5.0 CONFINED DISPOSAL FACILITY MONITORING

The St. Paul Waterway Confined Disposal Facility (CDF) was constructed to confine contaminated sediments that were dredged as part of the Thea Foss and Wheeler-Osgood Waterways Remediation Project. Contaminated sediments are contained within the CDF and separated from direct contact with surface water by a containment berm constructed across the St. Paul Waterway on the north, the St. Paul/Middle Waterway Peninsula on the west, the Simpson Tacoma Kraft property to the east, and the Simpson log storage property to the south. Commencement Bay, the outer St. Paul Waterway, Middle Waterway, and the Puyallup River are surface waters located in proximity to the CDF (Figure 5-1). Monitoring of the CDF will be performed to characterize post-construction groundwater quality and flow conditions to ensure the protection of adjacent surface water. Additionally, visual observations of the CDF containment and offset berms and CDF cap will be performed to document the condition of berms and cap.

CDF monitoring includes identifying baseline groundwater and surface water conditions followed by performance monitoring that includes comparison of the results of baseline monitoring to the results of subsequent groundwater monitoring. Baseline groundwater quality will be measured at monitoring well locations selected based on post-construction groundwater flow conditions. Once baseline groundwater quality has been established, performance monitoring will commence. The performance monitoring program is designed to assess whether concentrations of selected constituents demonstrate a statistically significant increase, relative to baseline groundwater quality, as a result of the construction of the CDF.

The CDF monitoring program presented in this section describes the purpose, objectives, approach, and procedures for performing post-construction monitoring of the CDF. The monitoring plan also presents the methods and procedures for field sampling and quality control/quality assurance protocols (Appendix D – Confined Disposal Facility Monitoring Operations Manual). Health and Safety protocols regarding CDF monitoring activities are presented in Appendix F.

5.1 Monitoring Objectives and Rationale

The objective of this monitoring program is to protect water quality in adjacent surface water bodies from contaminants which could potentially migrate in groundwater from the CDF. The monitoring program is designed to evaluate groundwater quality at and in areas surrounding the CDF to ensure compliance with the performance criteria. The monitoring program includes the collection, analysis, and interpretation of groundwater data from 15 new monitoring wells installed within and around the perimeter of the CDF (Figure 5-2). Additionally, visual observations of the CDF containment and offset berms and surface of the CDF cap will be made to document the condition of berms and cap.

The CDF monitoring objectives as described in this plan are consistent with the Record of Decision (ROD) (EPA 1989), Administrative Order on Consent (AOC) (EPA 1994), Explanation of Significant Differences (ESD) (EPA 2000, EPA 2004), and Consent Decree (CD) Statement of Work (SOW) (EPA 2003) for the Thea Foss and Wheeler-Osgood Waterways Remediation Project. CDF monitoring activities specifically address the following objectives stated in the ROD and CD SOW:

- Monitoring at the disposal site to evaluate the effectiveness of the remedy; and
- The St. Paul disposal site will be subject to long-term monitoring to ensure that the selected remedy remains protective, including that marine chronic water quality standards or background concentrations, whichever are higher, are not exceeded in surface water outside of the CDF after construction.

5.2 Monitoring Approach

5.2.1 Overview of Monitoring Activities

The CDF monitoring approach is designed to characterize and monitor groundwater conditions and quality to evaluate the protection of surface water adjacent to the CDF.

The scope of work for the CDF monitoring activities is as follows:

- Install new monitoring wells in and adjacent to the CDF (i.e., MW-01 through MW-15);
- Conduct a 72-hour tidal study and slug tests to evaluate the post-construction groundwater flow conditions in the area of the CDF;
- Document the post-construction hydrogeologic conditions in a report to be submitted to EPA;
- Select monitoring wells to be used for baseline groundwater quality monitoring;
- Perform quarterly groundwater and surface water monitoring for two years to identify baseline conditions;
- Document the baseline conditions in a report to be submitted to EPA;
- Identify the performance monitoring program for the CDF;
- Monitor groundwater quality over time in accordance with the performance monitoring program;
- Perform visual observations of the berms and CDF cap; and
- Implement appropriate response actions, as necessary.

All monitoring activities, including groundwater and surface water sampling activities will be conducted using the same procedures to provide consistency of data for use in establishing baseline conditions as well as statistical evaluations. The field sampling and quality control/quality assurance protocols are presented in Appendix D – Confined Disposal Facility Monitoring Operations Manual. Health and Safety protocols for CDF monitoring are presented in Appendix F.

5.2.2 Performance Monitoring Criteria and Decision Matrix

The decision matrix flow chart for CDF performance groundwater monitoring is presented in Figure 5-3. The performance standard for this groundwater monitoring program is the evaluation of statistically significant increases in contaminant concentrations relative to the established groundwater baseline concentrations.

An intra-well evaluation will be performed for the CDF groundwater monitoring results. Baseline CDF groundwater monitoring is being performed for the purpose of establishing the baseline (i.e., background) groundwater quality conditions in individual wells that are selected for monitoring prior to possible impacts from contaminated sediment placed in the CDF. Baseline groundwater conditions for individual wells will be established based on the results of monitoring to be done quarterly for two years. Statistical analysis of the results of quarterly analyses performed on an individual well will establish the baseline groundwater quality for each individual well and will be used to evaluate possible changes in groundwater quality in the individual well during performance monitoring. The results of performance monitoring for an individual well will be compared to the baseline groundwater quality conditions for that individual well (i.e., intra-well comparison) to evaluate whether there is a significant change in groundwater quality conditions at that location.

If statistically significant increases in groundwater concentrations are observed, the City will propose to EPA whether to initiate one or more response actions appropriate to the nature of the increase as described in Section 5.8.

The point of compliance for CDF monitoring is the sediment/surface water interface outside of the berm and peninsula surrounding the CDF. Surface water criteria (WAC 173-201A) or ambient surface water concentrations (whichever are higher) are performance criteria at the point of compliance.

Surface water monitoring is also being performed at a station adjacent to the CDF, post-CDF construction and prior to possible impacts from groundwater discharge to identify baseline surface water conditions and to evaluate changes in surface water quality conditions due to seasonal effects. The results of performance monitoring of groundwater quality will not be compared to the surface water monitoring results. The results from performance monitoring of groundwater will be compared to the results of baseline groundwater quality conditions as described above. The surface water monitoring is being done to provide an understanding of baseline, ambient surface water conditions in the area of the CDF, for possible future reference should evaluation of possible impacts to surface water conditions be needed.

Visual observations of the containment and offset berms will be made to document the condition of berms and noticeable changes to the berm structures. Visual observations will also be made of the surface of the CDF cap to document the integrity of the cap. If observations indicate noticeable changes in the berm structures or integrity of the cap, the City will propose to EPA whether to initiate response actions as described in Section 5.9.

5.2.3 Schedule and Reporting Overview

The schedule for CDF monitoring activities is presented in Table 5-1 and includes the following:

- Installation of new monitoring wells;
- A 72-hour tidal study and slug tests will be completed within six weeks of the completion of well installation and development;
- Baseline monitoring will be performed following EPA's approval of the Post-Construction Hydrogeologic Conditions Report and identification of baseline

monitoring wells. Baseline monitoring activities will be conducted quarterly for a period of two years;

- Performance monitoring will be performed following EPA's approval of the Baseline Water Quality Conditions Report and development of the performance monitoring program. The frequency of performance monitoring will be determined based on groundwater flow conditions as well as the results of the baseline monitoring; and
- Visual observations of the containment and offset berms and CDF cap will be performed quarterly during the first two years, coincident with quarterly groundwater and surface water monitoring. Recommendations on the schedule for subsequent observations will be included in the Performance Monitoring Plan.

