# 2019 Annual Monitoring Data Report
# Queen City Farms
# Maple Valley, Washington

October 14, 2020

Prepared for

The Boeing Company
Seattle, Washington

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# EXECUTIVE SUMMARY

This annual monitoring data report, prepared by Landau Associates, Inc. (LAI), presents the results of groundwater monitoring activities and field investigations conducted over the period January through December 2019 at the Queen City Farms (QCF) Superfund Site (Site; U.S. Environmental Protection Agency [EPA] Identification Number WAD980511745). The 324-acre Site is located in a rural, rolling upland area approximately 2.5 miles northwest of Maple Valley in King County, Washington.

The Site was historically used as a pig farm, an airport, a chemical mixing operation, a gravel source, and for disposal of industrial waste in unlined ponds. These received wastes included solvents, polychlorinated biphenyls (PCBs), and heavy metals (Landau Associates, Inc.; LAI 1990, EPA 1992). The disposal ponds are the source of volatile organic compound (VOC) groundwater contamination at the Site. Currently, the primary VOC of concern in groundwater is trichloroethene (TCE).

The QCF Site is undergoing cleanup under a 1994 Consent Decree between EPA and The Boeing Company (Boeing). The selected remedy for the Site, presented in a 1992 Record of Decision (ROD) issued by EPA, includes isolation of the primary contaminant source area with a final containment cell (FCC) within and above local perched Aquifer 1, followed by monitored natural attenuation (MNA) of the VOC plume in the underlying regional aquifer (Aquifer 2). The ROD also identified a groundwater extraction and treatment system (GETS) as a contingent component of the selected remedy to address Aquifer 2 groundwater contamination in the event that minimum performance criteria were not met at the Conditional Point of Compliance within 10 years following construction of the Final Containment Cell (i.e., by 2006).

Although the remedy has successfully reduced concentrations across much of the Site since 1997, certain groundwater remedial action objectives (RAOs) stated in the ROD and goals documented in the 1994 Consent Decree scope of work have not been achieved. Specifically, the minimum performance standard for TCE has not been achieved at the conditional point of compliance within the specified 10-year timeframe. In addition, the southwestern margin of the Aquifer 2 TCE plume expanded locally onsite from 2000 to 2011. Consequently, Boeing conducted supplemental investigations and constructed the contingent Aquifer 2 GETS, which began operating on February 23, 2015.

In addition to routine semiannual groundwater monitoring and GETS operation and maintenance activities, Boeing continued to perform supplemental activities as part of ongoing Site management. In 2019, supplemental activities included vegetation maintenance and inspection of the FCC, removal and cleaning of GETS well pumps due to biofouling, modification of GETS pumping and associated documentation, evaluation of recent offsite domestic well construction, and assessment of vapor intrusion potential at shallow monitoring well locations.

Monitoring results obtained in 2019 are generally consistent with recent results and with the working conceptual site model. Evaluation of remedy performance supports the appropriateness of the MNA remedy for addressing TCE in groundwater at the Site, although some concentrations have recently appeared to stabilize or increase in some areas of the plume. A review of MNA parameters in 2019 indicates that aquifer redox conditions are similar to previous results. In general, the aquifer redox conditions become more reducing with depth and when nitrate-to-iron reducing conditions are present. Concentration trends at select wells were reviewed and analyzed to evaluate restoration timeframes for TCE concentrations to fall below the minimum performance standard of 5 micrograms per liter (µg/L) via natural attenuation. Restoration timeframes were greater at wells within the conditional point of compliance (CPOC) than outside of the CPOC, and attenuation rates vary north of Main Gravel Pit Lake (MGPL) and south of MGPL.

With EPA concurrence, a modified pumping strategy was implemented beginning April 2019 that involved shutting down four of seven wells in order to limit further spread of contaminated groundwater while continuing to meet the GETS RAOs. Performance monitoring results confirm that the GETS has continued to affect hydraulic gradients and establish capture in the southwestern Aquifer 2 TCE plume and is successfully treating influent groundwater to concentrations below discharge limits. Performance monitoring data collected following implementation of the GETS modified pumping strategy indicates a stronger influence of the GETS on the wells to the south, west and east, with no or minimal influence on wells to the north of the GETS. Comparison of GETS influent data from fall 2018 and fall 2019 indicate an improvement in TCE mass removal efficiency from Aquifer 2 following implementation of the GETS modified pumping strategy.

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| | |
|---|---|
| BE | barometric efficiency |
| Boeing | The Boeing Company |
| BRF | barometric response function |
| cDCE | cis-1,2-dichloroethene |
| CHRL | Cedar Hills Regional Landfill |
| CPOC | conditional point of compliance |
| CSM | conceptual site model |
| DO | dissolved oxygen |
| Ecology | Washington State Department of Ecology |
| EPA | US Environmental Protection Agency |
| FCC | final containment cell |
| FSP | field sampling plan |
| ft | feet/foot |
| FYR | 5-Year Review |
| g | grams |
| gpd | gallons per day |
| GETS | groundwater extraction and treatment system |
| gpm | gallons per minute |
| LAI | Landau Associates, Inc. |
| lb(s) | pound(s) |
| LLI | Eurofins Lancaster Laboratories Environmental, Inc. |
| µg/L | micrograms per liter |
| µg/L/m$^3$ | micrograms per cubic meter |
| Mgal | millions of gallons |
| MGPL | Main Gravel Pit Lake |
| MNA | monitored natural attenuation |
| MPS | modified pumping strategy |
| MSL | mean sea level |
| MV | millivolts |
| NPL | National Priorities List |
| O&M | operations and maintenance |
| OM&M | operations, maintenance, and monitoring |
| ORP | oxygen reduction potential |
| PCE | tetrachloroethene |
| PCB | polychlorinated biphenyl |
| PLC | programmable logic controller |
| QAPP | quality assurance project plan |

| | |
|---|---|
| QCF | Queen City Farms |
| RAO | remedial action objective |
| ROD | Record of Decision |
| Site | QCF Superfund Site |
| SL | screening level |
| TCE | trichloroethene |
| VC | vinyl chloride |
| VI | vapor intrusion |
| VOC | volatile organic compound |

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# 1.0 INTRODUCTION

This annual monitoring data report, prepared by Landau Associates, Inc. (LAI) presents the results of groundwater monitoring activities and field investigations conducted during the period January through December 2019 at the Queen City Farms (QCF) Superfund Site (Site; U.S. Environmental Protection Agency [EPA] Identification Number WAD980511745). The Site is located in a rural, rolling upland area approximately 2.5 miles northwest of Maple Valley in King County, Washington. The Site location is shown on Figure 1-1. Site topography and key features are shown on Figure 1-2, and an aerial photograph showing the Site setting and monitoring locations is presented on Figure 1-3.

## 1.1 Site Description

QCF is an approximately 320-acre site located in rural King County. Surface water features at QCF include lakes, streams, springs, and wetlands (Figure 1-2). The Site is bounded to the north by the Cedar Hills Regional Landfill (CHRL). West of QCF is undeveloped land zoned for timber. Southwest of QCF is Cedar Shores, a sand and gravel mining and reclamation operation. The southern and eastern borders of QCF adjoin private residential properties. A regional composting facility currently operates on 26 acres in the northwestern portion of the Site. The Site boundary and above-described abutting properties are shown on Figure 1-2.

The Site was historically used as a pig farm, an airport, a gravel source, and for disposal of industrial waste in unlined ponds. The disposal ponds received waste from 1957 until the late 1960s. These received wastes included solvents, polychlorinated biphenyls (PCBs), and heavy metals (LAI 1990, EPA 1992). The disposal ponds are the source of volatile organic compound (VOC) groundwater contamination at the Site where VOCs migrated to groundwater in a localized perched aquifer (Aquifer 1). Leakage of VOC-contaminated groundwater from Aquifer 1 is the source of VOCs in the regional aquifer system comprising Aquifer 2 (including 2a and 2) and Aquifer 3 (including 3a and 3). Currently, the primary VOC of concern in groundwater is trichloroethene (TCE). Additional discussion regarding the Site's environmental setting is provided in Section 2.0.

Commercial gravel mining activities were conducted on the Site from the mid-1970s to the mid-1990s. Somewhat concurrently, remedial actions were conducted at the Site in the 1980s and 1990s and included removal of contaminated soil and waste from the ponds, and construction of a containment cell around the former ponds. The containment cell was constructed in several phases; the final containment cell (FCC; Figure 1-2) consists of a vertical barrier system keyed into the underlying aquitard and a cap to prevent infiltration of precipitation. Ongoing Site monitoring and treatment of groundwater is occurring at the Site. Locations of active monitoring wells, groundwater extraction wells, and the above-grade groundwater extraction and treatment (GETS) enclosure are shown on Figure 1-3.

## 1.2 Regulatory Background

QCF was placed on the National Priorities List in 1984. Between 1983 and 1993, a series of Site investigations and removal actions were conducted by the Site owner, Queen City Farms, Inc., and The Boeing Company (Boeing), which culminated in the issuance of a Record of Decision (ROD) by EPA on December 31, 1992 (EPA 1992).

The ROD documented a selected remedy for the Site, which is being conducted under the terms of a September 9, 1994 Consent Decree between Boeing and EPA (EPA 1994); the selected Site remedy and status are described in Section 1.2.1. The ROD and Consent Decree require comparison of water quality monitoring data with minimum performance standards to evaluate compliance; groundwater performance criteria are discussed in Section 1.2.2. Remedial action objectives (RAOs) for groundwater were presented in the ROD (EPA 1992) and are presented in Section 1.2.3.

### 1.2.1 Selected Remedy and Status

The selected remedy consists of isolating the primary contaminant source area (the FCC) within and above Aquifer 1 (completed in 1996), followed by monitored natural attenuation (MNA) of the VOC plume in the underlying regional aquifer (Aquifer 2; ongoing). The Consent Decree defined an onsite conditional point of compliance (CPOC) for Aquifer 2 around the FCC and to the southeast for the groundwater VOC plume (EPA 1994). The ROD also identified consideration of a GETS as a contingent component of the selected remedy to address Aquifer 2 groundwater contamination; the contingent component of the remedy has been in place since 2015 and is described further under Section 1.2.3.

The ROD requires institutional controls to prevent exposure to onsite contaminated media. The restrictive covenants that were placed on the property are intended to protect the remedy and to notify any potential purchaser that the land has been used to manage hazardous waste. The covenants prevent extraction of contaminated groundwater (except for remediation and monitoring purposes) and prevent development of the land within the FCC boundary for residential or agricultural uses. The covenants also place restrictions on the use of Queen City Lake, and requirements in regards to the monitoring well network.

Following active remediation measures completed in 1996, long-term groundwater monitoring has been conducted to document and evaluate natural attenuation of groundwater plumes. Since 1997, TCE concentrations have generally declined in Site groundwater plumes. Site evaluations conducted by EPA and Boeing during the time period from 1998 to 2003 determined that the selected remedy was effective and protective of human health and the environment, and that implementation of a contingent action in Aquifer 2 was unnecessary at the time (EPA 1998, 2003, King Groundwater Science 2000). The TCE plume expanded locally in the southwest portion of the Site between 2000 and 2011. Consequently, in 2008, EPA requested additional actions to refine the understanding of the nature and extent of contamination and to demonstrate plume containment, and also requested implementation of contingent actions (Aquifer 2 GETS) to prevent further expansion of the plume

(EPA 2008a, b). Supplemental investigation, system design, and construction occurred in 2008 through 2014. System startup occurred in 2015. QCF groundwater contamination continues to be contained onsite with the exception of relatively low concentrations of TCE and cis-1,2-dichloroethene (cDCE), which have migrated across the northern property boundary beneath the CHRL.

### 1.2.2 Groundwater Performance Criteria

Three primary aquifers have been defined at QCF (LAI 1990, 2011) and are described in Section 2.2. When the ROD was composed, Aquifer 1 was not considered a drinking water aquifer, but was recognized to directly recharge Aquifer 2. Aquifer 1 monitoring and observation are still conducted at wells E-1, X-5[1], and spring SP-5 (shown on Figure 1-3) to verify ongoing compliance of the Aquifer 1 portion of the remedy.

The ROD considers Aquifer 2 to be a drinking water aquifer. Aquifer 2 minimum performance standards were developed to evaluate compliance with RAOs. The minimum performance standards are:

- Tetrachloroethene (PCE): 5 micrograms per liter (µg/L)
- TCE: 5 µg/L
- cDCE: 70 µg/L
- trans-1,2-dichloroethene: 100 µg/L
- vinyl chloride (VC): 2 µg/L.

Once the minimum performance standards are met, then Aquifer 2 groundwater quality data must be evaluated against adjusted performance standards that include:

- PCE: 1 µg/L
- VC: 0.02 µg/L.

Although the 1994 Consent Decree does not address Aquifer 3, it is assumed that Aquifer 2 minimum performance standards also apply to Aquifer 3 since it also qualifies as a drinking water aquifer.

### 1.2.3 Groundwater Remedial Action Objectives

The RAOs for groundwater are:

- Prevent exposure to contaminated groundwater
- Prevent migration of the contaminant plume
- Restore groundwater for future use.

[1] Well X-5 is located within the FCC boundary and went dry following installation of the FCC. Thus, VOC sampling is no longer conducted at X-5. However, water level measurements continue to be collected annually during the wet season to confirm that water is not infiltrating the FCC.

Although VOC concentrations have attenuated, certain groundwater RAOs stated in the ROD and goals for Aquifer 2 documented in the 1994 Consent Decree scope of work have not been met. Specifically, the minimum performance standard for TCE has not been attained at the CPOC within the specified 10-year timeframe (i.e. by 2006). In addition, the southwestern margin of the Aquifer 2 TCE plume expanded locally onsite from 2000 to 2011. Consequently, EPA requested additional actions to refine the understanding of the nature and extent of contamination and to demonstrate plume containment, and requested implementation of the contingent component of the remedy referenced in the ROD (an Aquifer 2 GETS) to prevent further expansion of the plume (EPA 2008b, a).

Boeing conducted supplemental investigations and, in 2013, Boeing agreed[2] to undertake contingent action in the southwest portion of the Aquifer 2 TCE plume near the S well area[3] (LAI 2013c). In 2014, the GETS engineering design report was approved by EPA (EPA 2014, LAI 2014a). System construction began in June 2014 and was largely completed by December 2014. System startup occurred on February 23, 2015. The GETS has been in operation continually since system startup. Further discussion of the GETS operation and performance monitoring is provided in subsequent sections.

## 1.3 Report Overview

Annual monitoring data reports are intended to document Site activities and assist in evaluating the effectiveness of Site remediation. Long-term groundwater monitoring activities at QCF include annual (March) and semiannual (September) water quality sampling and synoptic water level monitoring. Additional Site activities in 2019 included operations and maintenance (O&M) of the Aquifer 2 GETS, implementation of a modified GETS pumping strategy, an abbreviated offsite domestic water supply well evaluation, an update to the vapor intrusion (VI) assessment, wet season and dry season FCC inspections, FCC cap maintenance, and meetings with EPA and King County. In addition, in June 2019 a Partial Deletion Petition was submitted by LAI on behalf of Queen City Farms.  EPA indicated that they would be able to proceed with the petition and expect to have the process completed prior to September 2020 (EPA 2020).  The petition for partial delisting from the National Priorities List (NPL) addresses soil from the ground surface and underlying soil down to the water table throughout the Site, not including groundwater or soil below the water table at the Site.

Groundwater monitoring in 2019 focused on semiannual and annual water level and VOC data collection, in addition to annual MNA data collection. Groundwater VOC results in 2019 were generally consistent with historical concentration trends. Long-term declines in groundwater VOC concentrations in the majority of groundwater wells demonstrate progress toward achieving Site RAOs including preventing exposure to contaminated groundwater, preventing migration of the contaminant plume, and restoring groundwater for future use. GETS monitoring data indicate that the contingent Aquifer 2 remedy has established groundwater capture across the southwestern portion of the TCE plume, and

[2] The project team meeting was attended by Eric Weber and Toni Smith of Landau Associates, Inc. (LAI); Jeremy Jennings and Marcia Knadle of EPA; and Joseph Flaherty and Wayne Schlappi of Boeing on December 17, 2012.

[3] The S-well area refers to the southwestern portion of the Aquifer 2 TCE plume in the vicinity of monitoring wells S-2, SA-2, SB-2, SC-2, SD-2, and SE-2.

has enhanced recharge and flushing effects through the lower portion of Aquifer 2. In addition, a GETS performance evaluation (LAI 2019b) identified that increasing TCE concentrations at well I-2 (within the CPOC) appears to be related to GETS pumping at extraction wells EW-6 and EW-7, and that groundwater extraction in this area may be causing unintended migration of TCE from the CPOC toward the GETS. Based on recommendations outlined in the GETS performance evaluation, a GETS modified pumping strategy (MPS) and associated performance monitoring sampling was implemented in April of 2019. Initial results from the performance monitoring are outlined in a GETS Modified Pumping Performance Monitoring Memorandum (LAI 2019a). These results indicate that the capture zone of the GETS has decreased, and influence of the GETS within the CPOC at well I-2 has decreased, coinciding with TCE concentration decreases at I-2 and SD-2. Analysis of changes in groundwater elevation concurrent with implementation of the MPS suggest that the influence of the GETS extends furthest in the east and southeasterly direction and minimally to the north. In addition, initial groundwater monitoring following the MPS indicates that the GETS is still meeting its goals of capturing the southwestern lobe of the plume. GETS influent and effluent data, in combination with pumping rates, indicate that the mass removal rate of the GETS is more efficient since implementation of the MPS.

VOC concentrations have declined across much of the Site since groundwater monitoring began in the 1990s. However, consistent with recent years (LAI 2019c), TCE concentrations are present above the minimum performance standard (5 µg/L) in groundwater beneath the CPOC, and at locations north of the CPOC (Aquifers 2a and 2), southwest of the CPOC (Aquifer 2), and southeast of the CPOC (Aquifer 3a). Long-term declines in groundwater VOC concentrations have slowed or stabilized in some areas of the Site (e.g., beneath the CPOC and south of the GETS) in recent years, and local areas of increasing TCE concentrations were documented at wells in the vicinity of the GETS (SA-2), west of the CPOC (D-2a) and within the CPOC (I-3a and IA-3). While the GETS has been effective at establishing hydraulic capture in the S-well area as designed, VOC concentrations in influent groundwater are low, and the capacity of the GETS to further improve the rate of groundwater restoration across the Site is limited.

Groundwater monitoring results in 2019 continue to support the general effectiveness of the MNA remedy based on long-term declines in groundwater VOC concentrations and on results analyses of MNA parameters.

This report includes the following:

- **Section 2.0:** Summarizes the Site's environmental setting including the geologic setting, hydrogeologic setting, and working conceptual site model (CSM)
- **Section 3.0:** Describes 2019 Site activities
- **Section 4.0:** Summarizes the groundwater monitoring program

- **Section 5.0:** Presents results from water level monitoring, VOC monitoring, MNA monitoring, and GETS monitoring
- **Section 6.0:** Provides discussion of the Site conditions and recommendations based on observations and evaluations of 2019 Site data.

# 2.0 ENVIRONMENTAL SITE SETTING

A brief description of the Site's geologic and hydrogeologic setting, along with the CSM is provided below. This brief summary assumes the reader is familiar with Site history and hydrogeologic nomenclature. Further detail into the Site history and hydrogeology can be found in numerous Site documents (EPA 1992, 2008b, 2013, LAI 1990, 2011, 2013d, 2014a, 2015a, 2016a).

## 2.1 Geologic Setting

QCF is located in an upland area that slopes to the south from approximately elevation 575 feet (ft) above mean sea level (MSL) at the northern property boundary with the King County Solid Waste Division's CHRL, to about elevation 370 ft MSL at the southern property boundary along Cedar Grove Road. Most of the Site is located on an upland area known as the Coalfield Drift Plain (LAI 2011). The southeast portion of QCF lies within an historical glacial outwash feature known as the Cedar Grove Channel (Figure 1-2). Site topography is characterized by varied terrain that reflects relatively complex glacial and non-glacial deposits, and gravel mining activities that took place over the southern portion of the Site in the mid-1970s to mid-1990s. A hillshade elevation model showing topography at QCF is presented on Figure 2-1.

Surface water features at QCF include both natural and man-made features. Queen City Lake, located in the northern portion of the Site, is a glacial kettle lake with no natural surface water outlet. The lake forms seasonally and leakage from the lake provides recharge to Aquifer 1. To the south of Queen City Lake, mining operations beginning in the mid-1970s formed a depression in the southern portion of the QCF property. A seasonal surface water feature known as Main Gravel Pit Lake (MGPL) began developing in the depression around 1988 (LAI 2011). In the early 1990s, an overflow pipe was installed in Queen City Lake to discharge water to the base of the gravel pit during storm events. Thus, MGPL receives precipitation, surface runoff, and overflow from Queen City Lake, and serves as a direct recharge source to Aquifer 2. In the southeastern portion of the Site, Cedar Grove Channel contains a series of natural wetlands. The eastern portion of this wetland complex appears to provide recharge to Aquifer 2a. The wetland complex also discharges as surface water to a small creek at the west end of the channel during times of high precipitation.

The geologic stratigraphy at QCF was defined during remedial investigation work in 1990 and 1991 (LAI 1990, 1992). In 2010, the geologic conceptual model was refined to include data from 27 additional QCF wells and select CHRL wells (LAI 2011). The stratigraphy is segmented into 12 Vashon age and pre-Vashon age deposits. Unit A represents a thin layer of alluvium or colluvium surface deposits on top of glacial till. Geologic units B, C, D, Dr, and E consist of glacial deposits associated with the most recent Vashon glaciation. These deposits are fine-grained ice contact (Unit B), coarse-grained recessional outwash (Unit C), glacial till (Units D and Dr), and advance outwash (Unit E). Older geologic units F, G, H, I, J, and U represent interglacial deposits typically consisting of fine to medium sand (Units F, H, and J) with distinct silt layers (Units G and I). Unit U is an older clay deposit encountered along the eastern portion of the Site. Detailed summaries of geologic units are presented in the 2010 Expanded Hydrogeology Assessment (LAI 2011) and the QCF Remedial Investigation Report (LAI 1990).

## 2.2 Hydrogeologic Setting

Three primary aquifers have been defined at QCF (LAI 1990, 2011). Aquifer 1 is a localized perched aquifer consisting of saturated recessional outwash deposits on top of a glacial till aquitard[4] and a leaky clayey silt aquitard. Aquifer 2 is an unconfined regional aquifer that is used as a drinking water source for area residences. Aquifer 3 is a confined aquifer that is also used as a drinking water source for area residences. Aquifer 2 has been subdivided into an upper portion termed Aquifer 2a and lower portion referred to as Aquifer 2. Similarly, the upper portion of Aquifer 3 is termed Aquifer 3a, and the lower portion is referred to as Aquifer 3.

Groundwater recharge to Aquifer 1 is primarily through leakage from Queen City Lake. Discharge from Aquifer 1 is through leakage across the clayey silt Aquifer 1 aquitard, into unsaturated outwash deposits, and eventually to Aquifers 2a and 2. Discharge from Aquifer 1 is also expressed as spring flow at the East Airstrip Spring and in other smaller springs on the gravel pit face, which flow into MGPL (Figure 1-2). Groundwater in Aquifers 2a and 2 flows radially outward from an area of focused recharge approximately beneath MGPL. Aquifer 2a generally consists of relatively permeable Vashon deposits (Unit E) and less permeable pre-Vashon interglacial deposits (Unit F), while Aquifers 2 and 3 consist of less permeable, saturated fine to medium pre-Vashon interglacial sand deposits (LAI 2011). Aquifers 2 and 3 are separated by the Unit G aquitard. Aquifer 3 is separated from the underlying Deep Water Bearing Zone by the Unit I aquitard.

Groundwater recharge at QCF occurs primarily through infiltration from three main surface water features:  Queen City Lake, MGPL, and the wetlands in the eastern Cedar Grove Channel. These surface water bodies, in turn, receive precipitation and surface runoff generated on the surrounding upland areas (LAI 1990, 1992, 2011, Luzier 1969, Mullineaux 1970).

The surface water hydrology and the QCF hydrogeologic conceptual model are described in detail in the 2010 Expanded Hydrogeology Assessment (LAI 2011), the Remedial Investigation Report (LAI 1990), and the original Supplemental Remedial Investigation Report (LAI 1992). An aerial photograph of the Site and surrounding area, along with the monitoring well network, is shown on Figure 1-3. A hillshade elevation model and locations of cross section lines are shown on Figure 2-1. Hydrogeologic units and stratigraphy are presented in cross sections on Figures 2-2 and 2-3. A discussion of the monitoring well network is provided in Section 4.0.

### 2.2.1 Main Gravel Pit Lake Interactions with Groundwater

A detailed discussion of the MGPL interactions with groundwater is included in the 2018 annual report (LAI 2019c), a brief summary of which is presented here. Historical water level data in MGPL, and

[4] Seasonally saturated deposits above the till are termed the Near Surface Water Bearing Zone.

Aquifers 2a, 2, 3a, and 3 illustrate several key hydrogeologic attributes at QCF. MGPL is a depression that receives and infiltrates surface water, acting as a direct local recharge source to the shallow regional aquifer system at the Site. Groundwater contour patterns in Aquifer 2a and 2 consistently display a mound radiating outward from the MGPL. A less pronounced groundwater mound is also visible in Aquifer 3 and 3a. Water level fluctuations in Aquifers 2a and 2, in general, mimic seasonal trends seen in MGPL, with the highest water levels observed in the winter and early spring and the lowest water levels observed in the late summer and early fall. Water level trends in MGPL over the observation period have not historically shown a discernable influence of GETS operations on surface water levels. Seasonal water level trends in Aquifer 3a and 3 are muted relative to responses in the shallow aquifer system; however, seasonal water level trends at MGPL indicate some infiltration of water from Aquifer 2 to Aquifer 3.

## 2.3 Conceptual Site Model

The working CSM provides a framework for evaluating data trends. The model is intended to represent and communicate the structure, processes, and factors affecting plume development and behavior (Pope et al. 2004). Key elements of the QCF CSM include the following:

- PCE and TCE were the primary contaminants released into Aquifer 1 from disposal ponds
- Reductive dechlorination in Aquifer 1 resulted in production of cDCE and VC in Aquifer 1
- Dissolved PCE, TCE, and cDCE migrated into Aquifer 2 through leakage across the Aquifer 1 aquitard
- Remedial actions from 1986 through 1997 removed and isolated sources of contamination in Aquifer 1
- Natural attenuation mechanisms are causing groundwater VOC concentrations to slowly decline. Natural attenuation mechanisms include biotic and abiotic dechlorination, dispersion (flushing and dilution) and adsorption in all aquifers, and reductive dechlorination in Aquifers 2, 3a, and 3.

Ongoing evaluation and refinement of the CSM occurs as new data are collected and interpreted. Based on 2019 data presented herein, the CSM appears consistent with interpretation presented in the 2018 annual report (LAI 2019c). The CSM is presented on Figure 2-4.

# 3.0 2019 SITE ACTIVITIES SUMMARY

This section summarizes 2019 Site activities, which included:

- Water level monitoring
- Water quality monitoring (VOCs and MNA)
- Aquifer 2 GETS Operation, Maintenance, and Monitoring (OM&M)
- Aquifer 2 GETS modified pumping and associated performance monitoring
- Abbreviated offsite well evaluation
- Abbreviated VI assessment
- Semiannual FCC inspection and maintenance
- Site-related meetings
- Reporting and evaluations.

2019 data collection was conducted in accordance with established QCF sampling and performance monitoring plans, which are discussed in Section 4.0.

## 3.1 Water Level Monitoring

Water levels are monitored in groundwater wells and MGPL to evaluate hydrogeologic trends, flow patterns, and interactions between surface water and groundwater. Groundwater levels at QCF are hand-measured in synoptic events concurrent with annual and semiannual groundwater sampling (late March and late September, respectively) at select wells, as outlined in the Groundwater Monitoring Plan Update (LAI 2018b). Per the GETS Performance Assessment and Recommendations (LAI 2019b), additional groundwater monitoring was completed approximately one week following the initiation of the GETS modified pumping, and monthly thereafter, at MGPL and select groundwater monitoring wells near the GETS. All 2019 hand-measured water levels are presented in Appendix A. In addition to monthly hand measurements, hourly water level data was also recorded at the MGPL and select groundwater monitoring wells near the GETS using datalogging pressure transducers (dataloggers). Dataloggers were installed at select locations approximately one month prior to initiation of the GETS modified pumping in order to examine groundwater gradient changes near the GETS and MGPL (LAI 2019b). Processing procedures for datalogger measurements are described in section 3.1.2. Hourly water level data for locations with dataloggers in 2019 are presented in Appendix B.

### 3.1.1 Semi-continuous Water Level Readings

A supplemental water level monitoring program was conducted from September 2013 through 2017 to characterize interactions between MGPL levels and groundwater. The program included installation of a staff gage and datalogger at MGPL and datalogger observations in wells IB-2a, IA-3a, IB-2, and IB-3a, and in the S-wells area (S-2, SC-2, and SF-2). In 2017, analysis of the data indicated objectives of the semi-continuous water level monitoring had been met and Boeing recommended that semi-continuous water level monitoring of the S-wells and IB-wells be discontinued (LAI 2018a). EPA concurred with Boeing's recommendation in their concurrence letter (EPA 2018a). In March 2019, in anticipation of beginning the GETS modified pumping, the dataloggers from the IB-wells were moved to SD-2, I-2 and SA-2. Hourly datalogger monitoring at MGPL continued through 2019.

### 3.1.2 Datalogger Data Processing Procedures

Dataloggers record pressure data, which is then compensated for atmospheric pressure using a barometric pressure transducer installed at the Site. Pressure data from the dataloggers under confined (or semi-confined) conditions are also corrected for aquifer-specific barometric response using barometric efficiency (BE; Brassington 2006) or barometric response function (BRF; Bohling, W. Jin, and J.J. Butler 2011) methods[5].

## 3.2 Water Quality Monitoring

Annual spring water quality sampling was conducted from March 25 through March 29, 2019. The 2019 annual sampling matrix comprised 51 groundwater monitoring locations and represented the biennial sampling event (LAI 2018b)[6]. Three water quality field duplicates and five trip blanks were included in the sample set for data validation and quality control purposes. Water levels were measured in monitoring wells prior to sampling.

Semiannual fall water quality sampling was conducted on September 23 through September 25. The semiannual sampling matrix comprised 29 groundwater monitoring locations. Two field duplicates and three trip blanks were included in the sample set for data validation and quality control purposes. Water levels were measured in monitoring wells prior to sampling.

Additional groundwater quality monitoring occurred at the Site between April and June 2019 associated with implementation of the GETS modified pumping strategy (LAI 2019a). The groundwater monitoring included VOC sampling of influent and effluent, 4 hours following initiation of the modified pumping, followed by sampling of influent, effluent, and all seven extraction wells at one week, one month, and two month intervals.

## 3.3 GETS Operation, Maintenance, and Monitoring

GETS activities in 2019 included routine O&M (primarily monthly inspections, extraction well cleanings, PLC system updates, and daily/weekly reporting), semiannual performance monitoring

[5] Both BE and BRF correction methods quantify and correct for the effect of barometric pressure on the water elevation in the well compared to the surrounding aquifer. However, BRF method is considered a more robust method of correction, and therefore has been used for the recently installed datalogger data. For consistency, BE was continued as the correction method for well data where the BE method was historically used. BE method appears to provide adequate correction of datalogger data where used at this Site.

[6] Wells sampled biennially that are not associated with GETS monitoring include: D-2a, E-1, E-2a, F-2, F-2a, I-3, IB-3a, M-2, N-3a and O-3a.

activities in accordance with the GETS O&M manual (LAI 2015c), and implementation of a modified pumping strategy and associated performance monitoring in accordance with the GETS Performance Assessment and Recommendations (LAI 2019b). As part of GETS performance monitoring, extraction well water level data and overall system data is monitored remotely on a weekly basis, and in-person on a monthly basis during inspections of the GETS.

Maintenance activities included:

- Cleaning of pumps in wells EW-2 and EW-4
- Updates to the PLC system including remote shutoff of discharge pump and setting the timer on the discharge pump to shut off after 15 minutes, as long as the middle clear well float was no longer triggered. This update avoids the discharge pump running unnecessarily for long periods of time
- Replacement of deterrent cameras installed on the outside of GETS shed
- Replacement of damaged transducer in EW-5 and installation of desiccant within all extraction wells to avoid water damage to associated transducers
- Identification and replacement of a broken flapper valve within the GETS shed
- Replacement of sump pump outlet within the EW-4 vault
- Energized and de-energized electrical equipment inspection and maintenance for the interior and exterior GETS shed equipment, as well as all seven associated extraction wells and vaults.

A summary of GETS system shutdown periods in 2019 are summarized in Table 3-1 and are generally related to power loss and maintenance activities.

Pumping rates generally increased at wells EW-1, EW-3, EW-5, EW-6, and EW-7 since the diffused-bubble aerator system replaced the former air stripper system in 2017 (LAI 2017b). Following the GETS modified pumping (i.e. stopping pumping at EW-1, EW-2, EW-6, and EW-7), total system pumping rates decreased from an average flow rate of 86 gallons per minutes (gpm) in winter of 2018 to an average of 37 gpm in winter of 2019. Pumping rate data for individual extraction wells and total influent flow rate data are measured by the GETS programmable logic controller (PLC) system, and are recorded by LAI staff weekly. Pumping rate data is presented on Figure 3-1. In addition, average seasonal flow rates for 2019 are provided in Table 3-2.

GETS extraction wells, GETS influent and effluent groundwater, GETS vapor discharge, and select monitoring wells near the GETS were sampled semiannually in 2019, concurrent with annual (March) and semiannual (September) monitoring events. GETS extraction wells and GETS influent and effluent were also sampled as part of the performance monitoring associated with the GETS modified pumping that began in April of 2019. Sampling occurred following the start of the modified pumping on a 4-hour (influent and effluent only), 1 week, 1 month, and 2 month interval. All VOC data results are provided and discussed in Section 5.0.

## 3.4 Offsite Well Evaluation

Boeing periodically assesses potential health risk associated with the use of offsite groundwater in the vicinity of QCF as a drinking water source. The evaluation area is generally restricted to parcels with residential zoning within 1,000 feet south and east of the QCF property boundary (properties to the north and west do not have residential land use). The most recent offsite well evaluation was completed in 2018 (LAI 2019c).

An abbreviated offsite well evaluation update was completed in 2019 by querying the Washington State Department of Ecology (Ecology) online Washington State Well Report Viewer[7] on February 13, 2020. The query indicated no new private groundwater supply wells were constructed within the evaluation area in 2019. A review of the King County Parcel Viewer[8] was also completed to monitor property sales or new construction on parcels within the evaluation area. This review indicated that parcel 332306-9081 was purchased as a trust for $0 on February 12, 2019 and parcel 272306-9104 was purchased on October 23, 2019. However, no new construction or well installation was apparent associated with either property. Lastly, review of publically available aerial imagery from 2019 did not identify new construction in the evaluation area[9].

## 3.5 Vapor Intrusion

Boeing completed a VI assessment for QCF in 2015, in response to EPA's recommendations in the Fourth Five-Year Review (FYR) (LAI 2015d, EPA 2013). The assessment was conducted to evaluate the potential for VI in the context of hypothetical future development (currently the VI pathway is not complete and VI is not a human health concern at QCF [LAI 2015d, 2016a]). The VI assessment concluded that the long-term (chronic) TCE screening level (SL) for shallow groundwater protective of residential indoor air is 2.0 µg/L, and the SL protective of industrial indoor air is 37 µg/L. Additionally, TCE SLs were calculated for short-term (acute) exposure in residential and industrial indoor air (8.4 µg/L and 35 µg/L, respectively). The assessment also identified 25 QCF monitoring wells[10] as fitting EPA's definition of a shallow well; that is, a well at which the depth to water and depth to the well screen is less than 100 ft (Ecology 2016). Upon approving the 2015 VI assessment (LAI 2015d), EPA requested that TCE concentrations in shallow wells exceeding the above-listed residential and industrial SLs be tracked as part of the Site's annual monitoring data reports, and that the VI pathway be re-evaluated prior to residential development in potentially impacted areas. This section presents the VI assessment results for 2019 shallow groundwater data presented in Table 3-3.

The wells included in this VI assessment are designated as Aquifer 2 (e.g. H-2) and Aquifer 2a (e.g. H-2a) wells based on screening depth intervals. Data results from Aquifer 2a wells represent water table

[7] Available online at https://fortress.wa.gov/ecy/waterresources/map/WCLSWebMap/.

[8] Available online at http://www.kingcounty.gov/services/gis/Maps/parcel-viewer.aspx.

[9] Imagery was collected from the SENTINEL-2 satellite imager in November 2019 and has a resolution of 10 meters. Imagery was downloaded in February 2020 from the Copernicus Open Access Hub https://scihub.copernicus.eu/dhus/#/home.

[10] Shallow monitoring wells identified in the 2015 VI Assessment include D-2a, E-1, H-2a, H-2, I-2a, I-2, IB-2a, IB-2, K-2, M-2, N-2, O-2, R-2a, R-2, S-2a, S-2, SA-2, SB-2, SC-2, SD-2, SE-2, U-2a, U-2, V-2a, and (b)

conditions in Aquifer 2, whereas Aquifer 2 wells represent deeper groundwater conditions. This difference is important to note because the potential for VI is related to the ability of VOCs in groundwater to partition to soil gas and migrate to the ground surface. VOCs can only partition from groundwater to soil gas at the water table surface; therefore, only concentrations at the water table surface are representative of potential for VI.

In 2019, none of the wells had concentrations exceeding the acute industrial TCE SL (35 µg/L) or the chronic industrial TCE SL (37 µg/L).

A total of six wells had concentrations exceeding the chronic residential TCE SL (2.0 µg/L): I-2, S-2a, SA-2, SC-2, SD-2, and V-2a. The six well locations are shown on Figure 4-2 (Aquifer 2a) and Figure 4-3 (Aquifer 2), and are at the northern property boundary and south of MGPL. Of the six wells, two (S-2a and V-2a) are screened in Aquifer 2a. Of the six well locations that exceeded the chronic residential TCE SL, three also exceeded the acute residential TCE SL (8.4 µg/L): I-2, SD-2, and V-2a. Additional discussion is provided for the two Aquifer 2a well locations with concentrations exceeding the acute and/or chronic residential TCE SLs (S-2a and V-2a).

Well location S-2a is southwest of MGPL and exceeded the chronic residential TCE SL with a maximum concentration in 2019 of 3.5 ug/L. No residential development is currently proposed near the S-wells area, and TCE concentrations are expected to continue to decline over time in Aquifers 2a and 2 in this area.

Well location V-2a is just south of the northern property boundary where QCF meets the CHRL. Well location V-2a exceeded the chronic and acute residential TCE SLs with a maximum concentration in 2019 of 19 mg/L. At location V-2a, Aquifer 2a is separated from the land surface by a layer of glacial till approximately 100 ft thick; this low-permeability deposit is an impediment to the migration of contaminants from the Aquifer 2a water table (LAI 2011) to the ground surface in the northwest portion of the Site. Furthermore, well V-2a is located in a sizable wetland area located between QCF and the CHRL (Figure 2-1). The CHRL currently has permitted capacity to continue landfilling through approximately 2028, but King County is considering additional development at CHRL to expand capacity. As a result, residential development is not likely to occur near well V-2a.

Land above the QCF VOC groundwater plumes (which are presented on Section 4.0 figures) is undeveloped or used for industrial purposes, and no residential development is planned. Residential development cannot occur in the area without regulatory review and approval. Boeing will continue annual re-evaluation of the VI pathway and changes to the existing and planned land uses on the property, and will summarize the evaluation in annual data monitoring reports.

## 3.6 Final Containment Cell Inspection and Maintenance

Boeing conducts biannual inspections and regular maintenance of the FCC and associated drainage system. A wet season inspection was conducted on March 11, 2019 and a dry season inspection was conducted on August 27, 2019[11]. The purpose of the inspections is to examine the containment area and cap for signs of water accumulation (i.e. standing water), erosion, subsidence, fissures, burrowing animals, damage, and vegetation overgrowth; to verify Site security features such as fencing and signage are intact; and to verify that the drainage system is operational and free of debris. Inspection forms and an updated map of the FCC are presented in Appendix C.

During the March inspection, no issues related to settlement, burrowing animals, subsidence, fissures, erosion, or other damage were encountered within the containment cell area or cap. No water accumulation was noted on the cap surface. Related to security, a hole was noted in the fence along the interior fence on the south side of the FCC. The hole was large enough for a person, but not a vehicle, and no damage (besides the fence) related to trespassing was evident. The fence was repaired in April 2019. The drainage system was found to be flowing freely and minimal sediment build up was noted in the underground drainage system. It was noted that the cap area was due for vegetation maintenance (mowing and brush removal), which was conducted in June 2019.

During the August inspection, no issues related to water accumulation, settlement, burrowing animals, subsidence, fissures, erosion, or damage were encountered within the containment cell area or cap. Minimal vegetation build up and debris in swales were noted but were not significant enough to impede surface water flow. The drainage system was noted to be in good condition and generally clear of sediment build up. No Site security issues were noted.

Maintenance of the surface drainage features including swales, catch basins, and outfalls is conducted annually in spring and again in fall to remove debris, sediment, and leaves. Vegetation maintenance is conducted, as needed, to minimize growth of shrub species on the cap and to clear vegetation from access roads and around wells. Access roads are cleared twice a year prior to the annual and semiannual groundwater monitoring events. Cap mowing was conducted in June 2019 to remove brush (primarily Scotch broom) from the cap area.

## 3.7 Meetings

In 2019 Boeing met twice with King County Solid Waste Division (March 27, 2019 and September 23, 2019) to discuss updates to the CHRL development plan and changes to the groundwater monitoring program. Additionally, EPA sent a letter to King County on May 2, 2019 regarding CHRL groundwater monitoring and data dissemination. The following points of discussion were raised during the meetings and in EPA's letter.

- King County intends to continue landfilling at CHRL until approximately 2040, and updates to the development plan, which is currently under review, include areas at the south end of the landfill bordering the QCF property. Currently, there is a required 1,000-ft buffer between the

[11] Inspection form from the FCC O&M manual (Kennedy/Jenks 1998) was updated in 2019 to add clarification on monitoring points and procedures and translated to an electronic form.

landfill development and QCF property; however, King County may request a reduction of the buffer to 500 ft to facilitate future development.

- A portion of the stormwater from CHRL currently discharges to the QCF property to both Queen City Lake and to an engineered drainage channel that infiltrates on the southern portion of the QCF property. As part of future development at CHRL King County anticipates changes to the stormwater management system. EPA and Boeing requested the basis of design documents for the current stormwater collection system at CHRL. King County provided partial documentation, including a 2013 hydrogeologic report, but did not provide the basis of design engineering report in 2019.
- As part of the expansion of Area 8, King County decommissioned MW-70, MW-77, and MW-78. EPA requested, at a minimum, that King County reinstall MW-70 and MW-78 and that the placement of the new wells be discussed with Boeing and EPA. A request was also made for King County to share the location and well installation work plan. None of the requests were fulfilled in 2019.
- King County discontinued VOC sampling at well MW-58a in 2013 and wells MW-57 and MW-60 in 2015. Discontinuation of sampling was reportedly due to changes in CHRLs groundwater monitoring program that were approved by Ecology; however, the changes were not discussed with Boeing or EPA. During the March meeting and in the May letter, EPA requested that King County reinstate sampling at the monitoring wells. During the September meeting King County agreed to reinstate sampling at the wells but requested that Boeing pay the sampling and analysis costs. Boeing agreed to pay for the sampling and analysis and requested that King County provide a written cost estimate. King County did not provide a cost estimate in 2019.
- Boeing and EPA requested that, in addition to King County sending CHRL sampling data directly to EPA, it be sent electronically to Landau Associates (Boeing's consultant) to expedite its inclusion in the QCF annual report.

## 3.8 Reporting and Evaluations

The GETS Performance Assessment and Recommendations memorandum was finalized and submitted to EPA on March 22, 2019. This report examines the effect of the GETS on Aquifer 2 TCE concentrations, progress on remedial objectives, and includes recommendations for modification to the pumping strategy. EPA provided formal approval of the performance assessment in a letter dated April 25, 2019 (EPA 2019). The modified pumping strategy was implemented following EPA approval on April 29, 2019.

The GETS Modified Pumping Performance Monitoring memorandum was finalized and submitted to EPA on October 15, 2019. This report summarized the initial (i.e. 2 month) effect of the modified pumping on the GETS system and surrounding groundwater levels and VOC concentrations. EPA provided concurrence in an email dated October 28, 2019.

The draft 2018 annual report was submitted to EPA on April 30, 2019. EPA provided formal approval in a letter dated May 30, 2019 (EPA 2018a). The 2018 annual report (LAI 2019c) was finalized and submitted to EPA on June 13, 2019.

# 4.0 GROUNDWATER MONITORING PROGRAM

Remedy effectiveness at the Site is assessed through an extensive groundwater and surface water monitoring network. The current groundwater monitoring program consists of semiannual water level measurements, semiannual groundwater and surface water quality sampling, and GETS performance monitoring. These data are validated and managed in a project database (QCF database). In 2019, semi-continuous monitoring of water levels using dataloggers at select locations was also conducted for supplemental data (discussed in Section 3.1).

## 4.1 Monitoring Network

The monitoring network includes groundwater monitoring wells and GETS extraction wells installed by Boeing on the QCF property, select offsite groundwater monitoring wells installed by CHRL on the southern portion of the landfill property, surface water (spring) sampling locations, and two offsite residential water supply wells. Actively sampled monitoring locations included in the QCF monitoring network are shown on Figure 1-3 and listed in Table 4-1, along with monitoring well construction details and aquifer associations.

QCF well designations follow conventions described in the 2010 Expanded Hydrogeology Assessment (LAI 2011). Monitoring locations in Aquifer 2 are subdivided into the upper aquifer (i.e. Aquifer 2a) and the lower aquifer (i.e. Aquifer 2) wells. Aquifer 2a wells are screened in the upper portion of the aquifer, typically near the water table. The Aquifer 2 water table intersects the contact between Vashon-age deposits (Units B, C, and E) and pre-Vashon deposits (Unit F) in a number of places, and Aquifer 2a transitions from Unit E to Unit F as the water table gradually declines in elevation to the north below CHRL (LAI 2011). Aquifer 2a wells screened in Vashon-age deposits are designated as Aquifer 2ae wells. Aquifer 2a wells screened in pre-Vashon deposits are designated as Aquifer 2af wells. Aquifer 2 wells are typically screened in the bottom 10 to 15 ft of the aquifer and always in Unit F. Aquifer 3 monitoring locations are all screened in pre-Vashon deposits and are identified as upper aquifer (Aquifer 3a) and lower aquifer (Aquifer 3) wells. Additionally, one well on CHRL (MW-54), one well on QCF (G-3), and one offsite wel (b) (6) ) are screened below Aquifer 3 in the deep water bearing zone, also identified as Aquifer 4. Monitoring locations and key Site features are presented on Figure 4-1 (Aquifer 1), Figure 4-2 (Aquifer 2a), Figure 4-3 (Aquifer 2), and Figure 4-4 (Aquifers 3a, 3). For a detailed explanation of hydrogeologic designations, the reader is referred to previous Site documentation (LAI 2011).

