disturbances, erosion, scouring, or otherwise disturbing the landfill cap.

### 12.2.3 Developed Parcels within the Landfill Boundary

The stormwater management requirements established for this FS will also pertain to the future redevelopment of any of the parcels associated with the Settlement Area. Stormwater collection systems should be designed to meet the SMC and the limitations involved with developing on a closed landfill.

Because the existing developed sites are mostly covered in impervious surfacing, no additional stormwater flow controls may be necessary.

### 12.2.4 Roadway Improvements within the Landfill Boundary

Roadway improvements that are constructed to the current SDOT standards will provide adequate stormwater controls to minimize infiltration into the Landfill. Road improvements should include the addition of curb, gutter, and storm drain collection systems to convey the stormwater away from the Landfill and into the surrounding public stormwater systems. Drainage systems including ditches may be used along the roadway in place of curbs and gutters as long as they do not expose landfill waste, breach pre-existing cap, and prevent stormwater from coming into contact with landfill contents.

## 12.3 COMPLIANCE WITH MTCA REQUIREMENTS

The stormwater control component of the remedy described in this section complies with the MTCA requirements for a selected remedy. A description of how the MTCA requirements are met is included in Section 16.0.

# 13.0 Downgradient Groundwater Alternatives within the Settlement Area

This section of the RI/FS evaluates remedial action alternatives for groundwater within the Settlement Area.

## 13.1 OVERVIEW OF GROUNDWATER AND MIGRATION

The Landfill lies above and in the Shallow Aquifer. As discussed in Section 3.1, the Shallow Aquifer is part of the valley-wide Alluvial Aquifer. The uppermost zone of the aquifer at the Landfill is a thin layer of groundwater and infiltrating stormwater that is perched on the Silt Overbank Deposit and identified as the Perched Zone. The Silt Overbank Deposit is prevalent throughout the Duwamish Valley, but discontinuous due to both natural and man-made disturbances. Much of the Landfill sits on the Silt Overbank Deposit in contact with perched groundwater. Deeper sections of the Landfill, such as those on the KIP parcel, extend through the Silt Overbank Deposit deeper into the Shallow Aquifer. Three zones of the Shallow Aquifer were investigated at the Landfill:

- **The Perched Zone:** This zone is located just above the Silt Overbank Deposit.
- **The A-Zone of the Shallow Aquifer:** This zone is located beneath the Silt Overbank Deposit at depths of approximately 0 to -15 feet elevation NAVD 88.
- **The B-Zone of the Shallow Aquifer:** This zone is located deeper into the Shallow Aquifer at depths of approximately -15 to -35 feet elevation NAVD 88 above the estuarine/marine deposits.

Within the Shallow Aquifer, groundwater generally has a slight upward gradient from the A-Zone to the Perched Zone, due to the volume of groundwater recharge that enters the A-Zone from the adjacent hillside. The slight upward gradient and the presence of the Silt Overbank Deposit slow the transport of dissolved constituents from the Perched Zone into the A- and B-Zones. These deeper zones are the dominant groundwater pathway in the Shallow Aquifer. Contaminants from the Landfill have the potential to discharge directly into the lower Sand Aquifer where the Silt Overbank Deposit is missing. Once contaminants are in the A- and B-Zones, they will be transported toward the Lower Duwamish Waterway. During this migration pathway, chemical and physical processes affect individual chemical compounds, allowing them to precipitate or adsorb onto soil or degrade into other chemicals.

## 13.2 GROUNDWATER QUALITY AT THE CONDITIONAL POINT OF COMPLIANCE

Groundwater quality at the Landfill was assessed with over 150 samples collected over the last 20 years. Figure 5.1 shows the location of groundwater wells and direct push probes and identifies those that were upgradient of the Landfill, beneath the Landfill, and downgradient of the Landfill. Information from those wells was compared in Table 5.5 with preliminary CULs for the Landfill. The only groundwater COCs that are out of compliance at the CPOC are vinyl chloride, iron, and manganese. Three other chemicals will continue to be monitored: *cis*-1,2-DCE, the precursor of vinyl chloride, will continue to be monitored in wells where vinyl chloride is monitored. Benzene and arsenic will be monitored in select wells as discussed in Section 16.0.

Groundwater concentrations of vinyl chloride at the CPOC monitoring wells have ranged over the last five years from non-detect at 0.02 µg/L to 1.4 µg/L versus a preliminary CUL of 0.29 µg/L. Data were presented in Section 5.0. It should be noted that the CPOC for the Landfill is the downgradient edge-of-refuse (also called the downgradient Landfill boundary). For a large section of the Landfill, this CPOC is inaccessible due to two features—the pressurized RETS discharge line constructed in the mid-1980s and running in the SR 99 ROW between the Landfill and the SR 99 roadway and the SR 99, a major divided, limited access four-lane highway. Because of these two features, CPOC monitoring wells are not actually on the CPOC but as close as practicable.

The wells shown in Table 13.1 are part of the groundwater monitoring network.

**Table 13.1**
**Monitoring Well Network**

| Monitoring Well | Location | Zone | Screened Interval (feet bgs) |
|---|---|---|---|
| **Upgradient Wells Representing Quality of Groundwater Entering the Landfill** | | | |
| MW-12 | Upgradient | A-Zone | 10–15 |
| MW-14 | Upgradient | A-Zone | 12–22 |
| MW-29 | Upgradient | A-Zone | 20–30 |
| **Downgradient Wells Representing Conditions at the Edge-of-Refuse (CPOC wells)** | | | |
| MW-25 | Downgradient across South Kenyon Street | A-Zone | 22–27 |
| MW-26 | Downgradient, across SR 99 | A-Zone | 15–25 |
| MW-27 | Downgradient, across SR 99 | A-Zone | 10–20 |
| MW-32 | Within Landfill boundary; screened in aquifer | A-Zone | 19–24 |
| MW-33 | Within Landfill boundary; screened in aquifer | A-Zone | 20–25 |
| MW-08 | Downgradient, across SR 99 | B-Zone | 35–45 |
| MW-10 | Downgradient across South Kenyon Street | B-Zone | 35–45 |
| MW-18 | Within Landfill boundary; screened in aquifer | B-Zone | 30–40 |
| MW-24 | Downgradient, across SR 99 | B-Zone | 35–45 |
| **Downgradient Wells near the Former Glitsa Property** | | | |
| MW-30 | Nominally downgradient; but installed in Perched zone, which is too thin to be continuous | | 8–13 |
| MW-31 | Downgradient, across SR 99 | A-Zone | 18–23 |

### 13.2.1 Potential for Vapor Intrusion from Groundwater

Downgradient groundwater in the Perched Zone was also screened against Ecology screening levels for the potential to adversely affect structures downgradient of the Landfill. Because of the presence of the Silt Overbank Deposit, the groundwater of concern is that in the Perched Zone above the silt. The highest concentrations in this zone were measured near the Former Glitsa property in MW-30. TCE, *cis*-1,2-DCE, and vinyl chloride were detected but at concentrations less than the industrial screening levels in *Guidance for Evaluating Soil Vapor Intrusion in Washington State: Investigation and Remedial Action* (Ecology 2009c; revised by Ecology in April 2015 to update toxicity factors).

## 13.3 GROUNDWATER TRAVEL TIMES

Groundwater velocity calculations presented in Section 5.5.5 indicate that groundwater in the Shallow Aquifer in the vicinity of the Landfill moves relatively quickly, between 200 ft/yr (southern region of the Landfill) and 700 ft/yr (northern region of the Landfill). Based on these groundwater velocities, and a distance of approximately 1,600 feet between the downgradient boundary of the Landfill and the Lower Duwamish Waterway, it would take approximately 2 to 7 years for groundwater at the downgradient edge of the Landfill to reach the Lower Duwamish Waterway, where the first exposure occurs. Travel times from the CPOC wells within the Landfill boundary to downgradient properties on the far side of SR 99 are around 6 months.

Vinyl chloride is mobile in groundwater, travelling at almost the same speed as groundwater (the retardation factor calculated by the model was 1.6 discussed in Appendix K); however, vinyl chloride will continue to degrade as it moves causing its concentrations to continue to decline as it migrates toward the Lower Duwamish Waterway. Given the measured groundwater flowrates, TOC values for the Silt Overbank Deposit and literature values for retardation rates for vinyl chloride; in the southern section of the Landfill, groundwater moves approximately 200 ft/yr and vinyl chloride would move between 100 and 150 ft/yr. In the northern sections where groundwater flow rates are faster (primarily due to less silt), groundwater travels up to 700 ft/yr and vinyl chloride 350 to 500 ft/yr.

## 13.4 ESTIMATED VINYL CHLORIDE CONCENTRATIONS

As vinyl chloride moves, it also continues to degrade. CPOC wells across SR 99 have been in compliance for vinyl chloride since at least 2011, except for MW-27 which occasionally exceeds the preliminary CUL by about 10% (maximum of 0.31 µg/L vs CUL of 0.29 µg/L).

During the RI, MW-31 was installed to be downgradient of the northwest corner of the Landfill and was expected to have a vinyl chloride concentration similar to the other wells across SR 99. Instead it was found to be contaminated at levels that could not have originated solely from the Landfill. The question then arose as to whether it would be possible to estimate the concentration that was likely due to the Landfill. After discussions with Ecology, it was decided that the Bioscreen Model would be appropriate for estimating vinyl chloride at the CPOC.

The Bioscreen Model, developed by USEPA, was used to estimate vinyl chloride concentrations coming from the landfill and reaching MW-31, using maximum and average concentrations from MW-25, MW-32, and MW-33 as typical source area concentrations. The model runs are discussed in Appendix K. Aquifer parameters were those developed during the RI (refer to Section 3.0) and retardation factors were from the literature (including default values within Bioscreen). To estimate the degradation factor, which is site-dependent, the model was calibrated to the southern section of the site using vinyl chloride concentrations at FB-12 during the RI as a steady state source term and measured results at MW-27 as a calibration set. This yielded a 1$^{st}$ order degradation rate of between 0.5 and 0.8 per year.

These degradation rates were then used to model the northern section of the Landfill, using the aquifer characteristics of that section, and using maximum and average concentrations at MW-25, MW-32, and MW-33 as steady state source terms to MW-31. Results varied by location. Because MW-25 had the highest concentrations and is the closest well to MW-31, it represents worst-case conditions. The estimated vinyl chloride concentration at MW-31 coming from a source near MW-25 is 0.25 µg/L; estimated concentrations at MW-31 coming from MW-32 and MW-33 are less than 0.03 µg/L. These estimated concentrations are below the preliminary CUL of 0.29 µg/L.

In summary, the Bioscreen Model was used to estimate the contribution from the Landfill reaching MW-31. The model used site-specific aquifer characteristics and measured concentrations at other monitoring wells to calibrate the degradation and travel rates. This evaluation allowed for the likely contribution from the Landfill to be separated from the contribution from the other source at MW-31. Based on this, the estimated contribution of vinyl chloride from the Landfill to MW-31 is between 0.03 and 0.25 µg/L versus its preliminary CUL of 0.29 µg/L.

### 13.5 GROUNDWATER REMEDIATION ALTERNATIVES

As discussed in Section 5.0, the primary reservoir of vinyl chloride is the anaerobic degradation of *cis*-1,2-DCE, and the primary reservoir of *cis*-1,2-DCE appears to be in the saturated zone of the aquifer. Based on lessons learned from other solvent sites in the aquifer, the *cis*-1,2-DCE is likely entrained on fine-grained silts (such as the Silt Overbank Deposit) and slowly diffuses into the A-Zone. This would also be consistent with trend plots showing slowing declining concentrations of *cis*-1,2-DCE and vinyl chloride, and would explain a sudden spike of concentration during construction projects that disturb the subsurface, followed by a rapid return to base conditions.

Given the low concentrations of vinyl chloride leaving the Landfill since monitoring began in the late 1990s, the relatively fast groundwater velocities, the on-going degradation of vinyl chloride with reasonably high degradation rate constants of 0.5 to 0.8 per year, and the vinyl chloride concentrations in wells such as MW-24, MW-08, MW-26, and MW-27 (Figures 5.11A and 5.11B), it is unlikely that vinyl chloride in groundwater flowing from the landfill is greater than preliminary CULs downgradient of the landfill edge-of-refuse.

There are two potential alternatives for remediation of the groundwater at the downgradient edge of the Settlement Area: (1) no further action or (2) long-term groundwater monitoring with contingent action if triggers related to rising concentrations from the Landfill occur.

### 13.5.1 No Further Action

For this proposed alternative, no additional actions would be taken to address the concentrations of vinyl chloride along the Settlement Area boundary. Vinyl chloride would continue to attenuate, but groundwater would not be monitored. This alternative is not consistent with regulatory requirements and will not be considered further.

### 13.5.2 Long-Term Groundwater Monitoring with Contingent Action

The downgradient vinyl chloride concentrations are only slightly greater than the preliminary CUL. In addition, it is likely that these concentrations will be further reduced through transport processes, initially under anaerobic conditions and later under aerobic conditions. Based on these conditions, the recommended groundwater remediation alternative is long-term groundwater monitoring with contingent action via the presumptive remedy requirements.

Long-term groundwater monitoring will confirm whether trends in the concentrations remain stable or further decrease. During implementation of the remedial actions there may be temporary increases while the system is disturbed by construction. After construction, the groundwater system will return to baseline (current) conditions. Concentrations are expected to decrease over time as the *cis*-1,2-DCE and vinyl chloride continue to decay by degradation combined with diffusion from the Silt Overbank Deposit. Restoration timeframes are discussed in the next section.

### 13.5.3 Proposed Groundwater Remedial Action

Long-term groundwater monitoring with contingent action has been proposed as the cleanup alternative for downgradient groundwater. This alternative uses long-term groundwater monitoring and statistical trend analysis to track the residual vinyl chloride concentrations at the CPOC over time. The monitoring will confirm whether trends in the concentrations remain stable or decrease further over time.

Restoration timeframe for vinyl chloride will depend on the concentration of *cis*-1,2-DCE in the system and its conversion to vinyl chloride and the degradation rate of vinyl chloride. Because there is no detectable TCE in source area groundwater and only trace amounts in soil vapor, the reservoir of DCE that remains is limited to what has already been created and has sorbed onto the units such as the Silt Overbank Deposit. This reservoir will continue to decrease over time. The rate of decrease primarily depends on the rate at which DCE and/or vinyl chloride diffuse from the silt and move into groundwater. Once in groundwater, degradation rates are moderate based on the Bioscreen models and measured concentrations.

As discussed in Section 5.6.5.3, the restoration timeframe is estimated based on the combination of several factors:

- The reservoir of parent compound (*cis*-1,2-DCE) in the system and the rate of its diffusion from silt units such as the Silt Overbank Deposit.
- The degradation rate of *cis*-1,2-DCE and vinyl chloride in groundwater

Combining the information from the calibrated Bioscreen model and the trend plots for *cis*-1,2-DCE and vinyl chloride, the best estimate for restoration timeframe for vinyl chloride is within 10 years of the completion of the IA and redevelopment of the SRDS parcel. Based on historical trend plots, the last well to come into compliance will be MW-25. Trend lines for *cis*-1,2-DCE and vinyl chloride are presented in Section 5.0.

Contingent actions are proposed for vinyl chloride and are discussed in Section 16.0. Although iron, manganese, and arsenic will be monitored for at least a period of time as discussed in Section 16.0, no contingent action is needed or proposed.

### 13.6 COMPLIANCE WITH MTCA REQUIREMENTS

The downgradient groundwater component of the remedy described in this section complies with the MTCA requirements for a selected remedy. A description of how the MTCA requirements are met is included in Section 16.0.

# 14.0 Operations, Maintenance, and Monitoring within the Settlement Area

This section provides a general overview of the required long-term monitoring that is part of the presumptive remedy for landfills. The landfill cap, LFG, and groundwater must be monitored to ensure that the remedy remains effective and provides long-term protection of human health and the environment. In addition, as required by state and federal law, stormwater monitoring, if required, will be conducted on the Settlement Area.

To ensure that the selected components of the remedy are implemented efficiently and are operating properly, routine monitoring of the various components must be implemented. A Landfill Post-Closure OMMP, which will define OMM requirements for each of the presumptive remedy components, will be prepared and attached to the CAP. OMM requirements will ensure that the cleanup action is maintained over time, is protective of human health and the environment, and meets the expectations in WAC 173-340-7491 for protection of terrestrial receptors.

Stormwater monitoring is not required as part of the Settlement Area remedial action, because the stormwater that is conveyed off-site is blocked from contact with solid waste; however, operating facilities located at the Landfill may be required to monitor stormwater consistent with NPDES permit requirements. The requirements are triggered by facility operations.

A Landfill Site Coordinator will be designated to perform the long-term monitoring and reporting required under the CAP. The Landfill Site Coordinator will conduct the following work:

- Ongoing monitoring of LFG in perimeter probes as specified in the OMMP (Appendix A to the CAP), including monitoring of off-site buildings if triggered by the results of the perimeter probe monitoring.
- Ongoing groundwater monitoring as specified in the OMMP (Appendix A to the CAP).
- Annual inspections of the integrity of the landfill caps as specified in the OMMP.
- Annual inspections of surface water drainage effectiveness as specified in the OMMP.
- Creation and submittal of an annual report to Ecology of data/information related to the bullets above.
- Coordination and submittal of data required for Ecology 5-year site reviews.
- Informing Ecology of major OMM activities and incidents at the various parcels, as required in the OMMP, and acting as a central point of contact to field questions from Ecology and route them to the appropriate person, as needed.

The OMMP also specifies requirements for record keeping of inspections and repairs, and reporting. The OMMP consists of individual stand-alone plans that describe in greater detail the following sections.

## 14.1 LANDFILL CAP/COVER

The landfill cap, consisting of pavement, buildings, and geomembrane/soil layers, as described in Section 9.2, must be maintained in such a manner as to prevent contact with the solid waste/soil beneath the cap, prevent "short-circuiting" of the LFG controls, and support the stormwater controls that avoid solid waste contamination of runoff. The landfill cap is not required to entirely block the infiltration of stormwater. The cap must be inspected annually, and these records must be maintained for Ecology inspection. If the cap is damaged or becomes worn, it must be repaired and the repairs must be reported in accordance with requirements identified in the OMMP. In addition, if the landfill cap is disturbed and exposure to the underlying material (e.g., trenching or excavation) is necessary, a Material Handling Plan (also part of the OMMP) must also be followed.

## 14.2 LANDFILL GAS

Monitoring LFG collection systems serves two purposes: (1) performance monitoring within the system to guide its operation, and (2) compliance monitoring (confirmational monitoring under MTCA) to confirm that the system is controlling LFG emissions as required. Monitoring of the individual LFG collection systems will be performed on a parcel-by-parcel basis because the LFG controls are parcel-dependent. The primary goal of perimeter probe monitoring is to evaluate potential lateral off-site LFG migration and the primary goal of building monitoring is to protect human health. This monitoring is necessary to document the effectiveness of the LFG system(s) at the Landfill. Monitoring will be conducted in accordance with the OMMP attached to the CAP and will include requirements for perimeter probe and building monitoring along with contingencies and triggers necessary to document the effectiveness of the LFG system(s). Specific LFG probe locations, frequency of monitoring, and specific monitoring requirements are defined in the OMMP.

### 14.2.1 Perimeter Probe Monitoring

Methane concentrations in soil at the Landfill boundary must not exceed 5 percent by volume, the LEL for methane. This criterion will be measured by monitoring soil vapor probes along the Landfill boundary (perimeter probes) on a quarterly basis. The perimeter probes are shown on Figure 14.1.

### 14.2.2 Building Monitoring

Methane concentrations inside buildings and structures within the Settlement Area boundary must not exceed 1.25 percent by volume, or 25 percent of the LEL. This criterion is typically measured in the buildings/structures with either handheld or mounted equipment. All occupied buildings on the Landfill (on-site buildings) must have continuous (i.e., operate 24 hours per day, 7 days per week) methane detectors with alarms. The building locations are shown in yellow on Figure 14.2.

Methane concentrations inside buildings and structures outside the Settlement Area boundary (shown in green on Figure 14.2) must not exceed 100 ppmv. If results from perimeter probes in the vicinity of the off-site buildings exceed the compliance criteria of 5 percent, then indoor air is typically measured in the buildings/structures with either handheld or mounted equipment and compared to the criteria of 100 ppmv.

## 14.3 GROUNDWATER

Long-term groundwater monitoring is a fundamental component of both landfill closure requirements and MTCA. The long-term groundwater monitoring requirements are site-wide (not parcel-specific) and are described in greater detail in the OMMP. The goal of groundwater monitoring is to confirm whether the landfill remedy is performing as expected and to determine when groundwater comes into compliance for vinyl chloride.

### 14.3.1 Proposed Perimeter Monitoring Well Network

A long-term groundwater monitoring well network at and near the Settlement Area includes 14 perimeter wells, as described in this section. The existing monitoring well network will be used to monitor groundwater conditions at, and downgradient of, the Settlement Area. The locations of the wells, including the well descriptions, are shown on Figure 14.3.

The network contains three upgradient locations to track groundwater quality entering the Landfill. One of those locations, MW-12, is contaminated; the other two locations are in compliance (MW-14 and MW-29). All three locations monitor primarily the A-Zone of the Shallow Aquifer; the B-Zone does not exist upgradient of the Landfill because the aquifer becomes thinner near the valley wall. There are three edge of waste wells screened in the A-Zone. The unscreened sections of these wells extend through solid waste but are not screened in the solid waste. Five of the downgradient compliance wells are screened in the A-Zone, and four are screened in the B-Zone.

### 14.3.2 Proposed Analytical Schedule

The Landfill was closed in 1966 under requirements in effect at that time, and groundwater at the Landfill has been monitored since approximately 1996. Vinyl chloride, iron, and manganese are the only COCs for groundwater that still exceeds their CULs. The concentrations are low and trending downward. All groundwater samples will be analyzed for vinyl chloride and its precursor, *cis*-1,2-DCE, as well as iron and manganese. Benzene will be monitored in well MW-25 to track a localized plume that appears to originate upgradient of the Settlement Area. Arsenic will be monitored in wells MW-12, MW-08, MW-10, MW-18, MW-24, MW-25, MW-26, MW-27, MW-32, and MW-33. MW-25 is currently in compliance for benzene and arsenic and must remain so. Additionally, based on the discussion in Section 5.4.1.2, MW-27 is not a COPC well for arsenic. The analytical schedule presented in Table 14.1 is appropriate for the Landfill at this time in its history. The schedule may be modified in the future by modifying the OMMP with Ecology's approval.

## 14.4 REPORTING

Record keeping and reporting requirements are detailed in the OMMP. It is expected that annual OMM Reports will be prepared and submitted to Ecology by March 31 of each calendar year to document OMM activities at the Settlement Area over the course of each previous calendar year. The content of OMM Reports will include routine monitoring results from landfill cap annual inspections, LFG collection system monitoring, and groundwater monitoring.

The final details, including the selected locations to be monitored, frequency of sampling, and chemicals to be analyzed for are provided in the OMMP, attached to the CAP. The CAP also includes a Sampling and Analysis Plan/Quality Assurance Project Plan, which identifies the sampling procedures and the steps that will be taken to ensure quality assurance/quality control, and a Health and Safety Plan to protect the staff performing the sampling.

## 14.5 STORMWATER MONITORING

Stormwater monitoring is not required as part of the MTCA process for the Settlement Area because the stormwater will not come into contact with the solid waste. Stormwater monitoring may be required at individual facilities operating on the Landfill surface depending on specific operations conducted at the facility. Ecology’s Water Quality Program is delegated by USEPA as the state water pollution control agency responsible for implementing all federal and state laws and regulations related to stormwater runoff. This includes determining whether a specific facility needs a NPDES permit, and, if so, the type and terms of the permit. It is this permit that would specify monitoring requirements, if any, for the individual facilities.

In addition, during redevelopment, if more than 1 acre of area is disturbed, a Construction Stormwater General NPDES permit will be necessary to ensure that water leaving the parcels is not detrimental to downgradient water bodies. Any parcel that is to be redeveloped is responsible for obtaining these permits and meeting the requirements.

# 15.0 Environmental (Restrictive) Covenants

This section describes the institutional controls that will be required for owners of properties within the Settlement Area. The institutional controls will allow the preferred remedial alternative to function as intended and will provide a clear record of who is responsible for OMM of the selected remedial systems. The controls will also identify measures that will need to be taken to ensure that workers on and near the Landfill will conduct their work in a safe manner and not be exposed to any remaining contaminants. These controls will be documented in Environmental (Restrictive) Covenants[11] that will be attached to the properties and will be transferred to the new owner in event of a property transfer.

## 15.1 MTCA REQUIREMENTS

In accordance with WAC 173-340-440, MTCA requires that institutional controls such as environmental covenants be imposed on contaminated property whenever the remedial action conducted will result in hazardous substances remaining in soil, groundwater, or other media at concentrations that exceed applicable CULs, or when Ecology determines that such controls "are required to assure the continued protection of human health and the environment or the integrity of the interim or cleanup action."

The purpose of an Environmental (Restrictive) Covenant is to prohibit activities that may interfere with a cleanup action, OMM, or may result in the release of a hazardous substance that was contained as a part of the cleanup action. Environmental (Restrictive) Covenants must be recorded in order to give adjoining property owners, future purchasers, and tenants, as well as the general public, notice of the restrictions on use of the property. Property owners are also required to notify Ecology prior to any lease or sale of the restricted property.

The properties within the Settlement Area that will be subject to an Environmental (Restrictive) Covenant are shown on Figure 15.1 and include the following:

- The SPPD parcel
- The SRDS parcel

Ecology will work with the SDOT and WSDOT to define a notification process that transmits requirements applicable to the Settlement Area, as captured in the Environmental (Restrictive) Covenants, to ROWs that do not fall under the traditional environmental covenant process.

## 15.2 MODEL ENVIRONMENTAL (RESTRICTIVE) COVENANT

In order to provide a more consistent basis for the Environmental (Restrictive) Covenants, the State of Washington has adopted the Uniform Environmental Covenants Act (UECA), which is the

[11] The term "Environmental Covenant" or "Environmental (Restrictive) Covenant" as used in this document, is the same as the term "Restrictive Covenant." Restrictive Covenant is used in MTCA and Environmental Covenant is used in the Model Environmental Covenant prepared by Ecology.

basis for a model Environmental (Restrictive) Covenant that identifies the major components required for a legally binding covenant. The UECA also creates a system for maintaining a permanent record of the covenants so they can be easily identified during real estate transactions.

## 15.3 PROPOSED ENVIRONMENTAL (RESTRICTIVE) COVENANTS

The Environmental (Restrictive) Covenants will be attached to the CAP and will be mandated in the Consent Decree for the Settlement Area. The model Environmental (Restrictive) Covenant is the basis for a site-specific covenant for each of the parcels listed above. These covenants include the following:

- Access for Ecology personnel to inspect and review records, and to confirm compliance with the selected remedial action.
- Compliance with the selected remedial action and schedule presented in the CAP.
- On-going operation and maintenance of components of the remedial action, including LFG systems, the cap/cover systems, long-term groundwater monitoring, and any other engineered controls. These requirements will be based on OMMPs, a Compliance Monitoring Plan, or remedial system design reports prepared by the respective parties and submitted to Ecology.
- Requirements for worker safety when excavating.
- Requirements for construction practices to ensure that further construction continues to comply with the preferred remedial alternative. This may include foundation construction, pier and piling construction, and any subsurface construction.
- Notification requirements to Ecology of any ownership transfer of the parcels. Adequate and complete provision for ongoing operation and maintenance of the remedial action components must be accounted for in any property transfer.
- Land-use restrictions that will require the properties to remain as industrial or commercial sites and will prohibit any activity on the properties that may result in the release or exposure to the environment of a hazardous substance from the Landfill while allowing redevelopment and improvements of the properties.
- Restrictions of any groundwater use except for that of monitoring and remedial purposes as described in the CAP or 5-year review process.
- Restrictions of water supply wells within 1,000 feet of the Landfill, consistent with existing state law.

The Environmental (Restrictive) Covenants ensure the proposed remedial actions are properly implemented and maintained. The Environmental (Restrictive) Covenants will also ensure that the remedial action remains protective of human health and the environment, and that the necessary maintenance and monitoring occur as required.

# 16.0 Preferred Alternative for the Settlement Area

This section describes the components of the preferred remedial alternative for the Settlement Area. Each component is summarized below and was described in more detail in Sections 9.0 through 15.0 of this RI/FS Report. The preferred alternative is designed to meet MTCA cleanup action requirements, as described below. This section also identifies the schedule and next steps for implementing the selected remedial alternative.

## 16.1 COMPREHENSIVE PREFERRED REMEDIAL ALTERNATIVE

MTCA defines specific requirements that must be met for a selected remedy to be protective of human health and the environment and identifies criteria that must be met by each alternative. In addition, the selection of other requirements that must be met to protect human health and the environment is guided by the MFS. The regulations also ensure that a landfill must continue with operation and maintenance of the selected remedy and the appropriate long-term monitoring to ensure that the remedy is effective.

This section summarizes the components of the proposed cleanup action for the Settlement Area.

Under the terms of the Consent Decree, the signatory PLPs (collectively or individually) are required to implement the CAP. Ecology may institute legal or administrative action against the signatory PLPs for failure to meet the requirements of the Consent Decree, which includes a failure to implement any requirement of the CAP. MTCA establishes that PLPs for the Site are strictly, jointly, and severally liable for the remediation of the Site.

### 16.1.1 Landfill Cap

The first component of the preferred alternative for the Settlement Area is the presence of a landfill cap covering all areas containing solid waste. The goal of the landfill cap is to block access to the solid waste and contained soil; secondary goals are to limit stormwater infiltration and to facilitate the performance of the LFG system. Minimum standards for the landfill cap and requirements for continued monitoring and maintenance of the cap are discussed below.

#### *16.1.1.1 Minimum Standards for Landfill Cap*

All areas of the Settlement Area must be covered by a landfill cap that meets the minimum standards set out below. These requirements do not apply in areas that are covered by a structure. However, if redevelopment results in removal of a structure, then a Landfill cap meeting these minimum standards must be installed unless another Ecology-approved structure covers the same footprint.

The minimum standards for a landfill cap are as follows:

- A minimum thickness of 12 inches of fill material will be placed over the solid waste. This fill material does not need to meet a low-permeability standard. Existing fill that meets this depth requirement will be considered acceptable. Imported fill must not introduce new contaminants and must meet backfill requirements and specifications provided in the Materials Handling Plan (Appendix A, Attachment A.2 of the CAP). If an alternative to these fill specifications is requested by a PLP, a variance request and justification must be submitted to Ecology for approval.
- Additional fill or fill of specific geotechnical specification must be placed in order to meet the structural section requirements of road and foundation base as required by the geotechnical engineer responsible for the pavement design.
- A 3-inch minimum thickness for asphaltic concrete or a 4-inch minimum thickness for cement concrete will cover the fill.
- Pavement sections that fail to meet the primary and secondary goals of a Landfill cap must be replaced. For example, a pavement section that fails and develops large cracks, potholes, or settlement issues due to insufficient or incorrect pavement design (as opposed to routine maintenance needed due to age), must be replaced with an appropriate pavement section.
- Areas, such as landscaped buffers and slopes, planter islands, or gravel road shoulders, that will not be paved or receive hardscape (i.e., concrete), will require a soil layer with a minimum thickness of 24 inches and a distinct visible barrier between the new improvements and the top of the solid waste. The soil used as fill must not introduce new contaminants or contain contaminant concentrations exceeding MTCA industrial CULs.
- Stormwater conveyance and treatment facilities located above solid waste such as swales, ditches, or ponds on the Settlement Area are required to have cover, as prescribed by WAC 173-304-460, consisting of a low-permeability layer with a minimum 24-inch thickness of soil and permeability of $10^{-6}$ cm/sec or less, or an impermeable geomembrane that is at least 50 millimeters thick.
- There are also requirements for construction practices that will provide protection for the workers and ensure that construction at the Landfill is conducted in a manner that will minimize potential exposure or release of contaminants to the environment. These practices are described in Section 9.4 and will be referenced in the Environmental (Restrictive) Covenants for the Settlement Area.

On the SRDS parcel, there is an existing area with large, established trees. The landfill cap requirements specified above are not intended to require removal of the trees. The requirement associated with the trees is to ensure that the landscaping at the base of the trees blocks direct contact with refuse.

If a variance to the minimum standard requirements for a landfill cap is requested by a PLP or a property owner, then a variance request and justification must be submitted to Ecology for approval. Each proposed variance will be reviewed by Ecology to determine if the proposal will meet the goals of the Landfill cap and MTCA regulations. As an example, the following variances have been approved for the SPPD parcel within the Settlement Area:

- SDOT's standard sidewalk section of 2 inches instead of 3 inches is acceptable in areas where the sidewalk will not be driven over. The sidewalks must be maintained to prevent direct contact with refuse.
- In areas with steep slopes, the use of a multilayer cap with a geomembrane instead of asphalt, must be used. The designed and built layer must be stable and resistant to erosion; if erosion occurs, the area affected must be repaired.

#### *16.1.1.2 Relationship with Requirements in Minimum Functional Standards*

Although the minimum landfill cap requirements discussed above are protective of human health and the environment and meet the MTCA requirements, they are a variance to the specific cap design listed in the MFS. The proposed landfill cap does not consist of either 2 feet of low-permeability soil or a geomembrane layer and does not include a 6-inch-thick vegetative layer. As part of the CAP, Ecology is approving the variance from the closure methods set forth in WAC 173-304-460. This is allowed by MTCA in WAC 173-340-710(5), which allows for variances, or waivers, of provisions that are included in other applicable regulations. Allowing the asphaltic concrete cap to vary from the provisions of the MFS is appropriate at this Settlement Area for the following reasons:

- A low-permeability cap is not needed because the Landfill is already in late Stage 4/early Stage 5, and infiltration of stormwater has been occurring for decades.
- The Landfill is unlined and in direct contact with groundwater; therefore, blocking stormwater infiltration has no measurable impact on groundwater quality.
- The proposed landfill cap, supported by the OMMP and institutional controls that limit the uses of the Landfill, will effectively prevent direct contact with wastes, improve the effectiveness of the LFG system, and reduce stormwater infiltration.

A more detailed rationale for the variance, or waiver, of provisions in the MFS for the landfill cap was approved by Ecology in October 2012 and is available in Appendix B of the IAWP for the SPPD parcel (Farallon 2013).

#### *16.1.1.3 Allowance for Reinterment during Cleanup*

Regrading, including excavation and reinterment of the solid waste, is allowed during the implementation of the cleanup action, as long as the final configuration does not expand the footprint of the Landfill and all solid waste and contaminated soil remains contained beneath the landfill cap.

##### *16.1.1.4 Implementation Schedule*

At present, the SPPD parcel is in compliance with the requirements described above. The SRDS is undergoing an IA that will bring it into compliance in the next couple of years (the specific schedule will be in the IA EDR).

#### 16.1.2 Leachate Control Preferred Alternative

As discussed in Section 10.1, leachate controls are not needed at the site for the following reasons:

- The Landfill is old and in late Stage 4/early stage 5 conditions.
- The Landfill is unlined and in direct contact with groundwater.
- From its closure in 1966 until 2015, 60% of the Landfill surface was uncapped and allowed rainfall to the site to infiltrate.
- Leachate produced by infiltrating rainwater and groundwater is now similar to the surrounding groundwater, with a neutral pH and few contaminants as discussed in Section 5.6. Residual vinyl chloride appears to be coming from silts within the A-Zone of the aquifer, deeper than the solid waste layer.

IAs as part of redevelopment at the two largest parcels (SPPD and SRDS) include a landfill cap that will reduce rainwater infiltration; this will reduce the volume of leachate produced by infiltrating rainwater, but will have no effect on the overall volume of leachate, which is controlled by the elevation of the water table. The elevation of the water table is not controlled by on-site rainfall.

If pilings are used as part of redevelopment of one of the parcels, then the pilings must not create new vertical pathways for leachate to reach groundwater that results in an impact to groundwater quality, and must not drag down refuse and contaminated soil into the aquifer during installation. This requirement should be placed in the Environmental (Restrictive) Covenants for the Site.

#### 16.1.3 Landfill Gas Controls

LFG controls must be sufficient to eliminate explosion hazards due to methane buildup and to demonstrate that LFG is not migrating off the Landfill in unacceptable concentrations. Section 6.0 presents the nature and extent of LFG, including methane and VOCs. Measurements were collected in soil vapor probes and in ambient air in buildings. Monitoring of perimeter LFG probes has shown that LFG is still present in some locations at concentrations greater than 5 percent methane but with no measurable pressure. Buildings were measured for methane in four events as part of the RI, and no methane was detected with a detection limit of 0.5 ppmv and an action level of 100 ppmv. Although current conditions are protective in aboveground buildings, the continued slow generation of LFG requires ongoing monitoring and controls.

Indoor air in buildings that are closest to the LFG probes that had the greatest methane concentrations was monitored several times during the course of the RI, and no LFG intrusion was found.

LFG mitigation criteria under the MFS are defined in WAC 173-304-460 and King County Board of Health Title 10 regulations. The principal criteria relevant to the Landfill are the following:

- Methane concentrations in soil at the Edge of Refuse must not exceed 5 percent by volume, the LEL for methane.
- Methane concentrations inside buildings and structures within the Edge of Refuse must not exceed 1.25 percent by volume, or 25 percent of the LEL.
- Methane concentrations inside buildings and structures beyond the Edge of Refuse must not exceed 100 ppmv.

Routine perimeter probe monitoring and building monitoring will be conducted in accordance with the OMMP to ensure the above criteria are met. All occupied buildings within the Edge of Refuse will be required to have continuous methane detectors with alarms (i.e., operate 24 hours per day, 7 days per week); meters will be set to alarm at the 1.25 percent level.

The proposed cleanup action for the Settlement Area is presented in the following sections by parcel.

#### *16.1.3.1 SPPD Parcel and Adjacent 5th Avenue South*

As part of the redevelopment and IA, SPPD installed an active LFG control system in 2014 and 2015. The system was designed and installed in conjunction with the landfill cap and cover requirements described above, and new buildings and utilities on the parcel will be constructed to be compatible with the LFG system. LFG had been detected along 5th Avenue South adjacent to the SPPD parcel. The LFG system at the SPPD parcel was designed to control LFG along the section of 5th Avenue South adjacent to the parcel. Since the system became fully operational in late 2015, the probes along 5th Avenue South have been in compliance. The system at SPPD will continue to be responsible for compliance along the adjacent section of 5th Avenue South.

Monitoring, reporting, and contingent actions are also required (discussed in Section 16.1.6) and will be implemented through requirements in a site-wide OMMP.

#### *16.1.3.2 SRDS Parcel*

The buildings that are currently on the parcel are either naturally ventilated or are elevated and skirted with porous siding; both are appropriate methods of LFG mitigation. As part of the IAWP, SRDS will install a LFG control system, intended to be operated as passive with an option to convert to active if necessary. The final design for the SRDS system was described in the Ecology-approved IAWP for the redevelopment of the SRDS parcel, dated July 2015. The system has been designed in conjunction with the landfill cap and cover requirements described in Section 9.0, and new buildings and utilities on the parcel will be constructed to be compatible with the proposed system. This system also influences the ROW associated with 5th Avenue South adjacent to this parcel.

Monitoring, reporting, and contingent actions are also required (discussed in Section 16.1.6) and will be implemented through requirements in a site-wide OMMP.

#### *16.1.3.3 Building Construction*

Building construction at the landfill that does not disturb the landfill cap and does not affect the operations of the LFG systems or other remedial action components, must still comply with Seattle Building Code requirements for protection of structures from methane intrusion, which states:

> *"1811.2 Protection of structures. All enclosed structures to be built within the 1,000 foot (305 m) landfill zone shall be protected from potential methane migration. The method for protecting a structure from methane shall be identified in a report prepared by a licensed civil engineer and submitted by the applicant to the building official for approval. The report shall contain a description of the investigation and recommendations for preventing the accumulation of explosive concentrations of methane gas within or under enclosed portions of the building or structure. At the time of final inspection, the civil engineer shall furnish a signed statement attesting that, to the best of the engineer's knowledge, the building or structure has been constructed in accordance with the recommendations for addressing methane gas migration."*

This requirement is triggered by either a permitted remodel/modification of an occupied structure or new construction.

### 16.1.4 Stormwater Controls

The stormwater controls at the Settlement Area are designed to capture and divert the bulk of the stormwater before it can make contact with solid waste. Because the Landfill extends into the water table, stormwater controls for the Settlement Area are not intended to limit infiltration; rather, stormwater controls for the Settlement Area are intended to prevent solid waste constituents from contaminating stormwater runoff. The stormwater controls are also intended to minimize the potential for disturbances, erosion, scouring, or otherwise disturbing the landfill cap. The parcels within the Settlement Area boundary are paved and have stormwater infrastructures that are consistent with the goal stated above. As part of the cleanup action, the systems described below will be maintained:

- **SRDS parcel.** This parcel is undergoing redevelopment and plans are not yet final. Final plans will take into account the goal of stormwater controls for the Settlement Area and will be designed not to interfere with the cleanup action. Currently, the redevelopment plans indicate that stormwater drainage will be collected across the site and will require flow and quality mitigation using a subsurface stormwater vault, anticipated to be located on the northern portion of the site under the Vactor parking area where the site is more open (i.e., not under buildings). Discharge from the stormwater vault is anticipated to drain to the northwest to the 30-inch-diameter storm pipe located in 2nd Avenue South. This system ties in to the storm drain system on SR 509 that flows into the wetlands on the west side of SR 509. The design components of the system that are located beneath the landfill cap will be submitted to Ecology and reviewed for compatibility with the cleanup action.

- **SPPD parcel.** Stormwater capture on the SPPD parcel is achieved with a system of paved surfaces and catch basins, and conveyance via overland flow on paved surfaces and piping to detention and treatment in one of two SPPD property bioswales. A small proportion of SPPD parcel stormwater runoff (e.g., from the access driveway off 5th Avenue South) is outside the capture area of the bioswales and flows to catch basins in ROWs.

  The North and West Bioswales, described further below, discharge to a new 36-inch-diameter concrete storm drain line installed in the Occidental Avenue South ROW. The new storm drain line bypasses the private KIP storm drain line formerly used to convey stormwater flows from the SPPD property to a City drain line in South Kenyon Street. The new Occidental Avenue South storm drain line connects to the same City drain line in South Kenyon Street downstream of the inflow from KIP. The City drain line discharges into the wetland system west of SR 509, ultimately discharging to the Lower Duwamish Waterway.

  Past surface water control included construction of two bioswales: one in the northern portion of the SPPD parcel (North Bioswale), and the other in the northern portion of the former West Ditch (West Bioswale). As part of the construction of the West Bioswale and preparation of the subgrade for the bioswale and other redevelopment purposes, former West Ditch sediments were solidified by mixing in a Portland cement mixture. The low-permeability membrane cap system was installed along the eastern slope of the former West Ditch and keyed into the solidified material, effectively capping exposed solid waste in this area. Soil on the western side of the former West Ditch was covered with a distinct visible barrier that was overlain with a minimum of 18 inches of clean fill material or top soil. To minimize the effects to shallow groundwater flow from the solidified material, notches were cut into the top of the solidified mass and filled with drain rock, providing drainage to convey shallow groundwater from west to east across the top of the solidified mass. The design and the basis for the design of the former West Ditch sediment solidification aspect of the surface water control component of the IA are presented in the IAWP.

#### 16.1.5 Downgradient Groundwater Controls

The selected remedial action for groundwater is long-term groundwater monitoring with contingent action if triggers are met that are related to concentrations rising at the Settlement Area boundary in the future. The groundwater cleanup action uses monitoring and statistical analysis of well-by-well trend plots, as further described in the Groundwater Monitoring and Contingency Plan (part of the OMMP [Appendix A of the CAP]). This plan also contains the triggers for the contingent action. Long-term monitoring will confirm whether concentration trends remain stable or decrease further, especially once cleanup actions are implemented (landfill cap and LFG extraction). Finally, measured concentrations in MW-30, a shallow, perched well, are less than Ecology's screening levels for vapor intrusion concerns and so will not be addressed as part of the remedial action.

The only COCs greater than preliminary CULs for groundwater at the CPOC are vinyl chloride, iron, and manganese. Monitoring wells have been installed along the downgradient perimeter of the Landfill to monitor compliance at the CPOC for groundwater. There is no drinking water or water supply well downgradient of the Landfill, and the nearest point of exposure is 1,600 feet downgradient, where groundwater discharges to the Lower Duwamish Waterway.

Based on data collected in the RI/FS, residual vinyl chloride appears to be releasing very slowly from a silt lens in the upper sections of the aquifer. Iron and manganese are naturally high in the Alluvial Aquifer. Iron is periodically (but not consistently) elevated to concentrations greater than the background in MW-25, MW-32, MW-10, and MW-18; the other wells are in compliance. Manganese is periodically (but not consistently) elevated to concentrations greater than background in MW-25, MW-32, and MW-10; the remaining wells are in compliance. Based on existing trend plots (Appendix J), vinyl chloride, iron, and manganese concentrations are expected to come into compliance within 10 years of the completion of construction of cleanup elements at the Settlement Area.

Long-term groundwater monitoring will include *cis*-1,2-DCE (the precursor for vinyl chloride) in wells where vinyl chloride is measured, and benzene in well MW-25 to track a localized plume that appears to originate upgradient of the Settlement Area. Arsenic will be monitored in wells MW-12, MW-08, MW-10, MW-18, MW-24, MW-25, MW-26, MW-27, MW-32, and MW-33. Note that MW-27 is not a CPOC well for arsenic.

#### 16.1.6 Operations, Maintenance, and Monitoring Preferred Alternative

To ensure that the selected components of the cleanup action are implemented efficiently and are operating properly, long-term OMM of the various components must be implemented. An OMMP that outlines these specific requirements for long-term monitoring is included in Appendix A of the CAP. The following is a summary of the OMM requirements for the affected media at the Settlement Area:

- **Landfill cap.** The landfill cap, consisting of pavement, buildings, and geomembrane/soil layers, as described in Section 9.0, must be maintained in such a manner as to prevent contact with the solid waste/soil beneath the cap, prevent "short-circuiting" of the LFG controls, and support the stormwater controls that avoid solid waste contamination of runoff. The landfill cap is not required to entirely block the infiltration of stormwater. The cap must be inspected annually, and these records must be maintained for Ecology inspection. If the cap is damaged or becomes worn, it must be repaired and the repairs must be reported in accordance with the Landfill Cap Inspection and Maintenance Plan (Appendix A, Attachment A.1 of the CAP).

In addition, if the landfill cap is disturbed and exposure to the underlying material (e.g., trenching or excavation) is necessary, the Material Handling Plan (Appendix A, Attachment A.2 of the CAP) must also be followed.

- **Landfill gas.** Monitoring LFG collection systems serves two purposes: (1) performance monitoring within the system guides its operation, and (2) post-construction compliance monitoring (confirmational monitoring under MTCA) confirms that the system is controlling LFG emissions as required by the cleanup action. The long-term LFG monitoring requirements are described in the Landfill Gas Monitoring and Contingency Plan (Appendix A, Attachment A.3 of the CAP).
- **Groundwater.** Long-term groundwater monitoring is a fundamental component of both landfill closure requirements and MTCA. The long-term groundwater monitoring requirements are Settlement Area-wide and are described in the Groundwater Monitoring and Contingency Plan (Appendix A, Attachment A.4 of the CAP).

The plans referenced above make up the OMMP attachments and were prepared as individual stand-alone plans. The OMMP will also specify requirements for recordkeeping of inspections and repairs, and reporting.

#### 16.1.7 Site Coordinator Responsibilities

A Landfill Site Coordinator will be designated to perform the long-term monitoring and reporting required under the CAP. The Site Coordinator will conduct the following work:

- Ongoing monitoring of LFG in perimeter probes as specified in the OMMP (Appendix A of the CAP), including monitoring of off-site buildings if triggered by the results of the perimeter probe monitoring.
- Ongoing groundwater monitoring as specified in the OMMP.
- Annual inspections of the integrity of the landfill caps as specified in the OMMP.
- Annual inspections of surface water drainage effectiveness as specified in the OMMP.
- Creation and submittal of an annual report to Ecology of data/information related to the bullets above.
- Coordination and submittal of data required for Ecology 5-year site reviews.
- Informing Ecology of major OMM activities and incidents at the various parcels, as required in the OMMP, and acting as a central point of contact for field questions from Ecology, routing them to the appropriate person, as needed.

#### 16.1.8 Environmental (Restrictive) Covenants

WAC 173-340-440 establishes that when the final remedy does not remove all contaminants from the property, or MTCA Method C CULs, or industrial soil CULs are used, appropriate institutional controls shall be established in an Environmental (Restrictive) Covenant on the property. Covenants shall be executed by each owner of property within the Settlement Area boundary, and the covenants shall be recorded with the County. The Environmental (Restrictive) Covenants shall run with the land and be binding on each owner's successors and assigns.

The proposed Environmental (Restrictive) Covenants are attached as Appendix B of the CAP and apply to the SRDS parcel and the SPPD parcel. As required by WAC 173-340-440(9), "the restrictive covenants shall:

Prohibit activities on the site that may interfere with the cleanup action, operation and maintenance, monitoring, or other measures necessary to assure the integrity of the cleanup action and continued protection of human health and the environment.

(a) Prohibit activities that may interfere with the preferred remedy in the final cleanup action plan or that may result in the release of a hazardous substance that was contained as a part of the cleanup action.

(b) Require notice to the department of the owner's intent to convey any interest in the site.

(c) No conveyance of title, easement, lease, or other interest in the property shall be consummated by the property owner without adequate and complete provision for the continued implementation, operation, maintenance, and monitoring of the cleanup action, and for continued compliance with this subsection.

(d) Require the landowner to restrict leases to uses and activities consistent with the restrictive covenant and notify all lessees of the restrictions on the use of the property.

(e) Require the owner to include in any instrument conveying any interest in any portion of the property, notice of the restrictive covenant under this section.

(f) Require notice and approval by the department of any proposal to use the site in a manner that is inconsistent with the restrictive covenant.

(g) Grant the department and other property owners the right to enter the property at reasonable times for the purpose of evaluating compliance with the cleanup action plan and other required plans, including the right to take samples, inspect any remedial actions taken at the site, and to inspect records."

The landfill extends under three roads in the area. Typically, the refuse was shallow in these locations and often indistinguishable from other fill sources (CKD, concrete, etc.) used for roads throughout the valley. Ecology will work with SDOT and WSDOT under WAC 173-340-440(8)(b) to define a notification process that transmits requirements applicable to the ROWs, as captured in the Environmental (Restrictive) Covenants, to ROWs that do not fall under the traditional environmental covenant process. The schedule for completion is shown in Section 16.3.

## 16.2 COMPLIANCE WITH MTCA REQUIREMENTS

The presumptive remedy was evaluated for its compliance with MTCA cleanup goals, including those for containment remedies. As described below, the preferred alternative presented in this document meets the requirements of MTCA and attains the remedial action objectives set forth for the Settlement Area.

### 16.2.1 Requirements for Cleanup Actions (WAC 173-340-360(2))

The threshold criteria identified in WAC 173-340-360(2)(a) that must be met by the selected remedy and the reasons why the preferred alternative meets them, are as follows:

***(a)(i) Protect human health and the environment***

**Landfill cap**. The landfill cap described in Section 9.2 and implementation schedule will prevent direct contact with solid waste by humans, plants, and animals. It will also ensure that stormwater that leaves the Landfill through the stormwater conveyance systems has not come into contact with solid waste.

By limiting infiltration of stormwater, the cap will also decrease the amount of leachate produced. As discussed in Section 16.1.1, because the Landfill is unlined and the contents are already in contact with groundwater, this decrease in infiltrating stormwater is viewed as a minor benefit that may or may not produce measurable changes in groundwater quality.

**Landfill gas controls.** The LFG control described in Section 11.3 meets system requirements for preventing worker and visitor exposure to LFG that poses a risk to human health. The concentrations in buildings adjacent to the Landfill are already at acceptable levels; therefore, LFG systems will be limited to the footprint of the solid waste in the Settlement Area. The LFG system will also collect any VOCs entrained in the LFG system and vent them to avoid the accumulation of VOCs in buildings (control vapor intrusion).

**Stormwater controls.** The stormwater controls described in Section 12.0 meet the MTCA requirements by effectively separating the stormwater from the Landfill solid waste and contaminated soil. The captured stormwater will be conveyed and discharged off-site in accordance with the stormwater regulations and ordinances.

**Groundwater monitoring.** Long-term groundwater monitoring with contingent actions is an appropriate remedial action for groundwater because groundwater sampling data at the Landfill indicate that vinyl chloride, iron, and manganese are the only remaining COCs detected at concentrations greater than CULs for groundwater at the Settlement Area, is very close to being in compliance, and is continuing to decrease toward compliant concentrations less than CULs. The most recent concentrations of vinyl chloride data collected in CPOC wells ranged from not detected at 0.02 to 0.99 µg/L. Ecology has established a CUL for vinyl chloride in groundwater of 0.29 µg/L. This value was selected to protect potential drinking water uses, but it is also protective of surface water quality. The most recent concentrations of iron and manganese data collected in CPOC wells ranged from 4 to 29 mg/L in the A-Zone and 21 to 33 mg/L in the B-Zone for iron, and from 0.15 to 2.9 mg/L in the A-Zone and 1.1 to 1.5 mg/L in the B-Zone for manganese. Ecology has established CULs for iron in groundwater of 27 mg/L (A-Zone) and 31 mg/L (B-Zone) and for manganese in groundwater of 2.1 mg/L (A-Zone) and 1.1 mg/L (B-Zone).

There are no current or anticipated drinking water wells between the Landfill and the Lower Duwamish Waterway, located approximately 1,600 feet downgradient; therefore, there is no potential exposure to the groundwater.

**Operations, maintenance, and monitoring.** OMM requirements combined with the Environmental (Restrictive) Covenants will ensure that the cleanup action is maintained over time, is protective of human health and the environment, and meets the expectations in WAC 173-340-7491 for protection of terrestrial receptors.

***(a)(ii) Comply with cleanup standards (WAC 173-340-720 through 173-340-760)***

The containment remedy is an effective MTCA remedy for soil that complies with cleanup standards and allows solid waste within the closed Landfill to be left in place as long as the requirements for a containment remedy are met. Groundwater concentrations will comply with the MTCA Method B CULs at the CPOC for landfills at the edge-of-refuse. The groundwater concentrations of all the historical contaminants except for vinyl chloride, iron, and manganese are already in compliance at the CPOC. As described in Section 5.6.5, the downgradient groundwater will meet the cleanup standards within a reasonable timeframe (10 years for vinyl chloride, iron, and manganese) and will be monitored routinely to ensure that the groundwater is achieving the desired conditions within a reasonable restoration time. The LFG controls comply with the standards developed to prevent LFG levels greater than the permissible percentages of methane and carbon dioxide and any applicable cleanup standards. The LFG controls will also control VOC emissions from the Landfill.

***(a)(iii) Comply with applicable state and federal laws (WAC 173-340-710)***

The landfill cover specifications meet the alternative cap requirements for the landfill cap and cover allowed by WAC 173-340-710. The landfill cap, in conjunction with the recommended stormwater infrastructure, ensures compliance with these requirements. The LFG control requirements apply to the specific landfill regulations as outlined in Section 11.0. The other components of the remedy are consistent with the applicable regulations.

***(a)(iv) Provide for compliance monitoring (WAC 173-340-410 and WAC 173-340-720 through 173-340-760)***

Compliance monitoring will be conducted for both LFG and groundwater, as described in Appendix A, Attachments A.3 and A.4 of the CAP.

WAC 173-340-360(2)(b) specifies three other criteria that cleanup actions must achieve. The following list describes how these criteria are met by the preferred alternative:

***(b)(i) Use permanent solutions to the maximum extent practicable***

The preferred remedy is permanent to the maximum extent practicable for a closed solid waste landfill containing large volumes of hazardous substances at low concentrations. OMM requirements, along with Environmental (Restrictive) Covenants, ensure that the containment remedy for soil and solid waste will remain protective over time.

***(b)(ii) Provide for a reasonable restoration time frame***

Cleanup actions combined with OMM requirements in the CAP will ensure protection of human health and the environment. The IA cleanup actions were completed at the SPPD parcel in 2015 and are expected to be completed at the SRDS parcel in 2017 or 2018. A schedule for implementation of the remedial action is presented in Section 16.3. Groundwater contaminant concentrations are expected to come into compliance within 10 years; there are no current or anticipated uses of or exposures to the groundwater. Vinyl chloride concentrations are presently at or less than method detection limits where groundwater discharges to surface water (Lower Duwamish Waterway); therefore, there is no measurable impact from the Site on surface water.