Reporting

The following reporting will be performed and submitted to EPA to document the results of CDF monitoring activities:

- **Post-construction hydrogeologic conditions** determined from the results of the 72-hour tidal study and slug tests will be documented in a report that will be used to identify baseline monitoring locations and support selection of monitoring locations for performance monitoring. The components of the Post-Construction Hydrogeologic Conditions Report are discussed in Section 5.5. The Post-Construction Hydrogeologic Conditions Report will be submitted for EPA review and approval;
- **Baseline water quality conditions** determined from the results of two years of quarterly monitoring will be documented in Preliminary Findings Memoranda completed quarterly and in a Baseline Water Quality Conditions Report that will be produced at the end of the Baseline Monitoring period. This information will be used in combination with post-construction hydrogeologic conditions to identify analytes and locations for performance monitoring. The Preliminary Findings Memoranda will be submitted following the completion of quarterly monitoring activities, data analysis, and data validation. The components of the Baseline Water Quality Conditions Report are discussed in Section 5.6.2. The Baseline Groundwater Quality Conditions Report will be submitted for EPA review and approval;
- **The performance monitoring program** will be developed following completion of the baseline monitoring period. The City will submit a proposed long-term performance monitoring program for the CDF to EPA within 120 days of EPA approval of the baseline monitoring report. The components of the Performance Monitoring Plan are discussed Section 5.7. The Performance Monitoring Plan will be submitted for EPA review and approval;
- **Performance monitoring results** will be documented in a report that will compare the results of performance monitoring to baseline conditions as discussed in Section 5.7. The schedule for reporting of performance monitoring results will be identified as part of the performance monitoring program; and
- **Visual observations of the CDF containment and offset berms and CDF cap** will be reported as separate technical memoranda that will be submitted to EPA to provide timely transmittal of the results and facilitate implementation of response

actions, if necessary. The technical memoranda will be incorporated into the annual OMMP reports.

5.3 Hydrogeologic Conditions

This section briefly summarizes the current and expected future subsurface physical conditions pertinent to the design and operation of the monitoring program for the CDF. The CDF was built as designed and described in the Design Analysis Report (DAR) (City 2002). Construction included dredging the southern portion of the St. Paul Waterway to elevation -60 feet Mean Lower Low Water (MLLW), building a containment berm across the St. Paul Waterway, placing contaminated sediments into the southern portion of the waterway to elevations below the surface of the water table (9 feet MLLW), and placing a cap on the CDF to bring the surface of the CDF to the existing upland grade. A more detailed discussion of CDF construction is presented in the Remedial Action Construction Report (RACR; City of Tacoma 2006). Cross sectional illustrations of the CDF are shown on Figures 5-4 through 5-6. The monitoring wells and screening intervals are also shown on these figures.

The remainder of this section presents soil stratigraphy, groundwater occurrence and flow, and groundwater quality at the disposal site based on previous field investigations, as well as expected future conditions at the CDF based on experience with similar CDF sites and predictive groundwater modeling.

5.3.1 Subsurface Soil Stratigraphy

Based on previous field explorations summarized in the DAR, soil and sediments adjacent to and beneath the St. Paul Waterway have been divided into three distinct units. The following units are expected to be encountered below and/or adjacent to the dredged sediments deposited in the CDF:

- **Fill Material (Upland Areas).** Upland areas adjacent to the waterway are underlain by sandy fill material overlying natural deposited silts and sands. The fill material was present at all upland soil boring locations, with a thickness ranging from 16 to 31 feet. The fill consists predominantly of poorly graded sand and occasional wood fragments and silt layers;
- **Recent Sediment Deposits (Waterway).** Sediment cores advanced in the waterway encountered a very distinct geologic contact occurring in the upper 4-foot section of the cores. Material above this horizon, indicative of recent sediment deposits, was characterized by black silt/clay material with approximately 10 percent wood debris. Material below the horizon was comprised of gray silt and sand material with less than one percent wood debris and is interpreted as Deltaic/Marine Deposits. With the exception of the sediments at the mouth of the waterway, the recent sediments were removed during CDF construction; and
- **Deltaic/Marine Deposits (Uplands and Waterway).** The deeper geotechnical and sediment borings indicate the presence of variable layers of sand, silty sand, and sandy silt beginning at approximately 5 feet MLLW to -10 feet MLLW, and continuing to at least elevation -100 feet MLLW. These deposits are interpreted as deltaic and shallow marine deposits associated with sedimentation from the Puyallup River.

5.3.2 Groundwater Occurrence and Flow

The following two distinct hydrogeologic units are present in the vicinity of the CDF:

- **Shallow Unconfined Zone.** Groundwater was observed at depths ranging from 8 to 10 feet below ground surface in September 1997 and March 1999. In situ hydraulic conductivity tests (slug tests) were performed on three shallow groundwater monitoring wells (RD3-UMW-6, RD3-UMW-7, and RD3-UMW-8) (Figure 5-2). Horizontal hydraulic conductivity values estimated from these tests range from 7×10^3 to 4×10^2 cm/sec; and
- **Deeper Water-Bearing Zone.** One monitoring well, RD3-UMW-10, was completed below the Recent Fill Unit in the Deltaic/Marine Deposits (Figure 5-2). Due to the presence of interbedded silt and sand observed in the deeper borings completed in the waterway, the deeper water-bearing zone (below elevation 0 feet MLLW) appears to be confined near the site.

Net groundwater flow is toward Commencement Bay. Groundwater flow in sediments adjacent to the CDF is periodically reversed during tidal fluctuations. There is an assumed shallow groundwater divide to the east of the site, between the CDF and the Puyallup River. A second shallow groundwater divide exists between Middle Waterway and the CDF on the southwest side of the site. Because Commencement Bay and the remaining portion of the St. Paul Waterway are groundwater discharge areas, groundwater flow in the Deltaic/Marine Deposits offshore of the CDF is expected to be upward.

5.3.3 Groundwater Quality

Groundwater quality data beneath and adjacent to the St. Paul Waterway were collected during remedial design. Low salinity (less than 0.2 ppt) was observed in three monitoring wells (RD3-UMW-6, RD3-UMW-7, and RD3-UMW-8) completed near the south and east margin of the waterway. Higher salinity readings of up to 4 ppt were observed in a shallow monitoring well (RD3-UMW-5) completed on the peninsula between the St. Paul and Middle Waterways. The deep well (RD3-UMW-10) had a relatively high salinity reading of 14 ppt, reflecting a mixing zone of fresh groundwater and saline surface water.

5.3.4 Expected Future Conditions

The post-construction groundwater conditions below the CDF are expected to be similar to other fill areas of Commencement Bay (i.e., the Milwaukee fill) and the groundwater flow system will eventually establish a new equilibrium, with groundwater likely flowing generally to the northwest toward Commencement Bay and the Middle Waterway.

Numerical groundwater modeling was completed to predict the post-construction groundwater flow system within and around the CDF (City 1999). Based on this modeling, the predicted net groundwater flow from the CDF is northwestward through the berm and westward through the peninsula between the CDF and Middle Waterway. While the net hydraulic gradient will be toward Commencement Bay and Middle Waterway, short-term reversals (i.e., flow toward the CDF) will occur during high tides.

Based on this predictive groundwater flow and contaminant transport modeling, the shortest flow path is through the peninsula to the Middle Waterway. The shortest time for the leading edge of the contaminant front to travel from the fill to the adjacent surface water would be on the order of 50 to 100 years. Water quality exceedances are not expected due to a combination of factors, as explained in Section 5.2 of the DAR.