As part of landfill operations, King County monitors water quality and water levels in a groundwater monitoring well network on the CHRL. CHRL monitoring well designations begin with “MW” followed by a number. The CHRL wells are typically sampled quarterly or semiannually by CHRL staff.

Section 10.5.2 of the 1992 ROD indicates that groundwater monitoring on the south end of the landfill is being performed pursuant to a Consent Order between King County and EPA[12].

King County makes the CHRL monitoring results available in quarterly monitoring reports to EPA and Boeing. LAI imports water level data and concentration results for PCE, TCE, cDCE, and VC from select CHRL wells (those located in the southern portion of the landfill and screened in Aquifers 2a, 2, 3a, or 3) into the QCF database. King County also publishes quarterly data and annual reports on their website (King County 2018). One well on the landfill (MW-71) is monitored by Boeing[13].

King County recently decommissioned three monitoring wells on the south end of the CHRL facility and discontinued monitoring at an additional three wells that were traditionally part of the QCF monitoring network. Aquifer 2a wells MW-70, MW-77, and MW-78 were decommissioned in April 2015 to accommodate construction of a new landfill cell in Area 8 (King County 2018). King County ceased monitoring at Aquifer 2a well MW-60 and Aquifer 2 well MW-57 in October 2015. Aquifer 3 well MW-58a was last sampled for water quality analysis in January 2013. Quarterly water levels are still collected at these wells. The changes to CHRLs groundwater monitoring plan were reportedly approved by the Washington State Department of Ecology, who oversees their water quality program.

Boeing participated in several meetings during 2019 with King County and EPA with the express purpose of attempting to resume sampling at MW-57, MW-58a, and MW-60 and to understand the plan and timeline for reinstalling decommissioned wells MW-70, MW-77, and MW-78. King County has indicated that it intends to install replacement wells for MW-70, MW-77, and MW-78 in 2020, but the timing and locations were yet to be determined at the end of this reporting period. Despite engagement with King County and the involvement of EPA, Boeing and King County were unable to come to agreement on a process for reinstating sampling at MW-57, MW-58a, and MW-60. All three of these wells served as boundary wells for the northern lobe of the TCE plume in aquifers 2, 3, and 2a respectively. TCE was not historically detected in any of the three wells with the exception of one sample collected from MW-57 in October 2001, and the concentration was below the performance standard; cDCE has never been detected. Time series plots for all three wells can be found in Appendix E (Figures E-51, E-72, and E-16). The location and function of each well with respect to the plume boundary is outlined below:

- MW-60 is located northeast of the TCE plume boundary in Aquifer 2a (Figure 5-4)
- MW-57 is located along the northern QCF property boundary in Aquifer 2 (Figure 5-6). Well MW-71, which also does not have detections of VOCs, lies just north of the QCF property boundary in Aquifer 2 and provides an additional monitoring point for assessing potential migration of the plume

[12] EPA Docket Number 1088-01-05-106-A

[13] MW-71 was sampled for VOCs annually by Boeing; under the revised groundwater monitoring plan implemented in 2018, MW-71 is now sampled for VOCs every 5 years. Boeing continues to collect water levels from MW-71 annually.

- MW-58a is located along the northern QCF property boundary in Aquifer 3. The Aquifer 3 TCE plume is confined to and area south of the FCC and several other monitoring wells (B-3, MW-59, and MW-24) provide monitoring points to assess plume migration (Figure 5-10)

Based on the difficulty negotiating a monitoring solution with King County for sampling MW-57, MW-58a, and MW-60, the nature of the historical data, and the availability of other wells for monitoring the boundaries of the TCE plume, Boeing is requesting EPA's concurrence to cease monitoring at these wells indefinitely. Should the need arise to sample those wells in the future, Boeing will again initiate discussions with King County and attempt to negotiate a monitoring solution.

## 4.2 Monitoring Schedule and Analyses

Boeing began groundwater monitoring in 1988 and has continued monitoring on a regular basis as additional wells have been added to the monitoring network. QCF monitoring locations were sampled in 2019 consistent with the sampling schedule and protocols defined in the Field Sampling Plan (FSP) (LAI 2014b) with plan modifications (LAI 2018b), the monitoring schedule proposed in the GETS Performance Monitoring Report (LAI 2016c), and the monitoring schedule as outlined in the GETS Performance Assessment and Recommendations Report (LAI 2019a) following initiation of the GETS modified pumping in April 2019. A list of 2019 sampling locations, sampling frequency, and analytical methods is provided in Table 4-2.

Water quality samples collected in standard sampling events including the annual and semiannual sampling events at QCF are analyzed for a designated list of VOCs using EPA Method 524.2. A list of target analytes is provided in the Quality Assurance Project Plan (QAPP; EcoChem and LAI 2015) and consists of VOC (59; groundwater and surface water) and MNA parameters (six; groundwater). Analyses are performed at Eurofins Lancaster Laboratories Environmental, Inc. (LLI) located in Lancaster, Pennsylvania. Laboratory analyses and quality assurance/quality control methods were completed consistent with the current QAPP. In addition to annual and semiannual events, hand-measured water levels are collected on a monthly interval at locations where dataloggers are installed.

In addition to water quality samples, vapor samples are collected at the GETS air discharge concurrent with annual (March) and semiannual (September) groundwater sampling. GETS vapor samples are analyzed for TCE, VC, and cDCE, using EPA Method TO-15.

## 4.3 Data Management and Reporting

LAI assumed data validation and database maintenance responsibilities from EcoChem, Inc. (EcoChem) in 2015. EQuIS online data management software (EQuIS database) is used to store and manage water quality and discrete water level data collected by Boeing at QCF[14]. Discrete hand-measured groundwater elevation data collected at QCF in 2019 are provided in Appendix A, along

[14] Groundwater elevation data from dataloggers is stored locally and not stored within the EQuiS database.

with time series representing historical hand-water level observations at actively monitored QCF wells. Appendix D contains complete VOC concentration results from monitoring in 2019, and Appendix E presents historical time series plots for chemicals of concern (cDCE, PCE, TCE, and VC) in active and select historical monitoring wells at QCF.

In 2014, EPA approved a change from level IV to level II (EPA Stage 2A) data validation procedures (EPA 2014)[15]. As a result, LAI performed Stage 2A validation on all groundwater monitoring results collected by Boeing at QCF in 2019. GETS performance monitoring results have been included in the Stage 2A data verification and validation check since September 2016, when GETS monitoring was incorporated into the semiannual sampling schedule (LAI 2016c). Data from CHRL wells are supplied by King County and are not validated by LAI. Data validation reports for analyses completed in 2019 are presented in Appendix F.

Boeing reports monitoring and Site characterization results to EPA in annual data reports (LAI 2016a, 2015a, 2014a, 2013b, 2017a, 2018a). Additional reporting is dependent upon Site activities; in 2019, Boeing prepared a summary of GETS performance data following implementation of the modified pumping strategy (LAI 2019a). Once every 5 years, EPA reviews cleanup progress and Site conditions and summarizes its conclusions in a FYR report. The most recent FYR took place in 2018 (EPA 2018b), and the next is scheduled in 2023.

[15] Two emails were sent from Eric Weber, LAI, to Jeremy Jennings, EPA, Re: "QCF-Level II Data Validation" dated February 12, 2014 and re: "WQCF-Laboratory Switch Request" dated February 12, 2014. An email was sent from Jeremy Jennings, EPA to Eric Weber, LAI, re: "March 2014 Annual Sampling" dated March 4, 2014.

# 5.0 RESULTS

This section presents 2019 data results for water level monitoring, VOC monitoring and MNA monitoring at Site-wide monitoring well locations, and GETS performance monitoring data.

## 5.1 Water Level Monitoring

Spring 2019 groundwater elevations for Aquifers 2a, 2, and 3 (3a and 3) are presented on contour maps on Figures 5-1 through 5-3. Fall 2019 groundwater elevations were consistent with previous years with the exception of Aquifer 2 water levels near the GETS, which changed due to the modification in pumping at the GETS (LAI 2019a, b). Calculated groundwater elevation data from all 2019 hand-measured groundwater water levels are presented in tables and time series plots in Appendix A. Hourly groundwater measurements for select wells and surface water locations are included as Appendix B.

### 5.1.1 Synoptic Groundwater Level Monitoring

Overall groundwater flow patterns in 2019 are consistent with recent observations under present land use conditions (LAI 2011, 2013a, b, 2014a, 2015a, 2017a) with the exception of changes in the Aquifer 2 flow patterns towards the GETS due to a modification in pumping at select extraction wells. Groundwater in the shallowest regional aquifer, Aquifer 2a, flows predominantly north and south from an area of focused recharge near MGPL. Near the southern margin of the QCF property, shallow groundwater flow converges toward southwesterly discharge along Cedar Grove Channel (Figures 4-1, 4-2; LAI 2011). Groundwater flow gradients in Aquifer 2a are relatively flat in the northern portion of the QCF property, steepening as Aquifer 2a declines in elevation and transitions from the coarser-grained advance outwash of Unit E to finer-grained interglacial deposits of Unit F, to the north below CHRL. Gradients steepen in spring in response to higher rates of recharge from MGPL and Queen City Lake (via aquifer 1) during the wet season. Seasonal groundwater levels in Aquifer 2a were an average of 6.45 ft higher in spring relative to fall 2019 using annual and semi-annual data.

In Aquifer 2, groundwater flow radiates predominantly to the north, south, and west from an area of mounding near MGPL. Easterly flow is restricted due to thinning of Aquifer 2 toward the east (Figure 2-2; LAI 2011). Aquifer 2 groundwater levels south of MGPL reflect an area of drawdown around the GETS (LAI 2015b, 2016b, c). Seasonal groundwater levels in Aquifer 2 monitoring wells[16] were an average of 4.78 ft higher in spring relative to fall 2019, using annual and semi-annual data.

Groundwater levels observed in Aquifers 3a and 3 are nearly equivalent at clustered monitoring wells (I, IA and O clusters), indicating a minimal vertical gradient in Aquifers 3a and 3. Flow is directed primarily to the north, south, and west from an area north of MGPL. As with Aquifer 2, easterly flow is restricted due to thinning of Aquifer 3 toward the east (LAI 2011). Relatively high water levels observed at well TB-3a indicate a southwesterly flow direction in the southeastern corner of the Site, near the Cedar Grove Channel (Figures 4-5, 4-6; LAI 2011, 2015a). Seasonal groundwater levels in Aquifers 3a and 3 were an average of 1.84 ft higher in spring relative to fall 2019, using annual and

[16] Excluding extractions wells EW-1 through EW-7 due to pumping effects.

semi-annual data; this includes one well (O-3) where the fall groundwater level was greater than the spring groundwater level.

## 5.2 Volatile Organic Compound Monitoring Results

VOC concentration trends in 2019 were generally similar to trends in recent years. TCE continues to be the only VOC detected above minimum performance standards[17] in groundwater at the Site, making TCE the primary contaminant of concern at QCF. However, cDCE remains a contaminant of interest for evaluating spatial and temporal VOC trends since it is present at the Site in Aquifers 2a, 2, 3a, and 3. In addition, VC has been detected just above its adjusted[18] performance standard in groundwater at two Aquifer 3 CHRL wells. A brief summary of overall VOC trends is presented below, followed by analysis of individual well trends in each aquifer in Subsections 5.2.1 through 5.2.4. A summary of detected VOCs in 2019 along with VOC trends is provided in Table 5-1.

TCE trends are declining to stable (i.e. do not change appreciably over time) in monitoring wells north of and within the CPOC with the exception of wells E-2, IA-3, I-3a and IB-3a. The increase in concentrations in wells IA-3 and I-3a appears to correspond with the initiation of the GETS. Well I-2 initially had an increasing TCE trend following startup of the GETS, but appears to have a decreasing trend since March of 2018. Well V-2a north of the CPOC showed an increasing TCE concentration trend until September 2014; since then, maximum annual concentrations have been declining. To the west of the CPOC, well D-2a shows a slightly increasing TCE trend since 2014, however concentrations remain around 1 µg/L. TCE trends near and southwest of the southern CPOC area (in the vicinity of the GETS) are generally decreasing or stable with the exception of SA-2 which exhibits a stable to increasing trend, however TCE concentrations at SA-2 are only slightly above the minimum performance standard. Following startup of the GETS, Well S-2a showed an increasing trend but it appears concentrations are leveling off.

cDCE trends are declining to stable in all monitoring wells with the exception of F-2, G-2, B-3, I-2, IA-3, I-3a, and SD-3a. All concentrations are low and well within the performance standard of 70 µg/L. SD-3a is the only location outside of the CPOC with increasing cDCE trends.

Concentration contours for TCE and cDCE in Aquifers 2a, 2, 3a, and 3 are presented on Figures 5-4 through 5-11. Tabulated 2019 groundwater VOC results are provided in Appendix D. VOC time series plots for chemicals of concern at each actively sampled monitoring well, including applicable CHRL wells, are presented in Appendix E.

Two CHRL wells (MW-24 and MW-65) had VC concentrations in 2019 above the adjusted performance standard of 0.02 µg/L (King County 2019). The detection at MW-24 is the only exceedance of the VC adjusted performance standard at this well to-date. The 2019 MW-65 results are within the same order of magnitude as past years and concentrations indicate a stable to decreasing trend. VC is a

[17] Minimum performance standards exist for PCE, TCE, cDCE, trans-1,2-DCE, and VC, and are presented in Section 1.2.2.

[18] Adjusted performance standards exist for PCE and VC only, as presented in Section 1.2.2. Adjusted performance values are screened once concentrations fall below the minimum performance standards.

well-known municipal solid waste landfill contaminant and these detections may be attributed to releases from CHRL.

### 5.2.1 Aquifer 2a

In Aquifer 2a, TCE exceeds the minimum performance standard (5 µg/L) at locations beneath the northern portion of the CPOC and extending to the northwest below the CHRL (Figure 5-4). In 2019, concentrations of TCE above 5 µg/L were observed at four Aquifer 2a monitoring wells (C-2a, E-2a, V-2a, and MW-76). Of these four wells, two (V-2a and MW-76) are outside of the CPOC.

Results at well S-2a indicate a local region of low (less than 5 µg/L) TCE concentrations southwest of the CPOC. Other constituents occur only locally and below minimum performance standards in Aquifer 2a, including cDCE (at MW-76 and V-2a; Figure 5-5), and PCE (at C-2a and MW-76; Appendices B and C). Historically, cDCE was detected in a number of wells within and north of the CPOC; however, cDCE concentrations have declined substantially and are no longer detected in Aquifer 2a, except at MW-76 and V-2a.

Temporal TCE trends in most Aquifer 2a monitoring locations follow classic log-linear declining trends, (e.g., C-2a, E-2a; Appendix E Figures E-3 and E-5, respectively). Three exceptions to the stable trends include wells I-2a, V-2a, D-2a and S-2a, where trends can be described as follows:

- At I-2a (within the southern portion of the CPOC, Appendix E Figure E-9), TCE concentrations historically decreased following a log-linear trend until 2011 when concentrations began to slowly increase; however, following the initiation of the GETS, TCE concentrations have become stable
- At V-2a (located north of Queen City Lake, Appendix E Figure E-15), VOC concentrations have historically exhibited substantial seasonal variation and a unique trend wherein the TCE and cDCE signatures reverse seasonally, with the highest TCE and lowest cDCE concentrations observed in fall, and the highest cDCE and lowest TCE concentrations observed in spring. Observing only the maximum annual concentrations in TCE and cDCE, TCE appears to have peaked in fall of 2014, and then began a slight decreasing trend, while cDCE appears to have a decreasing trend since 2010
- Well D-2a (located west of the CPOC, Appendix E Figure E-4) experienced a steady declining TCE trend until 2014 when the trend began to increase slightly. Currently, the TCE concentration at D-2a is around 1.0 µg/L, well below the performance standard
- Well S-2a (located adjacent to EW-1 of the GETS system, Appendix E Figure E-13) concentrations exhibited a decreasing trend until shortly after startup of the GETS, recent trends may indicate concentrations are leveling off. The maximum TCE concentrations in 2019 was 3.5 µg/L, after having declined steadily to around 1 µg/L over the period from 1996 to 2015. The increase in TCE concentrations appears to coincide with operation of the GETS.

### 5.2.2 Aquifer 2

The TCE and cDCE plumes in Aquifer 2 are bifurcated into segments lying generally north and south of the MGPL. The bifurcated concentration pattern appears to be related to surface water infiltration and groundwater mounding below MGPL that pushes groundwater flow radially outward from the vicinity of the lake.

In Aquifer 2, TCE exceeds the minimum performance standard (5 μg/L) at locations beneath, north, and southwest of the CPOC (Figure 5-6). In 2019, concentrations of TCE above 5 μg/L were observed in nine Aquifer 2 monitoring wells (C-2, E-2, F-2, G-2, I-2, L-2, SA-2, SC-2, and SD-2) and in two GETS extraction wells (EW-2 and EW-3). The two extraction wells and three of the monitoring wells (SA-2, SC-2 and SD-2), are located outside and southwest of the CPOC; L-2 is located outside and north of the CPOC. Detections of cDCE occurred at concentrations below the minimum performance standard (70 μg/L) in areas of Aquifer 2 north and south of the MGPL (Figure 5-7). PCE is detected locally beneath the northern portion of the CPOC (e.g., at B-2, E-2, F-2, and G-2) in 2019, at concentrations below 2 μg/L; the minimum performance standard is 5 μg/L.

Temporal VOC concentration trends in Aquifer 2 continue to vary across the Site, especially in the southern portion, since startup of the Aquifer 2 GETS in February 2015. Areas beneath and north of the CPOC generally exhibit a declining TCE trend, with some wells stabilizing in recent years (e.g., B-2, E-2, F-2, and C-2). cDCE trends at well E-2, F-2 and G-2 show a slight increase in recent years (Appendix E). A shift in long-term concentration trends occurred in early 2015 coinciding with the GETS startup at six monitoring locations: I-2, N-2, S-2, SC-2, SD-2, and U-2. Concentration trends at these wells can be described as follows:

- At I-2 (Appendix E Figure E-33), TCE and cDCE generally declined together over the period from the early 1990s through 2014. In April of 2015, concentrations of TCE and cDCE began increasing. Concentrations of cDCE initially increased more steeply than concentrations of TCE, but have remained lower than TCE. Beginning in 2018, TCE and cDCE concentrations appear to be decreasing slightly
- At N-2 (Appendix E Figure E-40) south of the GETS, cDCE was detected at low concentrations from the early 1990s until 2005, and then was not detected for a decade. Since May 2015, low concentrations of cDCE have been detected intermittently (0.9 μg/L maximum in 2019) since startup of the GETS
- At S-2 (Appendix E Figure E-43), cDCE was the only VOC present in the 1990s. Beginning in 2000, cDCE concentrations began to decline coincident with a similar magnitude increase in TCE concentrations. By 2009, cDCE was no longer detected while TCE continued to increase gradually until 2015. TCE concentrations declined steeply after GETS startup in February 2015, and have not been detected since May 2015
- At SC-2 (Appendix E Figure E-46), from initial well construction in 2009 until January 2015, TCE appeared to follow a stable to gradually decreasing trend, and cDCE occurred at concentrations an order of magnitude lower than TCE and exhibited a similar decreasing trend. In March 2015 following the GETS startup, concentrations of TCE and cDCE decreased sharply, with cDCE stabilizing near the minimum reporting limit (0.5 μg/L) and TCE gradually declining to 5.7 μg/L in fall of 2019
- At SD-2 (Appendix E Figure E-47), concentrations of TCE and cDCE have been somewhat erratic but declining since startup of the GETS with the maximum TCE concentration (16 μg/L) occurring in March 2016. cDCE concentrations also show a declining trend since 2016. In general, cDCE concentrations at this well are an order of magnitude less than the TCE concentrations

- At U-2 (Appendix E Figure E-49), relatively low concentrations of cDCE occurred from 1996 until detections ceased in the mid-2000s. TCE was first detected in 2011 and gradually rose to concentrations near 2 µg/L. TCE concentrations have been somewhat erratic since startup of the GETS in 2015, and overall appear to be declining slightly.

### 5.2.3 Aquifer 3a

Aquifer 3a TCE concentrations exceeded the minimum performance standard in 2019 beneath the southeastern portion of the Site at three monitoring locations (I-3a, IA-3a, and MA-3a; Figure 5-8). Only MA-3a is located outside the CPOC. Relatively low detections of cDCE (below 70 µg/L) are present in Aquifer 3a beneath the southern portion of the CPOC and to the south and east (Figure 5-9). In several Aquifer 3a monitoring locations, cDCE is the only constituent of concern detected (IB-3a, O-3a, OA-3a, SD-3a). PCE has been consistently detected at well I-3a at low concentrations since 2009, but appears to be decreasing (Appendix E Figure E-52). The most recent PCE detection at I-3a was 0.9 µg/L in 2019.

VOC concentration trends are stable or gradually declining at several monitoring locations (e.g., IA-3a, MA-3a, O-3a and OA-3a; Appendix E Figures E-53, E-55, E-57, and E-58 respectively). TCE and cDCE concentrations at I-3a have generally declined since the 1990s; however, recent data suggest a subtle shift toward slightly increasing TCE and cDCE concentrations since the startup of the GETS (Appendix E Figure E-52). TCE concentrations at IB-3a appear to have been slightly increasing since the startup of the GETS (Appendix E Figure E-54).

Three Aquifer 3a monitoring wells were installed somewhat recently:  MA-3a and SD-3a in 2013, and OA-3a in 2016. The TCE trend at MA-3a appear stable since 2017. The cDCE trend has been decreasing. TCE has not been detected at OA-3a or SD-3a. Initial concentrations of cDCE at SD-3a were low (2.5 µg/L in August 2013), and appear to be increasing, with a maximum concentration in 2019 of 15 µg/L in spring 2019 (Appendix E Figure E-59). At OA-3a, consistently low concentrations of cDCE have been detected (ranging from 3.8 to 5.9 µg/L) (Appendix E Figure E-58).

### 5.2.4 Aquifer 3

TCE has been detected at one Aquifer 3 monitoring location (IA-3), at a maximum concentration of 12 µg/L in 2019 (Figure 5-10). TCE concentrations at IA-3 have been increasing since 2014 (Appendix E Figure E-69), but remain considerably lower than TCE concentrations observed in Aquifer 3a at the same location (IA-3a, maximum of 78 µg/L in 2019). Recent increasing concentration trends appear to coincide with startup of the GETS. This trend at well IA-3, along with similarly coincidental trends at M-3a, I-3a, and IA-3a, suggests some degree of connectivity between Aquifer 2 and Aquifer 3 in the I-wells area. Relatively low concentrations of cDCE (maximum concentration is 33 µg/L at well IA-3) are more widespread than TCE in Aquifer 3. To the north, cDCE was detected at CHRL wells MW-24 and MW-59, in addition to well B-3 within the CPOC. To the south, cDCE was detected at well I-3 and IA-3 (Figure 5-11). Vinyl Chloride (VC) was detected only north of the Site in CHRL wells MW-24, MW-59 and MW-65. Concentrations have historically been below the adjusted performance standard of 0.02 µg/L at MW-24 but in fall of 2019, the MW-24 spring sample was re-analyzed due to dilution (King County 2020) with a detection just above the adjusted performance standard at 0.0247 µg/L with lab qualifier "D." MW-24 is near the CHRL's South Solid Waste Area Original Refuse Limits (King County 2020, Figure 1). Concentrations at MW-65 have historically exceeded the performance standard and had a maximum concentration in 2019 of 0.0318 µg/L. The 2019 results are within the same order of magnitude as past years and concentrations indicate a stable to decreasing trend. MW-65 is on the property boundary of CHRL and QCF. The source of VC is unknown but it is not believed to be related to the VOC source at the Site. However, MW-24 is near the CHRL's South Solid Waste Area Original Refuse Limits (King County 2020, Figure 1), a former unlined landfill area.

## 5.3 Aquifer 2 Groundwater Extraction and Treatment System

Contingent implementation of an Aquifer 2 GETS was included in the ROD as a remedial action to address TCE groundwater contamination. The contingent GETS was constructed in 2014 based on Aquifer 2 conditions in the S-wells area, located in the southwest portion of the Site (LAI 2014b). The design RAOs for the GETS include 1) hydraulic containment of the Aquifer 2 TCE plume near the S-wells area with reduction in concentrations, and 2) minimizing migration of TCE in groundwater. The GETS consists of seven extraction wells (EW-1 through EW-7), each equipped with a submersible pump constructed to convey groundwater to an above-ground diffused-bubble aerator treatment system. Treated water is discharged to MGPL, which serves as a recharge source to Aquifers 2a and 2. The S-wells area monitoring locations, the GETS, and other related Site features are shown on Figure 5-12.

Startup of the GETS operation began on February 23, 2015. From 2015 to October 2017, the treatment unit had been an air stripper. A GETS optimization effort (LAI 2017b) was implemented in October 2017, which involved replacing the air stripper with a diffused-bubble aerator. Operations and performance monitoring results from February 2015 through December 2018 are summarized in previous Site documents (LAI 2016c, 2017a).

### 5.3.1 Modified Pumping Strategy

In 2019, Boeing completed a GETS performance evaluation with recommendations for a modified pumping strategy (MPS). The evaluation and MPS were presented to EPA in a report (LAI 2019b) that was finalized in March 2019, approved for implementation by EPA in April 2019 (EPA 2019), and the MPS was implemented beginning April 23, 2019.

Key observations from the GETS performance evaluation were as follows:

- Decreasing trends in TCE concentrations at S-well area wells located near the western portion of the GETS extraction well transect (e.g. EW-1 through EW-3, S-2, and SC-2)
- Apparent east-west bifurcation of the Aquifer 2 TCE plume near the center of the GETS extraction well transect, which revealed an apparent Eastern Lobe and Western Lobe
- Increasing TCE concentration trends in the Eastern Lobe of the TCE plume at EW-6, EW-7, and well I-2. Well I-2 is located within the CPOC, and the pumping of EW-6 and EW-7 from 2015 into 2019 appeared to influence westward to southwestward expansion of higher TCE concentrations from the CPOC.

From the above observations, the GETS had been succeeding in meeting the intent of design RAO #1 (hydraulic containment and TCE concentration reduction near S-wells area), but was not meeting the intent of RAO #2 (minimizing TCE plume migration) in all areas. Therefore, the objective of the MPS was to support progress on the RAOs by continuing to reduce concentrations in the Western Lobe of the TCE plume (i.e. the S-well area) *with* an increased removal efficiency (TCE pounds per million gallons of extracted groundwater [lbs/MG]), while reducing GETS-influenced mobilization and expansion of the Eastern Lobe of the TCE plume. The MPS involved shutting off extraction wells EW-1, EW-2, EW-6, and EW-7, increasing pumping rates at EW-3, EW-4, and EW-5, and adding dataloggers to three additional wells in the GETS area (I-2, SA-2, and SD-2) to monitor groundwater elevations.

The monitoring program included collection of VOC influent and effluent samples immediately following well shut down (within 4 hours), followed by 1 week, 1 month, and 2 month intervals. Groundwater elevation measurements were collected at select wells, VOC samples of influent and effluent were collected, and VOC samples were collected from all seven extraction wells (LAI 2019a). The following subsections provide an evaluation of 2019 data collection related to the GETS (before and since MPS implementation).

### 5.3.2 Capture Zone and Water Level Data

While extraction wells were sampled for VOC several times following implementation of the MPS, adjacent monitoring wells were only sampled during the semi-annual groundwater monitoring events. The only 2019 semi-annual groundwater monitoring event since implementation of the MPS occurred in September 2019. With only five months of modified operation of the GETS and one semiannual monitoring event, appreciable change in the nature and extent of the Aquifer 2 TCE plume by the GETS is not yet apparent. However, Aquifer 2 groundwater elevation and TCE data show that the GETS area of influence and TCE plume bifurcation in the S-well area approximately five months after MPS implementation are reduced (Figure 5-13). Comparison of groundwater flow lines between fall 2018 (Figure 5-14) and fall 2019 (Figure 5-13) indicates the GETS area of influence appears to be reduced, particularly in the I-well area, while still targeting the core of the plume in the S-well area (as intended).

Hourly water level elevation readings were collected in 2019 using data loggers for the MGPL surface water staff gauge (SWSG-1) and select GETS area wells (I-2, S-2, SA-2, SC-2, SD-2, and SF-2). Of these seven monitoring locations, four locations (SWSG-1, S-2, SC-2, and SF-2) have had operating data loggers since before the 2015 GETS startup, and the other three (I-2, SA-2, and SD-2) have had operating data loggers since March of 2019 just before the MPS was implemented. Figures with data logger readings over time for these seven data logger monitoring locations are provided in Appendix B. Each Appendix B figure shows the following GETS timeline milestones: GETS Startup (2015), GETS Optimization (after which pumping rates nearly doubled, 2017), and GETS Modified Pumping (i.e. MPS; 2019).

Hand measured water level elevations were also collected at select groundwater well and surface water locations (H-2, I-2, LL-1, N-2, S-2, SA-2, SB-2, SC-2, SD-2, SE-2, SWSG-1, and U-2) one day before, and one week, one month and two months following the MPS implementation. Figures with hand water level readings over time for select locations are included in Appendix A, on Figures A-22 through A-24. Water level elevations at observation wells showed varying levels of influence one week following the MPS. Water level time series graphs for these wells are presented in Appendix A. As with Appendix B, the graphs show GETS timeline milestones.

The MGPL staff gauge (SWSG-1) measures water level elevations in the lake and is located along the southern shoreline of MGPL close to the I-well area, as shown on Figure 5-14. From SWSG-1 Appendix B, Figure B-1, it appears seasonal variation of water levels at MGPL have been fairly consistent since before GETS startup through 2019. Lake levels are influenced by precipitation runoff and the operation of the GETS does not have a noticeable impact on lake levels.

Water level readings from dataloggers and hand readings provide an indication of the extent of the cone of depression created by the GETS and how operational changes affect the capture zone. Wells within the cone of depression experience rapid changes in water level in response to changes in GETS pumping. The degree of response at a given well also provides an indication of relative influence of the GETS at that location. Water levels for observation wells close to the GETS (S-2, SC-2, and SF-2), as expected, showed a rapid and significant response to the MPS. Wells to the south (Figure A-23) including wells SD-2, SE-2, and N-2 also showed a rapid and significant response, despite their distance from the GETS. Wells to the east and west of the GETS (Figure A-22) including I-2 (east), and H-2 and SB-2 (west) show small but noticeable response to the MPS despite the closer proximity to the GETS than the south wells. Northern wells (Figure A-24), including SA-2 and U-2, showed essentially no response to the MPS; these wells also showed no perceptible water level changes at GETS startup in 2015. This data indicates that the GETS influence extends farthest to the east and to the south, moderately to the west, minimally the north and northwest. The response of various wells, in combination with observation of the groundwater contours, indicates that the capture zone of the GETS under the MPS has been reduced but the system is continuing to capture groundwater in the core of the S-well area, as intended.

### 5.3.3 System Performance and VOC Concentration Data

Following implementation of the MPS, influent TCE concentrations increased slightly to between 3.8 µ/L and 4.9 µ/L. The diffused-bubble aerator system successfully treated influent to concentrations below the effluent discharge limit (4 µg/L), achieving effluent concentrations between 1.0 µ/L and 2.5 µ/L. cDCE influent and effluent concentrations since the MPS were similar to historical concentrations and are well below the effluent discharge limit of 16 µ/L. 2019 TCE and cDCE sample data results from GETS influent/effluent and extraction wells samples are presented in Table 5-2.

In the 2019 GETS performance evaluation (LAI 2019b), TCE mass removal efficiency was evaluated and is expressed as the ratio of TCE mass removed from Aquifer 2 in pounds (lbs) per million gallons (Mgal). The performance evaluation concluded that efficiency of the GETS could be improved by implementing the MPS. To evaluate the effect of the MPS on efficiency the TCE mass removal rate from fall 2018 was compared to fall 2019. While 2019 influent and effluent VOC concentrations are fairly consistent with prior years, the average total influent flow rate from fall 2018 to fall 2019 decreased by more than half (from 84 gpd to 35 gpd) due to implementation of the MPS (Table 5-2). The fall 2019 total influent flow rate of 35 gpd is the lowest recorded flow rate during a normal GETS operation monitoring event since GETS startup. The TCE mass removal rate from fall 2018 compared to fall 2019 increased by approximately 18 percent (from 0.028 lbs/Mgal to 0.033 lbs/Mgal) with implementation of the MPS. These results support an increased GETS system efficiency since MPS implementation. It may be beneficial to evaluate if additional efficiency can be gained by further reducing pumping rates at EW-5. The GETS total influent flow rate (in gallon per day [gpd]) and TCE mass removal rate (in pounds per million gallons of water [lbs/Mgal]) are plotted over time on Figure 5-15. The cumulative TCE mass removal (lbs) through fall 2019 is approximately 5.3 lbs over an approximate 4.5 year period and 171 Mgals of groundwater extracted, as shown on Figure 5-16.

To illustrate TCE concentrations trends at GETS extraction wells, individual TCE time series plots are provided in Appendix G. Each of the time series plots delineate the following GETS timeline milestones: GETS Startup (2015), GETS Optimization (2017), and GETS Modified Pumping (i.e. MPS; 2019). TCE trends since implementation of the MPS are as follows:

- **EW-1:** Concentrations declined steeply and have remained non-detect since May of 2019
- **EW-2:** Initially concentrations declined steeply, and then continued a slower decline since May of 2019
- **EW-3:** Concentrations declined initially and then stabilized
- **EW-4:** The concentration trend has been stable
- **EW-5:** Initially concentrations increased, declined, and then returned to a stable trend at slightly lower concentrations than before the MPS
- **EW-6:** Initially concentrations increased, and then returned to concentrations similar to pre-MPS
- **EW-7:** Initially concentrations increased, and have since returned to concentrations similar to pre-MPS.

Caution should be used in interpreting the effect of the MPS on concentration trends at individual wells as only one data point is available for monitoring well locations following implementation of the MPS. It is therefore difficult to discern what effect the MPS has had on the concentration trends at individual monitoring wells. TCE concentrations for Eastern Lobe area wells I-2, SD-2, EW-7, and EW-6 are plotted over time on Figure 5-17. Sampling results from I-2 and SD-2 show minimal change in TCE concentrations prior to the MPS (Fall 2018) and following the MPS (Fall 2019). SD-2 continues to show a decreasing TCE trend and I-2 continues to show a generally stable or potentially slightly decreasing TCE trend. While TCE concentrations at EW-6 and EW-7 initially increased following MPS implementation, concentrations have since decreased. TCE concentrations for select Western Lobe area wells U-2, SA-2, SC-2, and EW-3 are plotted over time on Figure 5-18. Concentration trends at Western Lobe wells are mixed. Well SC-2 appears to have a continued decreasing trend; wells U-2 and SA-2 appear to have continued increasing trends (though concentrations at U-2 have historically been erratic); and the trend at EW-3 appears to have stabilized since the MPS.

GETS air discharge vapor VOC data for TCE, cDCE, and VC, and averages before and after GETS optimization in October 2017 are summarized in Table 5-3. VC has not been detected in GETS vapor to date. TCE and cDCE vapor concentrations during the air stripper operation (GETS startup to GETS optimization) averaged 90.8 micrograms per cubic meter (µg/m$^3$) and 27.5 µg/m$^3$, respectively. Since GETS optimization when the air stripper was replaced with a diffused-bubble aerator, vapor concentrations of TCE and cDCE have averaged 26.3 µg/m$^3$ and 9.4 µg/ m$^3$, respectively, 3 to 4 times lower than pre-GETS optimization averages. Concentrations of TCE and cDCE in vapor from spring of 2019, prior to implementation of the MPS, were similar to concentrations from spring 2018. However, vapor concentrations in fall 2019 were 60 to 75 percent lower than fall 2018 concentrations. Coinciding with the lowest normal operating influent flow rate since GETS startup, the fall 2019 vapor concentrations of TCE and cDCE were the lowest since GETS startup. September 2019 vapor concentrations of TCE and cDCE were 12 µg/m$^3$ and 2.9 µg/m$^3$, respectively. September 2018 vapor concentrations of TCE and cDCE were 29 µg/m$^3$ and 12 µg/m$^3$, respectively, which was similar to the average concentrations since the GETS optimization. As previously indicated, the fall 2019 influent flow rate was less than 50 percent of the fall 2018 influent flow rate.

### 5.3.4 GETS Summary

Consistent with prior years, the GETS influent concentrations are low (less than 5 µg/L since 2015) which indicates the GETS has a limited capacity to aide in attainment of the long-term RAO of groundwater restoration across the Site. However, 2019 GETS operations appear to support the GETS design RAOs and the objectives of the 2019 MPS. In summary, since MPS implementation in April 2019:

- Radius of influence of the GETS system in areas north of the GETS is limited, and this area showed little to no effect from the MPS. However, areas directly to the west, east, and south showed a more significant response to the MPS
- Overall TCE concentrations continue to decrease in the S-well area. It is still unclear what effect the MPS will have on TCE concentrations at SA-2, which displays a stable to slightly increasing trend; however, the GETS appears to have little or no influence at SA-2 and it is likely that the TCE concentrations at this well will not be affected by the MPS
- Initial data appear to indicate an improvement in TCE mass removal efficiency of about 18 percent when comparing fall 2018 data to fall 2019 data
- GETS vapor concentrations from fall 2019 were the lowest since GETS startup (less than fall 2018), and the decrease in concentrations coincides with the decrease in influent flow rate.

In conclusion, limited data collection since the MPS implementation suggests that some goals are being met; however, the limited VOC data from observation wells since the MPS provide insufficient data to evaluate the impact on concentration trends. 2020 data will help clarify trends under this modified pumping regimen.

## 5.4 Monitored Natural Attenuation

MNA is part of the selected Site remedy presented in the ROD. Routine assessment of MNA performance monitoring data is important to evaluate the effectiveness of natural attenuation mechanisms at the Site, which include biotic and abiotic dechlorination, dispersion (flushing and dilution) and adsorption in all aquifers, and reductive dechlorination in Aquifers 2, 3a, and 3.

Under favorable (reducing) aquifer conditions, chlorinated compounds can be degraded by bacteria present in the subsurface through a sequence of redox reactions. Bacteria utilize an electron donor (such as organic carbon) in respiration to consume electron acceptors that may be present in the aquifer, including DO, manganese (IV), nitrate, iron (III), sulfate, and chlorinated compounds such as PCE, TCE, cDCE, and VC. PCE and TCE can be degraded under slightly reducing conditions (nitrate- and iron-reducing conditions) while reductive dechlorination of less oxidized cDCE and VC requires more highly reducing (sulfate reducing to methanogenic) conditions. Reductive dechlorination can also occur through abiotic processes, in which iron-bearing minerals can act as the electron donor for chlorinated solvents (Brown, Wilson, and Ferrey 2007).

The following subsections include a previous MNA results summary and 2019 MNA results and redox conditions evaluation.

### 5.4.1 Previous MNA Results Summary

The MNA conceptual model developed in the 2010 Expanded Hydrogeologic Assessment (LAI 2011) has generally been substantiated by subsequent MNA data. A main element of this conceptual model is that Aquifer 2a is generally aerobic with conditions not conducive to reductive dechlorination of TCE. As groundwater flows horizontally and vertically along a flow path from the area of recharge in the vicinity of the MGPL, it becomes progressively more reducing. Consequently portions of Aquifer 2 that are distant from the mound (e.g., well O-2), and most portions of Aquifers 3 and 3a, exhibit reducing conditions that are conducive to transformation of TCE to cDCE. Except in localized areas of Aquifer 3, it appears unlikely that cDCE will be transformed further to VC, ethane, and ethane.

MNA results through 2017 have been presented in previous Site documents (LAI 2011, LAI 2018a, LAI 2019c). To expand on the above MNA conceptual model understanding, the following is an understanding of aquifer redox conditions based on pre-2019 MNA sampling at the Site (LAI 2018b):

- **Aquifer 2a/2:** Aquifer 2a is generally aerobic with conditions not conducive to reductive dechlorination of TCE. As groundwater flows horizontally and vertically along a flow path from the area of recharge in the vicinity of the MGPL, it becomes progressively more reducing. Consequently, TCE is relatively widespread in Aquifer 2a and Aquifer 2; and cDCE is almost absent from Aquifer 2a, and has limited spatial distribution in Aquifer 2 except in portions of Aquifer 2 that are distant from the groundwater mound near MGPL
- **Aquifer 3a/3:** Aquifer 3a and 3 generally have anaerobic, nitrate- to iron-reducing conditions, which become increasingly reducing with depth from Aquifer 3a to Aquifer 3. cDCE is relatively widespread in Aquifer 3a and Aquifer 3 while TCE has limited distribution in Aquifer 3a and is only detected at a single well (IA-3) in Aquifer 3, indicating consistent capacity for

reductive dechlorination is prevalent in Aquifers 3a and 3. Although Aquifer 3a and 3 are generally reducing, the redox state is generally not sufficiently reducing to transform cDCE to VC, ethene, or ethane, which typically requires sulfate reducing to methanogenic conditions.

### 5.4.2 2019 MNA Results and Redox Conditions Evaluation

In accordance with the 2018 Groundwater Monitoring Plan Update (LAI 2018b), biennial and annual MNA sampling for 19 wells in Aquifer 2a, 2, 3a, and 3 was completed in March 2019. The primary objective for routine MNA sampling in 2019 was to evaluate aquifer redox conditions in Aquifers 2a, 2, 3a, and 3 to determine the potential for reductive dechlorination of VOCs over time.

2019 MNA results were fairly consistent with previous MNA results discussed above. MNA remedy performance highlights from 2019 data include indication of anaerobic, iron-reducing conditions present in localized areas within Aquifer 2, and Aquifer 3a, and Aquifer 3 where conditions become increasingly reducing with depth from Aquifer 3a to Aquifer 3. MNA data from the annual sampling event in March are presented on Figure 5-19 and in Table 5-4, and discussed in the following subsections.

#### 5.4.2.1 Dissolved Oxygen and Oxygen-Reduction Potential

Dissolved oxygen (DO) and Oxygen-reduction potential (ORP) are field parameters collected to evaluate aquifer redox conditions. ORP is notoriously difficult to measure in environmental water samples because of variability in redox-active species being measured by the sensor. ORP measurements can usually only give a general idea of the presence of redox active species in a given sample. Generally, as more reducing conditions develop in the aquifer, ORP values will tend to decline[19]. Median ORP values decline from greater than 77 millivolts (mV) in Aquifer 2 to 38.4 mV and 35.7 mV in Aquifer 3a and Aquifer 3, respectively, indicating a less oxidizing state in Aquifer 3a and 3. These median values are tabulated in Table 5-4.

DO measurements can vary with temperature and barometric pressure. DO data from the S-well and I-well area wells generally indicate dissolved oxygen levels decrease with depth from Aquifer 2a or Aquifer 2 to Aquifer 3a and Aquifer 3.

#### 5.4.2.2 Nitrate

Nitrate is readily oxidized under mildly reducing conditions. Consequently, the presence of nitrate is an indicator of an aerobic aquifer, and is often associated with near-surface recharge that contains nitrate. Of the wells samples in 2019, nitrate is detected occasionally (but at low concentrations, less than 2 mg/L) in Aquifer 2a and 2, and not detected in Aquifers 3a and 3 (Table 5-4).

[19] The accuracy of ORP readings is +/- 20 millivolts (mV) in a standard solution, but the accuracy is often much less in environmental samples. For this reason caution should be used in interpreting ORP values.

#### 5.4.2.3 Ferrous Iron

The presence of dissolved ferrous iron is an indicator of mild to moderately reducing groundwater conditions. Consistent with previous MNA sampling data sets, the 2019 data typically demonstrates an increase in ferrous iron concentrations with aquifer depth.

#### 5.4.2.4 Sulfate

As groundwater moves along a flow path it tends to evolve geochemically as progressively more mineral solids dissolve into the water (Freeze and Cherry 1979). Consistent with the 2017 annual report findings, this evolution is apparent at the QCF Site in the progressive increase in sulfate concentrations coinciding with aquifer depth. Median sulfate values increase from 5 mg/L in Aquifer 2a to 7.1 mg/L Aquifer 2 to 8.6 mg/L and 16.7 mg/L in Aquifer 3a and Aquifer 3, respectively. Increasing sulfate values also indicate that aquifer conditions are generally not sufficiently reducing to reduce the accumulated sulfate, hence the increasing concentrations with depth.

#### 5.4.2.5 Methane

Evidence of methanogenesis, an indicator of a highly reducing redox state, is limited at the Site, which is consistent with minimal presence of VC. However, 2019 MNA data included detections of methane at one or more wells in each aquifer. Methane was detected at one of three Aquifer 2a wells at a concentration of 180 mg/L (well I-2a). Methane was detected at three of nine Aquifer 2 wells, with low concentrations between 5 and 150 ug/L. Methane was detected at three of four Aquifer 3a wells with concentrations between 24 mg/L (SD-3a) and 150 mg/L (IA-3a). Low-level methane was detected at one of three Aquifer 3 wells at a concentration of 13 mg/L (well IA-3).

# 6.0 DISCUSSION AND RECOMMENDATIONS

This section provides a discussion on Site groundwater quality conditions and the Site remedy, and provides recommendations for Site activities in 2020.

## 6.1 Discussion

The discussion is organized by aquifer and includes an evaluation of RAOs with respect to the Site remedy.

### 6.1.1 Aquifer 2a

TCE in Aquifer 2a occurs as a relatively large, low concentration plume over the northern portion of QCF and the southern portion of CHRL (Figure 5-5). VOC concentrations outside the CPOC meet minimum performance standards in all Aquifer 2a monitoring wells except for TCE at well V-2a north of the CPOC (maximum of 19 µg/L in 2019), and at well MW-76 north of the QCF property boundary on CHRL (maximum of 7.89 µg/L in 2019). Well V-2a is located within the wetland north of Queen City Lake. Since its construction, well V-2a trends show significant seasonal variability in TCE concentrations, with seasonal high concentrations in fall and seasonal low concentrations in spring. Since fall 2014, seasonal max TCE concentrations at V-2a have been greater than or equal to 20 ug/L (higher than previously observed); however, a decreasing trend is currently observed in maximum concentrations.