***(b)(iii) Consider public concerns (WAC 173-340-600)***

Ecology provides the draft CAP and associated Consent Decree for public review and comment and responds to comments raised by the public. Ecology finalizes the CAP and Consent Decree after consideration of public input.

### 16.2.2 Requirements for Containment Systems (WAC 173-340-740(6)(f))

WAC 173-340-740(6)(f) includes specific requirements of a containment cleanup action that allow soil and solid waste with concentrations greater than the soil CULs to remain in place. These requirements are met by the preferred alternative in the following ways:

***(f)(iv) Institutional controls are put in place***

An Environmental (Restrictive) Covenant will be established for the two parcels and ROWs that overlies the Settlement Area to ensure that the requirements of the remedy, including OMM of the landfill cap, LFG control systems, and groundwater monitoring, are met.

***(f)(v) Compliance monitoring (WAC 173-340-410) and periodic reviews (WAC 173-340-430) are designed to ensure long-term integrity of the containment system***

The OMMP (Appendix A of the CAP) provides details for OMM requirements to ensure that the cleanup action components are implemented efficiently and are functioning as intended. In addition, each parcel with a LFG system will have a LFG OMMP designed to ensure the long-term integrity of the system. OMM information will be compiled and reported to Ecology in a site-wide Annual Monitoring Report. Periodic review of the remedial action in accordance with WAC 173-340-420 will occur as detailed in the Consent Decree.

***(f)(vi) Types, levels, and amount of hazardous substances remaining on-site and the measures that will be used to prevent migration and contact with those substances are specified in the CAP***

The material remaining within the Landfill is municipal solid waste containing low levels of hazardous substances. Containment of hazardous substances will be accomplished through the installation and maintenance of a landfill cap, as described in Section 16.1.1.

### 16.3 ANTICIPATED SCHEDULE

Implementation of the remedial actions included in the CAP will occur over the next 5 years. The restoration timeframe for groundwater compliance is 10 years. Table 16.1 lists the milestones that have been identified, along with the schedule timeframe.

**Table 16.1**
**Implementation Schedule**

| Item/Milestone | Timeframe |
|---|---|
| **Construction and Operations of Remedial Components** | |
| Remedial action construction at SPPD | Completed as an IA in 2015. |
| Operation of LFG system at SPPD | Operations began as an IA in 2015 and will continue until no longer needed per the OMMP. |
| Remedial action construction at new SRDS (South Transfer Station Phase II [STSII]) | To be performed as an IA under the schedule in the Agreed Order. |
| Operation of LFG system at new SRDS (STSII) | Operations to begin as part of an IA (2018 expected) and will continue until no longer needed per the OMMP. |
| Installation of methane alarms in buildings | Part of remedial action; 180 days after the effective date of the Consent Decree for all existing buildings; or at time of occupancy for any future new buildings. |
| **Long-Term Monitoring and Environmental (Restrictive) Covenants** | |
| Long-term monitoring of LFG, groundwater, and landfill cap integrity | Part of the OMMP; monitoring would begin 180 days after the effective date of the Consent Decree. |
| Environmental (Restrictive) Covenants for SPPD and SRDS parcels | Filed with the County Recorder within 180 days after the effective date of the Consent Decree. |

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**South Park Landfill**

# Remedial Investigation/ Feasibility Study

# Tables

## Table 2.1
## Owners and Tax Parcels

| Parcel Designation in RI/FS | King County Tax Payer | Street Address | King County Parcel Number | Land Area (acres)[1] |
|---|---|---|---|---|
| Kenyon Industrial Park (KIP) | Harsch Investment Properties, LLC | 121 S Kenyon Street St | 3224049007 | 6.49 |
| 7901 Parcel (7901) | 7901 2nd Ave S, LLC | 7901 2nd Ave S | 3224049077 | 0.72 |
| South Recycling and Disposal Station (SRDS)[2] | City of Seattle<br>Seattle Public Utility Solid Waste Utility | 8100 2nd Ave S | 7328400005<br>3224049110 | 10.55 |
| South Park Property Development Parcel (SPPD) | South Park Development | 8100 2nd Ave S[3] | 3224049005 | 21.0 |
| Lenci Parcel (Lenci) | Lenci Frank Corporation | 426 S Cloverdale St | 3224049045 | 2.77 |

Notes:
1 Land area is from King County Tax Parcel Viewer and is approximate.
2 Facility is closed at this location and property is being redeveloped by Seattle Public Utilities for other uses.
3 Address shown is from King County Parcel Viewer; and does not reflect current usage

# Table 2.2
## Summary of Regional Investigations

| Title | Reference | Primary Scope and Contents | Report Findings[1] |
|---|---|---|---|
| Duwamish Groundwater Study | Sweet, Edwards and Associates (1985) | • Identified target investigations to address contaminant contribution to Duwamish Waterway.<br>• Analyzed three groundwater monitoring programs to evaluate contaminant loading to Duwamish Waterway. | • Provided information regarding site hydrogeology.<br>• Identified potential contamination from sites upgradient of the Duwamish Waterway. |
| Duwamish Industrial Area Hydrogeologic Pathways Project: Duwamish Basin Groundwater Pathways Conceptual Model Report | Hart Crowser, Inc. (1998)<br>*Revised 2014, by Floyd\|Snider for Ecology (Ecology 2014b)* | • Improved understanding of regional hydrogeologic conditions within the Lower Duwamish River Basin.<br>• Formulated beneficial use strategy for shallow groundwater; groundwater was identified as a potential impact to surface water. | • Further developed the understanding of hydrogeologic conditions that define groundwater, including: geologic history and framework, aquifer and aquitard occurrence, recharge and discharge factors, groundwater flow patterns, and groundwater quality. |
| Lower Duwamish Waterway Remedial Investigation Report | Windward Environmental (2010) | • Identified extent and sources of contamination to the Lower Duwamish Waterway.<br>• Provided baseline Risk Assessment to identify areas of cleanup.<br>• Included data on tissue studies, organism surveys, and groundwater/porewater/sediment characterization.<br>• Provided a list of CSCSs, RCRA, and CERCLA properties, registered Brownfield properties, and LUSTs within the Lower Duwamish Waterway study area. | • Provided a summary of nearby CSCSs.<br>• Looked at upland sources of contamination to the Lower Duwamish Waterway.<br>• Identified the South Park Landfill as a potential upland source to the Lower Duwamish Waterway. |

Note:

1 Report findings relevant to the South Park Landfill.

Abbreviations:

CERCLA Comprehensive Environmental Response, Compensation, and Liability Act
CSCS Confirmed or Suspected Contaminated Site
LUST Leaking underground storage tank
RCRA Resource Conservation and Recovery Act
RI/FS Remedial Investigation/Feasibility Study

**Table 2.3**
**Summary of Previous Adjacent Investigations**

| Site | Title | Reference[1] | Primary Scope and Contents | Report Findings[2] |
|---|---|---|---|---|
| Former Glitsa Property | Glitsa American UST Closure | Bison Environmental Northwest (1992) | • Advanced three exploratory soil borings through UST. | • Mineral spirits exceeded MTCA Method A CULs in soil surrounding a 7,500-gallon UST. |
| | Phase 1 Environmental Site Assessment and Hazardous Materials Survey | Eco Compliance Corporation (2007) | • Environmental review was conducted to identify recognized environmental conditions associated with the property. | • On-site soil and groundwater contamination, and possible methane gas were suspected.<br>• Known contamination from a 6,000-gallon Stoddard-solvent UST.[3]<br>• Suspect that a 7,500-gallon UST exists on the property.[3] |
| | Not Available | Environmental Associates (2009b) | • Soil sampling and monitoring well installation at four locations (MW-1 to MW-4).<br>• One boring (B-5) advanced. | • No report available. |
| | Supplemental Exploration and Further Remediation Feasibility Study—Former Glitsa, Inc. Property, Seattle, Washington | Environmental Associates (2009a) | • Supplemental soil and groundwater investigation adjacent to the LUST. Installation of monitoring wells and soil sampling at two locations (MW-5 and MW-6).<br>• Targeted soil sampling in potentially impacted areas related to a former auto-wrecking yard/maintenance area and within the Glitsa warehouse. Advanced two soil borings (LAR1 and LAR2).<br>• Developed remediation alternatives, including a vapor extraction system, and advanced six soil borings for further soil and groundwater contaminant delineation. Included soil and groundwater sampling for HVOCs. Completed vapor extraction wells (HA1/VES-1 to HA6/VES-6).<br>• Sampled stockpile of topsoil located on the southern portion of the site (SS-1). | • Several soil samples exceeded MTCA Method A CULs for Stoddard-solvent (LAR2, HA1/VES-1, HA3/VES-3, and HA4/VES-4), ethylbenzene (HA4/VES-4), and total xylenes (LAR2, HA1/VES-1, and HA4/VES-4).<br>• Groundwater samples from monitoring wells/soil borings exceeded MTCA Method A CULs for Stoddard-solvent (MW-1, MW-4, LAR2, VES-4, VES-5, and VES-6), benzene, (LAR2 and VES-4), and vinyl chloride (LAR2). Other HVOCs were detected.<br>• Site Feasibility Study indicated remediation/site stabilization plan. It was mentioned that soil vapor extraction and free-phase solvent recovery, should be effective. |
| | Underground Storage Tank Removal Report and Checklist—Former Glitsa Property, Seattle, Washington | Environmental Associates (2009c) | • Removal of 7,500-gallon Stoddard-solvent LUST and contaminated soils.<br>• Confirmation sampling to assess removal of Stoddard-solvent impacted soil (N-6, S-6, E-6, W-4, B-12, B-12, and PSC-1).<br>Collected three follow-up soil samples (RE-W-6, RE-NW-6, and RE-SW-6). | • Removed LUST and 120 tons of contaminated soil.<br>• Confirmation samples exceeded MTCA Method A CULs for Stoddard-solvent (W-4 and PSC-1), ethylbenzene (W-4), and xylenes (W-4 and PSC-1).<br>• Removed an additional 58 tons of contaminated soil.<br>Follow-up confirmation samples contained Stoddard-solvent, ethylbenzene, and xylenes (RE-W-6 and RE-SW-6). |
| | Independent Cleanup Action Status Report—Former Glitsa Property, Seattle, Washington | Environmental Associates (2010) | • Evaluated existing remediation system. | • Determined that the remediation system appears to be effectively removing the contaminated mass beneath the site. |

**Table 2.3**
**Summary of Previous Adjacent Investigations**

| Site | Title | Reference[1] | Primary Scope and Contents | Report Findings[2] |
|---|---|---|---|---|
| Former South Kenyon Street Bus Yard | Site Assessment and Closure Report, Ryder Student Transportation Services, Inc. | Clearwater Group (1999) | • Removed and closed three 12,000-gallon USTs (one gasoline UST and two diesel fuel USTs).<br>• Soil borings were advanced at three locations and were converted to monitoring wells (MW-1 to MW-3).<br>• Seven soil borings were advanced (SB-1 to SB-3, CD, ES, ESD, and WSD). | • Petroleum hydrocarbon-contaminated soil surrounding the removed USTs and fueling station was documented.<br>• Determined that releases of petroleum compounds and/or metals occurred on-site. Historical operations may have also impacted soil and groundwater, with potential releases of metals, petroleum compounds, and solvents. |
| | Phase I Environmental Assessment Report, Bus Yard Properties | G-Logics (2007) | • Phase I Environmental Site Assessment was conducted. | • No report available. |
| | Remedial Investigation Report, South Kenyon Street Bus Yard | AMEC Earth and Environmental, Inc. (2009a) | • Advanced 75 soil borings (SB1, B3 to B5, DB6, DB9, B10 to B46, and B49 to B80).<br>• Soil and groundwater samples were collected at 17 locations, which were converted to groundwater monitoring wells (MW-4 to MW-20). | • Petroleum hydrocarbons were found to exceed MTCA Method A CULs in four of the primary soil samples where the former auto-wrecking facility was located.<br>• Diesel-range hydrocarbons were found at one location and oil-range TPH and chromium were found at two locations. CPAHs were also identified.<br>• Other chemicals (benzene, total xylenes, MTBE, methylene chloride, and naphthalene) were detected in soil at levels greater than the MTCA Method A CULs.<br>• Areas of CKD fill contained elevated levels of arsenic, cadmium, and lead in soils at levels exceeding the MTCA Method A CULs. Other areas (non-CKD fill areas) also contained elevated metals.<br>• Contaminants in groundwater exceeding MTCA Method A CULs include: gasoline-range TPH (MW-9); diesel-range TPH (MW-6); toluene, total xylenes, and MTBE (MW-9); and benzene (MW-6 and MW-9).<br>• Concentrations of 1-methynaphthalene (MW-6), benzo(a)anthracene (MW-2, B-3, B-4, B-5, B-10, B-11, and B-12), benzo(b)fluoranthene (MW-2), and chrysene (B-10 and B-12) in groundwater exceed MTCA Method B CULs.<br>• Arsenic and lead in groundwater exceed MTCA Method A CULs.<br>• Pesticides and herbicides (alpha-BHC, beta-BHC, dieldrin, heptachlor, and heptachlor epoxide) and the herbicide MCPA in groundwater were detected at levels exceeding the MTCA Method B CULs at MW-9 and MW-6, respectively. |

**Table 2.3**
**Summary of Previous Adjacent Investigations**

| Site | Title | Reference[1] | Primary Scope and Contents | Report Findings[2] |
|---|---|---|---|---|
| Former South Kenyon Street Bus Yard (continued) | Focused Feasibility Study, South Kenyon Street Bus Yard | AMEC Earth and Environmental, Inc. (2009b) | • Focused Feasibility Study. | • Established remedial action objectives.<br>• Developed and evaluated remedial alternatives.<br>• Selected appropriate remedial alternative: removal and off-site disposal of contaminated soil. |
| | Cleanup Action Plan, South Kenyon Street Bus Yard | AMEC Earth and Environmental, Inc. (2009c) | • Cleanup Action Plan. | • Presented approach for the removal of contaminated soil; included removal of 10–12 feet of CKD from existing swale. |

Notes:
1 Documents cited in this column are referenced in Section 17.0 of this RI/FS.
2 Report findings relevant to South Park Landfill.
3 Subsequent investigations by Environmental Associates (2009a, 2009c, and 2010) indicated the presence of a single 7,500-gallon Stoddard-solvent UST.

Abbreviations:
BHC Hexachlorocyclohexane
CKD Cement kiln dust
CPAH Carcinogenic polycyclic aromatic hydrocarbon
CUL Cleanup level
Glitsa Glitsa American, Inc.
HVOC Halogenated volatile organic compound
LUST Leaking underground storage tank
MCPA 2-methyl-4-chlorophenoxyacetic acid
MTBE Methyl tert-butyl ether
MTCA Model Toxics Control Act
RI/FS Remedial Investigation/Feasibility Study
UST Underground storage tank

**Table 2.4**
**Summary of Prior Investigations**

| Title | Reference[1] | Primary Scope and Contents | Report Findings |
|---|---|---|---|
| Abandoned Landfill Study in the City of Seattle | Seattle-King County Department of Public Health (1984) | • Eleven boreholes to monitor landfill gases (1 to 11) were advanced.<br>• One water sample was collected from the West Ditch (A). | • Two boreholes located within the north central portion of the Landfill had methane concentrations of 9 percent and 14 percent, which are within the explosive range.<br>• Additional methane and non-specific organic/inorganic testing to evaluate the site was recommended.<br>• A water sample from the West Ditch did not indicate impact from leachate. |
| Abandoned Landfill Toxicity/Hazard Assessment Project | Seattle-King County Department of Public Health (1986) | • Four water samples were collected from the East-West Channel and the West Ditch (W-01 to W-04).<br>• Seven surface soil samples were collected from the SRDS parcel (SA-A to SA-G).<br>• Three soil vapor locations were monitored for VOCs (OG-A to OG-C).<br>• Twenty-one LFG probes (CG-1 to CG-21) were monitored for landfill gases. | • The detection of combustible gases led to the recommendation of monitoring during construction activities within 1,000 feet of the Landfill.<br>• Water samples from W-01 and W-02 had greater levels of metals than other water samples.<br>• Surface soil samples contained elevated concentrations of heavy metals and PAHs.<br>• One significant combustible gas level was detected approximately 80 feet south of the KIP parcel. |
| Quality Risk Assessment: King County Landfills | Environmental Toxicology International (1986) | • Assessed if chemicals present at the Landfill created a toxic or hazardous environment. | • Indicated that although heavy metal concentrations in water and heavy metal and PAHs in surface soil were greater than background concentrations, elevated concentrations were likely due to the industrial nature of the area and did not pose a public health hazard. |
| Site Inspection Report for South Park Landfill | Ecology and Environment, Inc. (1988) | • Six water samples (SW-01 to SW-06) and six corresponding "sediment" samples (SS-01 to SS-06) were collected from the East-West Channel and the West Ditch. | • One water sample (SW-04) had pesticides/insecticides and PCBs at levels greater than background.<br>• Concluded that landfill waste, natural weathering of soils, and automobile emissions could be responsible for elevated concentrations.<br>• Data did not indicate that contaminants were migrating off-site. |
| Unknown | Unknown (1989) | • Four soil borings were advanced. | • No information or report available (Farallon 2010b). |
| Report to the Sammis Company on Monitoring Well Installation and Soil, Groundwater, and Gas Sampling—The Sammis Company Industrial Parks, Seattle, Washington | Golder Associates, Inc. (1989) | • Four monitoring wells (KMW-01, KMW-02, KMW-02B, and KMW-03) were installed.<br>• Three soil borings that were converted to monitoring wells (KMW-01, KMW-02, and KMW-02B) were advanced.<br>• Conducted a LFG survey and installed nine soil gas probes (SG-01 to SG-09), which were monitored for LFG.<br>• Indoor ambient air was assessed at four buildings on the KIP parcel for combustible LFG. | • Groundwater data indicated elevated concentrations of chlorobenzene, benzene, and methyl chloride in KMW-02B and also in soil samples collected at this location.<br>• Low concentrations of chlorobenzene, benzene, and *CIS*-1,2-DCE were found in KMW-01.<br>• Methane ranged from 0.001 percent to 30 percent for the nine samples. |
| Subsurface Exploration Geotechnical Engineering, and Environmental Assessment Report—South Park Detention Project, Seattle, Washington | RZA Agra (1992a) | • Ten soil borings (RB-01 to RB-10) were advanced and eight were converted to monitoring wells (RMW-01 to RMW-08).<br>• Aquifer test conducted at Well RMW-08. | • Groundwater quality data indicated that concentrations of TPH (RMW-06 to RMW-08) and chlorinated solvents (RMW-06 and RMW-08) exceeded the MTCA Method A CULs. |

**Table 2.4**
**Summary of Prior Investigations**

| Title | Reference[1] | Primary Scope and Contents | Report Findings |
|---|---|---|---|
| Subsurface Exploration Study—South Park Detention Project, Seattle, Washington | RZA Agra (1992b) | • Two soil borings (RB-9 and RB-10) completed on east side of the 5th Avenue South right-of-way.<br>• Three soil borings (RB-11 to RB-13) were later advanced north of South Kenyon Street. | • 5th Avenue South soil samples collected from boring RB-9 indicated concentrations of diesel-range TPH at levels less than MTCA Method A CULs.<br>• South Kenyon Street soil samples analyzed for TCLP metals and diesel-range TPH were reported either as non-detect or less than MTCA Method A CULs. |
| Phase II Environmental Site Assessment, Liberty/Sammis—Kenyon Industrial Park, Seattle, Washington | Diagnostic Engineering, Inc. (1992) | • Eight soil borings (KB-01 to KB-08) were advanced and five were completed as monitoring wells (KMW-04 to KMW-08). | • Soil samples indicated elevated concentrations of petroleum hydrocarbons. Concentrations exceeded MTCA Method A CULs at several locations (KB-02, KB-03, KMW-04, KMW-05, and KMW-06).<br>• VOCs were also detected in soil samples, but at levels less than MTCA Method A CULs.<br>• Analytical results from these and other monitoring wells on-site indicated that concentrations of TPH and VOCs (benzene) exceeded the MTCA Method A CULs in KMW-02B.<br>• Chlorobenzene, chloroform, 1,2-dichlorobenzene, and 1,4-dichlorobenzene were also detected. |
| Air Quality Investigation South Kenyon Street Property, Seattle, Washington | Professional Service Industries, Inc. (1993) | • Ambient indoor air of four buildings on the KIP parcel was screened for combustible organic vapors using a flame ionization detector and combustible gas indicator. | • The concentration of total organic vapors indoors was comparable to ambient background levels (4 to 12 ppm).<br>• Elevated concentrations of total organic vapors were found around a leaking gas meter and in three downspout catch basins (40 to greater than 1,000 ppm). |
| Extended Phase II Environmental Site Assessment—Seattle Kenyon Business Park, Seattle, Washington | Blasland, Bouck, and Lee, Inc. (1995) | • Ambient indoor air was sampled from seven building suites on the KIP parcel for explosive gases and organic vapor.<br>• Combustible LFG monitored at 27 locations (EG-01 to EG-27).<br>• Twenty-six temporary soil vapor probe locations (BH-01 to BH-09 and BH-11 to BH-27) were advanced (26 were sampled for methane and organic vapors, 4 for VOCs as well).<br>• Six soil borings locations (HP-01 to HP-06) plus groundwater grab samples were collected.<br>• Two monitoring wells (KMW-01A and KMW-03A) were installed. | • No methane was detected in any of the seven building suites.<br>• Of the 27 combustible LFG locations, 1 had methane concentrations at levels greater than the laboratory detection limit (EG-23).<br>• Of the 26 soil vapor locations, 20 had detected methane at levels greater than the detection limit (0.0063 percent to 74 percent, median value 12.4 percent).<br>• Of the 26 locations, 13 had methane concentrations greater than the 5 percent methane LEL.<br>• Some soil samples collected from these soil boring and monitoring well locations (KMW-01A, KMW-03A, HP-02, HP-04, and HP-06) contained petroleum hydrocarbons that exceeded the MTCA Method A CULs.<br>• Groundwater quality data from previously installed monitoring wells and groundwater samples collected during this investigation indicated exceedances of MTCA Method A CULs, including: TPH (KMW-05, HP-03, and HP-05), VOCs (KMW-02B, KMW-03A, KMW-05, KMW-6, HP-01, and HP-02), and RCRA metals (KMW-01A, KMW-02B, KMW-03A, KMW-04 to KMW-06, and HP-01 to HP-06). |
| Investigative Determination and Characterization of Intramural Aerial Methane Gas Concentrations at Various Businesses Comprising Kenyon Business Park | Joseph D. Wendlick (1997) | • Ambient indoor air was sampled for combustible gas in four buildings on the KIP parcel. | • Methane concentrations detected between 2 and 4 ppm in each of the buildings. |

**Table 2.4**
**Summary of Prior Investigations**

| Title | Reference[1] | Primary Scope and Contents | Report Findings |
|---|---|---|---|
| South Park Custodial Landfill, Environmental Site Investigation Data Gaps Memorandum | King County Solid Waste Division (1998) | • Fourteen test pits (TP-1 to TP-14) were excavated.<br>• Three soil borings (SB-01, SB-02, and SB-02A) were advanced with two converted into soil gas probes (GP-01 and GP-02).<br>• Three water samples were collected from standing water at three locations (SE, SW, and SP). | • Both gas probe locations (GP-01 and GP-02) had methane concentrations within the explosive range.<br>• Surface water samples had detections of metals, but no pesticides or PCBs. |
| South Park Custodial Landfill, Cover Soils Investigation | King County Solid Waste Division (1999) | • Ten test pits (TP-15 to TP-24) were excavated for environmental sampling of landfill cover material. | • Elevated concentrations of analytes were found in some test pits: PCB compounds (TP-20 and TP-22), metals (TP-20 and TP-24), and petroleum compounds (TP-21 and TP-22). |
| Memorandum Regarding Geotechnical Summary of South Transfer Station | Seattle Public Utilities Materials Laboratory (1998) | • Twenty-six soil borings (TB-01 to TB-06, TB-07A to TB-07C, TB-08A to TB-08C, TB-09A to TB-09B, TB-10 to TB-11, TB-12A to TB-12B, and TB-13 to TB-20) were advanced. | • Proposed the installation of several new monitoring wells and recommended a comprehensive quarterly groundwater monitoring program. |
| South Park Custodial Landfill Environmental Site Investigation Data Gaps Memorandum | Associated Earth Sciences, Inc. (1998) | • Existing information and identified data gaps were compiled.<br>• Quarterly water samples from the East-West Channel (SE, SW, and SP) were collected.<br>• Fourteen additional soil gas probes were installed to monitor LFG. | • Results indicated elevated concentrations of copper, lead, and zinc in water samples, with the greatest concentrations at the southeastern end of the Landfill.<br>• Based on findings, King County conducted periodic surface water sampling between 1999 and 2004.<br>• Recommended that quarterly groundwater monitoring be completed at all wells. |
| South Park Custodial Landfill Surface Water Evaluation | R. W. Beck, Inc. (1999) | • Stormwater issues related to development were evaluated. | • Determined on-site and off-site options for providing surface water management for the SPPD parcel. |
| Underground Storage Tank Closure and Site Assessment, South Transfer Station, Seattle, Washington | Herrera Environmental Consultants, Inc. (1999) | • Sixteen soil borings (DSB-1 to DSB-3, GSB-1 to GSB-3, GHA-1 to GHA-2, DHA-1 to DHA-7, and DHA-9) were advanced on the SRDS property.<br>• One monitoring well (HMW-01) was installed. | • Low-level diesel-range hydrocarbon and lead concentrations were detected in several of the soil samples collected in the vicinity of the USTs.<br>• Groundwater samples collected at HMW-01 indicate the presence of BTEX compounds at concentrations that exceeded the MTCA Method A CULs (as of April 1997), but decreased to levels less than the CULs as of October 1998. |
| South Park Custodial Landfill Cover Soils Investigation | Associated Earth Sciences, Inc. (1999a) | • Forty-three additional test pits (TP-25 to TP-67) were excavated to characterize cover soils.<br>• Presented results for 24 previously sampled test pits (TP-01 to TP-24). | • Results indicated that concentrations of PCBs (TP-39) and lead (TP-25, TP-27, TP-34, TP-56, and TP-63) were at levels great than the MTCA Method C soil CULs. |
| South Park Custodial Landfill Geotechnical Evaluation Memorandum | Associated Earth Sciences, Inc. (1999b) | • Geotechnical issues for redevelopment were addressed. | • Determined that deep pile-supported foundations appear to be feasible for development at the Landfill.<br>• Determined that a large percentage of surface cover soils could be re-compacted for base material support. |

**Table 2.4**
**Summary of Prior Investigations**

| Title | Reference[1] | Primary Scope and Contents | Report Findings |
|---|---|---|---|
| South Park Custodial Landfill Monitoring Well and Gas Probe Installation Technical Memorandum | Associated Earth Sciences, Inc. (2000) | • Eight monitoring wells (MW-04, MW-06, MW-08, MW-10, MW-12, MW-14, MW-18, and MW-24) were installed.<br>• Fourteen soil gas probes (GP-03, GP-05, GP-07, GP-09, GP-11, GP-13, GP-15 to GP-17, and GP-19 to GP-23) were installed to monitor LFG.<br>• Samples were collected from the soil gas probes and analyzed by USEPA Method TO-14 (October–November 2000).<br>• Two geotechnical borings (SB-26 and SB-27) were advanced. | • Low levels of VOCs and petroleum hydrocarbons were detected upgradient of the Landfill.<br>• Arsenic and vinyl chloride were the only groundwater constituents that exceeded the MTCA Method C CULs downgradient of the Landfill.<br>• LFG was detected in gas probes completed in refuse within the landfill boundary.<br>• Methane concentrations exceeded the 5 percent LEL along the eastern landfill boundary (GP-17).<br>• Subsurface methane gas levels did not exceed regulatory limits between the landfill boundary and adjacent residential neighborhoods.<br>• Geotechnical soil borings indicated competent bearing capacity between 40 and 45 feet bgs, but it was suggested that special pile design considerations might be necessary to prevent drag-down of impacted soil/groundwater or refuse material. |
| No Report Available | Associated Earth Sciences, Inc. and Aspect Consulting LLC (1999c) | • Periodic groundwater, surface water, and LFG monitoring events (no report) were conducted. | • No report available. |
| South Park Custodial Landfill Conceptual Landfill Gas System Design | R.W. Beck, Inc. (2001) | • LFG collection and treatment options were evaluated based on fieldwork and investigations conducted between 1997 and 2000. | • Concluded that soil gas monitoring probes located within the Landfill, or near the edge, contained subsurface methane at low, but variable levels. Concentrations appeared to vary with barometric pressure, rainfall, temperature, and time of day.<br>• Hydrogen sulfide gas was detected in concentrations that would be dangerous if encountered within confined spaces at GP-21.<br>• Concluded that the Landfill was similar in comparison to other municipal landfills closed since 1966. |
| Shallow Groundwater Characterization Data Report—South Park Custodial Landfill | Aspect Consulting, LLC (2006) | • Shallow groundwater was characterized in three monitoring wells (MW-25 to MW-27).<br>• A groundwater monitoring sampling event (new Wells MW-25 to MW-27 and upgradient Wells MW-4, MW-12, and MW-14) occurred.<br>• Site-wide groundwater levels were measured. | • These wells were paired with previously installed deeper monitoring wells (MW-8, MW-10, and MW-24) in order to compare groundwater quality in upper and lower groundwater bearing zones.<br>• Select soil samples were submitted for physical testing of fractional organic carbon, bulk density, and effective porosity.<br>• Groundwater was analyzed for HVOCs, vinyl chloride, ethene, and total and dissolved arsenic. |
| Letter Report Regarding Landfill Cover Soil Sampling and Analysis for Polychlorinated Biphenyls, South Park Property Development Site | Farallon Consulting, LLC (2007) | • Twenty-five test pits (C-01 to C-25) were excavated to investigate elevated PCB levels previously discovered. | • Elevated PCB levels were not detected and all samples were non-detections except one with a concentration of 90 µg/kg. |
| No Report Available | URS (2009) | • Results were summarized in tables (no report). | • No report available. |

**Table 2.4**
**Summary of Prior Investigations**

| Title | Reference[1] | Primary Scope and Contents | Report Findings |
|---|---|---|---|
| Groundwater Monitoring and Sampling Results | Farallon Consulting, LLC (2010b) | • Results from the site-wide semi-annual groundwater monitoring program was presented (2007 through 2009).<br>• Six temporary groundwater sampling locations (FB-01 to FB-06) were installed. | • Summary of semi-annual groundwater and reconnaissance groundwater sampling. |

Note:

1 Documents cited in this column are referenced in Section 17.0 of this RI/FS.

Abbreviations:

| | |
|---|---|
| bgs | Below ground surface |
| BTEX | Benzene, toluene, ethylbenzene, and xylene |
| CUL | Cleanup level |
| DCE | Dichloroethene |
| HVOC | Halogenated volatile organic compound |
| KIP | Kenyon Industrial Park |
| Landfill | South Park Landfill |
| LEL | Lower explosive limit |
| LFG | Landfill gas |
| µg/kg | Micrograms per kilogram |
| MTCA | Model Toxics Control Act |
| PAH | Polycyclic aromatic hydrocarbon |
| PCB | Polychlorinated biphenyl |
| ppm | Parts per million |
| RCRA | Resource Conservation and Recovery Act |
| RI/FS | Remedial Investigation/Feasibility Study |
| SPPD | South Park Property Development, LLC |
| SRDS | South Recycling and Disposal Station |
| TCLP | Toxicity Characteristic Leaching Procedure |
| TPH | Total petroleum hydrocarbon stet |
| USEPA | U.S. Environmental Protection Agency |
| UST | Underground storage tank |
| VOC | Volatile organic compound |

**Table 3.1**
**Geologic Description of Regional Deposits**

<table>
<tr><td colspan="2">Imported Fill</td></tr>
<tr><td colspan="2">Historical Duwamish Valley development included the use of bulk fill to raise land elevations. Unclassified fill (non-solid waste) has been encountered immediately outside of the South Park Landfill boundary. The South Park Landfill boundary soil conditions are discussed in Section 4.3. Fill depths are variable and may be more than 20 feet in the vicinity of the South Park Landfill. The composition and texture of the fill varies significantly, but generally consists of silt and/or sand with some gravel and organics. In addition, the fill can often contain brick fragments and woody debris, as observed in soil borings completed near the South Park Landfill (MW-01, MW-03, MW-04, and MW-14). The valley-wide unclassified fill is distinct from the solid waste material deposited into the South Park Landfill.</td></tr>
<tr><td colspan="2">Alluvial Channel and Flood Deposits</td></tr>
<tr><td>• Younger Alluvium ($Q_{yal}$)<br>• Alluvium ($Q_{al}$)</td><td>Include both alluvial channel and overbank flood deposits. Alluvial channel deposits consist of interbedded sand, silty sand, and silt. Overbank flood deposits generally consist of interbedded sand and silt with abundant organic matter.</td></tr>
<tr><td colspan="2">Estuarine Sediment Deposits</td></tr>
<tr><td colspan="2">Estuarine deposits can extend to depths of more than 100 feet in the center of the Duwamish Valley, but are usually present at shallower depths (40 to 50 feet) and are thinner near the edge of the valley. The estuarine deposits typically consist of sand and silty sand in the upper portion of the sequence and transition to a sandy silt toward the base of the sequence (Hart Crowser 1998). Estuarine deposits are often characterized by the presence of shell fragments.</td></tr>
<tr><td colspan="2">Glacial Sediment Deposits</td></tr>
<tr><td colspan="2">The maximum depth of the glacial deposits in the center of the Duwamish Valley is unknown. Glacial deposits are exposed at the surface along the edges of the valley and the uplands (Figure 3.1).</td></tr>
<tr><td>• Vashon Recessional Outwash ($Q_{vr}$)</td><td>Deposited by rivers and streams emerging from the base of the retreating ice sheet; generally consists of fine- to coarse-grained sand with gravel and occasional silt lenses.</td></tr>
<tr><td>• Vashon Subglacial Till ($Q_{vt}$)</td><td>Formed from the melt-out of debris at the base of the ice sheet; generally consists of a gravelly, silty to very silty sand. Glacially consolidated.</td></tr>
<tr><td>• Vashon Advance Outwash ($Q_{va}$)</td><td>Deposited by rivers and streams during the advance of the ice sheet; generally consists of sand with some gravel and silts. Glacially consolidated.</td></tr>
<tr><td>• Lawton Clay Member, Vashon Drift ($Q_{vlc}$)</td><td>Accumulated in lakes formed by the impoundment of drainages by the advancing ice sheet; generally consists of silt and clay. Glacially consolidated.</td></tr>
</table>

**Table 4.1**
**Historical Operations and Owners**

| Date | Current Parcels | Owner | Activity | Aerial Photograph[1] |
|---|---|---|---|---|
| **1936 and Earlier** | | | | |
| 1922 | SRDS | King County | First Addition River Park (South Recycling and Disposal Station [SRDS]) added to King County Tax Rolls via foreclosure (SPU 1997). | |
| 1927 | SPPD | King County | Tax Lot 5 (South Park Property Development [SPPD]) added to King County Tax Rolls via foreclosure (SPU 1997). | |
| 1934 | KIP, SPPD | King County | Reported dumping of garbage and rubbish on Kenyon Industrial Park (KIP) and SPPD parcels and sawdust fill on southern portion of SPPD parcel (Seattle Engineering Department 1934). | |
| **1936 to 1941** | | | | |
| 1936 | KIP, SPPD | King County | Active dumping of refuse on KIP and SPPD parcels. | X |
| 1941 | KIP, SPPD | King County | Continued active dumping of rubbish on KIP and SPPD parcels. Open burning of refuse was occurring. | X |
| **1941 to 1951** | | | | |
| 1946 | SRDS | King County | Active dumping of rubbish expanded onto SRDS parcel. Open burning of refuse was occurring | X |
| 1948 | SRDS, KIP, SPPD | King County | Open burning of rubbish was documented (AESI 1998). | X |
| 1951 | SRDS, KIP | City of Seattle | First Addition River Park (SRDS) and Tax Lot 7 (KIP) were purchased by the City of Seattle out of Tax Title Status (SPU 1997). Auto-wrecking evident on northwest KIP. | X |
| **1951 to 1956** | | | | |
| 1953 | KIP | John Farrell | John Farrell purchased the northwest corner of Tax Lot 7 (KIP) from the Ripley family; waived right to file claims related to burning of rubbish (SPU 1997). | X |
| 1955 | KIP | John Farrell | John Farrell purchased the rest of the parcel containing the northwest disposal area (and potentially 7901 2nd Avenue South) from the City of Seattle. | |
| 1956 | SRDS, KIP, SPPD | City of Seattle and King County | Auto-wrecking yards developed on the SPPD parcel. Aerial photograph evidence of active burning of rubbish on SRDS parcel. | X |
| **1956 to 1960** | | | | |
| 1957 | SPPD | King County | King County (Health Department) purchased Tax Lot 5 (SPPD) out of Tax Title Status (SPU 1997). | |
| 1958 | SPPD | King County | King County leased SPPD property to City of Seattle for rubbish disposal (10-year period). Deeded southwest portion of Tax Lot 5 (SPPD) to the State of Washington for SR 509 (SPU 1997). | |
| 1960 | SRDS, SPPD | City of Seattle and King County | Expansion of active dumping of rubbish on SRDS and SPPD parcels. Aerial photograph evidence of active burning of rubbish. | X |
| **1960 to 1969** | | | | |
| 1961 | SRDS, SPPD | City of Seattle and King County | Reported end of rubbish burning (Farallon 2010b). | |
| 1963 | SRDS, KIP, SPPD | City of Seattle and King County | Filling and grading activities on SRDS, KIP, and SPPD parcels. | X |
| 1965 to 1966 | SPPD | King County | King County deeded eastern portions of SPPD parcel to the City of Seattle for streets (SPU 1997). | |
| 1966 | SRDS | City of Seattle | SRDS parcel stopped receiving rubbish (SPU 1997; Ecology and Environment, Inc. 1988). | |
| 1967 | SRDS | City of Seattle | SRDS completed and opened. | X |
| 1967 | KIP | City of Seattle | Initial development of KIP (two buildings). | X |
| 1967 | SPPD | King County | East-West Channel constructed. | X |
| 1967 | KIP, SPPD | City of Seattle and King County | Continued filling and grading activities on KIP and SPPD parcels. | X |
| 1968 | SPPD | King County | City of Seattle renewed its lease from King County for clean fill and earthen material disposal for 10-year period (SPU 1997). | |
| 1969 | SPPD | King County | Continued filling and grading activities on SPPD parcel. Re-alignment of South Sullivan Street. | X |

**Table 4.1**
**Historical Operations and Owners**

| Date | Current Parcels | Owner | Activity | Aerial Photograph[1] |
|---|---|---|---|---|
| **1969 to 1980** | | | | |
| 1974 | KIP | City of Seattle | Completion of development of KIP (total of four buildings, as well as paved surfaces across entire parcel). Completion of KIP main stormwater line. | X |
| 1974 | SPPD | King County | Grading activities continue on SPPD parcel. | X |
| 1976 | SPPD | King County | City of Seattle submitted request to purchase the SPPD parcel (SPU 1997). | |
| 1977 | SPPD | King County | A portion of the SPPD parcel was used for storage. Filling and grading was occurring on the property. | X |
| 1978 | SPPD | King County | City of Seattle's lease of SPPD parcel expired (SPU 1997). | |
| 1979 to 1984 | SPPD | King County | Negotiations between King County and City of Seattle for purchase of SPPD parcel (SPU 1997). | |
| 1980 | SPPD | King County | Continued storage on SPPD parcel. | X |
| **1980 to 1997** | | | | |
| 1982 | SPPD | King County | Continued storage on SPPD parcel. | X |
| 1984 | SPPD | King County | King County leased the SPPD parcel to multiple entities (AESI 1998). | |
| 1985 | SPPD | King County | Continued leased storage on SPPD parcel. | X |
| 1986 | KIP | Liberty Service Corporation | Northwest corner of Tax Lot 7 (KIP) purchased by Liberty Service Corporation from John Farrell (King County 2016).[2] | |
| 1990 | SPPD | King County | Continued leased storage on SPPD parcel. | X |
| 1992 | SPPD | King County | Continued leased storage on SPPD parcel. | X |
| 1995 | SPPD | King County | Continued leased storage on SPPD parcel. | X |
| 1996 | SPPD | King County | Continued leased storage on SPPD parcel. | X |
| 1997 | SPPD | King County | Continued leased storage on SPPD parcel. | X |
| 1997 | KIP | Statewide Mortgage Service Corporation | Northwest corner of KIP parcel purchased by Statewide Mortgage Service Corporation from Liberty Service Corporation via foreclosure (King County 2016).[2] | X |
| **1997 to Present** | | | | |
| 2000 | SPPD | King County | SPPD parcel no longer leased for storage; King County actively pursued sale of parcel. | X |
| 2002 | SPPD | King County | No activity. | X |
| 2004 | SPPD | King County | No activity. | X |
| 2005 | KIP | John Hill | Northeast corner of KIP parcel purchased by John Hill from Janice Farrell (King County 2016).[2] | |
| 2005 | KIP | 7910 2$^{nd}$ Avenue South, LLC | Northeast corner of KIP parcel purchased by 7901 2$^{nd}$ Ave S, LLC from John Hill (King County 2016).[2] | |
| 2006 | SPPD | SPPD | SPPD parcel sold to SPPD in June 2006 (Farallon 2010b). Parcel was cleared of vegetation and crushed concrete was added to amend the grade. | |
| 2008 | KIP | Harsch Investment Properties, LLC | Northwest corner of KIP parcel purchased by Harsch Investment Properties, LLC from Statewide Mortgage Service Corporation (King County 2016).[2] | |

Notes:
1 Aerial photographs are presented in Appendix A.
2 Information taken from the King County Parcel Viewer (http://www.kingcounty.gov/operations/gis/propresearch/parcelviewer.aspx) in October 2011.

## Table 4.2
## Frequency of Detections and Exceedances in Historical Soil/Landfill Samples on the SPPD Parcel

| Chemical | Unit | Number of Results | Number of Detected Results | Percent of Detected Results | Minimum Detected Value | Maximum Detected Value | MTCA Method C Cleanup Level | Exceeds MTCA Method C Cleanup Level |
|---|---|---|---|---|---|---|---|---|
| **Volatile Organic Compounds** | | | | | | | | |
| Acetone | µg/kg | 71 | 8 | 11% | 33 | 270 | 1,000,000,000 | No |
| Methylene Chloride | µg/kg | 71 | 45 | 63% | 17 | 53 | 21,000,000 | No |
| **Semivolatile Organic Compounds: Polycyclic Aromatic Hydrocarbons (PAHs) and Phthalates** | | | | | | | | |
| CPAHs as BaP TEQ using half RL | µg/kg | 78 | 28 | 36% | 55 | 3,100 | 18,000 | No |
| CPAHs as BaP TEQ using zero as RL | µg/kg | 78 | 27 | 35% | 0.52 | 3,100 | 18,000 | No |
| Benzo(a)anthracene | µg/kg | 78 | 13 | 17% | 140 | 2,900 | Evaluated as total CPAHs calculated as a BaP TEQ (refer to CPAHs as BaP TEQ above) | |
| Benzo(a)pyrene | µg/kg | 78 | 8 | 10% | 79 | 2,200 | | |
| Benzo(b)fluoranthene | µg/kg | 78 | 13 | 17% | 79 | 2,800 | | |
| Benzo(g,h,i)perylene | µg/kg | 78 | 4 | 5% | 200 | 750 | | |
| Benzo(j)fluoranthene | µg/kg | 78 | 5 | 6% | 150 | 1,800 | | |
| Chrysene | µg/kg | 78 | 27 | 35% | 52 | 3,200 | | |
| 2-Methylnaphthalene | µg/kg | 78 | 4 | 5% | 110 | 380 | 14,000,000 | No |
| Acenaphthene | µg/kg | 78 | 5 | 6% | 45 | 290 | 210,000,000 | No |
| Fluoranthene | µg/kg | 78 | 30 | 38% | 43 | 3,400 | 140,000,000 | No |
| Fluorene | µg/kg | 78 | 4 | 5% | 110 | 350 | 140,000,000 | No |
| Naphthalene | µg/kg | 78 | 5 | 6% | 41 | 1,000 | 70,000,000 | No |
| Phenanthrene | µg/kg | 78 | 15 | 19% | 120 | 2,000 | R-ND | No |
| Pyrene | µg/kg | 78 | 23 | 29% | 83 | 3,200 | 110,000,000 | No |
| bis(2-ethylhexyl)phthalate | µg/kg | 78 | 27 | 35% | 86 | 27,000 | 9,400,000 | No |
| Di-n-octyl phthalate | µg/kg | 78 | 4 | 5% | 190 | 710 | R-ND | No |
| **Polychlorinated Biphenyls (PCBs)[1]** | | | | | | | | |
| PCB Aroclor 1254 | µg/kg | 71 | 13 | 18% | 130 | 4,300 | 66,000 | No |
| **PCB Aroclor 1260** | µg/kg | 71 | 17 | 24% | 79 | 18,000 | 66,000 | No |
| **Total PCBs** | µg/kg | 71 | 22 | 31% | 79 | 18,000 | 66,000 | No |
| **Herbicides and Pesticides** | | | | | | | | |
| Dieldrin | µg/kg | 71 | 9 | 13% | 8.2 | 500 | 8,200 | No |
| p,p'-DDD | µg/kg | 71 | 8 | 11% | 8.2 | 2,600 | 550,000 | No |
| p,p'-DDE | µg/kg | 71 | 4 | 6% | 12 | 51 | 390,000 | No |
| p,p'-DDT | µg/kg | 71 | 7 | 10% | 7.6 | 78 | 390,000 | No |
| **Petroleum Hydrocarbons** | | | | | | | | |
| Diesel-Range Hydrocarbons | mg/kg | 76 | 9 | 12% | 32.1 | 2,580 | 7,000 [2] | No |
| Motor Oil-Range Hydrocarbons | mg/kg | 92 | 37 | 40% | 37.1 | 5,940 | 7,000 [2] | No |
| **Metals[3]** | | | | | | | | |
| Antimony | mg/kg | 73 | 18 | 25% | 6.1 | 110 | 1,400 | No |
| **Arsenic** | mg/kg | 73 | 73 | 100% | 2 | 180 | 88 | **Yes** |
| Cadmium | mg/kg | 73 | 30 | 41% | 1 | 34 | 3,500 | No |
| Chromium | mg/kg | 73 | 73 | 100% | 12 | 260 | 1,000,000 | No |
| Copper | mg/kg | 73 | 73 | 100% | 9 | 4,300 | 140,000 | No |
| **Lead** | mg/kg | 73 | 70 | 96% | 9.6 | 6,800 | 1,000 [4] | **Yes** |
| Mercury | mg/kg | 73 | 31 | 42% | 0.1 | 5 | 1,050 | No |
| Nickel | mg/kg | 73 | 73 | 100% | 8 | 770 | 70,000 | No |
| Silver | mg/kg | 73 | 12 | 16% | 1.3 | 80 | 17,500 | No |
| Zinc | mg/kg | 73 | 73 | 100% | 29 | 7,900 | 1,000,000 | No |

Notes:

(grey shading) Mixture of CPAHs considered for TEQ calculations.

**Lead** Highlighted chemical is a chemical of concern for this media.

**PCB** Chemical was considered for inclusion as a chemical of concern but not retained. Refer to Section 4.3.1.2 in the text for details.

1 The MTCA Method A value for industrial soil has been used in place of MTCA Method C value that conflicts with a Federal ARAR. The following is a footnote from MTCA for the Method A value: "Cleanup level based on applicable federal law (40 C.F.R. 761.61). This is a total value for all PCBs. This value may be used only if the PCB contaminated soils are capped and the cap maintained as required by 40 C.F.R. 761.61. If this condition cannot be met, the value in Table 740-1

2 A site-specific MTCA Method C cleanup level was calculated using Washington State Department of Ecology's MTCATPH11.1 worksheets.

3 Natural Background Soil Metals Concentrations in Washington State (Ecology 1994), Statewide 90th Percentile Values are as follows: arsenic—7 mg/kg, cadmium—1 mg/kg, chromium—42 mg/kg, copper—36 mg/kg, lead—17 mg/kg, mercury—0.07 mg/kg, nickel—38 mg/kg, and zinc—86 mg/kg; however, the arsenic value was reevaluated and a value of 20 mg/kg replaced the 1994 Washington State Department of Ecology value (Task Force 2003).

4 MTCA Method A value was used for industrial soils for lead, as no Method B or C values exist.

Abbreviations:

ARAR Applicable or Relevant and Appropriate Requirement
BaP Benzo(a)pyrene
CPAH Carcinogenic polycyclic aromatic hydrocarbon
DDD Dichlorodiphenyldichloroethane
DDE Dichlorodiphenyldichloroethylene
DDT Dichlorodiphenyltrichloroethane
FOD Frequency of detection
FOE Frequency of exceedance
µg/kg Micrograms per kilogram
mg/kg Milligrams per kilogram
MTCA Model Toxics Control Act
RL Reporting limit
R-ND The chemical was researched by the Washington State Department of Ecology, and no toxicity data of acceptable quality were found
SPPD South Park Property Development, LLC
TEQ Toxicity equivalent

**Table 4.3**
**Analytical Results in Former West Ditch Solids Samples**

| | Location | SS-01 | | | SS-02 | | | | SS-03 | | | SS-P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sample Date | 12/6/2010 | | | 12/6/2010 | | | | 12/6/2010 | | | 12/8/2010 |
| | Depths (ft bgs) | 0–2 | 2–4 | 4–6 | 0–2 | 2–4 | 2–4 [1] | 6–8 | 0–2 | 2–4 | 4–6 | 0–0.5 |
| **Chemical** | **Unit** | | | | | | | | | | | |
| **Semivolatile Organic Compounds (USEPA Method 8270D/8041[2])** | | | | | | | | | | | | |
| CPAHs as BaP TEQ using Half RL | µg/kg | 200 | 120 J | 24 U | 170 J | 230 J | 270 J | 240 J | 600 J | 38 J | 1,100 J | 53 |
| CPAHs as BaP TEQ using zero as RL | µg/kg | 200 | 110 J | 34 U | 170 J | 220 J | 260 J | 230 J | 600 J | 34 J | 1,100 J | 51 |
| Benzo(a)anthracene | µg/kg | 120 | 110 | 34 U | 230 | 130 | 220 | 110 J | 370 J | 34 J | 710 | 34 |
| Benzo(a)pyrene | µg/kg | 150 | 80 | 34 U | 120 | 170 | 190 | 180 | 430 | 26 J | 870 | 39 |
| Benzo(g,h,i)perylene | µg/kg | 87 | 68 J | 34 U | 59 J | 130 | 120 | 110 J | 400 | 22 J | 470 | 24 |
| Benzofluoranthenes (Total) | µg/kg | 260 | 140 | 34 U | 210 | 290 | 370 | 300 | 1,000 | 41 | 1,200 | 81 |
| Chrysene | µg/kg | 120 | 220 | 34 U | 180 | 300 | 400 | 300 | 570 J | 48 | 1,000 | 65 |
| Indeno(1,2,3-cd)pyrene | µg/kg | 72 | 46 J | 34 U | 50 J | 99 J | 97 J | 85 J | 250 | 38 U | 380 | 23 U |
| 1-Methylnaphthalene | µg/kg | 48 J | 74 U | 34 U | 76 U | 110 U | 110 U | 110 U | 180 U | 38 U | 99 | 23 U |
| 2-Methylnaphthalene | µg/kg | 140 | 74 U | 34 U | 76 U | 110 U | 110 U | 110 U | 180 U | 38 U | 160 | 23 U |
| Acenaphthene | µg/kg | 110 | 170 | 34 U | 230 | 210 | 250 | 200 | 120 J | 25 J | 200 | 23 U |
| Acenaphthylene | µg/kg | 59 U | 74 U | 34 U | 76 U | 110 U | 110 U | 110 U | 180 U | 38 U | 36 | 23 U |
| Anthracene | µg/kg | 53 J | 74 U | 34 U | 62 J | 120 | 180 | 97 J | 180 U | 38 U | 350 | 12 J |
| Fluoranthene | µg/kg | 430 | 430 | 73 | 520 | 640 | 1,300 | 660 | 810 | 89 | 2,000 | 80 |
| Fluorene | µg/kg | 90 | 130 | 34 U | 74 J | 110 U | 160 | 63 J | 180 U | 32 J | 200 | 23 U |
| Naphthalene | µg/kg | 59 U | 74 U | 34 U | 76 U | 110 U | 110 U | 110 U | 180 U | 38 U | 210 | 23 U |
| Phenanthrene | µg/kg | 210 | 1,400 | 98 | 66 J | 160 | 580 | 170 | 240 | 91 | 1,900 | 43 J |
| Pyrene | µg/kg | 400 | 530 | 56 | 480 | 710 | 1,100 | 690 | 1,100 | 93 | 1,900 | 100 |
| bis(2-ethylhexyl)phthalate | µg/kg | 330 U | 5,700 U | 280 U | 850 | 520 U | 920 | 900 | 8,400 | 220 U | 230 U | 370 |
| Butyl benzyl phthalate | µg/kg | 59 U | 74 U | 34 U | 76 U | 110 U | 110 U | 110 U | 180 U | 38 U | 36 U | 71 |
| Diethylphthalate | µg/kg | 59 U | 74 U | 34 U | 76 U | 110 U | 160 | 110 U | 180 U | 24 J | 36 U | 13 J |
| Dimethyl phthalate | µg/kg | 59 U | 74 U | 34 U | 76 U | 110 U | 110 U | 110 U | 180 U | 38 U | 60 | 24 |
| Di-n-butyl phthalate | µg/kg | 59 U | 74 U | 21 J | 76 U | 110 U | 110 U | 110 U | 180 U | 38 U | 36 U | 23 U |
| 1,4-Dichlorobenzene | µg/kg | 59 U | 74 U | 34 U | 76 U | 110 U | 110 U | 110 U | 240 | 38 U | 36 U | 52 U |
| 4-Methylphenol | µg/kg | 59 U | 74 U | 34 U | 76 U | 110 U | 110 U | 110 U | 180 U | 38 U | 25 J | 23 U |
| Carbazole | µg/kg | 59 U | 74 U | 34 U | 76 U | 110 U | 110 U | 110 U | 180 U | 38 U | 140 | 23 U |
| Dibenzofuran | µg/kg | 57 J | 74 U | 34 U | 76 U | 110 U | 79 J | 110 U | 180 U | 38 U | 130 | 23 U |
| Pentachlorophenol (by USEPA 8041) | µg/kg | 50 J | 19 UJ | 15 UJ | 31 UJ | 33 UJ | 31 UJ | 30 UJ | 38 UJ | 16 UJ | 13 UJ | 11 UJ |
| Pentachlorophenol (by USEPA 8270D) | µg/kg | 300 U | 370 U | 170 U | 380 U | 550 U | 540 U | 550 U | 900 U | 190 U | 180 U | 110 U |
| **Polychlorinated Biphenyls (PCB; USEPA 8082)** | | | | | | | | | | | | |
| PCB Aroclor 1242 | µg/kg | 32 U | 32 U | 33 U | 540 | 130 U | 120 U | 120 U | 430 | 180 | 2,800 | 32 U |
| PCB Aroclor 1248 | µg/kg | 670 | 430 | 580 | 74 U | 1,300 | 1,700 | 1,500 | 92 U | 32 U | 160 U | 240 U |
| PCB Aroclor 1254 | µg/kg | 730 | 630 | 330 U | 400 | 2,200 | 2,300 | 2,000 | 240 | 150 | 510 | 630 |
| PCB Aroclor 1260 | µg/kg | 380 | 520 | 90 | 260 | 1,300 | 1,200 | 1,200 | 170 | 96 | 160 U | 96 U |
| Total PCBs | µg/kg | 1,780 | 1,580 | 670 | 1,200 | 4,800 | 5,200 | 4,700 | 840 | 426 | 3,310 | 630 |

## Table 4.3
## Analytical Results in Former West Ditch Solids Samples

| | Location | SS-01 | | | SS-02 | | | | SS-03 | | | SS-P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sample Date | 12/6/2010 | | | 12/6/2010 | | | | 12/6/2010 | | | 12/8/2010 |
| | Depths (ft bgs) | 0–2 | 2–4 | 4–6 | 0–2 | 2–4 | 2–4 [1] | 6–8 | 0–2 | 2–4 | 4–6 | 0–0.5 |
| **Chemical** | **Unit** | | | | | | | | | | | |
| **Herbicides and Pesticides (USEPA 8081B)** | | | | | | | | | | | | |
| alpha-Chlordane | µg/kg | 8.1 U | **31** JN | **8.2** J | **14** J | **300** J | **480** J | **250** J | **28** J | **14** J | **180** | **3.6** J |
| gamma-Chlordane | µg/kg | 8.1 U | **23** | **7.9** | **20** JN | **290** | **440** | **270** | **47** JN | **17** | **130** | **7.1** JN |
| p,p'-DDD | µg/kg | **24** JN | **1,800** | **770** | **240** | **3,900** | **5,100** | **2,800** | **40** JN | **39** JN | **120** JN | 3.1 U |
| p,p'-DDE | µg/kg | **85** JN | **330** | **82** J | **84** JN | **630** | **680** | **580** J | **20** JN | **17** JN | **18** JN | 3.1 U |
| p,p'-DDT[3] | µg/kg | 16 R | **66** JN | **6.3** J | 7.6 R | **450** | **120** JN | **92** JN | 9.3 R | 3.2 R | 16 R | 3.1 UJ |
| **Petroleum Hydrocarbons (NWTPH-Dx)** | | | | | | | | | | | | |
| Diesel-Range Hydrocarbons | mg/kg | **310** | **640** | **49** | **310** | **750** | **930** | **610** | **780** J | **130** | **260** | **120** |
| Motor Oil-Range Hydrocarbons | mg/kg | **860** | **2,100** | **76** | **750** | **2,400** | **2,700** | **2100** | **3,200** | **360** | **750** | **480** |
| **Metals (USEPA Method 6010B)[4]** | | | | | | | | | | | | |
| Aluminum | mg/kg | **16,600** | **28,100** | **15,100** | **17,400** | **18,500** | **14,000** | **19,000** | **26,800** | **15,700** | **7,050** | **7,400** J |
| Arsenic | mg/kg | **40** | **20** | 8 U | **30** | **20** | **20** | **20** | **60** | **10** | 6 U | **7** J |
| Barium | mg/kg | **325** | **251** | **46.8** | **198** | **238** | **121** | **237** | **152** | **106** | **32.6** | **26.3** |
| Cadmium | mg/kg | **5.2** | **3.2** | 0.3 U | **3.8** | **9.4** | **7.5** | **9.7** | **5** | **0.9** | 0.2 U | **0.6** |
| Chromium | mg/kg | **54** | **68** | **14.3** | **41** | **71** | **54** | **73** | **101** | **36.7** | **23.4** | **18.1** |
| Copper | mg/kg | **277** | **144** | **25.5** | **130** | **304** | **229** | **324** | **245** | **44.2** | **14.1** | **24.5** J |
| Iron | mg/kg | **49,700** | **49,200** | **14,700** | **66,300** | **29,700** | **31,200** | **31,200** | **92,800** | **28,300** | **11,100** | **12,300** |
| Lead | mg/kg | **461** | **239** | **6** | **280** | **600** | **440** | **620** | **380** | **83** | **63** | **29** J |
| Manganese | mg/kg | **474** | **535** | **120** | **319** | **304** | **226** | **312** | **470** | **211** | **120** | **148** J |
| Mercury | mg/kg | **0.59** | **0.52** | **0.08** | **0.5** | **0.7** | **0.88** | **0.8** | **1.2** | **0.17** | 0.02 U | **0.04** |
| Nickel | mg/kg | **48** | **73** | **10** | **45** | **64** | **46** | **90** | **73** | **43** | **20** | **24** |
| Silver | mg/kg | **2** | **0.8** | 0.5 U | 1 U | **4** | **3** | **3** | 2 U | 0.5 U | 0.3 U | 0.4 U |
| Zinc | mg/kg | **1,070** | **667** | **45** | **701** | **1,750** | **1,650** | **1760** | **999** | **190** | **49** | **392** |

Notes:

(shaded) Mixture of CPAHs considered for TEQ calculations.