5.4 Groundwater Monitoring Well Network

The groundwater monitoring well network has been designed to provide data for post-construction groundwater flow conditions and quality within and around the CDF. The monitoring well network will consist of newly installed monitoring wells that include the following (Figure 5-2):

- One shallow monitoring well in the CDF containment berm (MW-01);
- One shallow monitoring well on the northwestern end of the St. Paul/Middle Waterway Peninsula (MW-02);
- One shallow monitoring well east of the CDF (MW-03);
- One shallow monitoring well and one deep well in the CDF fill (MW-04 and MW-05);
- One shallow monitoring well (MW-06), one intermediate monitoring well (MW-07), and one deep monitoring well (MW-08) in the peninsula between the northern portion of the CDF and Middle Waterway;
- One shallow monitoring well in the CDF offset berm (MW-09);
- One shallow monitoring well (MW-10), one intermediate monitoring well (MW-11), and one deep well (MW-12) in the peninsula between the southern portion of the CDF and the Middle Waterway; and
- One shallow well (MW-13), one intermediate well (MW-14), and one deep well (MW-15) south of the CDF.

All of the wells in the monitoring well network will be used to evaluate the groundwater flow direction and gradients as part of the 72-hour tidal study. A subset of the wells included in the monitoring well network identified above will be selected for baseline monitoring based on the results of the 72-hour tidal study. The wells within the monitoring well network that will be sampled as part of performance monitoring will be selected based on the results of the 72-hour tidal study and baseline monitoring.

Monitoring wells RD3-UMW-5 through RD3-UMW-10 were installed prior to construction of the CDF (Figure 5-2). Monitoring wells RD3-UMW-5 through and RD3-UMW-8 were installed in August 1997 (Anchor Environmental and Parametrix 1998) and wells RD3-UMW-9 and RD3-UMW-10 were installed in February 1999 (City of Tacoma 1999) to support predictive contaminant transport modeling. Monitoring wells RD3-UMW-5 and RD3-UMW-10 were within the footprint of the CDF and were subsequently decommissioned during construction of the CDF. Monitoring wells RD3-UMW-6, RD3-UMW-7, and RD3-UMW-9 have not been located and are not currently included in the monitoring well network. Monitoring well RD3-UMW-8 has been located and is present east of the CDF (Figure 5-2). Monitoring well RD3-UMW-8 is

anticipated to be upgradient of the CDF based on predicted post-construction groundwater flow directions and may be used to monitor groundwater elevations.

5.4.1 Groundwater Well Installation

A total of 15 new wells (MW-01 through MW-15) will be installed as part of the monitoring well network (Figure 5-2). The actual location of the new wells may be adjusted during well installation based on field conditions and to reduce potential conflict with current and future property uses. Eight of the 15 new wells will be completed at shallow depths. The new shallow wells will be constructed with a 10-foot screened interval, set approximately from 10 feet MLLW to 0 feet MLLW, consistent with the shallow wells used to support predictive contaminant transport modeling. The shallow wells are located and screened to evaluate hydrogeologic conditions in near-surface soil, fill, and material used to construct the containment and offset berms and to allow characterization and monitoring of the quality of groundwater that is most likely to be impacted by the saltwater washout effect (i.e., where the lowest saline groundwater and stormwater infiltration come in contact with and flow over the surface of contaminated sediment placed in the CDF). Intermediate depth wells will also be constructed with a 10-foot screened interval, set approximately from 0 feet MLLW to -10 feet MLLW, an intermediate elevation within the shallow unconfined groundwater zone. The intermediate wells are located and screened to evaluate hydrogeologic conditions and allow characterization and monitoring of the quality of groundwater in the upper deltaic / marine deposits. Three deep wells will be constructed with a 20-foot screened interval, set approximately from -40 feet MLLW to -60 feet MLLW, the elevation of the bottom of the CDF. The deep wells are located and screened to evaluate hydrogeologic conditions and allow characterization and monitoring of the quality of groundwater in the deltaic / marine deposits at the bottom of the CDF. Details on the methods that will be used for well drilling explorations, well installations, and development are described in the CDF Monitoring Operations Manual (Appendix D).

The monitoring well network was designed to monitor the assumed “worst-case” groundwater quality at the CDF. It is anticipated that the highest potential for mobilization of contaminants from the CDF will occur with progressive flushing of the contaminated, dredged sediment with less saline groundwater (salt washout effect; Brannon et al. 1994). Comparison of salinity measurements from the deep well and the shallow wells indicate that the shallow groundwater will be the least saline groundwater entering and leaving the CDF. Therefore, the shallow well screens in the CDF monitoring well network are positioned vertically to provide a conservative representation of groundwater quality at the CDF.

5.5 Post-Construction Hydrogeologic Conditions (Tidal Study)

Upon completion of the installation of the monitoring well network, the post-construction groundwater flow conditions will be evaluated by performing a 72-hour tidal study and slug tests. Data collection will include continuous (every 15 minutes) water level measurements in wells MW-01 through MW-15, in the surface water swale between Simpson’s clarifier tanks and the offset berm, and in the Middle Waterway using electronic data loggers and well transducers.

Net groundwater flow directions determined from the tidal study will provide the basis for selection of wells to be included in the baseline and performance monitoring programs. In addition, aquifer hydraulic conductivity will be determined by conducting aquifer well slug tests. These data, with the net hydraulic gradient calculated from the tidal study, can be used to

calculate groundwater flow velocities and travel times, which will be used to identify the appropriate frequency for performance monitoring.

The post-construction hydrogeologic conditions will be documented in a report. The Post-Construction Hydrogeologic Conditions Report will present the geologic and tidal study data collected as part of the CDF monitoring program, an assessment of subsurface conditions, groundwater flow directions and velocities, and estimated times for groundwater to travel from the CDF to reach wells adjacent to the CDF and to adjacent surface water. The Post-Construction Hydrogeologic Conditions Report will be submitted for EPA review and approval.

5.6 Baseline Water Quality

Baseline water quality monitoring will consist of sampling groundwater from selected monitoring wells and surface water adjacent to the Peninsula Habitat Area at the end of the Middle/St. Paul Peninsula.

Because groundwater quality can vary by both location and time, comparisons of performance water quality data against baseline conditions will need to be made on an intra-well basis. As discussed above, the wells to be included in the groundwater monitoring program (both baseline and subsequent performance monitoring) will be determined based on the post-construction groundwater flow conditions. To establish baseline groundwater quality in the selected monitoring wells, and evaluate whether seasonal trends are apparent, the baseline monitoring will consist of quarterly groundwater sampling for two years (eight total events).

The wells installed within the CDF (MW-04 and MW-05) will be included in the baseline monitoring program. However, the primary objective for installing these wells is to determine hydraulic gradients within the CDF. Therefore, these wells will not be sampled as part of the performance monitoring program. The wells installed within the CDF may be decommissioned after baseline monitoring has been completed if it is determined that the wells are no longer needed.

Although baseline groundwater conditions will be established during the first two years following construction of the CDF, groundwater velocities are expected to be slow enough that groundwater from the CDF would not reach the performance monitoring wells until several years, possibly decades, after the baseline monitoring is completed.

To establish a baseline for ambient surface water conditions, surface water monitoring will also be performed quarterly as part of baseline monitoring. Surface water monitoring will be performed at high, slack tide at the northern end of the Middle/St. Paul Peninsula and Peninsula Habitat area (i.e., North Beach Habitat) (Figure 5-2). The surface water sampling location will provide water quality data representative of ambient surface water from Commencement Bay and the Puyallup River that enters the St. Paul and Middle Waterways adjacent to the CDF. Surface water samples will be collected from three feet below the water surface.

