Appendix F

Groundwater Modeling Report

CDM Smith

Groundwater Model Report

700 South 1600 East PCE Plume Site
Salt Lake City, Utah

CONTRACT NO.: W912DQ-18-D-3008
TASK ORDER NO.: W912DQ19F3048

U.S. Army Corps of Engineers
Kansas City District

Department of Veterans Affairs
Veterans Health Administration Salt Lake City
Health Care System

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Section 1

Introduction

This Groundwater Model Report describes the application of the groundwater flow and solute transport model (the VAMC Model) to support environmental investigations for Operable Unit 1 (OU1) at the 700 South 1600 East Tetrachloroethene (PCE) Plume Superfund Site (site), located near the George E. Wahlen Veterans Affairs Medical Center (VAMC) in Salt Lake City, Utah (**Figures 1-1 and 1-2**). OU1 includes the entire PCE plume and its associated potential source areas. This Groundwater Model Report is included as an Appendix to the OU1 Remedial Investigation (RI) Report.

The groundwater modeling discussed herein was performed under Contract No. W912DQ-18-D-3008, Task Order No. W912DQ19F3048, CDM Federal Programs Corporation (CDM Smith). The modeling work was performed by CDM Smith. CDM Smith has designated a project manager (PM) who works directly with the U.S. Army Corps of Engineers (USACE) Kansas City District and Veterans Health Administration (VHA). **Figure 1-3** presents the groundwater modeling organization chart.

The use of the VAMC Model for this project followed the roadmap documented in the Groundwater Model Quality Assurance Project Plan (QAPP) submitted to the U.S. Environmental Protection Agency (EPA) on March 9, 2021 (CDM Smith 2021a). The QAPP outlined the methods for project oversight, data usage, and modeling approach, and was developed in accordance with the U.S. Environmental Protection Agency (EPA) guidelines contained in *Guidance for Quality Assurance Project Plans for Modeling* (EPA 2002).

1.1 Project Objectives

A RI was completed for OU1 in accordance with the requirements of the tri-party Federal Facilities Agreement, signed on January 30, 2017, between VHA, EPA Region 8, and Utah Department of Environmental Quality (UDEQ). The OU1 RI work is summarized and presented in the Remedial Investigation Report, to which this Groundwater Model Report is an appendix.

The objectives of the groundwater modeling tasks executed for the OU1 RI are to improve the understanding of the future fate and transport of the PCE plume under a range of potential hydrologic and hydraulic conditions, to assess historical flow and transport pathways associated with public supply and irrigation pumping, and to support the continued development and evolution of the conceptual site model (CSM). Although there is not currently regulatory requirement for groundwater modeling, groundwater modeling has been used in conjunction with other site information and professional judgment to meet these objectives. In accordance with Table 2 of *Guidance for Quality Assurance Project Plans for Modeling* (EPA 2002) the level of QA required is relatively low, corresponding most closely to between “Basic research” and “Trends monitoring (non-regulatory)”.

The following steps were completed to achieve these objectives:

- One groundwater flow model (the VAMC Model) was constructed based on regional and site data and previous studies and models.
- The VAMC Model represents historical conditions at OU1 and the surrounding vicinity by running in transient (time varying) mode from January 1, 1979 through September 30, 2020, using monthly stress periods.
- Hydraulic properties were estimated through a combination of historical and newly collected hydraulic testing data.
- The VAMC Model was calibrated to historical piezometric head data available from the United States Geological Survey's (USGS) National Water Information System (NWIS) and the September 2020 synoptic round of piezometric head data collected at the site and documented in the Data Summary Report (DSR) from Q3 2020 (CDM Smith 2021b).
- Model calibration was validated to the September 2011 aquifer performance test-derived drawdowns at three wells, as documented in the *Hydrogeological and Groundwater Model Summary Report for SLC-18* (MWH 2012).
- PCE transport under historical flow conditions was simulated using the January 1, 1979 to September 30, 2020 transient flow field represented by the calibrated VAMC Model.
- Present-day PCE concentration data were interpolated onto the VAMC Model and used as a starting point to simulate the fate and transport of PCE under a range of prescribed future conditions. Site data were used to implement decaying sources of PCE for these simulations.

This report provides the documentation for each of these steps.

1.2 Background

The Salt Lake City Healthcare System VAMC is in Salt Lake City, Utah (**Figures 1-1 and 1-2**). The VHA operated a part-time dry-cleaning operation that used PCE in the late 1970s and early 1980s. During this period, dry cleaning residuals were disposed of in the sanitary sewer shown on **Figure 1-2**.

PCE contamination was first identified in groundwater in 1990 at the nearby Mount Olivet Cemetery irrigation well during routine monitoring by the Salt Lake City Department of Public Utilities (SLCDPU). A follow-up inspection, conducted by UDEQ's Division of Environmental Response and Remediation, found PCE at SLCDPU Drinking Water Well No. 18 (SLC-18). This led to EPA and UDEQ involvement and the preliminary determination that the source of PCE in groundwater was the historical dry-cleaning facility located at the VAMC.

The PCE groundwater plume is present beneath the VAMC property and in areas hydraulically downgradient, extending west to the East Side Springs (ESS) neighborhood . In addition, elevated concentrations of PCE in soil gas and subslab vapor (up to 46,101 micrograms per cubic meter [$\mu g/m^3$]) have been observed adjacent to VAMC Buildings 6 and 7 (location of the VAMC dry-cleaning facility).

Additional site information, its history, previous investigations, previous remedial actions, and potential exposure pathways is provided in Section 2 of the RI Report to which this report is an appendix of.

1.3 Groundwater Modeling Approach

The groundwater modeling executed as part of this project included the following tasks:

Development of Conceptual Model

The purpose of the conceptual model task is to synthesize the available data into an understanding of the water balance (flow inputs and outputs), groundwater flow directions and gradients, groundwater flow impediments (such as faults), and hydrostratigraphy of OU1 and surrounding areas before numerical modeling.

Selection of Numerical Groundwater Flow and Solute Transport Simulation (Model) Codes

Model codes were reviewed and selected in this task to meet the objectives of the project.

Numerical Model Creation

The creation of the numerical model included the translation of the conceptual model into the numerical model representation, using the model code(s) selected.

Groundwater Flow Model Calibration

A groundwater flow model is calibrated to measured water level data to establish confidence in its ability to represent the aquifer system and to be used to meet the objectives of the project. The VAMC Model was calibrated to water level data available for the model simulation period of January 1, 1979 through September 30, 2020. A parameter sensitivity analysis was also completed as part of the calibration.

Fate and Transport Simulations, Historical Conditions

Transport of PCE released from potential source areas under historical flow conditions was simulated using the VAMC Model's transient flow field. This transient flow field includes reported historical pumping, which likely had an impact on the movement of the PCE plume emanating from the potential source areas. Transport properties including degradation, retardation, and dispersivity were estimated and used in the simulations.

Fate and Transport Simulations, Future Conditions

Present-day PCE concentration data, as documented in the Data Summary Report (DSR) from Q4 2020 (CDM Smith 2021c), were interpolated onto the model and used as a starting point to simulate the fate and transport of PCE under prescribed, non-remedy, future conditions, using decaying sources based on site concentrations data.

Each of these tasks are described in detail in the sections below.

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Section 2

Conceptual Model

A conceptual hydrogeological model is a simplified representation or working description of a real hydrogeological system. It describes how such a system behaves, or is believed to behave, on the basis of data analysis using previous studies, mapping, field observations and available field data, and serves as a basis for the numerical simulation model.

2.1 Conceptual Model Approach

Data were collected and reviewed from multiple sources, including the USGS' Regional Model documentation, Regional Model files, previously developed technical memoranda and other relevant reports, and publicly available data from USGS, NOAA, the State of Utah, and others. These data were synthesized into the conceptual model using pre-processing and visualization tools, including ArcMap GIS software, and Leapfrog Hydro 3-dimensional visualization software. A Conceptual Model Workshop was conducted on January 21, 2021 to review the conceptual model with EPA.

2.2 Conceptual Model

2.2.1 Sources of Information and Data Used in the Conceptual Model

Documents, model files, and data were reviewed to support the development of the conceptual model. The following documents were reviewed to provide background on the hydrogeological setting, hydraulic properties, and inputs and outputs to the system:

- EA. 2017. Conceptual Site Model Update for the 700 South 1600 East PCE Plume AOU-1: East Side Spring, Salt Lake City, Utah.
- Wallace, J. and Lowe, M. 2009. Ground-Water Quality Classification for the Principal Basin-Fill Aquifer, Salt Lake Valley, Salt Lake County, Utah. Utah Geological Survey. Open-File Report 560.
- MWH. 2012. Final Hydrogeological and Groundwater Model Summary Report for: Culinary Water Supply Protection at Salt Lake City's Drinking Water Well #18.
- White, R. 2020. Potential Influence of Groundwater Pumping (U of U Well #1) and Injection (U of U Well #2) on the 700 South 1600 East PCE Plume.
- CH2M Hill. 2015. Preliminary Conceptual Site Model for the 700 South 1600 East Tetrachloroethylene (PCE) Plume, Salt Lake City, Utah.
- USGS (Stolp). 2007. Hydrogeologic Setting and Ground-Water Flow Simulations of the Salt Lake Valley Region Study Area, Utah.
- USGS (Thiros). 2010. Conceptual Understanding and Groundwater Quality of Selected Basin-Fill Aquifer in the Southwestern United States.