**BOLD** Indicates was detected (or detected and estimated).

1 Blind field duplicate of SS-02 from 2 to 4 feet; labeled on the Chain of Custody as SS-02-6-8-120610.

2 Only pentachlorophenol was measured by USEPA Methods 8270D and 8041.

3 During analysis, DDT can break down to form DDE and DDD. The analytical method (USEPA 8081B) includes a check sample to monitor this process. During analyses of these samples, DDT was found to be breaking down and could not be accurately quantified. This results in DDT concentrations flagged as rejected and DDD and DDE concentrations are flagged as estimated. The sum of DDT+DDE+DDD is not affected and is acceptable for use, as any DDT that breaks down is converted into DDD and DDE.

4 Natural Background Soil Metals Concentrations in Washington State (Ecology 1994), Statewide 90th Percentile Values are as follows: arsenic—7 mg/kg, cadmium—1 mg/kg, chromium—42 mg/kg, copper—36 mg/kg, lead—17 mg/kg, mercury—0.07 mg/kg, nickel—38 mg/kg, and zinc—86 mg/kg; however, the arsenic value was reevaluated and a value of 20 mg/kg replaced the 1994 Washington State Department of Ecology value (Task Force 2003).

Abbreviations:

BaP Benzo(a)pyrene
bgs Below ground surface
CPAH Carcinogenic polycyclic aromatic hydrocarbon
DDD Dichlorodiphenyldichloroethane
DDE Dichlorodiphenyldichloroethylene
DDT Dichlorodiphenyltrichloroethane
ft Feet
µg/kg Micrograms per kilogram
mg/kg Milligrams per kilogram
RL Reporting limit
TEQ Toxicity equivalent

Qualifiers:

J Estimated value
JN Estimated due to tentative identification
R Rejected as bad data, detect
UJ Not detected, estimated detection limit
U Not detected

**Table 4.4**
**Frequency of Detections and Exceedances in Solids Samples from the Former West Ditch**

| Potential Chemical of Concern | Unit | Number of Samples | Detected Results | Percent Detected | Minimum Detected Value | Maximum Detected Value | MTCA Method C Cleanup Level | Exceeds MTCA Criteria? |
|---|---|---|---|---|---|---|---|---|
| **Semivolatile Organic Compounds** | | | | | | | | |
| CPAHs as BaP TEQ using half RL | µg/kg | 11 | 10 | 91% | 24 | 1,100 | 18,000 | No |
| CPAHs as BaP TEQ using zero as RL | µg/kg | 11 | 10 | 91% | 34 | 1,100 | 18,000 | No |
| Benzo(a)anthracene | µg/kg | 11 | 10 | 91% | 34 | 710 | Evaluated as total CPAHs calculated as a BaP TEQ (refer to CPAHs as BaP TEQ above) | |
| Benzo(a)pyrene | µg/kg | 11 | 10 | 91% | 26 | 870 | | |
| Benzo(g,h,i)perylene | µg/kg | 11 | 10 | 91% | 22 | 470 | | |
| Benzofluoranthenes (Total) | µg/kg | 11 | 10 | 91% | 41 | 1,200 | | |
| Chrysene | µg/kg | 11 | 10 | 91% | 48 | 1,000 | | |
| Indeno(1,2,3-cd)pyrene | µg/kg | 11 | 8 | 73% | 46 | 380 | | |
| 1-Methylnaphthalene | µg/kg | 11 | 2 | 18% | 48 | 99 | NR | No |
| 2-Methylnaphthalene | µg/kg | 11 | 2 | 18% | 140 | 160 | 14,000,000 | No |
| Acenaphthene | µg/kg | 11 | 9 | 82% | 25 | 250 | 210,000,000 | No |
| Acenaphthylene | µg/kg | 11 | 1 | 9% | 36 | 36 | 210,000,000 | No |
| Anthracene | µg/kg | 11 | 7 | 64% | 12 | 350 | 1,100,000,000 | No |
| Fluoranthene | µg/kg | 11 | 11 | 100% | 73 | 2,000 | 140,000,000 | No |
| Fluorene | µg/kg | 11 | 7 | 64% | 32 | 200 | 140,000,000 | No |
| Naphthalene | µg/kg | 11 | 1 | 9% | 210 | 210 | 70,000,000 | No |
| Phenanthrene | µg/kg | 11 | 11 | 100% | 43 | 1,900 | R-ND | No |
| Pyrene | µg/kg | 11 | 11 | 100% | 56 | 1,900 | 110,000,000 | No |
| bis(2-ethylhexyl)phthalate | µg/kg | 11 | 5 | 50% | 370 | 8,400 | 9,400,000 | No |
| Butyl benzyl phthalate | µg/kg | 11 | 1 | 9% | 71 | 71 | 69,000,000 | No |
| Diethylphthalate | µg/kg | 11 | 3 | 27% | 13 | 160 | -- | No |
| Dimethyl phthalate | µg/kg | 11 | 2 | 18% | 24 | 60 | R-ND | No |
| Di-n-butyl phthalate | µg/kg | 11 | 1 | 9% | 21 | 21 | -- | No |
| 1,4-Dichlorobenzene | µg/kg | 11 | 1 | 9% | 240 | 240 | R-ND | No |
| 4-Methylphenol | µg/kg | 11 | 1 | 9% | 25 | 25 | 18,000,000 | No |
| Carbazole | µg/kg | 11 | 1 | 9% | 140 | 140 | R-ND | No |
| Dibenzofuran | µg/kg | 11 | 3 | 27% | 57 | 130 | 3,500,000 | No |
| Pentachlorophenol (by USEPA 8041) | µg/kg | 11 | 0 | 0% | 0 | 0 | 330,000 | No |
| Pentachlorophenol (by USEPA 8270D) | µg/kg | 11 | 1 | 9% | 50 | 50 | 330,000 | No |
| **Polychlorinated Biphenyls (PCBs)** [1] | | | | | | | | |
| PCB Aroclor 1242 | µg/kg | 11 | 4 | 36% | 180 | 2,800 | 10,000 | No |
| PCB Aroclor 1248 | µg/kg | 11 | 6 | 55% | 430 | 1,700 | 10,000 | No |
| PCB Aroclor 1254 | µg/kg | 11 | 10 | 91% | 150 | 2,300 | 10,000 | No |
| PCB Aroclor 1260 | µg/kg | 11 | 9 | 82% | 90 | 1,300 | 10,000 | No |
| Total PCBs | µg/kg | 11 | 10 | 91% | 426 | 5,200 | 10,000 | No |

**Table 4.4**
**Frequency of Detections and Exceedances in Solids Samples from the Former West Ditch**

| Potential Chemical of Concern | Unit | Number of Samples | Detected Results | Percent Detected | Minimum Detected Value | Maximum Detected Value | MTCA Method C Cleanup Level | Exceeds MTCA Criteria? |
|---|---|---|---|---|---|---|---|---|
| **Herbicides and Pesticides** | | | | | | | | |
| alpha-Chlordane | µg/kg | 11 | 10 | 91% | 3.6 | 480 | 350,000 | No |
| gamma-Chlordane | µg/kg | 11 | 10 | 91% | 7.1 | 440 | 350,000 | No |
| p,p'-DDD | µg/kg | 11 | 10 | 91% | 24 | 5,100 | 550,000 | No |
| p,p'-DDE | µg/kg | 11 | 10 | 91% | 17 | 680 | 390,000 | No |
| p,p'-DDT | µg/kg | 6 | 5 | 83% | 6.3 | 450 | 390,000 | No |
| **Petroleum Hydrocarbons** | | | | | | | | |
| Motor Oil-Range Hyrdocarbons | mg/kg | 11 | 11 | 100% | 76 | 3,200 | 7,000 [2] | No |
| Diesel-Range Hydrocarbons | mg/kg | 11 | 11 | 100% | 49 | 930 | 7,000 [2] | No |
| **Metals[3]** | | | | | | | | |
| Aluminum | mg/kg | 11 | 11 | 100% | 7,050 | 28,100 | NR | No |
| Arsenic | mg/kg | 11 | 9 | 82% | 7 | 60 | 88 | No |
| Barium | mg/kg | 11 | 11 | 100% | 26 | 325 | 700,000 | No |
| Cadmium | mg/kg | 11 | 9 | 82% | 0.6 | 10 | 3,500 | No |
| Chromium | mg/kg | 11 | 11 | 100% | 14 | 101 | 5,250,000 | No |
| Copper | mg/kg | 11 | 11 | 100% | 14 | 324 | 130,000 | No |
| Iron | mg/kg | 11 | 11 | 100% | 11,100 | 92,800 | NR | No |
| Lead | mg/kg | 11 | 11 | 100% | 6.0 | 620 | 1,000 | No |
| Manganese | mg/kg | 11 | 11 | 100% | 120 | 535 | 490,000 | No |
| Mercury | mg/kg | 11 | 10 | 91% | 0.04 | 1 | 1,050 | No |
| Nickel | mg/kg | 11 | 11 | 100% | 10 | 90 | 70,000 | No |
| Silver | mg/kg | 11 | 5 | 45% | 0.8 | 4 | 17,500 | No |
| Zinc | mg/kg | 11 | 11 | 100% | 45 | 1,760 | 1,100,000 | No |

Notes:

(grey shading) Mixture of CPAHs considered for TEQ calculations.

-- No value.

1 The MTCA Method A cleanup level for industrial soil has been used in place of the MTCA Method C cleanup level, which conflicts with a Federal ARAR. The following is a footnote from MTCA for the Method A cleanup level: "Cleanup level based on applicable federal law (40 C.F.R. 761.61). This is a total value for all PCBs. This value may be used only if the PCB contaminated soils are capped and the cap maintained as required by 40 C.F.R. 761.61. If this condition cannot be met, the value in Table 740-1 must be used."

2 A site-specific MTCA Method C cleanup level was calculated using Washington State Department of Ecology's MTCATPH11.1 worksheets.

3 Natural Background Soil Metals Concentrations in Washington State (Ecology 1994), Statewide 90th Percentile Values are as follows: arsenic—7 mg/kg, cadmium—1 mg/kg, chromium—42 mg/kg, copper—36 mg/kg, lead—17 mg/kg, mercury—0.07 mg/kg, nickel—38 mg/kg, and zinc—86 mg/kg; however, the arsenic value was reevaluated and a value of 20 mg/kg replaced the 1994 Washington State Department of Ecology value (Task Force 2003).

Abbreviations:

ARAR Applicable or Relevant and Appropriate Requirement
BaP Benzo(a)pyrene
CPAH Carcinogenic polycyclic aromatic hydrocarbon
DDD Dichlorodiphenyldichloroethane
DDE Dichlorodiphenyldichloroethylene
DDT Dichlorodiphenyltrichloroethane
FOD Frequency of detection
FOE Frequency of exceedance
µg/kg Micrograms per kilogram
mg/kg Milligrams per kilogram
MTCA Model Toxics Control Act
NR The chemical was not researched by the Washington State Department of Ecology
RL Reporting limit
R-ND The chemical was researched by the Washington State Department of Ecology and no toxicity data of acceptable quality were found
TEQ Toxicity equivalent

**Table 4.5**

**Chlorinated Dioxins and Furans Detected in Multi-Increment Soil Samples for Semivolatile Organic Compounds**

| Chemical | Unit | TEF | DU-1 (Former West Ditch) | | DU-2 (Transfer Station) | | DU-3 (SPPD Parcel) | |
|---|---|---|---|---|---|---|---|---|
| | | | Sample Results | TEQ | Sample Results | TEQ | Sample Results | TEQ |
| **Dioxins** | | | | | | | | |
| 2,3,7,8-Tetrachloro dibenzo-p-dioxin (2,3,7,8-TCDD) | ng/kg | 1 | 1.82 | 1.82 | 113 | 113 | 4.57 | 4.57 |
| 1,2,3,7,8-Pentachloro dibenzo-p-dioxin (1,2,3,7,8-PeCDD) | ng/kg | 1 | 4.72 | 4.72 | 72.9 | 72.9 | 9.87 | 9.87 |
| 1,2,3,4,7,8-Hexachloro dibenzo-p-dioxin (1,2,3,4,7,8-HxCDD) | ng/kg | 0.1 | 8.68 | 0.868 | 71.9 | 7.19 | 18.7 | 1.87 |
| 1,2,3,6,7,8-Hexachloro dibenzo-p-dioxin (1,2,3,6,7,8-HxCDD) | ng/kg | 0.1 | 35.1 | 3.51 | 169 | 16.9 | 51.2 | 5.12 |
| 1,2,3,7,8,9-Hexachloro dibenzo-p-dioxin (1,2,3,7,8,9-HxCDD) | ng/kg | 0.1 | 18.8 | 1.88 | 154 | 15.4 | 37.4 | 3.74 |
| 1,2,3,4,6,7,8-Heptachloro dibenzo-p-dioxin (1,2,3,4,6,7,8-HpCDD) | ng/kg | 0.01 | 551 | 5.51 | 2,430 | 24.3 | 1,230 | 12.3 |
| 1,2,3,4,6,7,8,9-Octachloro dibenzo-p-dioxin (1,2,3,4,6,7,8,9-OCDD) | ng/kg | 0.0003 | 4,990 | 1.50 | 18,100 | 5.43 | 15,500 | 4.65 |
| **Furans** | | | | | | | | |
| 2,3,7,8-Tetrachloro dibenzofuran (2,3,7,8-TCDF) | ng/kg | 0.1 | 8.17 | 0.817 | 48.2 | 4.82 | 15.6 | 1.56 |
| 1,2,3,7,8-Pentachloro dibenzofuran (1,2,3,7,8-PeCDF) | ng/kg | 0.03 | 5.87 | 0.1761 | 49.7 | 1.491 | 13.7 | 0.411 |
| 2,3,4,7,8-Pentachloro dibenzofuran (2,3,4,7,8- PeCDF) | ng/kg | 0.3 | 5.42 | 1.63 | 80.7 | 24.21 | 17.0 | 5.1 |
| 1,2,3,4,7,8-Hexachloro dibenzofuran (1,2,3,4,7,8-HxCDF) | ng/kg | 0.1 | 17.2 | 1.72 | 178 | 17.8 | 79.6 | 7.96 |
| 1,2,3,6,7,8-Hexachloro dibenzofuran (1,2,3,6,7,8- HxCDF ) | ng/kg | 0.1 | 9.51 | 0.951 | 102 J | 10.2 | 26.40 J | 2.64 |
| 2,3,4,6,7,8-Hexachloro dibenzofuran (2,3,4,6,7,8-HxCDF) | ng/kg | 0.1 | 11.1 | 1.11 | 107 | 10.7 | 28.5 | 2.85 |
| 1,2,3,7,8,9-Hexachloro dibenzofuran (1,2,3,7,8,9- HxCDF ) | ng/kg | 0.1 | 2.90 J | 0.29 | 18.6 | 1.86 | 10.7 | 1.07 |
| 1,2,3,4,6,7,8-Heptachloro dibenzofuran (1,2,3,4,6,7,8-HpCDF) | ng/kg | 0.01 | 123 | 1.23 | 650 | 6.5 | 223 | 2.23 |
| 1,2,3,4,7,8,9-Heptachloro dibenzofuran (1,2,3,4,7,8,9-HpCDF) | ng/kg | 0.01 | 7.67 | 0.0767 | 44.5 | 0.445 | 23.1 | 0.231 |
| 1,2,3,4,6,7,8,9-Octachloro dibenzofuran (1,2,3,4,6,7,8,9-OCDF) | ng/kg | 0.0003 | 190 | 0.057 | 1,170 | 0.351 | 480 | 0.144 |
| **Summary** | | | | | | | | |
| Total dioxin/furan TEQ | ng/kg | | | 27.9 | | 333 | | 66.3 |
| 2,3,7,8-TCDD | ng/kg | | | 1.82 | | 113 | | 4.57 |
| MTCA Method C CUL for dioxin/furan TEQ | ng/kg | | | 1,500 | | 1,500 | | 1,500 |
| MTCA Method B CUL for dioxin/furan TEQ | ng/kg | | | 11.0 | | 11.0 | | 11.0 |

Note:

Blank cells are intentional.

Abbreviations:

CUL Cleanup level
MTCA Model Toxics Control Act
ng/kg Nanograms per kilogram
SPPD South Park Property Development, LLC
SVOC Semivolatile organic compounds
TEF Toxicity equivalency factor
TEQ Toxicity equivalent

Qualifier:

J Estimated value.

## Table 5.1
## Results of Reconnaissance Probe Investigations

| Temporary Probe Location[1] | Sample Date | Sampled Interval (ft bgs) | Sampled Aquifer Unit | Trichloroethene (µg/L) | *cis-* 1,2-Dichloroethene (µg/L) | Vinyl Chloride (µg/L) | Benzene (µg/L) | Arsenic (Dissolved) (µg/L) |
|---|---|---|---|---|---|---|---|---|
| **Area 1: Vicinity of MW-12** | | | | | | | | |
| FB-07 | 3/7/2011 | 5–10 ft | Zone-A | 0.2 U | 0.2 U | 0.02 U | NM | 2.4 |
| FB-08 | 3/7/2011 | 8–13 ft | Zone-A | 0.2 U | 12 | 1.2 | NM | 1.5 |
| FB-09 | 3/7/2011 | 9–14 ft | Zone-A | 0.2 U | 4.3 | 0.11 | NM | 1.9 |
| FB-10 | 3/7/2011 | 9–14 ft | Zone-A | 0.2 U | 0.4 | 0.026 | NM | 2.8 |
| FB-11 | 3/7/2011 | 10–15 ft | Zone-A | 0.2 U | 0.5 | 0.02 U | NM | 2.6 |
| FB-11-DUP | 3/7/2011 | 10–15 ft | Zone-A | 0.2 U | 0.5 | 0.02 U | NM | 2.5 |
| **Area 2: 5th Ave Between Landfill and Off-Site CKD Deposits** | | | | | | | | |
| FB-12 | 3/8/2011 | 10–15 ft | Zone-A | 0.8 | 1.7 | 1.4 | NM | 2.2 |
| FB-13 | 3/8/2011 | 15–20 ft | Zone-A | 0.2 U | 0.2 U | 0.34 | NM | 1.6 |
| **Area 3: Downgradient of NE Corner of the Landfill (East of SR 99)** | | | | | | | | |
| FB-14 | 3/11/2011 | 8–13 ft | Perched | 2.6 | 0.4 | 0.029 | NM | 0.3 |
| FB-14-ES | 3/11/2011 | 8–13 ft | Perched | 3.5 | 0.36 | 1 U | 1.0 U | 0.4 |
| FB-14 | 3/11/2011 | 17–22 ft | Zone-A | 0.2 U | 20 | 5.1 | NM | 0.4 |
| FB-14-ES | 3/11/2011 | 17–22 ft | Zone-A | 1 U | 23 | 8.4 | 1.0 U | 1.5 |
| FB-14 | 3/11/2011 | 36–40 ft | Zone-B | 0.2 U | 7.7 | 0.4 | NM | 0.5 |
| FB-14-ES | 3/11/2011 | 36–40 ft | Zone-B | 1 U | 8.2 | 0.8 | 1.0 U | NM |

Note:

1 The "ES" at the end of a sample name indicates that the results presented are from the Washington State Department of Ecology split of this sample.

Abbreviations:

bgs Below ground surface
CKD Cement kiln dust
ft Feet
mg/L Micrograms per liter
NM Not measured (as part of the investigation at this location)
SR State Route

Qualifier:

U Not detected

## Table 5.2
## Slug Test Results[1]

| Well ID[2] | Sample Date | Sampled Aquifer Unit | Screen Elevation[3] (ft bgs) | Screen Length (ft) | Aquifer Thickness (ft) | Aquifer Condition | Aquifer Response | Analytic Method | Hydraulic Conductivity ft/min | Hydraulic Conductivity ft/day | Hydraulic Conductivity cm/sec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Well Pair MW-25/MW-10** | | | | | | | | | | | |
| MW-25 | 1/19/2011 | Zone-A | 22–27 | 5 | 25.5 | Confined | Underdamped | Butler-Zahn | 0.102 | 150 | 5.2E-02 |
| MW-10 | 1/19/2011 | Zone-B | 35–45 | 10 | 33.5 | Confined | Underdamped | Butler-Zahn | 0.045 | 65 | 2.3E-02 |
| **60-min Pumping Test/ Cooper-Jacob Pumping Analysis (Aquifer Thickness 35 ft)** | | | | | | | | | **0.120** | **170** | **6.0E-02** |
| **Well Pair MW-26/MW-24** | | | | | | | | | | | |
| MW-26 | 1/20/2011 | Zone-A | 15–25 | 10 | ≥37.5 | Confined | Underdamped | Butler-Zahn | 0.072 | 100 | 3.7E-02 |
| MW-24 | 1/20/2011 | Zone-B | 35–45 | 10 | ≥38 | Confined | Overdamped | Hvorslev | 0.018 | 26 | 9.1E-03 |
| **60-min Pumping Test/Cooper-Jacob Pumping Analysis (Aquifer Thickness 56 ft)** | | | | | | | | | **0.048** | **69** | **2.4E-02** |
| **Well Pair MW-27/MW-08** | | | | | | | | | | | |
| MW-27 | 1/20/2011 | Zone-A | 10–20 | 10 | ≥49 | Unconfined | Overdamped | Bouwer & Rice | 0.029 | 42 | 1.5E-02 |
| MW-08 | 1/20/2011 | Zone-B | 35.5–45.5 | 10 | ≥49 | Unconfined | Overdamped | Bouwer & Rice | 0.025 | 36 | 1.3E-02 |
| **60-min Pumping Test/Cooper-Jacob Pumping Analysis (Aquifer Thickness 56 ft)** | | | | | | | | | **0.049** | **71** | **2.5E-02** |
| **Slug Test Geometric Mean** | | | | | | | | | **0.04** | **60** | **2E-02** |
| **Slug Test Range** | | | | | | | | | **0.02 to 0.10** | **26 to 150** | **9E-03 to 5E-02** |
| **Pumping Test Geometric Mean** | | | | | | | | | **0.07** | **90** | **3E-02** |
| **Pumping Test Range** | | | | | | | | | **0.05 to 0.12** | **70 to 170** | **2E-02 to 6E-02** |

Notes:

1 Pumping test data are from AESI (2000).
2 Well pairs are listed top down from northwest to southeast.
3 All well screens are partially penetrating and fully submerged.

Abbreviations:

AESI Associated Earth Sciences, Inc.
bgs Below ground surface
cm Centimeter
ft Feet
min Minute
sec Second

## Table 5.3
## Vertical Groundwater Gradients

| Monitoring Well | Sample Date[1] | Sampled Aquifer Unit | Well Screen Interval (ft bgs) | Ground Surface Elevation (ft, NAVD 88) | Top of Well Casing Elevation (ft, NAVD 88) | Screen Midpoint Elevation (ft, NAVD 88) | Groundwater Level (ft bTOC) | Groundwater Elevation (ft, NAVD 88) | Vertical Gradient Upward (-) Downward (+) | Gradient Direction |
|---|---|---|---|---|---|---|---|---|---|---|
| MW-08 | 1/27/2011 | Zone-B | 35.5–45.5 | 12.88 | 14.76 | -27.62 | 6.70 | 8.06 | -0.0063 | Upgradient |
| MW-27 | 1/27/2011 | Zone-A | 10–20 | 12.72 | 14.76 | -2.28 | 6.86 | 7.90 | | |
| MW-08 | 7/16/2013 | Zone-B | 35.5–45.5 | 12.88 | 14.76 | -27.62 | 8.82 | 5.94 | Neutral Gradient[2] | |
| MW-27 | 7/16/2013 | Zone-A | 10–20 | 12.72 | 14.76 | -2.28 | 8.78 | 5.98 | | |
| MW-08 | 3/19/2014 | Zone-B | 35.5–45.5 | 12.88 | 14.76 | -27.62 | 6.70 | 8.06 | Neutral Gradient[2] | |
| MW-27 | 3/19/2014 | Zone-A | 10–20 | 12.72 | 14.76 | -2.28 | 6.70 | 8.06 | | |
| MW-10 | 1/28/2011 | Zone-B | 35–45 | 17.70 | 19.35 | -22.30 | 11.60 | 7.75 | Neutral Gradient[2] | |
| MW-25 | 1/27/2011 | Zone-A | 22–27 | 17.30 | 20.09 | -7.20 | 12.35 | 7.74 | | |
| MW-10 | 4/2/2013 | Zone-B | 35–45 | 17.70 | 19.35 | -22.30 | 12.78 | 6.57 | 0.0079 | Downgradient |
| MW-25 | 4/1/2013 | Zone-A | 22–27 | 17.30 | 20.09 | -7.20 | 13.40 | 6.69 | | |
| MW-10 | 7/15/2013 | Zone-B | 35–45 | 17.70 | 19.35 | -22.30 | 13.63 | 5.72 | Neutral Gradient[2] | |
| MW-25 | 7/15/2013 | Zone-A | 22–27 | 17.30 | 20.09 | -7.20 | 14.30 | 5.79 | | |
| MW-10 | 3/17/2014 | Zone-B | 35–45 | 17.70 | 19.35 | -22.30 | 11.60 | 7.75 | Neutral Gradient[2] | |
| MW-25 | 3/17/2014 | Zone-A | 22–27 | 17.30 | 20.09 | -7.20 | 12.32 | 7.77 | | |
| MW-24 | 1/27/2011 | Zone-B | 35–45 | 13.57 | 15.13 | -26.43 | 7.23 | 7.90 | Neutral Gradient[2] | |
| MW-26 | 1/27/2011 | Zone-A | 15–25 | 13.55 | 15.94 | -6.45 | 8.05 | 7.89 | | |
| MW-24 | 4/2/2013 | Zone-B | 35–45 | 13.57 | 15.13 | -26.43 | 8.47 | 6.66 | Neutral Gradient[2] | |
| MW-26 | 4/2/2013 | Zone-A | 15–25 | 13.55 | 15.94 | -6.45 | 9.25 | 6.69 | | |
| MW-24 | 7/16/2013 | Zone-B | 35–45 | 13.57 | 15.13 | -26.43 | 9.29 | 5.84 | Neutral Gradient[2] | |
| MW-26 | 7/16/2013 | Zone-A | 15–25 | 13.55 | 15.94 | -6.45 | 10.06 | 5.88 | | |
| MW-24 | 3/19/2014 | Zone-B | 35–45 | 13.57 | 15.13 | -26.43 | 7.21 | 7.92 | Neutral Gradient[2] | |
| MW-26 | 3/19/2014 | Zone-A | 15–25 | 13.55 | 15.94 | -6.45 | 7.99 | 7.95 | | |
| MW-30 | 6/20/2011 | Perched | 8–13 | 17.37 | 17.07 | 6.87 | 10.25 | 6.82 | 0.0573 | Downgradient |
| MW-31 | 6/20/2011 | Zone-A | 18–23 | 17.42 | 17.12 | -3.08 | 10.87 | 6.25 | | |
| MW-30 | 7/8/2011 | Perched | 8–13 | 17.37 | 17.07 | 6.87 | 10.48 | 6.59 | 0.0754 | Downgradient |
| MW-31 | 7/8/2011 | Zone-A | 18–23 | 17.42 | 17.12 | -3.08 | 11.28 | 5.84 | | |
| MW-30 | 4/2/2013 | Perched | 8–13 | 17.37 | 17.07 | 6.87 | 9.80 | 7.27 | 0.0824 | Downgradient |
| MW-31 | 4/2/2013 | Zone-A | 18–23 | 17.42 | 17.12 | -3.08 | 10.67 | 6.45 | | |
| MW-30 | 7/16/2013 | Perched | 8–13 | 17.37 | 17.07 | 6.87 | 10.67 | 6.40 | 0.0704 | Downgradient |
| MW-31 | 7/16/2013 | Zone-A | 18–23 | 17.42 | 17.12 | -3.08 | 11.42 | 5.70 | | |
| MW-30 | 3/19/2014 | Perched | 8–13 | 17.37 | 17.07 | 6.87 | 8.37 | 8.70 | 0.1025 | Downgradient |
| MW-31 | 3/18/2014 | Zone-A | 18–23 | 17.42 | 17.12 | -3.08 | 9.44 | 7.68 | | |

Notes:

1 MW-08/MW-27 well pair gradient not calculated during April 2013 due to a suspected erroneous water level measurement.

2 Difference in head between measurement points was either 0 or within measurement error inherent in water level measurement method, and so no vertical gradient was observed.

Abbreviations:

bgs Below ground surface
bTOC Below top of casing
ft Feet
NAVD 88 North American Vertical Datum of 1988

## Table 5.4
## Well Completion Information

| Monitoring Well | Installation Date | Coordinates Northing[1] (NAD 83) | Coordinates Easting[1] (NAD 83) | Ground Surface Elevation[2] (NAVD 88) | Monitoring Well Casing Elevation[2] (NAVD 88) | Well Casing Stickup Relative to Ground Surface (ft) | Total Boring Depth (ft bgs) | Total Well Depth (ft bgs) | Well Screen Interval (ft bgs) | Screened Aquifer Unit | Gradient Direction | Geologic Matter at Screened Interval |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| KMW-01A | 10/20/1995 | 197146.92 | 1269960.23 | - | 18.03 | - | 21.5 | 21 | 5.0–21.0 | Across both Perched and Zone-A | Interior | Silt and Sand with Organic Matter |
| KMW-03A | 10/20/1995 | 197585.09 | 1270170.48 | - | 18.62 | - | 24 | 24 | 9.0–24.0 | | Interior | Wood, Sand, Silt |
| KMW-04 | 3/11/1992 | 197374.76 | 1270149.88 | - | 19.71 | - | 21 | 20 | 5.0–20.0 | | Interior | Debris, Silty Clay, Sandy Silt |
| KMW-05 | 3/12/1992 | 197427.44 | 1269861.86 | - | 15.79 | - | 21 | 20 | 5.0–20.0 | | Upgradient | Sandy Silt, Silty Clay, & Silty Sand |
| KMW-06 | 3/12/1992 | 197637.24 | 1269878.36 | - | 17.77 | - | 21 | 20 | 5.0–20.0 | | Interior | Sandy Gravel, Silty Sand |
| KMW-07 | 3/12/1992 | 197626.24 | 1269684.96 | - | 19.64 | - | 20 | 20 | 5.0–20.0 | | Upgradient | Gravelly Sand, Silty Sand |
| KMW-08 | 3/12/1992 | 197356.14 | 1269692.89 | - | 19.76 | - | 21 | 20 | 5.0–20.0 | | Upgradient | Sand, Silty Clay |
| MW-01 | 10/9/1991 | 196235.09 | 1269862.09 | 19.75 | 19.61 | -0.14 | 13.5 | 13 | 3.0–13.0 | Zone-A | Upgradient | Silt and Sand with Organic Matter |
| MW-03 | 10/9/1991 | 196657.79 | 1269868.34 | 18.94 | 18.78 | -0.16 | 13.5 | 13 | 2.0–13.0 | Zone-A | Upgradient | Silt with Organic Matter, Sand |
| MW-04 | 12/2/1998 | 195985.22 | 1270372.47 | 20.15 | 21.98 | 1.83 | 50.59 | 50.59 | 40.6–50.6 | Zone-B | Upgradient | Sand with Interbedded Silt Laminae, Silty Sand |
| MW-06 [1] | 12/4/1998 | 195677.21 | 1271027.45 | 17.35 | 18.76 | 1.41 | 50 | 40 | 30.0–40.0 | Zone-B | Crossgradient | Sand with Interbedded Silt Laminae |
| MW-08 | 12/7/1998 | 196834.57 | 1271362.27 | 12.88 | 14.76 | 1.88 | 49 | 45.59 | 35.6–45.6 | Zone-B | Downgradient | Sand, Silty Sand |
| MW-10 | 12/9/1998 | 197659.19 | 1270559.83 | 17.7 | 19.35 | 1.65 | 49 | 45 | 35.0–45.0 | Zone-B | Downgradient | Sand with Interbedded Silt Laminae |
| MW-12 | 9/20/1999 | 196964.43 | 1269792.64 | 19.11 | 20.63 | 1.52 | 22.5 | 15.3 | 10.0–15.0 | Zone-A | Upgradient | Sand with Silty Interbeds |
| MW-14 | 9/14/1999 | 196399.9 | 1269963.7 | 19.05 | 19.85 | 0.8 | 34 | 21.8 | 11.5–21.5 | Zone-A | Upgradient | Sand with Silt Interbeds, Silt with Trace Sand Laminae |
| MW-18 | 9/17/1999 | 196350.26 | 1271077.67 | 20.78 | 22.03 | 1.25 | 49 | 40.4 | 30.0–40.0 | Zone-B | Downgradient | Sand |
| MW-24 | 9/21/1999 | 197110.02 | 1271165.6 | 13.57 | 15.13 | 1.56 | 49 | 45.3 | 35.0–45.0 | Zone-B | Downgradient | Sand, some Organic Silt Interbeds, Silt with Sand |
| MW-25 | 2/23/2006 | 197657.49 | 1270566.75 | 17.3 | 20.09 | 2.79 | 28 | 27 | 22.0–27.0 | Zone-A | Downgradient | Slightly Silty Sand |
| MW-26 | 2/23/2006 | 197121.6 | 1271164.4 | 13.55 | 15.94 | 2.39 | 26 | 25 | 15.0–25.0 | Zone-A | Downgradient | Sand |
| MW-27 | 2/23/2006 | 196835.06 | 1271357.64 | 12.72 | 14.76 | 2.04 | 21 | 20 | 10.0–20.0 | Zone-A | Downgradient | Silty Sand |
| MW-29 | 1/14/2011 | 196034.29 | 1270270.91 | 19.45 | 19.16 | -0.29 | 30 | 30 | 20.0–30.0 | Zone-A | Upgradient | Very Silty Sand, Sand |
| MW-30 | 6/15/2011 | 197655.77 | 1270826.64 | 17.6 | 17.07 | -0.53 | 16.5 | 13 | 8.0–13.0 | Perched | Not connected | Slightly Silty Sand, Sand |
| MW-31 | 6/15/2011 | 197660.37 | 1270825.71 | 17.58 | 17.12 | -0.46 | 26 | 23 | 18.0–23.0 | Zone-A | Downgradient | Sand |
| MW-32 | 6/29/2011 | 197416.52 | 1270622.16 | 17.51 | 17.07 | -0.44 | 24 | 24 | 19.0–24.0 | Zone-A | Downgradient | Sand |
| MW-33 | 6/29/2011 | 197257.91 | 1270751.02 | 17.81 | 17.34 | -0.47 | 25 | 25 | 20.0–25.0 | Zone-A | Downgradient | Sand |

Note:

1 MW-06 is located south and cross gradient of the South Park Landfill. It was sampled multiple times between 1998 and 2005 and bound to be clean (refer to RI/FS Work Plan [Farallon 2010a] for details). MW-06 has not been retained for use in the RI/FS.

Abbreviations:

bgs Below ground surface
ft Feet
NAD 83 North American Datum of 1983
NAVD 88 North American Vertical Datum of 1988
RI/FS Remedial Investigation/Feasibility Study

## Table 5.5
## Frequency of Detections and Exceedances in On-Site and Downgradient Groundwater

| Potential Chemicals of Concern | Unit | Cleanup Level: Proposed Cleanup Level | Cleanup Level: Source of Cleanup Level | Detections (since 1998): Number of Results | Detections (since 1998): Percentage of Detections | Detections (since 1998): Maximum Detected Value | Detections (since 1998): Location of Maximum Detection | Detections (since 1998): Date of Maximum Detection | Exceedances (since 2005): Number of Detections Exceeding Criterion | Exceedances (since 2005): Percentage of Samples Exceeding Criterion | Retained as a Groundwater COC?: Retained as COC? | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Volatile Organic Compounds** | | | | | | | | | | | | |
| 1,1-Dichloroethane | µg/L | 1,600 | MCTA B | 160 | 16% | 0.68 | MW-26 | 2/27/2006 | None | -- | No | |
| 1,2-Dichlorobenzene | µg/L | 720 | MCTA B | 162 | 6% | 0.68 | MW-25 | 3/31/2009 | None | -- | No | |
| 1,2-Dichloropropane | µg/L | NA | MCTA B | 160 | 6% | 0.32 | MW-10 | 12/17/2002 | None | -- | No | |
| **Benzene** | µg/L | 5.0 | MCL/MTCA | 150 | 26% | 5.8 | MW-25 | 1/27/2011 | 1 | 2% | No | One time exceedance in 2011: EF=1.2 |
| Chlorobenzene | µg/L | 160 | MCTA B | 160 | 53% | 46 | MW-25 | 3/31/2009 | None | -- | No | |
| ***cis*-1,2-Dichloroethene** | µg/L | 16 | MCTA B | 221 | 57% | 23 | FB-14 | 3/11/2011 | 1 | 0.8% | No | One time exceedance in 2011: EF=1.4 |
| *trans*-1,2-Dichloroethene | µg/L | 160 | MCTA B | 182 | 28% | 3.2 | FB-14 | 3/11/2011 | None | -- | No | |
| Trichloroethene | µg/L | 4.0 | MCL/MTCA | 221 | 10% | 3.5 | FB-14 | 3/11/2011 | None | -- | No | |
| **Vinyl chloride** | µg/L | 0.29 | MCL/MTCA | 221 | 76% | 11 | MW-24 | 12/27/1999 | 25 | 20% | Yes | |
| **Semivolatile Organic Compounds** | | | | | | | | | | | | |
| Naphthalene | µg/L | 160 | MTCA B | 99 | 2% | 0.3 | KMW-03A | 1/27/2011 | None | -- | No | |
| **Pesticides and Herbicides** | | | | | | | | | | | | |
| No pesticides or herbicides associated with the Landfill have been detected; refer to Appendix C for full listing of data. | | | | | | | | | | | | |
| **Polychlorinated Biphenyls (PCBs)** | | | | | | | | | | | | |
| No PCBs associated with the Landfill have been detected; refer to Appendix C for full listing of data. | | | | | | | | | | | | |
| **Petroleum Hydrocarbons** | | | | | | | | | | | | |
| Gasoline-Range Hydrocarbon | mg/L | 0.8 | MTCA A | 129 | 18% | 0.56 | MW-10 | 5/6/1999 | None | -- | No | |
| Diesel-Range Hydrocarbon | mg/L | 0.5 | MTCA A | 149 | 52% | 0.97 | MW-24 | 12/18/2002 | 1 | 2% | No | One time exceedance in 2002; EF=1.9 |
| Oil-Range Hydrocarbon | mg/L | 0.5 | MTCA A | 145 | 1% | 0.46 | MW-24 | 3/24/2000 | None | -- | No | |
| **Metals, Dissolved (Filtered)** | | | | | | | | | | | | |
| Aluminum | mg/L | 1.6 | MCTA B | 78 | 21% | 0.1 | MW-08 | 12/22/2000 | None | -- | No | |
| **Arsenic** | mg/L | 0.005 | MTCA A | 176 | 43% | 0.025 | MW-27 | 3/31/2009 | 11 | 14% | Yes | Not related to Landfill; refer to text |
| **Barium** | mg/L | 2.0 | MCL/MTCA | 157 | 78% | 6.0 | KMW--03A | 12/18/2007 | 4 | 7% | No | In compliance at POC |
| Cadmium | mg/L | 0.005 | MCL/MTCA | 160 | 9% | 0.009 | MW-10 | 10/26/1999 | None | -- | No | |
| Copper | mg/L | 0.64 | MCTA B | 114 | 28% | 0.00716 | MW-08 | 9/21/2005 | None | -- | No | |
| Iron (A Zone) | mg/L | 27 | MTCA C | 28 | 100% | 29 | MW-25 | 1/27/2011 | 3 | 11% | Yes | |
| Iron (B Zone) | mg/L | 39 | MTCA C | 125 | 100% | 63 | MW-18 | 12/28/1999 | 6 | 22% | Yes | |
| Lead | mg/L | 0.015 | MCL/MTCA | 169 | 5% | 0.0024 | MW-27 | 10/23/2008 | None | -- | No | |
| Manganese (A Zone) | mg/L | 2.2 | MTCA C | 36 | 100% | 3.5 | MW-10 | 12/13/2004 | 6 | 17% | Yes | |
| Manganese (B Zone) | mg/L | 2.2 | MTCA C | 125 | 100% | 3.1 | MW-25 | 1/27/2011 | 4 | 15% | Yes | |
| Selenium | mg/L | 0.05 | MCL/MTCA | 157 | 69% | 0.055 | MW-08 | 9/13/2001 | None | -- | No | |
| Vanadium | mg/L | 0.14 | MCTA B | 114 | 50% | 0.013 | MW-25 | 2/27/2006 | None | -- | No | |
| Zinc | mg/L | 5.0 | MCL/MTCA | 114 | 24% | 0.2 | MW-24 | 12/27/1999 | None | -- | No | |
| **Metals, Total (Unfiltered)** | | | | | | | | | | | | |
| Aluminum | mg/L | 1.6 | MCTA B | 81 | 58% | 0.55 | MW-10 | 3/19/1999 | None | -- | No | |
| **Arsenic** | mg/L | 0.005 | MTCA A | 137 | 38% | 0.055 | MW-27 | 3/27/2007 | 8 | 14% | No | Not related to Landfill; refer to text |
| Barium | mg/L | 2.0 | MCL | 120 | 71% | 0.086 | MW-18 | 10/28/1999 | 0 | -- | No | |
| Copper | mg/L | 0.64 | MCTA B | 85 | 25% | 0.013 | MW-08 | 8/3/2000 | 0 | -- | No | |
| Iron (A Zone) | mg/L | 27 | MTCA C | 28 | 100% | 32 | MW-25 | 1/27/2011 | 3 | 11% | Yes | |
| Iron (B Zone) | mg/L | 39 | MTCA C | 96 | 100% | 61 | MW-18 | 12/28/1999 | 3 | 20% | Yes | |
| **Lead** | mg/L | 0.015 | MCL | 132 | 8% | 0.023 | KMW-01A | 1/28/2011 | 1 | 2% | No | One time exceedance in 2011; EF=1.5 |
| Manganese (A Zone) | mg/L | 2.2 | MTCA C | 36 | 100% | 3.1 | MW-25 | 1/27/2011 | 5 | 14% | Yes | |
| Manganese (B Zone) | mg/L | 2.2 | MTCA C | 97 | 99% | 3.3 | MW-10 | 1/28/2011 | 1 | 6% | Yes | |
| Selenium | mg/L | 0.05 | MCL | 120 | 68% | 0.062 | MW-08 | 3/26/2002 | 0 | -- | No | |
| Vanadium | mg/L | 0.14 | MCTA B | 85 | 46% | 0.016 | MW-25 | 2/27/2006 | 0 | -- | No | |
| Zinc | mg/L | 5.0 | MCL | 85 | 14% | 0.011 | MW-10 | 3/19/1999 | 0 | -- | No | |

Notes:

-- No value.

**BOLD RED** Chemical is a COC for this medium.

**BOLD SHADED** Chemical was considered for inclusion as a COC but not retained. Refer to text for details.

Abbreviations:

COC Chemical of concern
EF Exceedance factor
Landfill South Park Landfill
MCL Maximum Contaminant Level (drinking water)
MCL/MTCA MCL modified to comply with MTCA risk levels
µg/L Micrograms per liter
mg/L Milligrams per liter
MTCA A Model Toxics Control Act Method A
MTCA B Model Toxics Control Act Method B
POC Point of compliance

# Table 5.6

## Ranges of Benzene, Chlorinated Ethenes, and Arsenic in Groundwater from January 2011 through March 2014[1]

| Monitoring Well | Trichloroethene (µg/L) MTCA CUL = 5 | | *cis*-1,2-Dichloroethene (µg/L) MTCA CUL = 16 | | Vinyl chloride (µg/L) MTCA CUL = 0.29 | | Benzene (µg/L) MTCA CUL = 5 | | Arsenic (µg/L) MTCA CUL = 5 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Minimum | Maximum | Minimum | Maximum | Minimum | Maximum | Minimum | Maximum | Dissolved | Total |
| **Upgradient and Cross Gradient Wells** | | | | | | | | | | |
| KMW-05 | 2 U | 4 U | 2 U | 4 U | 0.2 U | 0.4 U | **5.6** [2] | **8.2** [2] | **1,200** [2] | **1,200** [2] |
| KMW-07 | 0.2 U | 0.2 U | 0.2 U | 0.2 U | 0.02 U | 0.02 U | 0.2 U | 0.2 U | **4.2** | **5.7** [2] |
| KMW-08 | 0.2 U | 0.2 U | 0.2 U | 0.2 U | 0.02 U | 0.02 U | 0.2 U | 0.2 U | **4.2** | **5.1** [2] |
| MW-01 | 0.2 U | 0.2 U | 0.2 U | 0.2 U | 0.02 U | 0.02 U | 0.2 U | 0.2 U | **3.2** | **3.5** |
| MW-03 | 0.2 U | 0.2 U | 0.2 U | 0.2 U | 0.02 U | 0.02 U | 0.2 U | 0.2 U | **1.0** | **1.0** |
| MW-04 | 0.2 U | 0.2 U | 0.2 U | 0.2 U | 0.02 U | 0.02 U | 0.2 U | 0.2 U | 0.2 U | 0.2 U |
| MW-12 | **0.15** | **0.6** | **3.1** | **5.7** | **0.1** | **0.26** | 0.2 U | 0.2 U | **3.2** | **6.4** [2] |
| MW-14 | 0.02 U | 0.2 U | 0.02 U | 0.2 U | 0.02 U | 0.02 U | 0.2 U | 0.2 U | **0.3** | **0.3** |
| MW-29 | 0.02 U | 0.2 U | 0.2 U | 0.034 | 0.02 U | 0.02 U | 0.2 U | 0.2 U | **0.9** | **0.9** |
| MW-30[1] | **0.49** | **0.75** | **0.64** | **3.2** | **0.12** | **2.2** | NS | NS | NS | NS |
| **Interior Wells** | | | | | | | | | | |
| KMW-01A | 0.2 U | 0.2 U | 0.2 U | 0.2 U | **0.091** | **0.091** | 0.2 U | 0.2 U | **0.6** | **0.8** |
| KMW-03A | 0.2 U | 0.2 U | 0.2 U | 0.2 U | **0.3** | **0.39** | 0.2 U | 0.2 U | **8.0** | **8.7** |
| KMW-04 | 0.2 U | 0.2 U | 0.2 U | 0.2 U | **0.22** | **0.22** | 0.2 U | 0.2 U | **2.7** | **2.6** |
| KMW-06 | 0.2 U | 0.2 U | 0.2 U | 0.2 U | **0.31** | **0.31** | 0.2 U | 0.2 U | **1.5** | **1.3** |
| **Downgradient Wells, A-Zone** | | | | | | | | | | |
| MW-25 | 0.2 U | 0.2 U | **0.48** | **0.8** | **0.79** | **1.4** | 0.2 U | **5.8** | **0.6** | **0.6** |
| MW-26 | **0.31** | **0.42** | **0.2** | **0.43** | 0.02 U | **0.053** | 0.2 U | 0.2 U | **0.7** | **0.9** |
| MW-27 | 0.2 U | 0.2 U | 0.2 U | **0.41** | 0.11 | **0.31** | 0.2 U | 0.2 U | **14** [4] | **27** [4] |
| MW-31[1] | 0.2 U | 0.2 U | **3.9** | **6.3** | **4.3** | **9.0** | NS | NS | NS | NS |
| MW-32[3] | 0.2 U | 0.2 U | **1.5** | **2.0** | 0.2 | **0.36** | NS | NS | NS | NS |
| MW-33[3] | 0.2 U | 0.2 U | 0.2 U | **0.7** | **0.3** | **1.1** | NS | NS | NS | NS |
| **Downgradient Wells, B-Zone** | | | | | | | | | | |
| MW-08 | 0.2 U | 0.2 U | 0.2 U | **0.3** | **0.063** | **0.15** | 0.2 U | 0.2 U | **0.6** | **0.6** |
| MW-10 | 0.2 U | 0.2 U | **1.1** | **1.9** | **0.26** | **1.2** | 0.2 U | 0.2 U | **0.3** | **0.3** |
| MW-18[3] | 0.02 U | 0.2 U | 0.2 U | **0.044** | 0.02 U | **0.075** | 0.2 U | 0.2 U | **0.2** | **0.3** |
| MW-24 | 0.2 U | 0.2 U | 0.2 U | 0.2 U | 0.02 U | **0.051** | 0.2 U | 0.2 U | **0.3** | **0.3** |

Notes:

**BOLD RED** Detected at concentration greater than detection limit.

**BOLD SHADED** Exceeds CUL.

1 MW-30 is located in a discontinous zone of perched groundwater that is not hydraulically connected to the landfill. MW-31 while downgradient is not a CPOC well because it is impacted by an additional source of contamination.

2 Contamination in KMW-05 is from a known source upgradient of the Landfill; the other arsenic exceedances in upgradient wells have no known source and may simply represent background conditions in the area.

3 MW-18 is completed in refuse along the downgradient edge of the Landfill; MW-32 and MW-33 are completed beneath refuse along the downgradient edge.

4 Arsenic exceedances in MW-27 are unrelated to the landfill; refer to text for discussion.

Abbreviations:

CUL Cleanup Level
MTCA Model Toxics Control Act
µg/L Micrograms per liter
NS Not sampled

Qualifer:

U Not detected

## Table 5.7
## Ranges of Groundwater Quality Parameters and Dissolved Iron and Manganese in Groundwater from January 2011 through March 2014

| Monitoring Well | Dissolved Oxygen (mg/L) | | ORP (mV) | | pH | | Specific Conductance (µS/cm) | | Total Iron (mg/L) Criteria = 27(A) or 31(B)[1] | | Total Manganese (mg/L) 90/90 UTL = 2.1(A) or 1.1(B)[2] | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Minimum | Maximum | Minimum | Maximum | Minimum | Maximum | Minimum | Maximum | Minimum | Maximum | Minimum | Maximum |
| **Upgradient and Cross Gradient Wells** | | | | | | | | | | | | |
| KMW-05 | **0.6** | **1.1** | **-560** | **-540** | **13** | **13** | **32,000** | **32,000** | **5.7** | **6.9** | **0.01 U** | **0.02** |
| KMW-07 | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | **0.26** | **0.26** |
| KMW-08 | **0.95** | **1.4** | **66** | **110** | **6.7** | **6.7** | **400** | **400** | **0.15** | **0.31** | **0.17** | **0.36** |
| MW-01 | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | **0.49** | **0.49** |
| MW-03 | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | **0.0071** | **0.0071** |
| MW-04 | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | **0.009** | **0.009** |
| MW-12 | **2.1** | **2.3** | **-18** | **-14** | **6.7** | **6.7** | **380** | **440** | **11** | **18** | **0.5** | **0.77** |
| MW-14 | **1.7** | **2.4** | **-67** | **-50** | **6.7** | **6.8** | **500** | **600** | **4.6** | **5.8** | **0.37** | **0.67** |
| MW-29 | **2.2** | **2.3** | **-40** | **-29** | **6.4** | **6.5** | **1,100** | **1,200** | **17** | **27** | **1.1** | **2.1** |
| MW-30* | **1.3** | **3.2** | **2.6** | **6** | **6.5** | **6.5** | **490** | **520** | **2.3** | **4.5** | **0.08** | **0.11** |
| **Interior Wells** | | | | | | | | | | | | |
| KMW-01A | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | **1.6** | **1.6** |
| KMW-03A | **0.72** | **1.5** | **-230** | **-220** | **7.6** | **7.7** | **720** | **820** | **10** | **11** | **0.04** | **0.06** |
| KMW-04 | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | **0.069** | **0.069** |
| KMW-06 | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | **0.03** | **0.03** |
| **Downgradient Wells, A-Zone** | | | | | | | | | | | | |
| MW-25 | **1.2** | **2.3** | **-58** | **-54** | **6.6** | **6.8** | **290** | **400** | **7.3** | **32** | **0.53** | **3.1** |
| MW-26 | **1.7** | **2.1** | **-13** | **10** | **6.2** | **6.3** | **150** | **190** | **7.1** | **14** | **0.14** | **0.17** |
| MW-27 | **2.0** | **2.2** | **-94** | **-87** | **6.8** | **6.8** | **280** | **320** | **4** | **22** | **0.18** | **0.58** |
| MW-31* | **2.1** | **2.3** | **-50** | **-47** | **6.6** | **6.6** | **290** | **390** | **8.3** | **18** | **0.26** | **0.51** |
| MW-32** | **1.1** | **3.3** | **-98** | **-89** | **6.7** | **6.8** | **1,300** | **1,300** | **23** | **29** | **2.2** | **2.9** |
| MW-33** | **2.5** | **3.0** | **-100** | **-95** | **6.7** | **6.8** | **1,500** | **1,600** | **18** | **20** | **1.8** | **2.0** |
| **Downgradient Wells, B-Zone** | | | | | | | | | | | | |
| MW-08 | **2.2** | **2.3** | **-99** | **-87** | **6.8** | **6.8** | **1,100** | **1,300** | **18** | **21** | **1** | **1.2** |
| MW-10 | **1.7** | **1.9** | **-110** | **-92** | **6.7** | **6.8** | **720** | **780** | **18** | **42** | **1.1** | **3.3** |
| MW-18** | **2.5** | **3.0** | **-100** | **-76** | **6.6** | **6.6** | **1,100** | **1,200** | **33** | **60** | **0.66** | **1.8** |
| MW-24 | **2.5** | **2.7** | **-87** | **-43** | **6.7** | **6.7** | **770** | **910** | **14** | **30** | **1.1** | **1.8** |

Notes:

**BOLD RED** Exceeds background-based criteria.

* MW-30 is located in a discontinous zone of perched groundwater that is not hydraulically connected to the Landfill. MW-31, while downgradient, is not a CPOC well because it is impacted by an additional source of contamination.