5.6.1 Baseline Monitoring Parameters

Leaching test data representative of the dredged sediments placed in the CDF indicate that high molecular-weight polycyclic aromatic hydrocarbons (HPAHs) (e.g., benzo(a)anthracene) and the metals mercury, lead, copper, nickel, and zinc could leach at concentrations above ambient

water quality criteria (City 1999). Thin-layer column leaching tests (TCLT) were performed to evaluate leaching and transport of contaminants in groundwater from sediment disposed of in the St. Paul CDF. Analysis for metals including arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc were performed on 30 TCLT samples. Arsenic, cadmium, chromium, and silver were not detected at concentrations greater than surface water criteria in the TCLT samples. Copper, lead, mercury, and zinc were detected in multiple samples at concentrations greater than the surface water criteria. Nickel was detected in four samples at concentrations slightly above the surface water criteria. As copper, lead, mercury, nickel, and zinc were detected in multiple samples at concentrations greater than the surface water criteria, the five metals were chosen as indicator chemicals for CDF monitoring. Due to this result, baseline monitoring will involve sampling and analysis of groundwater for the five metals and PAHs.

Total organic carbon (TOC) and salinity analyses will also be performed on groundwater during the baseline monitoring to provide a baseline against which to compare potential changes in general groundwater chemistry over time (e.g., monitor for salt washout effect). Total suspended solids (TSS) analysis will be performed to assess potential turbidity bias in the total mercury results. Field parameters (temperature, pH, electrical conductivity, dissolved oxygen, and turbidity) will also be measured in the field during groundwater sampling. Baseline surface water samples will be collected and analyzed for salinity, total and dissolved mercury, and dissolved lead, copper, nickel, and zinc.

Groundwater and surface water sampling and analysis will be performed in accordance with sampling and quality assurance protocols presented in Appendix D – Confined Disposal Facility Monitoring Operations Manual.

5.6.2 Baseline Data Evaluation and Statistical Analysis

The baseline monitoring data will be evaluated to determine whether seasonality exists in detected concentrations (i.e., seasonal concentration fluctuations). Additional samples may be performed if data from the two years of quarterly monitoring show a seasonal variation. Assuming that seasonal variations are not evident, the baseline data will be summarized statistically to support subsequent data evaluation during performance monitoring, as discussed in Section 5.7.

The statistical analysis of baseline monitoring data will consist of the following:

- Assessing the overall range and statistical characteristics of the CDF baseline water quality at each well location for each analyte of concern using probability plots;
- Evaluating the degree of variation in the baseline water quality as detected in individual wells using box plots and analysis of variance (ANOVA); and
- Characterizing each individual data set for each analyte monitored at each well by identifying outliers, confirming data distributions, and trend analysis.

Probability Distribution Analysis

The statistical analysis initially involves looking at the site-wide characteristics of the baseline data after pooling the results for each analyte from the monitoring wells that were selected for

baseline monitoring. This analysis will provide an overview of groundwater quality for the analytes of concern and allows the overall consistency of the data and groundwater quality to be assessed by examining the statistical frequency distribution of the data using probability plots. This analysis will also provide an estimate of the 95th percentile value for each analyte across the CDF, based on the probability distribution. Additionally, the baseline values for analytes will be defined by the one-sided tolerance level providing 95% coverage of the observed data, with 95% confidence. This analysis provides the 95th percentile upper tolerance limit (UTL) for each analyte for the baseline data set that the performance monitoring results can be compared to (Gibbons 1994).

Site-Wide Variability

The degree of variability across the CDF for each analyte of concern will be examined by comparing box plots of the data from each well for each analyte. These data groups will also be compared statistically using the single factor analysis of variance (ANOVA), which will help to quantify spatial versus temporal variability in the data over the course of the baseline monitoring. The site-wide data will be divided into groups where each group consists of data from one monitoring well. ANOVA provides an analysis of the distribution of total variance in the data set between the groups and within the groups.

The use of box plots will provide graphic illustration of site-wide variability between wells, in addition to providing comparative ranges of values within wells over time. These analyses will help to establish the appropriate range of baseline concentrations observed during the baseline monitoring for each analyte as well as aiding in well selection for performance monitoring.

Intra-Well Data Sets

The statistical characteristics for each analyte at each individual well location will be determined on an intra-well basis by: assessing the probability distribution, addressing non-detect values, and testing for outliers.

The data distribution of each intra-well data set for each analyte will be initially assumed to have a log-normal distribution. This assumption will be confirmed by transforming the baseline analytical data to natural logs and then performing the Shapiro-Wilk Test (Gibbons 1994).

Additionally, a linear regression analysis on the time series data for each analyte in each well will be conducted to assess the presence of any statistically significant trend in the data. The trend that has been anticipated and will be evaluated is seasonality of the data. Data trends will be evaluated by linear regression to determine the slope of the best-fitting trendline to the data.

The statistical analysis of the baseline data will allow for the comparison of performance monitoring data to the established CDF baseline data and the determination of statistically significant changes in concentrations and analyte concentration trends. These statistical analyses will also be used for the surface water baseline data set.

5.6.3 Baseline Data Reporting

The baseline water conditions will be documented in Preliminary Findings Memoranda and in the Baseline Water Quality Conditions Report prepared at the end of the two years of quarterly

monitoring. The Preliminary Findings Memoranda will provide a summary of field activities, data summary tables, and identify any deviations from planned activities or significant findings. The Preliminary Findings Memoranda will be submitted following the completion of monitoring activities, data analysis, and data validation. The Baseline Water Quality Conditions Report will present the baseline data collected, assessment of seasonality, the results of the statistical analysis of the baseline data set, and a recommendation on whether the baseline monitoring completed is sufficient to establish baseline conditions. The Baseline Water Quality Conditions Report will be submitted for review and approval by EPA.

5.7 Performance Monitoring

The objective of performance monitoring is to compare post-construction groundwater quality to baseline conditions to determine if constituents are being transported in groundwater from the CDF at concentrations that could pose a potential threat to surface water quality at the point of compliance. The performance standard for the performance monitoring program is to evaluate if statistically significant increases in contaminant concentrations relative to the established groundwater baseline concentrations are observed. The decision matrix flow chart for CDF performance monitoring is presented in Figure 5-3.

Following completion of the baseline monitoring period, the City will submit a proposed long-term performance monitoring program for the CDF to EPA within 120 days of EPA approval of the baseline monitoring report. The performance monitoring program will be based on the post-construction hydrogeologic assessment and the baseline groundwater quality program. The proposed performance monitoring program will identify wells to sample, the sampling frequency and schedule, and chemical analyses to be performed. It will also identify periodic reporting and reviews to re-evaluate the program based on performance monitoring data trends.

The wells to be included in performance monitoring will be adequate in number to characterize groundwater quality conditions. The determination of wells to be used will be based on the post-construction groundwater flow conditions (groundwater flow direction and estimated travel times for the groundwater within the CDF to reach the monitoring wells). If it is demonstrated that groundwater within the CDF would reach one or more of the monitoring wells in substantially shorter time than the others, it is expected that these wells would be selected as indicator wells for performance monitoring. Surface water monitoring will be conducted as part of the baseline monitoring program and will not be conducted during the performance monitoring program unless it is determined to be necessary as part of a potential response action. If statistically significant increases in chemical concentrations above baseline groundwater conditions are observed in indicator wells or trends are observed in several wells that are screened at the same elevation (e.g., shallow, intermediate, or deep), monitoring of additional wells could be conducted as one of the potential response actions (discussed below). Similarly, during the course of the monitoring program, the City may propose to EPA to reduce the number of wells to be monitored, reduce the sampling frequency, or the analyte list based on the performance monitoring data.