The electronic Regional Model files from the USGS regional model described in Stolp (2007) were also used to provide a framework for model structure, stratigraphy, boundaries, and water balance terms. The model name included on the files was “SLVSS” and included the model structure, input files, and output for the Regional Model.

2.2.2 Regional Setting and Groundwater Flow

OU1 is located near the eastern edge of the Salt Lake Valley. The Salt Lake Valley is within a north-south trending normal-fault bounded basin (graben) on the eastern margin of the Basin and Range physiogeographic province (DuRoss et al. 2014). The Salt Lake Valley is bound by the Wasatch Range to the east, the Oquirrh Mountains to the west, the Traverse Mountains to the south, and the Great Salt Lake to the north (EA 2017b). The two quaternary geologic features that influence the modern physiogeography at the site are the Wasatch Fault Zone and the Pleistocene Lake Bonneville (DuRoss et al. 2014).

The Wasatch Fault Zone separates the Salt Lake Valley from the Wasatch Mountains to the east. The Wasatch Fault Zone has been divided into 10 segments including the Salt Lake City Segment, which has been subdivided into three sections from north to south: Warm Springs fault, East Bench fault, and Cottonwood fault (Personius and Scott 1992). OU1 is bisected by the west and east spurs of the East Bench fault (EA 2017b). Slip estimates on the East Bench fault have been estimated from 0.5 mm/yr (DuRoss et al. 2014) to 1 mm/yr (Scott and Shroba 1985).

Lake Bonneville, a predecessor to the Great Salt Lake, filled the Salt Lake basin from 30 kiloannum (ka) to 10 ka. The Lake Bonneville highstand (maximum shoreline elevation approximately 5,090 feet amsl) occurred approximately 18 ka. The Provo phase of Lake Bonneville occurred when elevation stabilized at approximately 4,760 feet amsl from 15 ka to 14 ka (DuRoss et al. 2014).

Regional hydrogeology has been explained in detail in Waddell et al. (1987), Thiros (2003), Stolp (2007), and Wallace and Lowe (2009), and summarized in EA (2017). Groundwater in the Salt Lake Valley occurs in alluvial fan and lacustrine deposits within perched, unconfined, and deep aquifers (EA 2017). The deposits are very complex and consist of multiple aquifers and semi-confining layers that are laterally discontinuous and internally heterogeneous (EA 2017). Groundwater flows from the primary recharge areas at the valley margins towards the Jordan River (Stolp, 2007).

Groundwater flow through the regional aquifer system was modeled in Stolp (2007) using MODFLOW-2000 (Harbaugh and others, 2000). The USGS Regional Model simulated average 1997 through 2001 conditions as a steady-state representation of the system. The model was used by the USGS to evaluate the water budget for 1997-2001 and estimate zones of contribution to 94 public supply wells in the Salt Lake Valley (Stolp, 2007).

The USGS Regional Model covers an area of 1,152 km^2 and includes 7 numerical layers. Each model cell is 1,850 feet by 1,850 feet, with the OU1 area covered by approximately seven of the 5,828 model cells. Simulated groundwater flow across OU1 is from east to west in all model layers. While regional in nature, the top three layers roughly correspond to the shallow aquifer – semi-confining unit – deep aquifer sequence across OU1 described in Section 2.2.3 below. Model layer 4 represents deep sediments of the basin-fill aquifer and has considerably lower hydraulic conductivity than layer 3.

Closer to OU1, data help to describe the local aquifer system, where groundwater flows through perched, unconfined shallow and semiconfined deep aquifer systems from the base of the Wasatch Mountains towards the west/southwest and across the East Bench Segment of the Wasatch Fault, referred to simply as “the Fault” herein. The Fault provides resistance to groundwater flow, resulting in surface discharge of groundwater through springs located to the east of the Fault. These spring discharges are cumulatively a significant component of the local water balance. East of the Fault is the East Bench Fault Spur, which may coincide with a change in surficial geology, but it not believed to impede groundwater flow. Water supply and irrigation pumping, primarily from the semiconfined deep aquifer, influence groundwater flow. These influences were more significant prior to 2004, when the closest water supply well, SLC-18, was shut down.

2.2.3 Groundwater Flow in OU1

Within OU1, the aquifer system is comprised of the following zones:

- Perched Zone: This zone is situated above the water table; it exhibits higher piezometric heads than observed at other deeper wells. The site wells that exhibit this characteristic are MW-06 (screened 100 to 130 feet bgs) and MW-29A (screened 120 to 130 feet bgs), both located near Red Butte Creek. While MW-06 and MW-29A are the only site wells that exhibit perched groundwater, a perched groundwater zone was encountered in all borings advanced at VAMC Buildings 6 and 7 (except MW-26). The saturated thickness of the perched zone near Buildings 6 and 7 was less than at MW-06 and MW-29 and was not sufficient to screen a monitoring well. Perched groundwater elevations at MW-29A are approximately 40 feet above the water table.
- Shallow aquifer zone: This zone extends to approximately 220 feet bgs at VAMC Building 7 and its vertical extents get shallower to the west as the ground surface dips. The shallow aquifer zone September 2020 interpreted head distribution is contoured (using a 10-foot-contour interval) in **Figure 2-1** based on measured heads at wells included in **Table 2-1**.
    - Groundwater flow directions are generally east to west, with horizontal gradients approximately 0.014 foot/foot along the 2,500 feet between MW-24 and MW-34. Over the next 1,000 feet between MW-34 and MW-18, the horizontal gradients are approximately 0.012 foot/foot. Between MW-13S and MW-14S (approximately 500 feet), horizontal gradients are an order of magnitude higher, at approximately 0.12 foot/foot.
- Silt/clay semi-confining unit: This unit is present between the shallow and deep aquifer zones. This unit was identified through the evaluation of piezometric heads and lithologic logs from borings across the site. Head differences between the shallow and deep aquifer zones in September 2020 were 17.65 feet at MW-03R (as measured by the difference in heads between MW-03RA and MW-03RB) and 15.3 feet at MW-01 (as measured by the difference in heads between MW-01S and MW-01D). These head differences represent a

vertical hydraulic separation between the two zones related to the presence of this semi-confining unit.

- Deep aquifer zone: This zone sits below approximately 260 feet bgs at VAMC Building 7 and gets shallower to the west as the ground surface dips. The deep aquifer zone September 2020 interpreted head distribution is contoured in **Figure 2-2** based on measured heads at wells included in **Table 2-1**.
  - Groundwater flow directions are generally east to west. Horizontal gradients between MW-23C and MW-34C are approximately 0.002 feet/foot, and 0.013 feet/foot between MW-34C and MW-13L.
  - Measured piezometric heads at MW-03RB/C/D are approximately 18 feet lower than in the Shallow Aquifer Zone situated approximately 40 feet above and measured in MW-03RA. These steep vertical gradients are indicative of hydraulic separation between the shallow and deep aquifer zones; likely because of the presence of the semi-confining unit of silt/clay between these two zones.
  - Heads at MW-03RB/C/D are nearly identical despite spanning nearly 100 vertical feet of the aquifer. This, along with inferences from the geophysical boring log, likely indicates the lack of significant and continuous aquitard units within the deep aquifer zone.

Vertical gradients, which are typically strongly downward near the VAMC property, dissipate along the east to west groundwater flow path. While MW-34C/D and MW-32C are estimated to be screened in the deep aquifer zone, there is little distinction in heads between MW-34C/D and MW-32C and the shallow aquifer zone at MW-34A/B and MW-32A/B. West of MW-34, vertical head gradients shift upwards within the shallow aquifer zone, with artesian conditions present in the deeper portions of the shallow aquifer zone at wells MW-17D and MW-14D, just east of the Fault.

West of the Fault, the vertical head differences are not present in the currently installed monitoring network, removing any distinction between the shallow and deep aquifer zones at MW-12S/D and MW-15S/D. The head difference across the Fault (as measured by the difference between heads at MW-14S and MW-15S) is approximately 112 feet. This head drop likely occurs abruptly across the Fault, which is acting as a semi-permeable barrier to flow. Groundwater flowing from OU1 is, therefore, laterally impeded at the Fault, with groundwater both flowing through the fault and mounding up at the eastern face. This mounding results in both the approximately 112-foot head difference between MW-14S and MW-15S, as well as the surface discharges to springs just east of the Fault.

The generalized hydrogeologic conceptual model for OU1 groundwater flow is presented in **Figure 2-3**.