In the core of the plume within the CPOC, TCE at wells C-2a and E-2a have generally been declining over the long-term. TCE concentration trends at Aquifer 2a wells C-2a, E-2a, and V-2a are presented on Figure 6-1. TCE concentration trends at downgradient Aquifer 2a wells on CHRL are declining, and only MW-76 has concentrations exceeding the minimum performance standard for TCE. Time series TCE concentrations trends at Aquifer 2a CHRL wells MW-76, MW-78, MW-82, MW-83, and MW-94 are presented on Figure 6-2.

Historically concentrations of cDCE have demonstrated a steeper decline than TCE in Aquifer 2a at individual wells. Consequently, cDCE has nearly disappeared from Aquifer 2a. Low concentrations are documented only at well MW-76 (maximum of 0.3 µg/L in 2019). The steeper decline in cDCE relative to TCE concentrations may reflect a number of factors including a different source history, changing redox conditions over time and cDCE's lower distribution coefficient, which results in cDCE flushing more quickly with groundwater. No wells at the Site exceed the minimum performance standard for cDCE.

### 6.1.2 Aquifer 2

Overall, the Aquifer 2 TCE plume is less widespread than the Aquifer 2a plume, but concentrations tend to be higher[20]. The Aquifer 2 TCE plume is bifurcated into a northern and a southern plume

[20] The 2017 annual report further describes this phenomenon and attributes the more widespread, but lower concentration distribution of TCE in Aquifer 2a to the more permeable nature of the aquifer (especially the Unit E portion), higher rates of flushing and dilution associated with MGPL, and lack of degradation.

(Figure 5-6). The bifurcation of the plume is attributed to flushing and groundwater gradients associated with recharge from MGPL. In the northern portion of the plume in the vicinity of the FCC, TCE concentrations continue to slowly decline at most wells. Time series TCE concentrations at select northern Aquifer 2 wells B-2, C-2, E-2, F-2, G-2 and L-2 are presented on Figure 6-3.

In the southern portion of the plume, TCE concentrations are variable in part due to infiltration from MGPL and varying responses to pumping from the GETS. Time series TCE concentration trends at select southern Aquifer 2 wells (i.e. I-2, S-2 and SC-2) are presented on Figure 6-4. In general, GETS pumping has resulted in contraction of the TCE plume near the western end of the extraction well transect in the S-Well area, and has resulted in some expansion of the TCE plume from the CPOC (near well I-2) westward toward the extraction well transect. Following startup of the GETS, TCE is no longer detected at S-2 near the west end of the extraction well transect.

The GETS MPS implemented in 2019 is intended (in part) to prevent further expansion of the TCE plume from the I-Well area while continuing to make progress on contracting the Western Lobe of the plume in this area. Initial data indicate that the MPS has reduced the influence of the GETS in the vicinity of I-2. A second objective of the MPS was to increase overall efficiency of the GETS. Data indicate the overall efficiency has increased significantly, though not as much as projected in the predictive model.

### 6.1.3 Aquifer 3a

In Aquifer 3a, TCE concentrations are localized to three wells (IA-3a, I-3a, and M-3a) in the southern portion of the Site. Locations IA-3a and I-3a are within the CPOC and concentrations are above the minimum performance standard for TCE. Location MA-3a also has TCE concentrations above the minimum performance standard and is located southeast of the CPOC. Well I-3a had a declining trend until 2015, when concentrations began to slowly increase. The shift in trend is possibly due to hydraulic continuity between Aquifer 2 and Aquifer 3a. Shifts in groundwater flow paths related to the GETS operation may influence contaminant transport from Aquifer 2 to Aquifer 3a upgradient of MA-3a and thus affect TCE concentrations at this well.  TCE concentrations at well MA-3a initially demonstrated an increasing trend, but concentrations appear to have stabilized around 25 ug/L. TCE trends at IA-3a appear to show a decreasing trend since 2017. Time series TCE concentration trends at Aquifer 3a wells IA-3a, I-3a, and M-3a are presented on Figure 6-5.

### 6.1.4 Aquifer 3

cDCE is widely distributed in Aquifer 3 (Figure 5-11), while TCE is only detected at a single well (IA-3). The relatively strong reducing conditions in Aquifer 3 (LAI 2018a) and the relatively widespread presence of cDCE indicate that the MNA remedy is effective in this portion of the aquifer system. TCE concentration trends at well IA-3 were somewhat variable, but generally stable, until 2015 and, since then, have been steadily increasing. It is unclear whether startup of the GETS has had an influence on VOC concentrations at this well. Time series VOC concentration trends at well IA-3 are presented in Figure E-69.

### 6.1.5 Remedial Action Objectives

Site RAOs including preventing migration of the Site VOC plume and preventing exposure to contaminated groundwater have been attained, and MNA supplemented by the GETS is acting to restore groundwater for future use. MNA processes reduce VOC concentrations throughout Aquifers 2a, 2, 3a, and 3 at QCF through flushing (i.e. dilution) and degradation by reductive dechlorination (LAI 2018a), and long-term VOC concentration trends show a declining trend in most locations, consistent with a gradually attenuating plume. A visual representation of remedy performance in Aquifer 2 is presented on Figure 6-6 in terms of the 25 µg/L TCE concentration contour for years 1999, 2009, and 2019. This figure demonstrates shrinking of the high-concentration core of the plume in Aquifer 2 over time, from the southern portion of the Site to the FCC/Queen City Lake area.

While the GETS has been effective at achieving its RAOs (i.e. containment, size reduction, and cleanup acceleration of S-wells area Aquifer 2 TCE plume), it has a limited capacity to aide in attainment of the long-term RAO of groundwater restoration across the Site. GETS influent TCE concentrations remain low (less than 5 µg/L) and fairly stable from startup to present (including consideration of the 2017 optimization and 2019 MPS). The GETS pumping has resulted in bifurcation of the TCE plume in the S-wells area into an eastern and western lobe. The GETS has contained the S-wells area plume from expanding to the southwest, reduced the size, and has locally accelerated cleanup. Although data results are limited, it appears the MPS has successfully reduced the GETS influence on migrating TCE from the CPOC towards the GETS, which should cause the eastern lobe to shrink over time. Furthermore, the GETS TCE removal efficiency has increased since the MPS.

## 6.2 Recommendations

Performance monitoring for MNA and the GETS should continue through 2020 in accordance with the updated groundwater monitoring plan (LAI 2018b) and GETS evaluation (LAI 2019b). Under the MPS, the GETS should continue to operate as-is for at least one full year (through March 2020) to allow for evaluation of performance and comparison of concentration and water level data. The MPS was implemented in April 2019, and performance monitoring occurs during semi-annual monitoring events (September and March) in addition to daily readings from the PLC system and hourly water level readings from data loggers. Following the March sampling event, it may be beneficial to further reduce the pumping rate at EW-5 and evaluate whether the system efficiency can be further improved. The GETS MPS should continue through at least fall 2020, and the next GETS performance evaluation will be included in the 2020 annual report. Boeing will continue to operate the data loggers at least through the fall 2020 semi-annual sampling event and, depending on the data trends, may opt to remove data loggers due to sufficient data collection.

Boeing is recommending removal of MW-57, MW-58a, and MW-60 from the QCF groundwater monitoring program. These wells were historically monitored by King County; however, they ceased monitoring at these locations between 2013 and 2015. Boeing has been unable to come to agreement with King County on reinstating the monitoring program. Additionally these wells historically did not have detections of VOCs. Boeing is requesting EPA's concurrence to remove the wells from the QCF monitoring program.

# 7.0 USE OF THIS REPORT

This annual data monitoring report has been prepared for the exclusive use of The Boeing Company and U.S. Environmental Protection Agency for specific application to the Queen City Farms Superfund Site. No other party is entitled to rely on the information, conclusions, and recommendations included in this document without the express written consent of LAI. Further, the reuse of information, conclusions, and recommendations provided herein for extensions of the project or for any other project, without review and authorization by LAI, shall be at the user's sole risk. LAI warrants that within the limitations of scope, schedule, and budget, our services have been provided in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions as this project. LAI makes no other warranty, either express or implied.

# 8.0 REFERENCES


Brown, Richard A., John T. Wilson, and Mark Ferrey. 2007. *Monitored Natural Attenuation Forum: The Case for Abiotic MNA*. Remediation Journal 17 (2):127-137. doi: 10.1002/rem.20128.

EcoChem and LAI. 2015. Quality Assurance Project Plan, Groundwater Monitoring and Groundwater Extraction and Treatment System Performance Monitoring, Queen City Farms Superfund Site, Maple Valley, King County, Washington. Edmonds, WA: EcoChem, Inc. and Landau Associates, Inc.

Ecology. 2016. Guidance for Evaluating Soil Vapor Intrusion in Washington State: Investigation and Remedial Action. Olympia, WA: Washington State Department of Ecology.

EPA. 1992. Record of Decision Declaration, Decision Summary, and Responsiveness Summary for Final Remedial Action, Queen City Farms Superfund Site, Maple Valley, King County, Washington. US Environmental Protection Agency, Region 10.

EPA. 1994. United States' Motion to Enter Consent Decree and Order; USA v. The Boeing Company. Edited by US Environmental Protection Agency.

EPA. 1998. Five-Year Review for Queen City Farms NPL Site. Edited by Neil E. Thompson: US Environmental Protection Agency, Region 10.

EPA. 2003. Second Five-Year Review for Queen City Farms Superfund Site, Maple Valley, King County, Washington. US Environmental Protection Agency, Region 10.

EPA. 2008a. Queen City Farms Superfund Site Contingent Ground Water Extraction and Treatment, Maple Valley, Washington, Civil Action No. C94-746WD. edited by Chris Bellovary.

EPA. 2008b. Third Five-Year Review Report for Queen City Farms Superfund Site, City of Maple Valley, King County, Washington. US Environmental Protection Agency, Region 10.

EPA. 2014. Approval of Change in Laboratory for Queen City Farms Superfund Site. Edited by Jeremy Jennings.

EPA. 2018a. Letter: 2017 Annual Report, Queen City Farms Superfund Site, Maple Valley, Washington: March 29, 2018. From Jeremy Jennings, Remedial Project Manager, Office of Environmental Cleanup, U.S. Environmental Protection Agency, to Joseph L.  Flaherty, EHS Remediation Group, The Boeing Company. December 7.

EPA. 2018b. Fifth Five Year Review Report for Queen City Farms Superfund Site, Maple Valley, King County, Washington. U.S. Environmental Protection Agency, Region 10. September 17.

EPA. 2019. EPA Comments; GETS Performance Assessment and Recommendations, Queen City Farms Superfund Site, Maple Valley, Washington; January 16, 2019. Edited by Jeremy Jennings: Remedial Project Manager, Office of Environmental Cleanup.

EPA. 2020. Email: Request for Deletion Petition – Institutional Controls. From Jeremy Jennings, U.S. Environmental Protection Agency, to Eric Weber, Landau Associates, Inc. and Steve Banchero, Queen City Farms, Inc. January 14.

Freeze, R.A., and J.A. Cherry. 1979. Groundwater. Englewood Cliffs, NJ: Prentice-Hall, Inc.

Kennedy/Jenks. 1998. Report: Vertical Barrier Wall Design Project Closure, Queen City Farms Superfund Site, Maple valley, Washington. Kennedy Jenks. January 1998.

King County. 2018. Solid Waste Division Documents, Cedar Hills Regional Landfill - Annual Report & Environmental Monitoring Reports. https://your.kingcounty.gov/solidwaste/facilities/documents.asp.

King County. 2019. Cedar Hills Regional Landfill 2020 Site Development Plan. King County, Washington. https://kingcounty.gov/depts/dnrp/solid-waste/facilities/landfills/cedar-hills-development.aspx.

King County. 2020. Cedar Hills Regional Landfill Quarterly Environmental Monitoring Report, Fourth Quarter 2019. King County Department of Natural Resources and Parks Solid Waste Division. King County, Washington. February.

King Groundwater Science. 2000. Performance Evaluation of Remedial Action, Queen City Farms, King County, Washington.

LAI. 1990. Remedial Investigation Report, Queen City Farms, King County, Washington, Volume 1 of 2. Edmonds, WA: Landau Associates, Inc.

LAI. 1992. Supplemental Remedial Investigation Report, Queen City Farms, King County, Washington Volume I of II. Landau Associates, Inc.

LAI. 2011. 2010 Expanded Hydrology Assessment, Queen City Farms, King County, Washington. Tacoma, WA: Landau Associates, Inc.

LAI. 2013a. 2011 Annual Groundwater Monitoring Data Report, Queen City Farms, Maple Valley, Washington. Tacoma, WA: Landau Associates, Inc.

LAI. 2013b. 2012 Annual Groundwater Monitoring Data Report, Queen City Farms, King County, Washington. Tacoma, WA: Landau Associates, Inc.

LAI. 2013c. Final Evaluation of Remediation Technologies, Queen City Farms, Maple Valley, Washington. Edited by Toni Smith and Eric Weber. Tacoma, WA: Landau Associates, Inc.

LAI. 2013d. Offsite Well Evaluation Report, Queen City Farms, Maple Valley, Washington. Edited by Toni Smith and Eric Weber: Landau Associates, Inc.

LAI. 2014a. 2013 Annual Groundwater Monitoring Data Report, Queen City Farms Superfund Site, King County, Washington. Tacoma, WA: Landau Associates, Inc.

LAI. 2014b. Field Sampling Plan, Queen City Farms Superfund Site, King County, Washington. Landau Associates, Inc.

LAI. 2015a. 2014 Annual Groundwater Monitoring Data Report, Queen City Farms, King County, Washington. Tacoma, WA: Landau Associates, Inc.

LAI. 2015b. 2014 Annual Report, Western Processing, Kent, Washington. Edmonds, WA: Landau Associates, Inc.

LAI. 2015c. Operation and Maintenance Manual, Groundwater Extraction and Treatment System, Queen City Farms, Maple Valley, Washington. Tacoma, WA: Landau Associates, Inc.

LAI. 2015d. Vapor Intrusion Assessment, Queen City Farms Superfund Site, King County, Washington. Tacoma, WA: Landau Associates, Inc.

LAI. 2016a. 2015 Annual Data Report, Queen City Farms, Maple Valley, Washington. Tacoma, WA: Landau Associates, Inc.

LAI. 2016b. Groundwater Extraction and Treatment System Interim Reporting, Queen City Farms, Maple Valley, Washington. Edited by LHG and Eric Weber Toni Smith, LHG. Tacoma, WA: Landau Associates, Inc.

LAI. 2016c. Groundwater Extraction and Treatment System Performance Monitoring Report, Queen City Farms, Maple Valley, Washington. Tacoma, WA: Landau Associates, Inc.

LAI. 2017a. 2016 Annual Monitoring Data Report, Queen City Farms, Maple Valley, Washington. Landau Associates, Inc.

LAI. 2017b. GETS Optimization Work Plan, Queen City Farms, Maple Valley, Washington. Landau Associates, Inc.

LAI. 2018a. 2017 Annual Monitoring Data Report, Queen City Farms, Maple Valley, Washington. Landau Associates, Inc.

LAI. 2018b. Groundwater Monitoring Plan Update, Queen City Farms, Maple Valley, Washington. Landau Associates, Inc.

LAI. 2019a. GETS Modified Pumping Performance Monitoring Technical Memorandum, Boeing Queen City Farms, Boeing Queen City Farms, Maple Valley, Washington. Landau Associates, Inc., Tacoma, Washington. September 19. .

LAI. 2019b. GETS Performance Assessment and Recommendations, Queen City Farms, Maple Valley, Washington. Landau Associates, Inc.

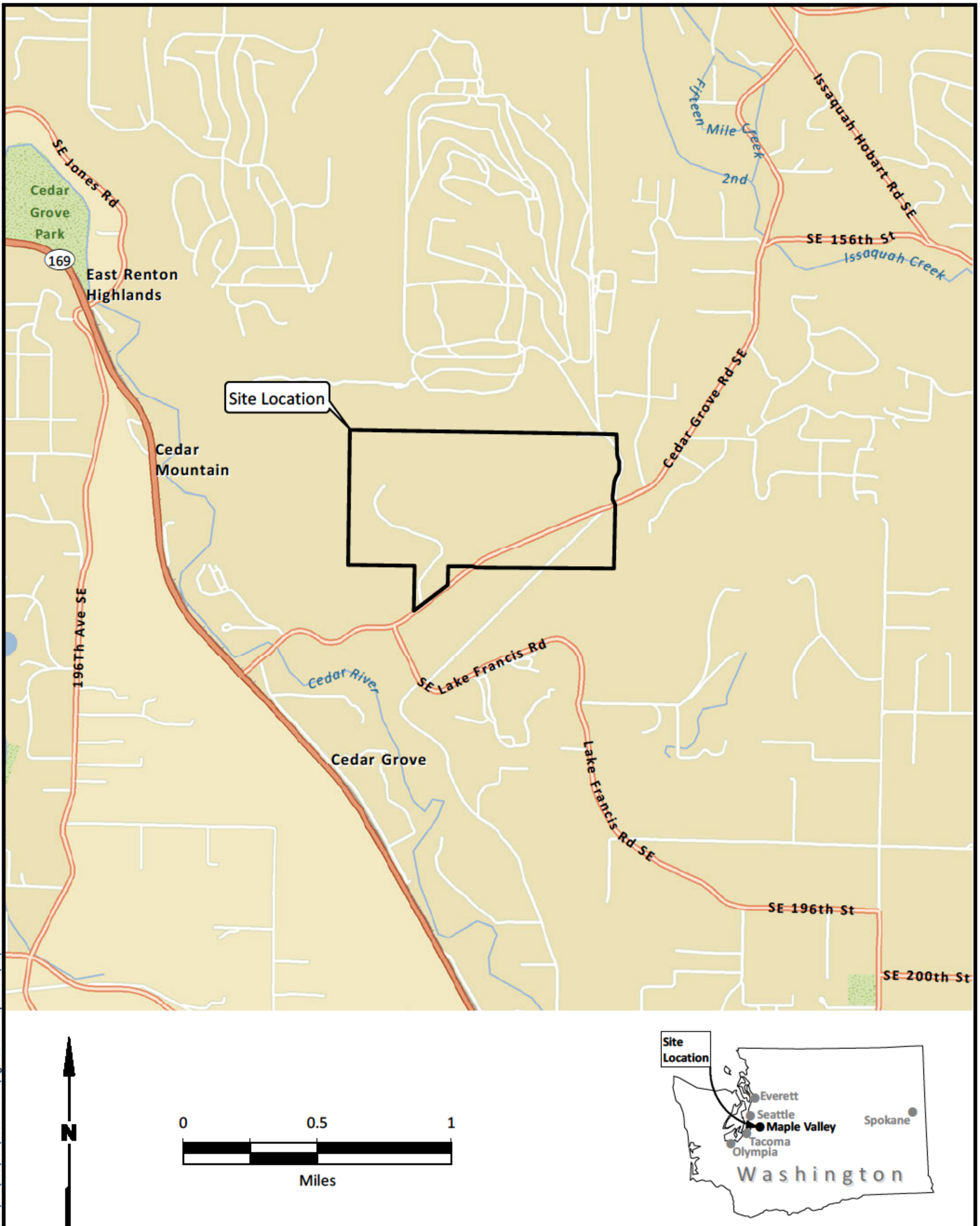
LAI. 2019c. Report, 2018 Annual Monitoring Data Report for QCF. Prepared for The Boeing Company. Landau Associates, Inc., June 13.

Luzier, JE. 1969. "Geology and Groundwater Resources of Southwestern King County, Washington." US Geological Survey (Bulletin No. 28).

Mullineaux, D.R. 1970. "Geology in Renton, Auburn, and Black Diamond Quadrangles, King County, Washington."  US Geological Survey (Professional Paper 672).

Pope, D., S. Acree, H.Levine, S. Mangion, J. Van Ee, K. Hurt, and B. Wilson. 2004. Performance Monitoring of MNA Remedies for VOCs in Ground Water. US Environmental Protection Agency.

Wilson, John T. 2011. An Approach for Evaluating the Progress of Natural Attenuation in Groundwater. Edited by National Risk Management Research Laboratory Office of Research and Development. Ada, OK: US Environmental Protection Agency.




Data Source: Esri 2012

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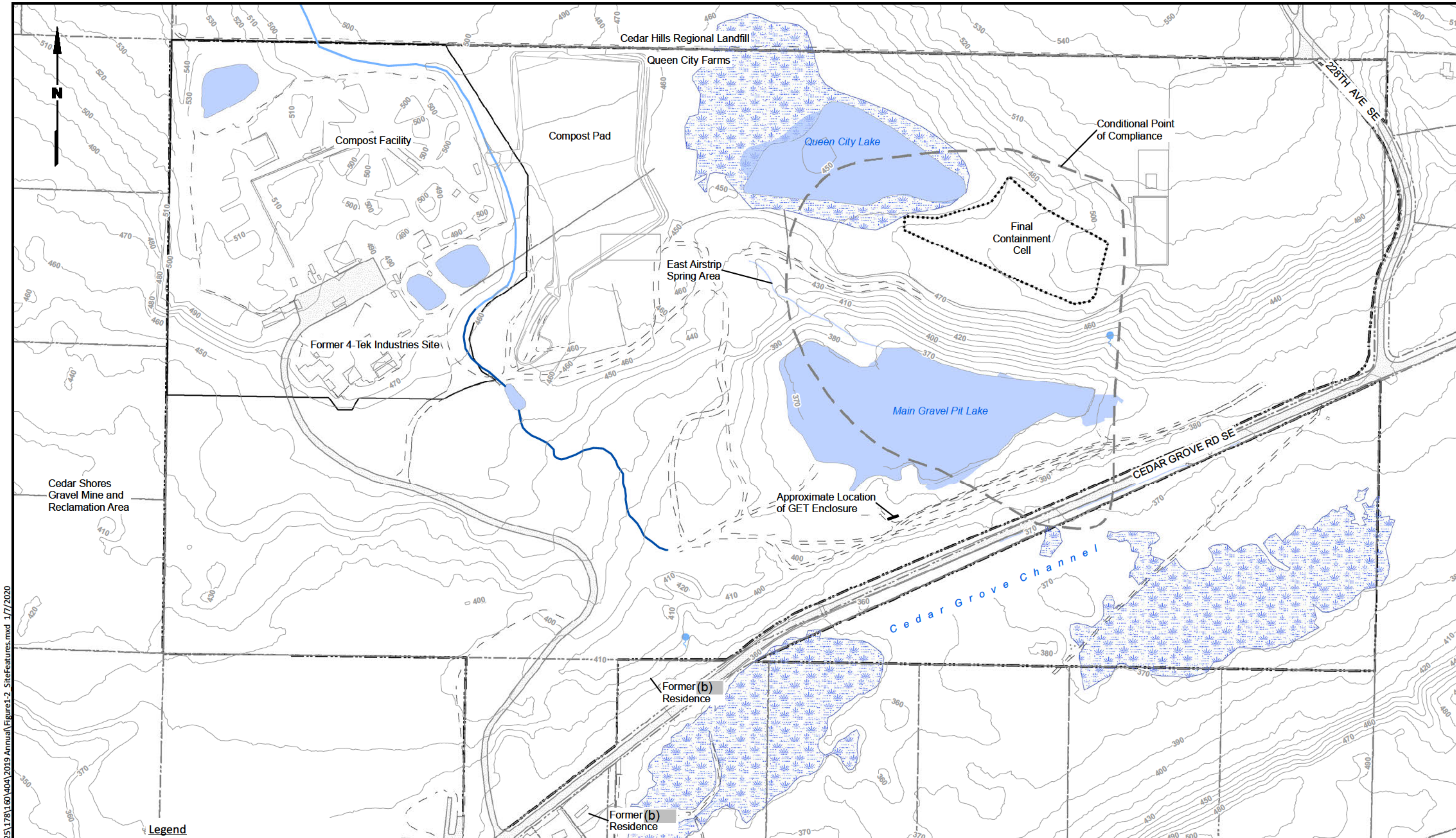
| Queen City Farms<br>Maple Valley, Washington | Vicinity Map | Figure<br>1-1 |
|---|---|---|




**Legend**

- Spring
- Wetland
- Lake or Pond
- Tributary 316A
- Engineered Drainage Channel
- Tax Parcel
- Property Boundary

**Notes**

1. Topographic contour interval is 10 ft. All elevations referenced to NGVD29.
2. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

0 400 800
Scale in Feet

Data Sources: Barghausen 2007; King County GIS 2015.

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Queen City Farms
Maple Valley, Washington

**Site Features**

Figure 1-2

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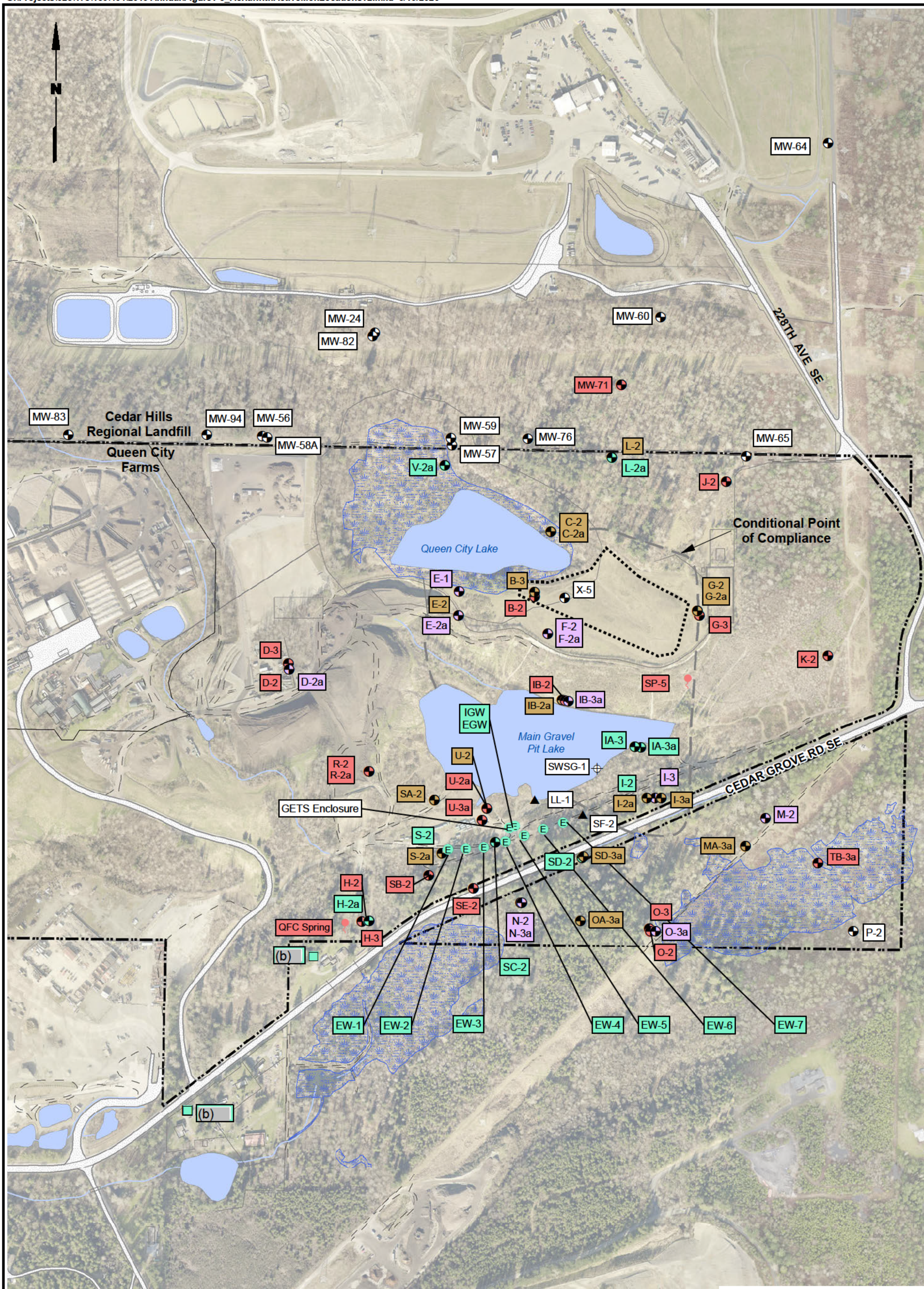


**Legend**

- Well Location
- Offsite Domestic Supply Well
- Piezometer Locations
- Staff Gauge
- Extraction Well Location
- Springs
- Wetland
- Lake or Pond
- Property Boundary
- Final Containment Cell

**Sampling Frequency**

- Semiannually
- Annually
- Biennial
- Quintennial

0 500 1,000

Scale in Feet

**Notes**

1. Cedar Hills Regional Landfill wells are not sampled as part of the Queen City Farms Field Sampling Plan with the exception of MW-71.
2. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

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| Queen City Farms<br>Maple Valley, Washington | Active Monitoring Locations | Figure<br>1-3 |
|---|---|---|

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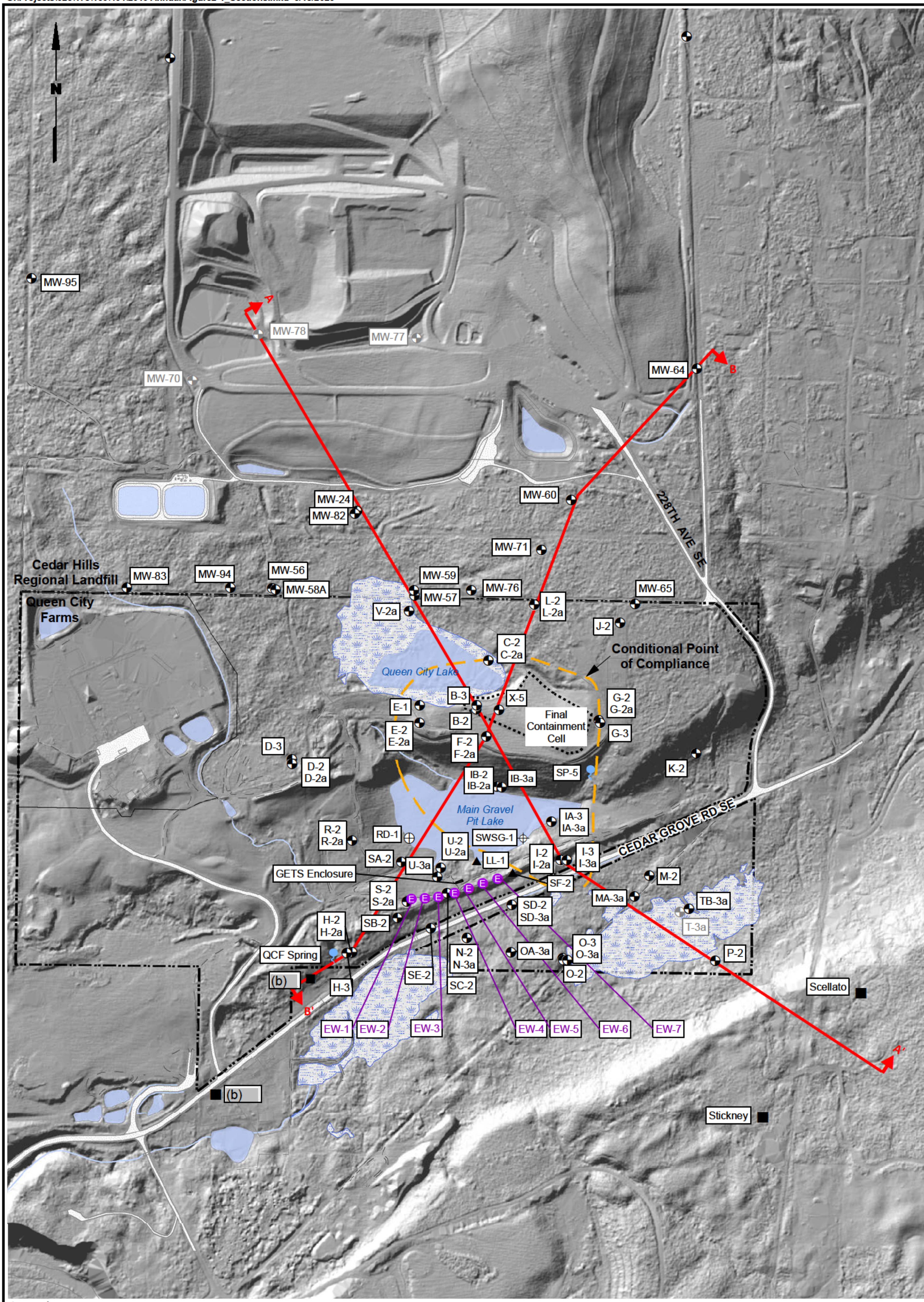


**Legend**

- Well Location
- Abandoned Well Location
- Offsite Domestic Supply Well
- Boring Location
- Piezometer Locations
- Staff Gauge
- Extraction Well Location
- Springs
- Wetland
- Lake or Pond
- Property Boundary
- Final Containment Cell
- Cross Section Location

0 600 1,200

Scale in Feet

**Notes**

1. Topographic contour interval is 10 ft. All elevations referenced to NGVD29.
2. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

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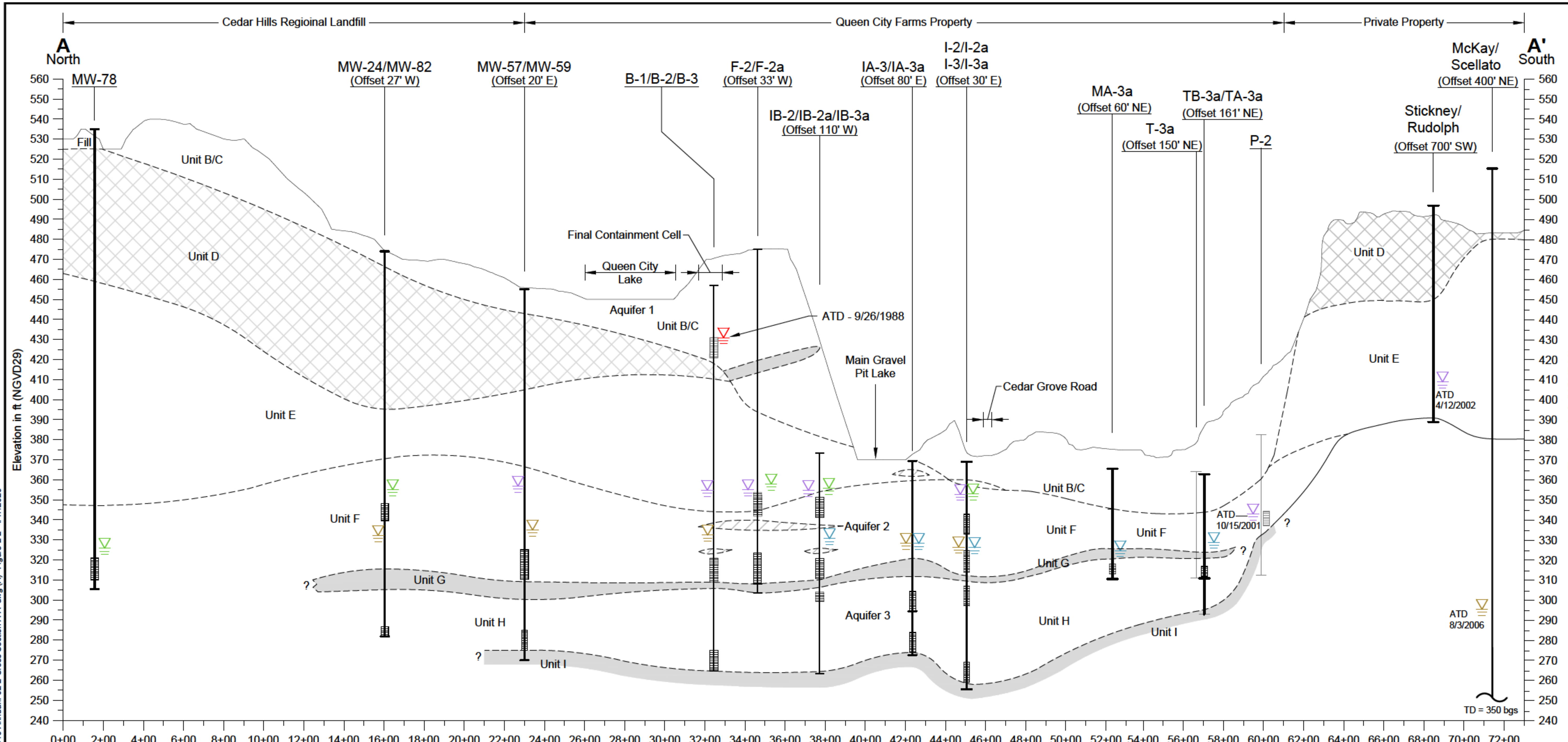
| Queen City Farms<br>Maple Valley, Washington | **Cross Section Location Map** | Figure<br>2-1 |
|---|---|---|






MW-1 – Exploration Designation
(Offset 10' W) Offset Distance in Feet and Direction

Till

Silty or Clayey Layer

Minor Silt Layer

Unit C Geologic Unit Name

— Top of Exploration

— Aquifer 1 Groundwater Level (ft, MSL)

— Aquifer 2a Groundwater Level (ft, MSL)

— Aquifer 2 Groundwater Level (ft, MSL)

— Aquifer 3a Groundwater Level (ft, MSL)

— Aquifer 3 Groundwater Level (ft, MSL)

— Inferred Geologic Contact

— Well Screen Interval

— Bottom of Exploration

## Geologic Unit Descriptions:

Unit B: Poorly to well-sorted CLAY, SILT, SAND, and GRAVEL (ice contact deposit; locally water bearing within First Aquifer)

Unit C: Stratified, poorly to well-sorted SAND and GRAVEL with occasional interbedded clayey SILT and "Flow Till" (recessional outwash and deltaic deposits; locally water bearing within First Aquifer)

Unit D: Unsorted CLAY, SILT, SAND and GRAVEL (till, Till Aquitard)

Unit E: Stratified poorly to well-sorted SAND and GRAVEL with occasional silty GRAVEL interbeds (advance outwash; locally water bearing within Second Aquifer)

Unit F: Well-sorted silty fine SAND to medium SAND with occasional clayey SAND to silty CLAY interbeds (upper section is dark red-brown to orange-brown color; water bearing within Second Aquifer)

Unit G: SILT, clayey SILT, fine sandy SILT, and silty fine SAND (Second Aquifer)

Unit H: Well-sorted very fine to medium SAND with sandy GRAVEL and gravelly SAND interbeds (occasional wood fragments; water bearing within Third Aquifer)

Unit I: SILT and fine sandy SILT (containing abundant wood fragments) to gravelly SILT with occasional SAND and sandy GRAVEL interbed (Woody Aquitard)

0 500 1000

Horizontal Scale 1" = 500'
Vertical Scale 1" = 50'

## Notes

1. QCF groundwater elevations measured in September 2014 unless otherwise noted. CHRL values collected in July 2014. "ATD" indicates water level observed at time of drilling.
2. Information for off-site private wells obtained from Department of Ecology's Well Log Viewer.
3. Topographic Contour Source: Barghausen 2007 (NGVD29).
4. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

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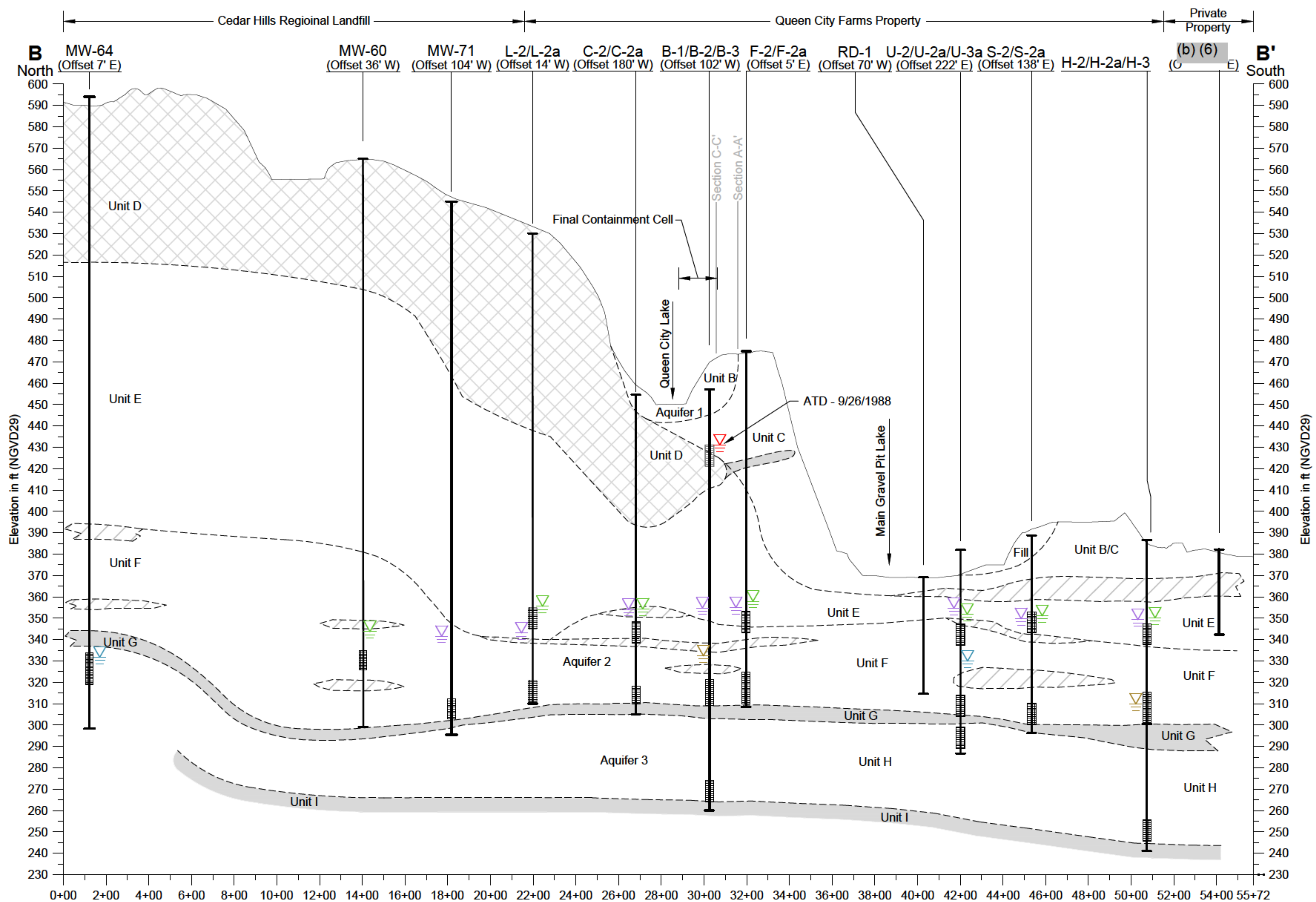
Queen City Farms
Maple Valley, Washington

**Geologic Cross Section A-A'**

Figure
2-2




## Legend

MW-1 – Exploration Designation
(Offset 10' W) – Offset Distance in Feet and Direction

- Top of Exploration
- Aquifer 1 Groundwater Level (ft, MSL)
- Aquifer 2a Groundwater Level (ft, MSL)
- Aquifer 2 Groundwater Level (ft, MSL)
- Aquifer 3a Groundwater Level (ft, MSL)
- Aquifer 3 Groundwater Level (ft, MSL)
- Inferred Geologic Contact
- Well Screen Interval
- Bottom of Exploration
- Till
- Silty or Clayey Layer
- Minor Silt Layer
- Unit C – Geologic Unit Name

## Notes

1. QCF groundwater elevations collected in September 2014; CHRL values collected in July 2014 unless otherwise noted.
2. Topographic Contour Source: Barghausen 2007 (NGVD29).
3. Geologic units are described on Figure 2-2.
4. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Landau Associates | G:\Projects\025\178\160\404\2019 Annual\F02-3 Cross Section B-B'.dwg (A) "Figure 2-3" 4/17/2020

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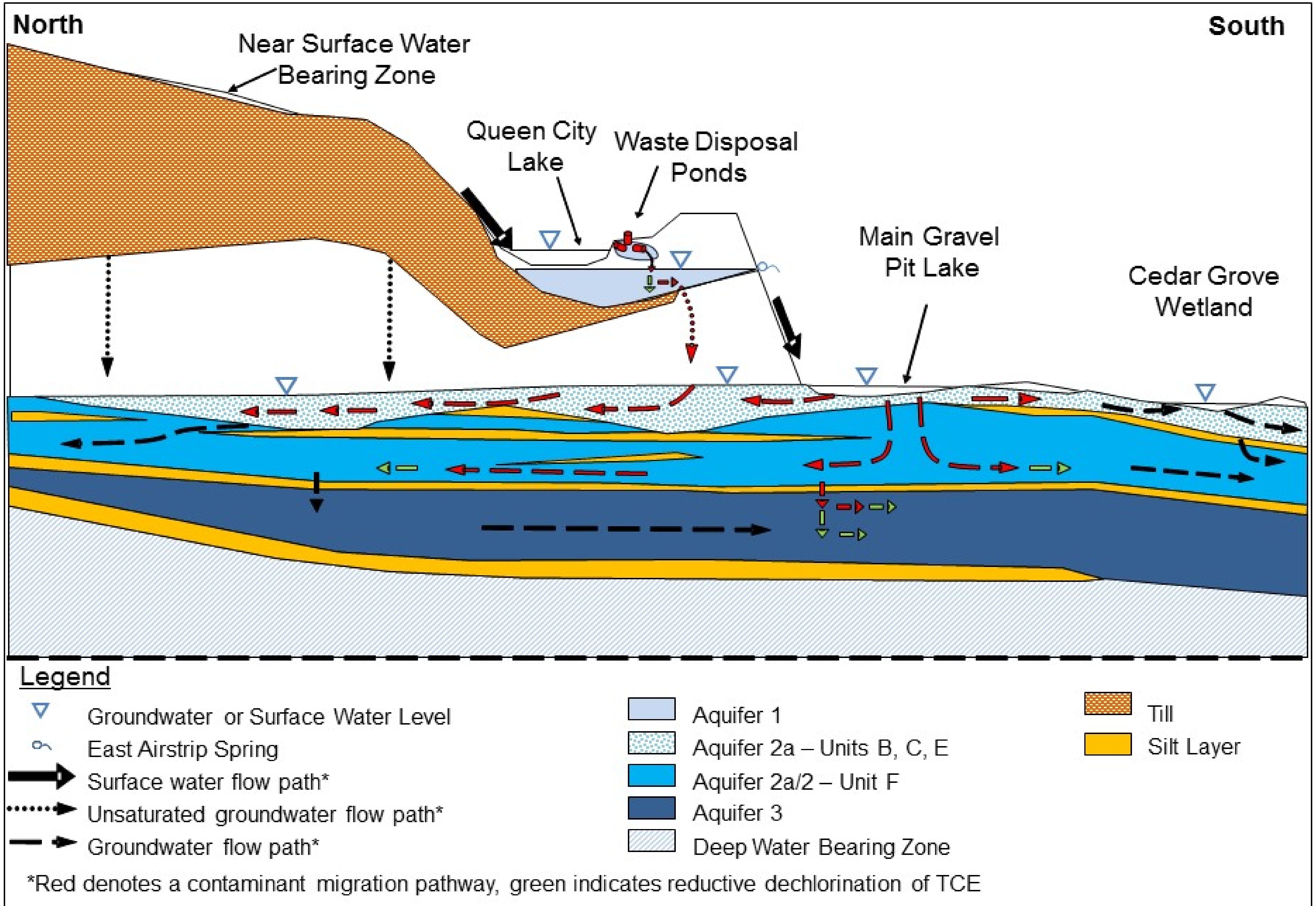
0 500 1000
Horizontal Scale 1" = 500'
Vertical Scale 1" = 50'