If statistically significant increases in an analyte are observed EPA will be notified immediately and resampling of the well(s) where the increase was observed will be conducted to confirm the analytical results prior to the evaluation of potential response actions. If concentration trends or gradients are observed in several wells that are screened at the same elevation (e.g., shallow, intermediate, or deep), the concentration data will be evaluated in consultation with EPA to

assess if additional monitoring or response action is needed. EPA notification of a statistically significant increase will initially be verbal or by email (i.e., if verbal communication is not possible) followed by written communication of the results.

In addition to the analytes that will be monitored during performance monitoring, as determined by the baseline monitoring data, TOC and salinity will be analyzed to track potential general changes in groundwater chemistry over time. TSS will be analyzed to assess potential turbidity bias in total mercury results. Field parameters (temperature, pH, electrical conductivity, dissolved oxygen, and turbidity) will also be measured in the field during groundwater sampling (see Appendix D – Confined Disposal Facility Monitoring Operations Manual).

5.7.1 Performance Monitoring Data Evaluation and Statistical Analysis

Analytical results of samples collected from performance monitoring wells will be statistically compared to each analyte's distribution observed during the two-year baseline monitoring program. First the data collected from performance monitoring wells will be compared to the baseline analyte geometric mean and 95th percentile UTL for each analyte in each monitoring well. If an analyte concentration measured during the performance monitoring program exceeds the baseline 95th percentile UTL for the specific analyte and well then the performance monitoring data will be further statistically evaluated relative to the baseline data set.

For baseline datasets that were determined statistically to be normally or log-normally distributed, the calculated geometric mean and the geometric standard deviation (GSD) will be used with a two-sided Student's t-distribution to determine whether the analytical results from the performance monitoring wells are statistically comparable to the baseline monitoring data set.

If baseline data sets did not conform to the normal or log-normal distributions, the observed maximum and minimums will be considered to bound the data set for comparative purposes. These data sets will be assessed by comparing the analytical results of the performance monitoring with the maximum and minimum detections observed in the baseline data set.

If the results of these analyses indicate no statistically significant increase in chemical concentrations at a given monitoring well, performance monitoring will continue as identified in the performance monitoring program, subject to changes proposed by the City or EPA over the course of the program. However, if statistically significant increases are indicated, the City will notify EPA immediately and propose to EPA that one or more response actions be initiated to further evaluate the potential for groundwater flowing from the CDF to adversely impact the adjacent surface water. If sampling adjacent surface water quality is determined to be necessary as part of a potential response action, the same statistical analyses will be employed to evaluate surface water performance data relative to the surface water baseline data set.

5.8 Potential Response Actions

If statistically significant increases in chemical concentrations are observed during performance groundwater quality monitoring of the CDF, potential response actions could include but are not limited to:

- Increase the frequency of sampling of the existing well(s) of concern and/or other performance monitoring well(s);
- Evaluate analyte concentrations of concern in upgradient monitoring wells adjacent to the CDF;
- Install additional monitoring well(s) around the existing well(s) of concern to further delineate whether the concentration increase(s) is a point anomaly or if the increase(s) appears to be representative of a larger aerial extent;
- Install sentinel monitoring well(s) near the surface water, downgradient of the detected increase in chemical concentration(s);
- Establish or refine predictive groundwater transport analyses, including tidal mixing, for the chemical(s) of concern to evaluate the potential for exceedance of performance criteria at the point of compliance;
- Complete a site-specific study of tidal mixing in the aquifer upgradient of the point of compliance;
- Conduct groundwater sampling during low tide at a well point (i.e., monitoring well-like screened sample location) located on the intertidal beach at the point of expected groundwater discharge (i.e., point of compliance).
- Sample ambient surface water quality to define the potential impact;
- Sediment quality monitoring to evaluate possible impacts of groundwater discharge on sediment quality; and/or
- Implement appropriate remediation techniques to prevent exceedance of the performance criteria.

One or more of the response actions, or other actions not listed above but determined to be appropriate in the future, may be warranted depending on the specific groundwater quality conditions indicated by the monitoring data. Based on the data, the City will establish a response plan for discussion with and approval by EPA.

5.9 Observations of CDF Berms and Cap

Visual observations of the CDF containment and offset berms will be performed to document the integrity of the berm structures. The exposed surfaces of the berms will be inspected to identify visible changes in the berm surfaces including possible settlement or sloughing. Additionally, the berm surfaces will be inspected for the presence of seeps and possible signs of contamination including sheen or discoloration. Visual observations of the CDF cap will also be performed to document the integrity of the cap. The surface of the cap will be inspected to identify whether operations on the cap have affected cap integrity including possible penetrations into the cap or actions causing loss of cap material. Additionally, the cap surface will be inspected for possible signs of contamination including sheen or discoloration.

Procedures for performing and documenting visual observations are presented in Appendix D.

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TABLE

5-1 – CDF Monitoring and Reporting Schedule

FIGURES

5-1 – Vicinity Map

5-2 – Monitoring Well and Surface Water Sampling Location Plan

5-3 – CDF Performance Monitoring Decision Matrix

5-4 – Cross Section A-A' St. Paul Confined Disposal Facility

5-5 – Cross Section B-B' St. Paul Confined Disposal Facility

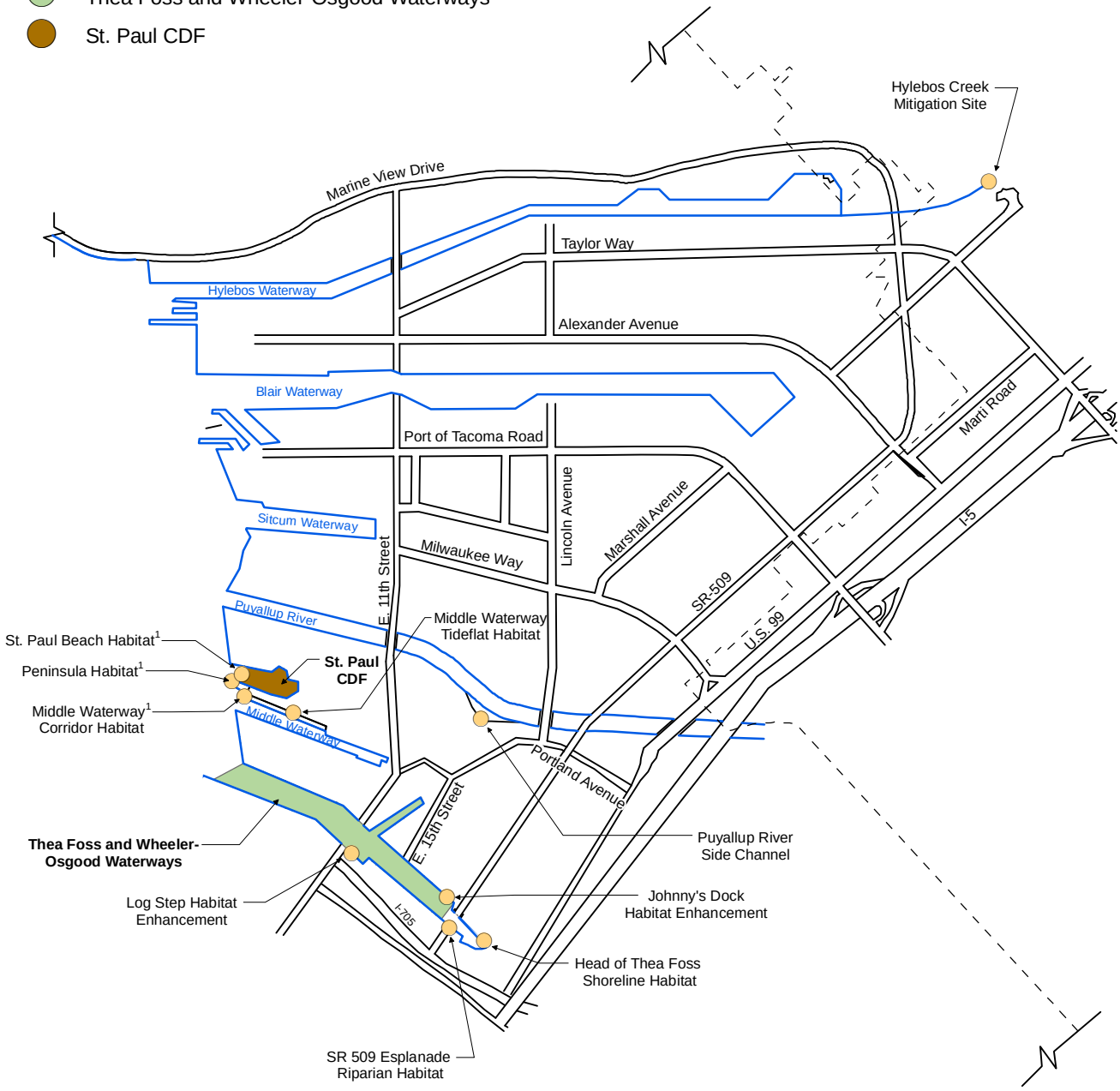
5-6 – Cross Section C-C' St. Paul Confined Disposal Facility