2.2.4 Hydraulic Properties

Horizontal hydraulic conductivity estimates were based on slug testing completed as part of the OU1 RI at select monitoring wells, and previously conducted aquifer performance testing conducted in 2011 and documented in MWH 2012. OU1 RI slug testing results are presented in **Figure 2-4** and **Table 2-2**, with additional details presented below:

- Shallow Aquifer Zone:
  - In the northeastern area of the site that includes MW-01S, MW-02, MW-03RA, and MW-04, slug test estimated hydraulic conductivities range from approximately 5 to 19 feet/day, with a representative value of 5 feet/day. Darcy velocities calculated by multiplying horizontal hydraulic conductivity by the horizontal gradient ranged from approximately 0.07 to 0.2 feet/day, with a representative Darcy velocity of 0.07 feet/day. Representative seepage velocity (which is the Darcy velocity divided by the effective porosity [assumed to be approximately 0.2]) can be approximated as 0.4 feet/day for this portion of the site. MW-01S hydraulic conductivity was also estimated via slug test in 2011, yielding a range of values from 0.03 to 0.04 ft/day (MWH, 2012). These estimates are 300-400 times lower than the 19 ft/day estimated using the OU1 RI slug testing data.
  - In the central area of the site that includes MW-08A, MW-18, MW-19, MW-20S/D, MW-21, MW-22, MW-32A, and MW-34A/B, slug-test estimated hydraulic conductivities range from approximately 10 to 200 feet/day, with a representative value of 50 feet/day. Representative Darcy and seepage velocities are estimated to be approximately 0.6 and 3 feet/day, respectively. These values are higher than what is observed at the other areas of the site and coincide with their locations west of (or very close to) the East Bench Fault Spur. These data indicate that shallow aquifer zone properties west of the spur differ from those east of the spur. This distinction is consistent with surface geology mapping (EA 2017) that indicates an abrupt change in geologic unit at the spur.
  - In the southwestern area of the site that includes MW-13S/D, hydraulic conductivity ranges from 0.1 to 2 feet/day, with a representative value of 5 feet/day. Representative Darcy and seepage velocities are estimated to be approximately 0.6 and 3 feet/day, respectively. The representative values are likely more applicable to the deep portion of the shallow aquifer in this area (screened by MW-13D), as the hydraulic conductivity in the shallow portion of the shallow aquifer is approximately one order of magnitude lower.
- Deep Aquifer Zone:
  - In the northeastern and central area of the site, hydraulic conductivity derived from MW-03RB/C, MW-08B/C, MW-13L, MW-26C/D, and MW-34C/D slug tests ranged from 0.75 to 51 feet/day, with a representative value of 45 feet/day. The representative Darcy velocity is approximately 0.09 feet/day, with a representative seepage velocity of approximately 0.45 feet/day.
  - MW-01D, which was not slug tested as part of OU1 RI, was included in the monitoring well network for the September 2011 aquifer performance test (APT) documented in MHW (2012). Analysis of these data, which monitored the drawdown at MW-01D

resulting from pumping public supply well SLC-18 at a rate of 1,320 gpm for 30 consecutive days, yielded a horizontal hydraulic conductivity range of 120 to 140 ft/day. MW-01D was also slug tested in 2011, with horizontal hydraulic conductivity estimated to be between 45 and 80 ft/day (MWH, 2012).

- Unlike in the shallow aquifer zone, a significant difference in hydraulic conductivities east and west of the East Bench Fault Spur was not noted.

- West of the Fault:
  - Hydraulic conductivity was estimated to be approximately 15 ft/day at MW-15D.

Vertical hydraulic conductivities are estimated to be 100 times lower than horizontal conductivities throughout the site based on both the USGS Regional Model and what is typical for alluvial fan and lacustrine deposits that are very complex and consist of multiple aquifers and semi-confining layers that are laterally discontinuous and internally heterogeneous (EA 2017). This heterogeneity tends to produce resistance to vertical flow, relative to more homogenous materials.

No direct measurements of hydraulic conductivity are available for the semi-confining silt/clay layer separating the shallow and deep aquifers zones or the Fault. These properties will be estimated in the VAMC Model through calibration to the measured piezometric head differences across these features, as follows:

- Head differences between the shallow and deep aquifer zones in September 2020 were 17.65 feet at MW-03R (as measured by the difference in heads between MW-03RA and MW-03RB) and 15.3 feet at MW-01 (as measured by the difference in heads between MW-01S and MW-01D). These head differences represent a vertical hydraulic separation between the two zones related to the presence of a semi-confining unit, which is noted in boring logs.

- Head differences between the east and west sides of the Fault in September 2020 were approximately 112 feet, as measured by the difference in heads between MW-14S and MW-15S. This head difference represents a lateral hydraulic separation across the Fault. As such, the hydraulic conductivity of the Fault is assumed to be relatively low.

Below the deep aquifer zone sits a layer of lower transmissivity that corresponds to USGS Regional Model layer 4 (Stolp, 2007). This layer is believed to have lower transmissivity and hydraulic conductivity than the deep aquifer zone. In 2011 MWH performed hydrophysical testing on SLC-18 to characterize the vertical distribution of flow across the SLC-18 well screen. The results of this test showed that despite having nearly 50% of the screen length within this deeper, lower transmissivity unit, only 3% of the pumped flow was drawn from there (MWH 2012). This confirms that there is a relative difference in properties between these two units and that the deeper layer of lower transmissivity is considerably less transmissive than the deep aquifer zone.

According to Stolp (2007), storage coefficient values in confined zones of the aquifer system are estimated to range from 0.001 to less than 0.0001, and specific yield in the unconfined aquifers was estimated to range from 0.10 to 0.30 (Hely and others, 1971).

2.2.5 Stratigraphy

The conceptual model stratigraphic interpretations were based on a review of the above referenced documents, the USGS Regional Model stratigraphy, geophysical logs, and piezometric head data. The lithologic log interpretations, USGS Regional Model layers, ground surface elevation data and piezometric head data were brought into the project's 3D visualization and analysis (3DVA) model of the site and used to build the conceptual model layering using the following approach:

- The top of the model was set to the ground surface elevation, which was based on a combination of 1-meter and 10-meter Digital Elevation Models (DEMs) obtained from USGS.
- Instances of silt/clay noted in boring logs were examined and compared to piezometric heads (from 2020) to estimate the bottom of the shallow aquifer zone, the top of the deep aquifer zone and the location of the semi-confining silt/clay layer separating them. Spatial interpolations were done to connect these contacts between wells.
- The bottom of the deep aquifer zone was set to the elevation of the top of USGS Region Model layer 4, which represents the deeper zone of lower transmissivity presented above.

Two cross sections, A-A' and B-B', have been included on **Figure 2-5**. Each section shows the conceptual stratigraphy from west to east, the monitoring and pumping well screens, and layering and lithologic interpretations of the silt/clay semi-confining unit. Cross Section A-A' extends from just east of the Fault through MW-05R, which is upgradient of the site. Cross Section B-B' extends from the University of Utah Irrigation Well #1, though USGS monitoring well 404531111510101(D-1-1)4cbc-1, SLC-18 and MW-30. As noted above, a significant portion of the SLC-18 well screen is located within the deeper zone of lower transmissivity that correlates to USGS Regional Model layer 4. The development and use of the 3DVA model to support the CSM is presented in the OU1 RI Report.

2.2.6 Water Balance

The groundwater balance between the Fault and the Wasatch Front includes:

- subsurface inflows from the Wasatch Front, referred to herein as mountain block recharge, inflows through precipitation recharge, return flow recharge, and from river infiltration at Red Butte Creek,
- outflows through pumping withdrawals from water supply and irrigation wells and at springs east of the Fault.

West of the Fault, groundwater flows from east to west, towards the Jordan River. As noted above, the Fault acts as a semi-permeable barrier to flow, with a portion of the upgradient groundwater flow discharging to springs, and the remainder passing through to the west side of the Fault and following the regional flow field towards the Jordan River. USGS piezometric head data at four surrounding wells provide insights on conditions west of the Fault and south of Red Butte Creek that can be used to inform boundary conditions for the VAMC Model. The locations of these monitoring wells, along with the spatial locations of inflows and outflows to the aquifer system are depicted in **Figure 2-6**. Each water balance component is discussed in detail below.

Precipitation Recharge

Precipitation recharge across the study area varies temporally and spatially. The amount of precipitation that becomes groundwater recharge is based on precipitation volume and groundwater recharge zones defined during previous studies.

Monthly precipitation data were obtained from three nearby climate stations with data available from the National Oceanic Atmospheric Administration's (NOAA's) National Centers for Environmental Information (NCEI) online database. The closest weather station to OU1 is at the University of Utah (approximately 0.6 miles from the VAMC campus). Data from this station are available through 1989, with an average annual precipitation between 1979 and 1989 of 21.2 inches per year.

The next closest NOAA weather station is at the Salt Lake Triad Center, approximately 3.5 miles to the northwest of the VAMC campus. Monthly rainfall totals are available for this weather station between May 1985 and May 2013. The average annual rainfall over that period was measured to be 16.2 inches. During the years when data were available at both the University of Utah weather station and the Triad Center station, annual average rainfall at the University was 20 percent higher than what was recorded at the Triad Center. This is expected as the University is approximately 550 feet higher elevation than the Triad Center.

The NOAA weather station located at the Salt Lake City International Airport is approximately 7.5 miles northwest of the VAMC campus (and also approximately 550 feet lower elevation than the University weather station). Monthly rainfall data are available for every year between 1979 and 2020 at this station, with an average annual rainfall of 15.6 inches per year over that period. During the years when data were available at both the University of Utah weather station and the Airport station, annual average rainfall at the University was 29 percent higher than what was recorded at the airport, which is expected owing to the elevation difference between the sites. Annual precipitation data for each site is included in **Table 2-3** for the years 1979 through 2020. All of these data can be obtained from the NCEI online database.