Queen City Farms
Maple Valley, Washington

**Geologic Cross Section B-B'**

Figure
2-3

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Queen City Farms
Maple Valley, Washington

**Conceptual Site Model**

Figure
2-4

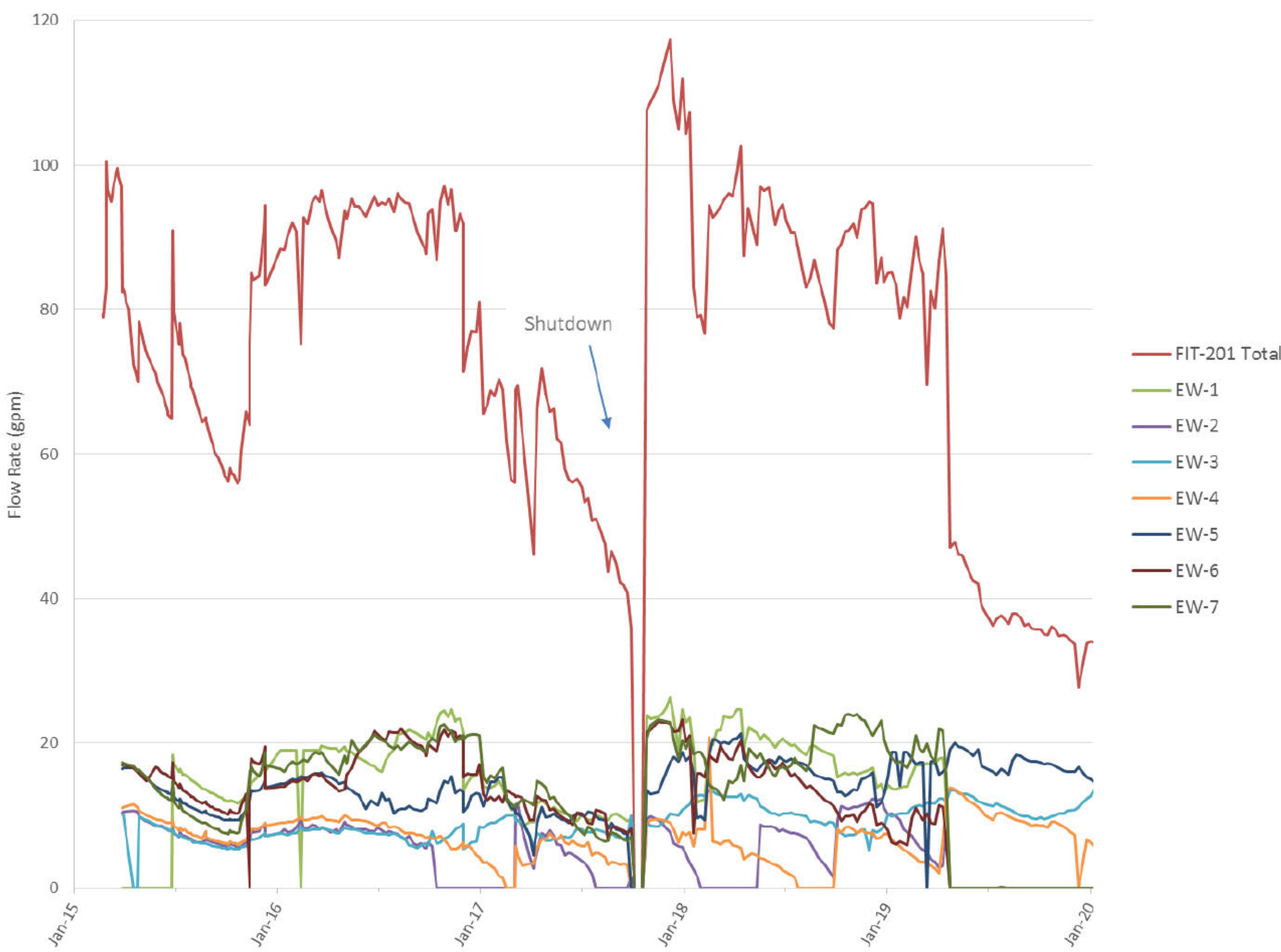


**Figure 3-1A:** Historical GETS System Flow Rates

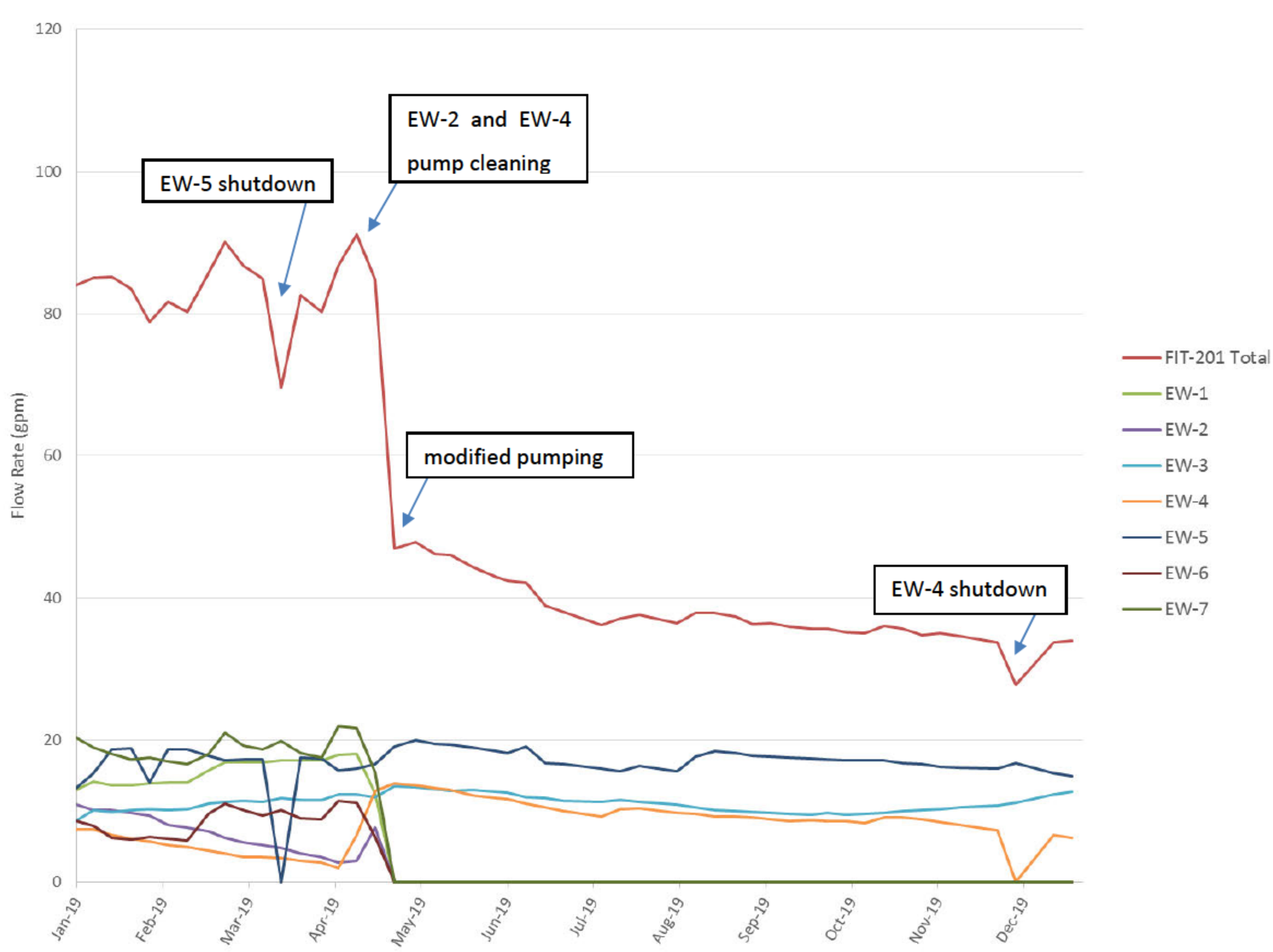


**Figure 3-1B:** 2019 GETS System Flow Rates

Note: Flow rate data from GETS programmable logic controller (PLC).

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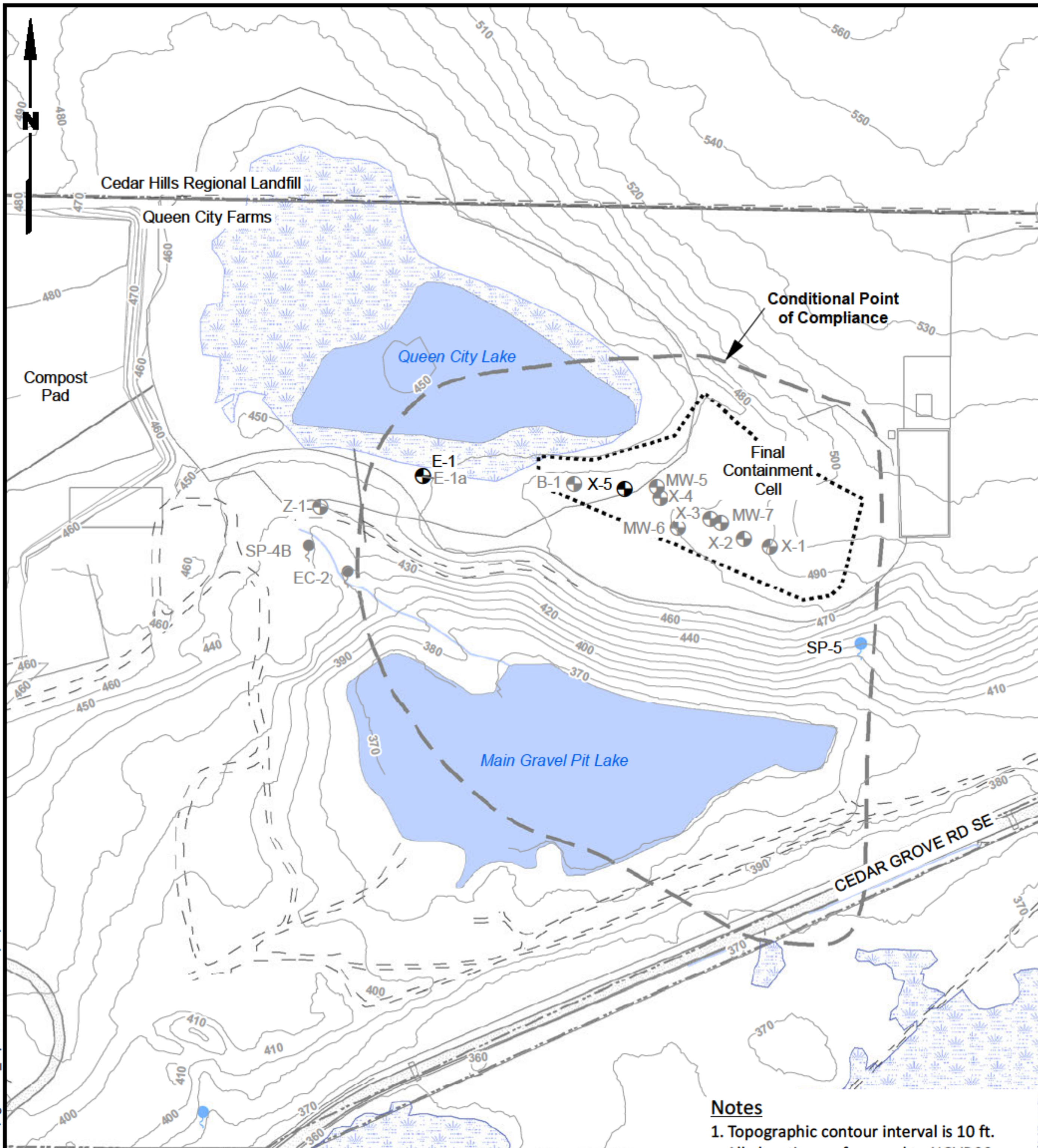
| | | |
|---|---|---|
| Queen City Farms<br>Maple Valley, WA | **GETS Total System Flow Rate and Extraction Well Pumping Rates** | Figure<br>**3-1** |




## Legend

| | | | |
|---|---|---|---|
| E-1 | Monitoring Well Location | | Final Containment Cell |
| MW-6 | Monitoring Well Location (Abandoned) | | Wetland |
| SP-5 | Surface Water Sampling Location | | Lake |
| EC-2 | Surface Water Sampling Location Not Currently Sampled | | |

## Notes

1. Topographic contour interval is 10 ft. All elevations referenced to NGVD29.
2. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

0 400 800

Scale in Feet

Data Sources: Barghausen 2007; King County 2015.

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Maple Valley, Washington

**Aquifer 1 Monitoring Locations**

Figure 4-1

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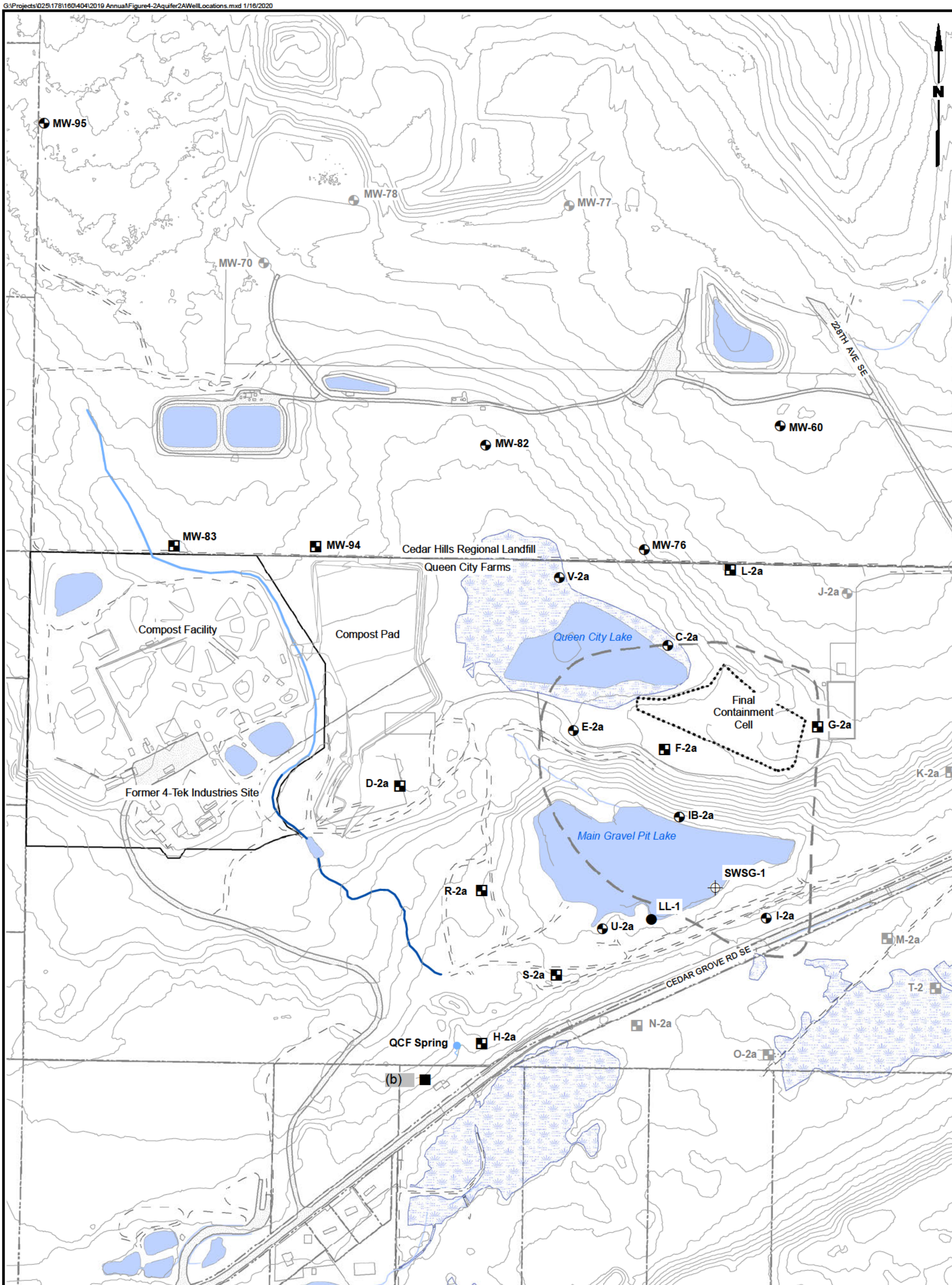



Legend

| | | |
|---|---|---|
| I-2a | | Monitoring Well Location Screened within Unit F |
| H-2a | | Monitoring Well Location Screened Above Unit F |
| J-2a | | Abandoned Well Screened within Unit F |
| N-2a | | Abandoned Well Screened Above Unit F |
| | | Domestic Supply Well Used for Monitoring |
| LL-1 | | Lake Level Monitoring Station |
| SWSG-1 | | Staff Gauge |

Springs
Final Containment Cell
Tributary 316A
Engineered Drainage Channel
Conditional Point of Compliance

Wetland
Lake
Tax Parcel

Notes
1. Cedar Hills Regional Landfill wells are not sampled as part of the Queen City Farms Field Sampling Plan.
2. Topographic contour interval is 10 ft. All elevations referenced to NGVD29.
3. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Data Sources: Barghausen 2007; King County 2012.

0 500 1,000
Scale in Feet

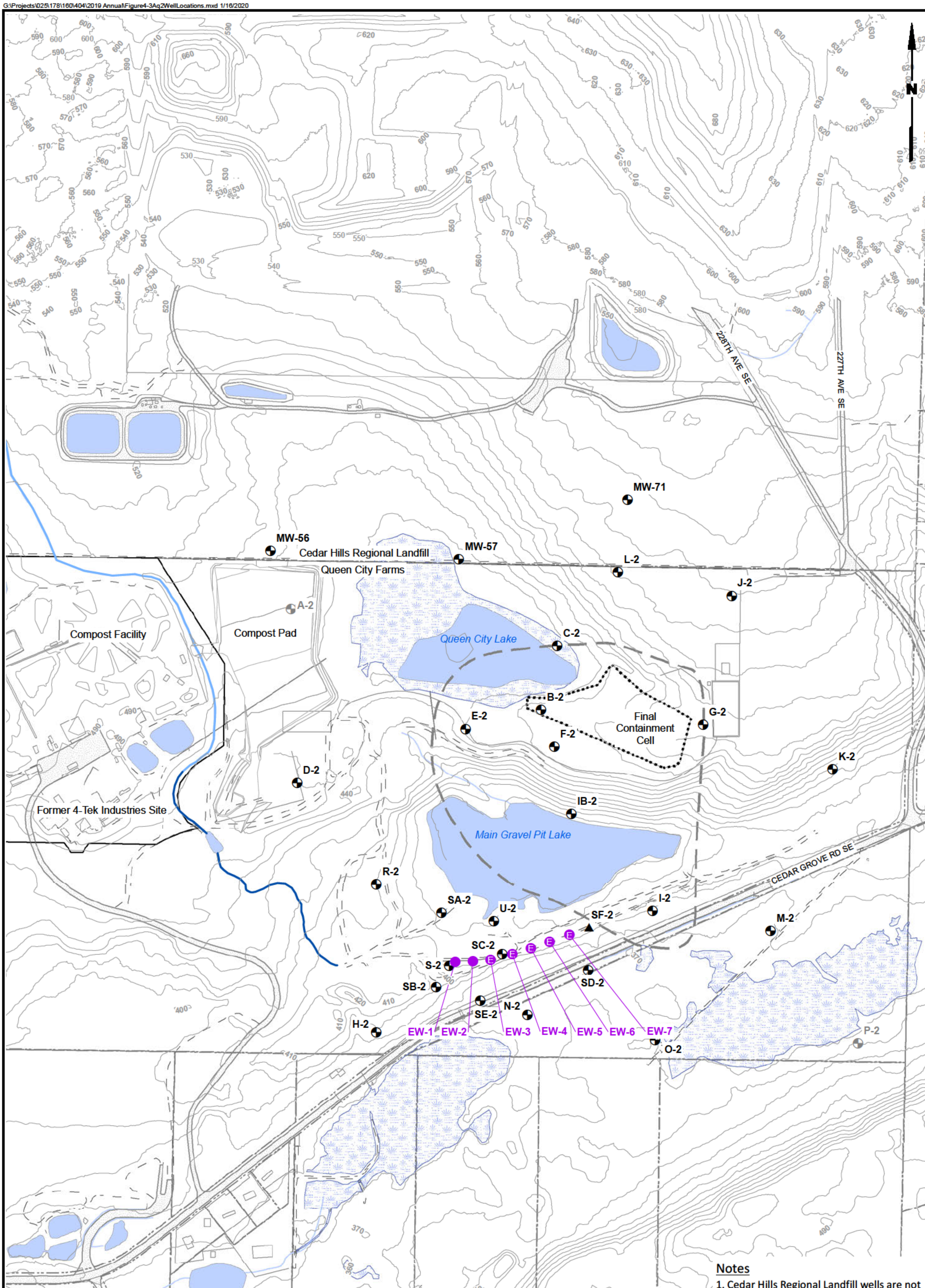
Landau Associates

Queen City Farms
Maple Valley, Washington

**Aquifer 2a**
**Monitoring Locations**

Figure
4-2

G:\Projects\025\178\160\404\2019 Annual\Figure4-3Aq2WellLocations.mxd 1/16/2020




## Legend

| | |
|---|---|
| B-2 | Monitoring Well Location |
| P-2 | Monitoring Well Location (Abandoned) |
| EW-1 | Extraction Well Location |
| SF-2 | Piezometer Location |
| | Final Containment Cell |
| | Conditional Point of Compliance |
| | Tributary 316A |
| | Engineered Drainage Channel |
| | Wetland |
| | Lake |
| | Tax Parcel |

0 500 1,000

Scale in Feet

## Notes

1. Cedar Hills Regional Landfill wells are not sampled as part of the Queen City Farms Field Sampling Plan, with the exception of MW-71.
2. Topographic contour interval is 10 ft. All elevations referenced to NGVD29.
3. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Data Sources: Barghausen 2007; King County 2015.

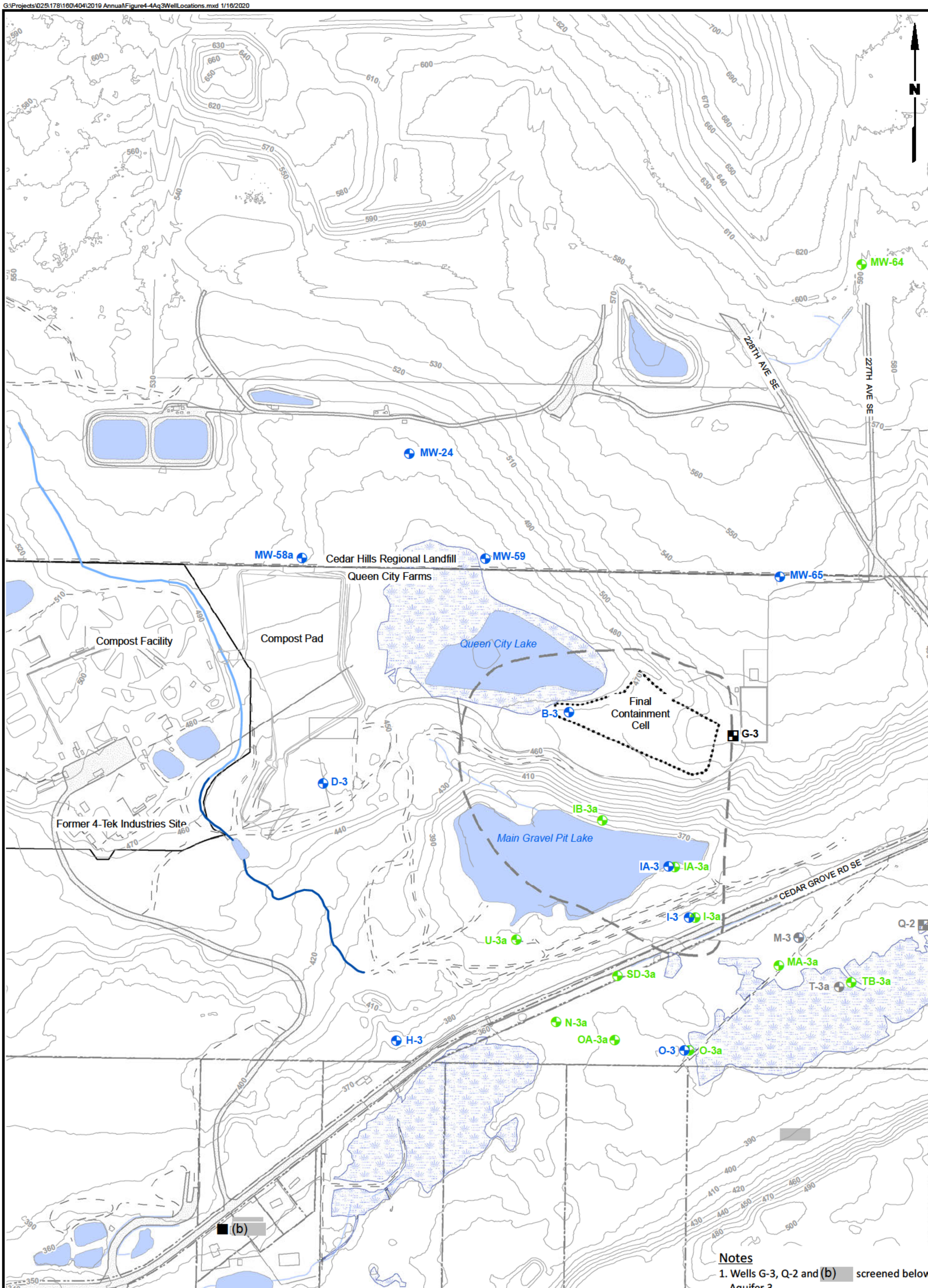
LANDAU ASSOCIATES

Queen City Farms
Maple Valley, Washington

**Aquifer 2 Monitoring Locations**

Figure 4-3

G:\Projects\025\178\160\404\2019 Annual\Figure4-4Aq3WellLocations.mxd 1/16/2020




## Notes

1. Wells G-3, Q-2 and (b) screened below Aquifer 3.
2. Cedar Hills Regional Landfill wells are not sampled as part of the Queen City Farms Field Sampling Plan.
3. Topographic contour interval is 10 ft. All elevations referenced to NGVD29.
4. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

## Legend

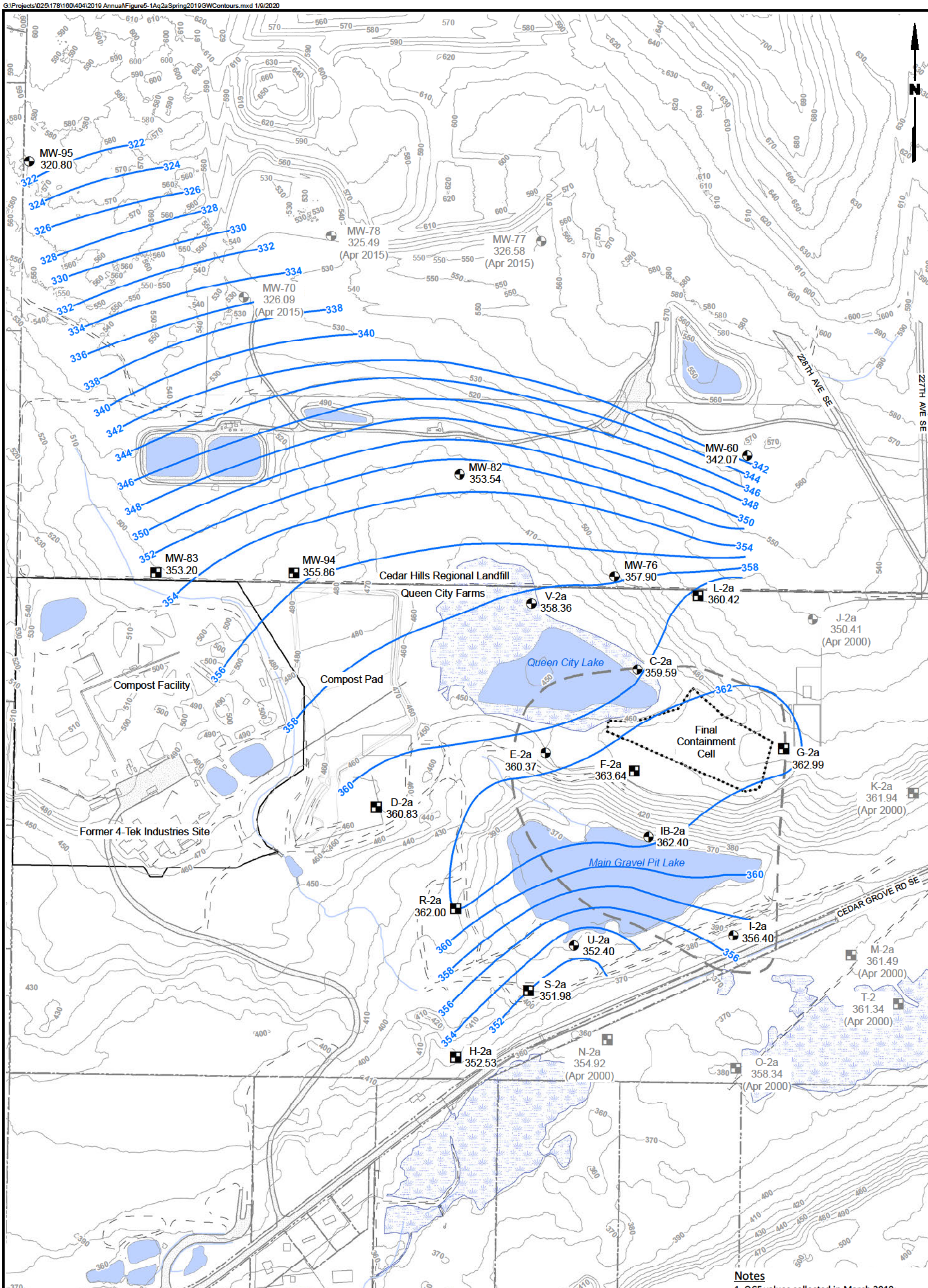
- N-3 Aquifer 3 Monitoring Well Location
- N-3a Aquifer 3a Monitoring Well Location
- G-3 Monitoring Well Location Screened Below Aquifer 3
- M-3 Monitoring Well Location (Abandoned)
- Domestic Supply Well Used for Monitoring
- Final Containment Cell
- Conditional Point of Compliance
- Tributary 316A
- Engineered Drainage Channel
- Wetland
- Lake
- Tax Parcel

Data Sources: Barghausen 2007; King County 2015.

0 500 1,000
Scale in Feet

Landau Associates

| Queen City Farms<br>Maple Valley, Washington | Aquifer 3a and Aquifer 3<br>Monitoring Locations | Figure<br>4-4 |
|---|---|---|




## Legend

| | | | |
|---|---|---|---|
| I-2a | Monitoring Well Location Screened within Unit F | Final Containment Cell | Lake |
| H-2a | Monitoring Well Location Screened Above Unit F | Groundwater Contours | Conditional Point of Compliance |
| J-2a | Previouisly Sampled Monitoring Well Location Screened within Unit F | Wetland | Tax Parcel |
| N-2a | Previouisly Sampled Monitoring Well Location Screened Above Unit F | | |

## Notes

1. QCF values collected in March 2019; CHRL wells measured in April 2019, unless otherwise noted.
2. Decommissioned well data from April 2000, unless otherwise noted.
3. Topographic contour interval is 10 ft. All elevations referenced to NGVD29.
4. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Data Sources: Barghausen 2007; King County 2012.

0 500 1,000

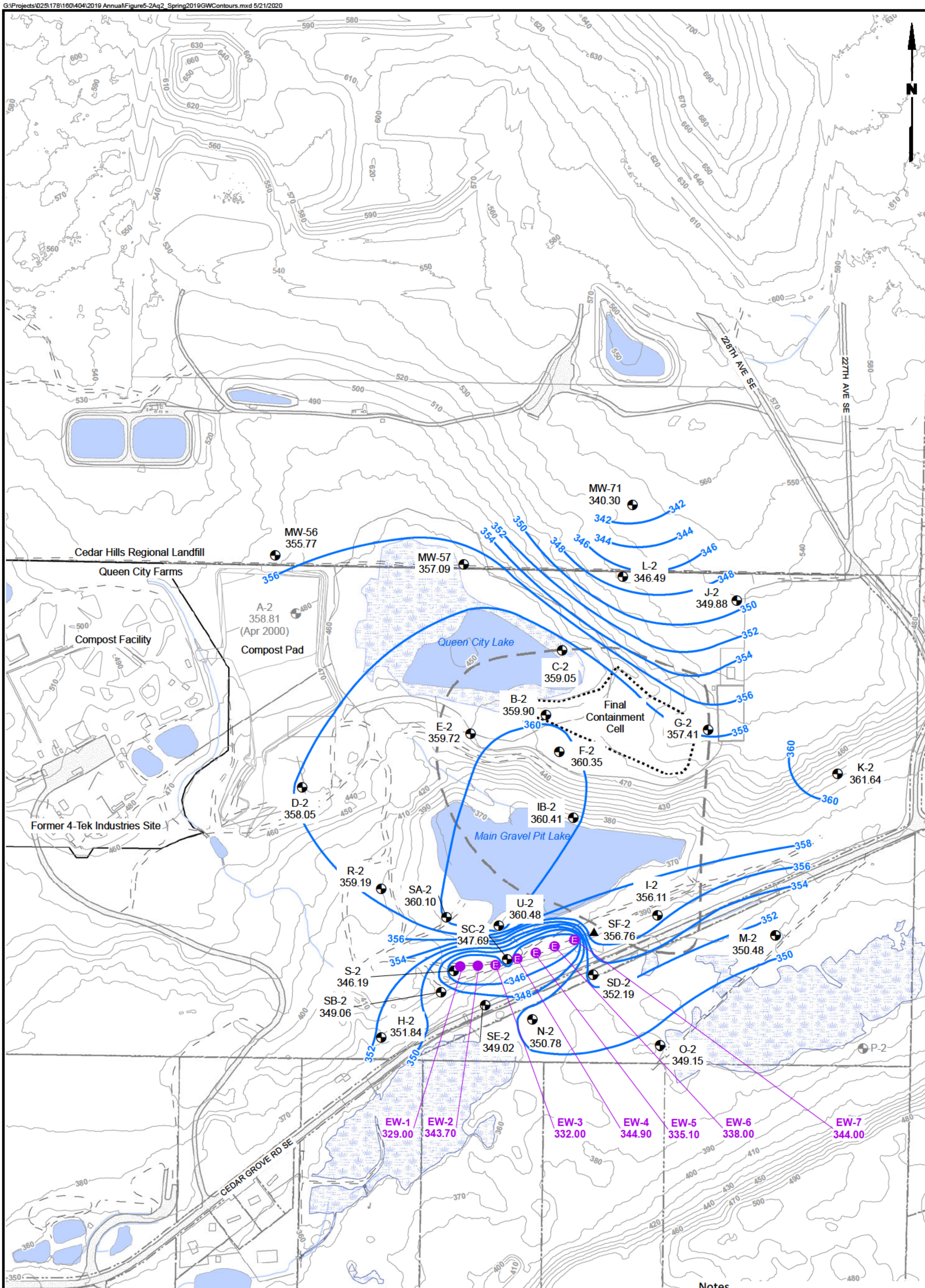
Scale in Feet

Landau Associates

Queen City Farms
Maple Valley, Washington

**Aquifer 2a**
**Groundwater Elevations**
**Spring 2019**

Figure
5-1




## Legend

- Extraction Well Location
- Monitoring Well Location
- Previously Sampled Monitoring Well Location
- Piezometer Location
- Final Containment Cell
- Groundwater Contours
- Conditional Point of Compliance
- Tax Parcel
- Wetland
- Lake

## Notes

1. QCF values collected in March 2019; CHRL wells measured in April 2019.
2. Topographic contour interval is 10 ft. All elevations referenced to NGVD29.
3. The <346 ft contour was used near extraction wells for graphical simplicity.
4. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Data Sources: Barghausen 2007; King County 2012.

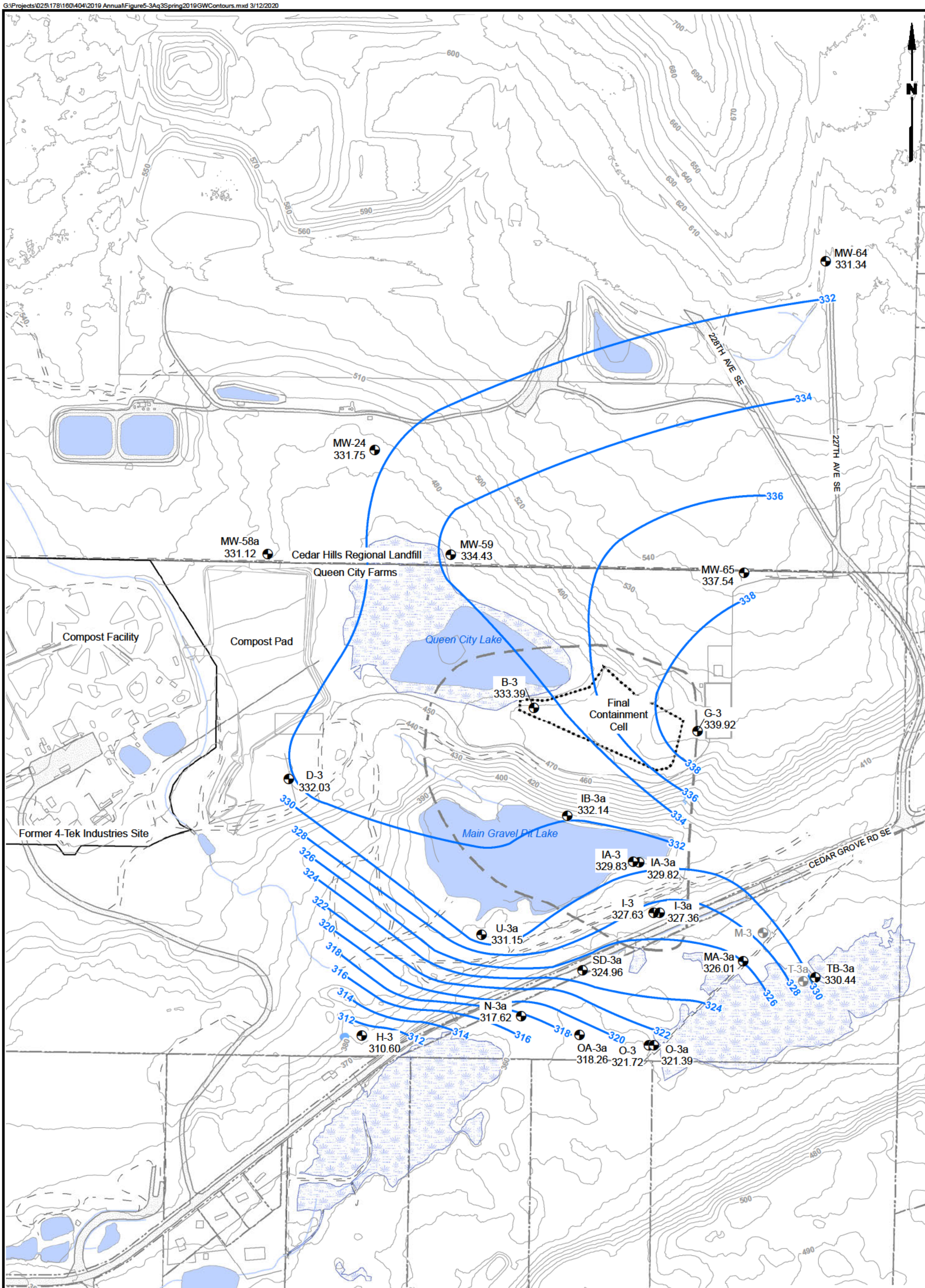
0 500 1,000
Scale in Feet

Landau Associates

Queen City Farms
Maple Valley, Washington

**Aquifer 2**
**Groundwater Elevations**
**Spring 2019**

Figure
5-2




## Legend

- Monitoring Well Location
- Previously Sampled Monitoring Well Location
- Final Containment Cell
- Groundwater Contours
- Conditional Point of Compliance
- Tax Parcel
- Wetland
- Lake

## Notes

1. Well G-3 is screened below Aquifer 3.
2. QCF values collected in March 2019, CHRL values collected in April 2019.
3. Topographic contour interval is 10 ft. All elevations referenced to NGVD29.
4. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Data Sources: Barghausen 2007; King County 2012.

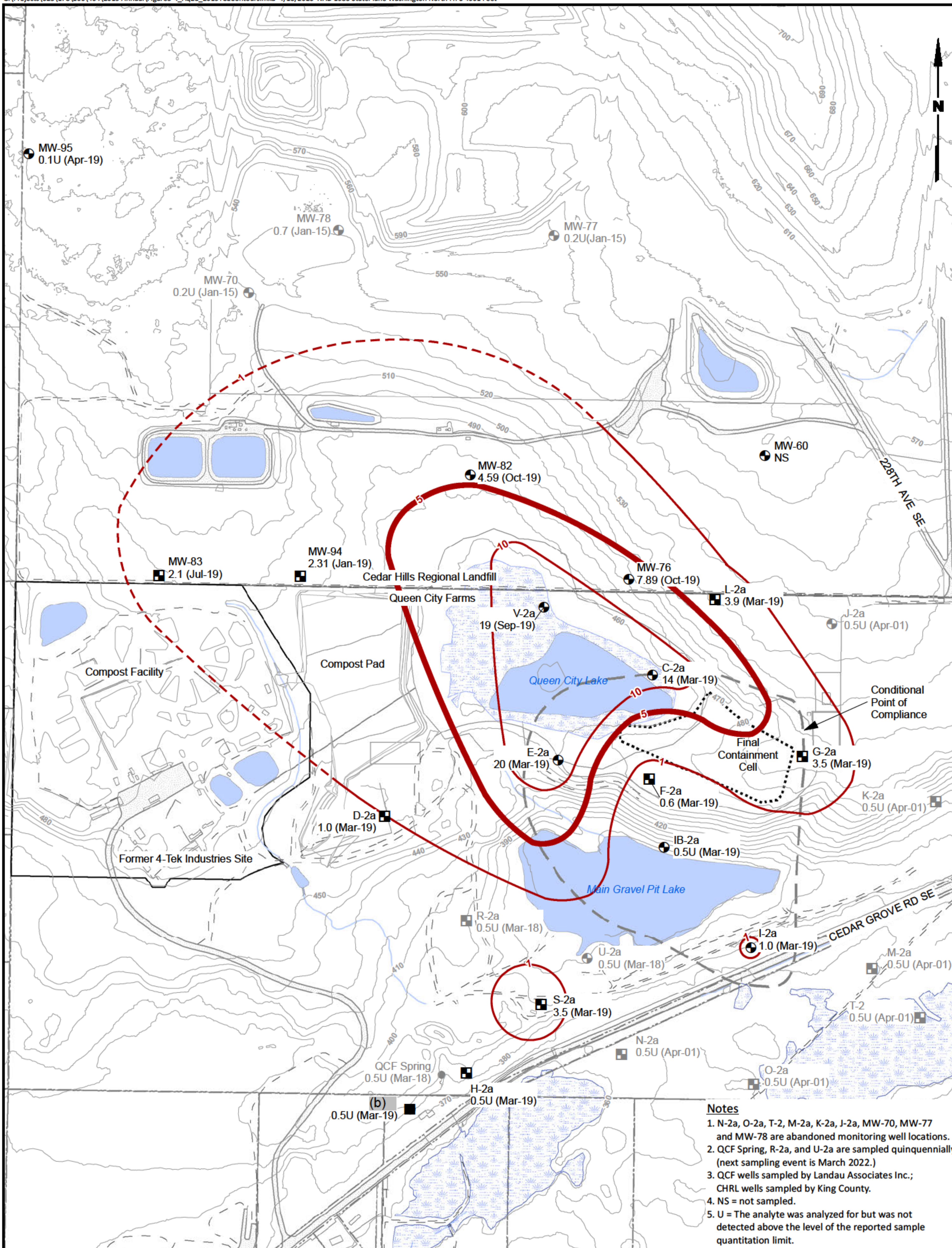
0 500 1,000
Scale in Feet

Landau Associates

Queen City Farms
Maple Valley, Washington

**Aquifer 3a and Aquifer 3 Groundwater Elevations Spring 2019**

Figure 5-3




## Notes

1. N-2a, O-2a, T-2, M-2a, K-2a, J-2a, MW-70, MW-77 and MW-78 are abandoned monitoring well locations.
2. QCF Spring, R-2a, and U-2a are sampled quinquennially (next sampling event is March 2022.)
3. QCF wells sampled by Landau Associates Inc.; CHRL wells sampled by King County.
4. NS = not sampled.
5. U = The analyte was analyzed for but was not detected above the level of the reported sample quantitation limit.
6. All data in µg/L.
7. Topographic contour interval is 10 ft. All elevations referenced to NGVD29.
8. Water quality sampling at CHRL well MW-60 was suspended after 2015.
9. Most QCF wells are sampled either annually (March) or semi-annually (March and September). The larger of the two concentration values is presented for wells that are sampled semi-annually. Where concentration values are the same for both semi-annual events, the annual sampling date is presented.
10. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

## Legend

I-2a 0.80 (Mar-14) — Monitoring Well Location Screened within Unit F TCE Concentration and Date

H-2a 1.10 (Sept-14) — Monitoring Well Location Screened Above Unit F TCE Concentration and Date

P-2 0.5U (Apr-01) — Previously Sampled Monitoring Well Location Screened within Unit F TCE Concentration and Date

N-2a 0.5U (Apr-01) — Previously Sampled Monitoring Well Location Screened Above Unit F TCE Concentration and Date

Domestic Supply Well Used for Monitoring

Springs

TCE Concentration Contour

Approximate TCE Concentration Contour

TCE Performance Standard 5 µg/L

Final Containment Cell

Wetland

Lake

Conditional Point of Compliance

Tax Parcel

Data Source: King County GIS 2013.