** MW-18 is completed in refuse along the downgradient edge of the Landfill; MW-32 and MW-33 are completed beneath refuse along the downgradient edge.

1 90/90 UTL is the upper 90 percent confidence level (UCL) on the 90th percentile of the upgradient wells from 2011 through 2014 of the distribution. The 90/90 UTL is calculated using upgradient wells MW-12, MW-14, and MW-29 from 2011 to present.

2 For the B-zone background concentrations, data from other MTCA sites within the valley were used to estimate a background concentration (the B-zone does not exist upgradient of the landfill). If more and/or better data become available in the future, the B-zone background estimate may be updated.

Abbreviations:

CPOC Chemical of potential concern
CUL Cleanup Level
µg/L Micrograms per liter
µS/cm Microsimiens per centimeter
MTCA Model Toxics Control Act
NS Not sampled

## Table 5.8
## Comparison of Common Water Quality Measures

| | pH | | | | Specific Conductance (µS/cm) | | | |
|---|---|---|---|---|---|---|---|---|
| | Avg | Max | Min | Count | Avg | Max | Min | Count |
| **Upgradient Wells[1] (not KMW-05)** | 6.6 | 6.8 | 6.4 | 6 | 703 | 1,200 | 380 | 6 |
| **Leachate (KMW-03A only)[2]** | 7.6 | 7.7 | 7.6 | 2 | 770 | 820 | 720 | 2 |
| **Downgradient, A-Zone Wells[3]** | 6.7 | 6.8 | 6.2 | 10 | 733 | 1,600 | 150 | 10 |

| | Alkalinity (mg/L as $CaCO_3$) | | | | Chloride (mg/L) | | | |
|---|---|---|---|---|---|---|---|---|
| | Avg | Max | Min | Count | Avg | Max | Min | Count |
| **Upgradient Wells[1] (not KMW-05)** | 240 | 390 | 150 | 9 | 20 | 37 | 13 | 9 |
| **Leachate (KMW-03A only)[2]** | 367 | 380 | 350 | 3 | 14 | 15 | 13 | 3 |
| **Downgradient, A-Zone Wells[3]** | 292 | 680 | 34 | 22 | 27 | 89 | 6.1 | 18 |

| | Dissolved Iron (mg/L) | | | | Dissolved Manganese (mg/L) | | | |
|---|---|---|---|---|---|---|---|---|
| | Avg | Max | Min | Count | Avg | Max | Min | Count |
| **Upgradient Wells[1] (not KMW-05)** | 11 | 26 | 4 | 9 | 0.8 | 2.0 | 0.0046 | 14 |
| **Leachate[2]** | 10 | 11 | 10 | 3 | 0.27 | 1.6 | 0.03 | 7 |
| **Downgradient, A-Zone Wells[3]** | 14 | 29 | 1.7 | 22 | 1.2 | 3.1 | 0.13 | 22 |

Notes:

1 Upgradient wells include: MW-01, MW-03, MW-12, MW-14, and MW-29.

2 Wells that represent leachate include: KMW-01A, KMW-03A, KMW-04, and KMW-06. However, common water quality measures including pH, specific conductance, alkalinity, and chloride were only collected in KMW-03A.

3 Downgradient, A-Zone wells include: MW-25, MW-26, MW-17, MW-32, and MW-33.

Abbreviations:

$CaCO_3$ Calcium carbonate
µS/cm Microsiemens per centimeter
mg/L Milligrams per liter

# Table 6.1
# Historical Subsurface Landfill Gas Measurements
# South Park Landfill 1995 through 2004

## Two investigations exist from the time period between 1995 and 2005:

**1995 Blasland, Bouck, and Lee, Inc. (BBL) Investigation**

The first was limited to the KIP Parcel and used temporary gas probes to take one-time measurements of LFG in the surface (BBL 1995); boring logs are included in Appendix B; locations are shown on Figure 6.1.

| Probe Name | Date | Methane (% vol) |
|---|---|---|
| BH-1 | 10/19/1995 | ND |
| BH-2 | 10/19/1995 | 36 |
| BH-3 | 10/19/1995 | ND |
| BH-4 | 10/19/1995 | 1.2 |
| BH-5 (HP-5) | 10/17/1995 | 5.8 |
| BH-6 | 10/16/1995 | 18 |
| BH-7 | 10/19/1995 | 0.06 |
| BH-8 | 10/19/1995 | 2.2 |
| BH-9 (HP-6) | 10/18/1995 | 9.8 |
| BH-10 | Not installed | NA |
| BH-11 | 10/19/1995 | 27 |
| BH-12 | 10/19/1995 | 3.9 |
| BH-13 | 10/19/1995 | 1.7 |
| BH-14 (HP-1) | 10/18/1995 | 7.6 |
| BH-15 | 10/19/1995 | 8.1 |
| BH-16 (HP-2) | 10/18/1995 | 0.5 |
| BH-17 | 10/18/1995 | 74 |
| BH-18 | 10/18/1995 | 0.24 |
| BH-19 (HP-3) | 10/17/1995 | 6.2 |
| BH-20 | 10/19/1995 | ND |
| BH-21 | 10/18/1995 | ND |
| BH-22 | 10/19/1995 | ND |
| BH-23 | 10/19/1995 | ND |
| BH-24 | 10/18/1995 | 8.7 |
| BH-25 | 10/19/1995 | 11 |
| BH-26 (HP-4) | 10/17/1995 | 13 |
| BH-27 | 10/19/1995 | 13 |

**1997–2004 Farallon Investigation**

The second installed 16 LFG probes around the perimeter of the South Park Landfill and sampled them regularly for more than 5 years beginning in 1997 (AESI 2004); boring logs are included in Appendix B; locations are shown in Figure 6.1; full data are listed in RI/FS Work Plan (Farallon 2010a).

| Methane Concentrations Between 1997–2004 | | | | | |
|---|---|---|---|---|---|
| Well | Max % | Min % | Mean % | Median % | Count |
| GP-01 | 13 | 0.0 | 1.8 | 0.6 | 83 |
| GP-02 | 25 | 0.0 | 7.6 | 6.9 | 80 |
| GP-03 | 5 | 0.0 | 0.26 | 0.0 | 65 |
| GP-05 | 0.2 | 0.0 | 0.02 | 0.0 | 55 |
| GP-07 | 0.2 | 0.0 | 0.02 | 0.0 | 63 |
| GP-09 | 1 | 0.0 | 0.04 | 0.0 | 64 |
| GP-11 | 0.3 | 0.0 | 0.03 | 0.0 | 49 |
| GP-13 | 0.3 | 0.0 | 0.04 | 0.0 | 42 |
| GP-15 | 0.2 | 0.0 | 0.03 | 0.0 | 31 |
| GP-16 | 2 | 0.0 | 0.16 | 0.0 | 53 |
| GP-17 | 43 | 0.0 | 5.7 | 5.0 | 53 |
| GP-19 | 10 | 0.2 | 4.3 | 4.0 | 53 |
| GP-20 | 10.1 | 1.00 | 3.6 | 3.2 | 52 |
| GP-21 | 22.8 | 0.0 | 16.8 | 17 | 52 |
| GP-22 | 15 | 2.8 | 8.2 | 8.3 | 52 |
| GP-23 | 0.2 | 0.0 | 0.02 | 0.0 | 44 |

Abbreviations:

KIP Kenyon Industrial Park
LFG Landfill gas
NA Not applicable
ND Non-detect
RI/FS Remedial Investigation/Feasibility Study

**Table 6.2**
**Remedial Investigation Landfill Gas Monitoring Results 2011, 2015, and 2016**

| Sampling Stations | Date | Barometric Pressure (inches Hg) | Well Head Pressure (inches $H_2O$) | Methane (percent volume) | Carbon Dioxide (percent volume) | Oxygen (percent volume) | Volatiles by PID Final Reading (ppmv) | Volatiles by PID Maximum Reading (ppmv) |
|---|---|---|---|---|---|---|---|---|
| **Interior LFG Monitoring Probes** | | | | | | | | |
| GP-01 | 2/9/2011 | 30.46 | 0.10 | 11 | 22 | 0.0 | 1.4 | 1.4 |
| GP-02 | 2/9/2011 | 30.44 | -0.04 | 21 | 16 | 0.0 | 0.7 | 0.7 |
| GP-16 | 2/8/2011 | 30.29 | 0.00 | 0.0 | 19 | 19.0 | 7.3 | 7.7 |
| GP-16 | 5/25/2011 | 29.69 | -0.06 | 0.0 | 0.1 | 20.2 | 0.0 | 0.0 |
| GP-16 | 6/27/2011 | 29.68 | 0.12 | 0.0 | 20 | 0.8 | 1.0 | 1.4 |
| GP-16 | 9/23/2011 | 29.91 | 0.25 | 0.0 | 18 | 2.9 | 0.0 | 0.0 |
| GP-16 | 11/17/2011 | 29.61 | -0.29 | 0.0 | 21 | 0.0 | 3.6 | 4.1 |
| GP-16 | 12/28/2011 | 29.96 | -0.18 | 0.0 | 20 | 0.0 | -- | -- |
| GP-16 | 03/18/16 | 29.91 | NM | 0.0 | 0.1 | 21.2 | -- | -- |
| GP-17 | 2/8/2011 | 30.29 | 0.00 | 10 | 19 | 0.0 | 7.9 | 7.9 |
| GP-17 | 5/25/2011 | 29.70 | -0.06 | 5.8 | 19 | 0.0 | 0.0 | 0.0 |
| GP-17 | 6/27/2011 | 29.67 | 0.11 | 8.3 | 18 | 0.0 | 0.0 | 0.7 |
| GP-17 | 9/23/2011 | 29.97 | 0.31 | 1.0 | 19 | 0.0 | 0.1 | 0.1 |
| GP-17 | 11/17/2011 | 29.56 | -0.30 | 2.1 | 23 | 0.0 | NM | NM |
| GP-17 | 12/28/2011 | 29.96 | -0.18 | 7.4 | 21 | 0.0 | NM | NM |
| GP-17 | 03/18/16 | 29.91 | NM | 28 | 26 | 0.0 | NM | NM |
| GP-19 | 2/8/2011 | 30.37 | -0.02 | 1.9 | 14 | 0.0 | 8.4 | 8.4 |
| GP-19 | 03/18/16 | 29.86 | NM | 4.2 | 14 | 0.0 | NM | NM |
| GP-20 | 2/9/2011 | 30.45 | -0.06 | 3.3 | 8.9 | 0.0 | 2.1 | 2.2 |
| GP-20 | 03/18/16 | 29.91 | 0.22 | 5.1 | 9.9 | 0.0 | NM | NM |
| GP-21 | 2/9/2011 | 30.44 | -0.07 | 20 | 18 | 0.0 | 7.1 | 7.2 |
| GP-22 | 2/9/2011 | 30.44 | 0.01 | 7.1 | 11 | 0.0 | 10.7 | 10.7 |
| GP-22 | 03/18/16 | 29.84 | NM | 19 | 11 | 0.0 | NM | NM |
| GP-33 | 03/18/16 | NM | NM | 18 | 5.5 | 0.0 | NM | NM |
| GP-35 | 03/18/16 | 29.91 | NM | 11 | 4.1 | 0.0 | NM | NM |
| GP-36 | 03/18/16 | 29.86 | 0.015 | 0.0 | 0.0 | 19.9 | NM | NM |
| **Interior Piezometers Screened Across the Unsaturated Zone (SRDS Parcel)** | | | | | | | | |
| N Piezo | 5/12/2011 | 30.09 | 0.02 | 0.0 | 0.1 | 20.3 | 0.5 | 0.6 |
| N Piezo | 5/26/2011 | 29.88 | -0.04 | 0.0 | 0.1 | 20.4 | 0.0 | 0.2 |
| S Piezo | 5/11/2011 | 29.76 | 0.00 | **21** | 5.5 | 10.3 | 0.0 | 0.0 |
| **Interior Groundwater Monitoring Wells Screened Across the Unsaturated Zone (KIP)** | | | | | | | | |
| KMW-01A | 10/15/2015 | 30.00 | NM | 13 | 7.2 | 0.1 | NM | NM |
| KMW-03A | 10/15/2015 | 30.00 | NM | 7.5 | 0.8 | 0.1 | NM | NM |
| KMW-04 | 5/12/2011 | 30.11 | 0.06 | 0.0 | 0.1 | 20.2 | 0.0 | 0.2 |
| KMW-04 | 5/26/2011 | 29.88 | -0.06 | 0.0 | 0.1 | 20.3 | 0.0 | 0.0 |
| KMW-04 | 10/15/2015 | 30.00 | NM | 5.2 | 1.6 | 0.0 | NM | NM |
| **Perimeter LFG Monitoring Probes (and Barehole Measurements in Area Prone to Flooding)** | | | | | | | | |
| GP-03 | 2/9/2011 | 30.41 | 0.00 | 0.2 | 5.8 | 9.5 | 2.3 | 2.5 |
| GP-03 | 5/25/2011 | 29.69 | -0.01 | 0.1 | 3.5 | 14.9 | 1.0 | 1.2 |
| GP-03 | 9/23/2011 | 29.86 | 0.14 | 0.0 | 11.0 | 6.4 | 0.0 | 0.0 |
| GP-03 | 12/28/2011 | 29.66 | -0.20 | 0.0 | 1.0 | 2.2 | NM | NM |
| GP-03 | 03/18/16 | 29.91 | 0.0 | 0.0 | 3.4 | 14.2 | NM | NM |
| GP-05 | 2/9/2011 | 30.41 | -0.05 | 0.2 | 8.6 | 0.0 | 2.9 | 7.9 |
| GP-05 | 5/25/2011 | 29.69 | -0.08 | 0.1 | 4.0 | 11.5 | 4.4 | 8.7 |
| GP-05 | 6/27/2011 | 29.65 | 0.10 | 0.0 | 9.2 | 1.4 | 1.8 | 2.3 |
| GP-05 | 9/23/2011 | 29.98 | 0.27 | 0.0 | 11.9 | 3.6 | 0.0 | 0.0 |
| GP-05 | 11/17/2011 | 29.55 | -0.28 | 0.0 | 13.9 | 0.4 | NM | NM |
| GP-05 | 12/28/2011 | 29.51 | -0.18 | 0.0 | 11.8 | 0.0 | NM | NM |
| GP-07 | 2/9/2011 | 30.42 | 0.00 | 0.2 | 1.3 | 18.3 | 2.5 | 4.1 |
| GP-07 | 5/25/2011 | 29.70 | -0.08 | 0.1 | 1.4 | 18.5 | 2.8 | 19.5 |
| GP-07 | 9/23/2011 | 29.86 | 0.09 | 0.0 | 3.2 | 17.0 | 0.1 | 0.2 |
| GP-07 | 12/28/2011 | 29.74 | -0.18 | 0.0 | 3.1 | 16.3 | NM | NM |
| GP-07 | 03/18/16 | 29.84 | NM | 0.0 | 0.3 | 20.4 | NM | NM |
| GP-09 | 2/7/2011 | 30.11 | 0.00 | 0.0 | 5.0 | 14.2 | 0.1 | 0.8 |
| GP-09 | 5/25/2011 | 29.72 | -0.04 | 0.0 | 2.0 | 18.1 | 0.0 | 0.0 |
| GP-09 | 9/23/2011 | 29.91 | 0.22 | 0.0 | 3.1 | 17.4 | 0.0 | 0.0 |
| GP-09 | 12/28/2011 | 29.76 | -0.17 | 0.0 | 3.9 | 15.2 | 1.1 | 1.6 |
| GP-09 | 03/18/16 | 29.84 | 0.00 | 0.0 | 4.0 | 15.0 | NM | NM |
| GP-11 | 2/8/2011 | 30.34 | -0.01 | 0.0 | 3.8 | 10.5 | 1.6 | 1.6 |
| GP-11 | 5/25/2011 | 29.68 | -0.08 | 0.1 | 0.1 | 20.0 | 0.0 | 0.0 |
| GP-11 | 9/23/2011 | 29.88 | 0.17 | 0.0 | 4.9 | 9.3 | 9.7 | 10.2 |
| GP-11 | 12/28/2011 | 29.70 | -0.18 | 0.0 | 4.7 | 4.9 | NM | NM |
| GP-11 | 03/18/16 | 29.89 | FWS | FWS | FWS | FWS | NM | NM |
| GP-13 | 03/18/16 | 29.91 | FWS | FWS | FWS | FWS | NM | NM |
| GP-15 | 9/23/2011 | 29.99 | 0.28 | 0.0 | 11.8 | 7.7 | 16.0 | 16.0 |
| GP-15 | 11/17/2011 | 29.61 | **3.35** | 0.0 | 0.2 | 19.4 | 0.9 | 1.3 |
| GP-15 | 03/18/16 | 29.91 | FWS | FWS | FWS | FWS | NM | NM |

**Table 6.2**
**Remedial Investigation Landfill Gas Monitoring Results 2011, 2015, and 2016**

| Sampling Stations | Date | Barometric Pressure (inches Hg) | Well Head Pressure (inches $H_2O$) | Methane (percent volume) | Carbon Dioxide (percent volume) | Oxygen (percent volume) | Volatiles by PID Final Reading (ppmv) | Volatiles by PID Maximum Reading (ppmv) |
|---|---|---|---|---|---|---|---|---|
| **Perimeter LFG Monitoring Probes (and Barehole Measurements in Area Prone to Flooding) (Cont.)** | | | | | | | | |
| GP-23 | 2/8/2011 | 30.36 | 0.01 | 0.0 | 1.1 | 19.7 | 0.0 | 0.5 |
| GP-23 | 5/25/2011 | 29.71 | -0.08 | 0.1 | 0.4 | 19.8 | 20.2 | 39.2 |
| GP-23 | 9/23/2011 | 29.86 | -0.23 | 0.0 | 4.6 | 15.7 | 0.0 | 0.7 |
| GP-23 | 12/28/2011 | 29.75 | -0.18 | 0.0 | 5.0 | 6.9 | NM | NM |
| GP-23 | 03/18/16 | FWS | FWS | FWS | FWS | FWS | NM | NM |
| GP-26 | 3/8/2011 | 29.86 | 0.14 | 0.0 | 0.8 | 18.8 | 0.0 | 0.0 |
| GP-26 | 3/10/2011 | 29.53 | 0.05 | 0.0 | 1.7 | 18.4 | 0.0 | 0.0 |
| GP-26 | 5/25/2011 | 29.71 | -0.10 | 0.1 | 1.5 | 18.7 | 18.5 | 34.8 |
| GP-26 | 6/27/2011 | 29.66 | 0.12 | 0.0 | 3.1 | 16.6 | 2.4 | 3.1 |
| GP-26 | 9/23/2011 | 30.02 | 0.24 | 0.0 | 2.4 | 17.6 | 0.0 | 0.0 |
| GP-26 | 11/17/2011 | 29.67 | -0.28 | 0.0 | 2.6 | 17.5 | 5.7 | 7.1 |
| GP-26 | 12/28/2011 | 29.76 | -0.48 | 0.0 | 2.9 | 16.4 | NM | NM |
| GP-27 | 2/7/2011 | 30.09 | -0.01 | **6.1** | 7.8 | 0.9 | 0.5 | 0.6 |
| GP-27 | 2/17/2011 | 29.73 | 0.13 | 2.9 | 4.7 | 9.1 | 0.0 | 0.0 |
| GP-27 | 2/21/2011 | 29.90 | 0.10 | 3.1 | 4.8 | 9.1 | 0.0 | 0.0 |
| GP-27 | 5/11/2011 | 29.73 | 0.05 | **6.5** | 8.3 | 0.1 | 0.0 | 0.0 |
| GP-27 | 5/25/2011 | 29.68 | -0.08 | 2.6 | 4.0 | 11.1 | 0.3 | 1.4 |
| GP-27 | 6/27/2011 | 29.69 | 0.12 | **6.3** | 8.9 | 0.0 | 1.9 | 1.9 |
| GP-27 | 9/23/2011 | 29.98 | 0.10 | 4.3 | 11.4 | 0.0 | 0.0 | 0.0 |
| GP-27 | 11/17/2011 | 29.76 | -0.17 | 3.3 | 8.4 | 5.2 | 0.3 | 0.4 |
| GP-27 | 12/28/2011 | 29.92 | 0.00 | 6.0 | 11.9 | 0.0 | NM | NM |
| GP-27 | 03/18/16 | 30.01 | NM | 0.4 | 9.8 | 0.0 | NM | NM |
| GP-28 | 2/7/2011 | 30.11 | 0.01 | 0.0 | 3.1 | 8.1 | 0.3 | 1.2 |
| GP-28 | 2/21/2011 | 29.89 | 0.10 | 0.0 | 2.0 | 15.3 | 0.0 | 0.0 |
| GP-28 | 5/11/2011 | 29.73 | 0.05 | 0.5 | 5.4 | 0.4 | 0.0 | 0.0 |
| GP-28 | 5/25/2011 | 29.70 | -0.05 | 0.6 | 3.1 | 11.7 | 0.0 | 0.0 |
| GP-28 | 6/27/2011 | 29.70 | 0.06 | 2.8 | 7.7 | 0.0 | 0.0 | 0.0 |
| GP-28 | 9/23/2011 | 29.99 | 0.06 | 0.2 | 8.9 | 2.8 | 0.0 | 3.5 |
| GP-28 | 11/17/2011 | 29.73 | -0.19 | 0.1 | 8.9 | 4.2 | 0.0 | 0.1 |
| GP-28 | 12/28/2011 | 29.94 | -0.01 | 0.0 | 6.2 | 4.9 | NM | NM |
| GP-28 | 03/18/16 | 30.01 | NM | 0.0 | 2 | 12.7 | NM | NM |
| GP-29 | 2/7/2011 | 30.10 | 0.06 | **7.1** | 12.5 | 0.0 | 1.6 | 1.6 |
| GP-29 | 2/21/2011 | 29.89 | 0.09 | 3.6 | 6.9 | 9.0 | 0.0 | 0.0 |
| GP-29 | 5/11/2011 | 29.73 | -0.03 | **6.9** | 12.2 | 0.3 | 0.0 | 0.0 |
| GP-29 | 5/25/2011 | 29.70 | -0.06 | 2.4 | 4.1 | 12.6 | 0.0 | 0.0 |
| GP-29 | 6/27/2011 | 29.68 | 0.11 | **8.5** | 13.1 | 0.0 | 0.1 | 1.8 |
| GP-29 | 9/23/2011 | 29.99 | 0.03 | **7.2** | 14.2 | 0.0 | NM | NM |
| GP-29 | 11/17/2011 | 29.73 | -0.22 | **7.1** | 12.2 | 3.7 | 0.5 | 0.5 |
| GP-29 | 12/28/2011 | 29.95 | -0.11 | **8.1** | 15.1 | 0.0 | NM | NM |
| GP-29 | 03/18/16 | 29.63 | 0.00 | 1.3 | 10.6 | 0.0 | NM | NM |
| GP-30 | 5/11/2011 | 29.74 | 0.02 | 0.0 | 0.1 | 20.2 | 0.0 | 0.0 |
| BH-30 | 3/10/2011 | 29.54 | -0.03 | 0.0 | 0.7 | 15.2 | 0.0 | 0.0 |
| BH-30 | 5/25/2011 | 29.68 | -0.04 | 0.0 | 0.2 | 19.8 | 0.0 | 0.0 |
| BH-30 | 6/28/2011 | 29.61 | 0.05 | 0.0 | 1.6 | 18.5 | 0.4 | 0.6 |
| BH-30 | 9/23/2011 | 29.93 | 0.27 | 0.0 | 0.8 | 19.1 | 0.0 | 0.0 |
| BH-30 | 12/28/2011 | 29.59 | -0.21 | 0.0 | 1.5 | 17.7 | NM | NM |
| GP-31 | 5/11/2011 | 29.75 | 0.02 | 0.0 | 0.1 | 19.9 | 0.1 | 0.1 |
| GP-31 | 5/25/2011 | 29.72 | -0.05 | 0.0 | 0.1 | 20.3 | 0.0 | 0.0 |
| GP-31 | 6/27/2011 | 29.72 | 0.08 | 0.0 | 9.6 | 6.6 | 0.0 | 0.0 |
| GP-31 | 9/23/2011 | 29.97 | 0.05 | 0.0 | 14.7 | 4.4 | NM | NM |
| GP-31 | 11/17/2011 | 29.61 | -0.42 | 0.0 | 10.4 | 7.5 | 4.9 | 6.0 |
| GP-31 | 12/28/2011 | 29.56 | -0.22 | 0.0 | 8.0 | 3.7 | NM | NM |
| GP-31 | 03/18/16 | 30.02 | NM | 0.0 | 0.5 | 20.9 | NM | NM |
| GP-32 | 03/18/16 | NM | FWS | FWS | FWS | FWS | NM | NM |
| BH-32 | 3/10/2011 | 29.54 | 0.00 | 0.0 | 1.4 | 17.5 | 0.0 | 0.0 |
| BH-32 | 5/25/2011 | 29.70 | -0.08 | 0.1 | 0.3 | 19.9 | 0.0 | 0.0 |
| BH-32 | 5/25/2011 | 29.70 | -0.08 | 0.1 | 0.3 | 19.9 | 0.0 | 0.0 |
| BH-32 | 6/28/2011 | 29.63 | 0.03 | 0.0 | 5.9 | 13.7 | 0.3 | 0.5 |
| BH-32 | 9/23/2011 | 29.99 | 0.31 | 0.0 | 3.4 | 16.7 | 0.0 | 0.0 |
| BH-32 | 11/17/2011 | 29.62 | -0.29 | 0.0 | 1.2 | 18.8 | 1.3 | 1.6 |
| BH-32 | 12/28/2011 | 29.64 | -0.20 | 0.0 | 4.2 | 15.3 | NM | NM |
| GP-37 | 10/15/2015 | 30.00 | NM | 0.4 | 14 | 1.2 | NM | NM |
| GP-37 | 03/18/16 | 30.03 | NM | 0.0 | 12.3 | 4.6 | NM | NM |
| GP-38 | 10/15/2015 | 30.00 | NM | 0.5 | 16 | 1.5 | NM | NM |
| GP-38 | 03/18/16 | 30.03 | NM | 0.0 | 10.7 | 2.0 | NM | NM |

**Table 6.2**
**Remedial Investigation Landfill Gas Monitoring Results 2011, 2015, and 2016**

| Sampling Stations | Date | Barometric Pressure (inches Hg) | Well Head Pressure (inches $H_2O$) | Methane (percent volume) | Carbon Dioxide (percent volume) | Oxygen (percent volume) | Volatiles by PID Final Reading (ppmv) | Volatiles by PID Maximum Reading (ppmv) |
|---|---|---|---|---|---|---|---|---|
| **Perimeter LFG Monitoring Probes Located within the Historical KIP Swale** | | | | | | | | |
| GP-24 | 2/7/2011 | 30.12 | NM | **15** | 0.0 | 6.1 | 3.7 | 3.7 |
| GP-24 | 2/9/2011 | 30.45 | 0.00 | **14** | 0.0 | 5.4 | 2.0 | 3.1 |
| GP-24 | 2/18/2011 | 29.81 | 0.14 | 4.6 | 0.0 | 17.4 | 0.0 | 0.0 |
| GP-24 | 2/21/2011 | 29.93 | 0.11 | 4.7 | 0.0 | 16.1 | 0.0 | 0.0 |
| GP-24 | 5/25/2011 | 29.71 | 0.02 | **8.5** | 0.0 | 15.1 | 0.0 | 0.0 |
| GP-24 | 6/27/2011 | 29.65 | 0.13 | **35** | 0.0 | 0.0 | 0.2 | 0.2 |
| GP-24 | 9/23/2011 | 29.97 | 0.02 | **48** | 0.0 | 0.0 | 0.0 | 0.0 |
| GP-24 | 11/17/2011 | 29.72 | -0.02 | **29** | 0.1 | 5.5 | 1.0 | 1.0 |
| GP-24 | 12/28/2011 | 29.78 | -0.15 | **19** | 0.0 | 4.2 | 0.0 | 0.0 |
| GP-24 | 10/15/2015 | 30.00 | NM | **53** | 0.0 | 0.1 | NM | NM |
| GP-24 | 03/18/16 | 29.87 | 0.00 | 0.0 | 0.0 | 20.6 | NM | NM |
| GP-25 | 2/7/2011 | 30.11 | NA | **62** | 0.1 | 0.0 | 1.0 | 2.2 |
| GP-25 | 2/9/2011 | 30.43 | -0.03 | **56** | 0.1 | 0.4 | 0.7 | 1.9 |
| GP-25 | 2/18/2011 | 29.77 | -3.22 | **30** | 0.0 | 9.7 | 0.0 | 0.0 |
| GP-25 | 2/21/2011 | 29.93 | 0.07 | **33** | 0.1 | 9.0 | 0.0 | 0.0 |
| GP-25 | 5/11/2011 | 29.75 | 0.02 | **73** | 0.1 | 0.1 | 0.0 | 0.0 |
| GP-25 | 5/25/2011 | 29.71 | 0.00 | **26** | 0.1 | 12.4 | 0.0 | 0.0 |
| GP-25 | 6/27/2011 | 29.65 | 0.13 | **76** | 0.0 | 0.0 | 0.0 | 0.0 |
| GP-25 | 9/23/2011 | 29.95 | 0.02 | **85** | 0.1 | 0.0 | 0.0 | 0.0 |
| GP-25 | 11/17/2011 | 29.74 | -0.33 | **62** | 0.1 | 4.8 | 0.5 | 0.7 |
| GP-25 | 12/28/2011 | 29.76 | -0.13 | **51** | 0.1 | 2.0 | 6.9 | 19.5 |
| GP-25 | 10/15/2015 | 30.00 | NM | **61** | 0.1 | 3.8 | NM | NM |
| GP-25 | 03/18/16 | 29.87 | NM | **43** | 0.0 | 5.4 | NM | NM |
| **Groundwater Monitoring Wells with Screens Intersecting the Vadose Zone within the Historical KIP Swale** | | | | | | | | |
| KMW-05 | 5/11/2011 | 29.84 | 0.00 | **50** | 0.0 | 2.0 | 0.0 | 1.0 |
| KMW-05 | 10/15/2015 | 30 | NM | **47** | 0.0 | 5.0 | NM | NM |
| KMW-06 | 11/17/2011 | 29.66 | -0.24 | **12** | 1.7 | 0.0 | 13.6 | 13.6 |
| KMW-06 | 10/15/2015 | 30 | NM | 2.1 | 4.7 | 0.2 | 0 | -- |
| **Groundwater Monitoring Wells with Screens Intersecting the Vadose Zone West of the Historical KIP Swale** | | | | | | | | |
| KMW-07 | 11/17/2011 | 29.69 | -0.26 | 0.0 | 5.4 | 12.0 | 24.7 | 24.7 |
| KMW-07 | 10/15/2015 | 30.1 | NM | 0.0 | 0.1 | 21 | NM | NM |
| KMW-08 | 11/17/2011 | 29.71 | -0.26 | 0.2 | 0.1 | 8.3 | 0.3 | 0.4 |
| KMW-08 | 10/15/2015 | 30.1 | NM | 0.0 | 0.0 | 8.4 | NM | NM |

Notes:
-- Not recorded.
\# Highlighted results are greater than 5% by volume methane.
1 Probes GP-13, GP-15, GP-30, GP-31, and GP-32 were in low-lying areas and were prone to flooding of the well screens.

Abbreviations:
FWS The well screen of the probe was flooded; therefore, it could not be measured.
$H_2O$ Water
Hg Mercury
KIP Kenyon Industrial Park
LEL Lower explosion level
LFG Landfill gas
NM Not measured
PID Photoionization detector
ppmv Parts per million by volume
SRDS South Recycling and Disposal Station

# Table 6.3
# Summary of Remedial Investigation Subsurface Landfill Gas Measurements
# South Park Landfill between 2011 and 2016

| | Summary of Percent Methane by Probe | | | | |
|---|---|---|---|---|---|
| | Methane Concentrations (% by volume) between 2011 and 2016 | | | | |
| Well | Max % | Min % | Mean % | Median % | Count |
| GP-01 | 11 | 11 | NC | NC | 1 |
| GP-02 | 21 | 21 | NC | NC | 1 |
| GP-03 | 0.2 | 0.0 | 0.1 | 0.0 | 6 |
| GP-05 | 0.2 | 0.0 | 0.1 | 0.0 | 6 |
| GP-07 | 0.2 | 0.0 | 0.1 | 0.0 | 5 |
| GP-09 | 0.0 | 0.0 | 0.0 | 0.0 | 5 |
| GP-11 | 0.1 | 0.0 | 0.0 | 0.0 | 4 |
| GP-13 | 0.0 | 0.0 | NC | NC | 1 |
| GP-15 | 0.0 | 0.0 | 0.0 | 0.0 | 2 |
| GP-16 | 0.0 | 0.0 | 0.0 | 0.0 | 7 |
| GP-17 | 28 | 1 | 9.0 | 7.4 | 7 |
| GP-19 | 4.2 | 1.9 | 3.1 | 3.1 | 2 |
| GP-20 | 5.1 | 3.3 | 4.2 | 4.2 | 2 |
| GP-21 | 20 | 20 | NC | NC | 1 |
| GP-22 | 19 | 7 | 13 | 13 | 2 |
| GP-23 | 0.1 | 0 | 0.03 | 0.00 | 4 |
| GP-24 | 53 | 0 | 21 | 15 | 11 |
| GP-25 | 85 | 26 | 55 | 59 | 12 |
| GP-26 | 0.1 | 0 | 0.01 | 0.00 | 7 |
| GP-27 | 6.5 | 0.4 | 4.2 | 3.8 | 10 |
| GP-28 | 2.8 | 0 | 0.5 | 0.1 | 9 |
| GP-29 | 8.5 | 1.3 | 6.1 | 7.1 | 10 |
| GP-30/BH-30 | 0.0 | 0.0 | 0.0 | 0.0 | 6 |
| GP-31 | 0.0 | 0.0 | 0.0 | 0.0 | 7 |
| GP-32/BH-32 | 0.1 | 0.0 | 0.03 | 0.0 | 7 |
| GP-33 | 18 | 18 | NC | NC | 1 |
| GP-35 | 11 | 11 | NC | NC | 1 |
| GP-36 | 0.0 | 0.0 | NC | NC | 1 |
| GP-37 | 0.4 | 0.0 | 0.2 | 0.2 | 2 |
| GP-38 | 0.5 | 0.0 | 0.3 | 0.3 | 2 |

Note:

**Bold** Indicates a perimeter probe.

Abbreviations:

NC Not calculated because there was only one result

NM Not measured under scope of event

FWS The well screen of the probe was flooded; therefore, it could not be measured

**Table 6.4**
**Temporary Landfill Gas Probe Measurements for Historical Kenyon Industrial Park Swale Investigation**
**September 29 and October 13 and 14, 2015[1]**

| Location | Date | Time | Total Depth (ft bgs) | Water Level (ATD) (ft bgs) | Methane (% volume) in borehole | Bar Hole Probe Setting (ft bgs) | Methane (% volume) Bar Hole Test | CKD Thickness (ft) | Barometer (inches Hg) |
|---|---|---|---|---|---|---|---|---|---|
| TGP-1 | 9/29/2015 | 12:02 | 10 | None | 0.2 | 9.5 | 1.8 | None | 29.90 |
| TGP-2 | 9/29/2015 | 12:50 | 10 | None | 0.3 | 7.0 | 0.6 | 3.0 | 29.86 |
| TGP-3 | 9/29/2015 | 13:30 | 10 | None | 0.0 | 7.0 | 0.0 | 3.0 | 29.88 |
| TGP-4 | 9/29/2015 | 14:18 | 10 | None | 0.1 | 7.0 | 0.1 | None | 29.91 |
| TGP-5 | 9/29/2015 | 15:25 | 10 | None | 23 | 6.0 | 14 | None | 29.81 |
| TGP-6 | 9/29/2015 | 16:25 | 10 | 7.0 | 9.6 | 5.0 | 0.0 | 8.5 | 29.77 |
| TGP-7 | 10/13/2015 | 9:35 | 10 | None | 0.9 | 6.0 | 18 | None | 30.23 |
| TGP-8 | 10/13/2015 | 10:45 | 12 | 6.5 | 0.1 | 5.0 | 0.0 | 6.0 | 30.24 |
| TGP-9 | 10/13/2015 | 11:31 | 8 | 6.0 | 0.2 | 5.0 | 1.7 | 0.2 | 30.25 |
| TGP-10 | 10/13/2015 | 12:28 | 10 | 8.1 | 0.0 | 5.0 | 0.0 | None | 30.23 |
| TGP-11 | 10/13/2015 | 13:50 | 12 | 7.0 | 0.4 | 3.5 | 1.4 | 5.5 | 30.22 |
| TGP-12 | 10/13/2015 | 15:15 | 10 | None | 2.1 | 8.0 | 36 | 1.5 | 30.21 |
| TGP-13 | 10/13/2015 | 16:40 | 8 | 3.5 | 0.0 | 3.0 | 0.0 | 3.5 | 30.22 |
| TGP-14 | 10/14/2015 | 13:20 | 10 | 7.5 | 4.9 | 3.0 | 16 | 0.3 | 30.21 |
| TGP-15 | 10/14/2015 | 14:01 | 10 | 8.0 | 5.7 | 5.0 | 6.5 | None | 30.18 |
| TGP-16 | 10/14/2015 | 14:36 | 10 | 9.6 | 0.0 | 4.0 | 26 | 2.0 | 30.14 |
| TGP-17 | 10/14/2015 | 15:15 | 10 | 6.8 | 1.4 | 5.0 | 65 | 3.8 | 30.11 |
| TGP-18 | 10/14/2015 | 10:35 | 10 | None | 2.9 | 8.0 | 0.9 | None | 30.25 |
| TGP-19 | 10/14/2015 | 11:08 | 10 | None | 4.2 | 6.0 | 1.0 | 7.6 | 30.24 |
| TGP-20 | 10/14/2015 | 11:35 | 10 | 5.4 | 0.9 | 3.0 | 16 | 1.0 | 30.23 |
| TGP-21 | 10/14/2015 | 12:33 | 10 | 5.0 | 0.5 | 3.0 | 0.2 | 0.3 | 30.22 |
| TGP-22 | 10/14/2015 | 15:54 | 5 | 3.0 | 0.0 | 2.0 | 0.0 | 2.5 | 30.12 |
| TGP-23 | 10/14/2015 | 16:56 | 15 | 12.0 | 4.8 | 5.0 | 4.7 | None | 30.12 |
| TGP-24 | 10/14/2015 | 17:28 | 10 | None | 4.2 | 5.0 | 2.1 | None | 30.11 |
| TGP-25 | 10/14/2015 | 18:00 | 10 | None | 4.6 | 9.5 | 4.4 | None | 30.10 |

Note:

1 Table sourced from: Herrera Environmental Consultants. 2016. *September/October 2015 LFG Sampling Results at Kenyon Industrial Park.* Technical Memorandum from Bruce Carpenter and Michael Spillane, Herrera, to Teri Floyd, Floyd|Snider. 19 August.

Abbreviations

ATD At time of drilling
bgs Below ground surface
CKD Cement kiln dust
ft Feet
Hg Mercury
KIP Kenyon Industrial Park

**Table 6.5**
**Landfill Gas Probe Measurements at the Kenyon Industrial Park and South Transfer Station**
**King County, Washington – October 15, 2015[1]**

| Results from 2015 Supplemental Investigation at Kenyon Industrial Park | | | | | | | | Historical Results | |
|---|---|---|---|---|---|---|---|---|---|
| Location | Date | Time | Barometer (inches Hg) | Carbon Dioxide (% volume) | Oxygen (% volume) | Hydrogen Sulfide (ppmv) | Methane (% volume) | Methane (% volume) | No. of Events |
| **Temporary Gas Probes ($CO_2$, $O_2$, and $H_2S$ are from Borehole; $CH_4$ from Barhole Punch)** | | | | | | | | | |
| TGP-1 | 9/29/2015 | 12:02 | 29.90 | 0.1 | 21 | 0 | 1.8 | NA | NA |
| TGP-2 | 9/29/2015 | 12:50 | 29.86 | 6.6 | 0.6 | 0 | 0.6 | NA | NA |
| TGP-3 | 9/29/2015 | 13:30 | 29.88 | 0.0 | 22 | 0 | 0.0 | NA | NA |
| TGP-4 | 9/29/2015 | 14:18 | 29.91 | 1.6 | 19 | 0 | 0.1 | NA | NA |
| TGP-5 | 9/29/2015 | 15:25 | 29.81 | 20 | 0.0 | 1 | 14 | NA | NA |
| TGP-6 | 9/29/2015 | 16:25 | 29.77 | 0.0 | 18 | 2 | 0.0 | NA | NA |
| TGP-7 | 10/13/2015 | 9:35 | 30.23 | 0.7 | 20 | 0 | 18 | NA | NA |
| TGP-8 | 10/13/2015 | 10:45 | 30.24 | 3.3 | 13 | 0 | 0.0 | NA | NA |
| TGP-9 | 10/13/2015 | 11:31 | 30.25 | 0.2 | 17 | 0 | 1.7 | NA | NA |
| TGP-10 | 10/13/2015 | 12:28 | 30.23 | 0.5 | 20 | 0 | 0.0 | NA | NA |
| TGP-11 | 10/13/2015 | 13:50 | 30.22 | 0.0 | 21 | 0 | 1.4 | NA | NA |
| TGP-12 | 10/13/2015 | 15:15 | 30.21 | 0.0 | 21 | 0 | 36 | NA | NA |
| TGP-13 | 10/13/2015 | 16:40 | 30.22 | 0.0 | 21 | 0 | 0.0 | NA | NA |
| TGP-14 | 10/14/2015 | 13:20 | 30.21 | 0.2 | 16 | 0 | 16 | NA | NA |
| TGP-15 | 10/14/2015 | 14:01 | 30.18 | 4.6 | 4.8 | 0 | 6.5 | NA | NA |
| TGP-16 | 10/14/2015 | 14:36 | 30.14 | 0.0 | 9.8 | 0 | 26 | NA | NA |
| TGP-17 | 10/14/2015 | 15:15 | 30.11 | 0.0 | 21 | 0 | 65 | NA | NA |
| TGP-18 | 10/14/2015 | 10:35 | 30.25 | 0.2 | 19 | 0 | 0.9 | NA | NA |
| TGP-19 | 10/14/2015 | 11:08 | 30.24 | 0.0 | 20 | 0 | 1.0 | NA | NA |
| TGP-20 | 10/14/2015 | 11:35 | 30.23 | 0.0 | 21 | 0 | 16 | NA | NA |
| TGP-21 | 10/14/2015 | 12:33 | 30.22 | 0.1 | 21 | 0 | 0.2 | NA | NA |
| TGP-22 | 10/14/2015 | 15:54 | 30.12 | 0.0 | 22 | 0 | 0.0 | NA | NA |
| TGP-23 | 10/14/2015 | 16:56 | 30.12 | 1.7 | 0.3 | 0 | 4.7 | NA | NA |
| TGP-24 | 10/14/2015 | 17:28 | 30.11 | 2.8 | 3.4 | 0 | 2.1 | NA | NA |
| TGP-25 | 10/14/2015 | 18:00 | 30.10 | 6.3 | 0.3 | 0 | 4.4 | NA | NA |
| **Groundwater Monitoring Wells Screened across the Unsaturated Zone** | | | | | | | | | |
| KMW-01A | 10/15/2015 | 13:25 | 30 | 7.2 | 0.1 | 2 | 13 | 13 | 1 |
| KMW-03A | 10/15/2015 | 12:40 | 30 | 0.8 | 0.1 | 0 | 7.5 | 7.5 | 1 |
| KMW-04 | 10/15/2015 | 13:00 | 30 | 1.6 | 0.0 | 0 | 5.2 | 0 | 1 |
| KMW-05 | 10/15/2015 | 11:38 | 30 | 0.0 | 5.0 | 0 | 47 | 50 | 1 |
| KMW-06 | 10/15/2015 | 10:13 | 30 | 4.7 | 0.2 | 0 | 2.1 | 12 | 1 |
| KMW-07 | 10/15/2015 | 9:31 | 30.1 | 0.1 | 21 | 0 | 0 | 0 | 1 |
| KMW-08 | 10/15/2015 | 8:45 | 30.1 | 0 | 8.4 | 0 | 0 | 0.2 | 1 |
| **LFG Permanent Probes at or adjacent to KIP Parcel** | | | | | | | | | |
| GP-24 | 10/15/2015 | 11:11 | 30 | 0.0 | 0.1 | 0 | 53 | 4.6–48 | 9 |
| GP-25 | 10/15/2015 | 12:05 | 30 | 0.1 | 3.8 | 0 | 61 | 26–85 | 10 |
| GP-37 | 10/15/2015 | 14:15 | 30 | 14 | 1.2 | 0 | 0.4 | New probes; no historical data available | |
| GP-38 | 10/15/2015 | 13:45 | 30 | 16 | 1.5 | 0 | 0.5 | | |

Note:

1 Table sourced from: Herrera Environmental Consultants. 2016. *September/October 2015 LFG Sampling Results at Kenyon Industrial Park* . Technical Memorandum from Bruce Carpenter and Michael Spillane, Herrera, to Teri Floyd, Floyd|Snider. 19 August.

Abbreviations:

$CH_4$ Methane
$CO_2$ Carbon Dioxide
$H_2O$ Water
$H_2S$ Hydrogen sulfide
Hg Mercury
KIP Kenyon Industrial Park
LFG Landfill gas
NA Not applicable
$O_2$ Oxygen
ppmv Parts per million volume

# Table 6.6
## Percent Methane in Perimeter Probes
## First Post-SPPD Interim Action Event, March 2016

| Well | Date | Methane % | Carbon Dioxide % | Oxygen % |
|---|---|---|---|---|
| **Perimeter Probes** | | | | |
| GP-03 | 3/18/2016 | 0.0 | 3.4 | 14 |
| GP-07 | 3/18/2016 | 0.0 | 0.3 | 20 |
| GP-09 | 3/18/2016 | 0.0 | 4.0 | 15 |
| GP-11 | 3/18/2016 | FWS | FWS | FWS |
| GP-13 | 3/18/2016 | FWS | FWS | FWS |
| GP-15 | 3/18/2016 | FWS | FWS | FWS |
| GP-16 | 3/18/2016 | 0.0 | 0.1 | 21 |
| GP-23 | 3/18/2016 | FWS | FWS | FWS |
| GP-24 | 3/18/2016 | 0.0 | 0.0 | 21 |
| GP-25 | 3/18/2016 | **43** | 0.0 | 5.4 |
| GP-27 | 3/18/2016 | 0.4 | 9.8 | 0.0 |
| GP-28 | 3/18/2016 | 0.0 | 2.0 | 13 |
| GP-29 | 3/18/2016 | 1.3 | 11 | 0.0 |
| GP-31 | 3/18/2016 | 0.0 | 0.5 | 21 |
| GP-32 | 3/18/2016 | FWS | FWS | FWS |
| GP-33 | 3/18/2016 | **18** | 6 | 0.0 |
| GP-37 | 3/18/2016 | 0.0 | 12 | 4.6 |
| GP-38 | 3/18/2016 | 0.0 | 11 | 2.0 |
| **Other Probes Interior to Landfill, but along SPPD Boundary** | | | | |
| GP-17 | 3/18/2016 | 28 | 26 | 0.0 |
| GP-19 | 3/18/2016 | 4.2 | 14 | 0.0 |
| GP-20 | 3/18/2016 | 5.1 | 9.9 | 0.0 |
| GP-22 | 3/18/2016 | 19 | 11 | 0.0 |
| GP-35 | 3/18/2016 | 11 | 4 | 0.0 |
| GP-36 | 3/18/2016 | 0.0 | 0.0 | 20 |

Note:

**Bold & Red** Exceeds the screening level of 5%, only applies to perimeter probes.

Abbreviations:

FWS The well screen of the probe was flooded; therefore, it could not be measured

SPPD South Park Property Development, LLC

**Table 6.7**
**Additional Landfill Gas Probe Measurements at the SPPD Parcel**
**May 2013 through December 2016**

| Probe | Date | Methane % |
|---|---|---|
| **Landfill Long Term Compliance Probe** | | |
| GP-33[x] | 5/22/13 | 1.5 |
| | 6/18/13 | 0 |
| | 6/19/13 | 0 |
| | 6/25/14 | 0 |
| | 10/13/14 | 4.9 |
| | 11/6/14 | 0 |
| | 2/26/15 | 0 |
| | 5/12/15 | 7.6 |
| | 12/17/15 | 18.7 |
| | 3/18/16 | 18.2 |
| | 4/13/16 | 22 |
| | 5/11/16 | 4.6 |
| | 6/13/16 | 0 |
| | 9/26/16 | 0 |
| | 12/8/16 | 4.5 |
| | 12/22/16 | 8 |
| | 12/29/16 | 4 |
| GP-27 | 5/22/13 | 5.1 |
| | 6/25/14 | 0.6 |
| | 9/2/14 | 1.5 |
| | 10/13/14 | 2.1 |
| | 11/6/14 | 1.5 |
| | 2/26/15 | 0 |
| | 5/12/15 | 0.6 |
| | 12/17/15 | 0.9 |
| | 3/18/16 | 0.4 |
| | 6/13/16 | 0.1 |
| | 9/26/16 | 0 |
| | 12/8/16 | 0.5 |
| GP-28 | 5/22/13 | 0.1 |
| | 6/25/14 | 0 |
| | 9/2/14 | 0 |
| | 10/13/14 | 0 |
| | 11/6/14 | 0.2 |
| | 2/26/15 | 0 |
| | 5/12/15 | 0.1 |
| | 12/17/15 | 0 |
| | 3/18/16 | 0 |
| | 6/13/16 | 0 |
| | 9/26/16 | 0 |
| | 12/8/16 | 0.1 |

**Table 6.7**
**Additional Landfill Gas Probe Measurements at the SPPD Parcel**
**May 2013 through December 2016**

| Probe | Date | Methane % |
|---|---|---|
| **Landfill Long Term Compliance Probe (cont.)** | | |
| GP-29 | 5/22/13 | 7.9 |
| | 6/25/14 | 6.6 |
| | 9/2/14 | 8.1 |
| | 10/13/14 | 8.5 |
| | 11/6/14 | 8.9 |
| | 1/28/15 | 1 |
| | 2/26/15 | 1 |
| | 5/12/15 | 4.9 |
| | 12/9/15 | 10.3 |
| | 12/17/15 | 6.2 |
| | 2/17/16 | 2.9 |
| | 3/1/16 | 1.3 |
| | 3/18/16 | 1.7 |
| | 4/13/16 | 2.2 |
| | 5/11/16 | 1.2 |
| | 6/13/16 | 0.4 |
| | 9/26/16 | 0 |
| | 12/8/16 | 3.4 |
| | 12/22/16 | 3.1 |
| | 12/29/16 | 0 |
| GP-16[y] | 5/22/13 | 0.2 |
| | 6/18/13 | 0.1 |
| | 10/13/14 | 0.4 |
| | 2/26/15 | 0 |
| | 3/18/16 | 0 |
| | 6/13/16 | 0.1 |
| | 9/26/16 | 0 |
| | 12/8/16 | 0.1 |
| GP-31[y] | 5/22/13 | 0.1 |
| | 6/25/14 | 0 |
| | 9/2/14 | 0 |
| | 10/13/14 | 0 |
| | 2/26/15 | 0 |
| | 5/12/15 | 0.2 |
| | 12/17/15 | 0 |
| | 3/18/16 | 0 |
| | 6/13/16 | 0.1 |
| | 9/26/16 | 0 |
| | 12/8/16 | 0.2 |

**Table 6.7**
**Additional Landfill Gas Probe Measurements at the SPPD Parcel**
**May 2013 through December 2016**

| Probe | Date | Methane % |
|---|---|---|
| **Landfill Long Term Compliance Probe (cont.)** | | |
| GP-15 | 5/22/13 | 3.6 |
| | 6/25/14 | 2.4 |
| | 9/2/14 | 0 |
| | 10/13/14 | 0 |
| | 11/6/14 | 0 |
| | 3/18/16 | FLOODED |
| | 6/13/16 | FLOODED |
| | 9/26/16 | FLOODED |
| | 12/8/16 | FLOODED |
| GP-32[y] | 9/2/14 | 0 |
| | 10/13/14 | 0 |
| | 2/26/15 | 0 |
| | 5/12/15 | 0.3 |
| | 12/17/15 | 0 |
| | 3/18/16 | FLOODED |
| | 6/13/16 | FLOODED |
| | 9/26/16 | 0 |
| | 12/8/16 | FLOODED |
| GP-03[y] | 5/22/13 | 0.1 |
| | 9/2/14 | 1.7 |
| | 12/17/15 | 0 |
| | 3/18/16 | 0 |
| | 6/13/16 | 0.1 |
| | 9/26/16 | 0 |
| | 12/8/16 | 0.1 |
| GP-13 | 5/22/13 | 0.2 |
| | 6/25/14 | 0 |
| | 9/2/14 | 0 |
| | 10/13/14 | 0 |
| | 2/26/15 | 0 |
| | 5/12/15 | 0.3 |
| | 3/18/16 | FLOODED |
| | 4/13/16 | FLOODED |
| | 6/13/16 | FLOODED |
| | 9/26/16 | 0 |
| | 12/8/16 | FLOODED |

**Table 6.7**
**Additional Landfill Gas Probe Measurements at the SPPD Parcel**
**May 2013 through December 2016**

| Probe | Date | Methane % |
|---|---|---|
| **Landfill Long Term Compliance Probe (cont.)** | | |
| GP-11 | 5/22/13 | 0.1 |
| | 6/25/14 | 0 |
| | 10/13/14 | 0 |
| | 2/26/15 | 0 |
| | 3/18/16 | FLOODED |
| | 4/13/16 | FLOODED |
| | 6/13/16 | FLOODED |
| | 9/26/16 | 0 |
| | 12/8/16 | FLOODED |
| **SPPD IA Perimeter Probe** | | |
| GP-22 | 5/22/13 | 8.6 |
| | 6/18/13 | 9.9 |
| | 9/2/14 | 9.5 |
| | 10/13/14 | 14.5 |
| | 2/26/15 | 1.3 |
| | 5/12/15 | 17.1 |
| | 12/17/15 | 23.6 |
| | 3/18/16 | 19.3 |
| | 5/11/16 | 7.3 |
| | 6/13/16 | 3.3 |
| | 9/26/16 | 2.3 |
| | 12/8/16 | 5.3 |
| | 12/22/16 | 7.8 |
| | 12/29/16 | 1.9 |
| GP-21 | 5/22/13 | 15.8 |
| | 6/18/13 | 0 |
| | 6/25/14 | 19.8 |
| | 9/2/14 | 14.9 |
| | 10/13/14 | 19.4 |
| | 11/6/14 | 14.3 |
| | 2/26/15 | 0 |
| | 5/12/15 | 14.7 |
| | 12/17/15 | 29.4 |
| | 3/18/16 | 25.6 |
| | 6/13/16 | 1 |
| | 9/26/16 | 1.2 |
| | 12/8/16 | 4.5 |

**Table 6.7**
**Additional Landfill Gas Probe Measurements at the SPPD Parcel**
**May 2013 through December 2016**

| Probe | Date | Methane % |
|---|---|---|
| **SPPD IA Perimeter Probe (cont.)** | | |
| GP-34 | 5/22/13 | 22 |
| | 6/18/13 | 12.1 |
| | 6/25/14 | 13.7 |
| | 9/2/14 | 11.6 |
| | 10/13/14 | 11.9 |
| | 2/26/15 | 1.5 |
| | 5/12/15 | 25.7 |
| | 5/11/16 | 4.7 |
| | 6/13/16 | 1.1 |
| | 9/26/16 | 1.5 |
| | 12/8/16 | 6.9 |
| GP-02 | 5/22/13 | 16.5 |
| | 6/19/13 | 14.8 |
| GP-35 | 5/22/13 | 3.4 |
| | 6/18/13 | 1 |
| | 6/19/13 | 1.6 |
| | 6/25/14 | 1.7 |
| | 9/2/14 | 4.1 |
| | 10/13/14 | 5.4 |
| | 11/6/14 | 6.7 |
| | 2/26/15 | 0.9 |
| | 5/12/15 | 2.1 |
| | 12/17/15 | 9.5 |
| | 3/18/16 | 10.8 |
| | 5/11/16 | 8.8 |
| | 6/13/16 | 4.2 |
| | 9/26/16 | 1.4 |
| | 12/8/16 | 3.8 |
| GP-20 | 5/22/13 | 2.5 |
| | 6/18/13 | 1.9 |
| | 6/19/13 | 2.1 |
| | 6/25/14 | 2.5 |
| | 9/2/14 | 4.1 |
| | 10/13/14 | 6 |
| | 11/6/14 | 7.5 |
| | 2/26/15 | 0.1 |
| | 5/12/15 | 3.7 |
| | 12/17/15 | 9.5 |
| | 3/18/16 | 5.1 |
| | 6/13/16 | 0 |
| | 9/26/16 | 1.8 |
| | 12/8/16 | 3.6 |

**Table 6.7**
**Additional Landfill Gas Probe Measurements at the SPPD Parcel**
**May 2013 through December 2016**

| Probe | Date | Methane % |
|---|---|---|
| **SPPD IA Perimeter Probe (cont.)** | | |
| GP-36 | 5/22/13 | 0.5 |
| | 6/18/13 | 0 |
| | 6/19/13 | 0 |
| | 6/25/14 | 0.8 |
| | 9/2/14 | 2.2 |
| | 10/13/14 | 4.6 |
| | 2/26/15 | 0.6 |
| | 5/12/15 | 4.7 |
| | 12/17/15 | 2.6 |
| | 3/18/16 | 0 |
| | 6/13/16 | 0.1 |
| | 9/26/16 | 0 |
| | 12/8/16 | 0 |
| GP-19 | 5/22/13 | 4.5 |
| | 6/18/13 | 1.3 |
| | 6/19/13 | 2 |
| | 6/25/14 | 6.9 |
| | 9/2/14 | 12 |
| | 10/13/14 | 14.6 |
| | 11/6/14 | 12.4 |
| | 2/26/15 | 0 |
| | 5/12/15 | 0.1 |
| | 12/17/15 | 10.8 |
| | 3/18/16 | 4.2 |
| | 6/13/16 | 2.4 |
| | 9/26/16 | 5.1 |
| | 12/8/16 | 9.5 |
| GP-30 | 6/25/14 | 0 |
| | 9/2/14 | 0 |
| | 10/13/14 | 0 |
| | 2/26/15 | 0 |
| | 5/12/15 | 0.1 |

**Table 6.7**
**Additional Landfill Gas Probe Measurements at the SPPD Parcel**
**May 2013 through December 2016**

| Probe | Date | Methane % |
|---|---|---|
| **Other Locations** | | |
| GP-17 | 5/22/13 | 18.2 |
| | 6/18/13 | 19 |
| | 6/25/14 | 19.6 |
| | 9/2/14 | 28.9 |
| | 10/13/14 | 33.1 |
| | 11/6/14 | 34.7 |
| | 2/26/15 | 4.5 |
| | 5/12/15 | 33 |
| | 12/17/15 | 48.1 |
| | 3/18/16 | 28 |
| | 6/13/16 | 13.1 |
| | 9/26/16 | 11.1 |
| | 12/8/16 | 17.7 |
| MH-1 | 5/22/13 | 0.2 |
| | 10/13/14 | 0 |
| | 3/18/16 | 0 |
| | 6/13/16 | 0 |
| MH-02 | 5/22/13 | 0.2 |
| | 6/25/14 | 0 |
| | 3/18/16 | 0 |

Notes:

x Additional perimeter probes may be installed in the future, as warranted. Final perimeter probe monitoring locations are identified in the Cleanup Action Plan.
GP-33 is not a perimeter probe and is, therefore, not part of the required quarterly monitoring. However, data collection from this point could be used to conclude that there is not an active pathway from SPPD to the W.G. Clark Construction Co. buildings.

y Due to shallow groundwater, these probes are only measured when the water table is low enough for the probes to function.