The percent of precipitation that becomes groundwater recharge varies spatially based on the three zones delineated for the entire basin in Thiros (2010) and depicted in **Figure 2-7** for OU1 and vicinity. The Primary Recharge Area receives the most recharge (as percent of rainfall) and is located near the Wasatch Mountain Front. In this area, the alluvial fan and lacustrine deposits at the surface consist of more coarse-grained materials, and any confining layers that are present are relatively thin (Anderson et al. 1994). The Secondary Recharge Area, which borders the primary recharge area on the west, receives less recharge (as percent of rainfall) than the primary recharge area due to the presence of localized perched aquifers and finer-grained materials (Anderson et al. 1994). OU1 is primarily within both the Primary and Secondary Recharge Areas, though a portion of the third area, the Discharge Area is present west of the

Fault. A map of the recharge areas for the full regional aquifer system can be seen in Figure 4 of *Conceptual Understanding and Groundwater Quality of Selected Basin-Fill Aquifer in the Southwestern United States* (Thiros 2010). The USGS Regional Model uses approximately 12% of precipitation as groundwater recharge to the Discharge Area (Stolp 2007).

Precipitation that does not become groundwater recharge makes up the surface runoff and evapotranspiration portion of the water balance.

Return Flow Recharge

Return flow is water recharging the aquifer from irrigation, lawn watering and leaky water distribution pipes. The USGS Regional Model applied approximately 1.75 inches per year as return flow within the vicinity of the site. While precipitation recharge varies over time, return flow recharge is assumed to be a relatively constant input of water to the aquifer system.

Stream Infiltration

The site is located in the lower Red Butte Creek sub-watershed within the Jordan River Watershed (FE 2015). The closest surface water body to the site is Red Butte Creek, which extends from the northeast to southwest near the east side of the VAMC campus near Buildings 6 and 7, before traveling more westerly at a distance of about 1,500 feet to the southwest of OU1 in the ESS area. Red Butte Creek is a perennial stream with an average annual baseflow of approximately 2.5 MGD based on USGS data from 1965 until 2020. In the vicinity of the site and east of the Fault, Red Butte Creek is a losing stream. Hely et al. (1971) estimated average losses to groundwater from Red Butte Creek to be 0.48 MGD between 1964 and 1968. The USGS Regional Model, which had cell sizes of 1,850 feet by 1,850 feet, did not explicitly represent Red Butte Creek.

Mountain Block Recharge

Stolp (2007) estimated that the movement of groundwater from the "fractures, joints, and pore space of the (Wasatch Range) mountain block into the adjacent basin fill recharges the aquifer at an estimated rate of approximately 402,000 m^3/day (106 MGD) for 1997-2001", with inflow distributed along the Wasatch mountain front on the basis of inferred relative permeability of the different consolidated rock units (Hely and others, 1971; Waddell and others, 1987). Along the mountain front upgradient of OU1 coincident with the conceptual boundary shown in **Figure 2-6**, the USGS Regional Model includes approximately 5.2 MGD of mountain block recharge into the Deep Aquifer Zone. It is noted that while values taken from the USGS Regional Model offer a conceptual understanding of how the aquifer system works, the USGS Regional Model was not designed to quantify flow across, or represent heads within, the area between the VAMC site and the Fault.

Pumping Withdrawals

Groundwater withdrawals within the vicinity of OU1 are limited to public supply pumping from SLC-18, and irrigation pumping from the Mount Olivet Cemetery irrigation well and the University of Utah irrigation wells #1 and #2, which are included on **Figure 1-2**. All four of these wells are screened to extract water from the Deep Aquifer Zone, though a portion of the Mount

Olivet well screen likely extends into the Shallow Aquifer Zone and consequently may draw some of its water from there.

SLC-18 monthly pumping data are available for download from the Utah Division of Water Rights website from January 1979 through present day. Data for January 1979 through September 2020 are plotted in **Figure 2-8**. Pumping at this well varied seasonally, averaging 1,538 gpm in July (highest pumping month) and 18 gpm in January (lowest pumping month) between 1979 and 2004 after which pumping for water supply ceased due to PCE detections.

Unlike public supply wells, the irrigation wells within the study area do not have withdrawal records. Limited data were available for review. No Mount Olivet Cemetery irrigation pumping data are available for any of the 1979-2020 time period. Correspondences with the cemetery did not provide any insights into typical operations. In lieu of data, it was assumed that no irrigation takes place in the months of October through March and that irrigation pumping in April through September can be estimated by calculating the volume of water required to meet the monthly water deficit (difference between average evapotranspiration and average precipitation for each month) and account for a 20% irrigation inefficiency factor. This resulted in April through September pumping estimates of 60, 135, 215, 265, 215, and 125 gpm, respectively. These values are repeated for each year in the simulation period.

2018 University of Utah irrigation pumping at University Well #1 was included in Figure 2 of a letter report submitted by Richard B. White on June 8, 2020 titled *Potential Influence of Groundwater Pumping (U of U Well #1) and Injection (U of U Well #2) on the 700 South 1600 East PCE Plume*. This figure is reproduced as **Figure 2-9**. It is unstated whether these values, which range from 0 to just over 270,000 ft^3/day (1,400 gpm) were “instantaneous” values, representing a measurement at a point in time or based on volumes of water taken over a known period of time. The spike in pumping up to 270,000 ft^3/day in mid-June suggests the values may be instantaneous measurements. If this well is not continuously operated (for example, pumped for 8 or 12 hours per day), instantaneous measurement could overestimate the monthly withdrawals at the well by 2 to 3 times.

Discharge to Springs

Springs are present alongside the scarp of the Fault. Four of those springs have been named and are listed below, with several others documented as shown in **Figure 2-6**. A subset of these springs makes up the discharges to the ESS neighborhood, where PCE has been detected in surface water.

- Our Lady of Lourdes Spring to the north-northwest of the ESS just south of the Our Lady of Lourdes Catholic School and the Judge Memorial Catholic High School
- Benson Spring in the north main area of the ESS
- Smith Spring in the central ESS area, on Alpine Place
- Bowen Spring to the south in the ESS

Many of the unnamed springs surface on residential properties near residential structures. Some of the springs are expressed as diffuse wet areas that form small trickling streams on slopes, while others have been altered by property owners to collect and channel flowing water into landscape features (e.g., ponds, streams) or water collection systems (e.g., buried drains, sump pumps) (FE 2015, EA 2017).

As part of the OU1 RI field activities, surface water flows were measured in April 2021 at 11 locations where springs were known to occur. The total measured flow rate at these locations was approximately 0.6 MGD. While this value does not account for all of the surface discharges within the ESS and surrounding areas, it does provide an order of magnitude estimate of the springs discharge component of the water balance.

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Section 3

Numerical Model and Calibration

The numerical groundwater flow and solute transport model creation and applications were completed following QA protocol and procedures described in the *Groundwater Model Quality Assurance Project Plan* (QAPP; CDM Smith, 2021a). The QAPP is a road map which describes how the model will be developed, assessed, and applied at the site. It was developed in accordance with the U.S. Environmental Protection Agency (EPA) guidelines contained in Guidance for Quality Assurance Project Plans for Modeling (EPA 2002).

The creation and validation of the VAMC Model includes the selection of model codes, the translation of the conceptual model into the numerical model representation, and the calibration and sensitivity testing of the model.

3.1 Model Code Selection

A review of model codes in light of the objectives of the project and the characteristics of the site was performed before groundwater model creation and application. Some characteristics that informed this review included:

- The degree of water level variability over the selected simulation time period
- The vertical and horizontal discretization needed to meet the project objectives
- Stratigraphic features, including the orientation of aquifer layers and anisotropy
- The representation of faults or other hydraulic flow barriers within the aquifer system
- The number and spatial distribution of pumping wells within the model domain
- The solute transport processes needed to be represented in the model

Following this review, it was determined that the groundwater flow and fate and transport modeling would be performed using MODFLOW-SURFACT, implemented within the Groundwater Vistas graphical user interface. MODFLOW-SURFACT is a proprietary version of the MODFLOW (McDonald and Harbaugh 1996) family of codes that has been used extensively in groundwater evaluations worldwide for more than 20 years. MODFLOW-SURFACT is well-documented and is an enhanced version of MODFLOW that includes a Newton-Raphson linearization approach to solving the governing groundwater flow equations.

The modeling code dealing with contaminant fate and transport was the version of MT3D embedded within MODFLOW-SURFACT. MT3D (Zheng 1990, 2010; Zheng and Wang 1999) is a modular three-dimensional transport program for simulation of advection, dispersion, and chemical reactions of contaminants in groundwater. MT3D is intended for use with MODFLOW or any other finite-difference flow model code.

MODFLOW is a modular three-dimensional finite-difference groundwater flow model that was developed by the USGS (McDonald and Harbaugh 1988; Harbaugh and McDonald 1996) during the early 1980s. MODFLOW is a standard groundwater flow modeling program used throughout the world.

Groundwater Vistas served as the primary graphical user interface for the groundwater flow and fate and transport models. Groundwater Vistas was developed by Jim Rumbaugh and Doug Rumbaugh and distributed by Environmental Simulations, Inc. Esri ArcGIS and Microsoft Excel were also used to preprocess and postprocess model data. All software programs were run on a standard PC running the 64-bit versions of Windows.

3.2 Numerical Model Creation

The creation of the numerical model includes the translation of the conceptual model into the numerical model representation, using the model codes. The basis for the VAMC Model is the data and analyses completed as part of the conceptual model development. The model domain and boundaries, hydraulic properties, and simulation time period used for the VAMC Model are described below.