Table 5-1
CDF Monitoring and Reporting Schedule

Task		Task Type	Timeline and Description
1	Installation and Development of New Monitoring Wells	Field Activities	Following approval of OMMP
2	Conduct 72-Hour Tidal Study	Field Activities	Within 6 weeks of the completion of the well installation and development
3	Preparation of a Post-Construction Hydrogeologic Conditions Report	Reporting	Within 45 days of completing data validation following completion of the tidal study and data analysis
4	Identify Baseline Monitoring Wells	Meeting /Reporting	Following EPA review of Post-Construction Hydrogeologic Conditions Report
5	Perform Baseline Monitoring—Quarterly Wells and Surface Water Sampling and Observations of CDF Berms and Cap	Field Activities	Quarterly sampling for 2 years
6	Preparation of Report Presenting Baseline Water Quality Conditions	Reporting	Within 45 days of completing data validation following completion of eight quarterly sampling events
7	Identify Compliance Monitoring Program	Meeting/Reporting	120 days following EPA review of the Baseline Water Quality Conditions Report
8	Conduct Compliance Monitoring	Field Activities	To be determined

Legend

- Enhancement, Mitigation, and Habitat Areas
- Thea Foss and Wheeler-Osgood Waterways
- St. Paul CDF



NOTES

1. The St. Paul Beach Habitat, Peninsula Habitat, and the Middle Waterway Corridor Habitat are collectively called the North Beach Habitat.
2. All locations are approximate.

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Thea Foss and Wheeler-Osgood Waterways OMMP

Figure 5-1 Vicinity Map

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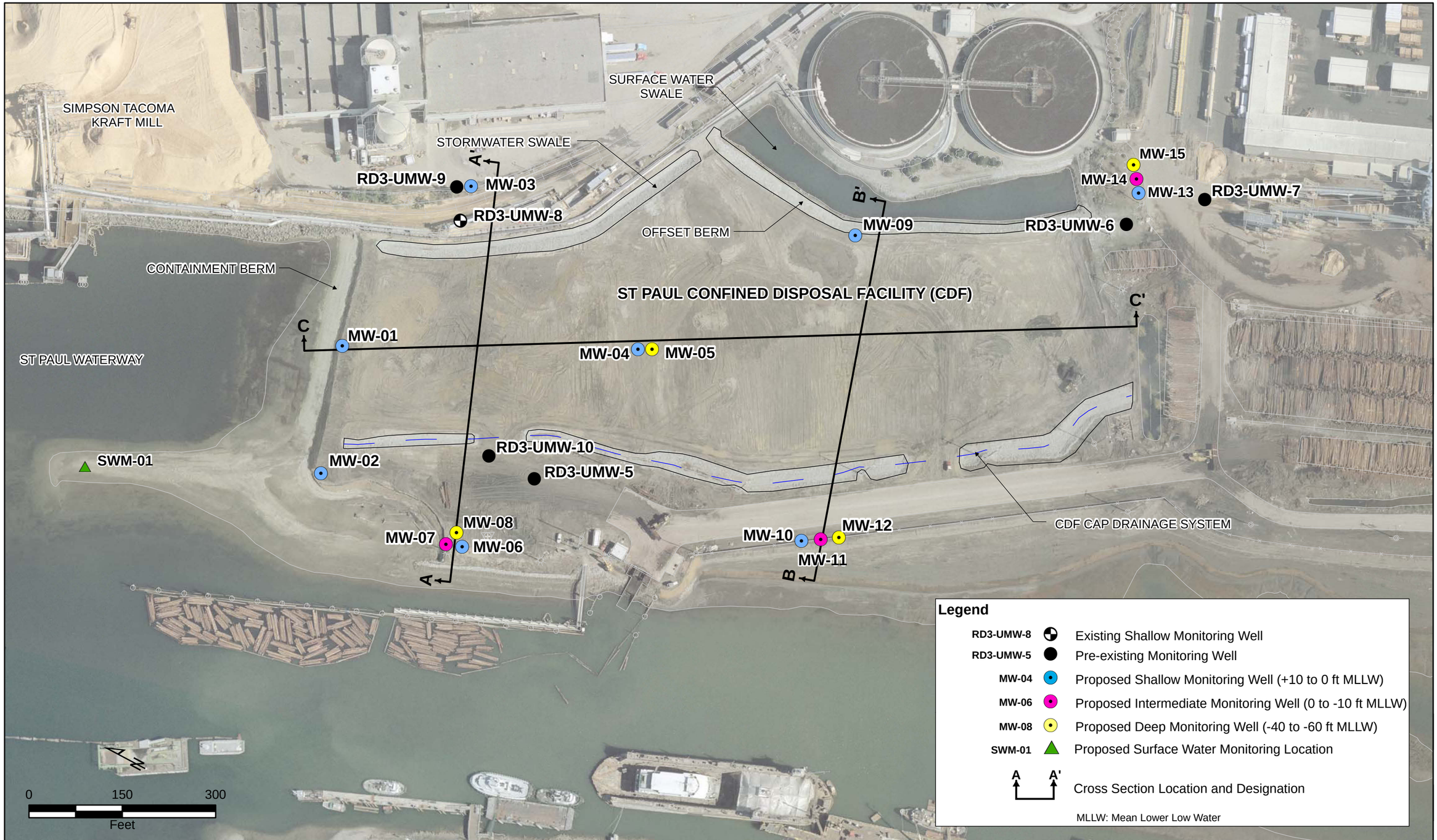