Abbreviation:

SPPD South Park Property Development, LLC

# Table 6.8
## Landfill Gas Probe Measurements at the KIP Swale
## September 2016 through April 2017

| Monitoring Stations | Screen Setting (ft bgs) | Range of CKD (ft bgs) | Date | Barometric Pressure (inches Hg) | Well Head Pressure (inches $H_2O$) | Static Water Level (ft bgs) | Methane % | Carbon Dioxide % | Oxygen % | Hydrogen Sulfide (ppmv) |
|---|---|---|---|---|---|---|---|---|---|---|
| **Landfill Long Term Compliance Probe** | | | | | | | | | | |
| GP-39 | 5.0–12.3 | 4.8–9.5 | 9/26/16 | 30.03 | NM | 10.54[1] | 0.1 | 2.5 | 14.0 | 0 |
| | | | 10/3/16 | 29.91 | NM | 10.57[1] | 0 | 3.1 | 14.6 | 0 |
| | | | 11/18/16 | 29.83 | NM | 10.13[1] | 0 | 1.2 | 19.2 | 0 |
| | | | 12/14/16 | 29.98 | 0 | 10.12[1] | 0 | 1.1 | 21.6 | NM |
| | | | 1/31/17 | 30.31 | 0 | 10.15[1] | 0 | 0.4 | 20.2 | 0 |
| | | | 2/27/17 | 29.76 | 0 | 9.94[1] | 0 | 0.6 | 20.5 | 0 |
| | | | 3/20/17 | 29.96 | 0.03 | 9.42[1] | 0 | 0.5 | 20.1 | 0 |
| | | | 4/12/17 | 29.75 | 0 | 9.95[1] | 0 | 0.5 | 20.2 | 0 |
| | | | 5/15/17 | 29.93 | 0 | 10.03[1] | 0 | 0.6 | 19.7 | 0 |
| | | | 6/15/17 | 29.82 | 0 | 10.16[1] | 0 | 1.0 | 16.8 | 0 |
| | | | 7/18/17 | 29.83 | 0 | 10.33 | 0 | 1.3 | 15.1 | 0 |
| | | | 8/28/17 | 29.66 | 0 | 10.63 | 0 | 2.3 | 14.6 | 0 |
| GP-40 | 1.3–8.6 | 4.0–4.5 | 9/26/16 | 30.01 | NM | 3.25 | 3.6 | 4.5 | 11.0 | 0 |
| | | | 10/3/16 | 29.91 | NM | 3.27 | 1.2 | 4.5 | 11.2 | 0 |
| | | | 11/18/16 | 29.82 | NM | 2.28 | 0[2] | 0 | 20.6 | 0 |
| | | | 12/14/16 | 29.97 | -0.03 | 2.52 | 0.7 | 2.4 | 13.5 | NM |
| | | | 1/31/17 | 30.31 | 0 | 3.06 | 0 | 2.0 | 13.2 | 0 |
| | | | 2/27/17 | 29.76 | 0 | 2.26 | 1.5 | 2.0 | 13.0 | 0 |
| | | | 3/20/17 | 29.96 | 0 | 2.10 | 0 | 0.2 | 20.1 | 0 |
| | | | 4/12/17 | 29.96 | 0 | 1.78[2] | 1.3 | 1.0 | 5.5 | 0 |
| | | | 5/15/17 | 29.93 | 0 | 2.64 | 0.3 | 3.4 | 14.2 | 0 |
| | | | 6/15/17 | 29.82 | 0 | 3.08 | 4.0 | 5.6 | 8.0 | 0 |
| | | | 7/18/17 | 29.83 | 0 | 3.36 | 2.4 | 6.5 | 7.9 | 0 |
| | | | 8/28/17 | 29.67 | 0 | 3.36 | 7.5 | 7.5 | 4.5 | 0 |
| GP-41 | 2.3–9.6 | 0.8–4.5 | 9/26/16 | 30.01 | NM | 4.36 | 0 | 0.4 | 19.0 | 0 |
| | | | 10/3/16 | 29.91 | NM | 4.28 | 0 | 0.4 | 19.5 | 0 |
| | | | 11/18/16 | 29.82 | NM | 2.57 | 0[2] | 0 | 19.6 | 0 |
| | | | 12/14/16 | 29.97 | -0.08 | 3.04 | 0 | 0.1 | 22.3 | NM |
| | | | 1/31/17 | 30.31 | 0 | 3.64 | 0 | 0 | 21.2 | 0 |
| | | | 2/27/17 | 29.76 | 0 | 1.85[6] | 0[2] | 0 | 20.9 | 0 |
| | | | 3/20/17 | 29.96 | NM | 1.92[6] | 0[2] | 0 | 20.9 | 0 |
| | | | 4/12/17 | 29.75 | NM | 1.73[6] | 0[2] | 0 | 20.6 | 0 |
| | | | 5/15/17 | 29.93 | NM | 2.44 | 0.0[2] | 0 | 20.8 | 0 |
| | | | 6/15/17 | 29.82 | NM | 1.88[6] | 0.0[2] | 0 | 20.6 | 0 |
| | | | 7/18/17 | 29.83 | 0.00 | 4.27 | 0.0 | 0 | 19.5 | 0 |
| | | | 8/28/17 | 29.67 | 0.00 | 4.43 | 0.0 | 0 | 19.0 | 0 |

# Table 6.8
## Landfill Gas Probe Measurements at the KIP Swale
## September 2016 through April 2017

| Monitoring Stations | Screen Setting (ft bgs) | Range of CKD (ft bgs) | Date | Barometric Pressure (inches Hg) | Well Head Pressure (inches $H_2O$) | Static Water Level (ft bgs) | Methane % | Carbon Dioxide % | Oxygen % | Hydrogen Sulfide (ppmv) |
|---|---|---|---|---|---|---|---|---|---|---|
| **Landfill Long Term Compliance Probe (cont.)** | | | | | | | | | | |
| GP-42 | 4.2–11.5 | 6.0–6.5 | 9/26/16 | 30.01 | NM | 7.62[1] | 0 | 1.2 | 17.8 | 0 |
| | | | 10/3/16 | 29.91 | NM | 7.73[1] | 0 | 1.2 | 18.2 | 0 |
| | | | 11/18/16 | 29.82 | NM | 6.32[1] | 0 | 0.5 | 19.8 | 0 |
| | | | 12/14/16 | 29.95 | -0.04 | 6.70[1] | 0 | 0.6 | 21.6 | NM |
| | | | 1/31/17 | 30.31 | 0 | 7.32[1] | 0 | 0.2 | 20.6 | 0 |
| | | | 2/27/17 | 30.31 | 0 | 6.20[1] | 0 | 0.3 | 20.4 | 0 |
| | | | 3/20/17 | 29.96 | 0 | 6.19[1] | 0 | 0.2 | 20.5 | 0 |
| | | | 4/12/17 | 29.74 | 0 | 5.76[1] | 0 | 0.3 | 20.1 | 0 |
| | | | 5/15/17 | 29.93 | 0 | 6.58[1] | 0 | 0.5 | 20.1 | 0 |
| | | | 6/15/17 | 29.82 | 0 | 7.15[1] | 0 | 0.7 | 19.0 | 0 |
| | | | 7/18/17 | 29.83 | 0 | 7.75 | 0 | 0.7 | 18.4 | 0 |
| | | | 8/28/17 | 29.67 | 0 | 7.93 | 0 | 1.0 | 17.3 | 0 |
| GP-43 | 2.6–9.9 | 3.0–3.7 | 9/26/16 | 30.01 | NM | 4.90 | **32.5** | 2.8 | 0.6 | 0 |
| | | | 10/3/16 | 29.91 | NM | 5.05 | **32.7** | 2.9 | 0.6 | 0 |
| | | | 11/18/16 | 29.82 | NM | 4.05 | 1.5[3] | 3.5 | 15.4 | 0 |
| | | | 12/14/16 | 29.95 | 0 | 2.94 | 1.1[4] | 2.7 | 19.5 | NM |
| | | | 1/31/17 | 30.31 | 0 | 3.94 | 0.9 | 1.2 | 17.8 | 0 |
| | | | 2/27/2017[5] | 29.76 | 0.02 | 3.78 | **21.2[2]** | 3.2 | 2.7 | 0 |
| | | | 2/27/2017[5] | 29.72 | NM | 3.70 | **11.9[2]** | 1.9 | 13.5 | 0 |
| | | | 3/20/17 | 29.96 | 0 | 3.62 | 4.5[2] | 1.0 | 0.9 | 0 |
| | | | 4/12/17 | 29.74 | 0.05 | 4.03 | **7.2[7]** | 1.2 | 0.4 | 0 |
| | | | 5/15/17 | 29.94 | 0.00 | 4.35 | **46.4[7]** | 2.5 | 2.3 | 0 |
| | | | 6/15/17 | 29.82 | 0.00 | 4.60 | **16.3** | 2.1 | 0.3 | 0 |
| | | | 7/18/17 | 29.83 | 0.00 | 4.98 | **17.1** | 2.9 | 3.3 | 0 |
| | | | 8/28/17 | 29.68 | 0.00 | 5.05 | 0.5 | 1.5 | 17.3 | 0 |
| GP-33 | 5.0–10.0 | NP | 10/3/16 | 29.83 | 0 | NM | 0.7 | 9.9 | 0.2 | 0 |
| | | | 11/18/16 | 29.85 | 0 | NM | 1.5 | 4.5 | 7.0 | 0 |
| | | | 12/14/16 | 29.91 | -0.06 | NM | **5.3** | 3.6 | 0 | NM |
| | | | 1/31/17 | 30.04 | 0 | NM | 1.3 | 6.0 | 0.8 | 0 |
| | | | 2/27/17 | Well screen flooded - no gas monitoring data collected. | | | | | | |
| | | | 3/20/17 | 29.91 | 0 | NM | 4.3 | 6.9 | 0.7 | 0 |
| | | | 4/12/17 | Well screen flooded - no gas monitoring data collected. | | | | | | |
| | | | 5/15/17 | 29.94 | 0.00 | NM | 1.30 | 3.40 | 1.90 | 0.00 |
| | | | 6/15/17 | 29.82 | NM | NM | 0.00 | 4.00 | 7.30 | 0.00 |
| | | | 7/18/17 | 29.92 | -0.01 | NM | 0.00 | 7.30 | 5.00 | 0.00 |
| | | | 8/28/17 | 29.74 | 0.00 | NM | 0.00 | 8.70 | 3.30 | 0.00 |

# Table 6.8
## Landfill Gas Probe Measurements at the KIP Swale
## September 2016 through April 2017

| Monitoring Stations | Screen Setting (ft bgs) | Range of CKD (ft bgs) | Date | Barometric Pressure (inches Hg) | Well Head Pressure (inches $H_2O$) | Static Water Level (ft bgs) | Methane % | Carbon Dioxide % | Oxygen % | Hydrogen Sulfide (ppmv) |
|---|---|---|---|---|---|---|---|---|---|---|
| **Other Locations** | | | | | | | | | | |
| GP-22 | 5.0–21.0 | NP | 10/3/16 | 29.83 | 0 | NM | 4.2 | 11.3 | 0.1 | 0 |
| | | | 11/18/16 | 29.85 | 0 | NM | 3.9 | 8.0 | 0.1 | 4 |
| | | | 12/14/16 | 29.90 | -0.07 | NM | **9.2** | 8.6 | 0 | NM |
| | | | 1/31/17 | 30.34 | -0.01 | NM | 3.3 | 5.3 | 0 | 2 |
| | | | 2/27/17 | Well screen flooded - no gas monitoring data collected. | | | | | | |
| | | | 3/20/17 | Well screen flooded - no gas monitoring data collected. | | | | | | |
| | | | 4/12/17 | Well screen flooded - no gas monitoring data collected. | | | | | | |
| | | | 5/15/17 | Well screen flooded - no gas monitoring data collected. | | | | | | |
| | | | 6/15/17 | Well screen flooded - no gas monitoring data collected. | | | | | | |
| | | | 7/18/17 | Well screen flooded - no gas monitoring data collected. | | | | | | |
| | | | 8/28/17 | Well screen flooded - no gas monitoring data collected. | | | | | | |
| GP-24 | 5.5–10.5 | 1.0–7.0 | 1/31/17 | 30.32 | 0 | 5.77 | **21.1** | 0 | 3.3 | 0 |
| | | | 2/27/17 | 29.74 | -0.01 | 5.18[6] | **16.0[2]** | 0 | 4.4 | 0 |
| | | | 3/20/17 | 29.96 | NM | 5.37[6] | 4.3[2] | 0 | 4.2 | 0 |
| | | | 4/12/17 | 29.75 | NM | 5.45[6] | **8.1[2]** | 0 | 5.8 | 0 |
| | | | 5/15/17 | 29.93 | NM | 5.60 | **16.0[2]** | 0 | 4.0 | 0 |
| | | | 6/15/17 | 29.82 | -0.02 | 5.80 | **38.0** | 0 | 1.5 | 0 |
| | | | 7/18/17 | 29.83 | 0.00 | 6.42 | **47.4** | 0 | 0.3 | 6 |
| | | | 8/28/17 | 29.67 | 0.00 | 6.49 | **53.1** | 0 | 0.1 | 5 |
| GP-25 | 5.4–10.4 | 1.0–5.0 | 1/31/17 | 30.44 | NM | 6.54 | **70.7** | 0 | 9.8 | 0 |
| | | | 2/27/17 | 29.76 | NM | 6.08 | **68.5** | 0.1 | 0 | 0 |
| | | | 3/20/17 | 29.96 | NM | 6.00 | **70.0** | 0 | 0.2 | 0 |
| | | | 4/12/17 | 29.74 | NM | 5.85 | **73.2** | 0 | 0.3 | 1 |
| | | | 5/15/17 | 29.93 | NM | 6.10 | **72.1** | 0 | 0.2 | 0 |
| | | | 6/15/17 | 29.82 | NM | 6.02 | **77.5** | 0 | 0.2 | 1 |
| | | | 7/18/17 | 29.83 | NM | 6.36 | **75.3** | 0 | 0.0 | 0 |
| | | | 8/28/17 | 29.67 | NM | 6.41 | **76.5** | 0 | 0.1 | 0 |
| KMW-01A | 5.6–21.6 | NP | 10/3/16 | 29.87 | NM | 11.02 | **8.3** | 6.5 | 0.6 | 2 |
| | | | 11/18/16 | 29.86 | NM | 9.81 | 4.7 | 4.8 | 0.3 | 5 |
| | | | 12/14/16 | 30.00 | 0 | NM | 4.0 | 5.0 | 0.00 | NM |
| | | | 1/31/17 | 30.40 | 0 | 10.09 | 1.6 | 3.9 | 0 | 3 |
| | | | 2/27/17 | 29.72 | 0 | 9.29 | 0.9 | 3.6 | 0 | 2 |
| | | | 3/20/17 | 29.90 | -0.04 | 9.14 | 0.8 | 2.7 | 0.2 | 1 |
| | | | 4/12/17 | 29.72 | 0 | 8.83 | 0.7 | 2.7 | 0.2 | 2 |
| | | | 5/15/17 | 29.94 | 0 | 9.43 | 0.8 | 2.6 | 0.2 | 2 |
| | | | 6/15/17 | 29.82 | 0 | 9.97 | 0.8 | 3.2 | 0.2 | 0 |
| | | | 7/18/17 | 29.83 | 0 | 10.61 | **5.8** | 3.6 | 0.1 | 8 |
| | | | 8/28/17 | 29.70 | 0 | 11.08 | **11.9** | 5.5 | 0.0 | 12 |

# Table 6.8
## Landfill Gas Probe Measurements at the KIP Swale
## September 2016 through April 2017

| Monitoring Stations | Screen Setting (ft bgs) | Range of CKD (ft bgs) | Date | Barometric Pressure (inches Hg) | Well Head Pressure (inches $H_2O$) | Static Water Level (ft bgs) | Methane % | Carbon Dioxide % | Oxygen % | Hydrogen Sulfide (ppmv) |
|---|---|---|---|---|---|---|---|---|---|---|
| **Other Locations (cont.)** | | | | | | | | | | |
| KMW-03A | 9.7–24.7 | NP | 11/18/16 | 29.89 | NM | 11.23 | 1.2 | 2.3 | 6.2 | 0 |
| | | | 12/14/16 | 30.00 | NM | 11.27 | 2.2 | 2.4 | 0.1 | NM |
| | | | 1/31/17 | 30.43 | NM | 11.02 | 3.2 | 2.7 | 0 | 0 |
| | | | 2/27/17 | 29.72 | NM | 10.50 | 2.7 | 2.8 | 0 | 0 |
| | | | 3/20/17 | 29.91 | NM | 10.25 | 3.8 | 3.0 | 0.4 | 0 |
| | | | 4/12/17 | 29.72 | NM | 10.10 | 4.1 | 4.0 | 0.2 | 0 |
| | | | 5/15/17 | 29.94 | NM | 10.30 | 2.4 | 4.4 | 0.3 | 0 |
| | | | 6/15/17 | 29.82 | NM | 10.78 | 1.3 | 3.8 | 0.3 | 0 |
| | | | 7/18/17 | 29.87 | NM | 11.30 | 1.5 | 3.1 | 0.5 | 0 |
| | | | 8/28/17 | 29.72 | NM | 11.70 | 0.7 | 4.1 | 0.0 | 0 |
| KMW-04 | 5.3–20.3 | NP | 11/18/16 | 29.88 | NM | 12.22 | 3.8 | 1.9 | 0.2 | 0 |
| | | | 12/14/16 | 30.00 | NM | 11.89 | 3.0 | 1.4 | 4.9 | NM |
| | | | 1/31/17 | 30.40 | NM | 11.74 | 0.3 | 0.4 | 17.3 | 0 |
| | | | 2/27/17 | 29.71 | NM | 11.20 | 2.7 | 1.3 | 0.2 | 0 |
| | | | 3/20/17 | 29.90 | NM | 11.10 | 1.3 | 0.6 | 9.7 | 0 |
| | | | 4/12/17 | 29.72 | NM | 10.92 | 0.2 | 0.4 | 18.6 | 0 |
| | | | 5/15/17 | 29.94 | NM | 11.01 | 2.1 | 1.1 | 0.3 | 0 |
| | | | 6/15/17 | 29.82 | NM | 11.49 | 2.2 | 1.5 | 0.2 | 0 |
| | | | 7/18/17 | 29.87 | NM | 11.95 | 0.6 | 0.6 | 13.2 | 0 |
| | | | 8/28/17 | 29.71 | NM | 12.38 | 2.3 | 1.6 | 0.0 | 0 |
| KMW-06 | 5.5–20.5 | NP | 11/18/16 | 29.90 | NM | 9.77 | 0.2 | 6.3 | 0.2 | 0 |
| | | | 12/14/16 | 30.04 | NM | 9.80 | 0.2 | 6.6 | 0 | NM |
| | | | 1/31/17 | 30.43 | NM | 9.75 | 0 | 3.9 | 9.2 | 0 |
| | | | 2/27/17 | 29.72 | NM | 9.18 | 0 | 4.7 | 6.8 | 0 |
| | | | 3/20/17 | 29.91 | NM | 8.91 | 0 | 6.0 | 0.3 | 0 |
| | | | 4/12/17 | 29.71 | NM | 8.80 | 0 | 5.2 | 6.0 | 0 |
| | | | 5/15/17 | 29.95 | NM | 9.10 | 0 | 4.1 | 10.8 | 0 |
| | | | 6/15/17 | 29.82 | NM | 9.70 | 0 | 9.1 | 0.5 | 0 |
| | | | 7/18/17 | 29.92 | NM | 10.22 | 0 | 9.9 | 0.1 | 0 |
| | | | 8/28/17 | 29.69 | NM | 10.65 | 0 | 10.9 | 0.1 | 0 |

# Table 6.8
# Landfill Gas Probe Measurements at the KIP Swale
# September 2016 through April 2017

| Monitoring Stations | Screen Setting (ft bgs) | Range of CKD (ft bgs) | Date | Barometric Pressure (inches Hg) | Well Head Pressure (inches $H_2O$) | Static Water Level (ft bgs) | Methane % | Carbon Dioxide % | Oxygen % | Hydrogen Sulfide (ppmv) |
|---|---|---|---|---|---|---|---|---|---|---|
| **Other Locations (cont.)** | | | | | | | | | | |
| Manhole | NA | NA | 9/26/16 | 30.01 | NA | NA | 0 | 0 | 20.4 | 0 |
| | | | 10/3/16 | 29.91 | NA | NA | 0 | 0.1 | 20.8 | 0 |
| | | | 11/18/16 | 29.83 | NA | NA | 0 | 0 | 21.2 | 0 |
| | | | 12/14/16 | 29.93 | NA | NA | 0 | 0 | 22.6 | 0 |
| | | | 1/31/17 | 30.31 | NA | NA | 0 | 0 | 21.2 | 0 |
| | | | 2/27/17 | 29.76 | NA | NA | 0 | 0.1 | 21.0 | 0 |
| | | | 3/20/17 | 29.91 | NA | NA | 0 | 0.1 | 21.0 | 0 |
| | | | 4/12/17 | 29.68 | NA | NA | 0 | 0.1 | 21.3 | 0 |
| | | | 5/15/17 | 29.95 | NA | NA | 0 | 0.1 | 21.1 | 0 |
| | | | 6/15/17 | 29.83 | NA | NA | 0 | 0.2 | 20.5 | 0 |
| | | | 7/18/17 | 29.93 | NA | NA | 0 | 0.0 | 21.0 | 0 |
| | | | 8/28/17 | 29.98 | NA | NA | 0 | 0.0 | 20.4 | 0 |

Notes:

**Bold & Red** Highlighted results are greater than the LEL of 5.1 percent at 20°C.

1 Probe installed on loading dock 4 ft above ground surface
2 Unable to purge more than one probe volume, water level too high
3 Measurements did not stabilize, GEM 2000 Gas Analyzer faulted due to high water level after purging 2-1/4 volumes
4 Measurements did not stabilize, GEM 2000 Gas Analyzer faulted due to high water level after purging 2-1/2 volumes
5 Initial measurement at 9:30 am, re-monitored at 2:37 pm
6 Water level above top of screen
7 Measurements did not stabilize, GEM 2000 Gas Analyzer faulted due to high water level after purging 1-1/4 volumes

Abbreviations:

bgs Below ground surface
C Celsius
CKD Cement kiln dust
$H_2O$ Water
Hg Mercury
LEL Lower explosion level
NA Not applicable
NM Not measured
NP Not present
ppmv Parts per million by volume

# Table 6.9
## Chemicals Detected in Soil Vapor Samples for Volatile Organic Compounds[1]

| Chemicals | Screening Level[1] | Unit | GP-25 | GP-27 | KMW-04 | KMW-05 | North Piezometer | South Piezometer |
|---|---|---|---|---|---|---|---|---|
| | | Sample Date | 5/11/2011 | 5/11/2011 | 5/12/2011 | 5/11/2011 | 5/12/2011 | 5/11/2011 |
| | | Screen Interval | 5–10 ft bgs | 9–14 ft bgs | 9–19.5 ft | 8.5–18.5 ft | ~19 ft | ~16–20 ft |
| | | | Results by USEPA Method TO-15 | | | | | |
| **Chlorinated Volatile Organic Compounds** | | | | | | | | |
| 1,1-Dichloroethene | 13,000 | μg/m³ | 6.4 U | **19** | 13 U | 12 U | 3.2 U | 4.6 U |
| *cis*- 1,2-Dichloroethene | -- | μg/m³ | 6.4 U | **99** | 13 U | 12 U | 3.2 U | 4.6 U |
| Chlorobenzene | 3,000 | μg/m³ | **9.9** | **20** | 15 U | 14 U | 3.7 U | 5.3 U |
| Methylene chloride | -- | μg/m³ | 5.6 U | 3.0 U | 11 U | 11 U | **7.4** | 4.0 U |
| Tetrachloroethene | 3,000 | μg/m³ | 11 U | **13** | 22 U | **27** | 5.5 U | 7.8 U |
| *trans*- 1,2-Dichloroethene | -- | μg/m³ | 6.4 U | **45** | 13 U | 12 U | 3.2 U | 4.6 U |
| Trichloroethene | 130 | μg/m³ | 8.7 U | **80** | 17 U | 17 U | 4.3 U | 6.2 U |
| Vinyl chloride | 190 | μg/m³ | 4.1 U | **270** | **100** | **18** | 2.0 U | 2.9 U |
| **Benzene, Toluene, Ethylbenzene, and Xylene (BTEX) Constituents** | | | | | | | | |
| Benzene | 210 | μg/m³ | **190** | **22** | **16** | **460** | **8.9** | 3.7 U |
| Ethylbenzene | 67,000 | μg/m³ | **160** | **9.7** | **15** | **260** | **37** | 5.0 U |
| Toluene | 330,000 | μg/m³ | **190** | **61** | **66** | **790** | **110** | 4.3 U |
| Xylene (meta and para) | 6,700 | μg/m³ | **360** | **16** | **46** | **690** | **97** | 5.0 U |
| Xylene (ortho) | 6,700 | μg/m³ | **110** | **7.9** | **16** | **210** | **32** | 5.0 U |
| **Other Volatile Organic Compounds Associated with Total Petroleum Hydrocarbons** | | | | | | | | |
| 1,2,4-Trimethylbenzene | 470 | μg/m³ | **24** | **16** | 16 U | **46** | **11** | 5.6 U |
| 1,3,5-Trimethylbenzene | -- | μg/m³ | **17** | **7.3** | 16 U | **35** | **6.4** | 5.6 U |
| 2,2,4-Trimethylpentane | -- | μg/m³ | 7.6 U | **310** | **110** | **8,800** J | **24** | 5.4 U |
| 4-Ethyltoluene | -- | μg/m³ | **17** | **10** | 16 U | **62** | **16** | 5.6 U |
| Cyclohexane | -- | μg/m³ | **3,600** J | **130** | **220** | **1,600** | **14** | 22 |
| iso-Propanol | -- | μg/m³ | 16 U | 8.6 U | 32 U | **54** | **23** | 11 U |
| iso-Propylbenzene | -- | μg/m³ | **11** | 4.3 U | 16 U | **39** | **5.1** | 5.6 U |
| n-Heptane | -- | μg/m³ | **1,800** | **30** | **72** | **1,400** | **17** | 4.7 U |
| n-Hexane | 47,000 | μg/m³ | **4,500** J | **300** | **540** | **1,700** | **11** | 5.7 |
| n-Propylbenzene | -- | μg/m³ | 8 U | **7.0** | 16 U | **17** | 4.0 U | 5.6 U |
| Styrene | 67,000 | μg/m³ | 6.9 U | 3.7 U | 14 U | **86** | **13** | 4.9 U |
| **Miscellaneous Volatile Organic Compounds** | | | | | | | | |
| Acetone | -- | μg/m³ | **28** | **9.8** | **32** | **420** | **110** | **130** |
| Carbon disulfide | 46,700 | μg/m³ | **27** | 11 U | 40 U | **38** J | 10 U | 14 U |
| Dichlorodifluoromethane | 6,700 | μg/m³ | 8.0 U | **16** | 16 U | 15 U | 4.0 U | 5.7 U |
| Ethanol | -- | μg/m³ | 12 U | 6.6 U | **32** | **73** | **45** | 8.7 U |
| Methyl ethyl ketone | 330,000 | μg/m³ | 19 U | 10 U | 38 U | **76** | 9.5 U | **40** |

Notes:

1 Soil gas screening levels were developed by Ecology in their *Guidance for Evaluating Soil Vapor Intrusion in Washington State: Investigation and Remedial Action* (Ecology 2009c; revised by Ecology in April 2015 to update toxicity factors). Soil vapor samples from gas probe and monitoring well locations collected at the South Park Landfill are representative of intermediate soil vapor conditions deeper than just below slab and less than the 15 feet bgs guideline depth for the MTCA deep soil vapor screening levels. Therefore, an intermediate site-specific screening level was calculated for each chemical by calculating half the difference between the MTCA Method C below-slab and deep screening levels from Table B-1 in the guidance.

**Bold** Indicates compound was detected in the sample.

**Bold & Red** Exceeds the screening level.

-- No screening level value available from Ecology Gudiance.

Abbreviations:

ft Feet
bgs Below ground surface
Ecology Washington State Department of Ecology
μg/m³ Micrograms per cubic meter
MTCA Model Toxics Control Act
VOC Volatile organic compound

Qualifiers:

J Estimated value
U Not detected

**Table 11.2**
**Landfill Gas Building Control Technologies**

| LFG Building Control Technology | Advantages | Disadvantages | Applicability to South Park Landfill |
|---|---|---|---|
| Impermeable floor/slab barriers | • Simple<br>• Low maintenance<br>• Low cost<br>• Positive barrier<br>• Easy to construct in new construction | • Not applicable for existing slab on grade<br>• Expansion joints, penetrations, interfaces, or cracks may allow gas access without careful design | High |
| Interior building monitoring | • Provides emergency alarm | • Requires routine O&M<br>• Moderate/expensive cost<br>• Not always compatible with building use<br>• Coverage area is small<br>• False-positive alarms | Moderate/High |
| Passive venting | • Simple<br>• Low maintenance<br>• Easily combined with impermeable barriers<br>• Low cost | • Not applicable for existing slab on grade<br>• Limited to perimeter trenching | Moderate/High |
| Impressed air curtain | • Easy to monitor discharge air<br>• Applicable for existing buildings<br>• Moderate operation cost<br>• Moderate construction cost<br>• Can be tied into existing below-slab aggregate layer<br>• Easy to retrofit<br>• Vents LFG from below existing buildings | • May need odor treatment<br>• Requires routine O&M | Moderate |
| Active perimeter collection below buildings (trench or wells) | • Applicable for existing buildings<br>• Moderate operation cost<br>• Moderate construction cost<br>• Can be tied into existing below-slab aggregate layer | • Less effective than vents and barriers<br>• Methane and possible odors<br>• Requires routine O&M | Moderate/Low |

Abbreviations:
LFG Landfill gas
O&M Operation and Maintenance

**Table 11.3**
**Landfill Gas Control Technologies**

| LFG Control Technology | Advantages | Disadvantages | Applicability to South Park Landfill |
|---|---|---|---|
| Cap/Cover systems | • Simple<br>• Low maintenance | • Moderate cost<br>• Needs to work in concert with LFG system | Moderate/High |
| Passive trench venting | • Low cost<br>• Minimal O&M<br>• Convertible to active<br>• Compatible with multiple systems<br>• Effective at waste extents<br>• Works well with impermeable cover systems<br>• Works well with semi-permeable covers over subsurface collection layers (i.e., crushed rock under asphalt pavement) | • Limited radius of influence within landfill | Moderate |
| Perimeter barriers | • Controls migration at waste extents | • Moderate to high cost<br>• Utility conflicts | Moderate |
| Extraction wells | • Discrete zone control<br>• Shallow depth makes affordable<br>• Compatible with multiple systems | • Moderate maintenance required<br>• Moderate cost<br>• Limited influence radius<br>• Requires blower and possible treatment | Moderate |
| Active collection trenches | • Discrete zone control<br>• Compatible with multiple systems | • Moderate maintenance required<br>• Moderate cost<br>• Limited influence radius<br>• Requires blower and possible treatment | Moderate |

Abbreviations:
LFG Landfill gas
O&M Operation and Maintenance

# Table 11.4
# Landfill Gas Treatment Technologies

| LFG Treatment Technology | Advantages | Disadvantages | Applicability to South Park Landfill |
|---|---|---|---|
| Flare | • Simple<br>• Low maintenance<br>• Complete destruction of NMOC, methane, and odors | • Requires high auxiliary fuel use<br>• Requires enclosed flame—large footprint<br>• Moderate cost | Low |
| Thermal oxidizer | • Complete destruction of NMOCs, methane, and odors | • Requires auxiliary fuel<br>• Moderate maintenance required<br>• High cost | Moderate/Low |
| Regenerative catalytic resin membrane | • Destroys NMOCs | • Moderate maintenance required<br>• Vents methane and possible odors<br>• High cost | Low |
| Carbon filter | • Simple<br>• Controls some NMOCs and odors<br>• Low cost | • Vents methane<br>• Requires frequent carbon replacement<br>• Selective control | Moderate |
| Compost filter | • Simple<br>• Effective on odors<br>• Low cost | • Vents methane<br>• Large footprint<br>• Maintenance of compost media | Moderate/Low |

Abbreviations:
LFG Landfill gas
NMOC Non-methane organic compound

**Table 14.1**
**Proposed Analytical Schedule[1]**

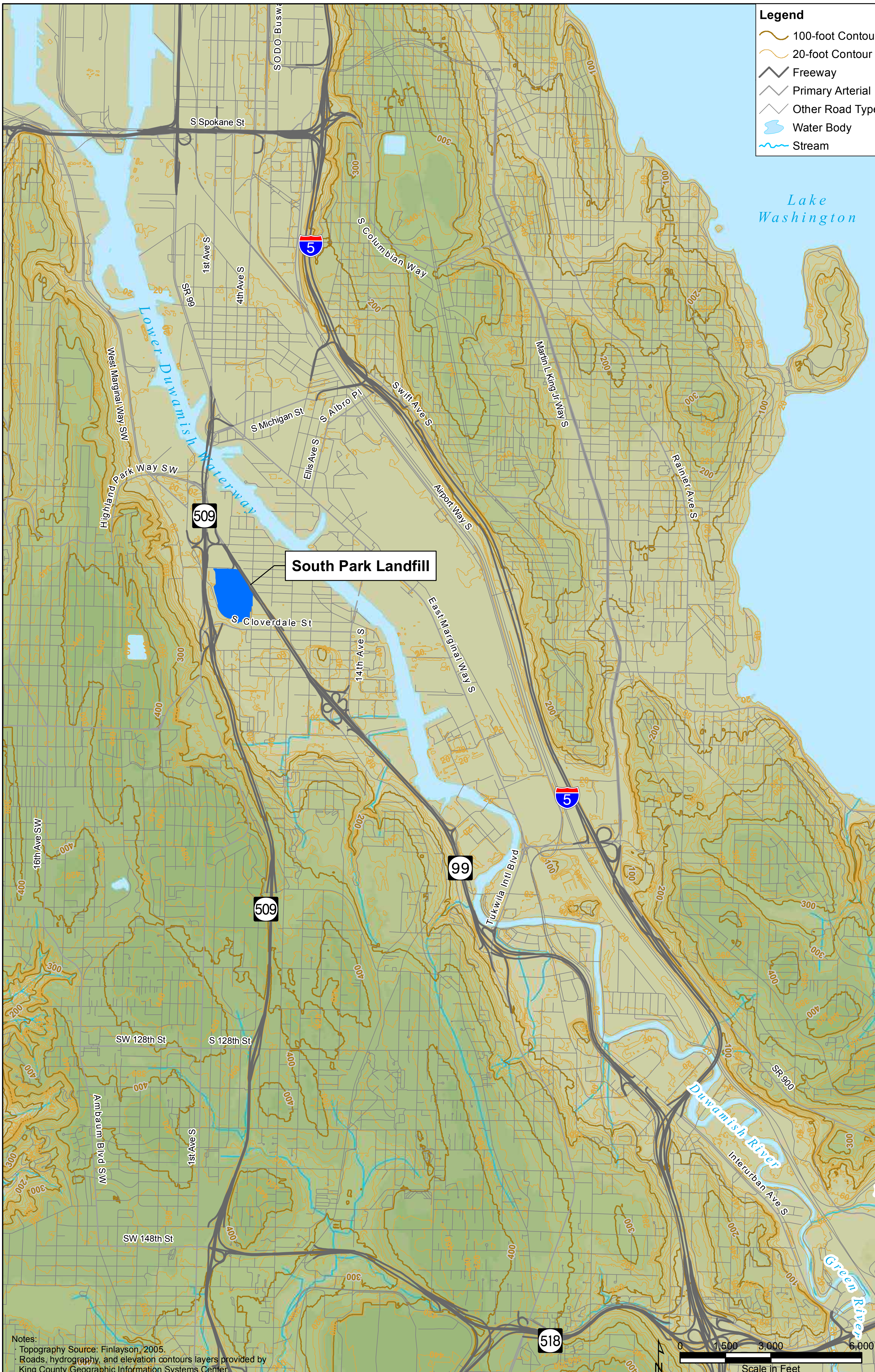
| Chemical/Parameter | Analytical Method[1] | Monitoring Well |
|---|---|---|
| Vinyl chloride | SW846 – 8260 Short List | All wells |
| Iron, total | SW846 –6020 Short List | All wells |
| Manganese, total | SW846 – 6020 Short List | All wells |
| Benzene | SW846 – 8260 Short List | MW-25 |
| *cis*-1,2-DCE | SW846 – 8260 Short List | All wells |
| Arsenic, dissolved | SW846 – 6020 Short List | MW-12, MW-08, MW-10, MW-18, MW-24, MW-25, MW-26, MW-27, MW-32, and MW-33 |
| Specific conductivity | Field parameter | All wells |
| pH | Field parameter | All wells |

Note:
1 An equivalent, U.S. Environmental Protection Agency-approved method may be substituted.

**South Park Landfill**

# Remedial Investigation/ Feasibility Study

# Figures

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**Seattle, Washington**

Figure 2.1
Site Location Map

I:\GIS\Projects\COS-SPARK\MXD\RIFS\RIFS_2016\Figure 2.1 Site Location Map.mxd
9/28/2017

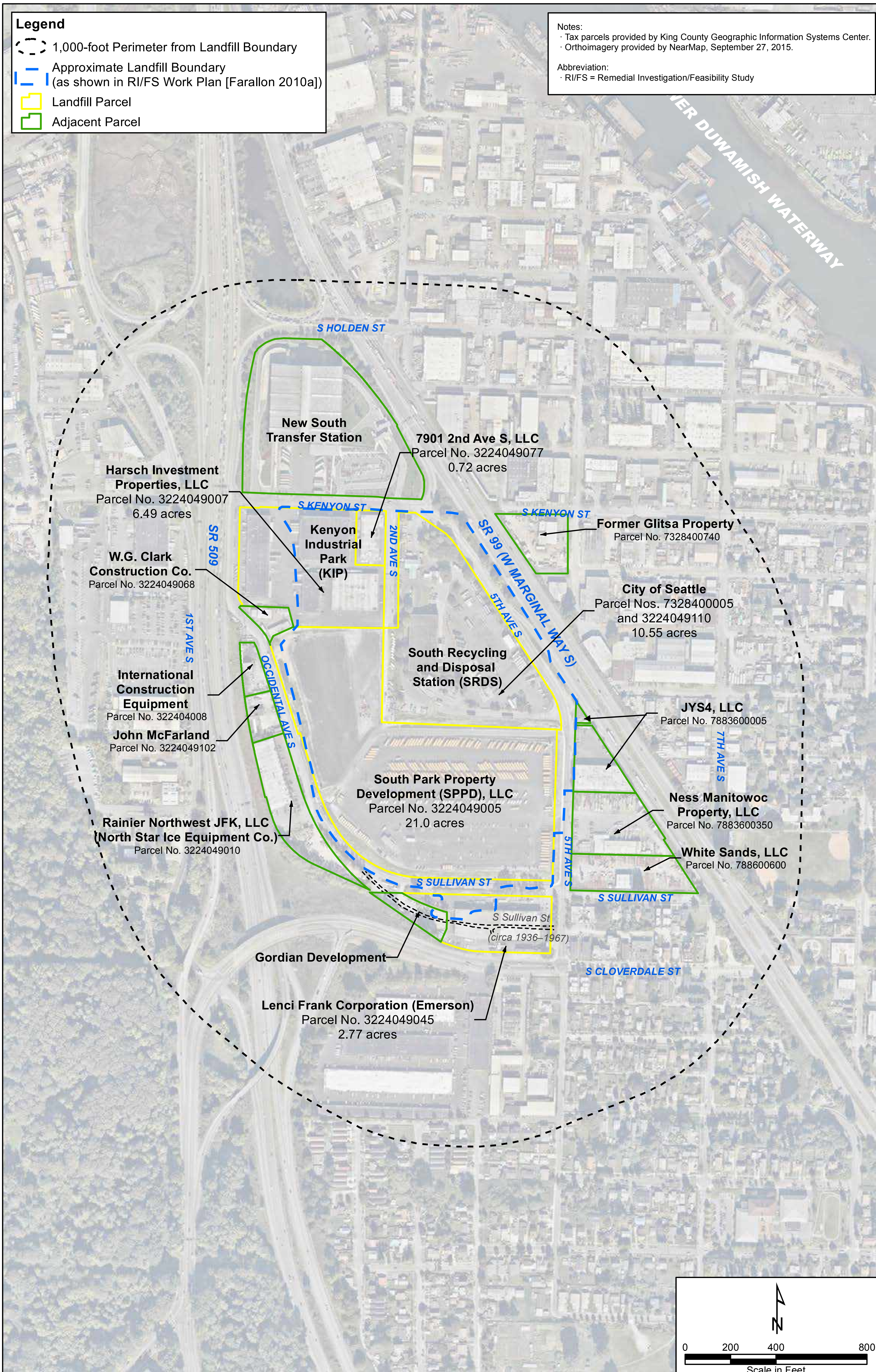


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Figure 2.2
Site Plan and Parcel Map

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9/28/2017

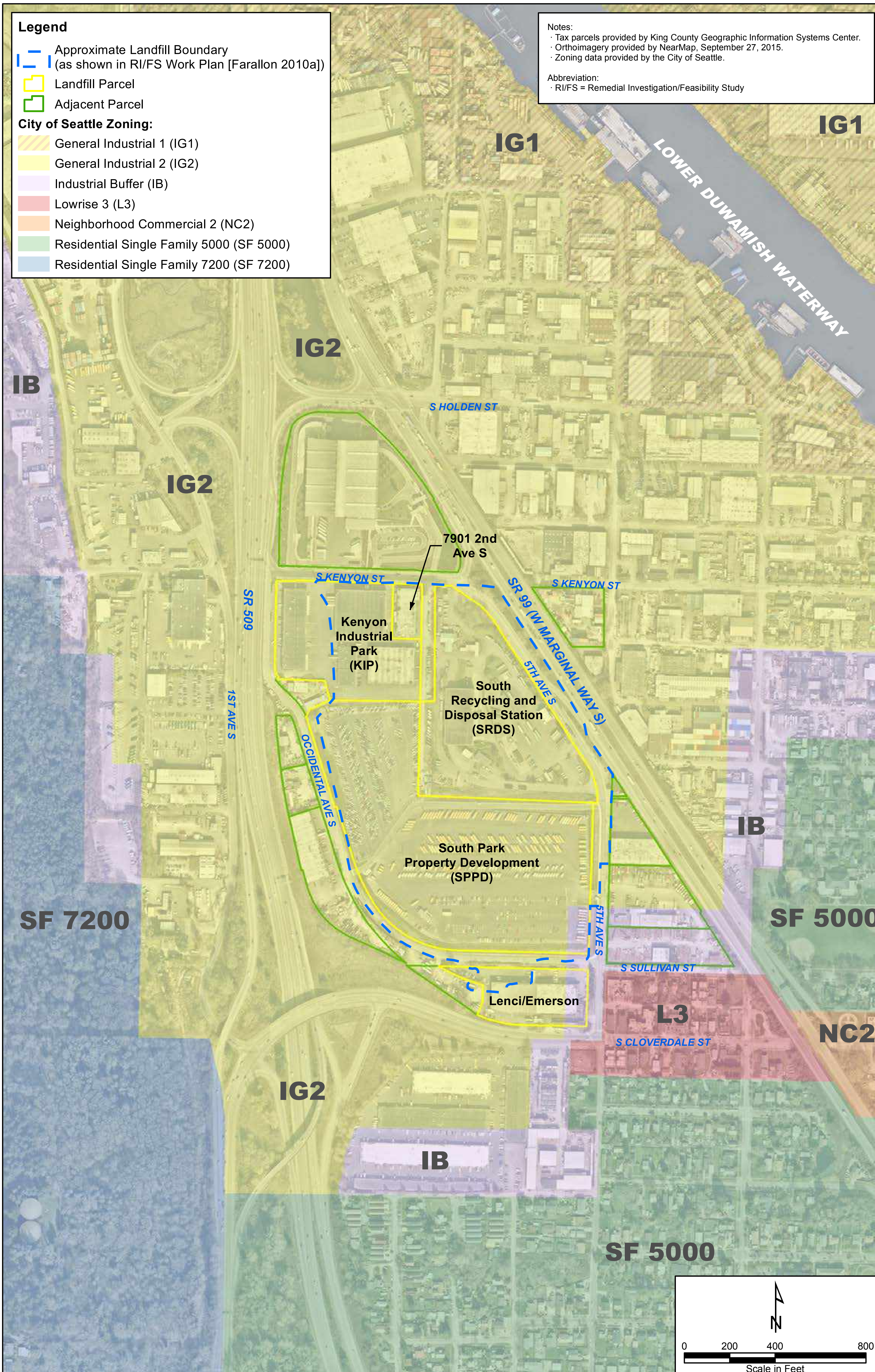


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Figure 2.3
Land Use and Zoning

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9/28/2017

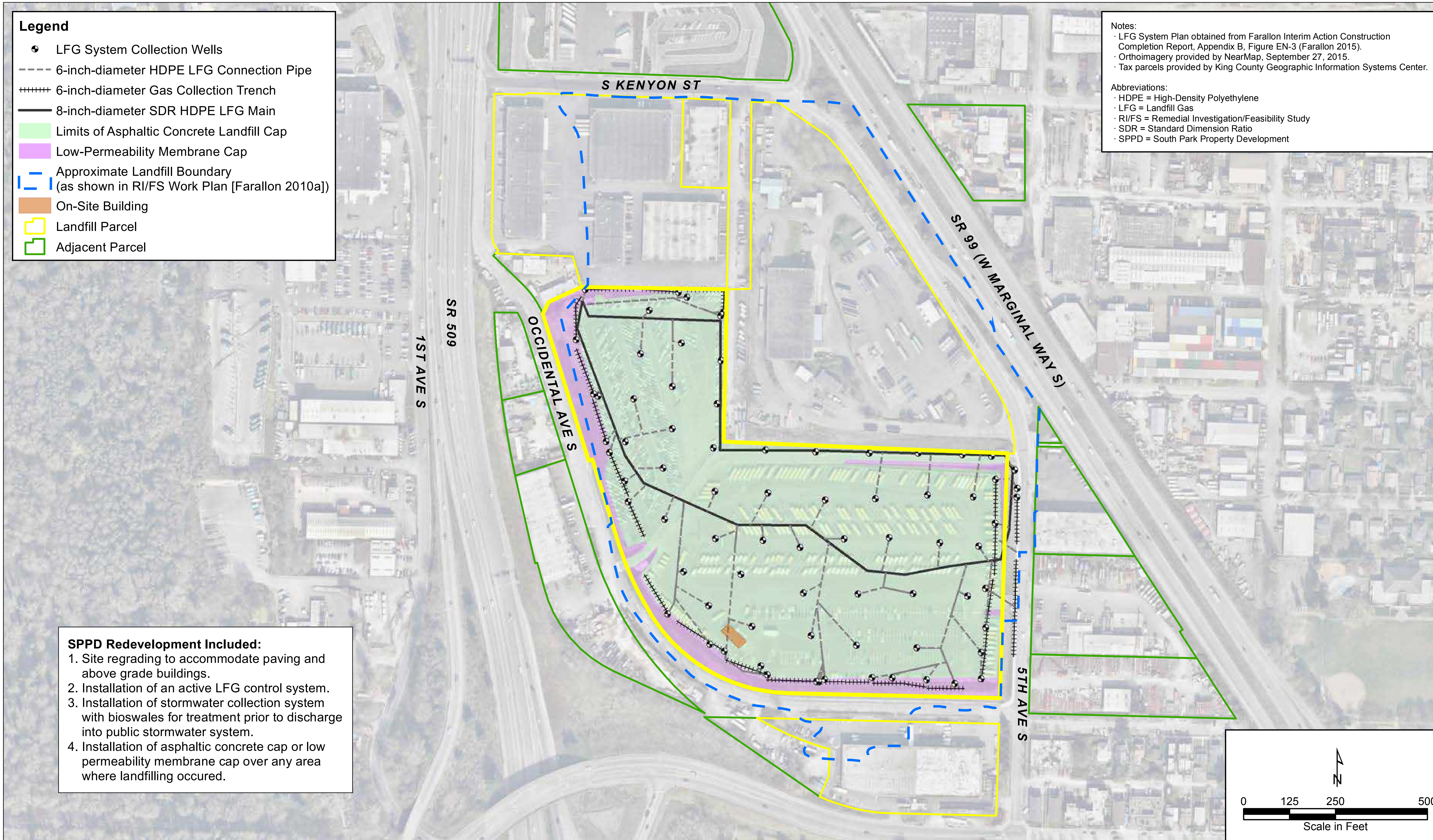


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Figure 2.4
SPPD Current Configuration

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9/28/2017


**Current Site Plan**

Current conditions at the SRDS parcel include an active solid waste transfer facility for Seattle. The parcel contains several large paved areas and buildings. Areas in green are either existing landscaped areas or areas along 2nd Avenue South with a gravel surface for parking.


**Proposed Future Site Plan**

Beginning in 2017, the parcel will be developed to other uses. Between demolition of existing structures and development of new structures, an Interim Action under the MTCA Agreed Order will be conducted to implement remedial action requirements. Design is underway and will incorporate LFG controls, a new cap and stormwater system, and location of long-term monitoring wells and LFG probes.

**Legend**

- Landfill Parcel
- Adjacent Parcel
- Asphalt
- Building
- Concrete
- Landscaping or Unpaved Areas in Current Site Plan

N

0 100 200 400

Scale in Feet

Notes:
- Proposed future site plan digitized from information obtained from HDR, 2016.
- Orthoimagery provided by NearMap, 2015.
- Tax parcels provided by King County Geographic Information Systems Center.