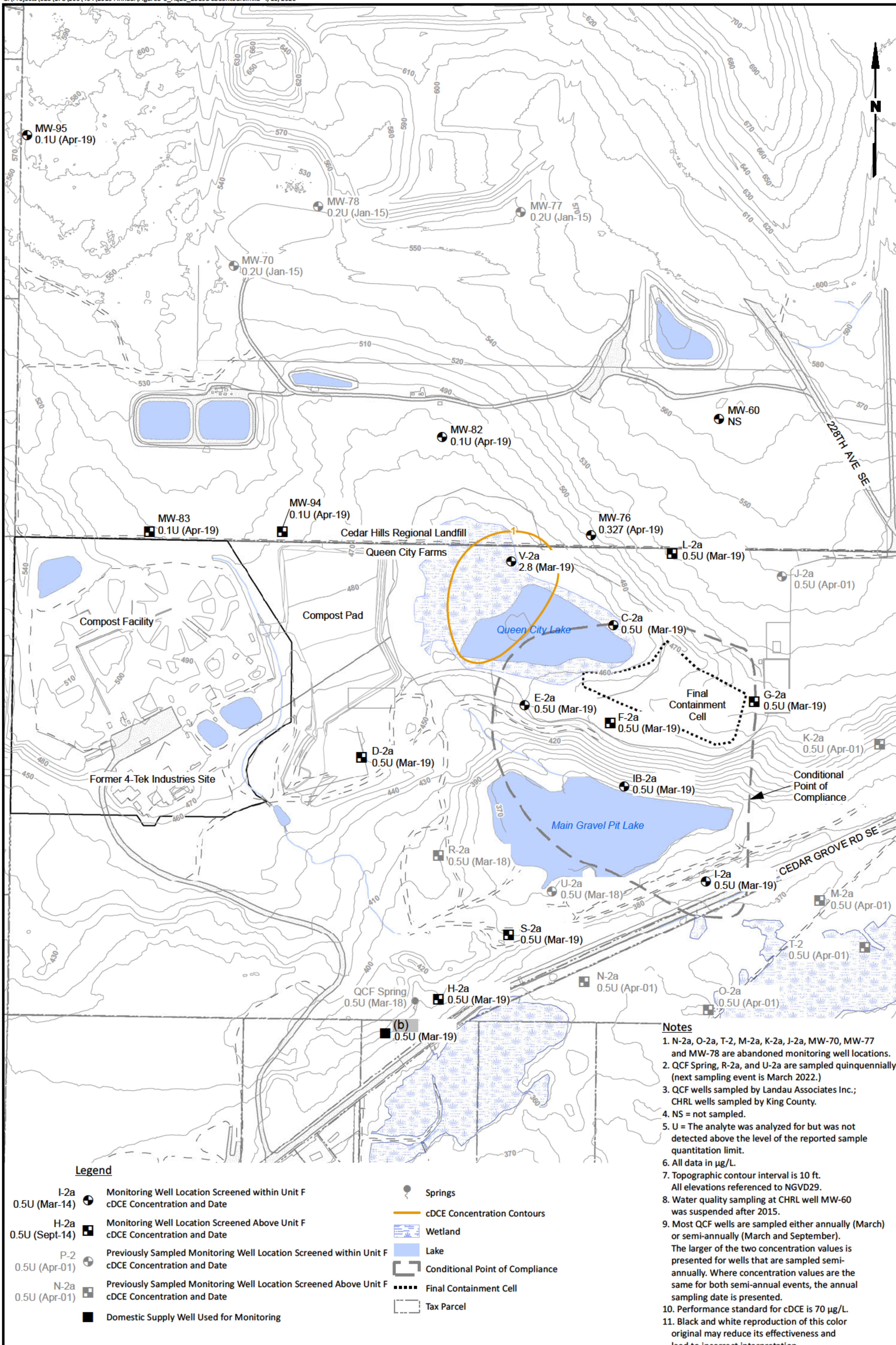
0 500 1,000
Scale in Feet

Landau Associates

Queen City Farms
Maple Valley, Washington

**Aquifer 2a**
**TCE Contours**
**Maximum 2019**

Figure
5-4




**Notes**

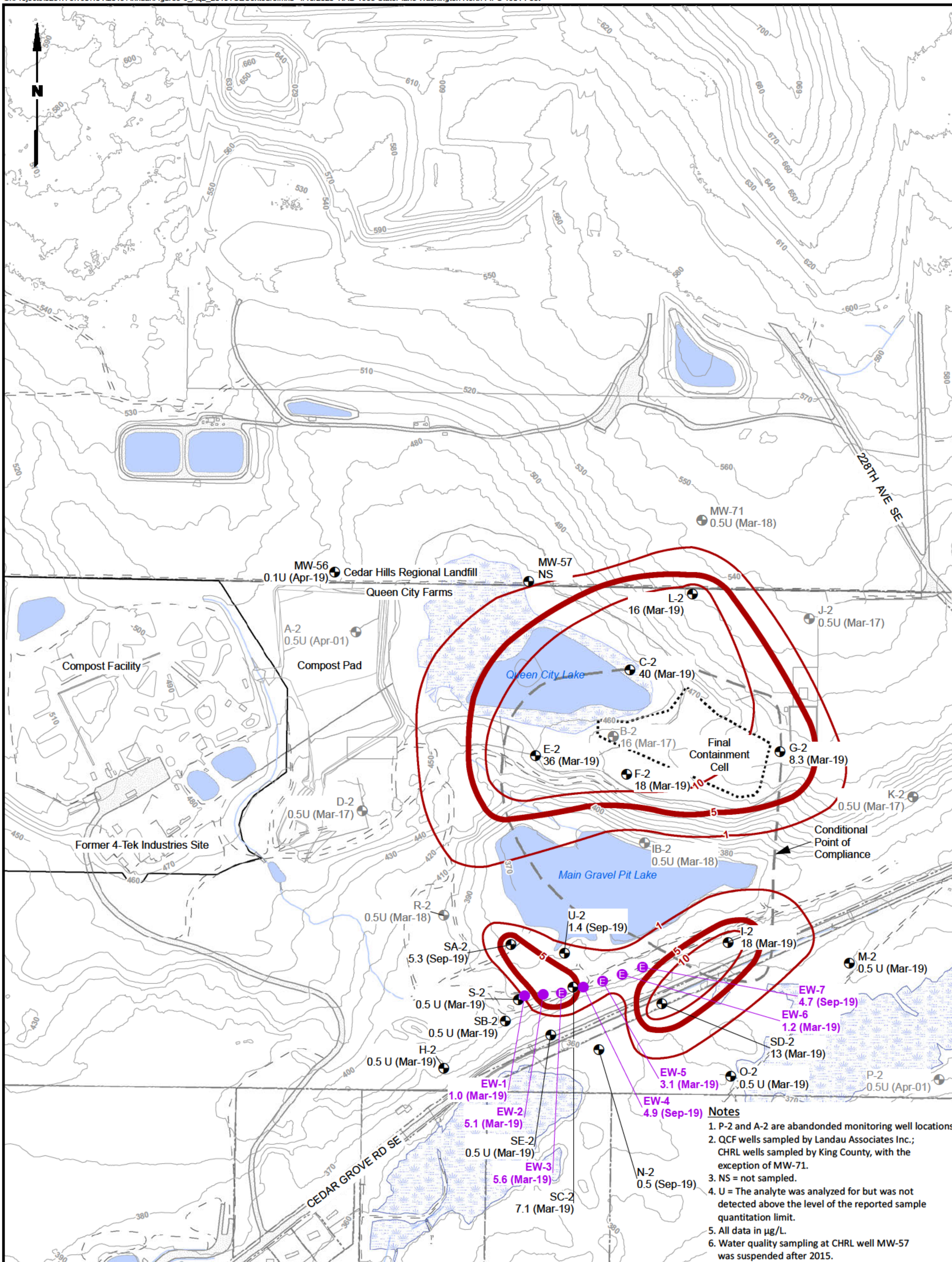
1. N-2a, O-2a, T-2, M-2a, K-2a, J-2a, MW-70, MW-77 and MW-78 are abandoned monitoring well locations.
2. QCF Spring, R-2a, and U-2a are sampled quinquennially (next sampling event is March 2022.)
3. QCF wells sampled by Landau Associates Inc.; CHRL wells sampled by King County.
4. NS = not sampled.
5. U = The analyte was analyzed for but was not detected above the level of the reported sample quantitation limit.
6. All data in µg/L.
7. Topographic contour interval is 10 ft. All elevations referenced to NGVD29.
8. Water quality sampling at CHRL well MW-60 was suspended after 2015.
9. Most QCF wells are sampled either annually (March) or semi-annually (March and September). The larger of the two concentration values is presented for wells that are sampled semi-annually. Where concentration values are the same for both semi-annual events, the annual sampling date is presented.
10. Performance standard for cDCE is 70 µg/L.
11. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

LANDAU ASSOCIATES

Queen City Farms
Maple Valley, Washington

**Aquifer 2a**
**cDCE Contours**
**Maximum 2019**

Figure
5-5




**Notes**

1. P-2 and A-2 are abandoned monitoring well locations.
2. QCF wells sampled by Landau Associates Inc.; CHRL wells sampled by King County, with the exception of MW-71.
3. NS = not sampled.
4. U = The analyte was analyzed for but was not detected above the level of the reported sample quantitation limit.
5. All data in µg/L.
6. Water quality sampling at CHRL well MW-57 was suspended after 2015.
7. Topographic contour interval is 10 ft. All elevations referenced to NGVD29.
8. D-2, K-2, J-2, B-2, R-2, IB-2, and MW-71 are sampled quinquennially (next sampling event is March 2022).
9. Most QCF wells are sampled either annually (March) or semi-annually (March and September/October). The larger of the two concentration values is presented for wells that are sampled semi-annually. Where concentration values are the same for both semi-annual events, the annual sampling date is presented.
10. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

**Legend**

- C-2 40.0 (Mar-14) — Monitoring Well Location TCE Concentration and Date
- P-2 0.5U (Apr-01) — Previously Sampled Monitoring Well Location TCE Concentration and Date
- Final Containment Cell
- TCE Concentration Contours
- TCE Performance Standard 5 µg/L
- Wetland
- Lake
- Conditional Point of Compliance
- Tax Parcel

Data Source: King County GIS 2013.

0 500 1,000
Scale in Feet

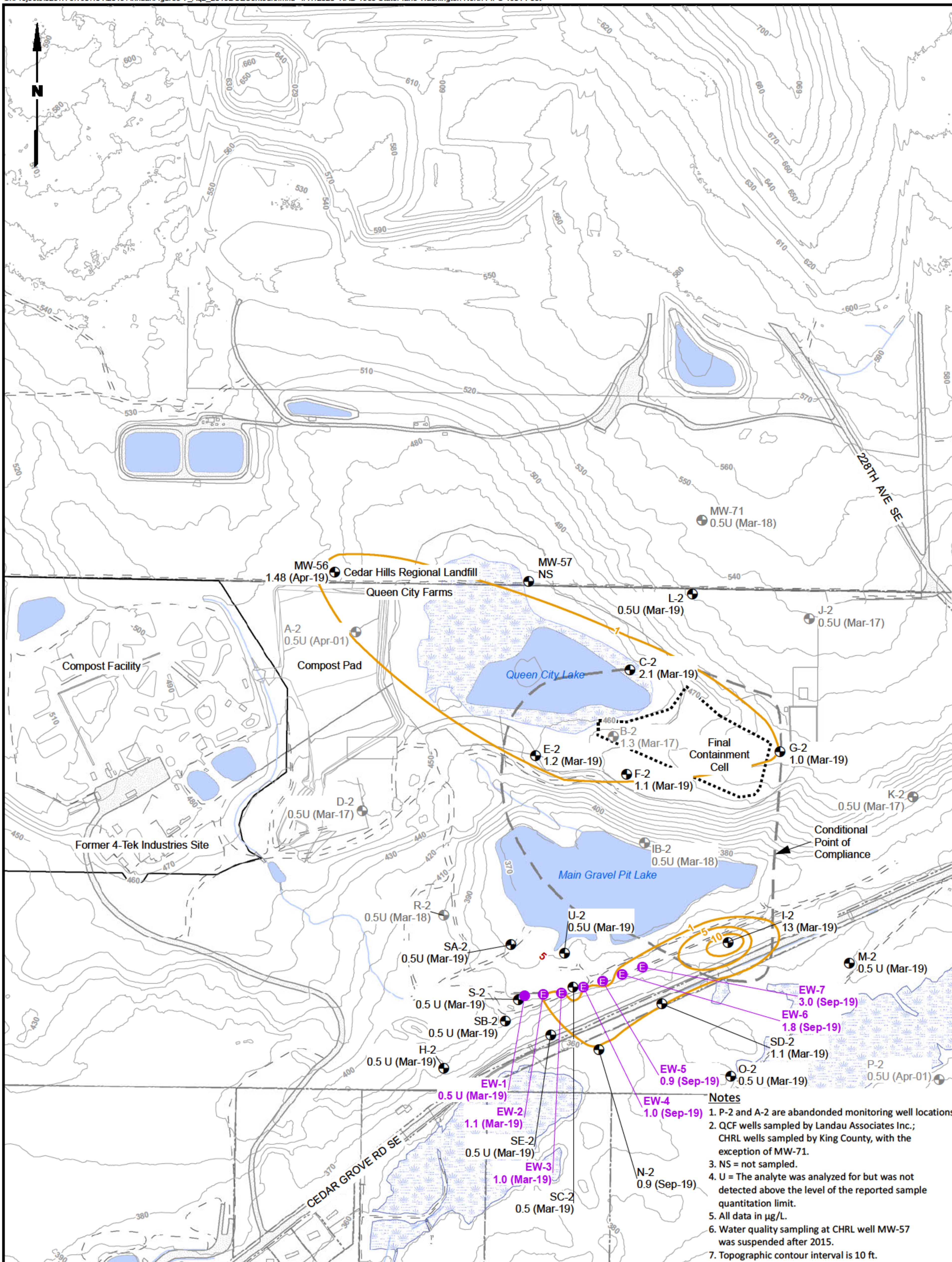
Landau Associates

Queen City Farms
Maple Valley, Washington

**Aquifer 2**
**TCE Contours**
**Maximum 2019**

Figure
5-6

G:\Projects\025\178\160\404\2019 Annual\Figure5-7_Aq2_2019DCEContours.mxd 4/17/2020 NAD 1983 StatePlane Washington North FIPS 4601 Feet




**Notes**

1. P-2 and A-2 are abandoned monitoring well locations.
2. QCF wells sampled by Landau Associates Inc.; CHRL wells sampled by King County, with the exception of MW-71.
3. NS = not sampled.
4. U = The analyte was analyzed for but was not detected above the level of the reported sample quantitation limit.
5. All data in µg/L.
6. Water quality sampling at CHRL well MW-57 was suspended after 2015.
7. Topographic contour interval is 10 ft. All elevations referenced to NGVD29.
8. D-2, K-2, J-2, B-2, R-2, IB-2, and MW-71 are sampled quinquennially (next sampling event is March 2022).
9. Most QCF wells are sampled either annually (March) or semi-annually (March and September/October). The larger of the two concentration values is presented for wells that are sampled semi-annually. Where concentration values are the same for both semi-annual events, the annual sampling date is presented.
10. Performance standard for cDCE is 70 µg/L.
11. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

**Legend**

- C-2 40.0 (Mar-14) — Monitoring Well Location cDCE Concentration and Date
- P-2 0.5U (Apr-01) — Previously Sampled Monitoring Well Location cDCE Concentration and Date
- Final Containment Cell
- cDCE Concentration Contours
- Wetland
- Lake
- Conditional Point of Compliance
- Tax Parcel

Data Source: King County GIS 2013.

0 500 1,000

Scale in Feet

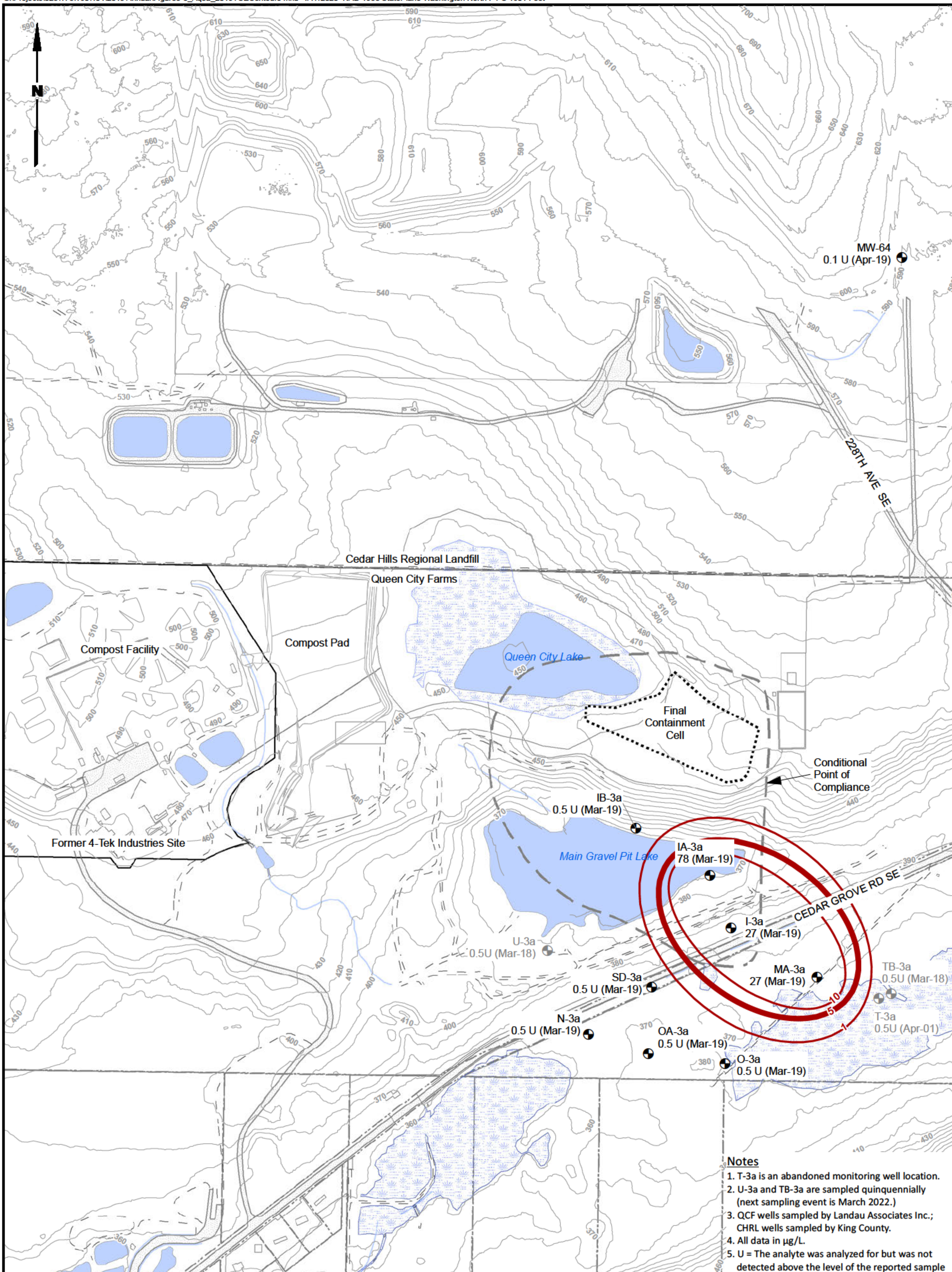
LANDAU ASSOCIATES

Queen City Farms
Maple Valley, Washington

**Aquifer 2**
**cDCE Contours**
**Maximum 2019**

Figure 5-7

G:\Projects\025\178\160\404\2019 Annual\Figure5-8_Aq3a_2019TCEContours.mxd 4/17/2020 NAD 1983 StatePlane Washington North F PS 4601 Feet




## Legend

| | |
|---|---|
| I-3a 2.5 (Sept-14) | Monitoring Well Location, TCE Concentration and Date |
| P-2 0.5U (Apr-01) | Previously Sampled Monitoring Well Location, TCE Concentration and Date |
| | Final Containment Cell |
| | TCE Concentration Contours |
| | TCE Performance Standard 5 µg/L |
| | Wetland |
| | Lake |
| | Conditional Point of Compliance |
| | Tax Parcel |

## Notes

1. T-3a is an abandoned monitoring well location.
2. U-3a and TB-3a are sampled quinquennially (next sampling event is March 2022.)
3. QCF wells sampled by Landau Associates Inc.; CHRL wells sampled by King County.
4. All data in µg/L.
5. U = The analyte was analyzed for but was not detected above the level of the reported sample quantitation limit.
6. Topographic contour interval is 10 ft. All elevations referenced to NGVD29.
7. Most QCF wells are sampled either annually (March) or semi-annually (March and September). The larger of the two concentration values is presented for wells that are sampled semi-annually. Where concentration values are the same for both semi-annual events, the annual sampling date is presented.
8. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Data Source: King County GIS 2013.

0 500 1,000

Scale in Feet

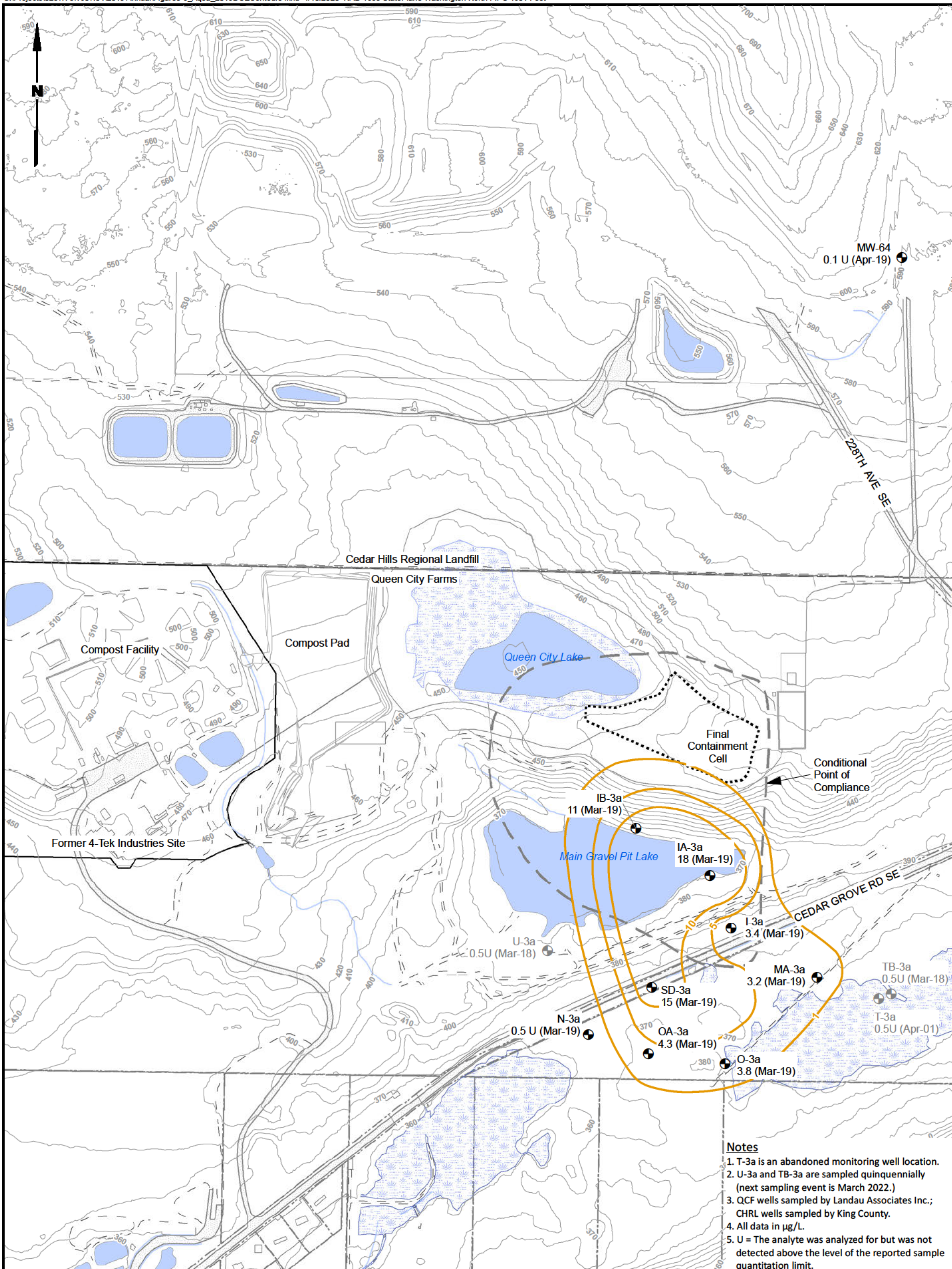
LANDAU ASSOCIATES

Queen City Farms
Maple Valley, Washington

**Aquifer 3a**
**TCE Contours**
**Maximum 2019**

Figure
5-8

G:\Projects\025\178\160\404\2019 Annual\Figure5-9_Aq3a_2019DCEContours.mxd 4/10/2020 NAD 1983 StatePlane Washington North FIPS 4601 Feet




**Notes**

1. T-3a is an abandoned monitoring well location.
2. U-3a and TB-3a are sampled quinquennially (next sampling event is March 2022.)
3. QCF wells sampled by Landau Associates Inc.; CHRL wells sampled by King County.
4. All data in µg/L.
5. U = The analyte was analyzed for but was not detected above the level of the reported sample quantitation limit.
6. Topographic contour interval is 10 ft. All elevations referenced to NGVD29.
7. Most QCF wells are sampled either annually (March) or semi-annually (March and September). The larger of the two concentration values is presented for wells that are sampled semi-annually. Where concentration values are the same for both semi-annual events, the annual sampling date is presented.
8. Performance standard for cDCE is 70 µg/L.
9. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

**Legend**

I-3a 2.5 (Sept-14) — Monitoring Well Location cDCE Concentration and Date

P-2 0.5U (Apr-01) — Previously Sampled Monitoring Well Location cDCE Concentration and Date

Final Containment Cell

cDCE Concentration Contours

Wetland

Lake

Conditional Point of Compliance

Tax Parcel

Data Source: King County GIS 2013.

0 500 1,000

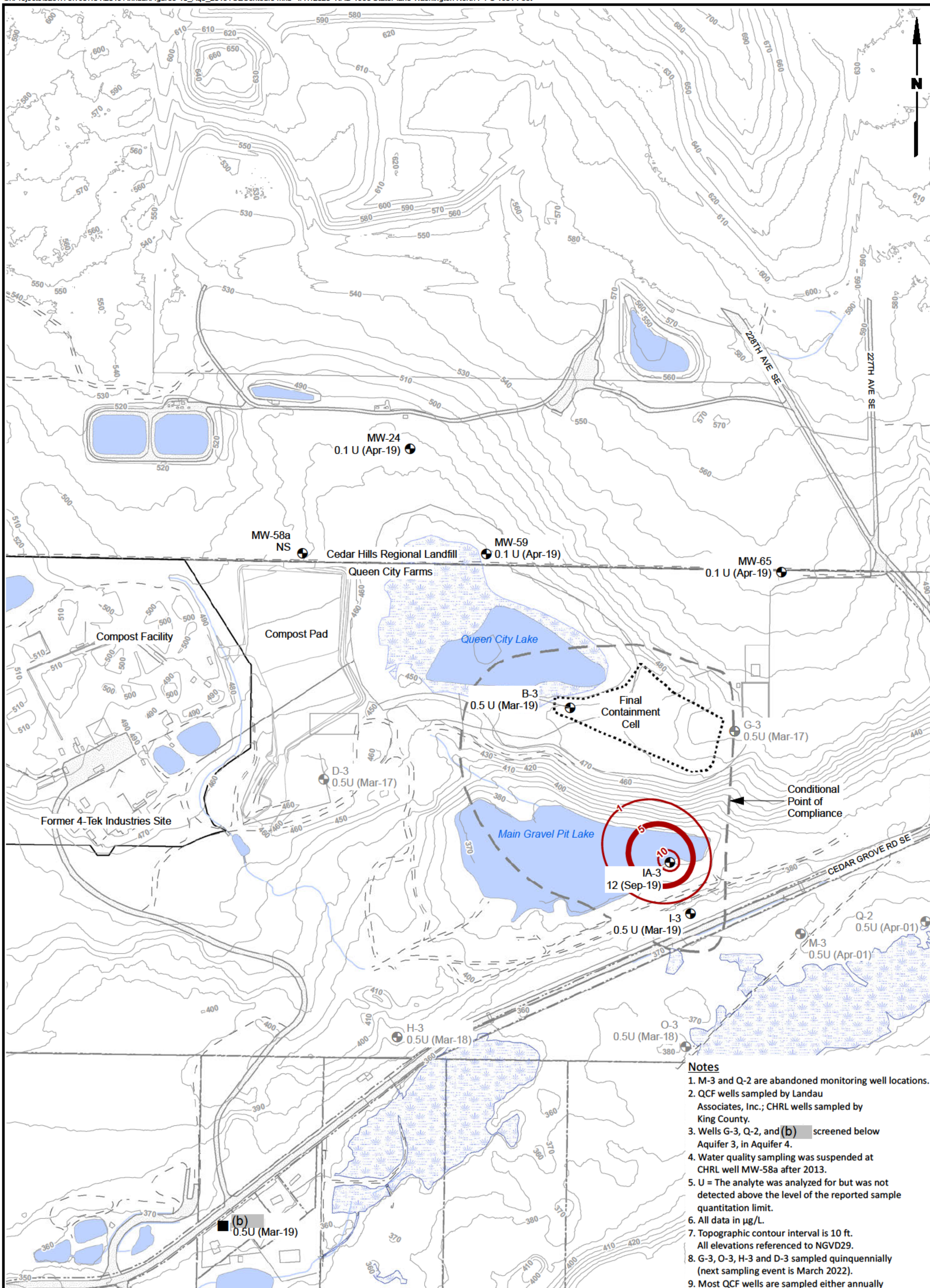
Scale in Feet

LANDAU ASSOCIATES

Queen City Farms
Maple Valley, Washington

**Aquifer 3a**
**cDCE Contours**
**Maximum 2019**

Figure
5-9




**Notes**

1. M-3 and Q-2 are abandoned monitoring well locations.
2. QCF wells sampled by Landau Associates, Inc.; CHRL wells sampled by King County.
3. Wells G-3, Q-2, and (b) screened below Aquifer 3, in Aquifer 4.
4. Water quality sampling was suspended at CHRL well MW-58a after 2013.
5. U = The analyte was analyzed for but was not detected above the level of the reported sample quantitation limit.
6. All data in µg/L.
7. Topographic contour interval is 10 ft. All elevations referenced to NGVD29.
8. G-3, O-3, H-3 and D-3 sampled quinquennially (next sampling event is March 2022).
9. Most QCF wells are sampled either annually (March) or semi-annually (March and September). The larger of the two concentration values is presented for wells that are sampled semi-annually. Where concentration values are the same for both semi-annual events, the annual sampling date is presented.
10. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

**Legend**

- I-3 18.0 (Mar-13) — Monitoring Well Location, TCE Concentration and Date
- Q-2 0.5U (Apr-01) — Previously Sampled Monitoring Well Location, TCE Concentration and Date
- Domestic Supply Well Used for Monitoring
- Springs
- TCE Concentration Contours
- TCE Performance Standard 5 µg/L
- Final Containment Cell
- Wetland
- Lake
- Tax Parcel
- Conditional Point of Compliance

Data Source: King County GIS.

0 500 1,000
Scale in Feet

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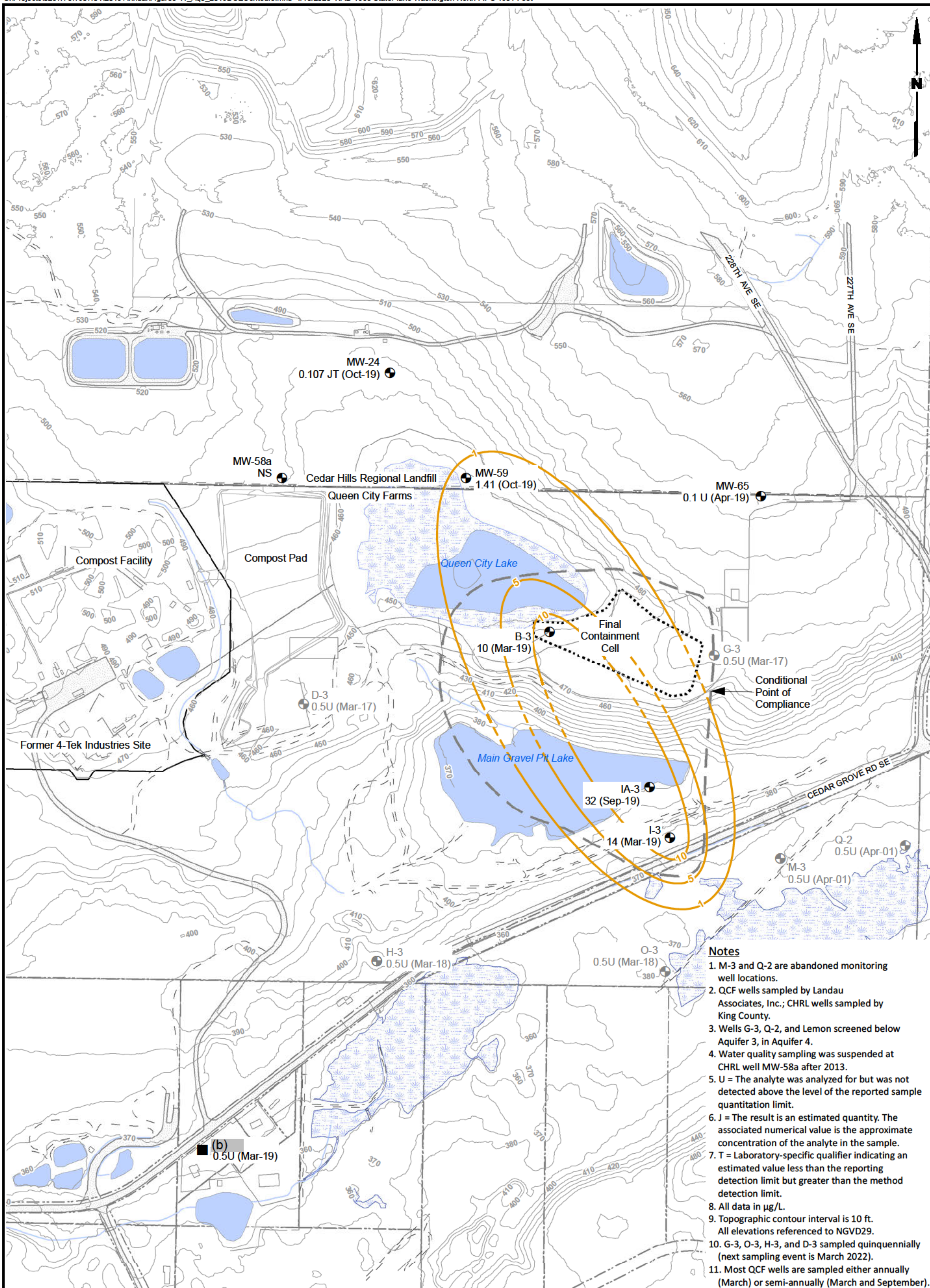
Queen City Farms
Maple Valley, Washington

**Aquifer 3**
**TCE Contours**
**Maximum 2019**

Figure
5-10

G:\Projects\025\178\160\404\2019 Annual\Figure5-11_Aq3_2019DCEContours.mxd 4/13/2020 NAD 1983 StatePlane Washington North FIPS 4601 Feet




## Notes

1. M-3 and Q-2 are abandoned monitoring well locations.
2. QCF wells sampled by Landau Associates, Inc.; CHRL wells sampled by King County.
3. Wells G-3, Q-2, and Lemon screened below Aquifer 3, in Aquifer 4.
4. Water quality sampling was suspended at CHRL well MW-58a after 2013.
5. U = The analyte was analyzed for but was not detected above the level of the reported sample quantitation limit.
6. J = The result is an estimated quantity. The associated numerical value is the approximate concentration of the analyte in the sample.
7. T = Laboratory-specific qualifier indicating an estimated value less than the reporting detection limit but greater than the method detection limit.
8. All data in μg/L.
9. Topographic contour interval is 10 ft. All elevations referenced to NGVD29.
10. G-3, O-3, H-3, and D-3 sampled quinquennially (next sampling event is March 2022).
11. Most QCF wells are sampled either annually (March) or semi-annually (March and September). The larger of the two concentration values is presented for wells that are sampled semi-annually. Where concentration values are the same for both semi-annual events, the annual sampling date is presented.
12. Performance standard for cDCE is 70 μg/L.
13. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

## Legend

I-3 18.0 (Mar-13) — Monitoring Well Location cDCE Concentration and Date

Q-2 0.5U (Apr-01) — Previously Sampled Monitoring Well Location cDCE Concentration and Date

Domestic Supply Well Used for Monitoring

cDCE Concentration Contours

Approximate cDCE Concentration Contours

Final Containment Cell

Conditional Point of Compliance

Wetland

Lake

Tax Parcel

Data Source: King County GIS 2013.

0 500 1,000

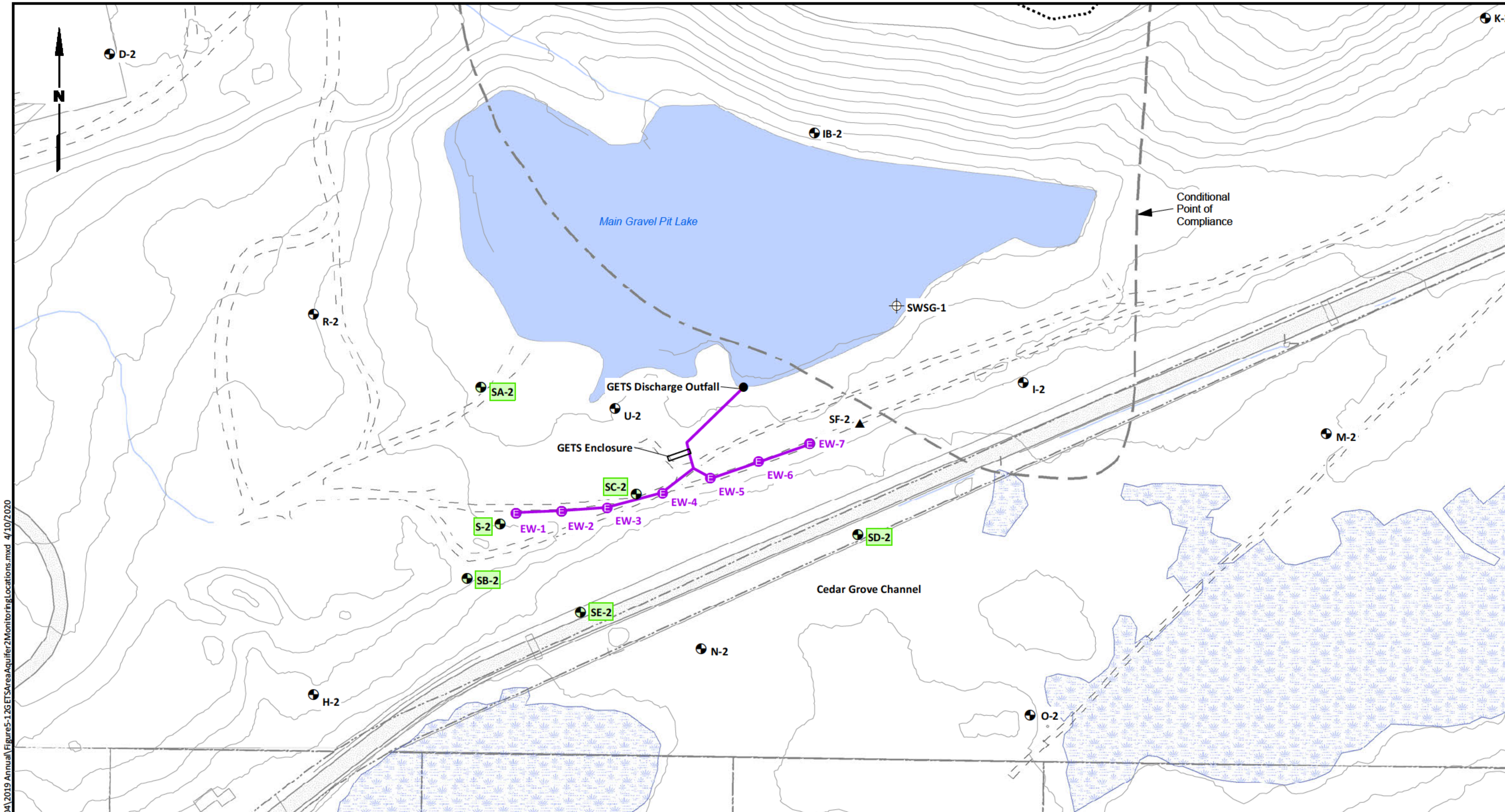
Scale in Feet

LANDAU ASSOCIATES

Queen City Farms
Maple Valley, Washington

**Aquifer 3**
**cDCE Contours**
**Maximum 2019**

Figure
5-11




## Legend

- H-2 — Monitoring Well Location
- S-2 — S-Well Area Monitoring Well Location
- Extraction Well Location (Installed April/May 2014)
- Piezometer Location
- Staff Gauge
- GETS Discharge Outfall
- Water Conveyance Piping
- Lake
- Conditional Point of Compliance
- Tax Parcel

## Notes

1. Topographic contour interval is 10 ft. All elevations referenced to NGVD29.
2. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

0 200 400
Scale in Feet

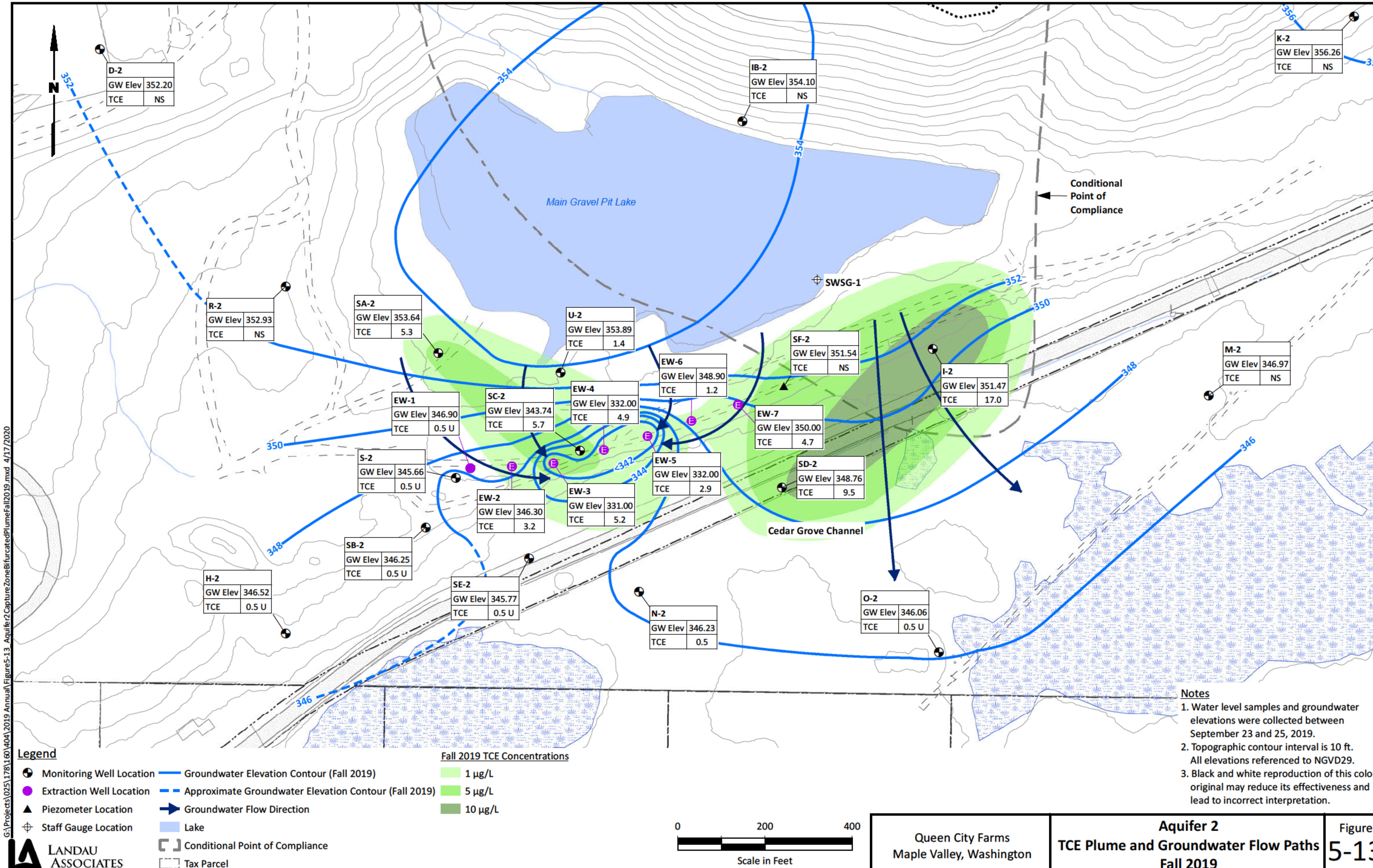
G:\Projects\025\178\160\404\2019 Annual\Figure5-12GETSAreaAquifer2MonitoringLocations.mxd 4/10/2020