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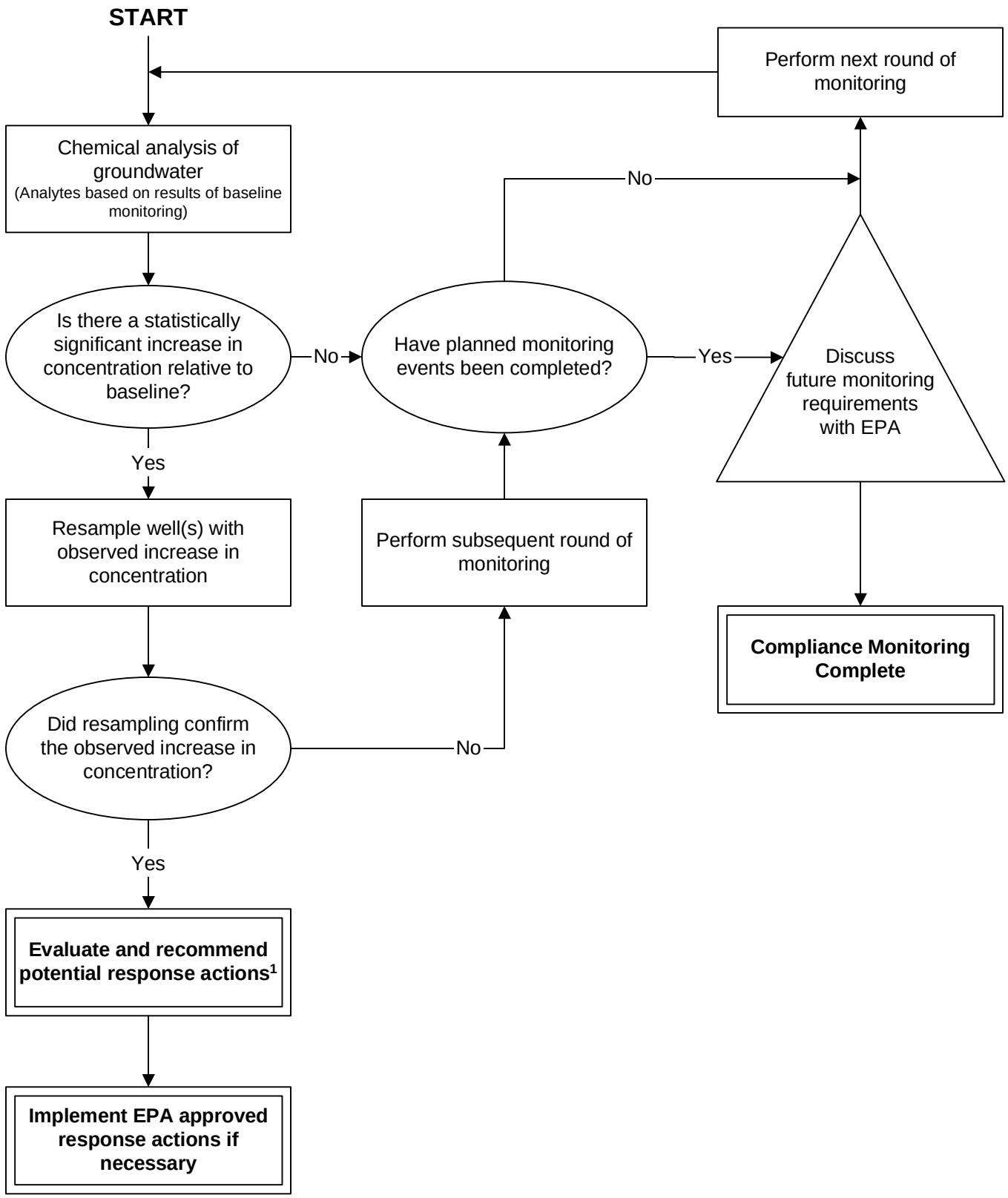
Figure 5-2
Monitoring Well and
Surface Water Sampling Location Plan

DATE: 8/24/2006 1:45:16 PM
MXD NAME: F:\projects\KPFF Foss\GIS\Revised OMMP\St Paul CDF GW\Figure 5-2 Well Location Plan and Cross Section Locations 082406.mxd



Notes:
1 See Section 5.8 of the OMMP for additional evaluations and potential response actions.

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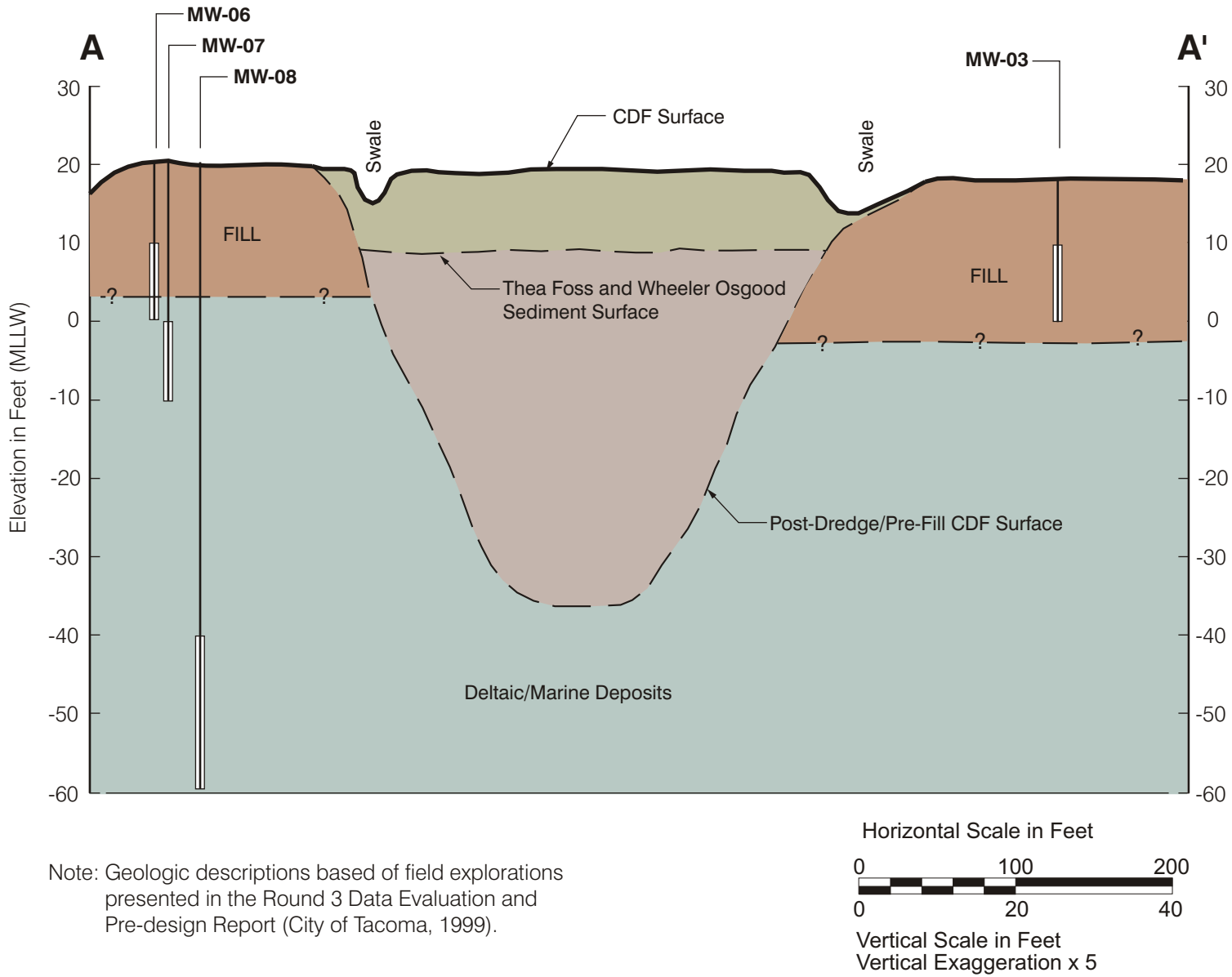
Figure 5-3
CDF Performance Monitoring Decision Matrix

F:\projects\KPFF Foss\Revised OMMP\Section 5.0 CDF Groundwater Text and Manual\Figures\Figure 5-3 Performance Monitoring Flow Chart 080406.vsd



Note: Geologic descriptions based of field explorations presented in the Round 3 Data Evaluation and Pre-design Report (City of Tacoma, 1999).