Abbreviations:
- LFG = Landfill gas
- MTCA = Model Toxics Control Act
- SRDS = South Recycling and Disposal Station

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Figure 2.5
SRDS Current Configuration and Planned Redevelopment

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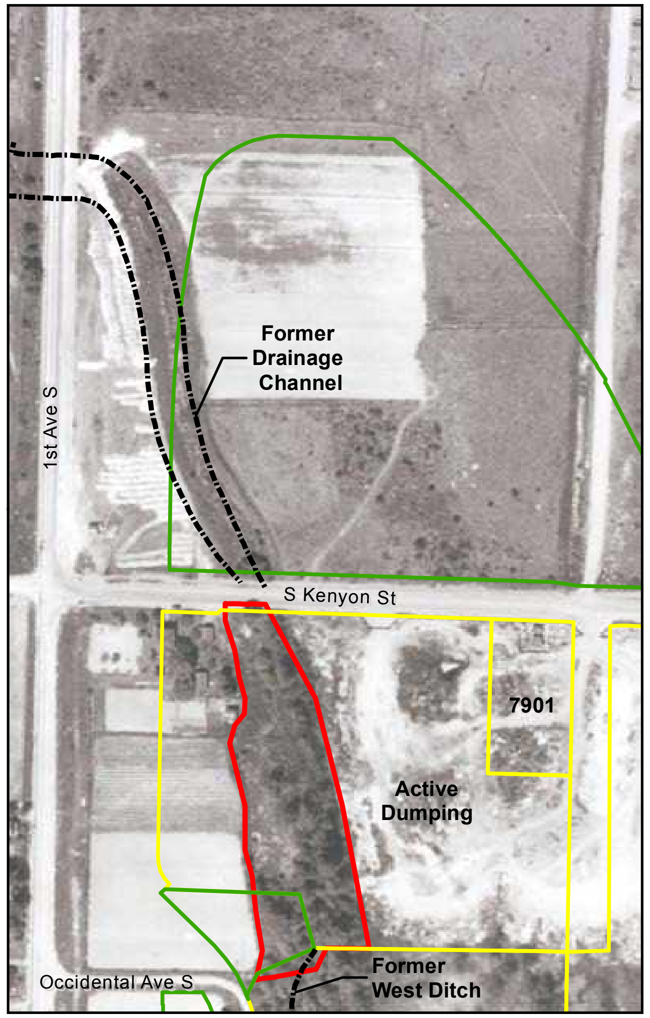
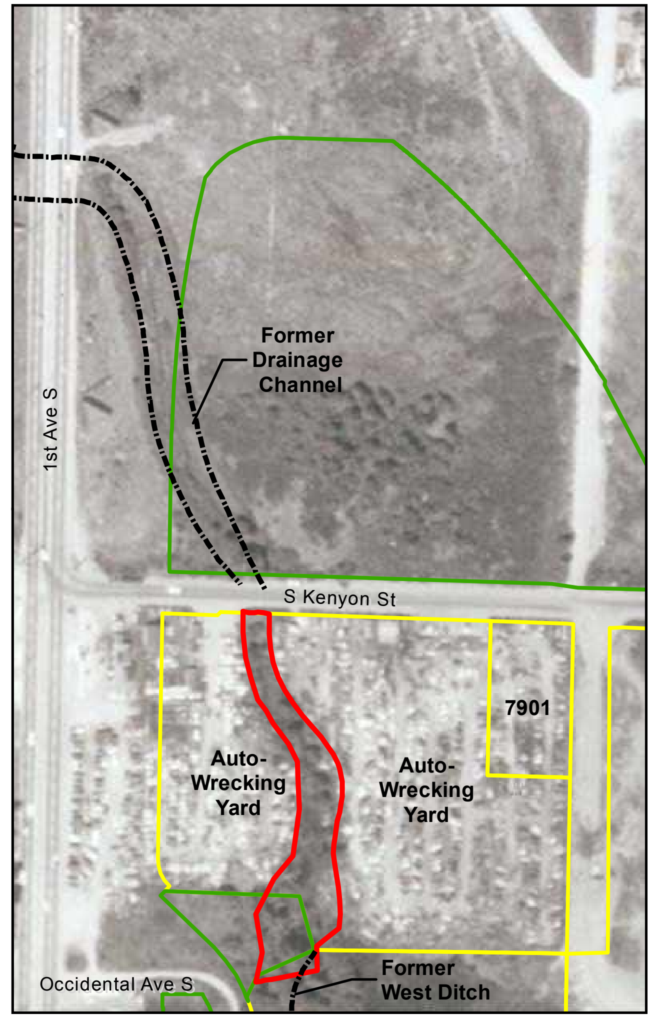
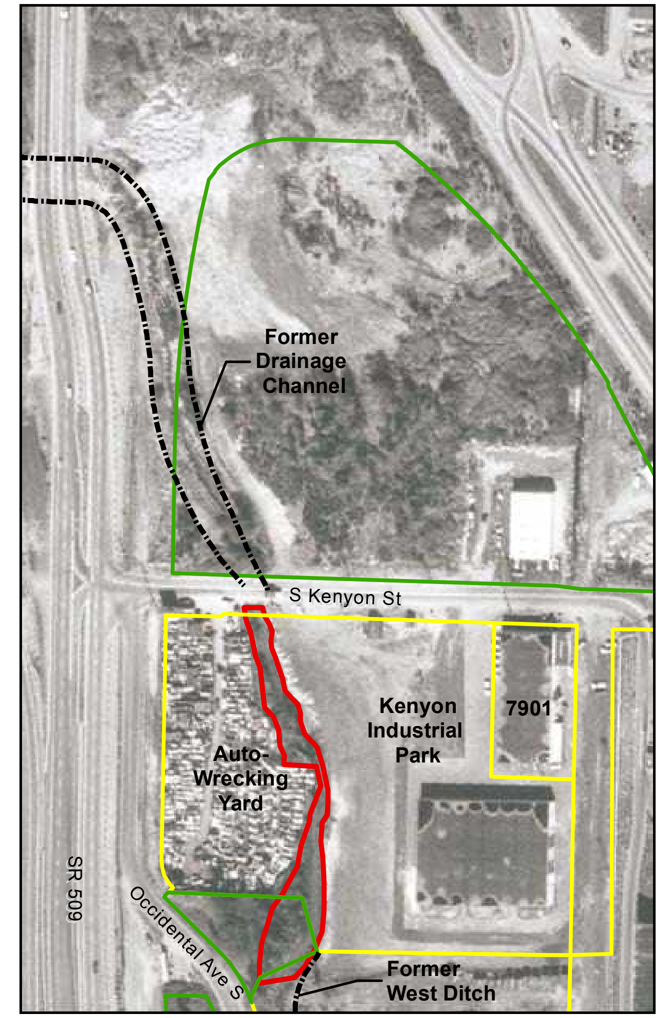
9/28/2017




**1946**
Activities on the KIP and 7901 parcels include active dumping, farming, commercial operating, and residential.




**1960**
Activities on the KIP and 7901 parcels include auto-wrecking.




**1969**
Activities on the KIP parcel include auto-wrecking and the development of a building on the present day KIP parcel and another on the 7901 parcel.


**1974**
Activities on the KIP parcel include filling of the swale, development of the three remaining buildings, paving, and building of a stormwater collection system.

**Legend**

Landfill Parcel | Adjacent Parcel | KIP Swale Boundary

N

0 150 300 600
Scale in Feet

Notes:
· Tax parcels provided by King County Geographic Information Systems Center.
· Aerial imagery provided by Seattle Public Utilities.

Abbreviation:
7901 = 7901 2nd Ave S, LLC
KIP = Kenyon Industrial Park

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Figure 2.6
Time Lapse Aerial Photographs of Kenyon Industrial Park and 7901 Parcels

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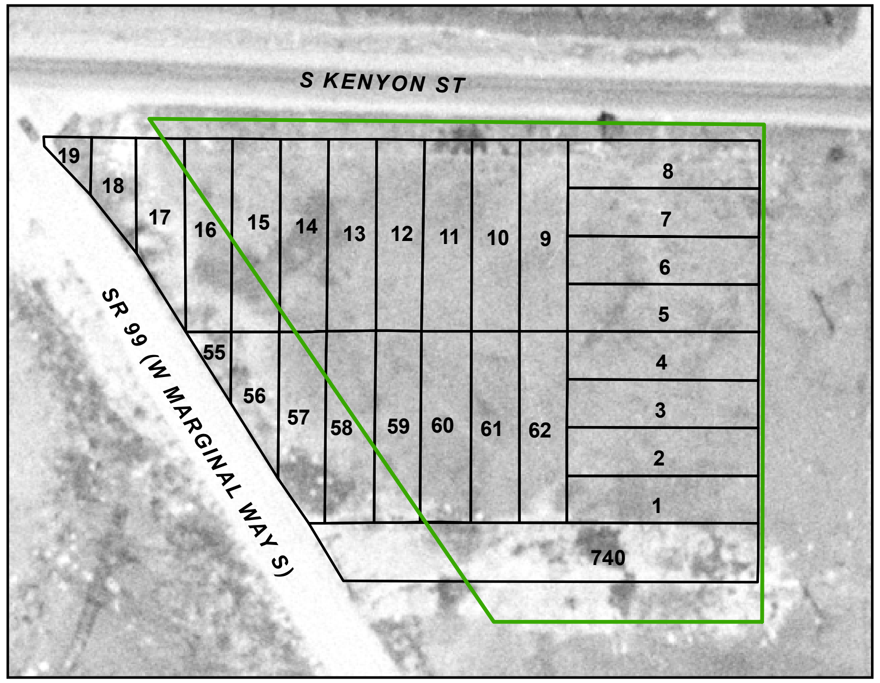
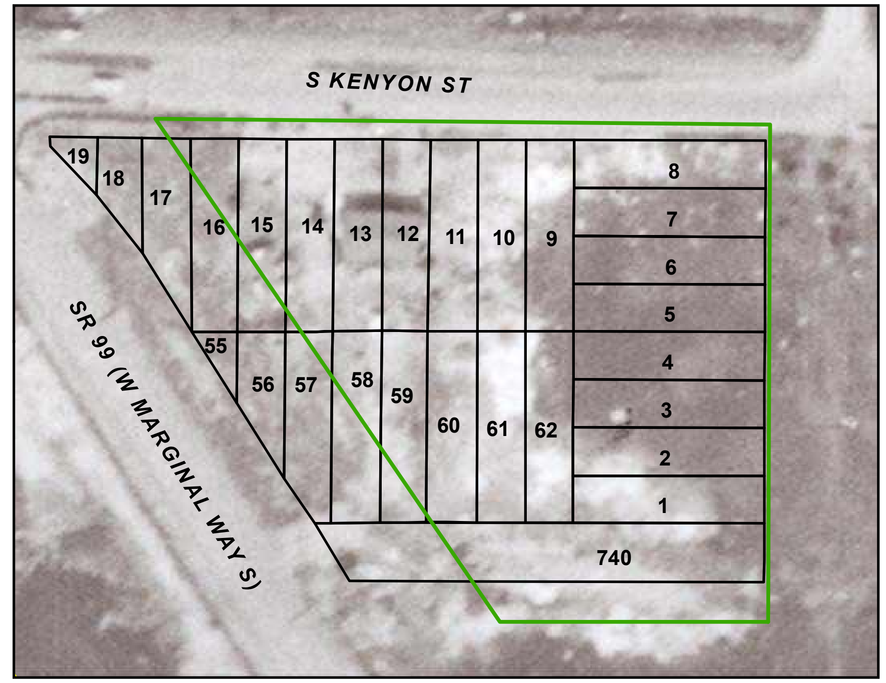
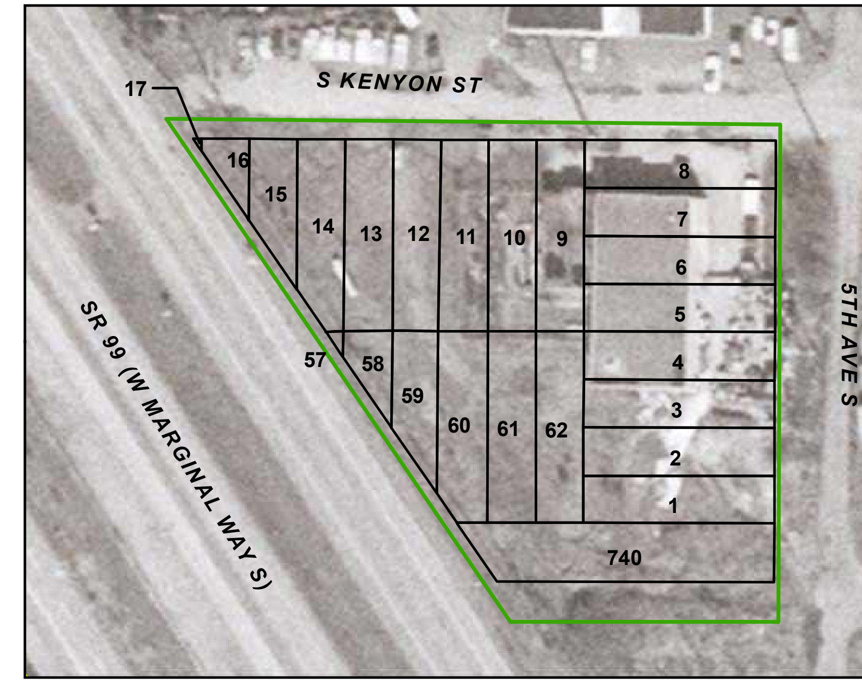
9/28/2017



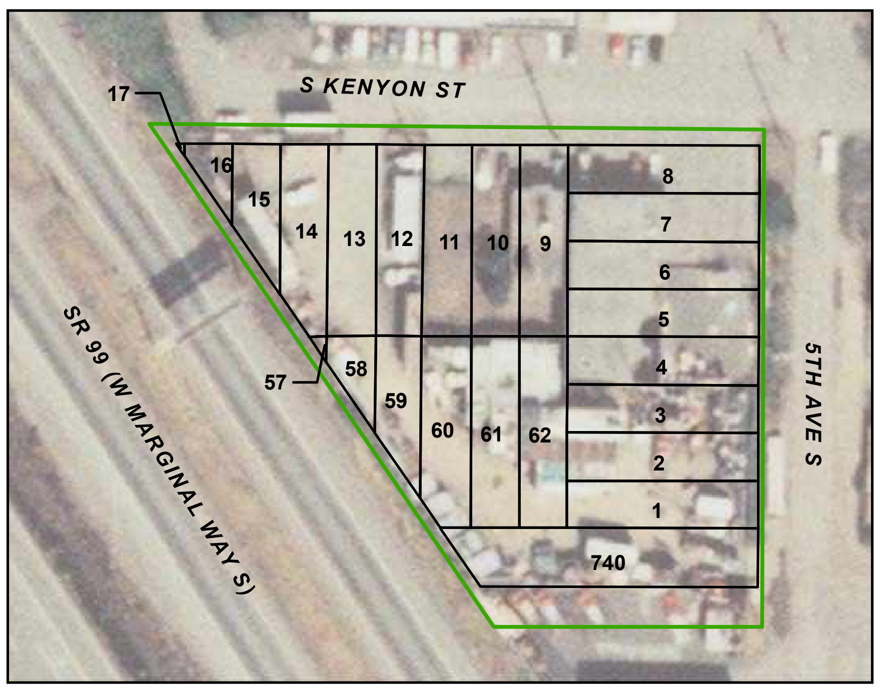

1948




1956




1974




1992

**Historical Property Notes**

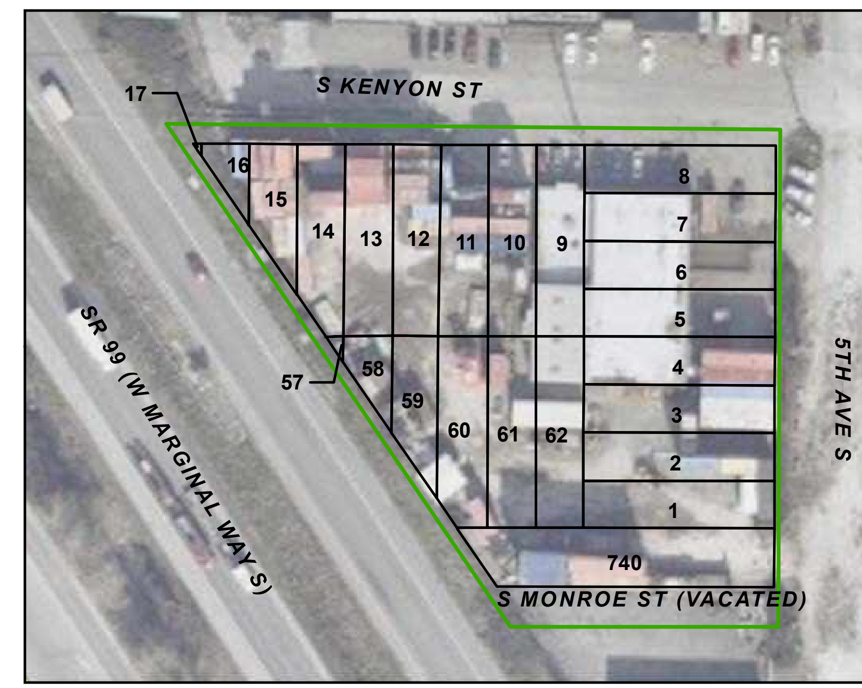
1948: Property not in use.

1956: Property in use as a commercial facility operated by a private party (variously, as Auto Top & Trim Company, M.B. Barker, and Austin's Welding) starting in 1953.

1974: Property owned and operated by Farwest Paint Manufacturing Company.

1992: Property in use by Glitsa American Inc., a floor finishing manufacturer.

2015: Property in use by Tenor Company, LLC.




2015

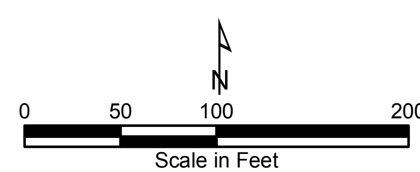
**Legend**

Former Glitsa Parcel

Historical Lot Line

Notes:

- Aerial imagery provided by Seattle Public Utilities.
- Historical lots lines georeferenced from the First Addition to River Park Plat Map (ca. 1892). Map obtained from King County Archives.
- Tax parcels provided by King County Geographic Information Systems Center.

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**Seattle, Washington**

Figure 2.7
Time Lapse Aerial Photographs
of Former Glitsa Property and Farwest Paint Parcel

I:\GIS\Projects\COS-SPARK\MXD\RIFS\RIFS_2016\Figure 2.7 Time Lapse Aerial Photographs of Former Glitsa and Farwest Paint Parcel.mxd
9/28/2017

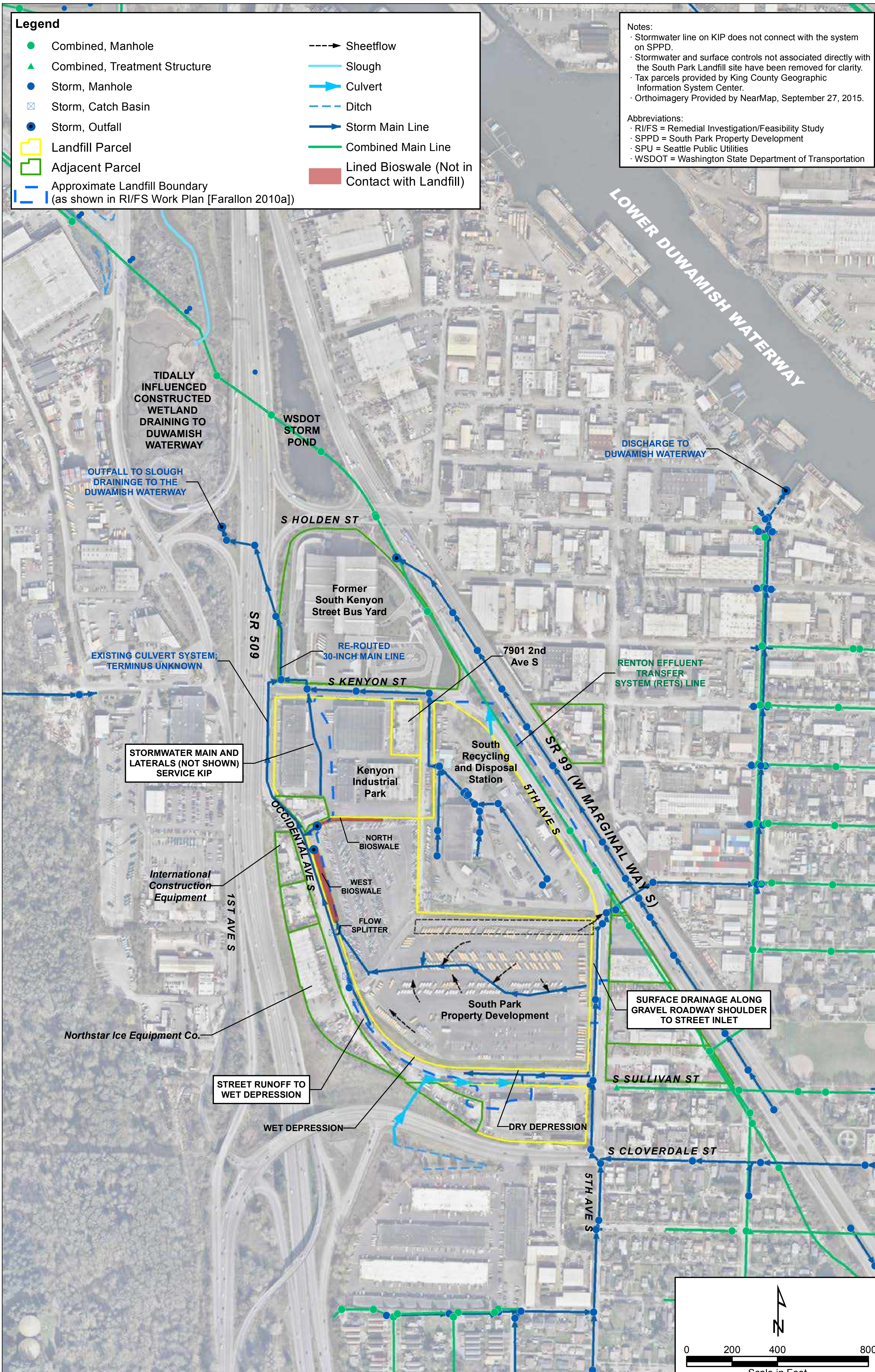


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Figure 2.8
Current Surface Water Drainages and Stormwater Controls

I:\GIS\Projects\COS-SPARK\MXD\RIFS\RIFS_2016\Figure 2.8 Surface Water Drainages and Stormwater Controls.mxd
9/28/2017


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Figure 2.9
Properties with a Known or Suspected Hazardous Substance Release

I:\GIS\Projects\COS-SPARK\MXD\RIFS\RIFS_2016\Figure 2.9 Properties with a Known or Suspected Hazardous Substance Release.mxd
9/28/2017

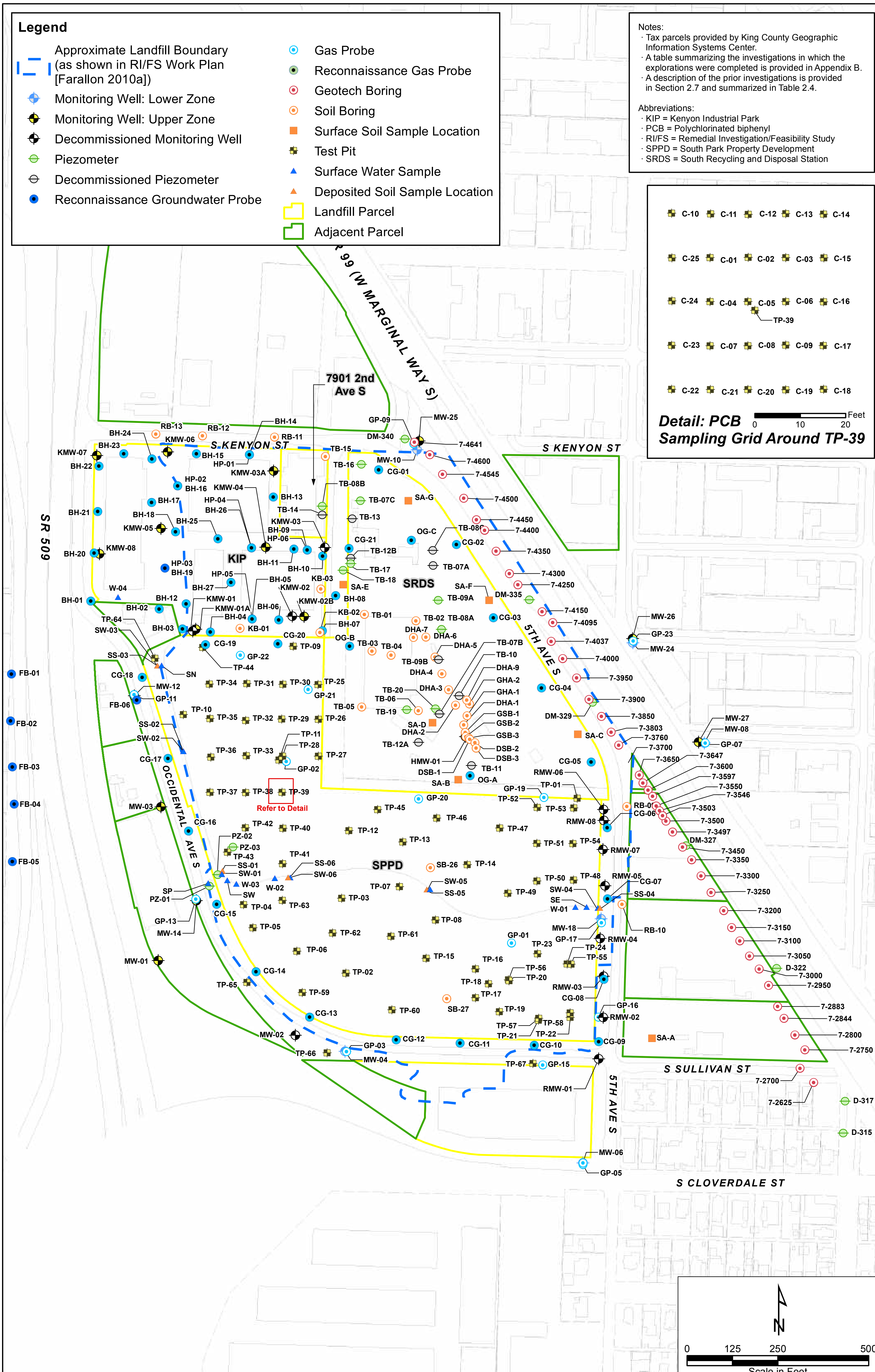


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Figure 2.10
Prior Site Explorations

I:\GIS\Projects\COS-SPARK\MXD\RIFS\RIFS_2016\Figure 2.10 Previous Site Explorations.mxd
9/28/2017

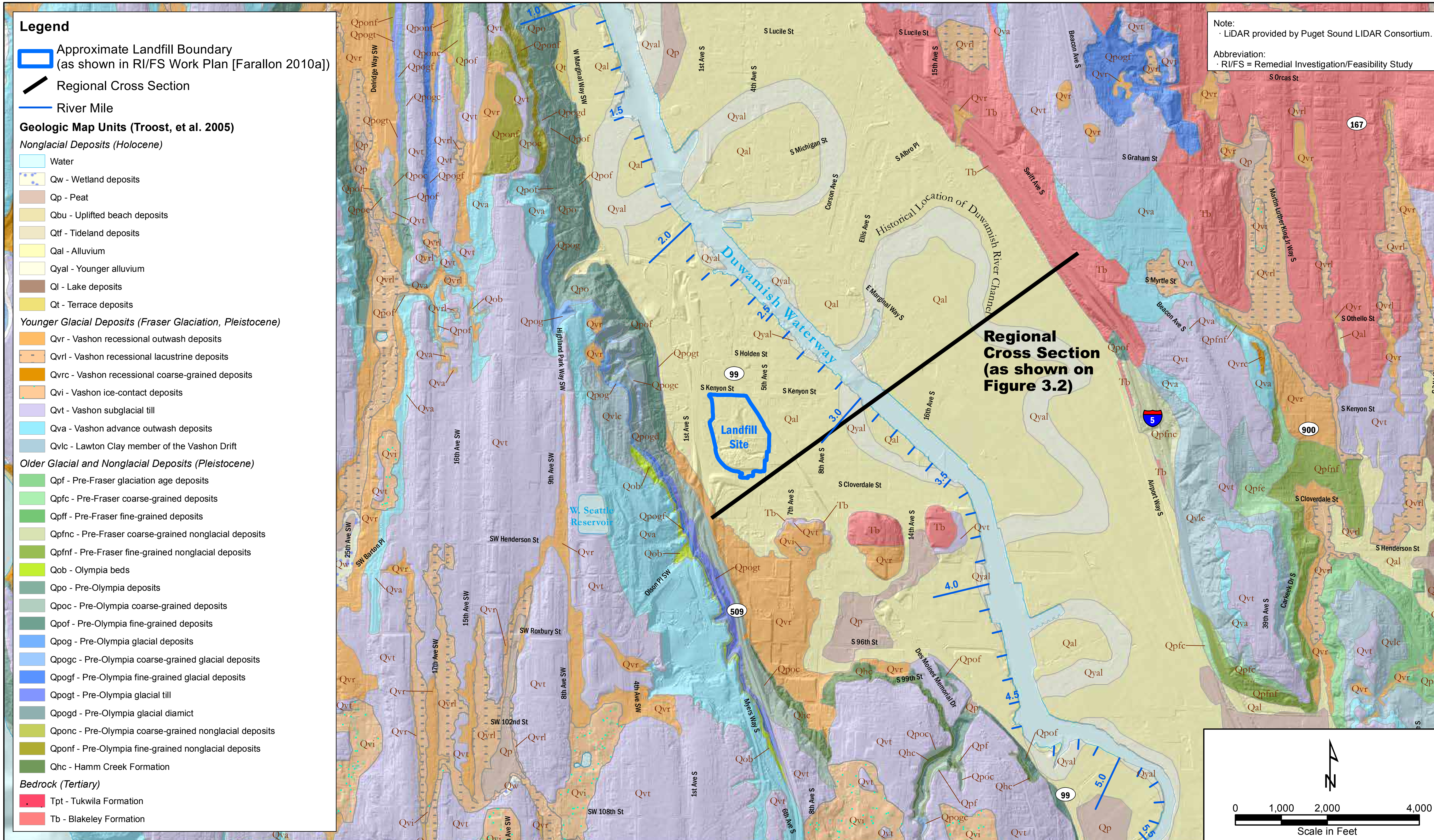


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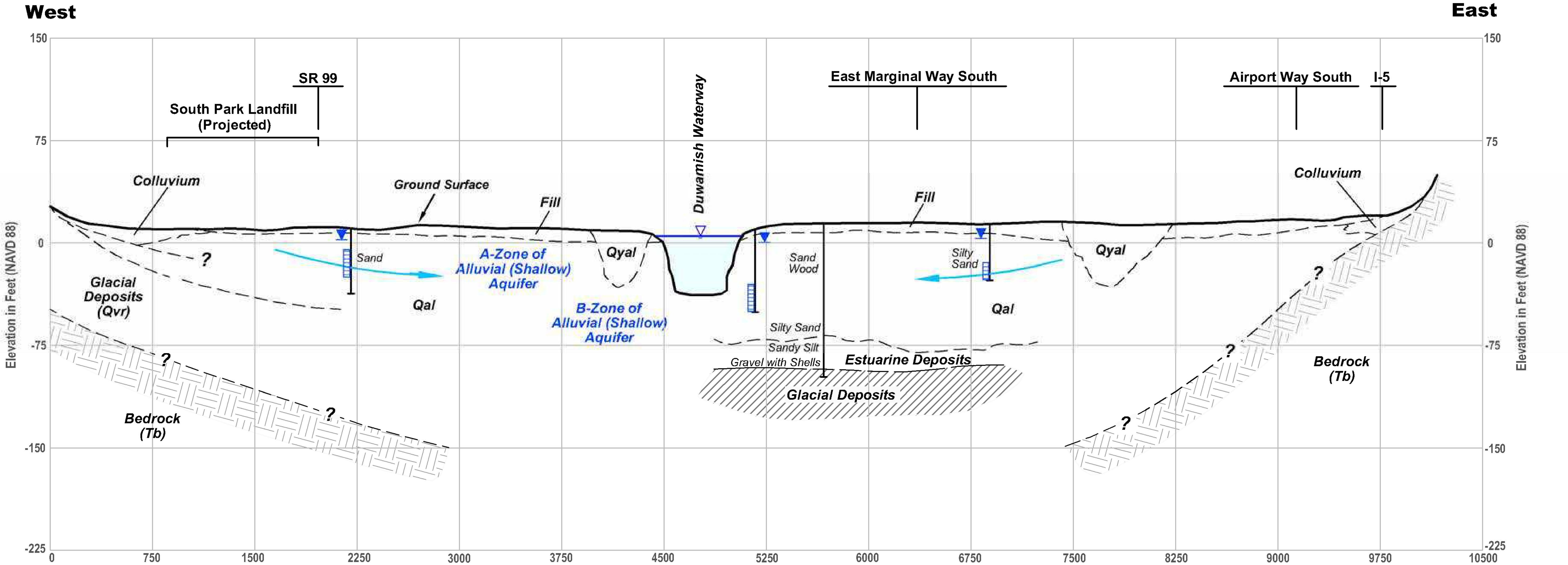
Figure 3.1
Surface Geology Map

I:\GIS\Projects\COS-SPARK\MXD\RIFS\RIFS_2016\Figure 3.1 Surface Geology Map.mxd
9/28/2017




## Legend

**Non-glacial Deposits (Holocene)**

- ***Qyal*** Younger Alluvium
- ***Qal*** Alluvium

**Younger Glacial Deposits (Frasier Glaciation, Pleistocene)**

- ***Qvr*** Vashon Recessional Outwash Deposits
- Undifferentiated Glacial Deposits

**Bedrock (Tertiary)**

- ***Tb*** Blakeley Formation

**Well Completion Information**

- Well
- Surface Water Level
- Static Water Level
- Approximate Geologic Unit Contact
- Inferred Geologic Unit Contact
- Screen Interval
- Groundwater Flow

Vertical Exaggeration x 10

0 750 1500

0 75 150

Scale: 1" = 750' Horizontal

1" = 75' Vertical

*From the Duwamish Basin Groundwater Pathways Conceptual Model Report (Hart Crowser 1998)*

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Figure 3.2
Regional Cross Section

CAD Path: Q:\South Park Landfill\2011-09\100116-3.2.dwg || 11x17 Landscape || Date Saved: March 20, 2012 || User: pbaker

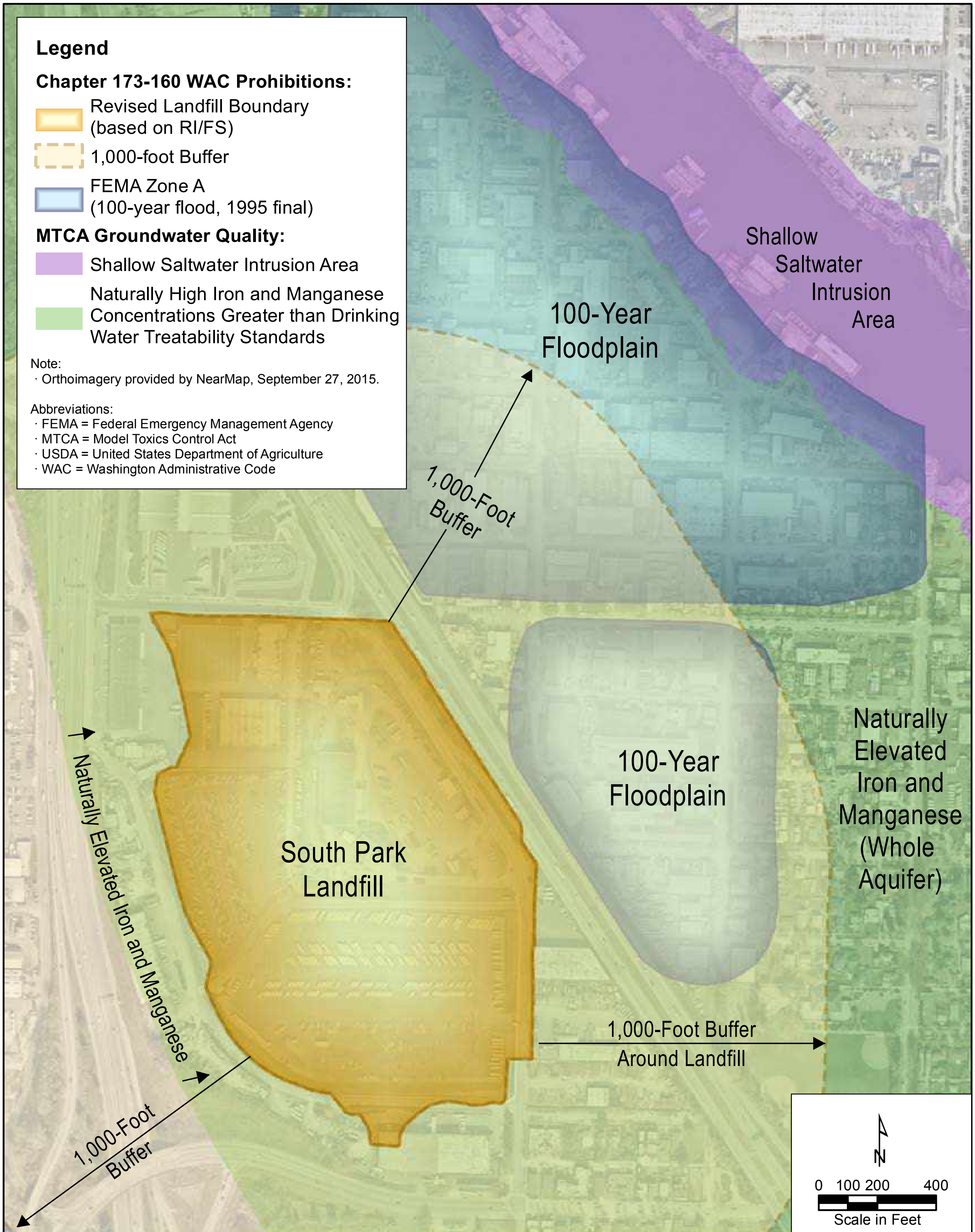


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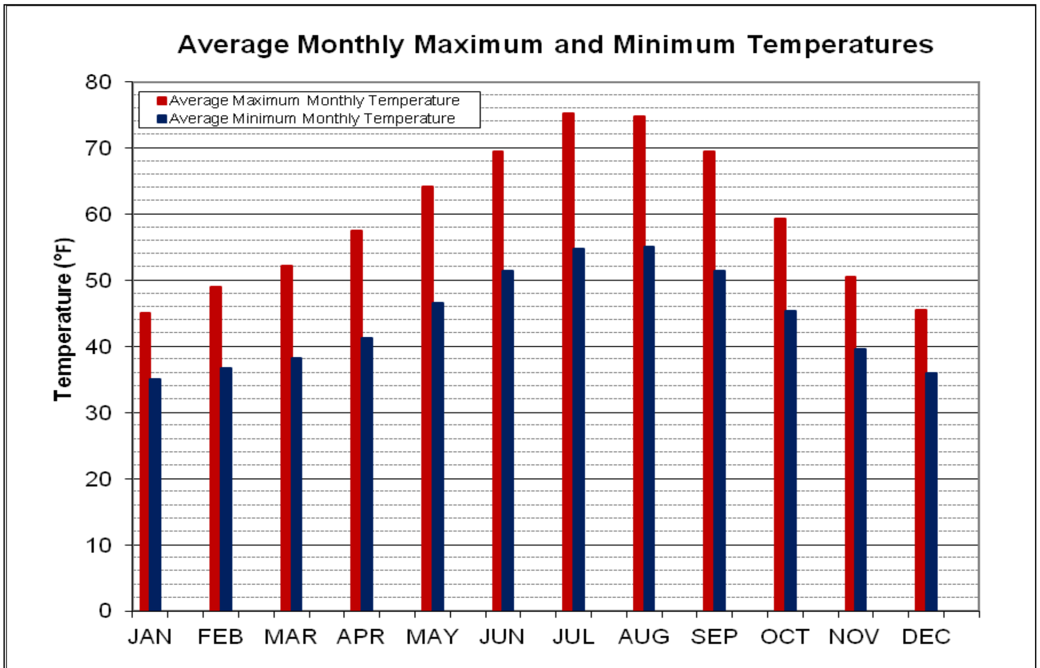
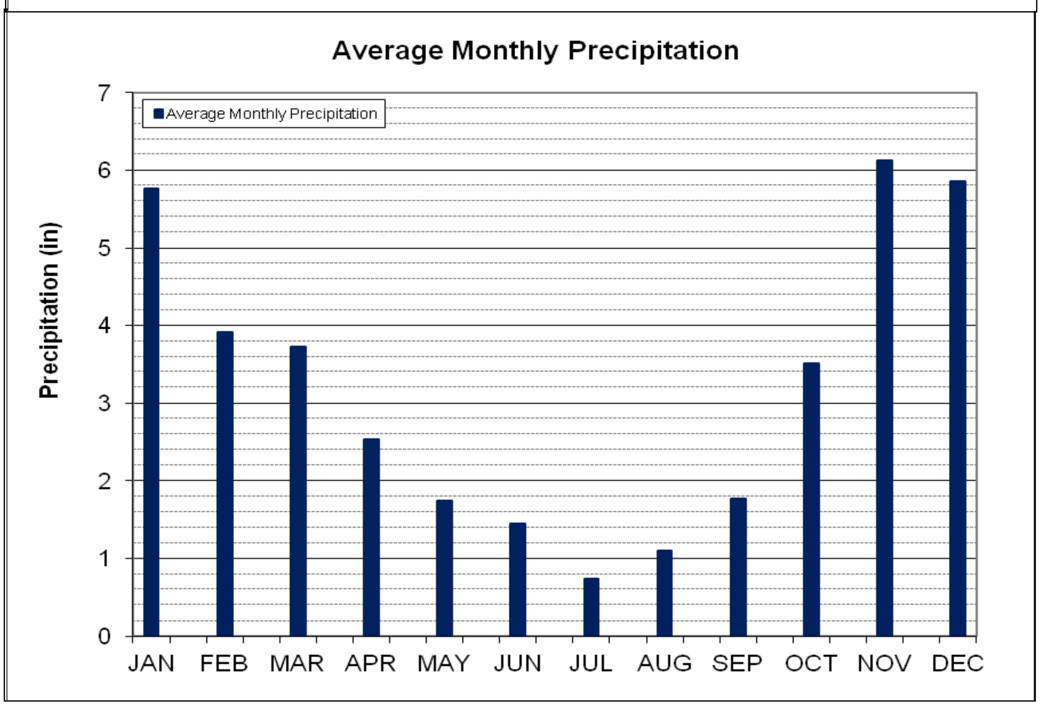
Figure 3.3
Groundwater Restrictions

I:\GIS\Projects\COS-SPARK\MXD\RIFS\RIFS_2017\Figure 3.3 GW Restrictions.mxd
9/28/2017




Notes:

- Seattle monthly temperature and precipitation data from Seattle Tacoma International Airport (National Oceanic and Atmospheric Administration Station No. 457473).
- Individual months with more than 5 days of missing data were not used for either monthly or annual statistics.

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Figure 3.4
Monthly Temperature and Precipitation Data


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Figure 4.1
Historical Footprint of Operations and Fill

I:\GIS\Projects\COS-SPARK\MXD\RIFS\RIFS_2016\Figure 4.1 Historical Footprint of Operations.mxd
9/28/2017

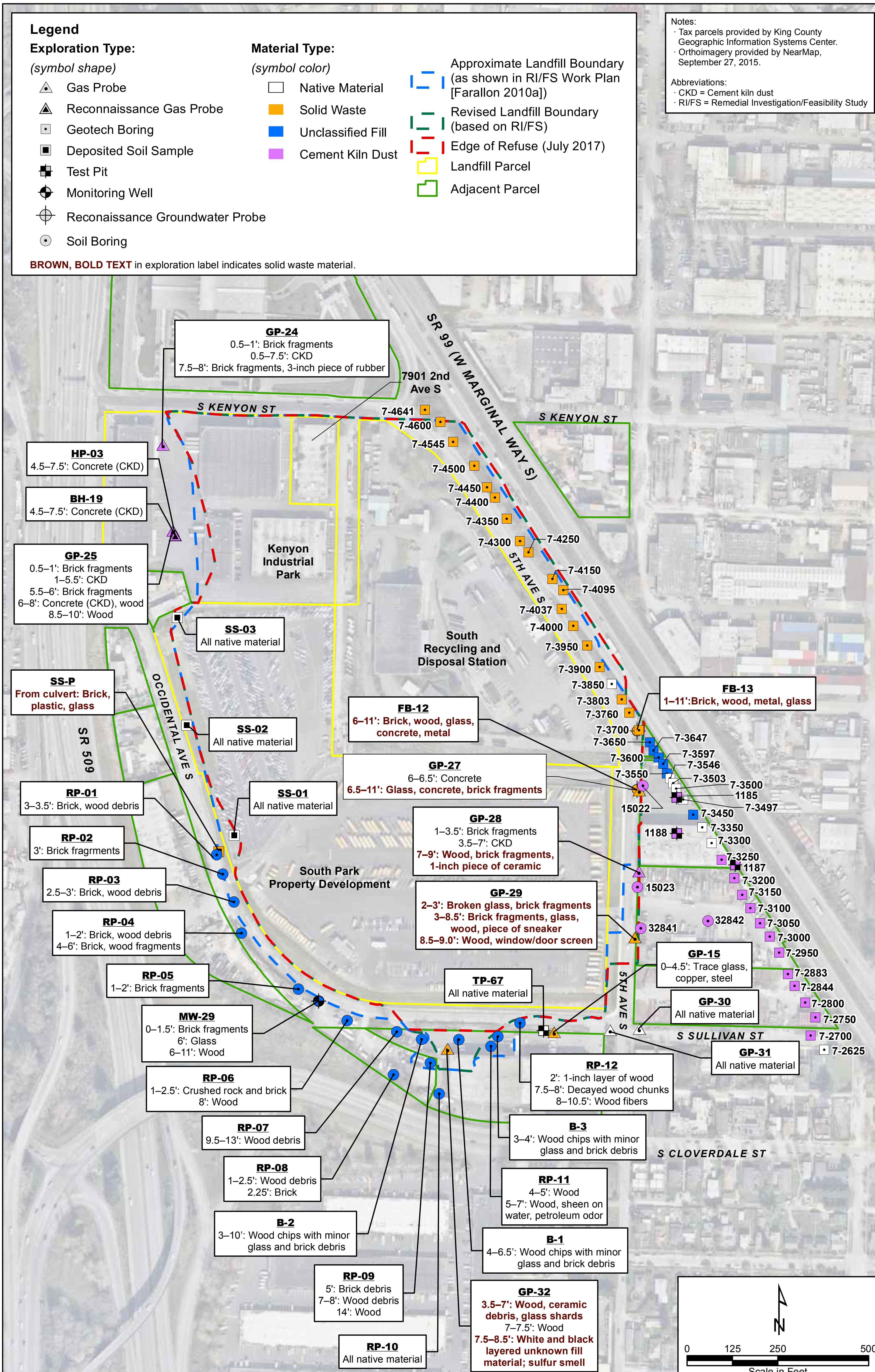


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Figure 4.2
Extent of Solid Waste

I:\GIS\Projects\COS-SPARK\MXD\RIFS\RIFS_2017_FEB18\Figure 4.2 Extent of Solid Waste.mxd
2/12/2018

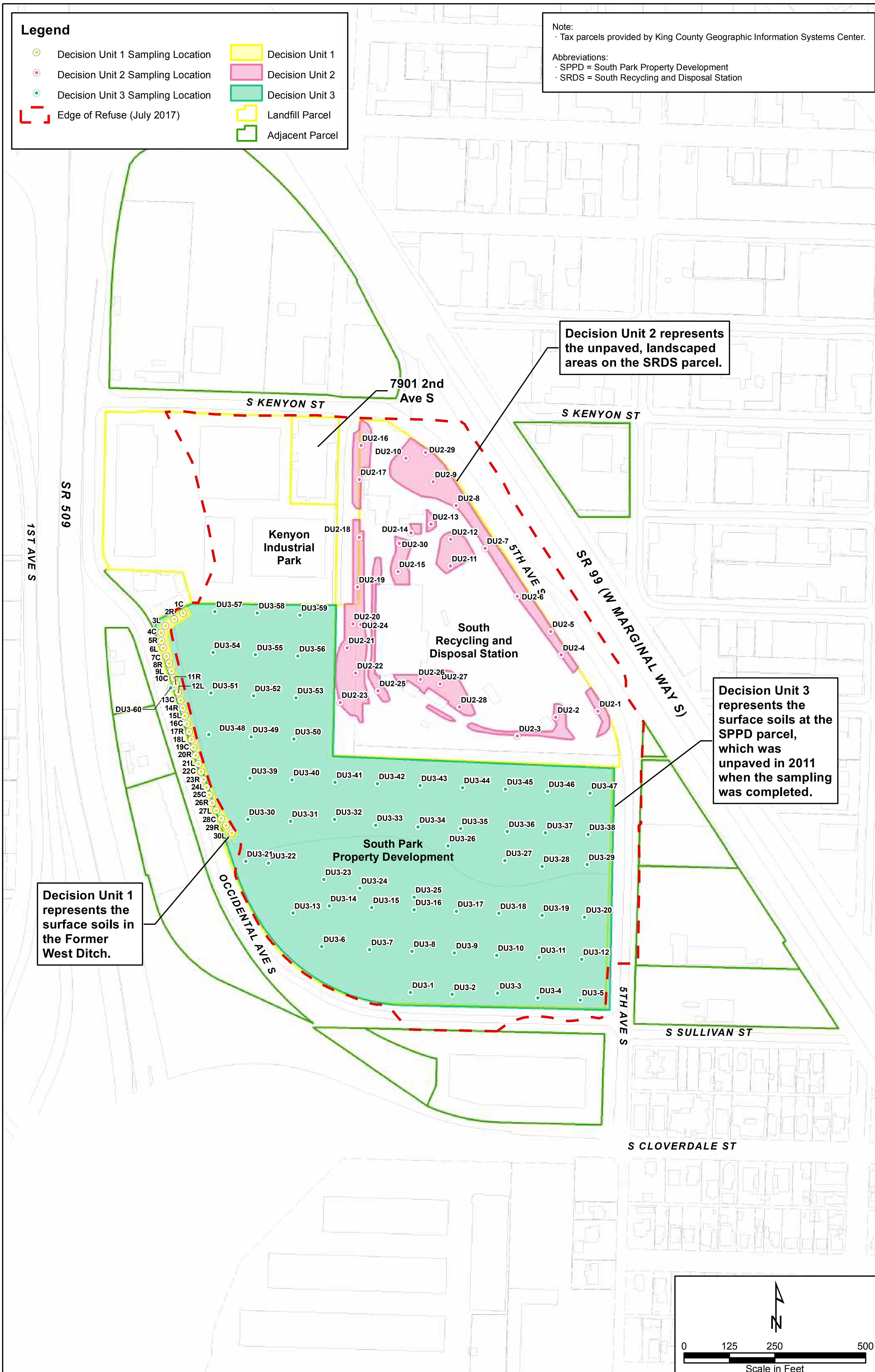


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Figure 4.3
Dioxins/Furans Multi-Increment Sample Locations

I:\GIS\Projects\COS-SPARK\MXD\RIFS\RIFS_2017_FEB18\Figure 4.3 DioxinFuran MI Sampling Locs.mxd 2/12/2018

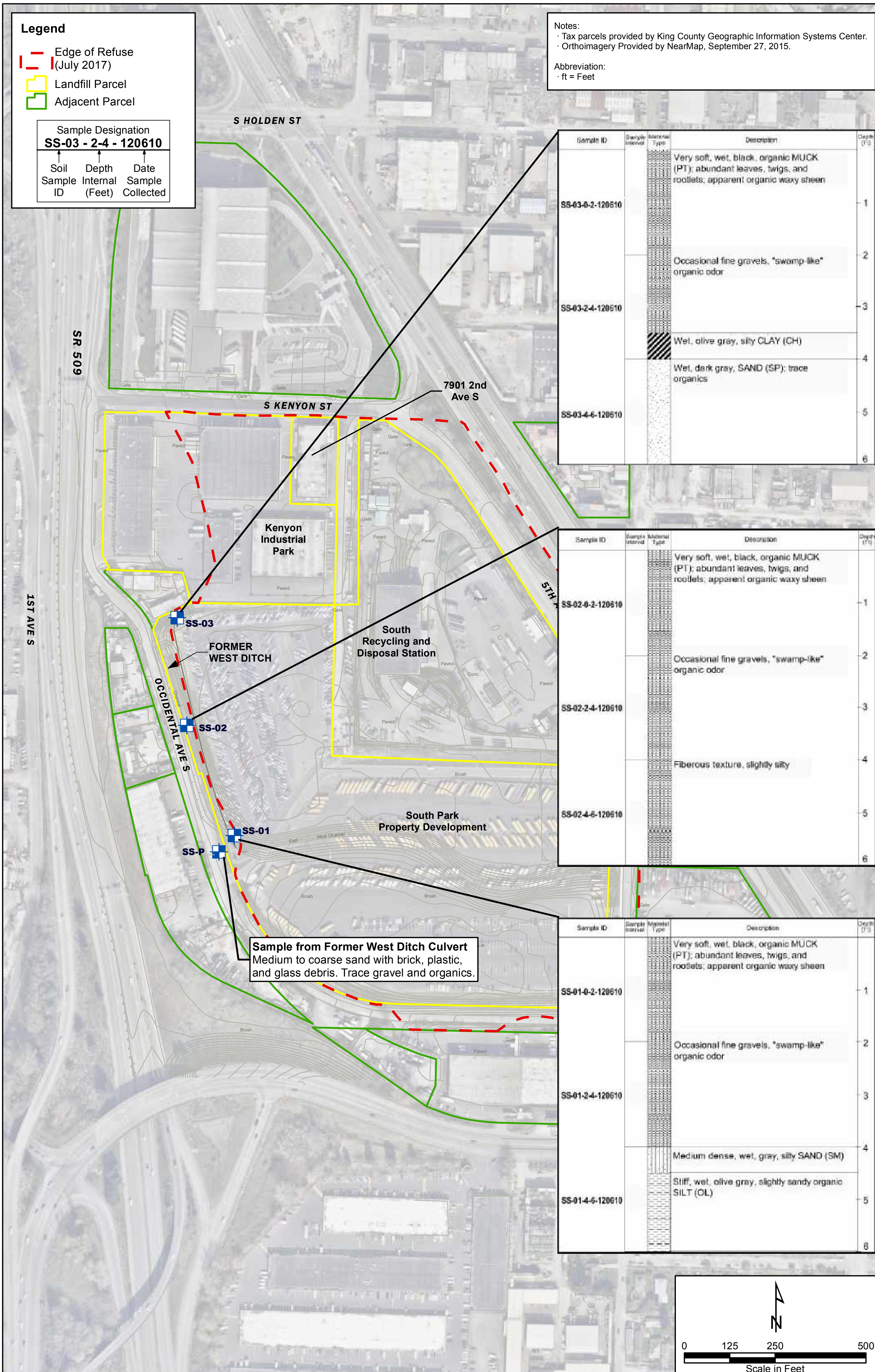


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Figure 4.4
Former West Ditch Soil Samples

I:\GIS\Projects\COS-SPARK\MXD\RIFS\RIFS_2017_FEB18\Figure 4.4 Former West Ditch Soil Samples.mxd
2/12/2018

| | STAGE 1 | STAGE 2 | STAGE 3 | STAGE 4 | STAGE 5 |
|---|---|---|---|---|---|
| **Description** | This stage occurs under aerobic conditions during placement of waste and for a period of days/weeks following. During this stage, $H_2O$ and $CO_2$ are the main products. As wastes hydrolyze, the leachate becomes salty from the dissolution of major cations (sodium, potassium, calcium, and magnesium), chloride from food and other degradable waste, and carbonate from the $CO_2$. The leachate is neutral in pH and salty. | Stage 1 processes resulted in a depletion of $O_2$ in the waste and changed the waste to anaerobic conditions. Carbohydrates, proteins, and lipids are further decomposed to $CO_2$ , $H_2$, ammonia, and organic acids. Gas concentrations in the waste during Stage 2 may rise to levels of up to 80% $CO_2$ and 20% $H_2$. Organic acids that are produced at this stage make the leachate acidic, with acetic acid becoming one of the major constituents. | During this stage under anaerobic conditions, the $H_2$ and $CO_2$ levels begin to decrease. The low $H_2$ levels promote the methane-generating micro-organisms, the methanogens, which begin to generate methane and $CO_2$. The leachate continues to be salty and slightly acidic. The common solvents, PCE and TCE, which were relatively stable during the first two stages, now readily undergo reductive dechlorination to produce DCEs and vinyl chloride. | This stage is the main landfill gas (LFG) generation stage with the LFG typically composed of approximately 60% methane and 40% $CO_2$. The reactions during this stage are relatively slow, taking many years for completion. The conditions continue to be anaerobic as in Stages 2 and 3. Stage 4 typically commences 6 months to several years after the waste has been placed in the landfill depending on the water content and water circulation. Significant concentrations of LFG are generated after between 3 and 12 months, depending on the available micro-organisms and waste-degradation products. The LFG will continue to be generated for periods of between 15 and 30 years after final deposition of waste, but can continue to generate low levels of LFG for up to 100 years after waste placement.<br>Early in this stage the majority of the easily degraded wastes, such as food, have been degraded. The salt content of the leachate decreases; the organic acids are consumed by micro-organisms as soon as they are produced to maintain the methane production and the leachate returns to neutral.<br>Very little solvent (TCE and PCE) remains because it is degraded to DCEs as quickly as it comes into contact with the methanogenic microbes. The methanogenic microbes then convert the DCEs to vinyl chloride and vinyl chloride to non-toxic end-products. This conversion will continue past vinyl chloride as long as there is sufficient waste degradation occurring in the landfill mass to maintain methanogenic conditions. | This final stage of degradation occurs when the acids used in the production of methane and $CO_2$ have been depleted and the landfill returns to aerobic conditions. |
| **Processes** | Waste placement and burial<br>Primary physical breakdown, hydrolysis, and aerobic degradation | Hydrolysis and fermentation | Acetogenesis | Methanogenesis | Oxidation |
| **Leachate** | Aerobic, salty | Organic acids, ammonia, anaerobic, pH begins to drop | Anaerobic, salty, pH acidic due to acetic acid | Anaerobic, slightly salty, near neutral pH | Aerobic, neutral pH |
| **Landfill Gas** | $CO_2$ & $H_2O$ | $H_2$, $CO_2$, $H_2O$, & $NH_3$ | $H_2$, $CO_2$, $H_2O$, $NH_3$, & $CH_4$ | $CH_4$ & $CO_2$ | $CO_2$ |

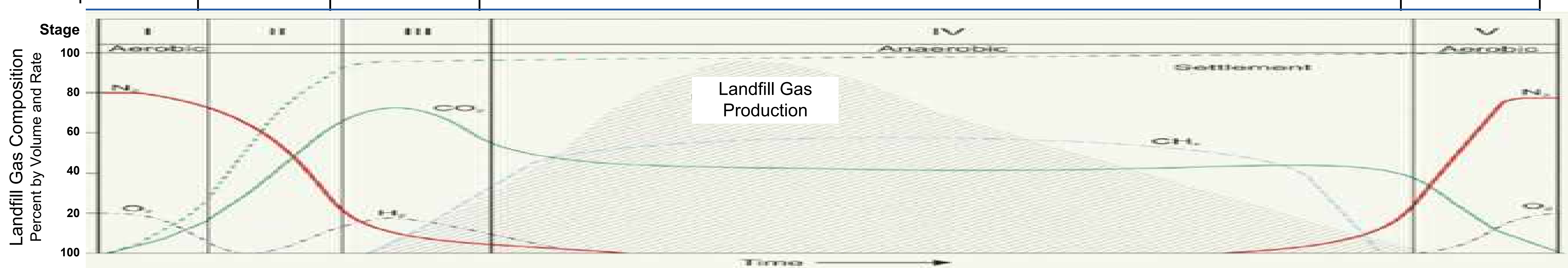


Figure: Changes in the Production and Composition of Landfill Gas with Time (based on Farquhar and Rovers 1973 with additions from Golder 2011).