LANDAU ASSOCIATES

Queen City Farms
Maple Valley, Washington

**S-Well Area, GETS, and Aquifer 2 Monitoring Locations**

Figure
5-12

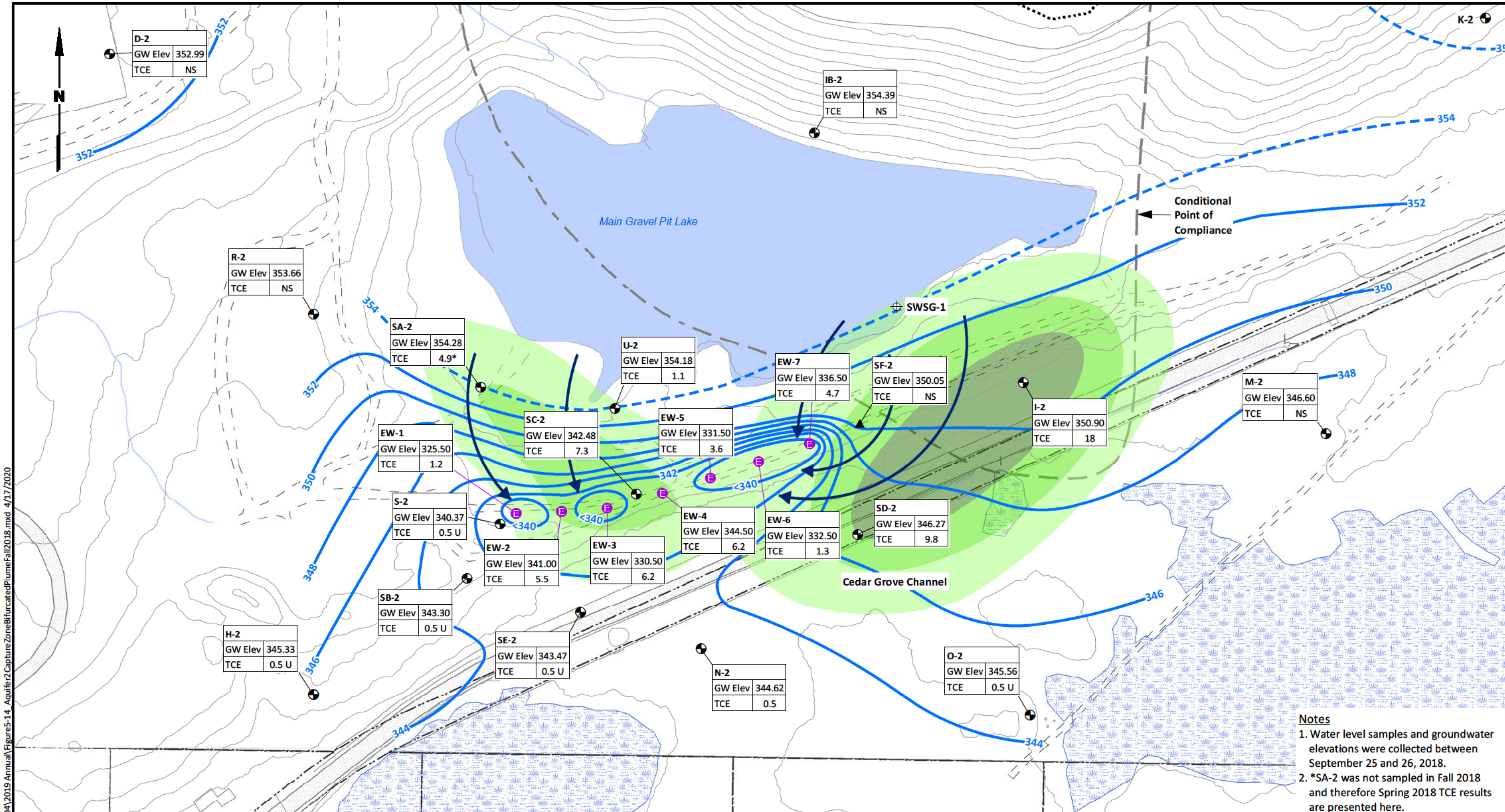



Notes
1. Water level samples and groundwater elevations were collected between September 23 and 25, 2019.
2. Topographic contour interval is 10 ft. All elevations referenced to NGVD29.
3. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Queen City Farms
Maple Valley, Washington

**Aquifer 2**
**TCE Plume and Groundwater Flow Paths**
**Fall 2019**

Figure 5-13




G:\Projects\025\178\160\404\2019 Annual\Figure5-14_Aquifer2CaptureZoneBifurcatedPlumeFall2018.mxd 4/17/2020

**Legend**

- Monitoring Well Location
- Extraction Well Location
- Piezometer Location
- Staff Gauge Location
- Groundwater Elevation Contour (Fall 2018)
- Approximate Groundwater Elevation Contour (Fall 2018)
- Groundwater Flow Direction
- Lake
- Conditional Point of Compliance
- Tax Parcel

**Fall 2018 TCE Concentrations**

- 1 µg/L
- 5 µg/L
- 10 µg/L

**Notes**

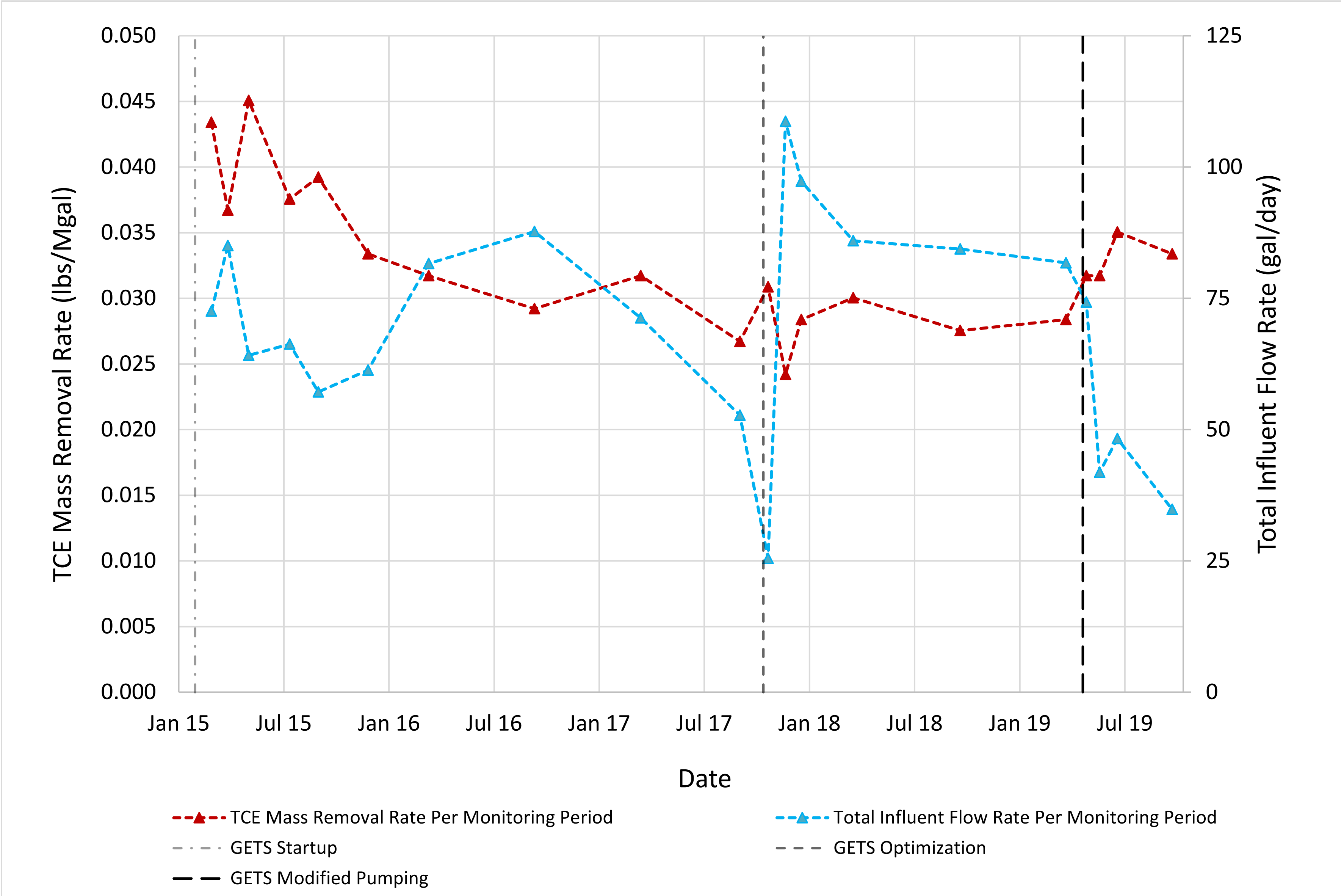
1. Water level samples and groundwater elevations were collected between September 25 and 26, 2018.
2. *SA-2 was not sampled in Fall 2018 and therefore Spring 2018 TCE results are presented here.
3. Topographic contour interval is 10 ft. All elevations referenced to NGVD29.
4. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

0 200 400

Scale in Feet

Landau Associates

| Queen City Farms Maple Valley, Washington | Aquifer 2 TCE Plume and Groundwater Flow Paths Fall 2018 | Figure 5-14 |
|---|---|---|

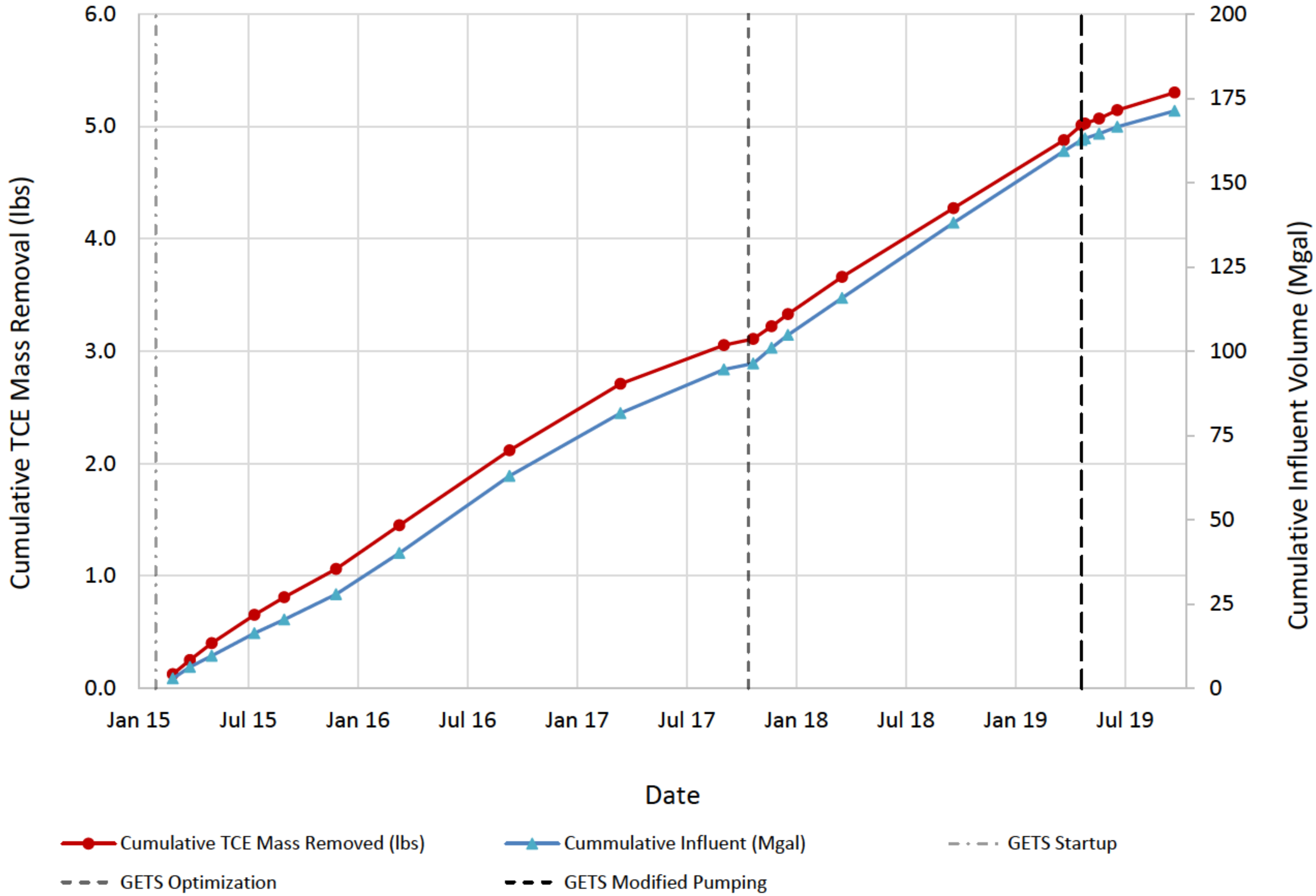



Landau Associates

Queen City Farms
Maple Valley, WA

**TCE Mass Removal Rate and Total Influent Flow Rate vs. Time**

Figure
5-15

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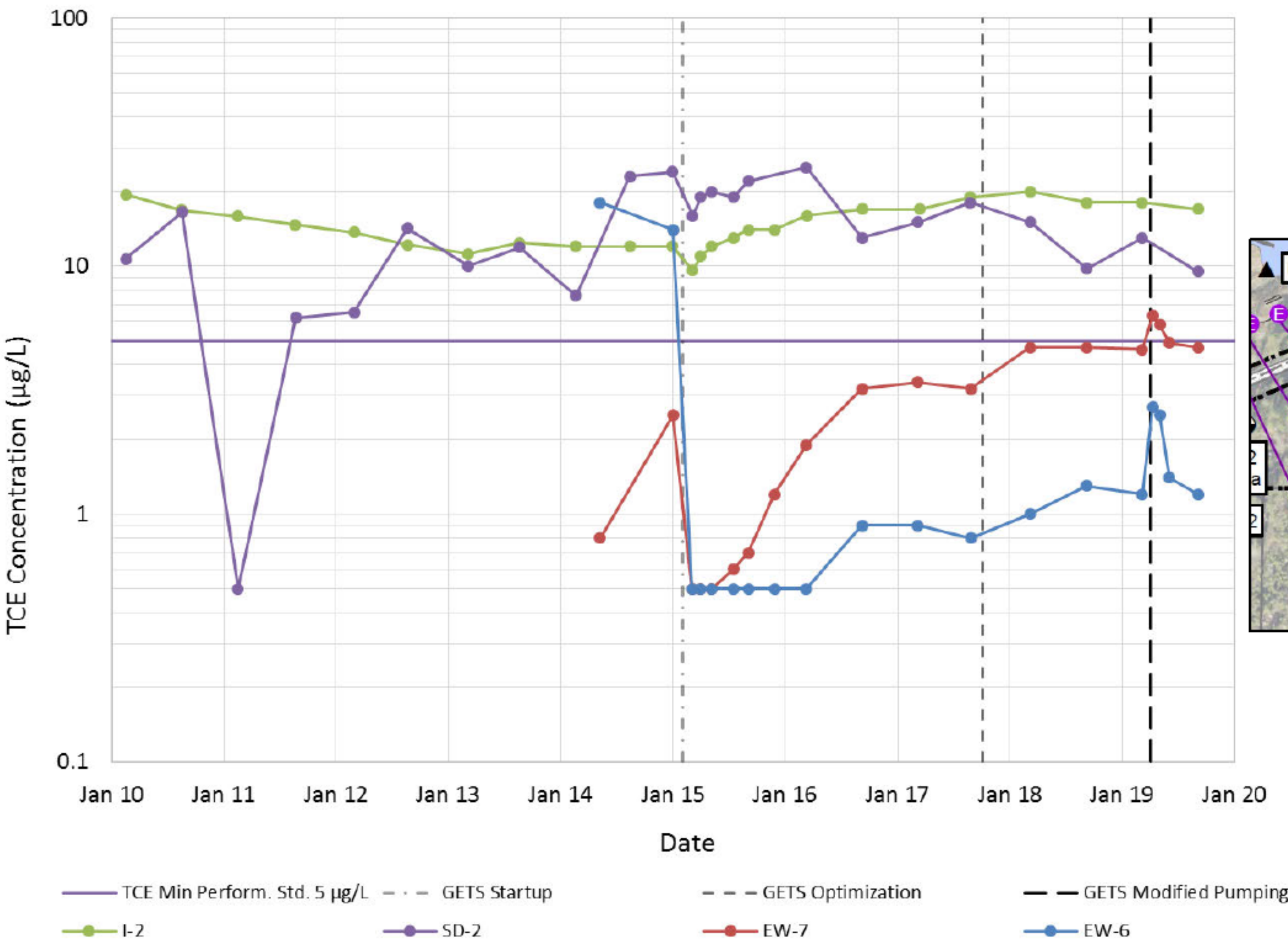
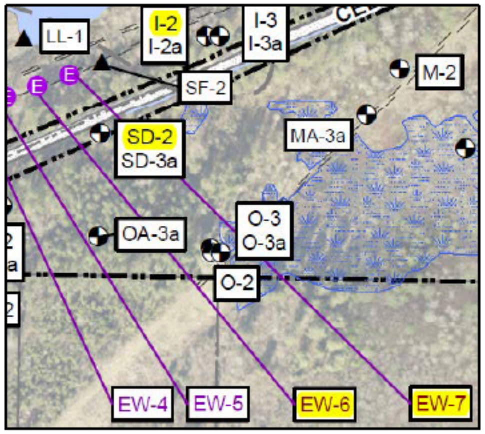
Queen City Farms
Maple Valley, WA

**Cumulative TCE Mass Removal and Influent Volume vs. Time**

Figure
5-16

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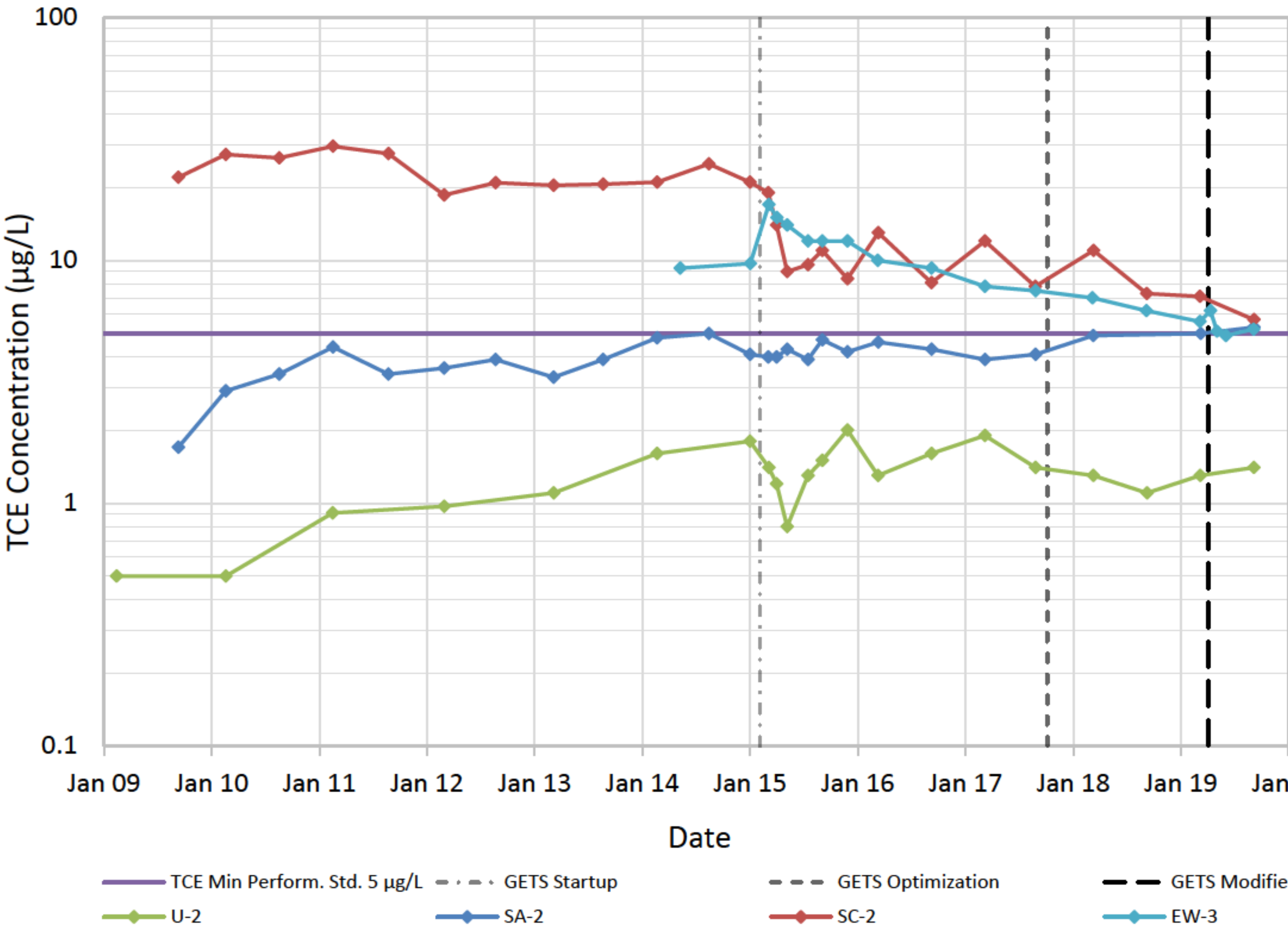
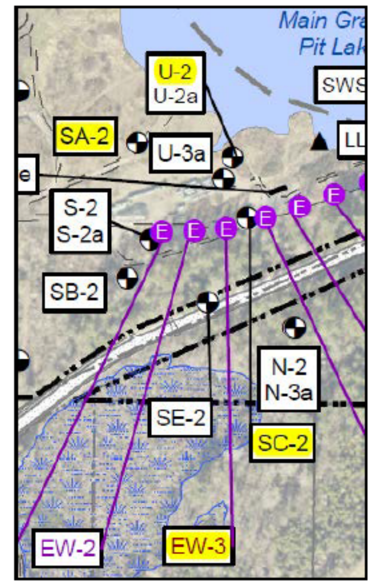
Maple Valley, WA

**TCE Concentrations at Eastern Lobe Wells (I-2, SD-2, EW-7, and EW-6)**

Figure
5-17

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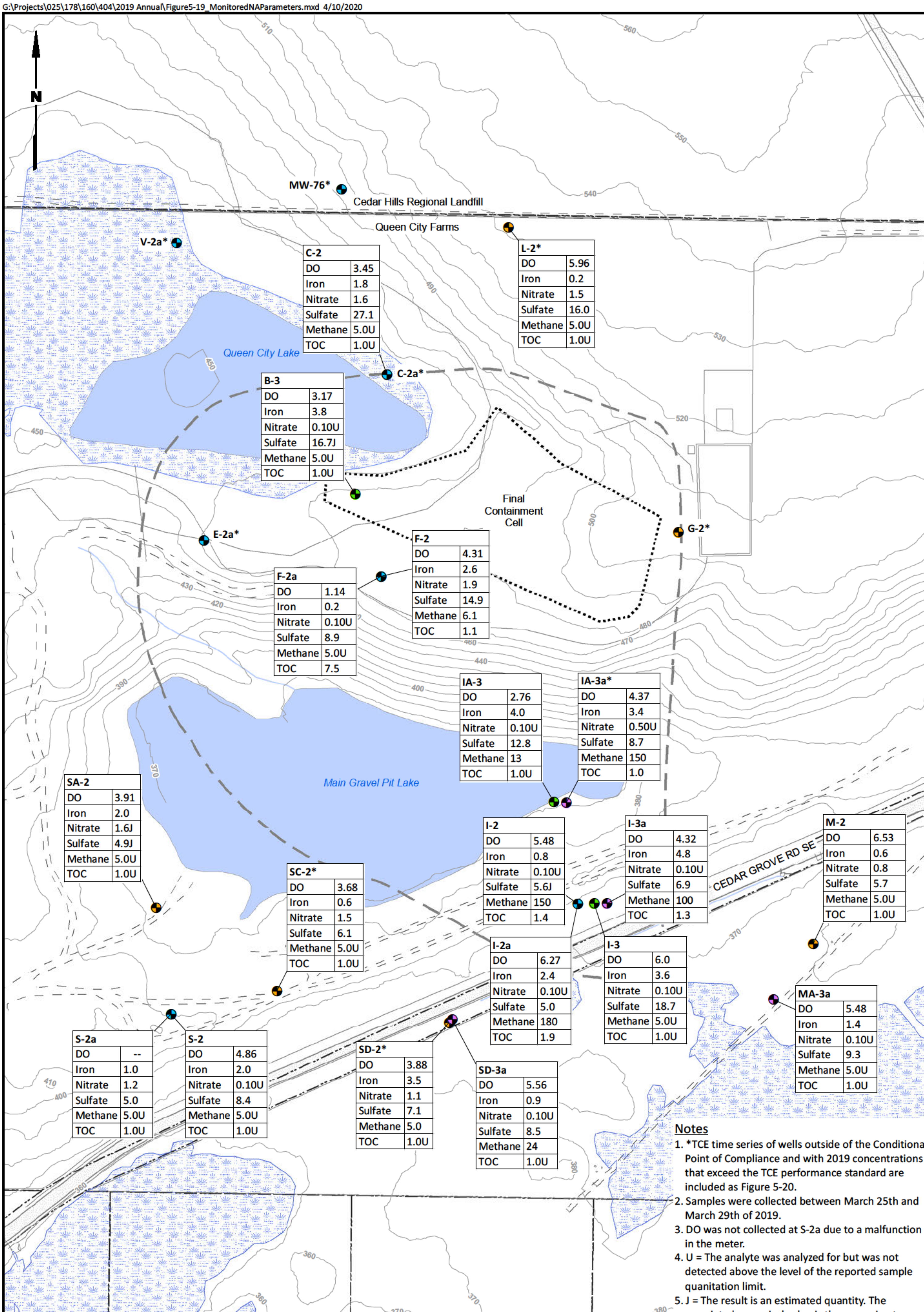
Maple Valley, WA

**TCE Concentrations at Western Lobe Wells (U-2, SA-2, SC-2, and EW-3)**

Figure
5-18

G:\Projects\025\178\160\404\2019 Annual\Figure5-19_MonitoredNAParameters.mxd 4/10/2020




**Notes**

1. *TCE time series of wells outside of the Conditional Point of Compliance and with 2019 concentrations that exceed the TCE performance standard are included as Figure 5-20.
2. Samples were collected between March 25th and March 29th of 2019.
3. DO was not collected at S-2a due to a malfunction in the meter.
4. U = The analyte was analyzed for but was not detected above the level of the reported sample quanitation limit.
5. J = The result is an estimated quantity. The associated numerical value is the approximate concentration of the analyte in the sample.
6. Topographic contour interval is 10 ft. All elevations referenced to NGVD29.
7. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

**Legend**

- Monitoring Well (Aquifer 2)
- Monitoring Well (Aquifer 2a)
- Monitoring Well (Aquifer 3)
- Monitoring Well (Aquifer 3a)
- Final Containment Cell
- Wetland
- Lake
- Conditional Point of Compliance
- Parcels

0 250 500
Scale in Feet

Data Source: King County GIS.

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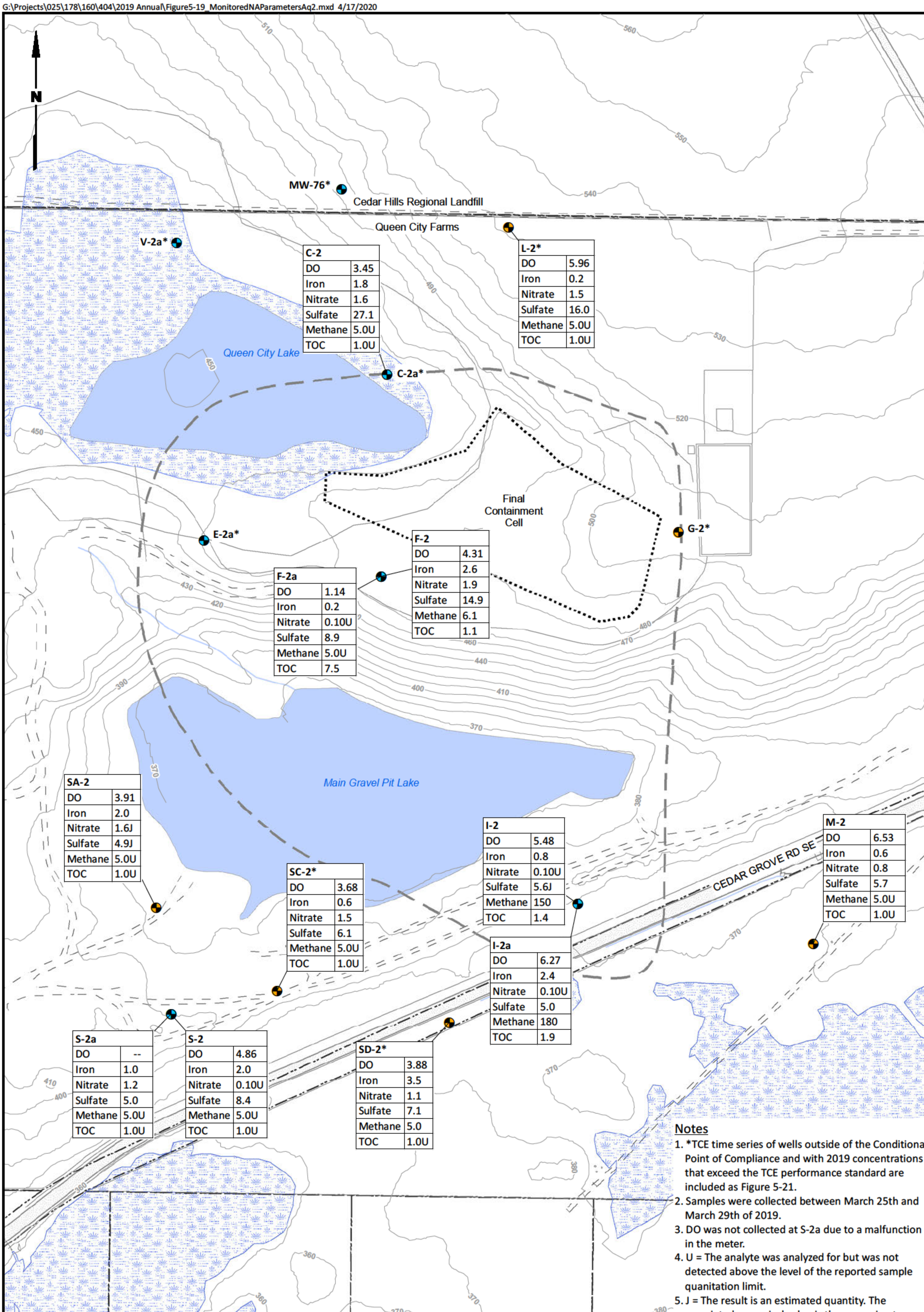
Queen City Farms
Maple Valley, Washington

**Monitored Natural Attenuation Parameters**

Figure 5-19




| C-2 | |
|---|---|
| DO | 3.45 |
| Iron | 1.8 |
| Nitrate | 1.6 |
| Sulfate | 27.1 |
| Methane | 5.0U |
| TOC | 1.0U |

| L-2* | |
|---|---|
| DO | 5.96 |
| Iron | 0.2 |
| Nitrate | 1.5 |
| Sulfate | 16.0 |
| Methane | 5.0U |
| TOC | 1.0U |

| F-2 | |
|---|---|
| DO | 4.31 |
| Iron | 2.6 |
| Nitrate | 1.9 |
| Sulfate | 14.9 |
| Methane | 6.1 |
| TOC | 1.1 |

| F-2a | |
|---|---|
| DO | 1.14 |
| Iron | 0.2 |
| Nitrate | 0.10U |
| Sulfate | 8.9 |
| Methane | 5.0U |
| TOC | 7.5 |

| SA-2 | |
|---|---|
| DO | 3.91 |
| Iron | 2.0 |
| Nitrate | 1.6J |
| Sulfate | 4.9J |
| Methane | 5.0U |
| TOC | 1.0U |

| SC-2* | |
|---|---|
| DO | 3.68 |
| Iron | 0.6 |
| Nitrate | 1.5 |
| Sulfate | 6.1 |
| Methane | 5.0U |
| TOC | 1.0U |

| I-2 | |
|---|---|
| DO | 5.48 |
| Iron | 0.8 |
| Nitrate | 0.10U |
| Sulfate | 5.6J |
| Methane | 150 |
| TOC | 1.4 |

| I-2a | |
|---|---|
| DO | 6.27 |
| Iron | 2.4 |
| Nitrate | 0.10U |
| Sulfate | 5.0 |
| Methane | 180 |
| TOC | 1.9 |

| M-2 | |
|---|---|
| DO | 6.53 |
| Iron | 0.6 |
| Nitrate | 0.8 |
| Sulfate | 5.7 |
| Methane | 5.0U |
| TOC | 1.0U |

| S-2a | |
|---|---|
| DO | -- |
| Iron | 1.0 |
| Nitrate | 1.2 |
| Sulfate | 5.0 |
| Methane | 5.0U |
| TOC | 1.0U |

| S-2 | |
|---|---|
| DO | 4.86 |
| Iron | 2.0 |
| Nitrate | 0.10U |
| Sulfate | 8.4 |
| Methane | 5.0U |
| TOC | 1.0U |

| SD-2* | |
|---|---|
| DO | 3.88 |
| Iron | 3.5 |
| Nitrate | 1.1 |
| Sulfate | 7.1 |
| Methane | 5.0 |
| TOC | 1.0U |

**Notes**

1. *TCE time series of wells outside of the Conditional Point of Compliance and with 2019 concentrations that exceed the TCE performance standard are included as Figure 5-21.
2. Samples were collected between March 25th and March 29th of 2019.
3. DO was not collected at S-2a due to a malfunction in the meter.
4. U = The analyte was analyzed for but was not detected above the level of the reported sample quanitation limit.
5. J = The result is an estimated quantity. The associated numerical value is the approximate concentration of the analyte in the sample.
6. Topographic contour interval is 10 ft. All elevations referenced to NGVD29.
7. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

**Legend**

Monitoring Well (Aquifer 2)
Monitoring Well (Aquifer 2a)
Final Containment Cell
Wetland
Lake
Conditional Point of Compliance
Parcels

Data Source: King County GIS.

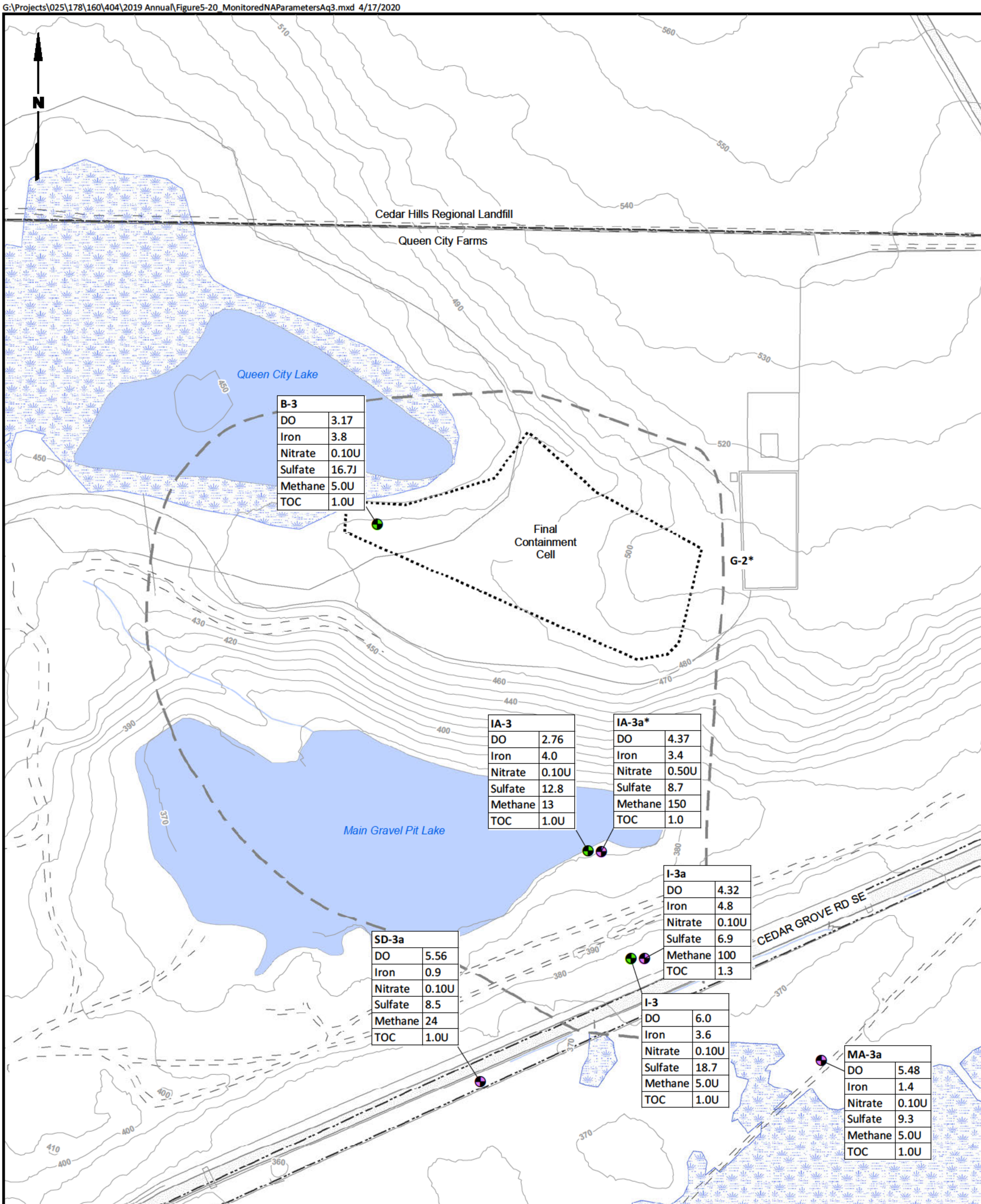
0 250 500
Scale in Feet

Landau Associates

Queen City Farms
Maple Valley, Washington

**Monitored Natural Attenuation Parameters Aquifer 2**

Figure 5-19




## Notes

1. *TCE time series of wells outside of the Conditional Point of Compliance and with 2019 concentrations that exceed the TCE performance standard are included as Figure 5-21.
2. Samples were collected between March 25th and March 29th of 2019.
3. U = The analyte was analyzed for but was not detected above the level of the reported sample quanitation limit.
4. J = The result is an estimated quantity. The associated numerical value is the approximate concentration of the analyte in the sample.
5. Topographic contour interval is 10 ft. All elevations referenced to NGVD29.
6. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

## Legend

- Monitoring Well (Aquifer 3)
- Monitoring Well (Aquifer 3a)
- Final Containment Cell
- Wetland
- Lake
- Conditional Point of Compliance
- Parcels

Data Source: King County GIS.

0 250 500
Scale in Feet

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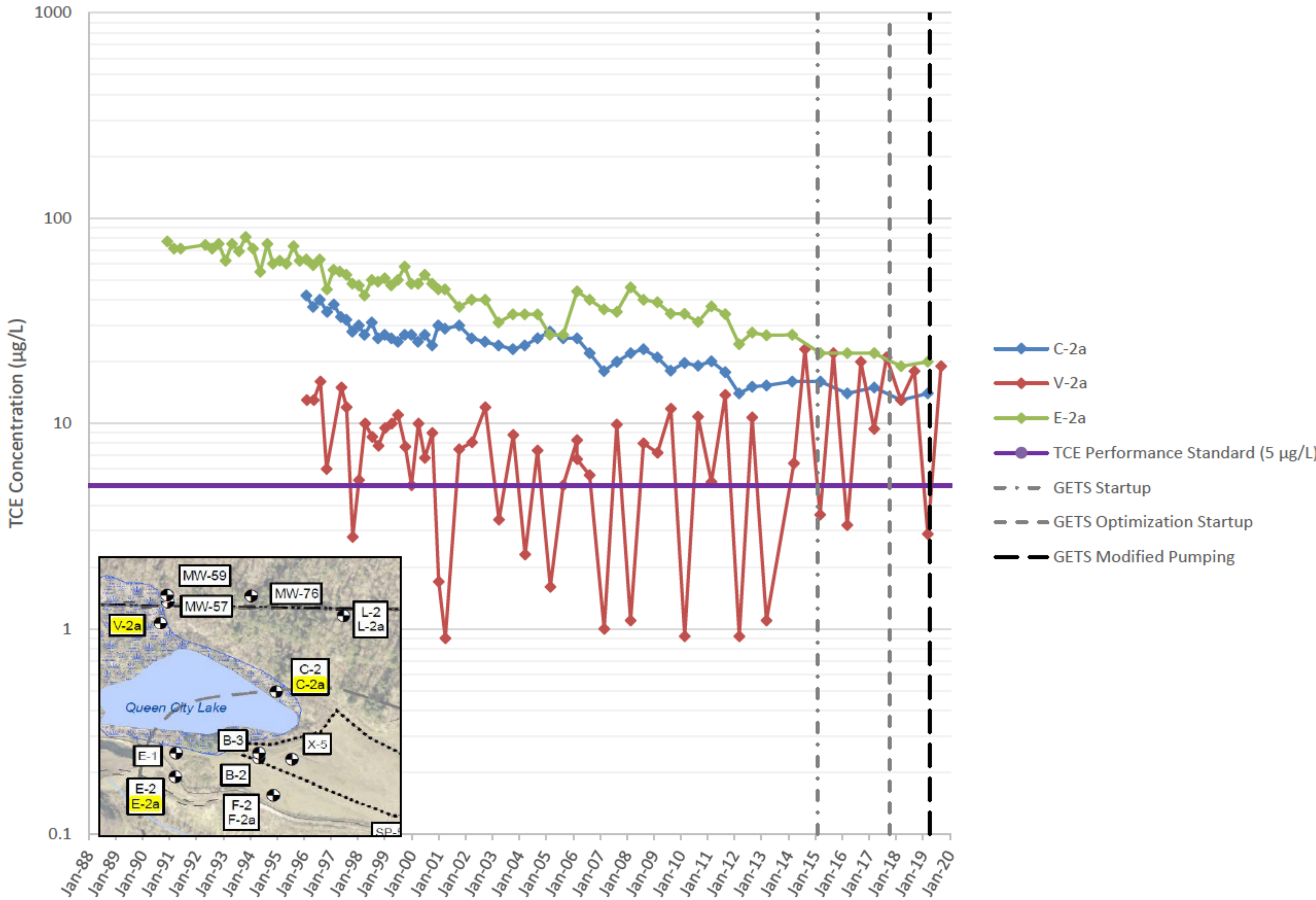
Maple Valley, Washington

**Monitored Natural Attenuation Parameters Aquifer 3**

Figure 5-20

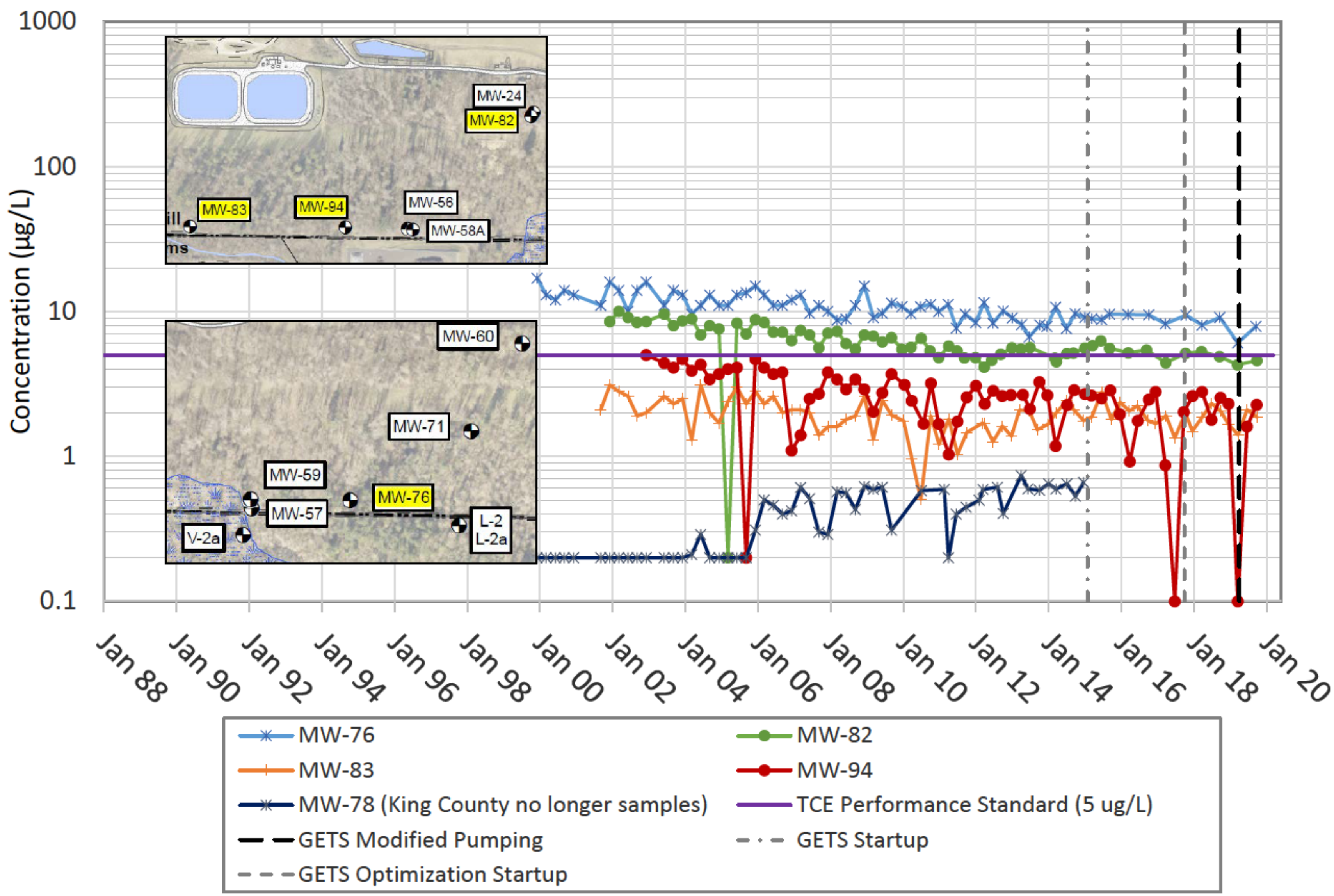



Landau Associates

Queen City Farms
Maple Valley, WA

**TCE at Select Aquifer 2a Wells: Plume Core**

Figure
6-1




Notes: MW-78 was decommissioned in 2015 and its location is not shown on the map.