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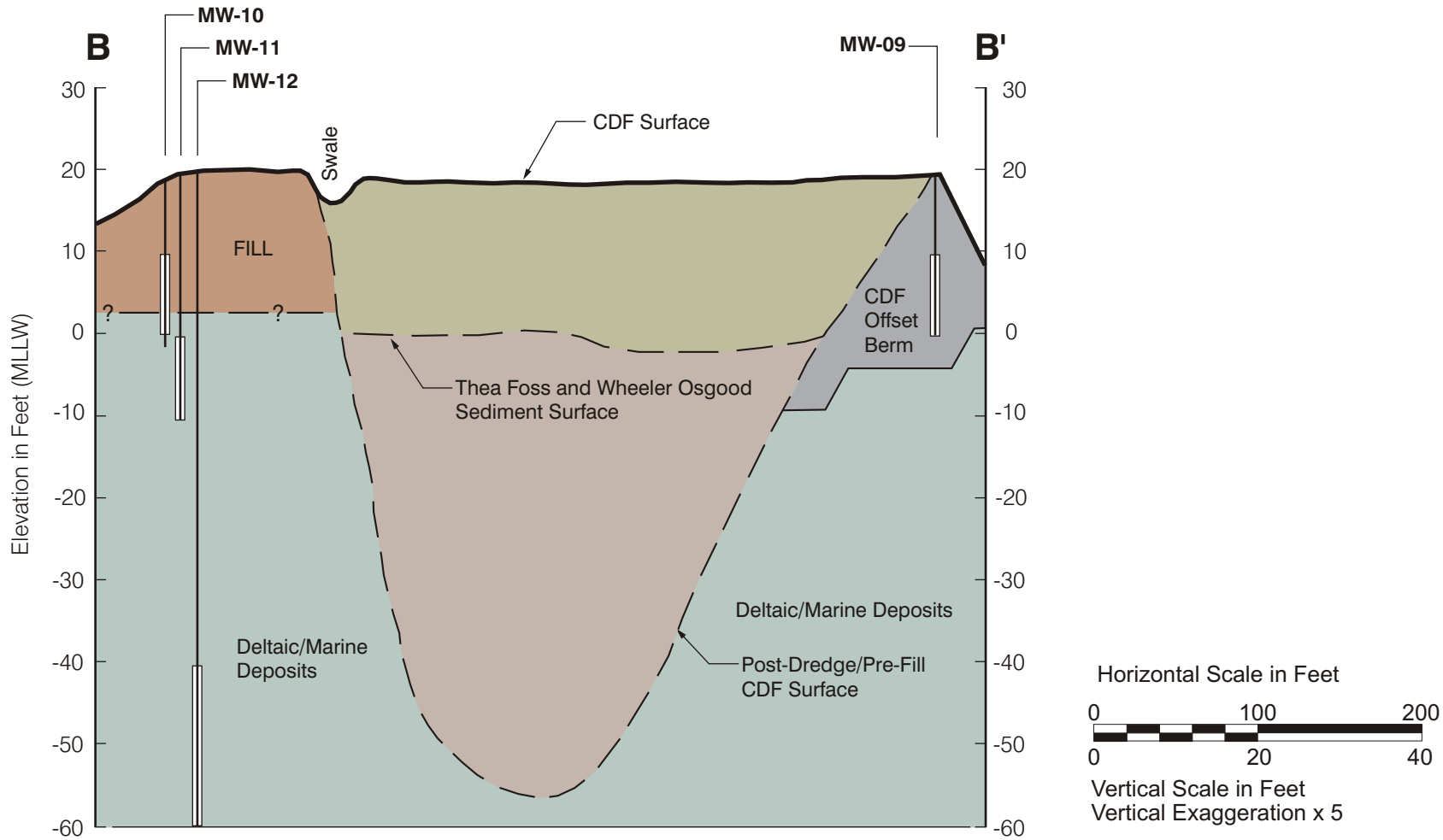
Figure 5-4
Generalized Subsurface Cross Section A-A'
St. Paul Confined Disposal Facility



Geologic descriptions based of field explorations presented in the Round 3 Data Evaluation and Pre-design Report (City of Tacoma, 1999).

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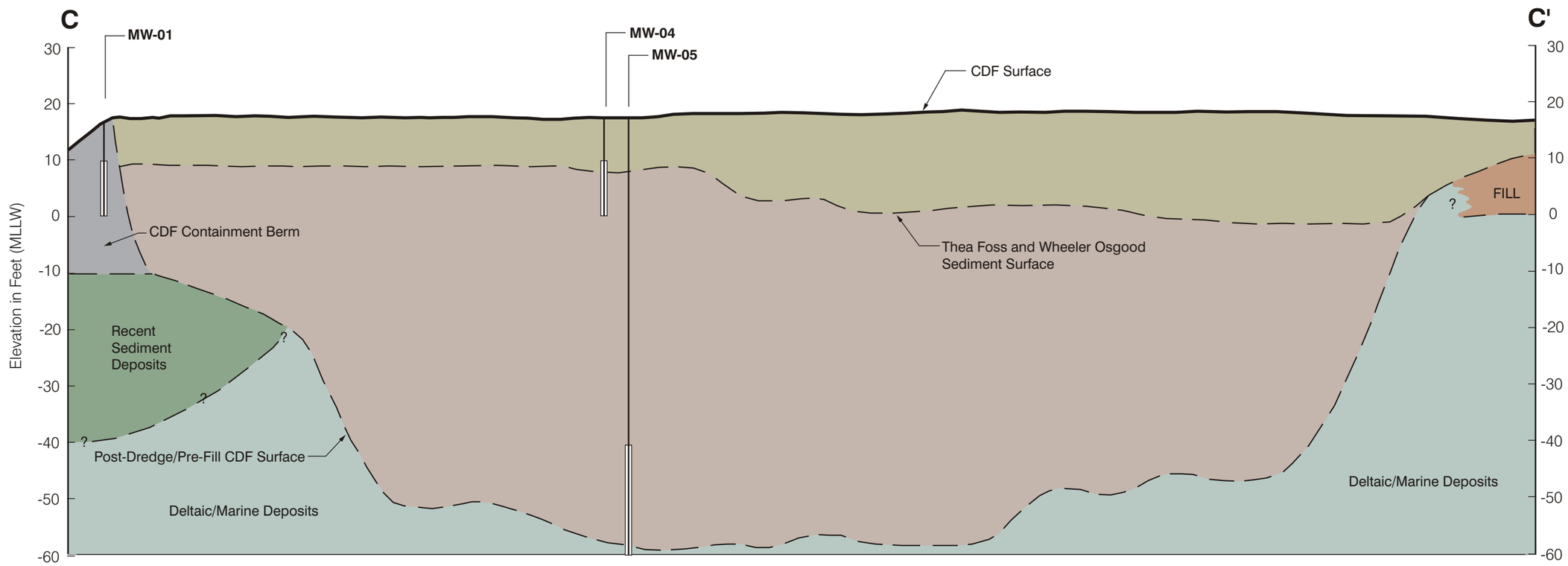
Figure 5-5
Generalized Subsurface Cross Section B-B'
St. Paul Confined Disposal Facility



Geologic descriptions based of field explorations presented in the Round 3 Data Evaluation and Pre-design Report (City of Tacoma, 1999).

Horizontal Scale in Feet

0 100 200

0 20 40

Vertical Scale in Feet
Vertical Exaggeration x 5

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Figure 5-6
Generalized Subsurface Cross Section C-C'
St. Paul Confined Disposal Facility