3.2.1 VAMC Model Grid, Domain, and Boundaries

The VAMC Model domain, finite-difference grid, and boundary conditions are depicted in **Figure 3-1.** The model grid and layering are described below:

- The VAMC Model has uniform grid cell size of 150 feet by 150 feet and contains 128 rows and 128 columns covering a total area of 368,640,000 ft^2, of which 52% (194,670,000 ft^2) comprises the 'active' area of the grid (only active cells are shown in **Figure 3-1**). The remaining 48% is inactive and not included in the model solution.

- The coordinate system of the model is NAD1983 State Plan Utah Central, Feet. All elevations are in NAVD88 vertical datum.

- The model contains 5 computational layers as described below:

  - Model layers 1 and 2 represent the shallow aquifer zone. The top of layer 1 is the ground surface interpolated onto the model grid from DEM data. The bottom of layer 2 is the inferred bottom of the shallow aquifer zone per Section 2.2.5. The shallow aquifer zone was divided equally into two layers (layers 1 and 2) to represent vertical head gradients and artesian conditions within the shallow aquifer zone, and to properly assign the drain boundary conditions to the springs.

  - Model layer 3 represents the silt/clay semi-confining layer in-between the shallow aquifer zone and deep aquifer zone. The position of this layer is based on lithologic logs and piezometric heads, as presented in Section 2.2.5.

  - Model layer 4 represents the deep aquifer zone. Only one layer was used for the deep aquifer zone due to the limited vertical piezometric head differences across the zone. The top of the layer is defined by lithologic logs and piezometric heads, as presented in

Section 2.2.5. The bottom of the layer corresponds to the top of the USGS Regional Model's layer 4, which has lower transmissivity than the deep aquifer zone.

- Model layer 5 is designed to match the USGS Regional Model layer 4. This layer, as noted in Section 2.2.4 has lower transmissivity and hydraulic conductivity than the deep aquifer zone and extends to rock. This layer was included in the model because SLC-18 is screened into the layer and draws some water from it (though minimal amounts per Section 2.2.4). The bottom of the model is assumed impermeable and coincides with the top of rock in the USGS Regional Model.

The selection of VAMC Model boundaries follows the guidance provided in ASTM standard D5609-16, *Standard Guide for Defining Boundary Conditions in Groundwater Flow Modeling* (ASTM, 2016a). The VAMC Model domain was aligned with natural site features where possible and positioned along estimated groundwater flow lines based on regional (USGS) piezometric head contour maps and recorded heads at long term monitoring locations when natural features were not present. The lateral boundaries of the groundwater model are far enough away from OU1 such that the boundary assignments do not have a significant impact on the simulation of historical groundwater flow and transport pathways near SLC-18, springs east of the Fault, and other potential receptors.

Boundary assignments were set as follows:

- The cells bordering the Wasatch Front (eastern and northern portions of the model domain) were assigned Specified Flux boundary conditions to represent mountain block recharge, with initial values based on the data presented in 2.2.6.

- Along the southern boundary, heads were set to a no flow condition, with head equipotential lines perpendicular to the boundary. Measured heads at 404356111503901 (D-1-1) 16caa-1, and 404438111494001 (D-1-1) 10cac-1 were used to check the appropriateness of this boundary condition.

- The remaining cells bordering the western portion of the model domain were assigned as specified head boundary conditions based on historic piezometric head data measured at 40450611523301 (D-1-1) 7abd-6, which was 4,276 feet amsl. Based on relatively little variation over time of the measured head values at this well, the specified head assigned to this boundary does not vary over time (aka constant head boundary). By positioning the boundary west of the Fault, the groundwater model can simulate the approximately 112-foot piezometric head drop across it. The transmissivity of the Fault, and the model's ability to match the head drop across it, are important factors in understanding the water balance. The western boundary is also reasonably aligned with regional head contours.

- The areas east of the Fault where springs are known to discharge were assigned drain boundary conditions, with the average ground surface elevation within each cell assigned as the drain stage (or elevation at which groundwater discharges to the drain). A conductance value of 15,625 ft^2/day was assigned to each drain cell, assuming a vertical hydraulic conductivity of 1 ft/day.

- Recharge, in the form of precipitation recharge, return flow and Red Butte Creek infiltration, is applied to the top layer of the model. Precipitation recharge is applied by zone as shown in **Figure 2-7** and **Table 3-1**. Return flow and Red Butte Creek infiltration were fixed over the course of the simulation at 1.75 inch per year and 0.4 MGD, respectively.
- Monthly pumping withdrawals were simulated at SLC-18, University of Utah Well #1, and the Mount Olivet Cemetery irrigation well per Section 2.2.6.

3.2.2 VAMC Model Hydraulic Properties

Informed by the conceptual model (Section 2.2.4), hydraulic testing, and model calibration (discussed below), values of horizontal hydraulic conductivity (K_h), vertical hydraulic conductivity (K_v), specific yield (S_y), and specific storage (S_s) were applied to each cell in the model and presented below.

- Shallow aquifer zone:
    - Shallow aquifer zone properties are depicted for layers 1 and 2 (identical) in **Figure 3-2**.
    - In the area of the site east of the East Bench Fault Spur and a portion of the area west of the spur but east of the fault coincident with low K_h values at MW-13, K_h and K_v values were set to 5 and 0.05 ft/day, respectively. West of the spur K_h and K_v values were set to 50 and 0.5 ft/day, respectively, except as noted.
    - West of the Fault K_h and K_v values were set to 15 and 0.15 ft/day, respectively.
    - Both horizontal and vertical hydraulic conductivities of the Fault were set to 0.1 ft/day throughout all layers of the model.
- Silt/clay semi confining layer:
    - Silt/clay semi-confining layer properties are depicted for layer 3 in **Figure 3-3**.
    - East of the Fault, K_h and K_v values were set to 0.01 and 0.001 ft/day, respectively.
    - West of the Fault K_h and K_v values were set to 15 and 0.15 ft/day, respectively.
    - Both horizontal and vertical hydraulic conductivities of the Fault were set to 0.1 ft/day throughout all layers of the model.
- Deep aquifer zone:
    - Deep aquifer zone properties are depicted for layer 4 in **Figure 3-4**.
    - East of the Fault, K_h and K_v values were set to 45 and 0.45 ft/day, respectively.
    - West of the Fault K_h and K_v values were set to 15 and 0.15 ft/day, respectively.

  - Both horizontal and vertical hydraulic conductivities of the Fault were set to 0.1 ft/day throughout all layers of the model.
  - Unlike in the Shallow Aquifer Zone, there was not a significant difference in hydraulic conductivities east and west of the East Bench Fault Spur.
- Deeper, lower transmissivity zone below the Deep Aquifer Zone:
  - K_h and K_v values were set to 1 and 0.1 ft/day, respectively both east and west of the Fault.

Specific yield (S_y) and specific storage (S_s) were set to 0.15 and 0.00001 throughout the model domain.

3.2.3 Historical Simulation Period

The VAMC Model simulates saturated groundwater flow over the historical period of January 1, 1979 through September 30, 2020 using time varying data and monthly transient stress periods. This simulation period is based on the availability of historical data and the current CSM.

3.3 Model Calibration

The VAMC Model was run in transient mode for the nearly 41-year historical period of January 1, 1979 through September 30, 2020, for which both water level (CDM Smith 2021a, USGS 2020) and public supply pumping data (Utah Division of Water Rights 2020) are available.

3.3.1 Calibration Approach

During model calibration model inputs are adjusted, within bounds identified during the development of the CSM, until a reasonable match with observed data is achieved. The model calibration approach for the VAMC Model followed the ASTM International (formerly known as American Society for Testing and Materials [ASTM]) standard D5981-18 *Standard Guide for Calibrating a Groundwater Flow Model Application* (ASTM 2018) and D5490-93 *Standard Guide for Comparing Groundwater Flow Model Simulations to Site-Specific Information* (ASTM 2014). The manual method of calibration was used, which is the process of "changing a model input, running the simulation with the new input, and then comparing the results of the simulation with the calibration targets" (ASTM 2018). This method is also called the trial-and-error method. The parameters that were varied included horizontal and vertical hydraulic conductivities, specific storage and specific yield, drain conductances, recharge, and pumping from the University of Utah irrigation well #1.

3.3.2 Calibration Data Sets

Model calibration predominantly focused on the shallow aquifer zone and the deep aquifer zone and was completed by producing a good match to the following three data sets.

September 2020 Synoptic Water Levels

Simulated piezometric heads from the model stress period associated with September 2020 were compared to those from the synoptic round of water level measurements taken from the wells listed in **Table 2-1**. This period was selected because it is the most comprehensive synoptic round within the simulation period. Water level data from these wells are also included in **Table 2-1**. Ten-foot piezometric head contours interpreted from these data are plotted up for the Shallow Aquifer Zone and the Deep Aquifer Zone in **Figure 2-1 and 2-2**, respectively.

Time Varying Piezometric Head Data, January 1980 through September 1984

Model calibration was also checked against piezometric head data measured from USGS well 404531111510101(D-1-1)4cbc-1 (4cbc-1) (available on USGS's NWIS at https://nwis.waterdata.usgs.gov/usa/nwis/gwlevels/?site_no=404531111510101) for the historical period of January 1980 through September 1984 (USGS 2020). This well, which is shown on **Figure 2-2**, is located near SLC-18, has a similar screened interval to SLC-18 (see **Figure 2-5**), and its 338 water level measurements taken between January 1980 and September 1984 can be used to correlate well pumping activity at SLC-18 with nearby water level variation. Calibration to these data provide a means to compare simulated and observed aquifer system responses to pumping stresses over time and to estimate deep aquifer zone hydraulic properties.