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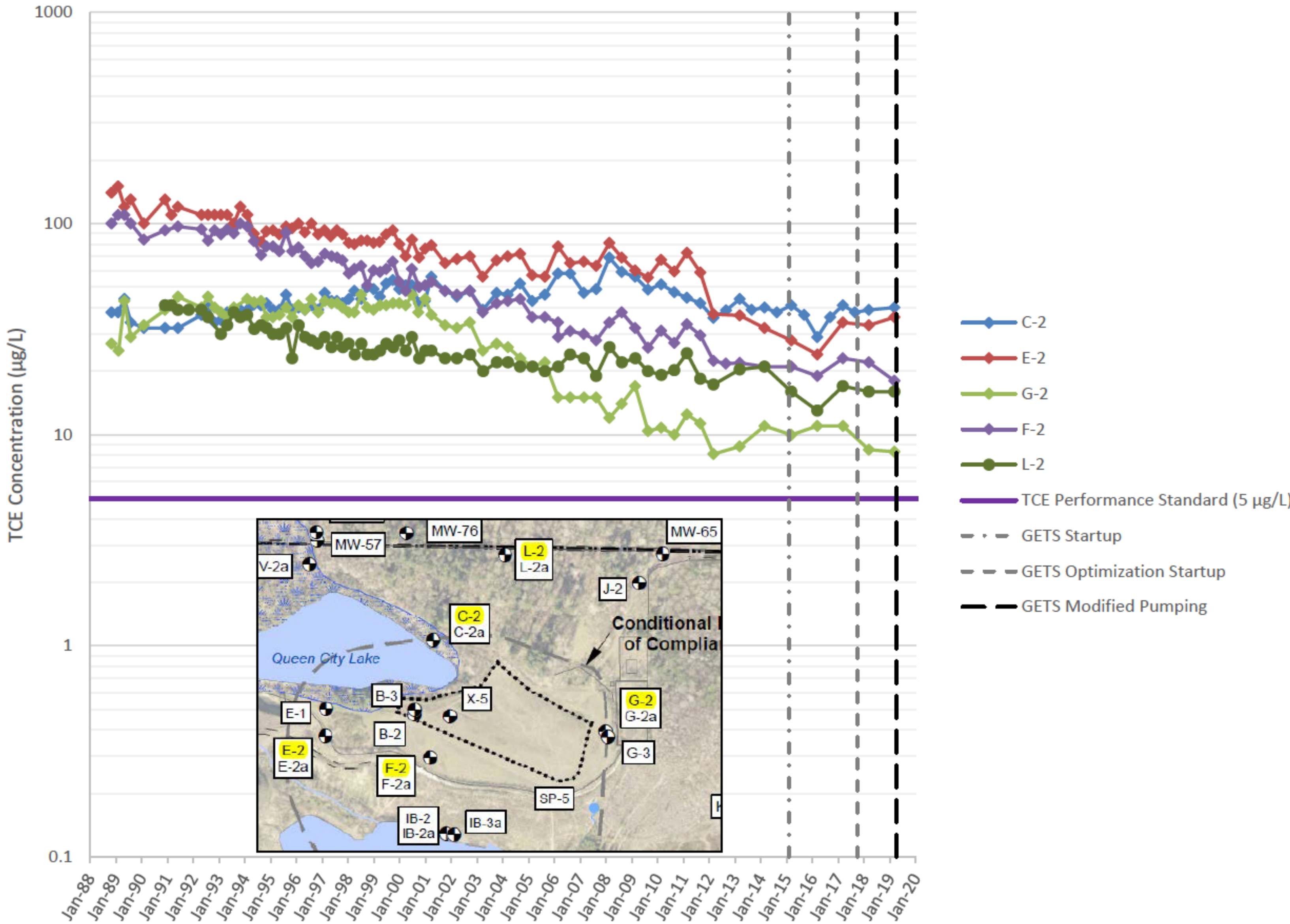
| Queen City Farms<br>Maple Valley, WA | **TCE at Select Aquifer 2a Wells: CHRL** | Figure<br>6-2 |
|---|---|---|

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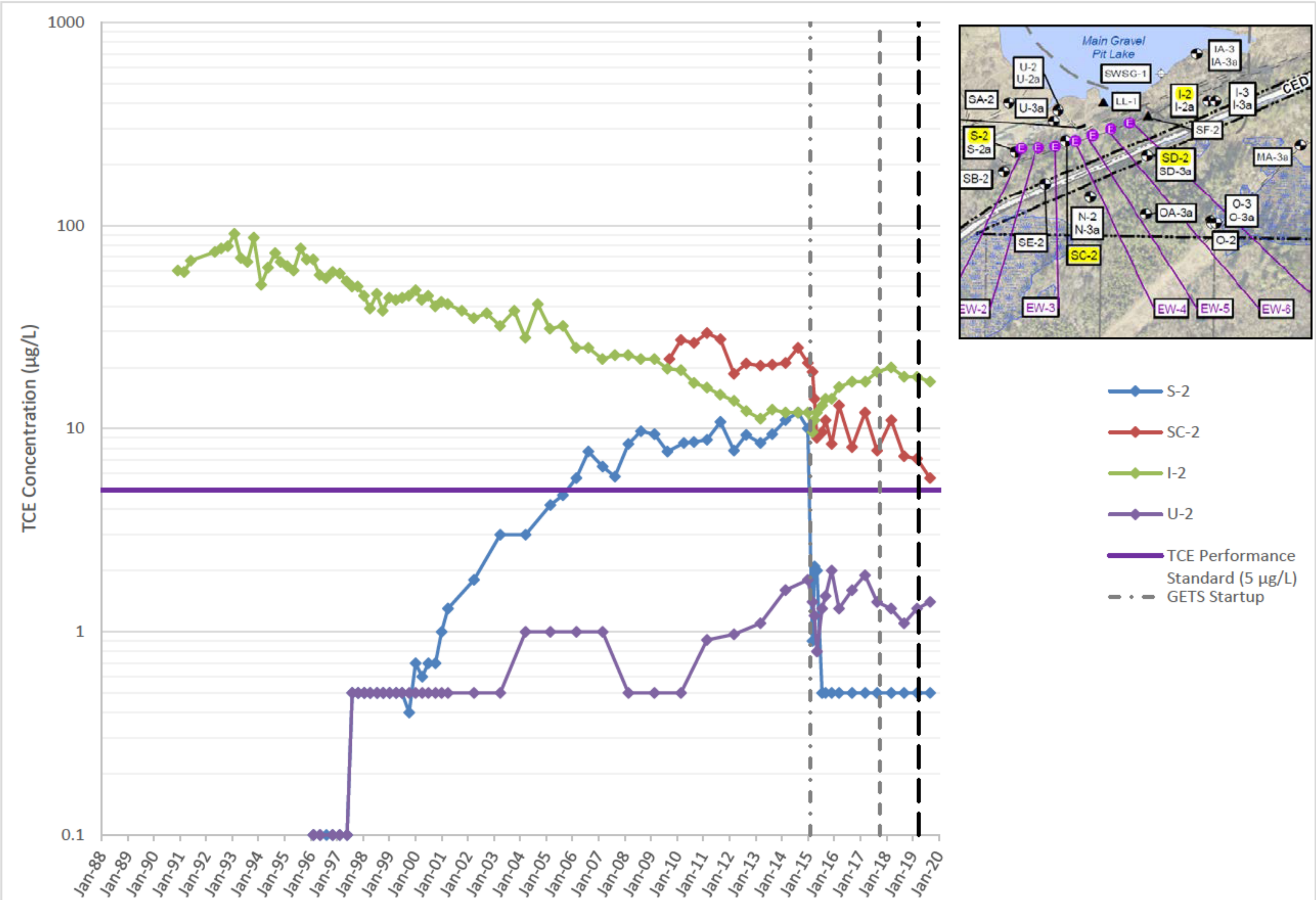
| Queen City Farms<br>Maple Valley, WA | TCE at Select Aquifer 2 Wells: North | Figure<br>6-3 |
|---|---|---|

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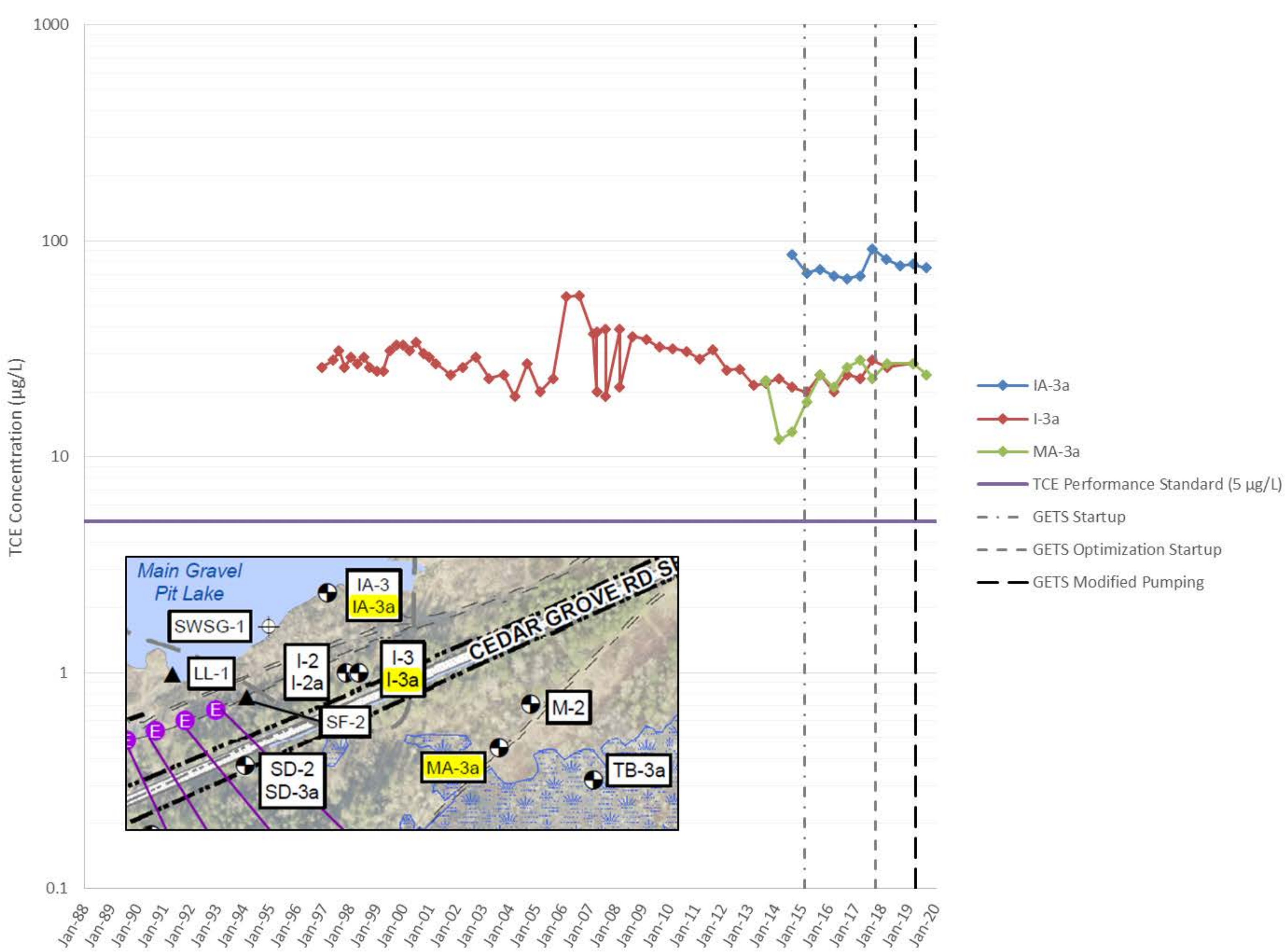
| Queen City Farms Maple Valley, WA | TCE at Select Aquifer 2 Wells: South | Figure 6-4 |
|---|---|---|




Queen City Farms
Maple Valley, WA

**TCE at Select Aquifer 3a Wells**

Figure
6-5

LANDAU ASSOCIATES

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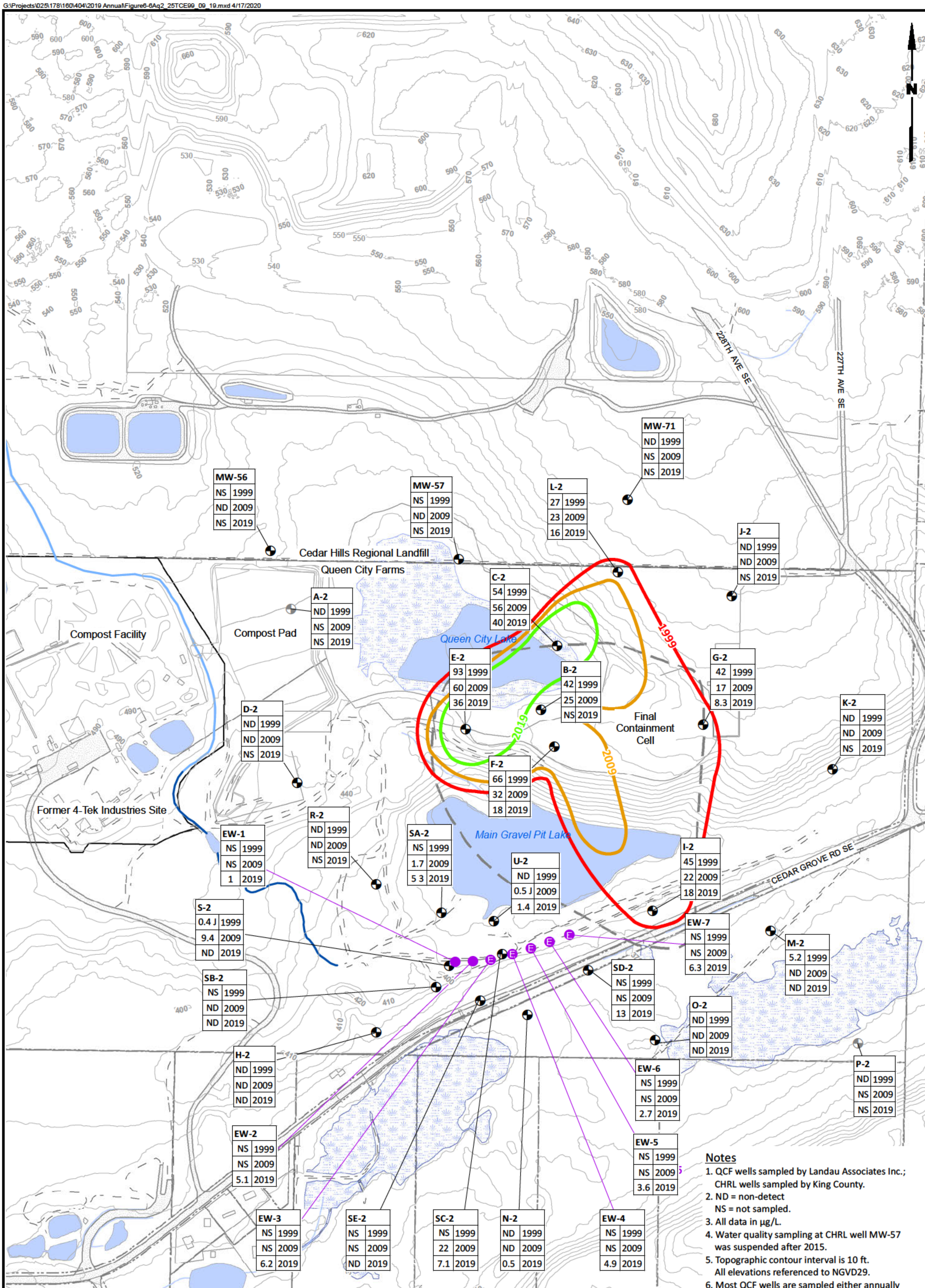


## Legend

- EW-1 Extraction Well Location
- B-2 Monitoring Well Location
- P-2 Monitoring Well Location (Abandoned)
- Final Containment Cell
- 25 µg/L TCE Contour - 1999
- 25 µg/L TCE Contour - 2009
- 25 µg/L TCE Contour - 2019
- Tributary 316A
- Engineered Drainage Channel
- Conditional Point of Compliance
- Wetland
- Lake
- Tax Parcel

## Notes

1. QCF wells sampled by Landau Associates Inc.; CHRL wells sampled by King County.
2. ND = non-detect
   NS = not sampled.
3. All data in µg/L.
4. Water quality sampling at CHRL well MW-57 was suspended after 2015.
5. Topographic contour interval is 10 ft. All elevations referenced to NGVD29.
6. Most QCF wells are sampled either annually (March) or semi-annually (March and September). The larger of the two concentration values is presented for wells that are sampled semi-annually. Where concentration values are the same for both semi-annual events, the annual sampling date is presented.
7. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Data Sources: Barghausen 2007; King County 2015.

0 500 1,000
Scale in Feet

LANDAU ASSOCIATES

Queen City Farms
Maple Valley, Washington

**Aquifer 2**
**TCE Plume - 25 µg/L Contour**
**1999, 2009, 2019**

Figure
6-6

**Table 3-1**
**Groundwater Extraction and Treatment System Shutdown Periods in 2019**
**Queen City Farms**
**Maple Valley, Washington**

| Shutdown Time | Restart Time | Shutdown Period Length (day:hours:minutes) | Reason |
|---|---|---|---|
| 1/6/2019 23:58 | 1/7/2019 5:48 | 1:05:48 | Power Outage |
| 1/8/2019 9:50 | 1/8/2019 10:05 | 0:00:15 | Power Outage |
| 3/18/2019 8:30 | 3/18/2019 15:00 | 0:07:30 | Replacing Transducer in EW-5 |
| 4/11/2019 7:00 | 4/11/2019 18:00 | 0:11:00 | Replacing Pumps in EW-2 and EW-4 |
| 4/23/2019 6:10 | -- | -- | Modified Pumping - EW-1, EW-2, EW-6, EW-7 shutdown |
| 4/29/2019 10:00 | 4/29/2019 11:45 | 0:01:45 | System Alarm |
| 5/24/2019 3:35 | 5/24/2019 5:15 | 0:01:40 | System Alarm |
| 5/24/2019 11:18 | 5/24/2019 12:48 | 0:01:30 | Communications Loss |
| 11/19/2019 5:00 | 11/19/2019 9:00 | 0:04:00 | Power Outage |
| 12/16/2019 15:00 | 12/20/2019 9:36 | 3:18:36 | EW-4 Sump not Operational |

# Table 3-2
## Groundwater Extraction and Treatment System Average Flow Rates in 2019
## Queen City Farms
## Maple Valley, Washington

| Extraction Well ID | Spring (a) | Summer (a) | Fall (a) | Winter (a) |
|---|---|---|---|---|
| EW-1 | 10 | 0 | 0 | 0 |
| EW-2 | 3 | 0 | 0 | 0 |
| EW-3 | 12 | 11 | 10 | 13 |
| EW-4 | 8 | 10 | 9 | 9 |
| EW-5 | 17 | 17 | 17 | 15 |
| EW-6 | 6 | 0 | 0 | 0 |
| EW-7 | 13 | 0 | 0 | 0 |
| System Total Flow Rate (b) | 69 | 39 | 36 | 37 |

**Notes:**

(a) Spring is defined here as March, April, and May 2019. Summer is defined here as June, July, and August 2019. Fall is defined here as September, October, and November 2019. Winter is defined here as December 2019 through January and February 2020.

(b) System total flows may not equal the sum of extraction well total flows because average total flows are computed from the GETS total flow meter FIT-201, while average extraction well flows are calculated from individual well flow meters.

1. All values in gallons per minute (gpm).
2. Pumping at EW-1, EW-2, EW-6 and EW-7 was discontinued on April 23rd, 2019.

**Abbreviations/Acronyms**

GETS = Groundwater Extraction and Treatment System

ID = identification

**Table 3-3**
**Vapor Intrusion Screening of Shallow Groundwater Trichloroethene**
**Queen City Farms**
**Maple Valley, Washington**

| Well ID (a) | Max TCE Concentration (2019) (µg/L) (b) | Exceed Chronic Residential TCE SL of 2.0 µg/L? (c) | Exceed Acute Residential TCE SL of 8.4 µg/L? (c) | Exceed Chronic Industrial TCE SL of 37 µg/L? (c) | Exceed Acute Industrial TCE SL of 35 µg/L? (c) |
|---|---|---|---|---|---|
| D-2a | **1** | No | No | No | No |
| E-1 | ND | No | No | No | No |
| H-2 | ND | No | No | No | No |
| H-2a | ND | No | No | No | No |
| I-2 | **18** | Yes | Yes | No | No |
| I-2a | **1** | No | No | No | No |
| IB-2 | NS | -- | -- | -- | -- |
| IB-2a | ND | No | No | No | No |
| K-2 | NS | -- | -- | -- | -- |
| M-2 | ND | No | No | No | No |
| N-2 | **0.5** | No | No | No | No |
| O-2 | ND | No | No | No | No |
| R-2 | NS | -- | -- | -- | -- |
| R-2a | NS | -- | -- | -- | -- |
| S-2 | ND | No | No | No | No |
| S-2a | **3.5** | Yes | No | No | No |
| SA-2 | **5.3** | Yes | No | No | No |
| SB-2 | ND | No | No | No | No |
| SC-2 | **7.1** | Yes | No | No | No |
| SD-2 | **13** | Yes | Yes | No | No |
| SE-2 | ND | No | No | No | No |
| U-2 | **1.4** | No | No | No | No |
| U-2a | NS | -- | -- | -- | -- |
| V-2a | **19** | Yes | Yes | No | No |
| (b) | ND | No | No | No | No |
| | **Number of Exceedances:** | 6 | 3 | 0 | 0 |

**Notes:**

(a) Only shallow monitoring wells identified in the 2015 VI Assessment were included in the 2019 VI Assessment.

(b) TCE concentrations are most recent as of September 2019. At wells that were sampled twice in 2019, the maximum concentration from 2019 is used.

(c) The shallow groundwater VI screening criteria for various land uses are:
- 2.0 µg/L TCE for groundwater protective of residential indoor air (chronic exposure).
- 8.4 µg/L TCE for groundwater protective of residential indoor air (acute exposure).
- 37.0 µg/L TCE for groundwater protective of industrial indoor air (chronic exposure).
- 35.0 µg/L TCE for groundwater protective of industrial indoor air (acute exposure).

1. Of the four COCs, only cDCE and TCE were detected. Between these two, only TCE is assessed for VI; cDCE does not have screening criteria.

**Bold** = detected analyte
Yellow box = TCE detection exceeds applicable SL.
Box = Exceedance at well screened at water table surface.

**Abbreviations/Acronyms:**

cDCE = cis-1,2-dichloroethene
COC = constituent of concern
ID = identification
µg/L = micrograms per liter
ND = not detected
NS = not sampled
SL = screening level
TCE = trichlorothene
VI = vapor intrusion
-- = not applicable

**Table 4-1**
**Comprehensive Well List**
**Queen City Farms**
**Maple Valley, Washington**

| Well ID | Aquifer | Status | Date Installed | Northing | Easting | Ground Elevation (ft) | Top of Casing Elevation (ft) | Total Depth of Well (ft bgs) | Top of Screen Elevation (ft) | Bottom of Screen Elevation (ft) |
|---|---|---|---|---|---|---|---|---|---|---|
| **Queen City Farms** | | | | | | | | | | |
| **Aquifer 1a** | | | | | | | | | | |
| E-1a | 1a | Decommissioned | --- | 166324.80 [a] | 1340153.66 [a] | 458.10 | 461.08 | 35.0 | 433.1 | 423.1 |
| **Aquifer 1** | | | | | | | | | | |
| B-1 | 1 | Decommissioned | 9/1988 | 166303.81 [b] | 1340575.24 [b] | 457.20 | 460.02 | 36 5 | 431.2 | 420.7 |
| E-1 | 1 | Active | 10/1988 | 166324.80 [a] | 1340153.66 [a] | 456.90 | 459.97 | 45 0 | 421.9 | 411.9 |
| MW-1 | 1 | Decommissioned | 7/1986 | 166510.89 [c] | 1341325.97 [c] | 512.00 | 513.94 | 17.5 | --- | 496.4 |
| MW-2 | 1 | Decommissioned | 7/1986 | 166465.89 [c] | 1341242.97 [c] | 498.00 | 500.15 | 16.9 | --- | 483.3 |
| MW-3 | 1 | Decommissioned | 7/1986 | 166577.89 [c] | 1341073.97 [c] | 496.00 | 498.28 | 14.5 | --- | 483.8 |
| MW-4 | 1 | Decommissioned | 9/1986 | 166445.89 [c] | 1340942.97 [c] | 458.00 [d] | 471.54 | 28 3 | --- | 443.2 |
| MW-5 | 1 | Decommissioned | 9/1986 | 166315.89 [c] | 1340862.97 [c] | 471.00 | 473.02 | 52.0 | 416.0 | 411.0 |
| MW-6 | 1 | Decommissioned | 9/1986 | 166256.89 [c] | 1340949.97 [c] | 477.00 | 478.93 | 55.0 | 425.0 | 414.0 |
| MW-7 | 1 | Decommissioned | 9/1986 | 166202.89 [c] | 1341048.97 [c] | 483.00 | 485.72 | 59.0 | 423.0 | 416.0 |
| MW-8 | 1 | Decommissioned | 8/1986 | 166168.89 [c] | 1341145.97 [c] | 487.00 | 490.07 | 50.0 | 435.0 | 429.0 |
| MW-9 | 1 | Decommissioned | 9/1990 | 166284.83 [b] | 1340741.20 [b] | 467.30 | 470.56 | 53.5 | 449.9 | 413.8 |
| MW-10 | 1 | Decommissioned | 10/1990 | 166096.34 [b] | 1340924.73 [b] | 475.20 | 477.92 | 44.6 | 441.1 | 430.6 |
| MW-11 | 1 | Decommissioned | 10/1990 | 166168.33 [b] | 1340854.23 [b] | 478.80 | 481.74 | 57.0 | 447.8 | 421.8 |
| MW-12 | 1 | Decommissioned | 4/1991 | 166057.59 [b] | 1341218.74 [b] | 490.70 | 493.20 | 63.7 | 449.0 | 427.0 |
| X-1 | 1 | Decommissioned | 5/1994 | 166128.27 [b] | 1341121.38 [b] | 492.80 | --- | 79.0 | 444.3 | 413.8 |
| X-2 | 1 | Decommissioned | 6/1994 | 166149.36 [b] | 1341049.40 [b] | 486.30 | --- | 71.5 | 474.3 | 414.8 |
| X-3 | 1 | Decommissioned | 6/1994 | 166205.96 [b] | 1340955.92 [b] | 482.60 | --- | 72.5 | 467.6 | 410.1 |
| X-4 | 1 | Decommissioned | 6/1994 | 166263.85 [b] | 1340817.25 [b] | 475.00 | --- | 76 0 | 457.0 | 399.0 |
| X-5 | 1 | Active | 7/1994 | 166290.49 [b] | 1340717.05 [b] | 467.80 | --- | 72.5 | 438.8 | 395.3 |
| Z-1 | 1 | Decommissioned | 8/1994 | 166238.74 [d] | 1339868.44 [d] | 440.60 | --- | 23.5 | 432.1 | 417.1 |

**Table 4-1**
**Comprehensive Well List**
**Queen City Farms**
**Maple Valley, Washington**

| Well ID | Aquifer | Status | Date Installed | Northing | Easting | Ground Elevation (ft) | Top of Casing Elevation (ft) | Total Depth of Well (ft bgs) | Top of Screen Elevation (ft) | Bottom of Screen Elevation (ft) |
|---|---|---|---|---|---|---|---|---|---|---|
| **Aquifer 2a** | | | | | | | | | | |
| C-2a | 2af [f] | Active | 9/1995 | 166644.51 [a] | 1340642.86 [a] | 456.18 | 458.73 | 116.6 | 350.0 | 339.6 |
| D-2a | 2ae [f] | Active | 10/1995 | 165949.62 [a] | 1339294.99 [a] | 461.17 | 465.36 | 116.9 | 356.3 | 345.9 |
| E-2a | 2af [f] | Active | 11/1990 | 166198.23 [a] | 1340150.41 [a] | 462.50 | 465.24 | 132.1 | 340.5 | 330.4 |
| F-2a | 2ae [f] | Active | 9/1995 | 166106.00 [a] | 1340625.36 [a] | 474.56 | 477.56 | 131.8 | 352.9 | 342.8 |
| G-2a | 2ae [f] | Active | 9/1995 | 166219.72 [a] | 1341427.41 [a] | 504.13 | 507.00 | 149.9 | 364.2 | 354.2 |
| H-2a | 2ae [f] | Active | 11/1995 | 164566.73 [a] | 1339671.03 [a] | 387.20 | 390.22 | 49 5 | 347.2 | 337.7 |
| I-2a | 2af [f] | Active | 9/1990 | 165220.67 [a] | 1341156.16 [a] | 369.40 | 372.37 | 36 0 | 343.4 | 333.4 |
| IB-2a | 2a [f] | Active | 8/2013 | 165746.20 [a] | 1340702.70 [a] | 373.10 | 375.71 | 32.0 | 351.4 | 341.4 |
| J-2a | 2af [f] | Decommissioned | 12/1990 | 166913.51 [a] | 1341580.51 [a] | 538.00 | 540.64 | 196.7 | 346.0 | 341.3 |
| K-2a | 2ae [f] | Decommissioned | 9/1995 | 165982.04 [a] | 1342122.98 [a] | 419.89 | 422.58 | 64.4 | 365.5 | 355.5 |
| L-2a | 2ae [f] | Active | 11/1990 | 167040.32 [a] | 1340969.50 [a] | 530.60 | 533.14 | 184.5 | 355.8 | 346.1 |
| M-2a | 2ae [f] | Decommissioned | 10/1996 | 165113.25 [a] | 1341789.96 [a] | 368.17 | 369.99 | 18 5 | 354.2 | 349.7 |
| N-2a | 2ae [f] | Decommissioned | 8/1995 | 164662.07 [a] | 1340482.08 [a] | 363.08 | 365.75 | 20 0 | 353.1 | 343.1 |
| O-2a | 2ae [f] | Decommissioned | 8/1995 | 164507.65 [a] | 1341170.93 [a] | 364.26 | 367.15 | 26.7 | 347.5 | 337.6 |
| R-2a | 2ae [f] | Active | 8/1995 | 165363.01 [a] | 1339671.03 [a] | 394.56 | 397.48 | 48.5 | 361.0 | 346.1 |
| S-2a | 2ae [f] | Active | 8/1995 | 164923.91 [a] | 1340061.78 [a] | 386.88 | 389.41 | 45.5 | 351.2 | 341.4 |
| T-2 | 2ae [f] | Decommissioned | 8/1995 | 164854.09 [a] | 1342041.07 [a] | 363.21 | 366.15 | 37.1 | 336.5 | 326.1 |
| U-2a | 2af [f] | Active | 8/2011 | 165158.49 [a] | 1340345.82 [a] | 382.40 | 384.89 | 47.7 | 347.2 | 337.2 |
| V-2a | 2af [f] | Active | 9/1995 | 166998.26 [a] | 1340076.83 [a] | 451.80 | 454.80 | 111.6 | 355.6 | 340.2 |

**Table 4-1**
**Comprehensive Well List**
**Queen City Farms**
**Maple Valley, Washington**

| Well ID | Aquifer | Status | Date Installed | Northing | Easting | Ground Elevation (ft) | Top of Casing Elevation (ft) | Total Depth of Well (ft bgs) | Top of Screen Elevation (ft) | Bottom of Screen Elevation (ft) |
|---|---|---|---|---|---|---|---|---|---|---|
| **Aquifer 2** | | | | | | | | | | |
| A-2 | 2 | Decommissioned | 10/1988 | 166842.77 [a] | 1339213.13 [a] | 469.50 | 472.47 | 159.6 | 322.5 | 309.9 |
| B-2 | 2 | Active | 9/1988 | 166298.94 [a] | 1340556.60 [a] | 457.40 | 475.69 | 147.9 | 321.5 | 309.5 |
| C-2 | 2 | Active | 9/1988 | 166644.51 [a] | 1340642.86 [a] | 455.60 | 458.81 | 144.5 | 319.1 | 311.1 |
| D-2 | 2 | Active | 10/1988 | 165935.78 [a] | 1339298.11 [a] | 460.79 | 464.97 | 155.6 | 323.3 | 306.8 |
| E-2 | 2 | Active | 9/1988 | 166198.23 [a] | 1340150.41 [a] | 463.00 | 465.85 | 155.0 | 315.0 | 308.0 |
| F-2 | 2 | Active | 9/1988 | 166101.55 [a] | 1340627.10 [a] | 474.50 | 477.39 | 165.0 | 324.5 | 309.5 |
| G-2 | 2 | Active | 10/1988 | 166219.72 [a] | 1341427.41 [a] | 505.00 | 507.82 | 179.6 | 335.4 | 325.4 |
| H-2 | 2 | Active | 9/1988 | 164566.73 [a] | 1339671.03 [a] | 386.50 | 389.73 | 86.0 | 315.5 | 300.5 |
| I-2 | 2 | Active | 9/1990 | 165220.67 [a] | 1341156.16 [a] | 369.30 | 372.08 | 55.6 | 324.5 | 313.7 |
| IB-2 | 2 | Active | 8/2013 | 165742.90 [a] | 1340719.70 [a] | 373.30 | 375.56 | 62.5 | 320.8 | 311.1 |
| J-2 | 2 | Active | 11/1990 | 166913.51 [a] | 1341580.51 [a] | 539.10 | 541.77 | 213.2 | 336.1 | 325.9 |
| K-2 | 2 | Active | 11/1990 | 165982.04 [a] | 1342122.98 [a] | 420.60 | 423.16 | 79.9 | 345.5 | 340.7 |
| L-2 | 2 | Active | 11/1990 | 167040.32 [a] | 1340969.50 [a] | 530.30 | 532.97 | 220.0 | 321.3 | 310.3 |
| M-2 | 2 | Active | 7/1991 | 165113.25 [a] | 1341789.96 [a] | 368.80 | 371.77 | 40.6 | 338.2 | 328.2 |
| MW-71 | 2 | active | 10/1995 | 167428.32 [j] | 1341020.44 [j] | 544.67 | 547.47 | 243.0 | 311.4 | 301.7 |
| N-2 | 2 | Active | 5/1991 | 164662.07 [a] | 1340482.08 [a] | 364.20 | 367.26 | 64.5 | 309.7 | 299.7 |
| O-2 | 2 | Active | 5/1991 | 164507.65 [a] | 1341170.93 [a] | 363.00 | 366.64 | 61.8 | 311.0 | 301.2 |
| P-2 | 2 | Decommissioned | 9/1991 | 164507.65 [a] | 1342258.60 [a] | 383.50 | 386.50 | 46 3 | 344.4 | 337.2 |
| R-2 | 2 | Active | 8/1995 | 165363.01 [a] | 1339671.03 [a] | 394.48 | 397.14 | 92.0 | 312.5 | 302.5 |
| RD-1 | 2 | Boring only | 9/2009 | 165380.10 [a] | 1340080.30 [a] | 369.11 | --- | --- | --- | --- |
| RD-2 | 2 | Boring only | 9/2009 | 155288.70 [a] | 1340291.60 [a] | 370.13 | --- | --- | --- | --- |
| S-2 | 2 | Active | 8/1995 | 164929.15 [a] | 1340107.35 [a] | 387.36 | 389.77 | 88.5 | 308.9 | 298.9 |
| SA-2 | 2 | Active | 9/2009 | 165206 94 [a] | 1340016.67 [a] | 376.43 | 378.14 | 72.0 | 314.9 | 304.4 |
| SB-2 | 2 | Active | 9/2009 | 164810.47 [a] | 1339992.54 [a] | 396.15 | 398.91 | 97.0 | 309.7 | 299.2 |
| SC-2 | 2 | Active | 9/2009 | 164986.86 [a] | 1340347.036 [a] | 383.75 | 386.16 | 76.5 | 317.3 | 307.3 |
| SD-2 | 2 | Active | 12/2009 | 164900.87 [a] | 1340806.78 [a] | 364.47 | 367.77 | 55.5 | 319.5 | 309.0 |
| SE-2 | 2 | Active | 12/2009 | 164752.31 [a] | 1340208.23 [a] | 362.39 | 365.28 | 59.5 | 313.4 | 302.9 |
| SF-2 | 2 | Active | 5/2014 | 165134.45 [a] | 1340814.91 [a] | 389.13 | 391.06 | 67.9 | 326.2 | 321.2 |
| U-2 | 2 | Active | 8/1995 | 165165.62 [a] | 1340302.14 [a] | 381.87 | 384.50 | 77.8 | 314.1 | 304.1 |

**Table 4-1**
**Comprehensive Well List**
**Queen City Farms**
**Maple Valley, Washington**

| Well ID | Aquifer | Status | Date Installed | Northing | Easting | Ground Elevation (ft) | Top of Casing Elevation (ft) | Total Depth of Well (ft bgs) | Top of Screen Elevation (ft) | Bottom of Screen Elevation (ft) |
|---|---|---|---|---|---|---|---|---|---|---|
| **Aquifer 3a** | | | | | | | | | | |
| I-3a | 3a | Active | 11/1996 | 165221.24 [a] | 1341200.57 [a] | 369.44 | 372.13 | 72.7 | 307.2 | 296.7 |
| IA-3a | 3a | Active | 8/2011 | 165479.20 [a] | 1341077.50 [a] | 369.78 | 374.91 | 77.5 | 302.0 | 292.0 |
| IB-3a | 3a | Active | 8/2013 | 165740.60 [a] | 1340737.30 [a] | 373.50 | 375.43 | 74 5 | 304.3 | 299.3 |
| MA-3a | 3a | Active | 8/2013 | 164963.00 [a] | 1341683.00 [a] | 363.80 | 365.80 | 52 5 | 316.6 | 311.6 |
| N-3a | 3a | Active | 10/1996 | 164663.81 [a] | 1340488.83 [a] | 363.29 | 365.99 | 79.5 | 293.8 | 283.8 |
| O-3a | 3a | Active | 8/1997 | 164509.50 [a] | 1341203.46 [a] | 364.00 | 366.80 | 78.3 | 296.0 | 285.7 |
| OA-3a | 3a | Active | 8/2016 | 164565.03 [a] | 1340802.20 [a] | 373.76 | 376.29 | 84.0 | 295.0 | 289.9 |
| SD-3a | 3a | Active | 8/2013 | 164909.90 [a] | 1340818.70 [a] | 364.90 | 367.50 | 73.0 | 297.2 | 292.2 |
| T-3a | 3a | Decommissioned | 11/1996 | 164851.87 [a] | 1342006.82 [a] | 362.90 | 365.59 | 52.6 | 320.3 | 310.3 |
| TB-3a | 3a | Active | 8/2014 | 164874.50 [a] | 1342070.781 [a] | 362.91 | 365.88 | 51 0 | 316.9 | 311.9 |
| U-3a | 3a | Active | 11/1996 | 165102.61 [a] | 1340276.66 [a] | 382.15 | 385.00 | 93.0 | 299.2 | 289.2 |
| **Aquifer 3** | | | | | | | | | | |
| B-3 | 3 | Active | 7/1988 | 166322.60 [a] | 1340557.30 [a] | 456.60 | 473.96 | 194.5 | 273.6 | 262.1 |
| D-3 | 3 | Active | 8/1988 | 165944.99 [a] | 1339281.44 [a] | 461.19 | 463.85 | 210.1 | 262.2 | 252.2 |
| H-3 | 3 | Active | 8/1988 | 164562.54 [a] | 1339633.39 [a] | 387.00 | 389.89 | 144.0 | 256.0 | 243.0 |
| I-3 | 3 | Active | 5/1989 | 165219.31 [a] | 1341157.17 [a] | 369.50 | 372.23 | 109.8 | 270.0 | 259.7 |
| IA-3 | 3 | Active | 8/2011 | 165495.00 [a] | 1341091.80 [a] | 369.20 | 374.31 | 95 0 | 284.2 | 274.2 |
| O-3 | 3 | Active | 8/1997 | 164508.53 [a] | 1341175.50 [a] | 364.34 | 367.24 | 113.1 | 261.3 | 251.3 |
| **Aquifer 4** | | | | | | | | | | |
| G-3 | 4 [g] | Active | 9/1988 | 166197.23 [a] | 1341437.82 [a] | 503.50 | 505.98 | 211.0 | 296.5 | 292.5 |
| Q-2 | 4 [g] | Decommissioned | 9/1991 | 165181.73 [a] | 1342458.68 [a] | 364.60 | 367.60 | 41 5 | 333.1 | 323.1 |
| **Groundwater Extraction and Treatment System** | | | | | | | | | | |
| EW-1 | 2 | Active | 4/2014 | 164946.41 [a] | 1340095.37 [a] | 385.87 | 382.06 | 86 5 | 314.4 | 299.4 |
| EW-2 | 2 | Active | 4/2014 | 164950.39 [a] | 1340190.92 [a] | 385.21 | 381.36 | 82 5 | 317.7 | 302.7 |
| EW-3 | 2 | Active | 4/2014 | 164957.47 [a] | 1340286.13 [a] | 384.42 | 380.96 | 79.7 | 319.7 | 304.7 |
| EW-4 | 2 | Active | 4/2014 | 164988.53 [a] | 1340402.34 [a] | 384.92 | 381.71 | 79 0 | 320.9 | 305.9 |
| EW-5 | 2 | Active | 5/2014 | 165019.81 [a] | 1340501.92 [a] | 387.84 | 384.29 | 80.9 | 321.9 | 306.9 |
| EW-6 | 2 | Active | 5/2014 | 165054.63 [a] | 1340603.00 [a] | 387.08 | 383.62 | 80 5 | 321.6 | 306.6 |
| EW-7 | 2 | Active | 5/2014 | 165091.95 [a] | 1340709.52 [a] | 386.49 | 383.42 | 78.1 | 323.4 | 308.4 |

**Table 4-1**
**Comprehensive Well List**
**Queen City Farms**
**Maple Valley, Washington**

| Well ID | Aquifer | Status | Date Installed | Northing | Easting | Ground Elevation (ft) | Top of Casing Elevation (ft) | Total Depth of Well (ft bgs) | Top of Screen Elevation (ft) | Bottom of Screen Elevation (ft) |
|---|---|---|---|---|---|---|---|---|---|---|
| **Surface Water** | | | | | | | | | | |
| LL-1 | N/A | Active | 5/2014 | 165214.85 [a] | 1340559.012 [a] | 370.48 | 373.02 | 14.2 | 366.3 | 356.3 |
| QCF Spring | N/A | Active | NA | 164537.03 [h] | 1339544.38 [h] | 387.44 | NA | NA | NA | NA |
| SWSG-1 | N/A | Active | 7/2/2013 | 165379.91 [a] | 1340891.47 [a] | 361.48 | NA | NA | NA | NA |
| SP-5 | N/A | Active | NA | 165843.39 [h] | 1341376.50 [h] | 428.51 | NA | NA | NA | NA |
| **Offsite** | | | | | | | | | | |
| (b) (LR) | 2ae | Active | 7/1982 | 164376.40 [i] | 1339376.17 [i] | 382.20 | --- | 40 0 | 342.2 [j] | 342.2 |
| (b) (LM) | 3 | Decommissioned | 6/1988 | 163552.88 [i] | 1338702.56 [i] | 364.65 | --- | 95 0 | 279.7 | 269.7 |
| (b) (LM) | 4 [g] | Active | 5/1996 | 163552.88 [i] | 1338702.56 [i] | 364.65 | --- | 158.0 | 222.7 | 206.7 |
| **Cedar Hills Regional Landfill** | | | | | | | | | | |
| **Aquifer 2a** | | | | | | | | | | |
| MW-60 | 2af | Water Level Only | 9/1991 | 167789.00 [m] | 1341232.72 [m] | 564.81 | 567.15 | 239.0 | 334.8 | 325.8 |
| MW-70 | 2af | Decommissioned | 5/1993 | 168623.28 [m] | 1338565.53 [m] | 527.85 | 530.57 | 218.8 | 322.8 | 309.1 |
| MW-76 | 2af | Active | 10/1999 | 167131.84 [m] | 1340466.16 [m] | 489.76 | 491.71 | 148.2 | 351.1 | 341.6 |
| MW-77 | 2af | Decommissioned | 10/1999 | 168899.89 [m] | 1340124.79 [m] | 550.47 | 552.67 | 239.5 | 320.5 | 311.0 |
| MW-78 | 2af | Decommissioned | 10/1999 | 168933.47 [m] | 1339021.67 [m] | 535.34 | 537.35 | 224.4 | 320.5 | 311.0 |
| MW-82 | 2af | Active | 11/2000 | 167657.36 [m] | 1339667.46 [m] | 472.78 | 474.85 | 133.4 | 348.9 | 339.4 |
| MW-83 | 2ae | Active | 10/2000 | 167163.47 [m] | 1338065.34 [m] | 494.49 | 496.81 | 153.8 | 350.2 | 340.7 |
| MW-94 | 2ae | Active | 7/2002 | 167161.36 [m] | 1338805.22 [m] | 493.22 | 495.51 | 144.7 | 357.2 | 348.5 |
| MW-95 | 2af | Active | 7/2002 | 169344.31 [m] | 1337452.81 [m] | 568.60 | 571.54 | 262.7 | 314.6 | 305.9 |
| **Aquifer 2** | | | | | | | | | | |
| MW-56 | 2 | Active | 10/1988 | 167168.28 [m] | 1339104.76 [m] | 479.15 | 480.33 | 166.0 | 323.2 | 313.2 |
| MW-57 | 2 | Water Level Only | 8/1988 | 167108.56 [m] | 1340114.51 [m] | 455.65 | 456.64 | 144.0 | 326.7 | 311.7 |
| **Aquifer 3a** | | | | | | | | | | |
| MW-64 | 3a [k] | Active | 3/1993 | 168621.33 [m] | 1342108.13 [m] | 594.33 | 596.55 [l] | 274.1 | 334.0 | 320.2 |
| **Aquifer 3** | | | | | | | | | | |
| MW-24 | 3 | Active | 6/1983 | 167660.73 [m] | 1339669.03 [m] | 473.76 | 475.99 | 192.0 | 286.8 | 281.8 |
| MW-58A | 3 | Water Level Only | 9/1988 | 167189.92 [m] | 1339157.37 [m] | 478.55 | 479.27 | 218.5 | 270.1 | 260.1 |
| MW-59 | 3 | Active | 8/1988 | 167145.25 [m] | 1340110.25 [m] | 455.58 | 457.13 | 180.5 | 285.1 | 275.1 |
| MW-65 | 3 | Active | 3/1993 | 167047.71 [m] | 1341687.21 [m] | 543.21 | 545.83 | 234.3 | 317.7 | 308.9 |

# Table 4-1
# Comprehensive Well List
# Queen City Farms
# Maple Valley, Washington

| Well ID | Aquifer | Status | Date Installed | Northing | Easting | Ground Elevation (ft) | Top of Casing Elevation (ft) | Total Depth of Well (ft bgs) | Top of Screen Elevation (ft) | Bottom of Screen Elevation (ft) |
|---|---|---|---|---|---|---|---|---|---|---|
| **Aquifer 4** | | | | | | | | | | |
| MW-54 | 4 [g, i] | Water Level Only | 9/1986 | 168287.37 [m] | 1342267.09 [m] | 579.25 | 580.43 | 351.0 | 250.3 | 228.3 |

**Notes:**

--- = data not found

Vertical Datum: NGVD29, US feet, MSL; Horizontal Datum: NAD 83(91) US feet. Coordinates originally referenced to any other datum have been converted for inclusion in this dataset.

a. From master survey file maintained by Landau Associates, Inc.

b. Survey coordinates geo-referenced from August 22, 1996 Remedial Action Report, Figure 2.

c. Converted to NAD83 from NAD27 datum listed in April 20, 1990 Remedial Investigation Report, Appendix C.

d. Surveyed ground surface elevation prior to installation of final containment cell cap; ground surface elevation after installation of cap is not available.

e. Survey coordinates geo-referenced from the March 30, 2010 Draft Revised 2008 Annual Monitoring Data Report, Figure 2-1.

f. Aquifer designation 2af indicates a well screened at the top of Aquifer 2, but within geologic unit F. Aquifer designation 2ae indicates an Aquifer 2 well screened above Unit F in geologic units B, C, or E.

g. Aquifer 4 is also referred to as the Deep Water Bearing Zone.

h. Survey coordinates geo-referenced from the August 6, 2014 Field Sampling Plan, Figure 4.

i. Survey coordinates geo-referenced from the July 8, 2009 Supplemental Remedial Investigation Work Plan, Figures 8 and 10.

j. (b) is an open bottom well with no screen; therefore, top of screen and bottom of screen elevations are listed as the same value.

k. Aquifer designation for MW-64 is inconclusive, as it might be screened in Aquifer 2a or 3a.

l. In January 2016, staff noted that the MW-64 top of casing elevation previously reported by Landau Associates, Inc. (595.6 ft) was in error; King County reports the elevation as 596.55 ft.

m. Converted to NAD 83 from NAD 27 datum listed in the Cedar Hill Regional Landfill Site-Wide Hydrogeologic Report, Volume I, May 2004, Table 4.2-2.