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**Seattle, Washington**

Figure 4.5
Changes in the Production and Composition of Landfill Gas with Time

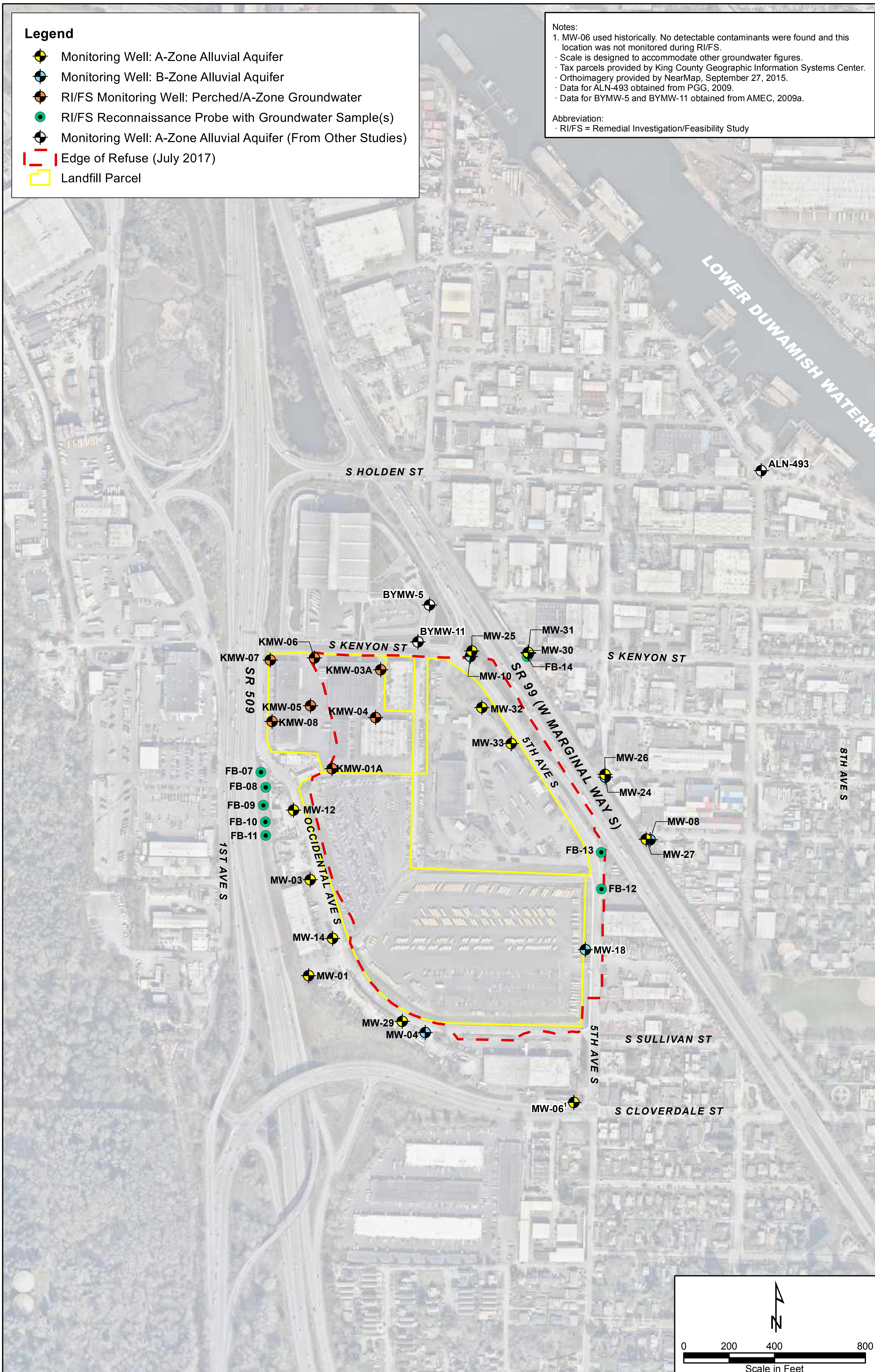


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Figure 5.1
Groundwater Sample Locations

I:\GIS\Projects\COS-SPARK\MXD\RIFS\RIFS_2017_FEB18\Figure 5.1 Groundwater Monitoring Well Locs.mxd
2/12/2018

**Legend**

- Cross Section Data Point
- Edge of Refuse (July 2017)
- Cross Section
- Landfill Parcel

Notes:
· Tax parcels provided by King County Geographic Information Systems Center.
· Orthoimagery provided by NearMap, September 27, 2015.
· For cross section purposes, only monitoring wells and soil borings within 200 feet of the cross sections were used and are shown on this figure. The locations of the historical explorations are presented on Figure 2.10 and the groundwater monitoring wells and reconnaissance probes sampled during this RI/FS are presented on Figure 5.1.

Abbreviation:
· RI/FS = Remedial Investigation/Feasibility Study

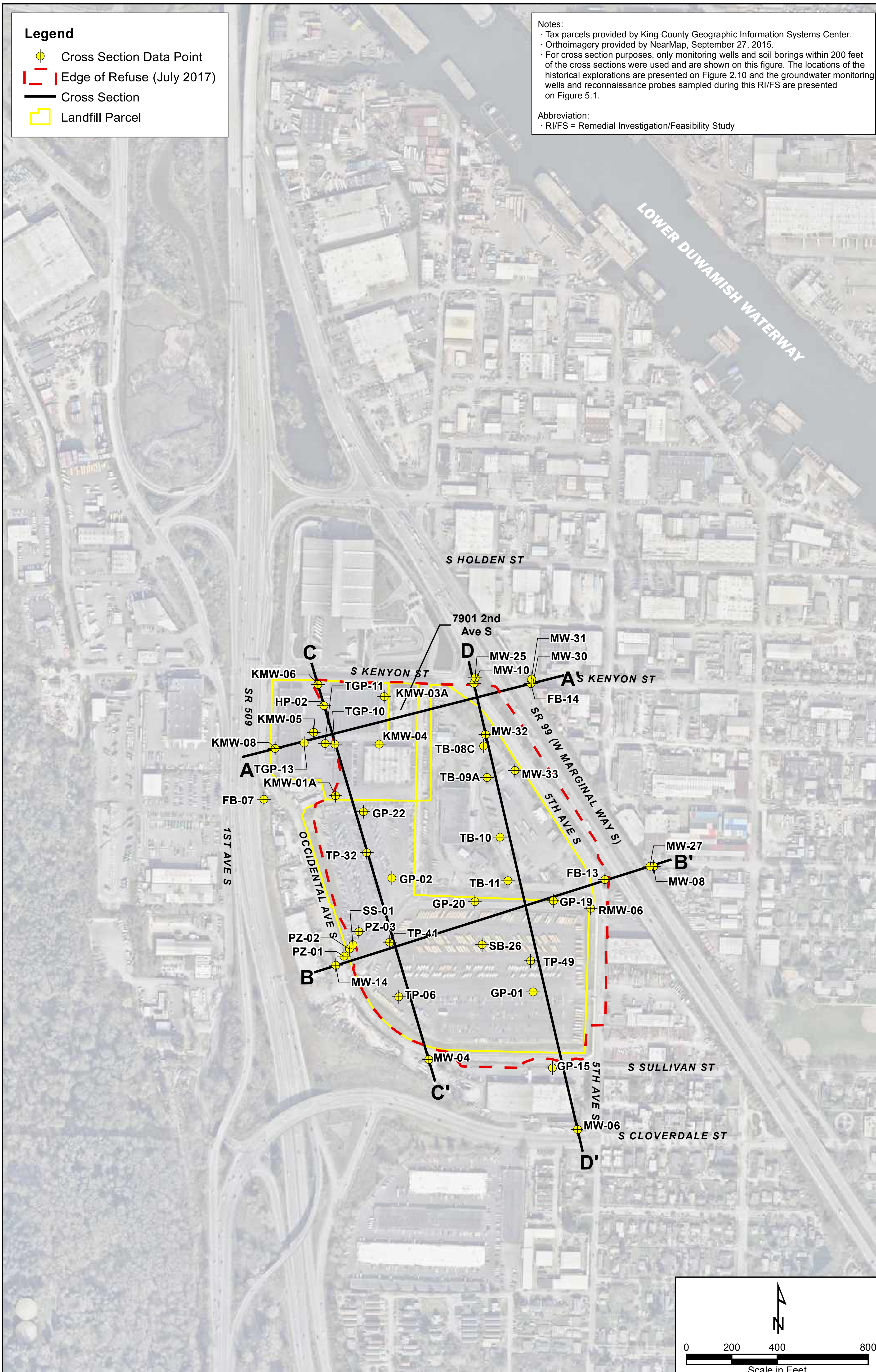


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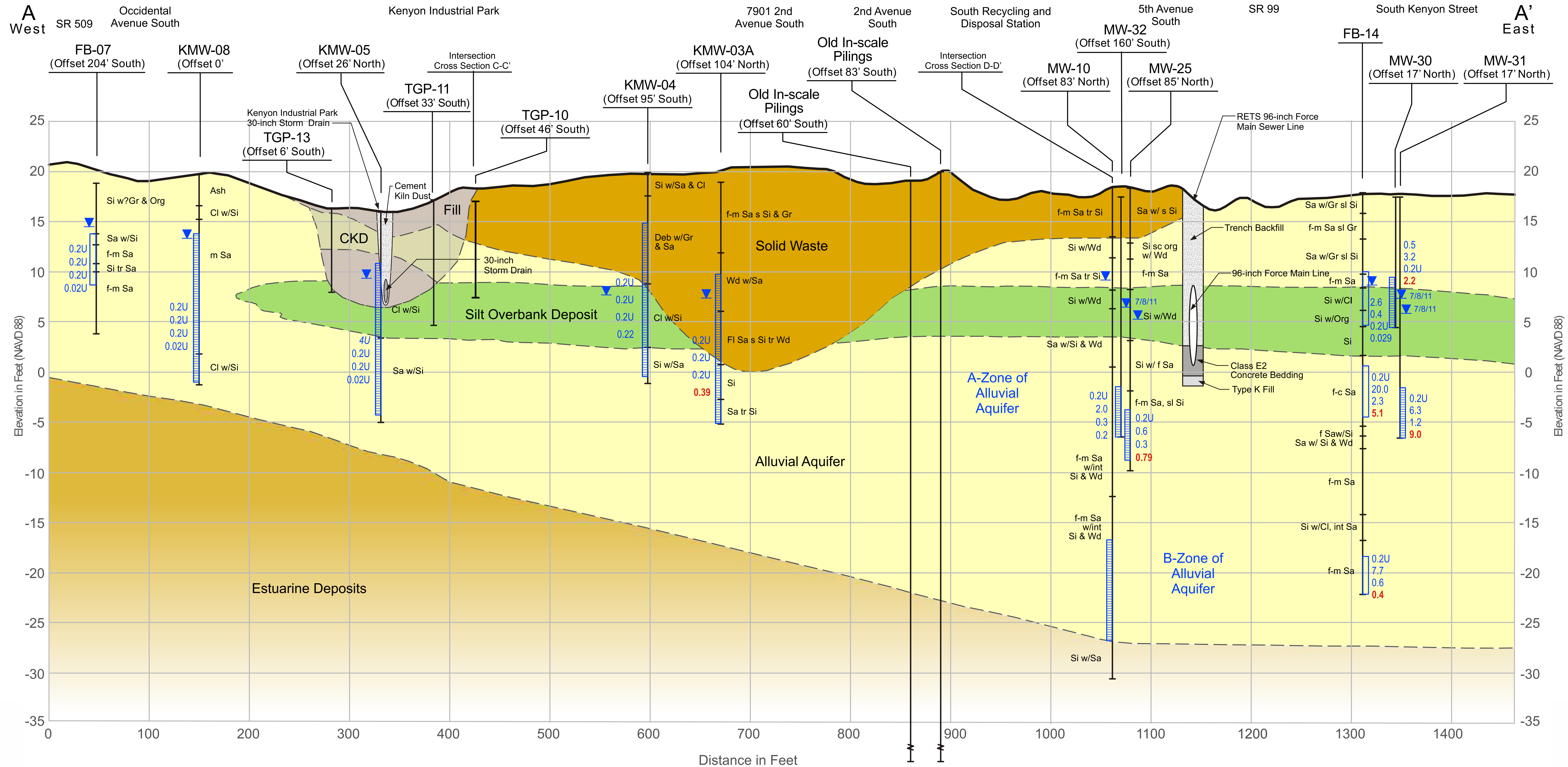
Figure 5.2
Cross Section Location Map

I:\GIS\Projects\COS-SPARK\MXD\RIFS\RIFS_2017_FEB18\Figure 5.2 Cross Section Location Map.mxd
2/12/2018




**Notes:**

**BOLD, RED TEXT** indicates exceedance of cleanup levels.
*ITALICS* indicate that the reporting limit is greater than the cleanup level.
Qualifier "U" = The analyte was not detected at the reported concentration.
Cleanup level: Trichloroethylene (TCE) = 5.0 µg/L, cis-1,2-dichloroethene (cis-DCE) = 16 µg/L, trans-1,2-dichloroethene (trans-DCE) = 160 µg/L, vinyl chloride = 0.29 µg/L.
bgs - Below Ground Surface
ft - Feet
NAVD 88 - North American Vertical Datum of 1988
RETS - Renton Effluent Tranfer System

**Legend**

Static Water Level (January or March 2011)
Approximate Ground Surface
Approximate Geologic Unit Contact
Inferred Geologic Unit Contact

**Groundwater Data**

Monitoring Well Screen
Data from 2011 RI Event
TCE Concentration in µg/L 0.2U
cis-DCE Concentration in µg/L 0.6
trans-DCE Concentration in µg/L 0.3
Vinyl Chloride Concentration in µg/L 0.4
Temporary Groundwater Collection Screen

**Soil Description**

| | |
|---|---|
| Cl = Clay | f = fine |
| Sa = Sand | m = medium |
| Si = Silt | c = course |
| Gr = Gravel | w/ = with |
| Org = Organic | s = some |
| Wd = Wood | & = and |
| Deb = Debris | sc = scattered |
| Fl = Fill | sl = slightly |
| | tr = trace |
| | int = interbedded |

Horizontal Scale in Feet (1" = 100')
0 100 200
Vertical Scale in Feet (1" = 10')
0 10 20
Vertical Exaggeration x 10

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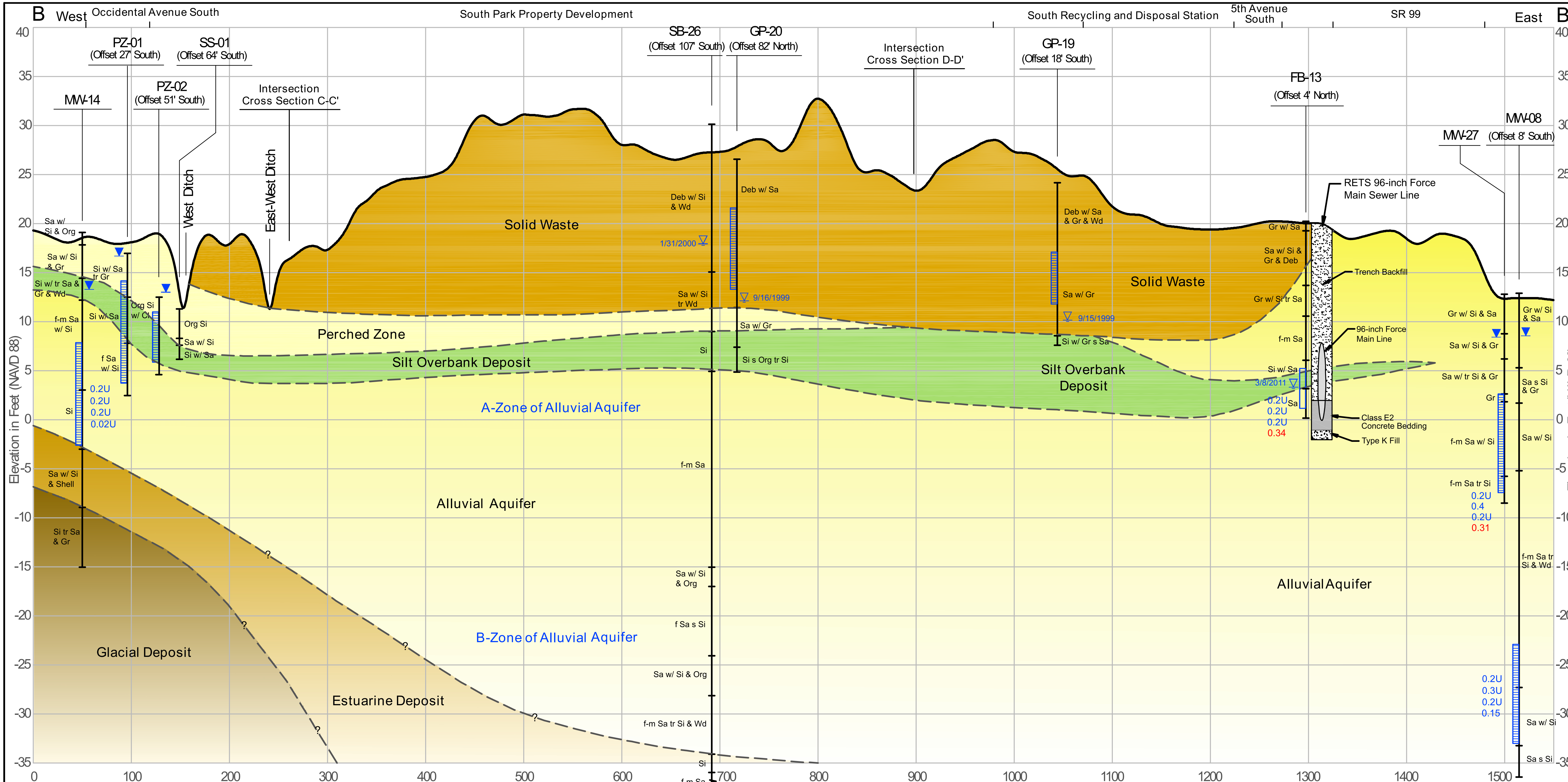
Figure 5.3
Cross Section A-A'

CAD Path: Q:\South Park Landfill\2011-09\100116-5.3.dwg 11x17 Landscape || Date Saved: March 20, 2012 || User: pbaker




## Notes:

**BOLD, RED TEXT** indicates exceedance of cleanup levels.
*ITALICS* indicate that the reporting limit is greater than the cleanup level.
Qualifier "U" = The analyte was not detected at the reported concentration.
Cleanup level: Trichloroethylene (TCE) = 5.0 µg/L, cis-1,2-dichloroethene (cis-DCE) = 16 µg/L, trans-1,2-dichloroethene (trans-DCE) = 160 µg/L, vinyl chloride = 0.29 µg/L.
bgs - Below Ground Surface
ft - Feet
NAVD 88 - North American Vertical Datum of 1988
RETS - Renton Effluent Tranfer System

## Legend

- At Time of Drilling Water Level
- Static Water Level (January or March 2011)
- Approximate Ground Surface
- Approximate Geologic Unit Contact
- Inferred Geologic Unit Contact

Groundwater Data

Monitoring Well Screen
Temporary Groundwater Collection Screen

Data from 2011 RI Event

| | |
|---|---|
| TCE Concentration in µg/L | 0.2U |
| cis-DCE Concentration in µg/L | 0.4 |
| trans-DCE Concentration in µg/L | 0.6 |
| Vinyl Chloride Concentration in µg/L | 0.3 |

Soil Description

| | | | |
|---|---|---|---|
| Cl | Clay | f | fine |
| Sa | Sand | m | medium |
| Si | Silt | c | course |
| Gr | Gravel | w/ | with |
| Org | Organic | s | some |
| Wd | Wood | & | and |
| Deb | Debris | sc | scattered |
| Fl | Fill | sl | slightly |
| Shell | Shell Fragments | tr | trace |
| | | int | interbedded |

Horizontal Scale in Feet (1" = 100')
Vertical Scale in Feet (1" = 10')
Vertical Exaggeration x 10

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Figure 5.4
Cross Section B-B'

CAD Path: Q:\South Park Landfill\2011-09\100116-5.4.dwg || 11x17 Landscape || Date Saved: March 20, 2012 || User: pbaker

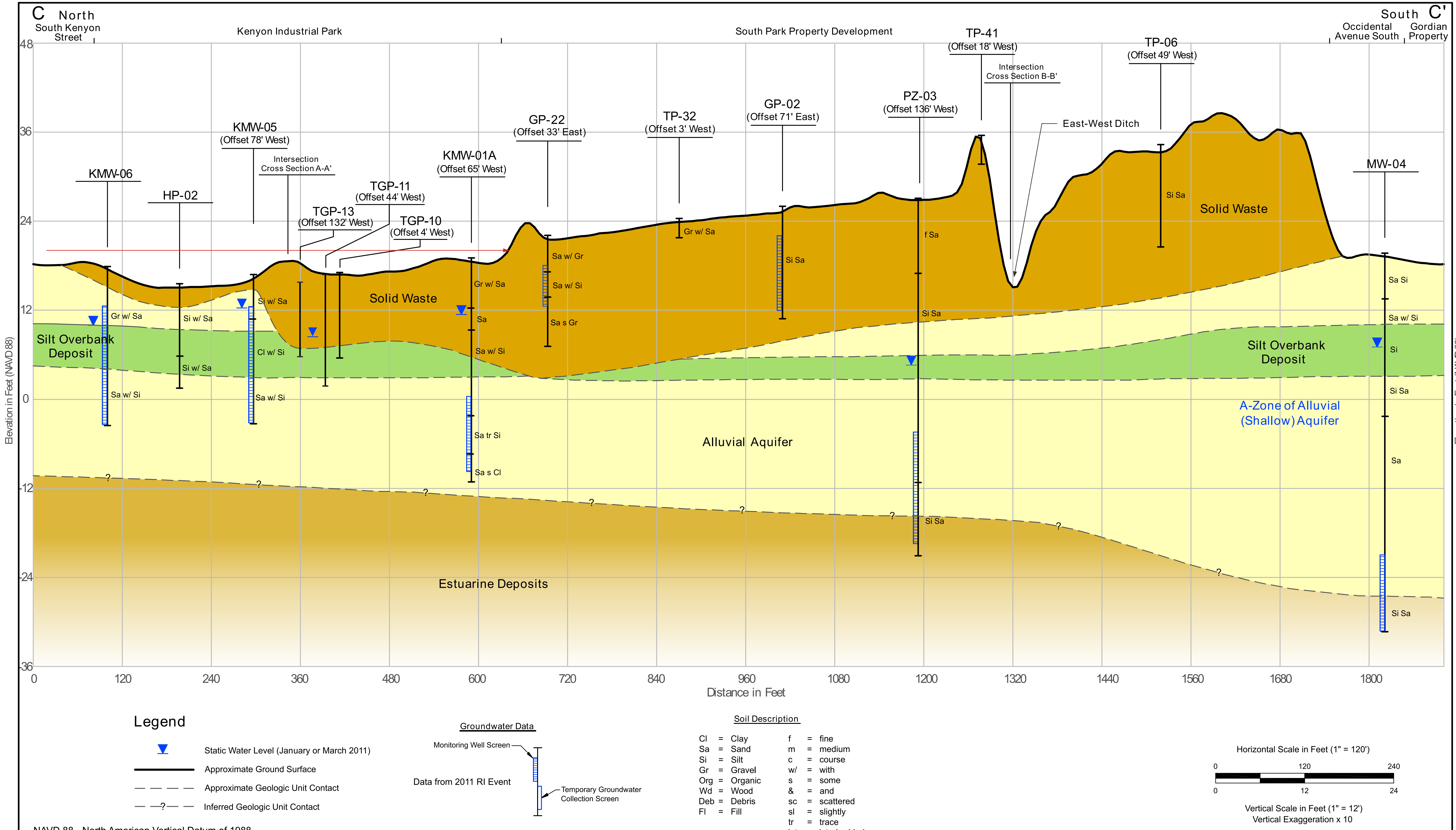


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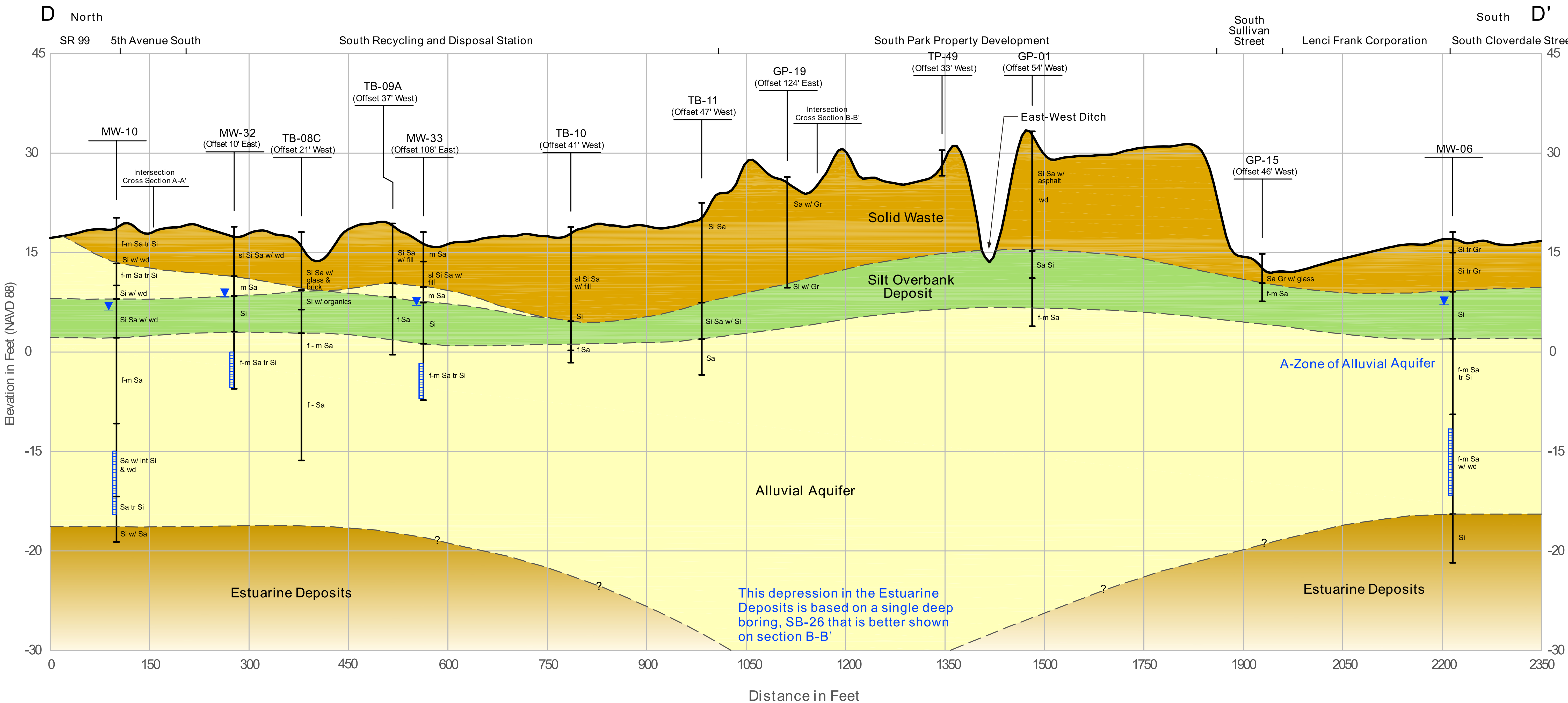
Figure 5.5
Cross Section C-C'




## Legend

Static Water Level (January or March 2011)

Approximate Ground Surface

Approximate Geologic Unit Contact

Inferred Geologic Unit Contact

NAVD 88 - North American Vertical Datum of 1988

**Groundwater Data**

Monitoring Well Screen

Data from 2011 RI Event

Temporary Groundwater Collection Screen

**Soil Description**

| | | | |
|---|---|---|---|
| Cl = Clay | | f = fine | |
| Sa = Sand | | m = medium | |
| Si = Silt | | c = course | |
| Gr = Gravel | | w/ = with | |
| Org = Organic | | s = some | |
| Wd = Wood | | & = and | |
| Deb = Debris | | sc = scattered | |
| Fl = Fill | | sl = slightly | |
| | | tr = trace | |
| | | int = interbedded | |

Horizontal Scale in Feet (1" = 150')

0 150 300

0 15 30

Vertical Scale in Feet (1" = 15')

Vertical Exaggeration x 10

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Figure 5.6
Cross Section D-D'

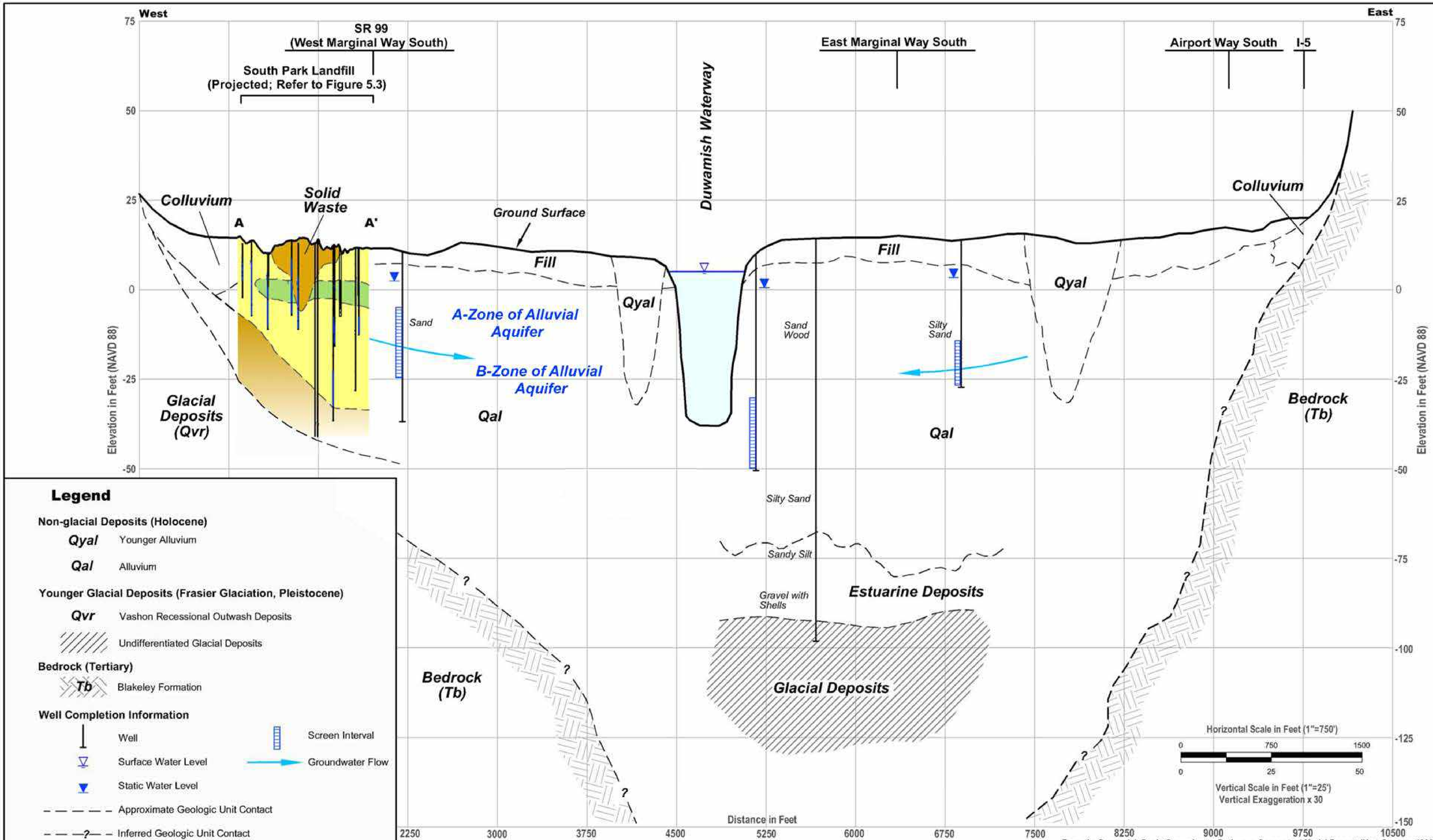


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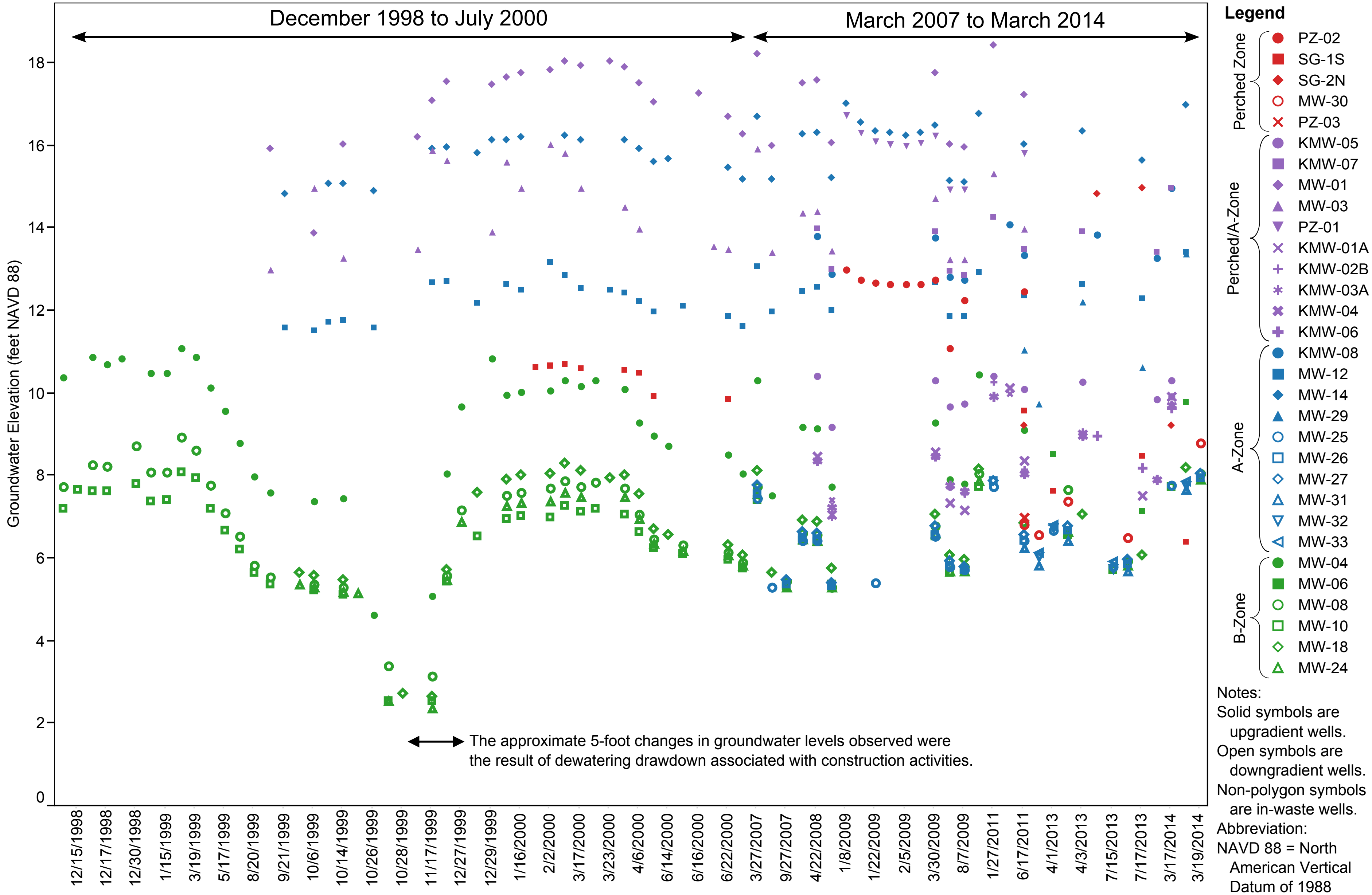
Figure 5.7
Cross Section A-A' Projected onto the Regional Cross Section

CAD Path: Q:\South Park Landfill\2011-09\100116-5.7.dwg || 11x17 Landscape || Date Saved: March 20, 2012 || User: pbaker




Notes:
Solid symbols are upgradient wells.
Open symbols are downgradient wells.
Non-polygon symbols are in-waste wells.
Abbreviation:
NAVD 88 = North American Vertical Datum of 1988

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Figure 5.8
Groundwater Hydrographs—
Alluvial Aquifer

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05/05/2014

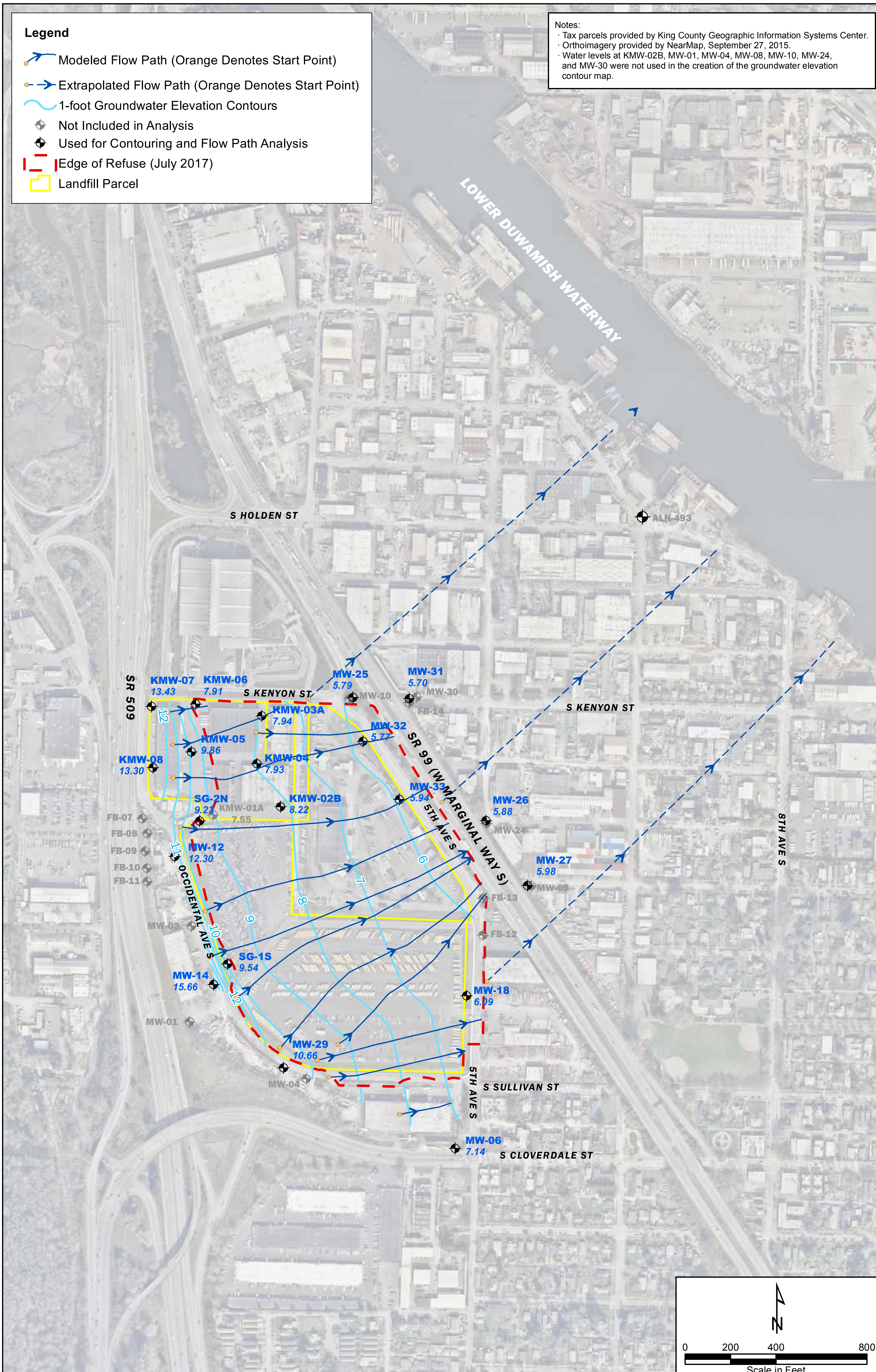


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Figure 5.9A
Groundwater Elevation Contour Map
Dry Season—July 2013

I:\GIS\Projects\COS-SPARK\MXD\RIFS\RIFS_2017_FEB18\Figure 5.9A Groundwater Elevation Contour Map Jul 2013.mxd
2/12/2018

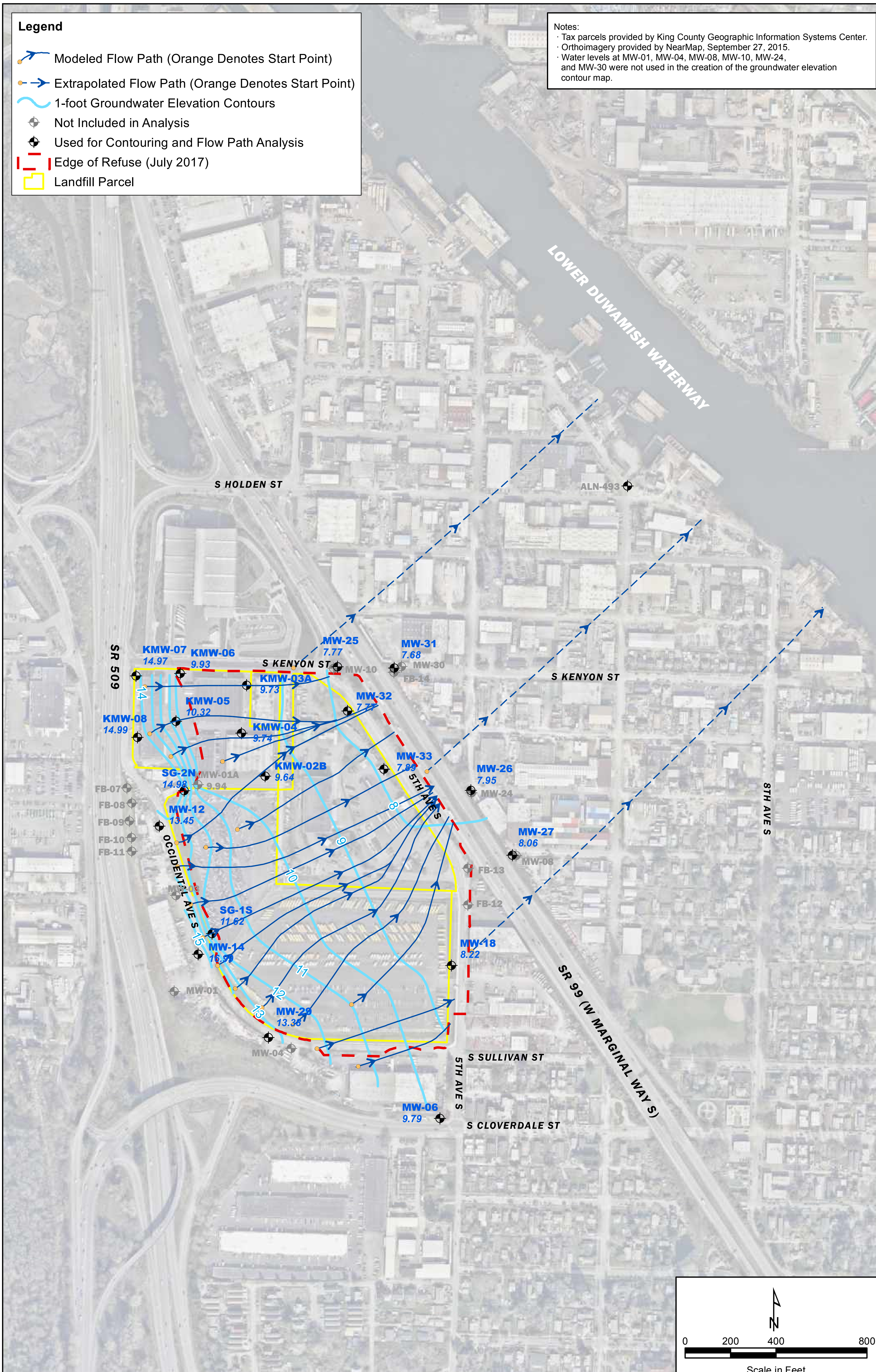


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Figure 5.9B
Groundwater Elevation Contour Map
Wet Season—March 2014

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2/12/2018

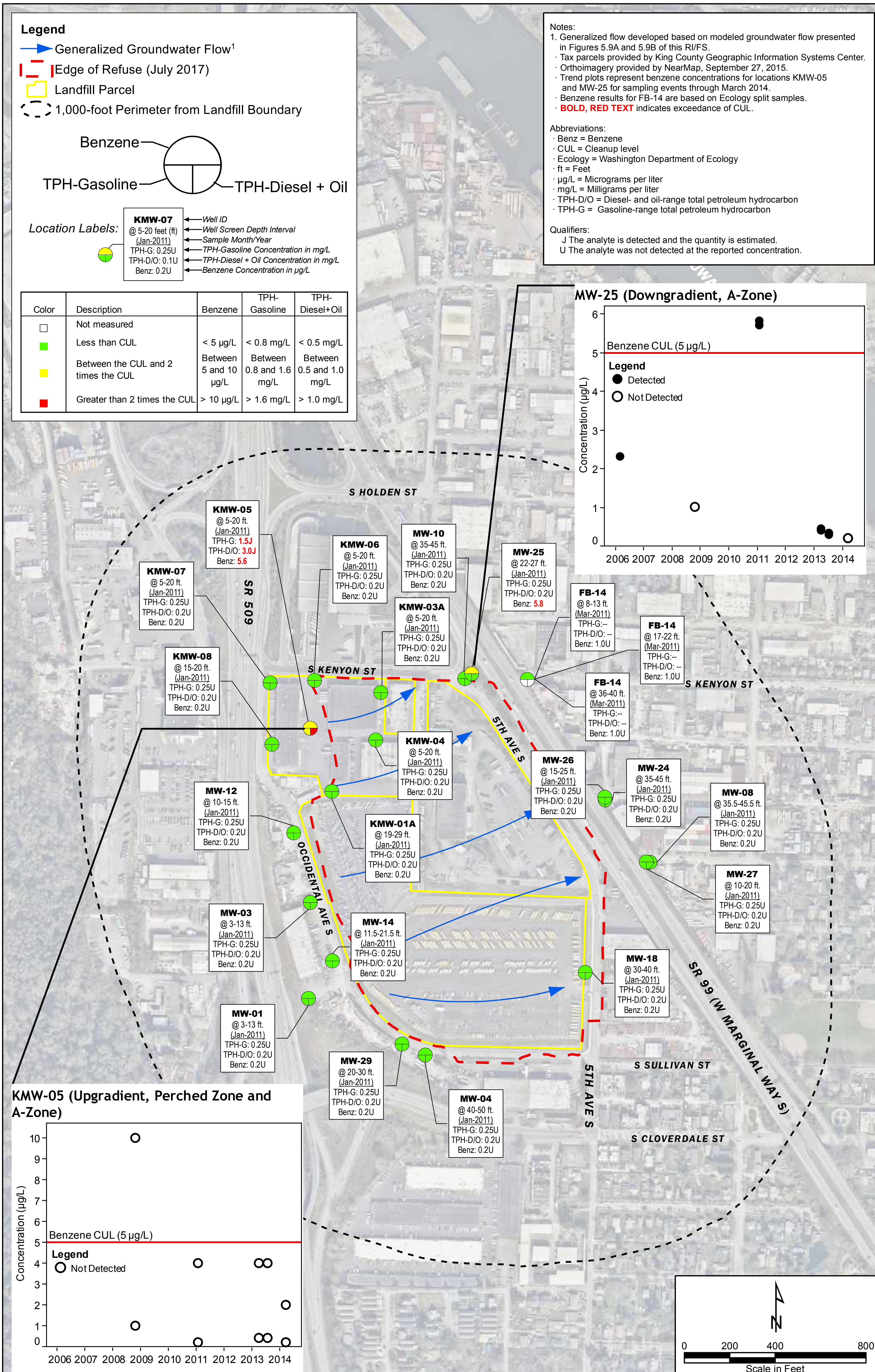


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Figure 5.10
2011 TPH and Benzene in Groundwater

I:\GIS\Projects\COS-SPARK\MXD\RIFS\RIFS_2017_FEB18\Figure 5.10 2011 TPH and Benzene in GW.mxd
2/12/2018

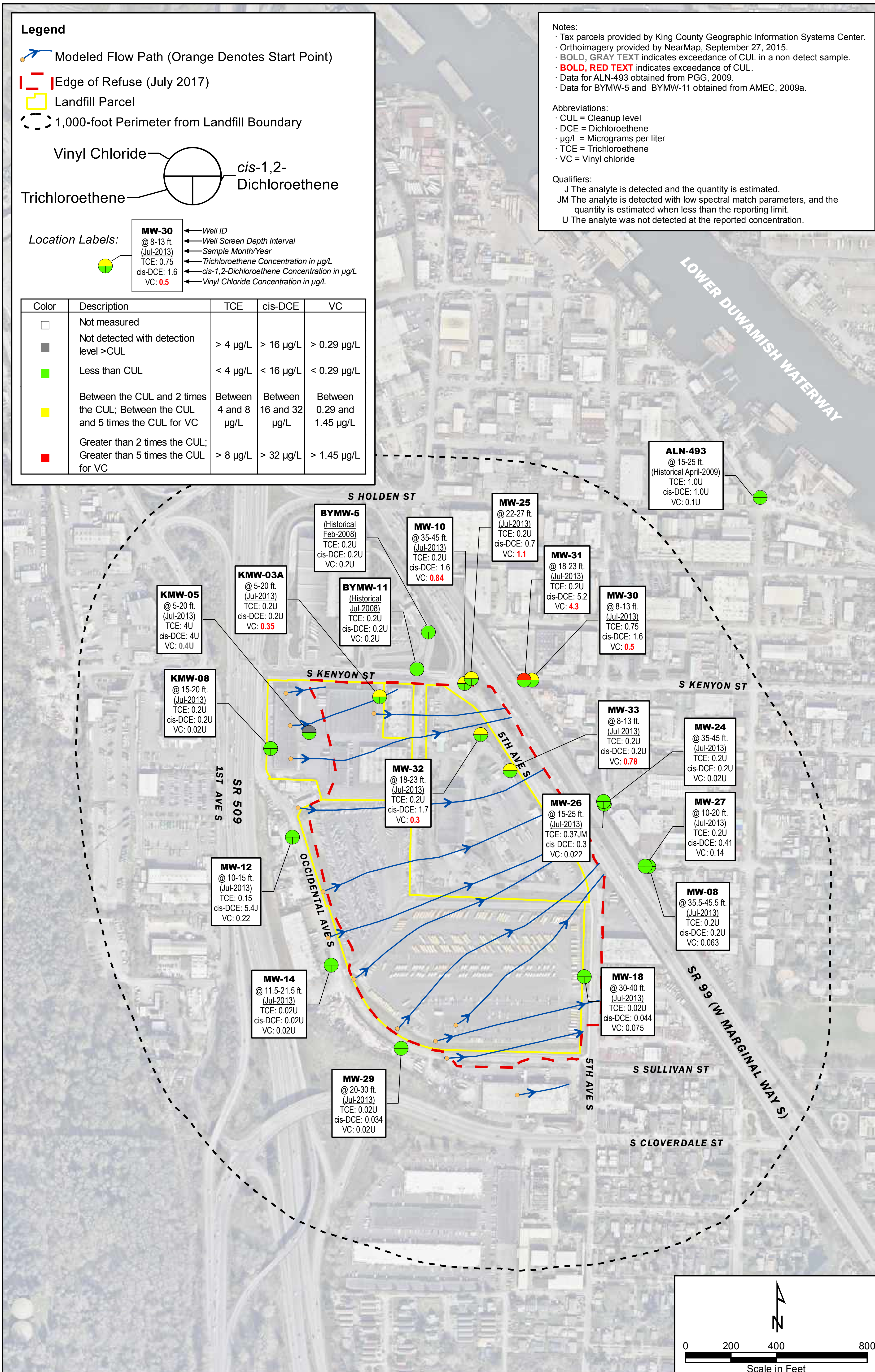


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Figure 5.11A
Chlorinated Ethenes in Groundwater
Dry Season—July 2013

I:\GIS\Projects\COS-SPARK\MXD\RIFS\RIFS_2017_FEB18\Figure 5.11A GW Chlorinated Ethenes.mxd
2/12/2018

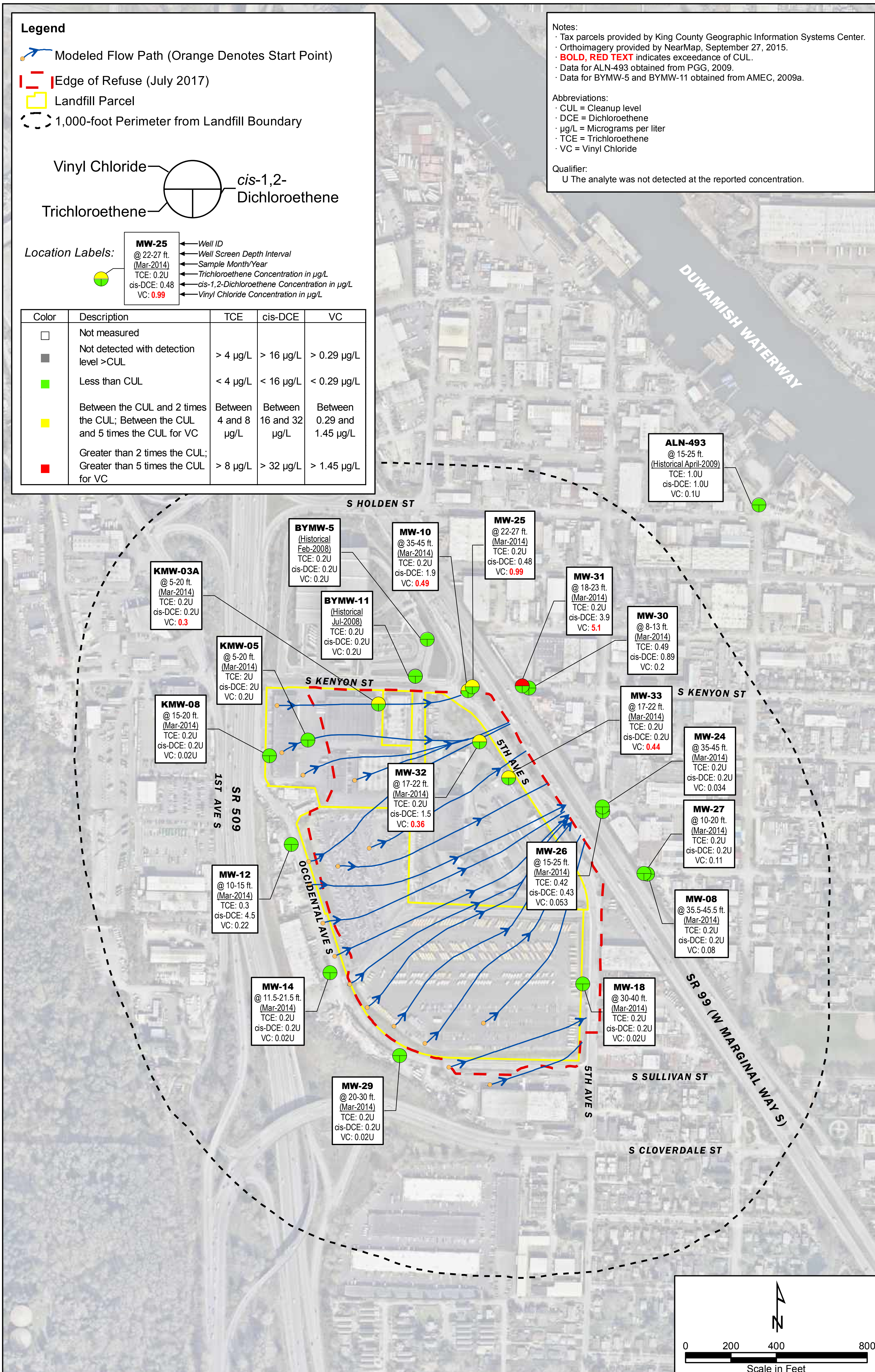


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Figure 5.11B
Chlorinated Ethenes in Groundwater
Wet Season—March 2014