September 2011 Aquifer Performance Test Data

The calibrated VAMC Model was validated to the September 2011 aquifer performance test-derived drawdowns at MW-1S, MW-1D and the Fountain of Ute irrigation well, as documented in the *Hydrogeological and Groundwater Model Summary Report for SLC-18* (MWH 2012). Matching to hydraulic testing data was intended to provide an independent check on aquifer properties.

3.3.3 Model Calibration Results

September 2020 Synoptic Water Levels

Table 3-2 lists a comparison of simulated and measured September 2020 water levels. A scattergram of simulated versus measured heads (residuals) in relation to a 45-degree line that represents a 1 to 1 match to the calibration data set is shown in **Figure 3-5.** The following statistics were calculated:

- Mean Error (ME): -0.6 feet; the mean difference between simulated and measured heads (positive value indicates simulated is higher than measured, negative value indicates simulated is lower than measured)
- Mean Absolute Error (MAE): 5.8 feet; the mean of the absolute value of the differences in measured and simulated heads
- Standard Deviation (STDEV): 7.0 feet; a statistic that measures the dispersion of a dataset relative to its mean
- Root Mean Squared Error (RMSE): 7.0 feet; the average of the squared differences in measured and simulated heads
- Range: 228 feet; the difference between the maximum and minimum measured values
- Scaled Root Mean Squared Error (SRMSE): 3.1%; the RMSE expressed as a percentage of the range

Residuals are plotted spatially along with 10-foot simulated September 2020 head contours in **Figure 3-6** for the Shallow Aquifer Zone and **Figure 3-7** for the Deep Aquifer Zone. ASTM no longer suggests prescribed statistical standards that govern an acceptable goodness of fit for groundwater model calibrations because each calibration should be assessed based on the project objectives and the limitations and uncertainties of the available data. A rule of thumb is that the SRMSE should be less than 10 percent. For this dataset, the range of values (228 feet) is large due to the 112-foot head difference across the Fault. In **Figure 3-5**, residuals for MW-12S/D and MW-15S/D (which are located west of the Fault) are not shown to keep the axes within a visible range on the scatterplot. If only the wells east of the Fault are considered in the calculation of the Range and SRMSE, those numbers would be 115 feet and 6.3%, respectively.

The residuals are not biased high or low, as evidenced by the scatterplot in **Figure 3-5** and the relatively small mean error of -0.6 feet. The maximum residual (indicating that the model simulated value is high compared to the measured value) is 10.5 feet at Shallow Aquifer Zone well MW-05R. As this is the furthest upgradient Shallow Aquifer Zone well, less data are available to inform the model at this location. Iterative model calibration simulations indicated that improvements made here would have detrimental effects on calibration elsewhere and were not carried through to the final model.

The minimum residual (indicating that the model simulated heads are low compared to measured values) is -15.9 feet at MW-13S. Similar residuals are seen at MW-21 (-15.1 feet) and MW-22 (-14.3 feet) where a localized mound is depicted in the interpreted contours. The nature of this mound is unclear as the residuals of the wells upgradient (MW-31A), cross gradient (MW-20S), and downgradient (MW-17D) at similar depths are -3.8, -1.0, and -0.9, respectively.

At MW-03RA and MW-03RB, which are screened just above and below the silt/clay semi-confining unit represented in model layer 3, the simulated vertical head difference is 18.7 feet, as compared to a vertical head difference of 17.6 feet calculated from water level measurements. Similarly, at MW-01S and MW-01D, the simulated vertical head difference is 15.9 feet, as compared to a vertical head difference of 15.3 feet calculated from water level measurements. These close matches suggest that the model properties influencing the hydraulic separation between shallow aquifer zone and the deep aquifer zone are reasonable.

The simulated head difference across the Fault (as measured by the difference between heads at MW-14S and MW-15S) is approximately 114 feet, which is only slightly higher than the measured head difference of approximately 112 feet. This close match suggests that the model hydraulic properties influencing the flow through the Fault are reasonable, and that the model represents the head drop across the fault.

The simulated discharge to surface springs is approximately 1.3 MGD, which is higher than the 0.6 MGD that was measured at 11 locations in April 2021 where springs are known to occur. The full discharge volume is expected to be greater than 0.6 MGD, when accounting for all springs including those that discharge directly to underground storm drains. While it is unclear what the actual discharge value is, the strong match with other nearby calibration targets (the head drop across the Fault and heads at MW-14S with 0.7-foot residual) suggest that the simulated discharge of 1.3 MGD is a reasonable value.

The water balance for the model stress period associated with these data is shown in **Table 3-3** below. Water enters the modeled system via approximately 9.1 MGD of recharge and lost to the constant head boundaries to the west (7.7 MGD), the drains representing springs (1.3 MGD), and pumping wells (0.7 MGD). Storage increased 0.6 MGD from the previous stress period, due to a decrease in pumping between August and September 2020. This water balance is for the September 2020 stress period within the transient model simulation. It therefore represents a snapshot in time in the simulation, and not steady-state conditions.

Table 3-3 Simulated Water Budget, September 2020

Water Budget Component	Inflows (MGD)	Outflows (MGD)	Volume In - Out (MGD)
Extraction from Pumping Wells	0	0.7	-0.7
Precipitation Recharge	1.0	0	1.0
Return Flow Recharge	0.6	0	0.6
Infiltration from Red Butte Creek	0.4	0	0.4
Mountain-Block Recharge	7.1	0	7.1
Discharge to Seeps and Springs	0	1.3	-1.3
Boundary Flux	0	7.7	-7.7
Change in Storage	0.6	0	0.6
Total	9.7	9.7	0.0

Time Varying Piezometric Head Data, January 1980 through September 1984

Model calibration against piezometric head data measured from USGS well 404531111510101(D-1-1)4cbc-1 (4cbc-1) for the historical period of January 1980 through September 1984 (USGS 2020) was completed to provide a means to evaluate how the aquifer system responds to pumping stresses over time and to estimate deep aquifer zone hydraulic properties. This well has a similar screened interval to SLC-18 (see **Figure 2-5**), and the seasonal fluctuations in its 338 water level measurements taken between January 1980 and September 1984 correlate well to pumping activity at SLC-18 during that time period.

A plot of simulated and observed head over time at this well is shown in **Figure 3-8**. Overall, and given the uncertainty around historic University of Utah Irrigation Well pumping, the VAMC Model represents the pumping-generated seasonal variations in deep aquifer zone heads well, as described below:

- Between 4/10/1982 and 8/25/1982 when SLC-18 and University of Utah Irrigation Well #1 were active, measured heads dropped from approximately 4,477 feet to approximately 4,445 feet. The model represents the drawdown, and the shape of the drawdown curve extremely well for this period. Simulated and measured drawdown were approximately 34 and 32 feet, respectively.

- Between 8/25/1982 and 5/20/1983 when pumping was mostly shut off at these wells, measured heads rose from approximately 4,445 feet to approximately 4,476 feet. While the simulated shape of the recovery curve for this period varies from the observed shape, the magnitude of the simulated recovery is 36 feet, higher than but similar to the 31 feet of measured recovery.

- The usual cycle of 20-to-30-foot drawdown and recovery was not observed between 5/5/1984 and 9/30/1984. Instead, only 11 feet of drawdown was observed during this period. Average SLC-18 May through September pumping for 1984 was 603 gpm, down from 978 gpm in 1983 and 1,063 gpm in 1982. This reduction makes sense, given that 1983 received the second most precipitation of the years between 1979 and 2004 (only 1998 had more) and surface water reservoirs would likely have been full, reducing the demand on groundwater extraction. This reduction in SLC-18 pumping was not enough to produce the measured reduction in drawdown. The University of Utah Irrigation Well #1 was assumed to have not pumped in summer 1984 to produce these disproportionately low drawdowns.

While historic University of Utah irrigation well pumping remains uncertain, calibrating to these data have provided clues that have strengthened both the understanding of the likely magnitudes and historic variations of the pumping rates, as well as the VAMC Model's ability to match changes in heads resulting from these stresses. Iterative calibration simulations indicated that the pumping rates documented in Figure 2 of White (2020) were likely instantaneous values and not volumes averaged over time. Except for 1984, in which zero pumping was applied at University of Utah Irrigation Wells #1, the VAMC Model applied 50% of the 2018 monthly average rates derived from Figure 2 of White (2020), which would correspond to 12 hours per day of irrigation pumping.

September 2011 Aquifer Performance Test Data

Finally, the calibrated VAMC Model was validated to the September 2011 aquifer performance test-derived drawdowns at MW-1S, MW-1D and the Fountain of Ute irrigation well, as documented in the *Hydrogeological and Groundwater Model Summary Report for SLC-18* (MWH 2012).

As documented in MWH (2012), SLC-18 was pumping approximately 1,320 gpm during September 2011. Water levels were monitored at deep aquifer zone wells MW-01D and the Fountain of Ute, as well as MW-01S in the shallow aquifer zone. Drawdown over time at each of those 3 monitoring wells was plotted in Figure A.1 of MWH (2012), which is reproduced here as **Figure 3-9**. This pumping was simulated in the VAMC Model and drawdowns simulated between the stress periods representing August 2011 and September 2011 were compared to those on **Figure 3-9** and summarized below:

- Approximately 8.5 feet of drawdown was measured at MW-01D. This well is approximately 1,680 feet to the south of from SLC-18 and screened near the bottom of the deep aquifer zone. Simulated drawdown at MW-01D was 8.9 feet. This match is another line of evidence that the deep aquifer zone hydraulic properties applied in the VAMC Model are representative of field conditions.