**Acronyms/Abbreviations:**

bgs = below ground surface
ft = feet
GETS = groundwater extraction and treatment system
ID = identification
MSL = mean sea level
NA = not applicable
NAD 83 = North American Datum of 1983
NGVD29 = National Geodetic Vertical Datum of 1929
QCF = Queen City Farms

**Table 4-2**
**2019 Groundwater Analyses**
**Queen City Farms**
**Maple Valley, Washington**

| Well ID | Aquifer | January | March | April | May | June | July | September | October |
|---|---|---|---|---|---|---|---|---|---|
| **Queen City Farms (QCF)** | | | | | | | | | |
| **Aquifer 1** | | | | | | | | | |
| E-1 | 1 | | EPA 524.2 | | | | | | |
| **Aquifer 2a** | | | | | | | | | |
| IB-2a | 2a | | EPA 524.2 | | | | | | |
| D-2a | 2ae | | EPA 524.2 | | | | | | |
| F-2a | 2ae | | EPA 300.0<br>EPA 524.2<br>RSK-175<br>SM 5310C | | | | | | |
| G-2a | 2ae | | EPA 524.2 | | | | | | |
| H-2a | 2ae | | EPA 524.2 | | | | | EPA 524.2 | |
| L-2a | 2ae | | EPA 524.2 | | | | | EPA 524.2 | |
| (b) | 2ae | | EPA 524.2 | | | | | EPA 524.2 | |
| S-2a | 2ae | | EPA 300.0<br>EPA 524.2<br>RSK-175<br>SM 5310C | | | | | EPA 524.2 | |
| C-2a | 2af | | EPA 524.2 | | | | | | |
| E-2a | 2af | | EPA 524.2 | | | | | | |
| I-2a | 2af | | EPA 300.0<br>EPA 524.2<br>RSK-175<br>SM 5310C | | | | | | |
| V-2a | 2af | | EPA 524.2 | | | | | EPA 524.2 | |
| **Aquifer 2** | | | | | | | | | |
| C-2 | 2 | | EPA 300.0<br>EPA 524.2<br>RSK-175<br>SM 5310C | | | | | | |
| E-2 | 2 | | EPA 524.2 | | | | | | |
| F-2 | 2 | | EPA 300.0<br>EPA 524.2<br>RSK-175<br>SM 5310C | | | | | | |
| G-2 | 2 | | EPA 524.2 | | | | | | |
| H-2 | 2 | | EPA 524.2 | | | | | EPA 524.2 | |
| I-2 | 2 | | EPA 300.0<br>EPA 524.2<br>RSK-175<br>SM 5310C | | | | | EPA 524.2 | |
| L-2 | 2 | | EPA 300.0<br>EPA 524.2<br>RSK-175<br>SM 5310C | | | | | | |
| M-2 | 2 | | EPA 300.0<br>EPA 524.2<br>RSK-175<br>SM 5310C | | | | | | |
| N-2 | 2 | | EPA 524.2 | | | | | EPA 524.2 | |
| O-2 | 2 | | EPA 524.2 | | | | | EPA 524.2 | |

**Table 4-2**
**2019 Groundwater Analyses**
**Queen City Farms**
**Maple Valley, Washington**

| Well ID | Aquifer | January | March | April | May | June | July | September | October |
|---|---|---|---|---|---|---|---|---|---|
| S-2 | 2 | | EPA 300.0<br>EPA 524.2<br>RSK-175<br>SM 5310C | | | | | EPA 524.2 | |
| SA-2 | 2 | | EPA 300.0<br>EPA 524.2<br>RSK-175<br>SM 5310C | | | | | EPA 524.2 | |
| SB-2 | 2 | | EPA 524.2 | | | | | EPA 524.2 | |
| SC-2 | 2 | | EPA 300.0<br>EPA 524.2<br>RSK-175<br>SM 5310C | | | | | EPA 524.2 | |
| SD-2 | 2 | | EPA 300.0<br>EPA 524.2<br>RSK-175<br>SM 5310C | | | | | EPA 524.2 | |
| SE-2 | 2 | | EPA 524.2 | | | | | EPA 524.2 | |
| U-2 | 2 | | EPA 524.2 | | | | | EPA 524.2 | |
| **Aquifer 3a** | | | | | | | | | |
| I-3a | 3a | | EPA 300.0<br>EPA 524.2<br>RSK-175<br>SM 5310C | | | | | | |
| IA-3a | 3a | | EPA 300.0<br>EPA 524.2<br>RSK-175<br>SM 5310C | | | | | EPA 524.2 | |
| IB-3a | 3a | | EPA 524.2 | | | | | | |
| MA-3a | 3a | | EPA 300.0<br>EPA 524.2<br>RSK-175<br>SM 5310C | | | | | EPA 524.2 | |
| N-3a | 3a | | EPA 524.2 | | | | | | |
| O-3a | 3a | | EPA 524.2 | | | | | | |
| OA-3a | 3a | | EPA 524.2 | | | | | | |
| SD-3a | 3a | | EPA 300.0<br>EPA 524.2<br>RSK-175<br>SM 5310C | | | | | | |

**Table 4-2**
**2019 Groundwater Analyses**
**Queen City Farms**
**Maple Valley, Washington**

| Well ID | Aquifer | January | March | April | May | June | July | September | October |
|---|---|---|---|---|---|---|---|---|---|
| **Aquifer 3** | | | | | | | | | |
| B-3 | 3 | | EPA 300.0<br>EPA 524.2<br>RSK-175<br>SM 5310C | | | | | | |
| I-3 | 3 | | EPA 300.0<br>EPA 524.2<br>RSK-175<br>SM 5310C | | | | | | |
| IA-3 | 3 | | EPA 300.0<br>EPA 524.2<br>RSK-175<br>SM 5310C | | | | | EPA 524.2 | |
| **Aquifer 4** | | | | | | | | | |
| (b) (LM) | 4 | | EPA 524.2 | | | | | EPA 524.2 | |
| **Groundwater Extraction and Treatment System (GETS)** | | | | | | | | | |
| EGW | N/A | | EPA 524.2 | EPA 524.2 | EPA 524.2 | EPA 524.2 | | EPA 524.2 | |
| EW-1 | N/A | | EPA 524.2 | EPA 524.2 | EPA 524.2 | EPA 524.2 | | EPA 524.2 | |
| EW-2 | 2 | | EPA 524.2 | EPA 524.2 | EPA 524.2 | EPA 524.2 | | EPA 524.2 | |
| EW-3 | 2 | | EPA 524.2 | EPA 524.2 | EPA 524.2 | EPA 524.2 | | EPA 524.2 | |
| EW-4 | 2 | | EPA 524.2 | EPA 524.2 | EPA 524.2 | EPA 524.2 | | EPA 524.2 | |
| EW-5 | 2 | | EPA 524.2 | EPA 524.2 | EPA 524.2 | EPA 524.2 | | EPA 524.2 | |
| EW-6 | 2 | | EPA 524.2 | EPA 524.2 | EPA 524.2 | EPA 524.2 | | EPA 524.2 | |
| EW-7 | 2 | | EPA 524.2 | EPA 524.2 | EPA 524.2 | EPA 524.2 | | EPA 524.2 | |
| IGW | 2 | | EPA 524.2 | EPA 524.2 | EPA 524.2 | EPA 524.2 | | EPA 524.2 | |
| **Cedar Hills Regional Landfill (CHRL)** | | | | | | | | | |
| **Aquifer 2a** | | | | | | | | | |
| MW-76 | 2a | | | SW-846<br>8260C | | | | | SW-846<br>8260C |
| **Aquifer 2ae** | | | | | | | | | |
| MW-83 | 2ae | SW-846<br>8260C | | SW-846<br>8260C | | | SW-846<br>8260C | | SW-846<br>8260C |
| MW-94 | 2ae | SW-846<br>8260C | | SW-846<br>8260C | | | SW-846<br>8260C | | SW-846<br>8260C |
| **Aquifer 2af** | | | | | | | | | |
| MW-82 | 2af | | | SW-846<br>8260C | | | | | SW-846<br>8260C |
| MW-95 | 2af | | | SW-846<br>8260C | | | | | SW-846<br>8260C |
| **Aquifer 2** | | | | | | | | | |
| MW-56 | 2 | | | SW-846<br>8260C | | | | | SW-846<br>8260C |

**Table 4-2**
**2019 Groundwater Analyses**
**Queen City Farms**
**Maple Valley, Washington**

| Well ID | Aquifer | January | March | April | May | June | July | September | October |
|---|---|---|---|---|---|---|---|---|---|
| **Aquifer 3a** | | | | | | | | | |
| MW-64 | 3a | | | SW-846 8260C | | | | | SW-846 8260C |
| **Aquifer 3** | | | | | | | | | |
| MW-24 | 3 | | | SW-846 8260C | | | | | SW-846 8260C |
| MW-59 | 3 | SW-846 8260C | | SW-846 8260C | | | SW-846 8260C | | SW-846 8260C |
| MW-65 | 3 | | | SW-846 8260C | | | | | SW-846 8260C |

**Notes:**
1. Aquifer designation 2af indicates a well screened at the top of Aquifer 2, but within geologic Unit F.
2. Aquifer designation 2ae indicates an Aquifer 2 well screened above Unit F in geologic Units B, C, or E.

**Abbreviations/Acronyms:**
EPA = US Environmental Protection Agency
ID = identification
SM = Standard Methods

**Table 5-1**
**Summary of Detected Volatile Organic Compounds**
**Queen City Farms**
**Maple Valley, Washington**

| Well ID | Analyte | Minimum Performance Standard (µg/L) | Number of Exceedances (2019) | Adjusted Performance Standards (µg/L) | Number of Exceedances (2019) | Maximum Detection (µg/L) (2019) | Minimum Detection (µg/L) (2019) | Number of Detections (µg/L) (2019) | Trend |
|---|---|---|---|---|---|---|---|---|---|
| **Queen City Farms (QCF)** | | | | | | | | | |
| **Aquifer 2a** | | | | | | | | | |
| C-2a | Tetrachloroethene | 5 | 0 | 1 | 0 | 0.9 | 0.9 | 1 | Decreasing |
| | Trichloroethene | 5 | 1 | -- | -- | 14.0 | 14.0 | 1 | Decreasing |
| D-2a | Trichloroethene | 5 | 0 | -- | -- | 1.0 | 1.0 | 1 | Increasing |
| E-2a | Trichloroethene | 5 | 1 | -- | -- | 20.0 | 20.0 | 1 | Decreasing |
| F-2a | Trichloroethene | 5 | 0 | -- | -- | 0.6 | 0.6 | 1 | Decreasing |
| G-2a | Trichloroethene | 5 | 0 | -- | -- | 3.5 | 3.5 | 1 | Decreasing |
| I-2a | Trichloroethene | 5 | 0 | -- | -- | 1.0 | 1.0 | 1 | Stable |
| L-2a | Trichloroethene | 5 | 0 | -- | -- | 3.9 | 3.1 | 2 | Decreasing |
| S-2a | Trichloroethene | 5 | 0 | -- | -- | 3.5 | 3.3 | 2 | Increasing |
| V-2a | Trichloroethene | 5 | 1 | -- | -- | 19.0 | 2.9 | 2 | Decreasing (max, spring) |
| | cis-1,2-Dichloroethene | 70 | 0 | -- | -- | 2.8 | 0.5 | 2 | Decreasing |
| **Aquifer 2** | | | | | | | | | |
| C-2 | Trichloroethene | 5 | 1 | -- | -- | 40.0 | 40.0 | 1 | Stable |
| | cis-1,2-Dichloroethene | 70 | 0 | -- | -- | 2.1 | 2.1 | 1 | Decreasing |
| E-2 | Tetrachloroethene | 5 | 0 | 1 | 0 | 0.6 | 0.6 | 1 | Stable |
| | Trichloroethene | 5 | 1 | -- | -- | 36.0 | 36.0 | 1 | Stable |
| | cis-1,2-Dichloroethene | 70 | 0 | -- | -- | 1.2 | 1.2 | 1 | Increasing |
| F-2 | Tetrachloroethene | 5 | 0 | 1 | 1 | 1.6 | 1.6 | 1 | Stable |
| | Trichloroethene | 5 | 1 | -- | -- | 18.0 | 18.0 | 1 | Slightly Decreasing |
| | cis-1,2-Dichloroethene | 70 | 0 | -- | -- | 1.1 | 1.1 | 1 | Increasing |
| G-2 | Tetrachloroethene | 5 | 0 | 1 | 0 | 0.9 | 0.9 | 1 | Stable |
| | Trichloroethene | 5 | 1 | -- | -- | 8.3 | 8.3 | 1 | Stable |
| | cis-1,2-Dichloroethene | 70 | 0 | -- | -- | 1.0 | 1.0 | 1 | Increasing |
| I-2 | Trichloroethene | 5 | 2 | -- | -- | 18.0 | 17.0 | 2 | Decreasing |
| | cis-1,2-Dichloroethene | 70 | 0 | -- | -- | 13.0 | 12.0 | 2 | Increasing |
| L-2 | Trichloroethene | 5 | 1 | -- | -- | 16.0 | 16.0 | 1 | Decreasing |
| N-2 | Trichloroethene | 5 | 0 | -- | -- | 0.5 | 0.5 | 1 | Stable |
| | cis-1,2-Dichloroethene | 70 | 0 | -- | -- | 0.9 | 0.9 | 1 | Stable |
| SA-2 | Trichloroethene | 5 | 1 | -- | -- | 5.3 | 5.0 | 2 | Increasing |
| SC-2 | Trichloroethene | 5 | 2 | -- | -- | 7.1 | 5.7 | 2 | Decreasing |
| SD-2 | Trichloroethene | 5 | 2 | -- | -- | 13.0 | 9.5 | 2 | Decreasing |
| | cis-1,2-Dichloroethene | 70 | 0 | -- | -- | 1.1 | 1.1 | 1 | Decreasing |
| U-2 | Trichloroethene | 5 | 0 | -- | -- | 1.4 | 1.3 | 2 | Variable No Trend |
| **Aquifer 3a** | | | | | | | | | |
| I-3a | Tetrachloroethene | 5 | 0 | 1 | 0 | 0.9 | 0.9 | 1 | Increasing |
| | Trichloroethene | 5 | 1 | -- | -- | 27.0 | 27.0 | 1 | Increasing |
| | cis-1,2-Dichloroethene | 70 | 0 | -- | -- | 3.4 | 3.4 | 1 | Increasing |
| IA-3a | Trichloroethene | 5 | 2 | -- | -- | 78.0 | 75.0 | 2 | Decreasing |
| | cis-1,2-Dichloroethene | 70 | 0 | -- | -- | 18.0 | 16.0 | 2 | Decreasing |
| IB-3a | cis-1,2-Dichloroethene | 70 | 0 | -- | -- | 11.0 | 11.0 | 1 | Increasing |
| MA-3a | Trichloroethene | 5 | 2 | -- | -- | 27.0 | 24.0 | 2 | Stable |
| | cis-1,2-Dichloroethene | 70 | 0 | -- | -- | 3.2 | 2.5 | 2 | Decreasing |
| O-3a | cis-1,2-Dichloroethene | 70 | 0 | -- | -- | 3.8 | 3.8 | 1 | Stable |
| OA-3a | cis-1,2-Dichloroethene | 70 | 0 | -- | -- | 4.3 | 4.3 | 1 | Stable |
| SD-3a | cis-1,2-Dichloroethene | 70 | 0 | -- | -- | 15.0 | 15.0 | 1 | Increasing |

# Table 5-1
## Summary of Detected Volatile Organic Compounds
## Queen City Farms
## Maple Valley, Washington

| Well ID | Analyte | Minimum Performance Standard (µg/L) | Number of Exceedances (2019) | Adjusted Performance Standards (µg/L) | Number of Exceedances (2019) | Maximum Detection (µg/L) (2019) | Minimum Detection (µg/L) (2019) | Number of Detections (µg/L) (2019) | Trend |
|---|---|---|---|---|---|---|---|---|---|
| **Queen City Farms (QCF)** | | | | | | | | | |
| **Aquifer 2a** | | | | | | | | | |
| **Aquifer 3** | | | | | | | | | |
| B-3 | cis-1,2-Dichloroethene | 70 | 0 | -- | -- | 10.0 | 10.0 | 1 | Increasing |
| I-3 | cis-1,2-Dichloroethene | 70 | 0 | -- | -- | 14.0 | 14.0 | 1 | Decreasing |
| IA-3 | Trichloroethene | 5 | 2 | -- | -- | 12.0 | 9.9 | 2 | Increasing |
| | cis-1,2-Dichloroethene | 70 | 0 | -- | -- | 32.0 | 31.0 | 2 | Increasing |
| | trans-1,2-Dichloroethene | 100 | 0 | -- | -- | 0.5 | 0.5 | 2 | -- |
| | 1,2-Dichloropropane | -- | 2 | -- | -- | 0.6 | 0.6 | 2 | -- |
| **Groundwater Extraction and Treatment System (GETS)** | | | | | | | | | |
| EGW | Trichloroethene | 5 | 0 | -- | -- | 2.5 | 1.0 | 6 | -- |
| | cis-1,2-Dichloroethene | 70 | 0 | -- | -- | 0.7 | 0.7 | 1 | -- |
| EW-1 | Trichloroethene | 5 | 0 | -- | -- | 1.0 | 0.8 | 2 | Decreasing |
| EW-2 | Trichloroethene | 5 | 1 | -- | -- | 5.1 | 3.2 | 5 | Decreasing |
| | cis-1,2-Dichloroethene | 70 | 0 | -- | -- | 1.1 | 0.5 | 4 | Decreasing |
| EW-3 | Trichloroethene | 5 | 4 | -- | -- | 6.2 | 4.9 | 5 | Decreasing |
| | cis-1,2-Dichloroethene | 70 | 0 | -- | -- | 1.1 | 1.0 | 5 | Stable |
| EW-4 | Trichloroethene | 5 | 0 | -- | -- | 4.9 | 4.4 | 5 | Stable |
| | cis-1,2-Dichloroethene | 70 | 0 | -- | -- | 1.0 | 0.6 | 5 | Stable |
| EW-5 | Trichloroethene | 5 | 0 | -- | -- | 3.6 | 2.8 | 5 | Decreasing |
| | cis-1,2-Dichloroethene | 70 | 0 | -- | -- | 0.9 | 0.7 | 5 | Stable |
| EW-6 | Trichloroethene | 5 | 0 | -- | -- | 2.7 | 1.2 | 5 | Potentially Stable (from increasing) |
| | cis-1,2-Dichloroethene | 70 | 0 | -- | -- | 2.0 | 1.7 | 5 | Stable |
| EW-7 | Trichloroethene | 5 | 2 | -- | -- | 6.3 | 4.6 | 5 | Stable |
| | cis-1,2-Dichloroethene | 70 | 0 | -- | -- | 3.1 | 2.6 | 5 | Stable |
| IGW | Trichloroethene | 5 | 0 | -- | -- | 4.9 | 3.4 | 6 | -- |
| | cis-1,2-Dichloroethene | 70 | 0 | -- | -- | 1.2 | 0.7 | 6 | -- |
| **Cedar Hills Regional Landfill (CHRL)** | | | | | | | | | |
| **Aquifer 2a** | | | | | | | | | |
| MW-76 | Tetrachloroethene | 5 | 0 | 1 | 0 | 0.401 | 0.309 | 2 | Decreasing |
| | Trichloroethene | 5 | 2 | -- | -- | 7.89 | 6.07 | 2 | Decreasing |
| | cis-1,2-Dichloroethene | 70 | 0 | -- | -- | 0.327 | 0.195 J | 2 | Decreasing |
| **Aquifer 2ae** | | | | | | | | | |
| MW-83 | Trichloroethene | 5 | 0 | -- | -- | 2.1 | 1.41 | 4 | Stable |
| MW-94 | Trichloroethene | 5 | 0 | -- | -- | 2.31 | 1.61 | 4 | Decreasing |
| **Aquifer 2af** | | | | | | | | | |
| MW-82 | Trichloroethene | 5 | 0 | -- | -- | 4.59 | 4.28 | 2 | Decreasing |
| **Aquifer 2** | | | | | | | | | |
| MW-56 | cis-1,2-Dichloroethene | 70 | 0 | -- | -- | 1.48 | 1.45 | 2 | Stable |
| **Aquifer 3** | | | | | | | | | |
| MW-24 | cis-1,2-Dichloroethene | 70 | 0 | -- | -- | 0.107 JT | 0.107 JT | 1 | Stable |
| | Vinyl Chloride | 2 | 0 | 0.02 | 1 | 0.0247 D | 0.0247 D | 1 | Variable No Trend |
| MW-59 | cis-1,2-Dichloroethene | 70 | 0 | -- | -- | 1.41 | 1.25 | 4 | Increasing |
| | Vinyl Chloride | 2 | 0 | 0.02 | 0 | 0.0103 DJT | 0.0103 DJT | 1 | Stable |
| MW-65 | Vinyl Chloride | 2 | 0 | 0.02 | 2 | 0.0318 | 0.0261 | 2 | Decreasing |

**Abbreviations/Acronyms:**

D = Laboratory specific qualifier indicating result is from a re-analysis due to dilution.
ID = identification
J = The result is an estimated quantity. The associated numerical value is the approximate concentration of the analyte in the sample.
T = Laboratory-specific qualifier indicating an estimated value less than the reporting detection limit but greater than the method.
µg/L = micrograms per liter
-- = not applicable

**Table 5-2**
**Groundwater Extraction and Treatment System Monitoring Results for TCE and cDCE**
**Queen City Farms**
**Maple Valley, Washington**

| | Post-Extraction Well Installation 29-May-14 | | Pre-System Startup 20-Jan-15 | | Monthly 23-Mar-15 | | Monthly (a, b) 20-Apr-15 | | Monthly (a) 26-May-15 | | Additional Event (c) 4-Aug-15 | | Quarterly 22-Sep-15 | | Quarterly 16-Dec-15 | | Quarterly 28-Mar-16 | | Fall 2016 26-Sep-16 | | Spring 2017 27-Mar-17 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Location ID** | TCE | cis-1,2-DCE | TCE | cis-1,2-DCE | TCE | cis-1,2-DCE | TCE | cis-1,2-DCE | TCE | cis-1,2-DCE | TCE | cis-1,2-DCE | TCE | cis-1,2-DCE | TCE | cis-1,2-DCE | TCE | cis-1,2-DCE | TCE | cis-1,2-DCE | TCE | cis-1,2-DCE |
| **Group 1 Wells** | | | | | | | | | | | | | | | | | | | | | | |
| S-2 | -- | -- | 10 | ND | 0.9 | ND | 2.1 | ND | 2.0 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| SA-2 | -- | -- | 4.1 | ND | 4.0 | ND | 4.0 | ND | 4.3 | ND | 3.9 | ND | 4.7 | ND | 4.2 | ND | 4.6 | ND | 4.3 | ND | 3.9 | ND |
| SB-2 | -- | -- | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| SC-2 | -- | -- | 21 | 1.0 | 19 | 0.9 | 14 | 0.6 | 9.0 | ND | 9.6 | ND | 11 | ND | 8.4 | ND | 13 | 0.6 | 8.1 | ND | 12 | 0.6 |
| SD-2 | -- | -- | 24 | 1.4 | 16 | 1.2 | 19 | 1.0 | 20 | 0.8 | 19 | 0.9 | 22 | 1.4 | (d) | (d) | 25 | 1.6 | 13 | ND | 15 | 1.1 |
| SE-2 | -- | -- | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| H-2 | -- | -- | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| I-2 | -- | -- | 12 | 2.0 | 9.6 | 2.0 | 11 | 2.8 | 12 | 3.3 | 13 | 5.0 | 14 | 6.9 | 14 | 8.8 | 16 | 12 | 17 | 10 | 17 | 11 |
| N-2 | -- | -- | ND | ND | ND | ND | ND | ND | ND | 1.1 | ND | 1.0 | ND | 1.0 | ND | 1 | ND | ND | ND | 1.1 | ND | ND |
| O-2 | -- | -- | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| U-2 | -- | -- | 1.8 | ND | 1.4 | ND | 1.2 | ND | 0.8 | ND | 1.3 | ND | 1.5 | ND | 2 | ND | 1.3 | ND | 1.6 | ND | 1.9 | ND |
| **EXTRACTION WELLS** | | | | | | | | | | | | | | | | | | | | | | |
| EW-1 | 2.2 | ND | 2.8 | ND | 3.4 | ND | 0.6 | ND | 2.1 | ND | 2.5 | ND | 2.3 | ND | 2.3 | 0.6 | 1.6 | 0.6 | 1.5 | 0.6 | 1.4 | 0.6 |
| EW-2 | 2.7 | ND | 2.2 | ND | 11 | ND | 9.7 | ND | 9.6 | 0.6 | 8.7 | 0.9 | 8.4 | 1 | 7.6 | 1 | 7.2 | 1.3 | 6.5 | 1.3 | 5.9 | 1.2 |
| EW-3 | 9.3 | 1.3 | 9.7 | 2.0 | 17 | 0.9 | 15 | 1.0 | 14 | 0.9 | 12 | 1.2 | 12 | 1.2 | 12 | 1.3 | 10 | 1.5 | 9.3 | 1.5 | 7.8 | 1.3 |
| EW-4 | 10 | 1.5 | 9.3 | 1.0 | 6.7 | 1.1 | 6.4 | 1.0 | 6.2 | 1.0 | 6.2 | 1.1 | 6.5 | 1.1 | 6 | 1 | 5.6 | 1.1 | 5.8 | 1.1 | 5.2 | 0.8 |
| EW-5 | 14 | 1.0 | 14 | 1.0 | 7.2 | 1.5 | 7.3 | 1.4 | 7.1 | 1.4 | 6.3 | 1.3 | 6.2 | 1.3 | 5.8 | 1.1 | 5.6 | 1.2 | 5 | 1 | 4.2 | 0.9 |
| EW-6 | 18 | 1.8 | 14 | 2.4 | ND | 0.8 | ND | 0.9 | ND | 0.9 | ND | 0.8 | ND | 0.9 | ND | 0.9 | ND | 1.1 | 0.9 | 1.4 | 0.9 | 1.4 |
| EW-7 | 0.8 | 3.4 | 2.5 | 5.9 | ND | 2.0 | ND | 2.4 | ND | 2.3 | 0.6 | 2.5 | 0.7 | 2.5 | 1.2 | 2.5 | 1.9 | 2.9 | 3.2 | 3 | 3.4 | 2.7 |
| **OTHER** | | | | | | | | | | | | | | | | | | | | | | |
| GET System Influent | -- | -- | 6.4 | 0.8 | 5.2 | 1.1 | 4.4 | 1.3 | 5.4 | 1.2 | 4.5 | 1.1 | 4.7 | 1.1 | 4 | 1.3 | 3.8 | 1.4 | 3.5 | 1.5 | 3.8 | 1.5 |
| GET System Effluent | -- | -- | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |

**Table 5-2**
**Groundwater Extraction and Treatment System Monitoring Results for TCE and cDCE**
**Queen City Farms**
**Maple Valley, Washington**

| Location ID | Semiannual 2017 13-Sep-17 | | GETS Optimization Initial 4-hr 24-Oct-17 | | GETS Optimization One Week 31-Oct-17 | | GETS Optimization First Monthly 30-Nov-17 | | GETS Optimization Second Monthly 27-Dec-17 | | Annual 2018 29-Mar-18 | | Semiannual 2018 (e) 25-Sep-18 | | Annual 2019 25-Mar-19 | | GETS 4 hours Post Modified Pumping 23-Apr-19 | | GETS 1 week Post Modified Pumping 29-Apr-19 | | GETS 1 month Post Modified Pumping 22-May-19 | | GETS 2 month Post Modified Pumping 21-Jun-19 | | Semiannual 2019 23-Sep-19 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TCE | cis-1,2-DCE | TCE | cis-1,2-DCE | TCE | cis-1,2-DCE | TCE | cis-1,2-DCE | TCE | cis-1,2-DCE | TCE | cis-1,2-DCE | TCE | cis-1,2-DCE | TCE | cis-1,2-DCE | TCE | cis-1,2-DCE | TCE | cis-1,2-DCE | TCE | cis-1,2-DCE | TCE | cis-1,2-DCE | TCE | cis-1,2-DCE |
| **Group 1 Wells** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| S-2 | ND | ND | -- | -- | -- | -- | -- | -- | -- | -- | ND | ND | ND | ND | ND | ND | -- | -- | -- | -- | -- | -- | -- | -- | ND | ND |
| SA-2 | **4.1** | ND | -- | -- | -- | -- | -- | -- | -- | -- | **4.9** | ND | -- | -- | **5.0** | ND | -- | -- | -- | -- | -- | -- | -- | -- | **5.3** | ND |
| SB-2 | ND | ND | -- | -- | -- | -- | -- | -- | -- | -- | ND | ND | ND | ND | ND | ND | -- | -- | -- | -- | -- | -- | -- | -- | ND | ND |
| SC-2 | **7.8** | ND | -- | -- | -- | -- | -- | -- | -- | -- | **11** | ND | **7.3** | ND | **7.1** | ND | -- | -- | -- | -- | -- | -- | -- | -- | **5.7** | ND |
| SD-2 | **18** | **0.8** | -- | -- | -- | -- | -- | -- | -- | -- | **15** | **0.8** | **9.8** | ND | **13** | **1.1** | -- | -- | -- | -- | -- | -- | -- | -- | **9.5** | ND |
| SE-2 | ND | ND | -- | -- | -- | -- | -- | -- | -- | -- | ND | ND | ND | ND | ND | ND | -- | -- | -- | -- | -- | -- | -- | -- | ND | ND |
| H-2 | ND | ND | -- | -- | -- | -- | -- | -- | -- | -- | ND | ND | ND | ND | ND | ND | -- | -- | -- | -- | -- | -- | -- | -- | ND | ND |
| I-2 | **19** | **14** | -- | -- | -- | -- | -- | -- | -- | -- | **20** | **12** | **18** | **11** | **18** | **13** | -- | -- | -- | -- | -- | -- | -- | -- | **17** | **12** |
| N-2 | ND | **0.8** | -- | -- | -- | -- | -- | -- | -- | -- | ND | ND | **0.5** | **1.1** | ND | ND | -- | -- | -- | -- | -- | -- | -- | -- | **0.5** | **0.9** |
| O-2 | ND | ND | -- | -- | -- | -- | -- | -- | -- | -- | ND | ND | ND | ND | ND | ND | -- | -- | -- | -- | -- | -- | -- | -- | ND | ND |
| U-2 | **1.4** | ND | -- | -- | -- | -- | -- | -- | -- | -- | **1.3** | ND | **1.1** | ND | **1.3** | ND | -- | -- | -- | -- | -- | -- | -- | -- | **1.4** | ND |
| **EXTRACTION WELLS** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| EW-1 | **1.4** | **0.5** | -- | -- | -- | -- | -- | -- | -- | -- | **1.4** | ND | **1.2** | ND | **1.0** | ND | -- | -- | **0.8** | ND | ND | ND | ND | ND | ND | ND |
| EW-2 | **1.6** | **0.5** | -- | -- | -- | -- | -- | -- | -- | -- | **1.4** | ND | **5.5** | **1.3** | **5.1** | **1.1** | -- | -- | **4.6** | **1.0** | **3.5** | **0.6** | **3.5** | **0.5** | **3.2** | ND |
| EW-3 | **7.5** | **1.1** | -- | -- | -- | -- | -- | -- | -- | -- | **7** | **1.2** | **6.2** | **1.2** | **5.6** | **1.0** | -- | -- | **6.2** | **1.1** | **5.1** | **1.1** | **4.9** | **1.1** | **5.2** | **1.0** |
| EW-4 | **4.8** | **0.7** | -- | -- | -- | -- | -- | -- | -- | -- | **4.9** | **0.8** | **6.2** | **0.9** | **4.5** | **0.6** | -- | -- | **4.6** | **0.7** | **4.5** | **0.7** | **4.4** | **0.7** | **4.9** | **1.0** |
| EW-5 | **4.2** | **0.9** | -- | -- | -- | -- | -- | -- | -- | -- | **3.7** | **0.8** | **3.6** | **0.8** | **3.1** | **0.7** | -- | -- | **3.6** | **0.8** | **3.0** | **0.8** | **2.8** | **0.8** | **2.9** | **0.9** |
| EW-6 | **0.8** | **1.5** | -- | -- | -- | -- | -- | -- | -- | -- | **1.0** | **1.7** | **1.3** | **1.7** | **1.2** | **1.7** | -- | -- | **2.7** | **2.0** | **2.5** | **2.0** | **1.4** | **2.0** | **1.2** | **1.8** |
| EW-7 | **3.2** | **2.5** | -- | -- | -- | -- | -- | -- | -- | -- | **4.7** | **3.0** | **4.7** | **3.0** | **4.6** | **2.6** | -- | -- | **6.3** | **3.1** | **5.8** | **3.0** | **4.9** | **2.8** | **4.7** | **3.0** |
| **OTHER** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| GET System Influent | **3.2** | **1.2** | **3.7** | **1.4** | **2.9** | **1.2** | **3.4** | **1.4** | **3.6** | **1.4** | **3.3** | **1.3** | **3.5** | **1.6** | **3.4** | **1.2** | **4.9** | **0.9** | **3.8** | **0.7** | **3.8** | **0.8** | **4.2 J** | **0.9 J** | **4.0** | **0.9** |
| GET System Effluent | ND | ND | **2.1** | **0.9** | **1.3** | **0.7** | **1.9** | **0.9** | **1.9** | **0.9** | **1.8** | **0.8** | **1.3** | **0.8** | **1.6** | **0.7** | **2.5** | ND | **1.0** | ND | **2.1** | ND | **2.0** | ND | **1.1** | ND |

**Abbreviations and Acronyms:**

DCE = Dichloroethene
GETS = groundwater extraction treatment system
-- = Location not sampled during this event
µg/L = micrograms per liter
ND = Not detected
PCE = tetrachloroethene
RAWP = remedial action work plan
TCE = trichloroethene

**Notes:**

**Bold** indicates a detection
All concentrations in micrograms per liter.

a. PIT-101, the pressure transducer associated with EW-1, malfunctioned beginning April 1, 2015. The EW-1 well pump was turned off until instrument fixed; therefore, the pump was not running prior to the sampling event, and the pump was turned on only to collect the sample.
b. FIT-103, the flow meter associated with EW-3, malfunctioned beginning April 17, 2015. The EW-3 well pump was turned off until instrument fixed; therefore, the pump was not running prior to the sampling event, and the pump was turned on only to collect the sample. FIT-103 was fixed May 1, 2015.
c. An additional sampling event was conducted once EW-1 and EW-3 were operational again.
d. SD-2 not sampled in Dec 2015 due to sampling error.
e. At EW-4, the pump was off from July 30, 2018 to October 3, 2018; therefore, the pump was not running during the sampling event. EW-4 was sampled on October 3, 2018 after the pump and motor were fixed.

Treated groundwater discharge limit for TCE in the GETS effluent is 4 µg/L, as presented in the RAWP and Construction Report.

Treated groundwater discharge limit for cis-1,2-dichloroethene (cis-1,2-DCE) in the GETS effluent is 16 µg/L, as presented in the RAWP and Construction Report.

Sampling events require 1-4 days. Date listed is first day of sampling event.

PCE, trans-1,2-DCE, and vinyl chloride were not detected.

# Table 5-3
## Groundwater Extraction and Treatment System Vapor Effluent Monitoring Results
## Queen City Farms
## Maple Valley, Washington

| Sample ID | Date | cDCE | TCE |
|---|---|---|---|
| **Air Stripper Treatment Unit Operational Period** | | | |
| QCF-GET-AIR-150224 | 2/24/2015 | **20** J | **120** J |
| QCF-GET-AIR-150324 | 3/24/2015 | **28** | **140** |
| QCF-GET-AIR-150421 | 4/21/2015 | **33** | **96** |
| QCF-GET-AIR-150526 | 5/26/2015 | **28** | **92** |
| QCF-GET-Air-150804 | 8/4/2015 | **31** | **120** |
| QCF-GET-Air-150922 | 9/22/2015 | **14** | **34** |
| QCF-GET-Air-151218 | 12/18/2015 | **35** | **110** |
| QCF-GET-Air-160328 | 3/28/2016 | **35** | **76** |
| QCF-GET-Air-160926 | 9/26/2016 | **30** | **69** |
| QCF-GET-Air-170327 | 3/27/2017 | **23** | **58** |
| QCF-GET-Air-170914 | 9/14/2017 | **25** | **84** |
| | Average: | **27.5** | **90.8** |
| **Diffused-Bubble Aerator Treatment Unit Operational Period** | | | |
| QCF-GET-Air-171024 | 10/24/2017 | **14** | **43** |
| QCF-GET-Air-171031 | 10/31/2017 | **8.8** | **23** |
| QCF-GET-Air-171130 | 11/30/2017 | **7.6** | **16** |
| QCF-GET-Air-171227 | 12/27/2017 | **11** | **28** |
| QCF-GET-AIR-180326 | 3/26/2018 | **9.5** | **33** |
| QCF-GET-AIR-180925 | 9/25/2018 | **12** | **29** |
| QCF-GET-AIR-190325 | 3/25/2019 | **9.2** | **26** |
| QCF-GET-AIR-190923 | 9/23/2019 | **2.9** | **12** |
| | Average: | **9.4** | **26.3** |

**Notes:**

**Bold** = Detected analyte

J = Indicates that the analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

VC was not detected in any of the samples.

Air samples were analyzed by standard laboratory method TO-15.

**Abbreviations/Acronyms:**

cDCE = cis-1,2-dichloroethene
ID = identification
$\mu g/m^3$ = micrograms per cubic meter
TCE = trichloroethene
VC = vinyl chloride

**Table 5-4**
**2019 Monitored Natural Attenuation Parameters**
**Queen City Farms**
**Maple Valley, Washington**

| Location | Aquifer | Date Collected | TCE (mg/L) | Cis-1,2-DCE (mg/L) | Nitrate (mg/L) (a) | Sulfate (mg/L) (a) | TOC (mg/L) (b) | Ethane (µg/L) (c) | Ethene (µg/L) (c) | Methane (µg/L) (c) | Ferrous Iron (mg/L) | pH (-) | Temperature (°C) | Conductivity (µS/cm) | DO (mg/L) | ORP (mV) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Queen City Farms** | | | | | | | | | | | | | | | | |
| **Aquifer 2a** | | | | | | | | | | | | | | | | |
| F-2a | 2ae | 3/28/2019 | **0.6** | 0.5 U | 0.10 U | **8.9** | **7.5** | 5.0 U | 5.0 U | 5.0 U | 0.2 | 6.53 | 10.07 | 220 | 1.14 | 77.4 |
| S-2a (d) | 2ae | 3/28/2019 | **3.5** | 0.5 U | **1.20** | **5.0** | 1.0 U | 5.0 U | 5.0 U | 5.0 U | 1.0 | -- | -- | -- | -- | -- |
| I-2a | 2af | 3/26/2019 | **1.0** | 0.5 U | 0.10 U | **5.0** | **1.9** | 5.0 U | 5.0 U | **180.0** | 2.4 | 6.09 | 9.41 | 192 | 6.27 | 59.5 |
| | | **Median** | **1.0** | **0.5** | **0.10** | **5.0** | **1.9** | **5.0** | **5.0** | **5.0** | 1.0 | 6.31 | 9.74 | 206 | 3.71 | 68.5 |
| **Aquifer 2** | | | | | | | | | | | | | | | | |
| C-2 | 2 | 3/29/2019 | **40.0** | **2.1** | **1.60** | **27.1** | 1.0 U | 5.0 U | 5.0 U | 5.0 U | 1.8 | 6.63 | 10.17 | 270 | 3.45 | 86.8 |
| F-2 | 2 | 3/28/2019 | **18.0** | **1.1** | **1.90** | **14.9** | **1.1** | 5.0 U | 5.0 U | **6.1** | 2.6 | 6.37 | 10.99 | 227 | 4.31 | 79.6 |
| I-2 | 2 | 3/26/2019 | **18.0** | **13.0** | 0.10 U | **5.6 J** | **1.4** | 5.0 U | 5.0 U | **150.0** | 0.8 | 6.61 | 8.62 | 239 | 5.48 | 52.3 |
| L-2 | 2 | 3/29/2019 | **16.0** | 0.5 U | **1.50** | **16.0** | 1.0 U | 5.0 U | 5.0 U | 5.0 U | 0.2 | 6.82 | 11.08 | 238 | 5.96 | 85.6 |
| M-2 | 2 | 3/27/2019 | 0.5 U | 0.5 U | **0.78** | **5.7** | 1.0 U | 5.0 U | 5.0 U | 5.0 U | 0.6 | 6.40 | 9.39 | 106 | 6.53 | 73.5 |
| S-2 | 2 | 3/25/2019 | 0.5 U | 0.5 U | 0.10 U | **8.4** | 1.0 U | 5.0 U | 5.0 U | 5.0 U | 2.0 | 7.22 | 11.78 | 188 | 4.86 | 102.2 |
| SA-2 | 2 | 3/28/2019 | **5.0** | 0.5 U | **1.60 J** | **4.9 J** | 1.0 U | 5.0 U | 5.0 U | 5.0 U | 2.0 | 7.14 | 13.77 | 280 | 3.91 | 67.9 |
| SC-2 | 2 | 3/25/2019 | **7.1** | 0.5 U | **1.50** | **6.1** | 1.0 U | 5.0 U | 5.0 U | 5.0 U | 0.6 | 6.77 | 11.08 | 255 | 3.68 | 194.7 |
| SD-2 | 2 | 3/26/2019 | **13.0** | **1.1** | **1.10** | **7.1** | 1.0 U | 5.0 U | 5.0 U | **5.0** | 3.5 | 6.43 | 10.13 | 223 | 3.88 | 52.7 |
| | | **Median** | **13.0** | **0.5** | **1.50** | **7.1** | **1.0** | **5.0** | **5.0** | **5.0** | 1.8 | 6.63 | 10.99 | 238 | 4.31 | 79.6 |
| **Aquifer 3a** | | | | | | | | | | | | | | | | |
| I-3a | 3a | 3/26/2019 | **27.0** | **3.4** | 0.10 U | **6.9** | **1.3** | 5.0 U | 5.0 U | **100.0** | 4.8 | 6.72 | 9.78 | 221 | 4.32 | 33.7 |
| IA-3a | 3a | 3/27/2019 | **78.0** | **18.0** | 0.50 U | **8.7** | **1.0** | 5.0 U | 5.0 U | **150.0** | 3.4 | 7.09 | 12.18 | 200 | 4.37 | 13.1 |
| MA-3a | 3a | 3/27/2019 | **27.0** | **3.2** | 0.10 U | **9.3** | 1.0 U | 5.0 U | 5.0 U | 5.0 U | 1.4 | 7.05 | 11.00 | 216 | 5.48 | 51.6 |
| SD-3a | 3a | 3/26/2019 | 0.5 U | **15.0** | 0.10 U | **8.5** | 1.0 U | 5.0 U | 5.0 U | **24.0** | 0.9 | 7.44 | 10.22 | 197 | 5.56 | 43.4 |
| | | **Median** | **27.0** | **9.2** | 0.10 | **8.6** | **1.0** | 5.0 | 5.0 | **62.0** | 2.4 | 7.07 | 10.61 | 208 | 4.93 | 38.55 |
| **Aquifer 3** | | | | | | | | | | | | | | | | |
| B-3 | 3 | 3/29/2019 | 0.5 U | **10.0** | 0.10 U | **16.7 J** | 1.0 U | 5.0 U | 5.0 U | 5.0 U | 3.8 | 6.92 | 10.97 | 192 | 3.17 | 35.7 |
| I-3 | 3 | 3/26/2019 | 0.5 U | **14.0** | 0.10 U | **18.7** | 1.0 U | 5.0 U | 5.0 U | 5.0 U | 3.6 | 6.70 | 9.41 | 172 | 6.00 | 7.6 |
| IA-3 | 3 | 3/27/2019 | **9.9** | **31.0** | 0.10 U | **12.8** | 1.0 U | 5.0 U | 5.0 U | **13.0** | 4.0 | 9.00 | 13.53 | 185 | 2.76 | 86.9 |
| | | **Median** | **0.5** | **14.0** | 0.10 | **16.7** | 1.0 | 5.0 | 5.0 | **5.0** | 3.8 | 6.92 | 10.97 | 185 | 3.17 | 35.7 |

**Notes:**

(a) Analyzed using EPA Method 300.0
(b) Analyzed using Method SM5310C
(c) Analyzed using Method RSK175
(d) Water quality meter readings were unable to be collected at time of sampling.
(e) The water was cloudy orange prior to sampling for ferrous iron. This value is therefore approximated.
(f) Sample collection form indicated sample was brown and cloudy with turbidity of 197 NTU. Sample was not filtered prior to analysis.
"-" = parameter not collected
**Bold** = Detected analyte.
J = Indicates the analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
U = Indicates the compound was undetected at the reported concentration.
UJ = The analyte was not detected in the sample; the reported sample reporting limit is an estimate.

**Abbreviations/Acronyms:**

°C = degrees Celsius
DO = dissolved oxygen
ID = identification
MGPL = Main Gravel Pit Lake
µg/L = micrograms per liter
µS/cm = microSiemens per centimeter
mg/L = milligrams per liter
mV = millivolt
ORP = oxygen-reduction potential
SW = surface water
TOC = total organic carbon