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2/12/2018

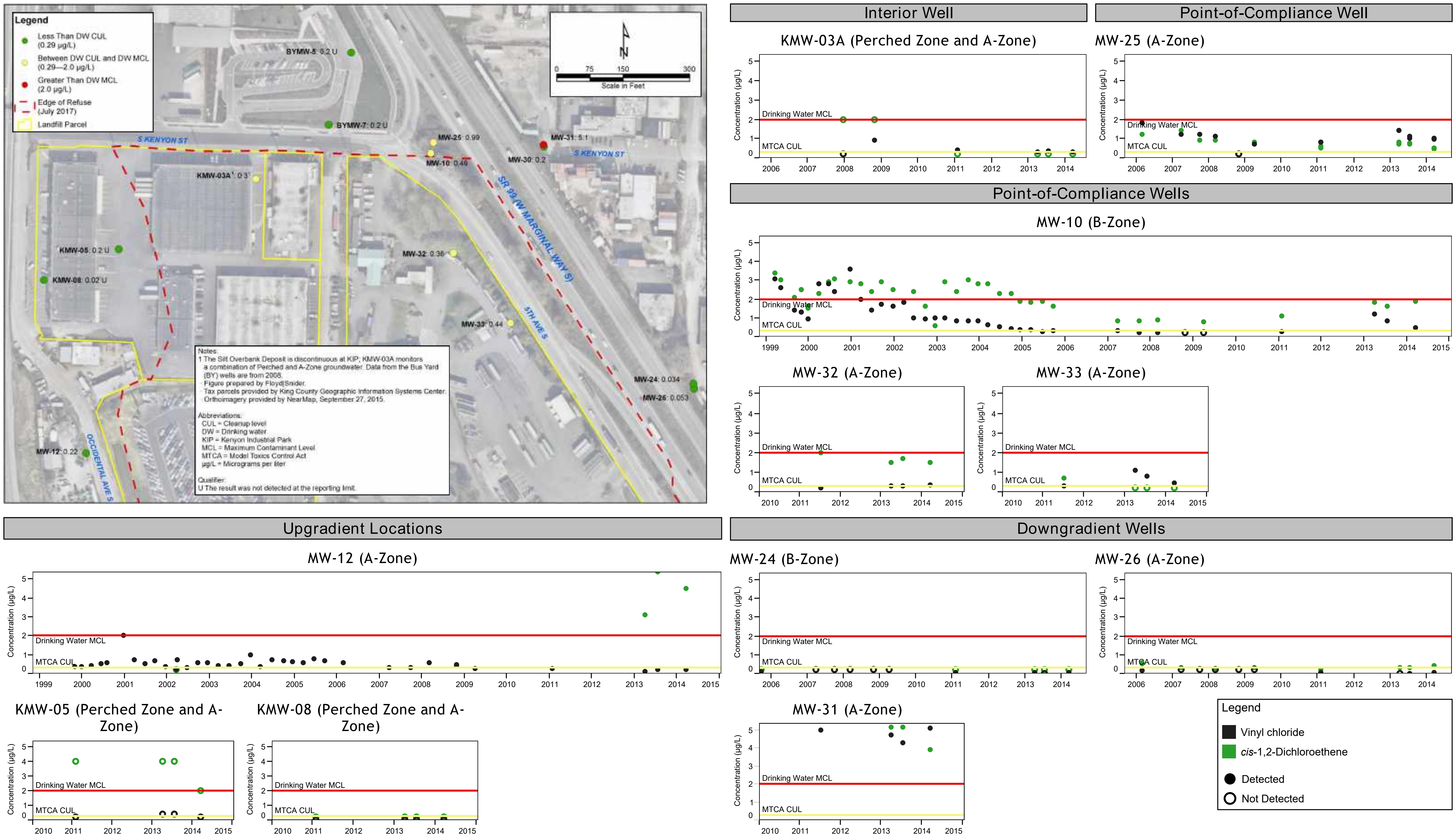


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Figure 5.12
Vinyl Chloride in Groundwater—
March 2014

F:\projects\COS-SPARK\4000 - RI-FS\10 SPARK RIFS Client Draft 2015\03 Figures\Figure 5.12 VC in GW.pdf
6/14/2016

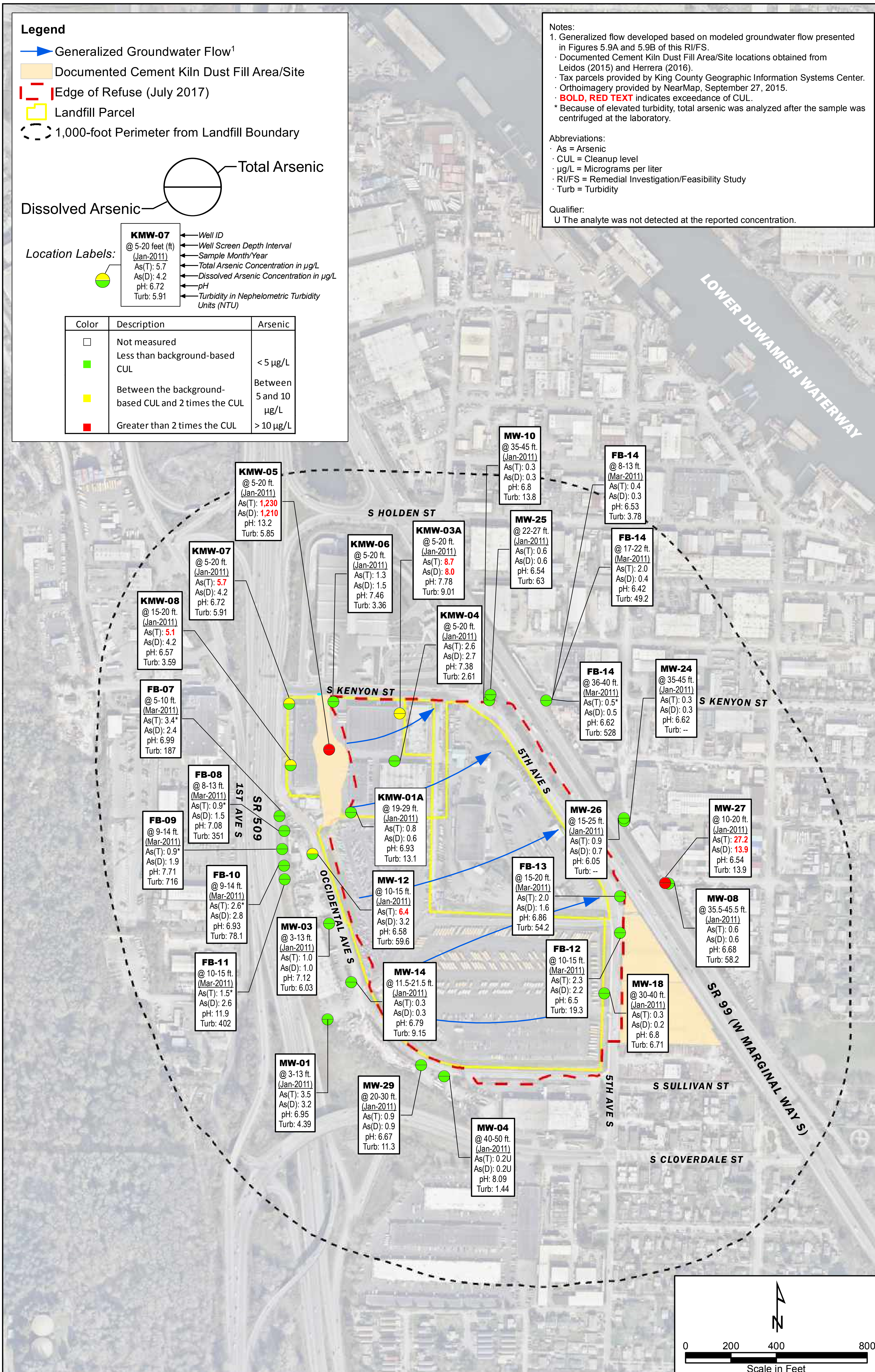


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Figure 5.13
Total and Dissolved Arsenic in Groundwater—January–March 2011

I:\GIS\Projects\COS-SPARK\MXD\RIFS\RIFS_2017_FEB18\Figure 5.13 Total and Dissolved Arsenic in Groundwater January-March 2011.mxd
2/12/2018

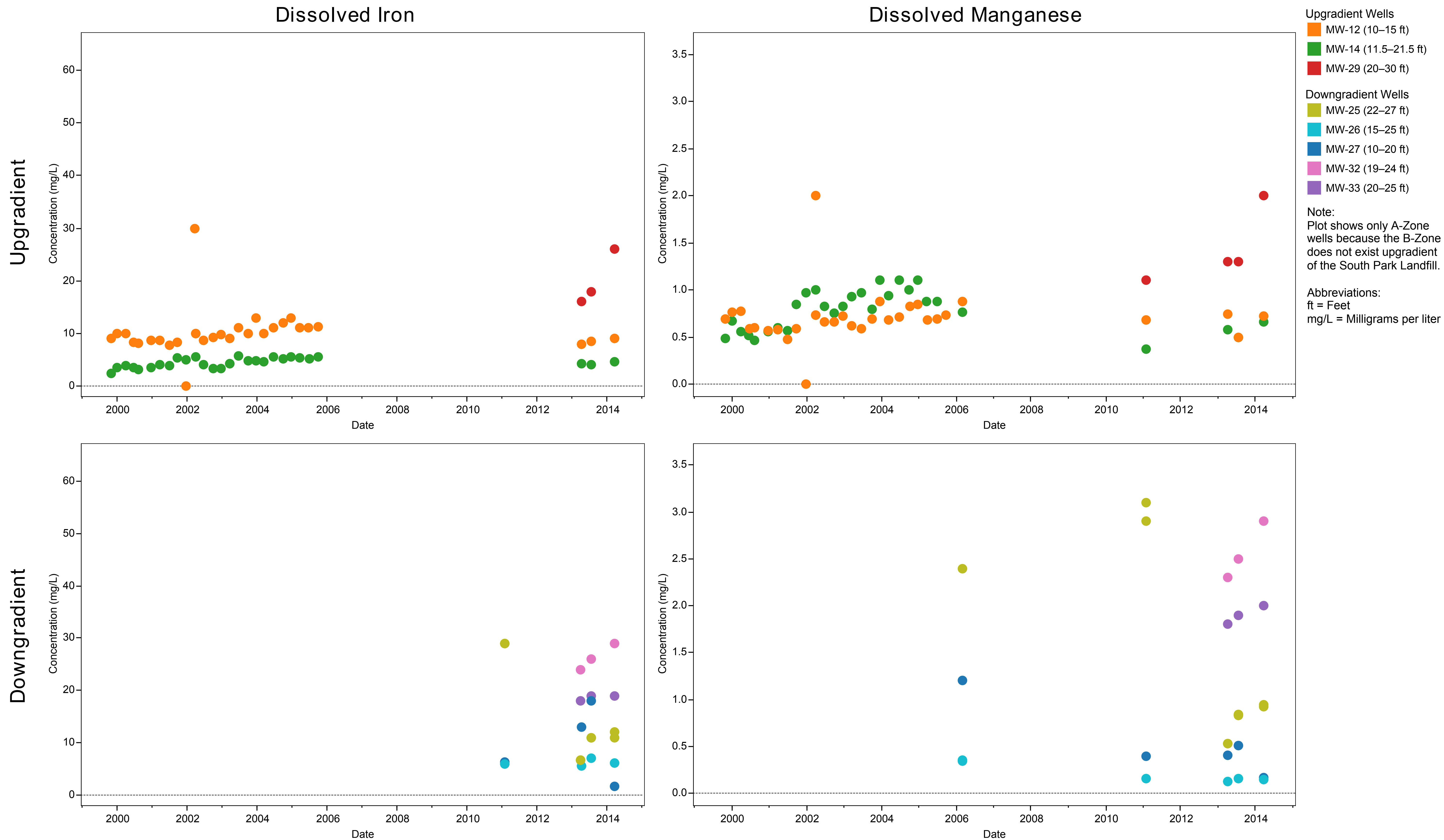


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Figure 5.14
Dissolved Iron and Manganese in
A-Zone Groundwater

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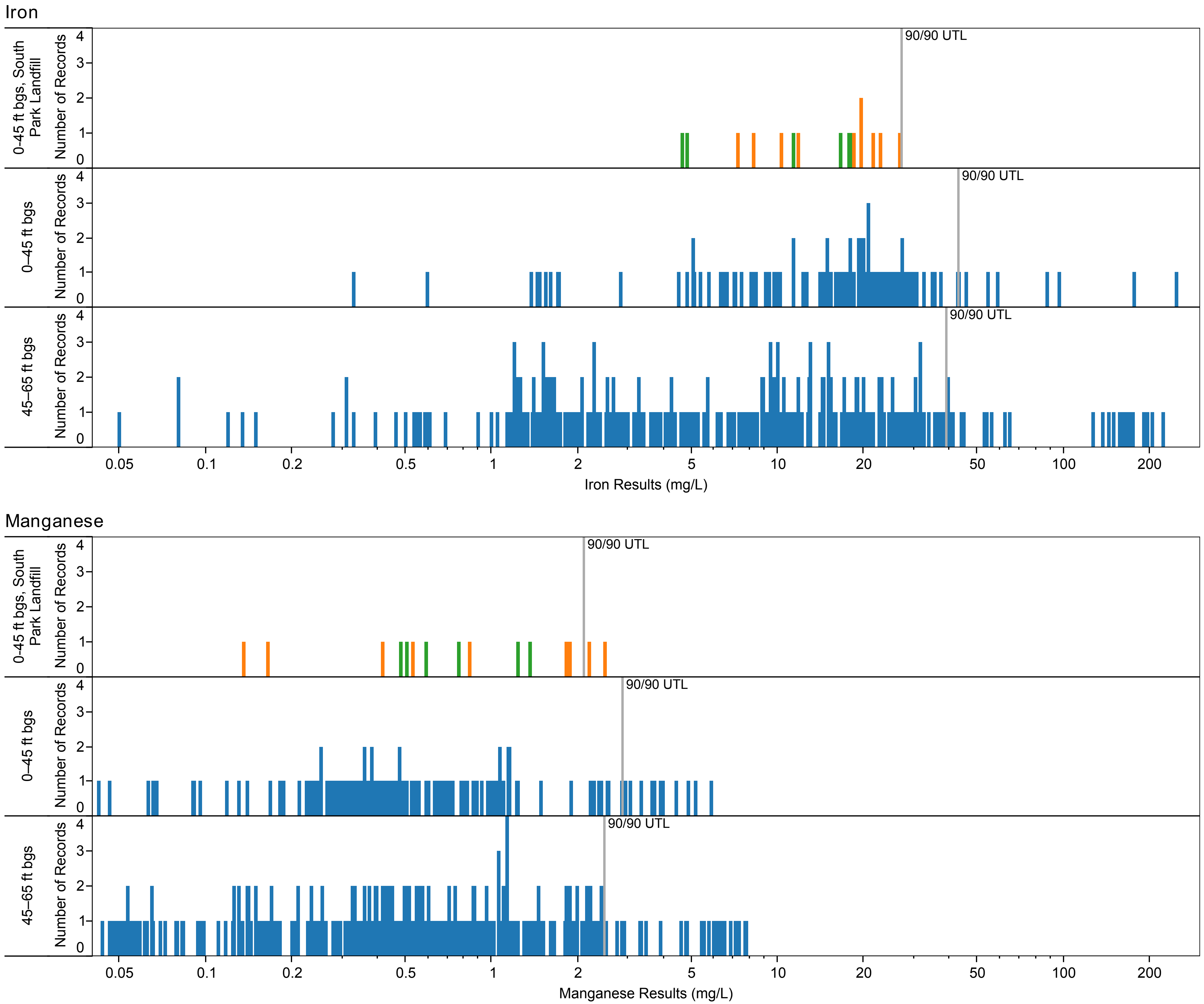
2/8/2013




Map shows location of groundwater wells where iron and manganese data are available. Data used are primarily from depths deeper than 40 feet bgs where contamination is too low to affect iron and manganese concentrations. Green wells are background locations within the South Park Landfill site.

Legend
- Duwamish Valley
- South Park Landfill, Downgradient
- South Park Landfill, Upgradient

Notes:
High iron and manganese concentrations exist throughout the Duwamish Valley Aquifer at all depths in the aquifer. When known, data excluded samples that had been impacted by contaminant releases.

Abbreviations:
ft bgs = Feet below ground surface
mg/L = Milligrams per liter
90/90 UTL = Upper 90 percent confidence level (UCL) on the 90th percentile of the distribution

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Figure 5.15
Total Iron and Manganese Concentrations in the Duwamish Valley Aquifer

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2/8/2013

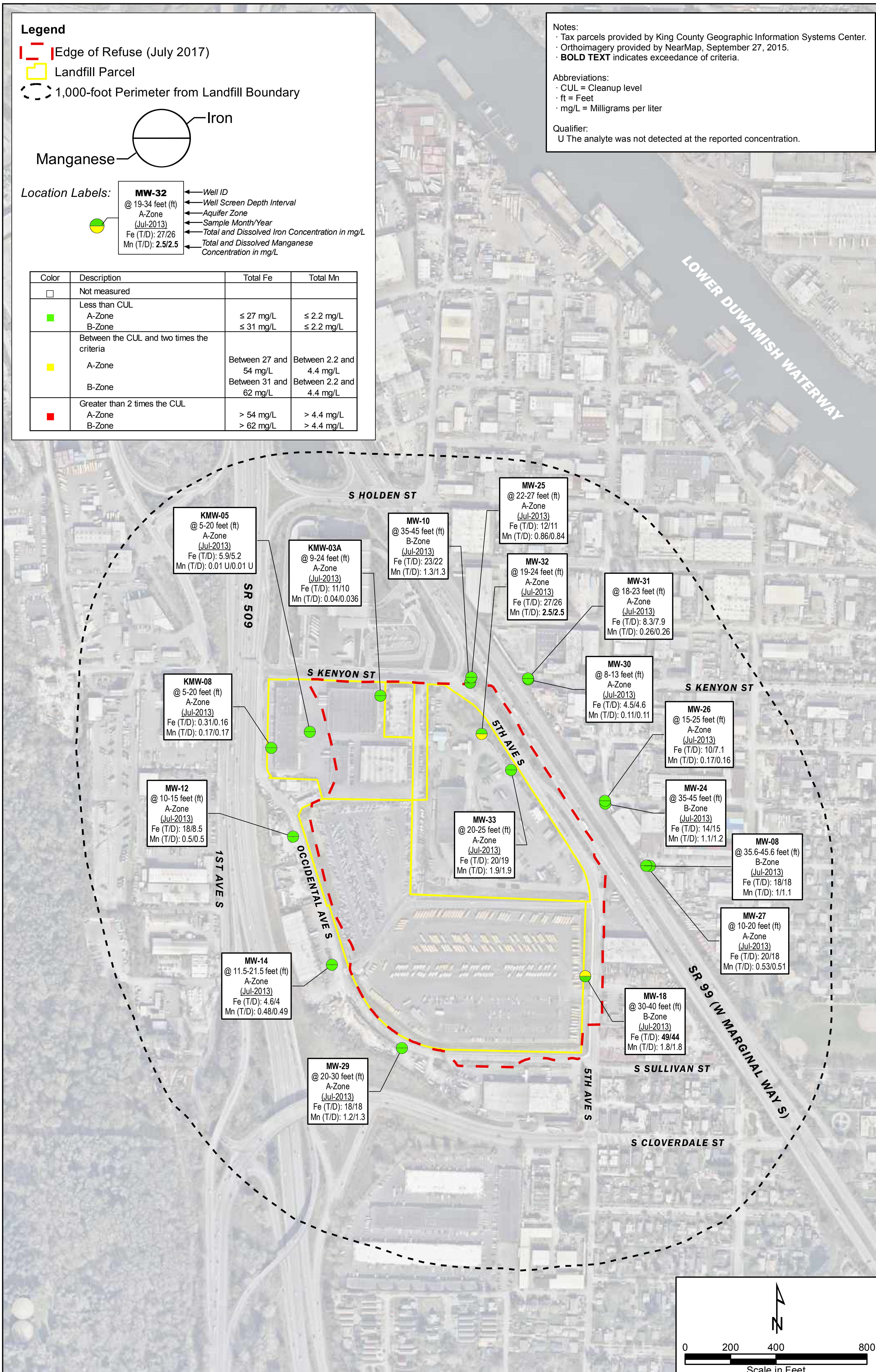


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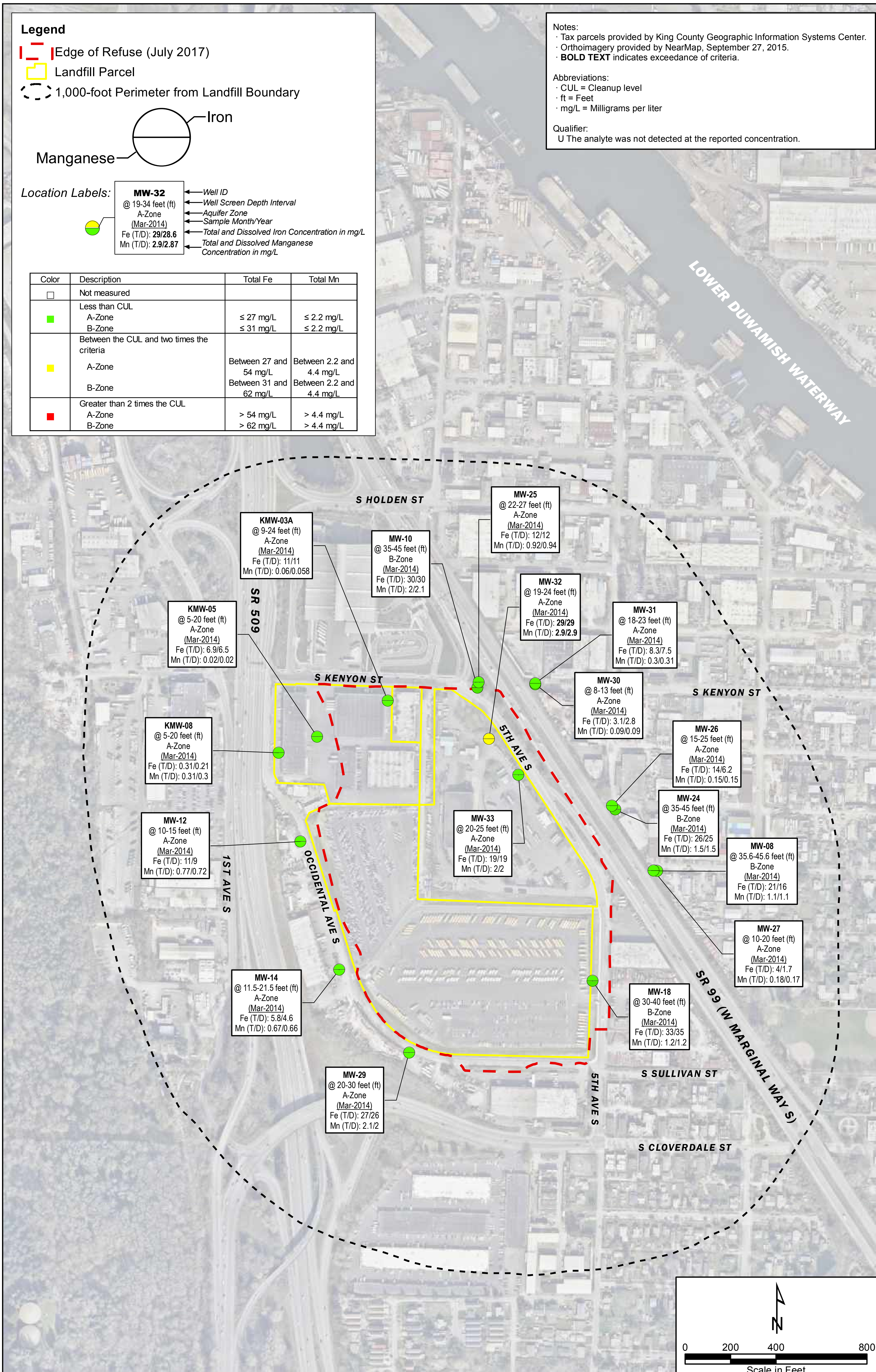
Figure 5.16A
Iron and Manganese in Groundwater
Dry Season—July 2013

I:\GIS\Projects\COS-SPARK\MXD\RIFS\RIFS_2017_FEB18\Figure 5.16A GW Iron and Mang—July 2013.mxd
2/12/2018




| Color | Description | Total Fe | Total Mn |
|---|---|---|---|
| □ | Not measured | | |
| Green | Less than CUL<br>A-Zone<br>B-Zone | ≤ 27 mg/L<br>≤ 31 mg/L | ≤ 2.2 mg/L<br>≤ 2.2 mg/L |
| Yellow | Between the CUL and two times the criteria<br>A-Zone<br>B-Zone | Between 27 and 54 mg/L<br>Between 31 and 62 mg/L | Between 2.2 and 4.4 mg/L<br>Between 2.2 and 4.4 mg/L |
| Red | Greater than 2 times the CUL<br>A-Zone<br>B-Zone | > 54 mg/L<br>> 62 mg/L | > 4.4 mg/L<br>> 4.4 mg/L |

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Figure 5.16B
Iron and Manganese in Groundwater
Wet Season—March 2014

I:\GIS\Projects\COS-SPARK\MXD\RIFS\RIFS_2017_FEB18\Figure 5.16B GW Iron and Mang—March 2014.mxd
2/12/2018

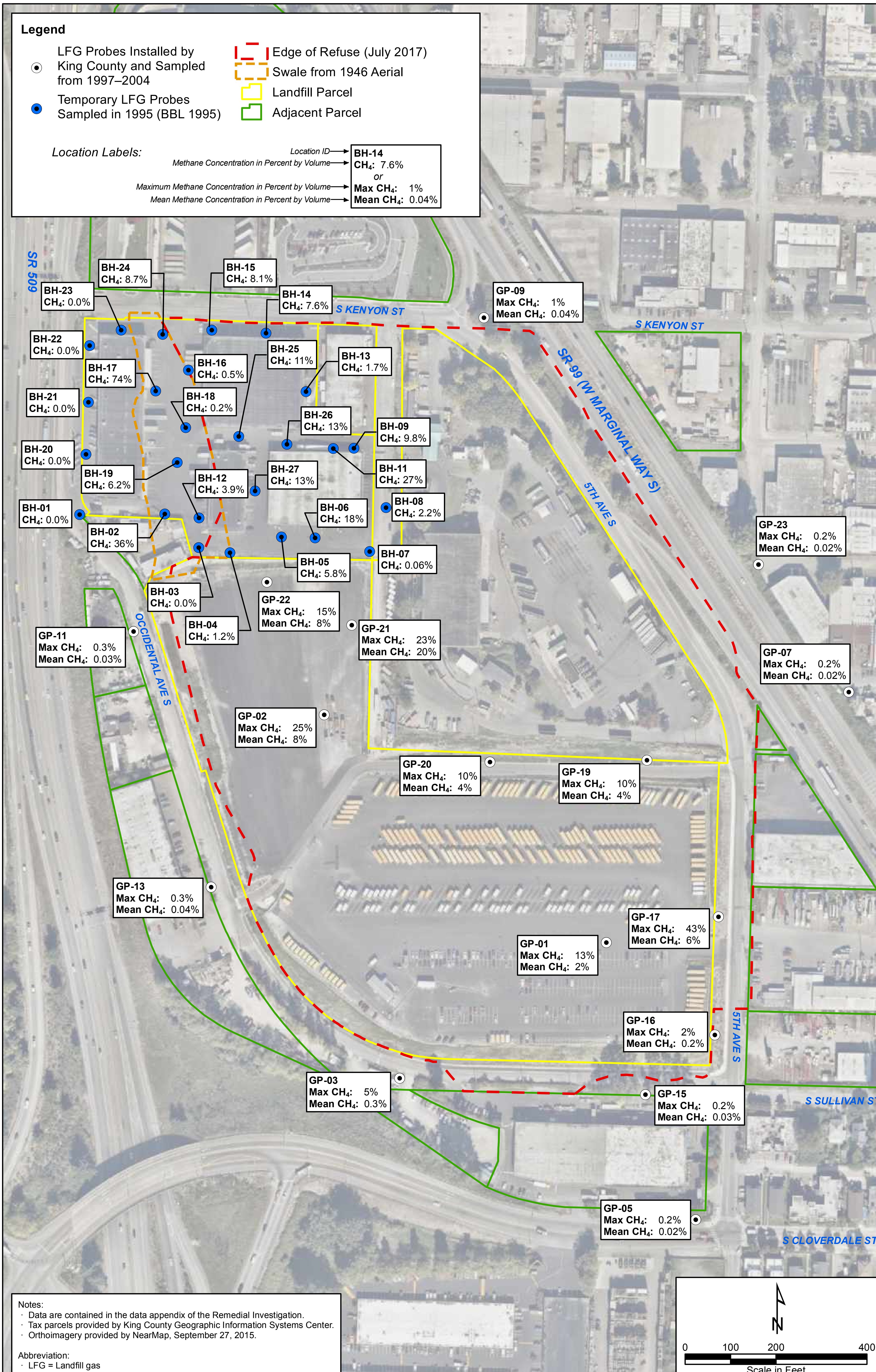


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Figure 6.1
Historical Subsurface LFG Measurements
(Data from 1995 to 2004)

I:\GIS\Projects\COS-SPARK\MXD\RIFS\RIFS_2017_FEB18\Figure 6.1 Historical Subsurface LFG Measurements.mxd
2/12/2018

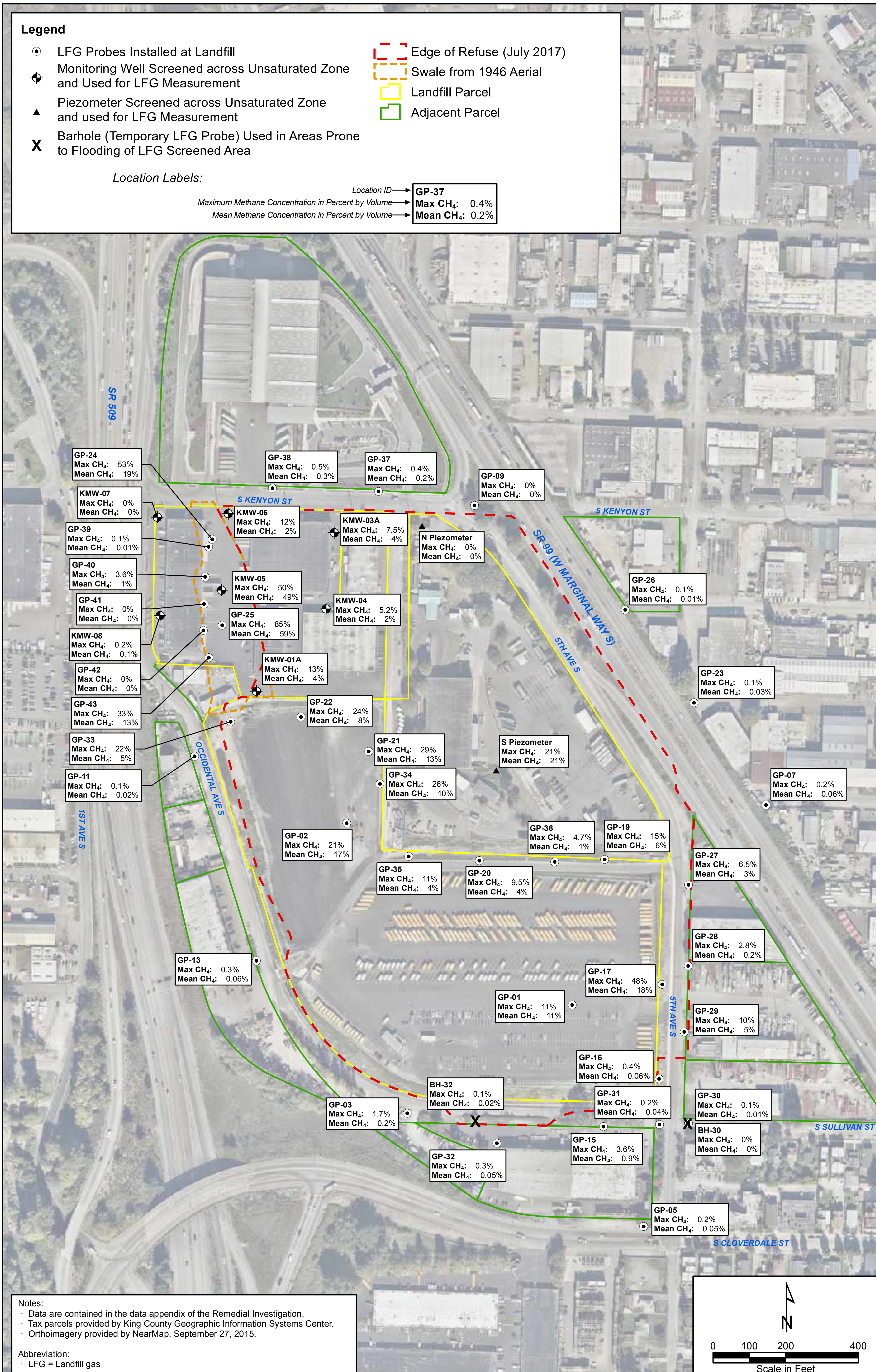


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Figure 6.2
RI LFG Subsurface Monitoring Locations
(Data from 2011 to 2017)

I:\GIS\Projects\COS-SPARK\MXD\RIFS\RIFS_2017_FEB18\Figure 6.2 RI LFG Subsurface Monitoring Locations.mxd
2/12/2018

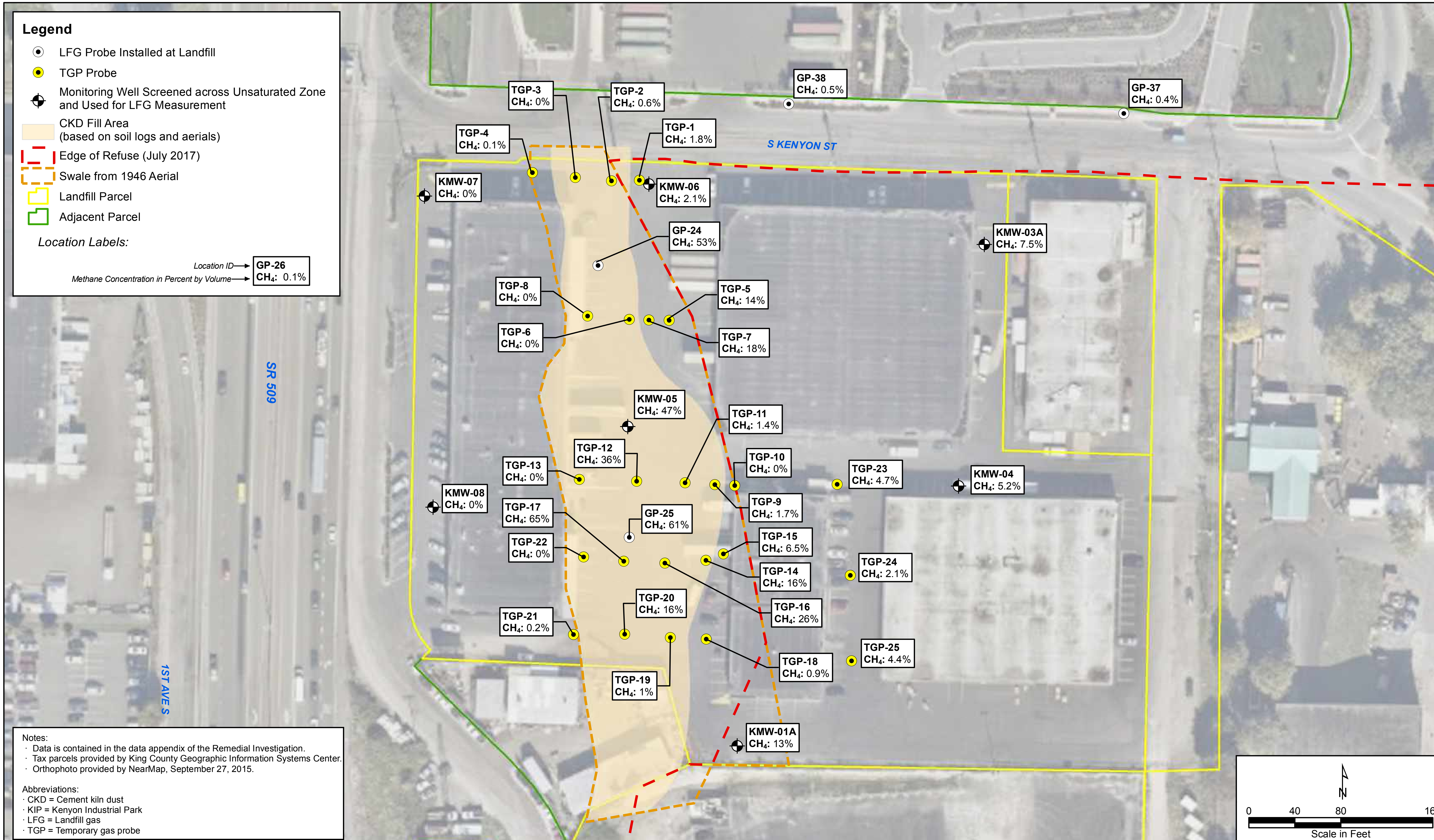


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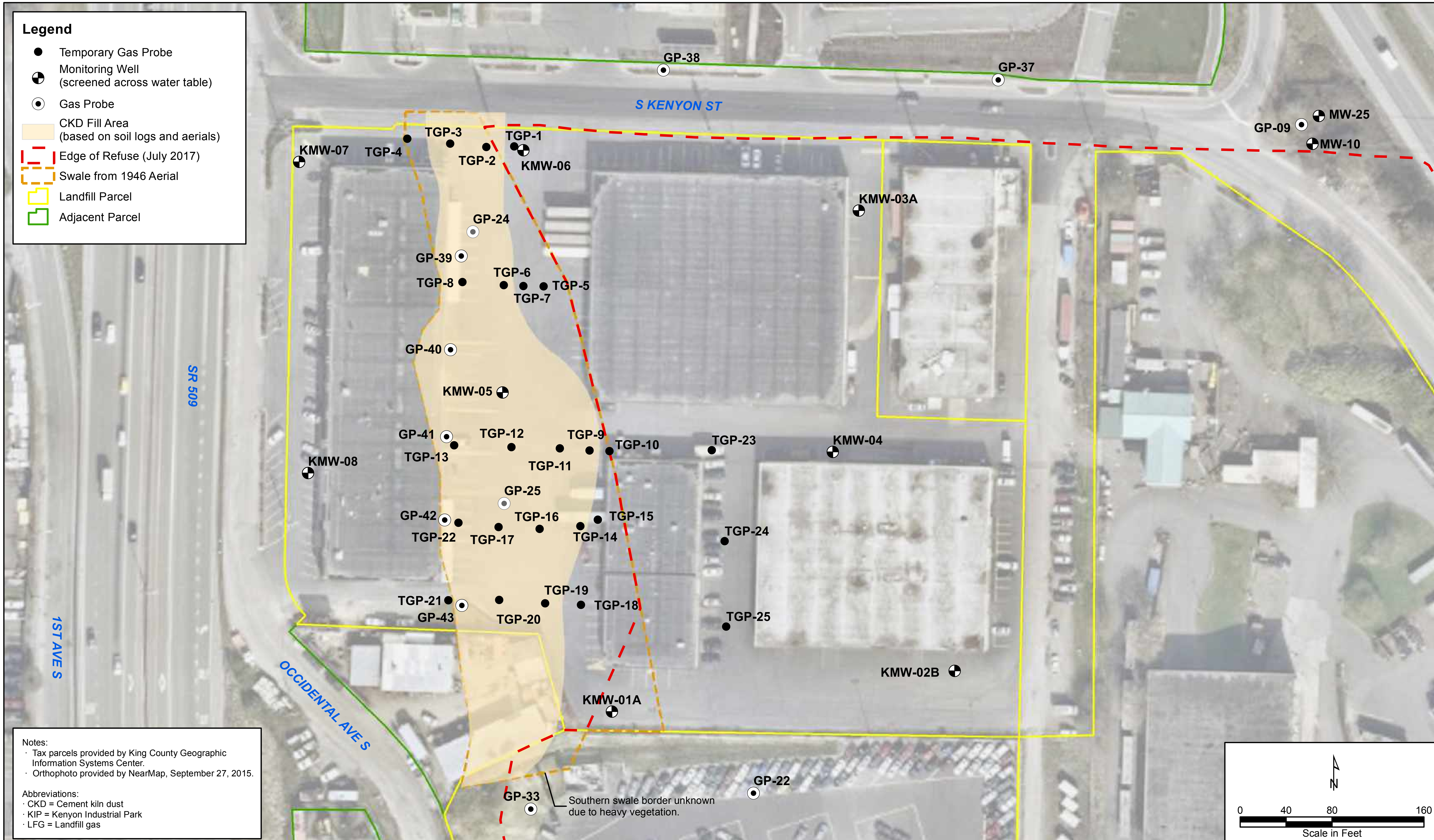
Figure 6.3
LFG Investigation in Historical KIP Swale

I:\GIS\Projects\COS-SPARK\MXD\RIFS\RIFS_2017_FEB18\Figure 6.3 LFG Investigation in Historical KIP Swale.mxd
2/13/2018




Notes:
- Tax parcels provided by King County Geographic Information Systems Center.
- Orthophoto provided by NearMap, September 27, 2015.

Abbreviations:
- CKD = Cement kiln dust
- KIP = Kenyon Industrial Park
- LFG = Landfill gas

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Figure 6.4
Locations of Temporary and Permanent LFG Probes
Historical KIP Swale Investigation

I:\GIS\Projects\COS-SPARK\MXD\RIFS\RIFS_2017_FEB18\Figure 6.4 Locations of Temporary and Permanent LFG Probes Historical KIP Swale Investigation.mxd
2/12/2018


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Figure 6.5A
Indoor Air Landfill Gas Monitoring Locations—
Kenyon Industrial Park and 7901 2nd Avenue South

G:\Graphics\10-04850-000\indoor_air_monitoring\kenyon_business_park\iam_kenyon.ai
9/15/2011


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Figure 6.5B
Indoor Air Landfill Gas Monitoring Locations—
8230 and 8250 5th Avenue South

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3/15/2012

**Soil Gas Probes with Adjacent Building Monitoring:**

- Perform soil gas probe monitoring every 4 to 6 weeks at GP-16, GP-17, GP-24, GP-25, and GP-27 to GP-30.
- Perform quarterly soil gas probe monitoring at GP-03 and GP-09.

**Soil Gas Probes without Adjacent Building Monitoring:**

- Perform soil gas probe monitoring every 4 to 6 weeks at GP-05, GP-15, GP-26, GP-31, and GP-32.
- Perform quarterly soil gas probe monitoring at GP-07, GP-11, GP-13, and GP-23.

Methane > 50,000 ppm (5%) at probe.

No

Continue normal monitoring program.

Yes

1. Initiate interior building monitoring program at locations according to Table 1, below.
2. Notify Potential Liable Persons (PLPs) Group.
3. PLP Group to coordinate building access agreements.
4. Perform interior monitoring.
5. Add building to Quarterly Interior Monitoring Program.
6. Notify Washington State Department of Ecology and Public Health - Seattle and King County.

Refer to Figure 6.6 for Interior Building Monitoring Process.

## Table 1

| Soil Gas Probe Location | Adjacent Buildings |
|---|---|
| GP-11 | International Construction Equipment, Inc. |
| GP-13 | North Star Ice Equipment |
| GP-23 | Bank of America (two buildings) |
| GP-07 | Eagle Eye Enterprises, LLC |
| GP-26 | Rick Larson Enterprises, Inc. |
| GP-05, GP-15, GP-31, GP-32 | Emerson Power Products |

*Refer to Figure 6.1 for locations.*

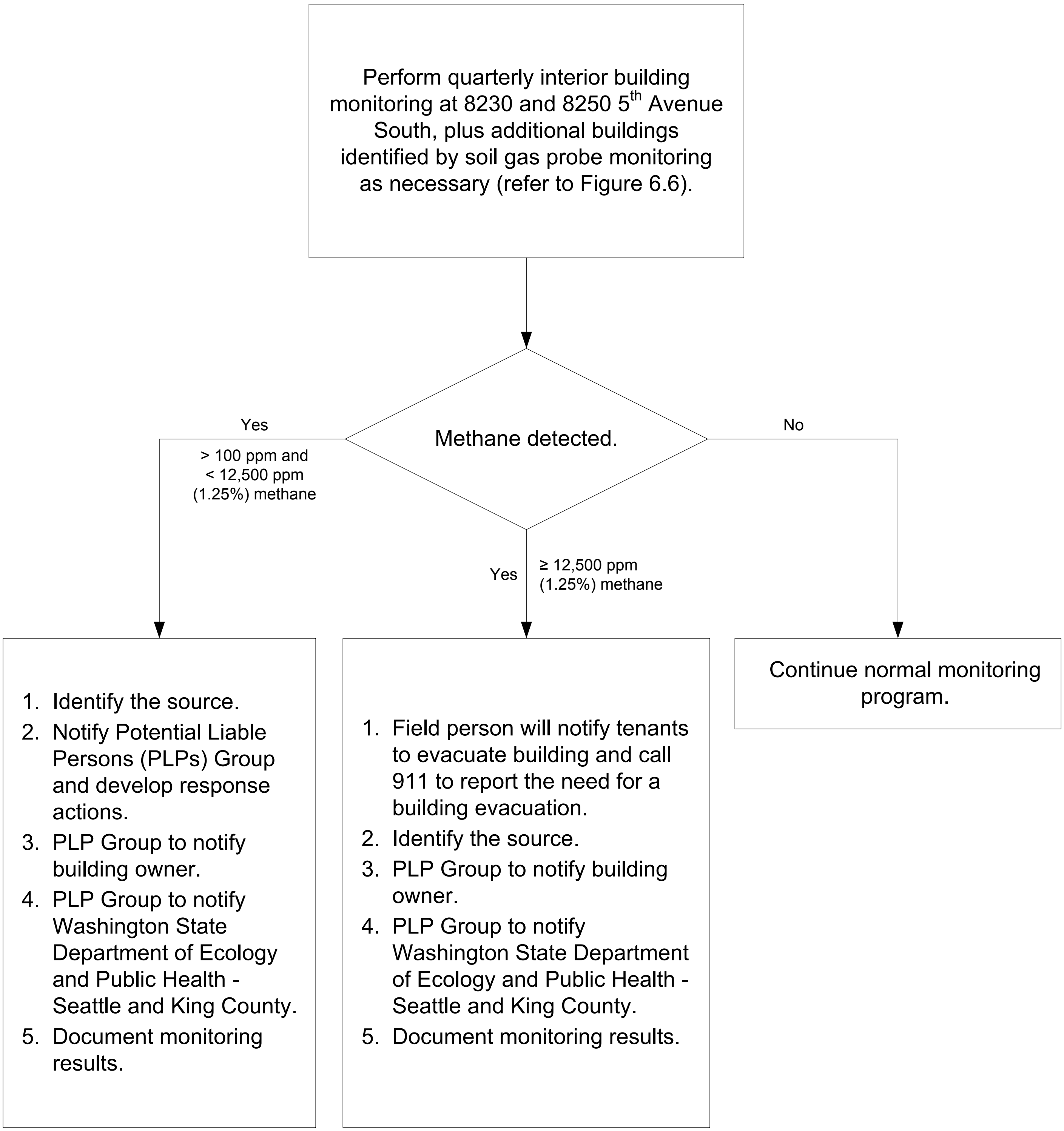


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Figure 6.7
Interior Building Monitoring Process Decision Tree

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5/11/2017


| Perimeter Probe | Adjacent LFG System | Adjacent Off-Site Buildings[1] |
|---|---|---|
| GP-37 | SRDS | No |
| GP-09 | SRDS | No |
| GP-26 | SRDS | Yes |
| GP-23 | SRDS | Yes |
| GP-07 | SRDS/SPPD | Yes |
| GP-27 | SPPD | Yes, $5^{th}$ Avenue South |
| GP-28 | SPPD | Yes, $5^{th}$ Avenue South |
| GP-29 | SPPD | Yes, $5^{th}$ Avenue South |
| GP-16[2] | SPPD | No |
| GP-31[2] | SPPD | Yes |
| GP-15 | SPPD | Yes, Lenci/Emerson |
| GP-32[2] | SPPD | Yes |
| GP-03[2] | SPPD | No |
| GP-13 | SPPD | Yes |
| GP-11 | SPPD | Yes |
| GP-38 | None | No |
| GP-33 | SPPD | Yes |

Notes:
1. Adjacent off-site buildings within 100 feet are shown on Figure 14.2.
2. Due to shallow groundwater, these probes are only measured when the water table is low enough for the probes to function.

Notes:
- Tax parcels provided by King County Geographic Information Systems Center.
- Orthoimagery provided by NearMap, September 27, 2015.

Abbreviation:
- LFG = Landfill Gas

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Figure 14.1
Perimeter Landfill Gas Probe Network

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2/12/2018


Notes:
- Tax parcels provided by King County Geographic Information Systems Center.
- Orthoimagery provided by NearMap, September 27, 2015.

Abbreviation:
- IA = Interim Action

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Figure 14.2
Buildings within the Landfill Boundary and within 100 feet of Landfill Boundary

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2/12/2018


Monitoring Well Network

| Monitoring Well | Location | Zone | Screened Interval (feet bgs) |
|---|---|---|---|
| **Upgradient Wells Representing Quality of Groundwater Entering the Landfill** | | | |
| MW-12 | Upgradient | A-Zone | 10–15 |
| MW-14 | Upgradient | A-Zone | 11.5–21.5 |
| MW-29 | Upgradient | A-Zone | 20–30 |
| **Downgradient Wells Representing Conditions at the Edge-of-Refuse (POC wells)** | | | |
| MW-18 | Edge-of-refuse | B-Zone | 30–40 |
| MW-25 | Downgradient | A-Zone | 22–27 |
| MW-32 | Edge-of-refuse | A-Zone | 19–24 |
| MW-33 | Edge-of-refuse | A-Zone | 20–25 |
| MW-26 | Downgradient | A-Zone | 15–25 |
| MW-27 | Downgradient | A-Zone | 10–20 |
| MW-10 | Downgradient | B-Zone | 35–45 |
| MW-24 | Downgradient | B-Zone | 35–45 |
| MW-08 | Downgradient | B-Zone | 35.5–45.5 |
| **Downgradient Wells Representing Conditions near the Former Glitsa Property** | | | |
| MW-30 | Downgradient | Perched Zone | 8–13 |
| MW-31 | Downgradient | A-Zone | 18–23 |

Notes:
· Tax parcels provided by King County Geographic Information Systems Center.
· Orthoimagery provided by NearMap, September 27, 2015.

Abbreviations:
· bgs = Below ground surface
· Glitsa = Glista American, Inc.

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Figure 14.3
Perimeter Groundwater Monitoring Well Network

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2/12/2018

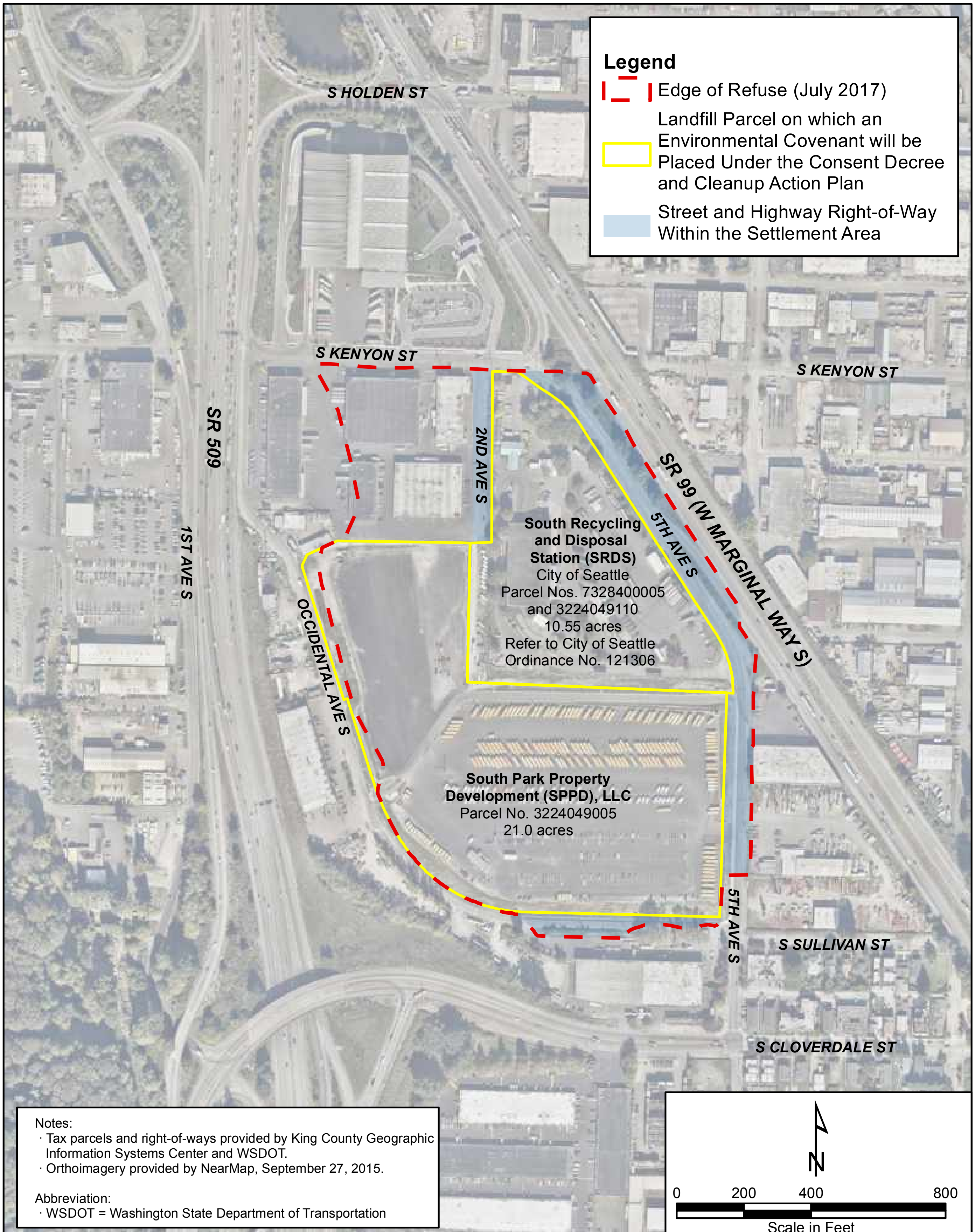


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Figure 15.1
Environmental Covenant Parcels

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2/13/2018