- Approximately 1 foot of drawdown was measured at MW-01S, which is co-located with MW-01D but screened in the shallow aquifer zone. Simulated drawdown was 0.3 feet at this well, indicating less connectivity between the deep and shallow aquifer zones than what was measured.

- The Fountain of Ute well is located approximately 1,430 feet west of SLC-18 and 55 feet from University of Utah Well #1. Despite the similar distance to SLC-18 relative to MW-01D, drawdown in this well was measured to be approximately 5 feet. However, this value may have been impacted by changes to University of Utah irrigation pumping. The VAMC Model simulates 8.9 feet of drawdown at this location, similar to what was simulated at MW-01D. This well has since collapsed and is no longer available to be measured.

Including this validation step in the calibration process allows the APT data collected in 2011 to be utilized towards strengthening the understanding of the aquifer system. It also provides an independent check on the conclusions drawn during the calibration to 1980-1984 conditions, where inferences had to be made regarding University of Utah irrigation pumping.

3.4 Sensitivity Testing

A parameter sensitivity analysis was completed following the calibration and is described below.

3.4.1 Sensitivity Analysis Approach

A sensitivity analysis was performed on the model calibration in accordance with ASTM standard D5611-94 *Standard Guide for Conducting a Sensitivity Analysis for a Groundwater Flow Model Application* (ASTM, 2016b). This sensitivity analysis focused on the quantitative goodness of fit of the model calibration with respect to changes in horizontal and vertical hydraulic conductivity, conductance of the drains representing the springs, properties of the Fault, University of Utah irrigation well pumping, and recharge. The objective of this sensitivity analysis was to determine if there are parameters to which the outcomes of the project depend on and which the calibration is not sensitive to. The intention of this process is thus to identify potential non-uniqueness of the calibrated input data sets (ASTM, 2016b).

3.4.2 Sensitivity Analysis Results

Sixteen simulations were conducted, as summarized in **Table 3-4**, and compared to the results from the calibrated model. **Table 3-4** lists the mean error and mean absolute error of the simulation results with respect the calibration data set, and a tabulation of the simulated discharge to drain cells and simulated head difference across the fault.

Review of the sensitivity simulations produced the following insights:

Sensitivity to Hydraulic Conductivity

- Sensitivity simulations suggest that model calibration is relatively sensitive to the choice of hydraulic conductivity in the shallow aquifer zone.
- An APT performed in the shallow aquifer zone could reduce some of the uncertainty regarding this parameter.

Sensitivity to Drain and Fault Properties

- The model calibration and simulated discharge at drain cells are not significantly influenced by drain conductivity but are to changes to the properties of the Fault.

Sensitivity to University of Utah Irrigation Pumping

- As noted above, pumping rates for the University of Utah irrigation wells were estimated from 2018 data published in White (2020). Sensitivity simulations 11 and 12 indicate a degraded calibration when pumping was not included or doubled in the model.

Sensitivity to Recharge

- Changes in recharge produce a worse match to the calibration data set relative to the magnitude of the change. Increased or decreased inputs of water produced more or less, respectively, discharge to the drains. These variations, as well as the degree of sensitivity to these changes, are expected.

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Section 4

PCE Fate and Transport Simulations

Two types of PCE fate and transport simulations were conducted with the VAMC Model. In the first, transport of PCE released from potential source areas associated with VHA dry cleaning operations was simulated for the period of January 1, 1979 through September 30, 2020 using the transient model flow fields. As noted above, these flow fields include the historical pumping record from SLC-18 and pumping information for irrigation wells, as well as historical time-varying recharge to the system. The transient nature of the aquifer system means that PCE transport pathways were likely different when the PCE releases are presumed to have begun than they are now. These simulations therefore allow for the examination of how the PCE plume movement changed over time and ultimately developed into its present-day position.

Second, a range of future conditions were simulated to predict possible trajectories and discharges of the present-day PCE plume. To do this, PCE monitoring well concentration data were used to estimate the present-day PCE mass and concentration distribution within the VAMC Model. PCE source characteristics were established from PCE concentration trends and plausible ranges of public supply and irrigation pumping were included in five model scenarios. Both sets of transport simulations are described in detail in the sections below.

4.1 Historical PCE Transport Simulations

The calibrated VAMC Model was used to simulate PCE transport from the presumed VHA dry cleaner source areas under historical flow conditions. The objectives of the historical PCE transport simulation are to estimate whether PCE released from suspected source areas likely impacted SLC-18, Mount Olivet Cemetery, and the ESS area, and to provide another line of evidence to support the VAMC Model's ability to represent the aquifer system. While precise information about the timing and extent of the presumed PCE release is unknown, below is a timeline from which clues can be discerned about the historic movement of the plume.

- The VHA operated a part-time dry-cleaning operation that used PCE from approximately 1976 through 1984 in Building 7. A single "closed loop" dry-cleaning system was operated, meaning the system contained a distillation process for the recovery of PCE at the end of each cycle. The condensate from the distillation process was emptied into a vitrified clay drain line attached to the sanitary sewer. The location of the drain line is shown on **Figure 4-1** together with model simulation results. This method of disposal was common practice in the 1980s (EPA 2012). Review of historical building construction drawings consisting of "as-built" drawings of the original buildings and plans for construction through the late 1960s, as well as historical photographs, indicate that gravel sumps, dry wells, a scale pit, an underground storage tank, and 55-gallon drum storage areas were present in the vicinity of the former dry-cleaning facility, however; there is no evidence that these features would have been associated with the dry-cleaning operations (Jacobs 2019). From this information, source areas could be the sumps at Building 7, all or a portion of the vitrified clay pipe, or both.

- PCE was first detected in 1990 during routine sampling of the Mount Olivet Cemetery irrigation well (UDEQ 2000). Concentrations measured at the irrigation well were between 100 and 300 µg/L during this time period.
- PCE was detected at SLC-18 in 1997 at a concentration of 0.6 µg/L. In 2004, PCE concentrations as high as 2.8 µg/L were detected at the well prompting the shut-down of the supply well.
- PCE concentrations as high as 40 µg/L were detected in water discharging to the ESS in 2010 (EPA 2012).

Iterative simulations were run using the historical groundwater flow field and variations on source strength, source location, source duration, dispersivity, and effective porosity to determine which combination resulted in the best match with the historical timeline and concentrations noted above and the present-day concentrations in the shallow and deep aquifer zones. The final solute transport property values are listed below.

- Dispersivity: 50 feet longitudinal; 5 feet lateral; 0.5 feet transverse
- Effective Porosity: 0.2
- Retardation Factor: 1.0 (no retardation)
- Decay Rate: 0 (no decay)

Dispersivity and effective porosity values were based on typical values used in advective-dispersive transport and tested during iterative simulations while the assumptions of no retardation and no decay were based on interpretations of site data.

The resulting simulation used a constant source of mass (as a prescribed concentration of 500 µg/L) for the full duration of the simulation spanning the middle portion of the vitrified clay drain line within model layer 2 (Shallow Aquifer Zone), as well as prescribed concentrations of 50 and 25 µg/L within model layers 2 and 4 at MW-03RA and MW-03RB, respectively. The simulated September 2020 concentrations generated from this simulation are shown in **Figures 4-1 and 4-2** for the shallow and deep aquifer zones, respectively. The use of a constant source of mass for the full duration of the simulation (through September 2020), as well as the simulated location in the shallow aquifer spanning the sewer line between Buildings 6 and 7 and Sunnyside Park, likely overestimate the plume mass and concentrations currently present in the area immediately west of the VAMC campus south of wells MW-02 and MW-03R. However, the simulation along this area represents a conservative approach to modeling the source strength and the historical migration of releases from two separate sources which combine into a single plume just west of the VAMC/Sunnyside Park.

An additional simulation was made with the constant source within the shallow aquifer zone along the drain line shut off in 2015. Under these conditions, simulated September 2020 PCE concentrations within the shallow aquifer zone just downgradient of the drain line provide a better match to those observed at MW-26A, MW-25A, MW-29B, and MW-04, as shown in **Figure 4-3.** The equivalent figure for the deep aquifer zone is shown in **Figure 4-4**. This alternate representation is less conservative with respect to mass loading from the drain source, but has no bearing on September 2020 simulated concentrations at, and downgradient of, MW-01. This representation also does not change the simulated PCE concentrations prior to 2015.

These two representations complement each other, as the exact nature, timing, and location of the source(s) is uncertain. While the presence of a continuous source of PCE to the shallow aquifer zone has not been established, concentration trends within MW-02, MW-03RA, MW-03RB, MW-01S, and MW-04 have been stable to slightly declining. This, combined with the relatively fast seepage velocities within the shallow aquifer zone, suggest that there may be a continuous, decaying source, perhaps in the vadose zone between the drain line and the higher concentrations observed at MW-03R, MW-02, and MW-04. Regardless, the width of the shallow aquifer zone PCE plume, which includes PCE concentrations of 49 to 53 μg/L (as of December 2020) at (from south to north) MW-13S, MW-19, MW-18, and MW-08A is indicative of a source dispersed along the drain line.

The following additional observations are taken from **Figures 4-1** through **4-4**:

- Simulated PCE concentrations along the northern and southern extents, as well as the middle of the plume match measured concentrations well.
- Limited to no PCE is simulated at Building 7, consistent with non-detect values at the monitoring wells in this vicinity. Elevated concentrations of PCE in soil gas and subslab vapor (up to 46,101 micrograms per cubic meter [μg/m^3] July 2019) have been observed adjacent to VAMC Buildings 6 and 7. It is hypothesized that PCE mass at this location may have traveled west within the perched zone and reached the shallow aquifer zone and the top of the deep aquifer zone somewhere between MW-26A and MW-03RA, where it became a continuing source of PCE mass. While it is possible that this source may have been strong in the past, concentrations at MW-03RA and MW-03RB have been relatively stable recently.
- PCE mass travels from the shallow aquifer zone, through the silt/clay semi-confining unit and into the deep aquifer zone. Lower-level concentrations that are shown south of the MW-03RB-generated plume are a result of this simulated downward migration.
- The simulated September 2020 PCE plume is shown to move across the fault within the deep aquifer zone. However, MW-37S/D, MW-12D, and MW-15S/D located west of the fault have been either non-detect, or barely detectable (0.39 J μg/L for MW-15S in December 2020) for PCE. Model simulations do not show PCE concentrations greater than 1 μg/L in the vicinity of the Artesian Park well (shown in **Figure 3-3** at 404506111523301(D-1-1)7abd-6) in September 2020. It is noted that while the inclusion of the area west of the Fault in the VAMC Model is useful, there is more uncertainty in model results within this area than east of the fault where more data are available.
- The simulated September 2020 deep aquifer zone PCE plume does not show PCE mass to be present at SLC-18. Model simulations indicate that University of Utah irrigation pumping alone since 2004 is not enough to generate significant PCE transport to the northwest of the source areas.

In comparison to the timeline note above, the following observations have been made:

- PCE was first detected in 1990 at 32 µg/L during sampling of the Mount Olivet Cemetery irrigation well (UDEQ 2000). Concentrations measured at the irrigation well between 1990 and 1997 were between 32 and 184 µg/L during this time period.
  - **Figure 4-5** shows simulated Shallow Aquifer Zone PCE concentrations in June 1990. Simulated concentrations at Mount Olivet are within the 5-25 µg/L contour. While this is not a perfectly timed match, it indicates that the assumption of no (or limited) retardation used in the model simulations is likely valid, as sorption to aquifer materials would delay breakthrough of the PCE plume generated from a late 1970s source to arrive at the Mount Olivet well at a later date.
- PCE concentrations of 0.6 µg/L were detected at SLC-18 in 1997 and at 2.8 µg/L in 2004, which prompted the supply well to be shut down.
  - **Figure 4-6** shows simulated Deep Aquifer Zone PCE concentrations in June 2004. Simulated concentrations at SLC-18 are less than 1 µg/L, though simulated mass is present at the well at 0.1 µg/L beginning around 1990. Consistent annual pumping from SLC-18 and University of Utah irrigation well #1 between 1979 and 2004 drew PCE originating from the MW-03RB source to the northwest of the site and into these extraction wells in the deep aquifer zone.
- PCE concentrations of up to 40 µg/L were detected in water discharging to the ESS in 2010.
  - **Figure 4-7** shows simulated Shallow Aquifer Zone PCE concentrations in June 2010. This depiction is similar to that of **Figure 4-1**. Groundwater concentrations at the ESS at this time are simulated to be as high as 25-50 µg/L, consistent with measured data.

The overall timing of simulated PCE migration through the aquifer system appears to be consistent with the observed timeline, while the present-day PCE plume is relatively well represented within the existing monitoring well network. Using the baseline historic transport simulation, the following is surmised:

- SLC-18 was likely to have drawn in PCE from a VHA source between 1997 and 2004, but the PCE plume is not expected to migrate towards SLC-18 if only irrigation pumping from the University of Utah and Mount Olivet Cemetery is occurring.
- Building 7 does not appear to be a source of PCE to the water table below it. Lateral migration of PCE could have occurred in the perched zone (not modeled) and contributed to a saturated zone source in the vicinity of MW-03R.
- If a late 1970s source release is assumed, the plume does not appear to have experienced significant sorption or retardation along its flowpaths.
- The silt/clay semi-confining unit does not fully prevent the downward migration of PCE from the shallow aquifer zone to the deep aquifer zone.
- The ESS and surrounding springs are a primary receptor of PCE mass.

- PCE mass may be migrating west of the East Bench Fault; however, . the monitoring wells west of the fault show very low or non-detected concentrations of PCE in the shallow groundwater. Additionally, PCE detections have not been reported at the wells at Artesian Well Park and Liberty Park (EA 2019). If PCE is migrating west of the East Bench Fault, it is likely present at very low concentrations predominantly in deeper groundwater intervals.

Understanding this past migration better through modeling enhances the CSM and provides another line of evidence in support VAMC Model's representation of the aquifer system.

4.2 Projected PCE Transport Simulations

A range of future conditions were simulated to predict possible trajectories and discharges of the present-day PCE plume. The primary objective of these simulations was to create a means for comparison of the impacts of plausible future pumping on the PCE plume.

As opposed to the historical transport simulations described in Section 4.1, the PCE projection simulations were conducted using simulated steady state groundwater flow fields. The following potential future scenarios were simulated as steady state using the groundwater flow component of the VAMC Model:

- Baseline Conditions: average (last ten years) pumping and recharge; represents current conditions continuing into the future[1]
- Scenario 1: Baseline recharge and irrigation pumping with SLC-18 pumping its historical (1979-2004) average rate
- Scenario 2: Baseline recharge and irrigation pumping with SLC-18 pumping its maximum extraction rate permitted under its water right
- Scenario 3: Baseline recharge and SLC-18 pumping with University of Utah Well #1 pumping set based on the July 2018 irrigation pumping specified in Table 1 of White[i] (2020) assuming 365 days
- Scenario 4: Baseline recharge and SLC-18 pumping with University of Utah Well #1 pumping set based on the July 2018 irrigation pumping specified in Table 1 of White (2020) assuming 365 days and SLC-18 pumping its maximum extraction rate permitted under its water right

Pumping rates for SLC-18, University of Utah Well #1 and Mount Olivet Cemetery well are listed for each of these five simulations in **Table 4-1**.

[1] The impact of the geothermal project evaluated in White (2020) was not included in the future simulation transport scenarios. The geothermal project assumes the water extracted is injected at an adjacent well, both screened in the deep aquifer zone, for a net-zero effect.

Table 4-1 Scenario Pumping

Scenario	SLC-18 Pumping (gpm)	University of Utah Well #1 Pumping (gpm)	Mount Olivet Cemetery Pumping (gpm)
Baseline	0	162	85
Scenario 1	566	162	85
Scenario 2	2,169	162	85
Scenario 3	0	545	85
Scenario 4	2,169	545	85

The simulated groundwater flow fields for the Baseline simulation and Scenarios 1-4 were used to simulate future PCE groundwater plume migration to evaluate the potential effect of pumping on the migration of the groundwater plume. The present-day PCE plume (CDM Smith 2021c) was interpolated onto the model and used as starting concentrations to simulate the fate and transport of PCE under potential future conditions in the scenarios described above. Starting concentrations are shown for model layers 1, 2, 3, and 4 in **Figures 4-8** through **4-11**, respectively**.** The interpolation was done using the 3DVA model. While no monitoring wells are screened directly in the silt/clay semi-confining unit represented by model layer 3, PCE mass is assumed to be present within this layer and was interpolated onto it for these simulations. Mass interpolations associated with the MW-03R cluster included vertical interpolations of the highest concentration well (MW-03RB) into model layer 3 (as MW-03RB is screened just below model layer 3) as well as vertically interpolated within model layer 4, which also includes MW-03RC and MW-03RD.

Sources of mass were added in the shallow aquifer zone layer 2 along the line between the greater than 5 µg/L concentration contour (**Figure 4-1**) south of MW-04 through the greater than 5 µg/L north of MW-03RA with prescribed source concentrations equivalent to the present-day concentrations. In the deep aquifer zone layer 4, a 25 µg/L prescribed concentration source was applied at and in the vicinity of MW-03R. All of these sources incorporated a first order decay rate of 10^{-4} per day, meaning that the source strength would diminish over time. The decay rate used was based on trend analyses of PCE concentration data within the most concentrated portions of the PCE plume.

The PCE transport simulation results were evaluated by reviewing the simulated PCE plume extent and concentrations at 5 years, 10 years, 15 years, and 20 years. Figures showing the simulated head contours and PCE concentrations for each run are included as follows:

- **Figures 4-12a through 4-12e**: Baseline, shallow aquifer zone (model layer 2) for starting conditions, 5 years, 10 years, 15 years, and 20 years, respectively.
- **Figures 4-13a through 4-13e**: Baseline, deep aquifer zone (model layer 4) for starting conditions, 5 years, 10 years, 15 years, and 20 years, respectively.
- **Figures 4-14a through 4-14e**: Scenario 1, shallow aquifer zone (model layer 2) for starting conditions, 5 years, 10 years, 15 years, and 20 years, respectively.

- **Figures 4-15a through 4-15e**: Scenario 1, deep aquifer zone (model layer 4) for starting conditions, 5 years, 10 years, 15 years, and 20 years, respectively.
- **Figures 4-16a through 4-16e**: Scenario 2, shallow aquifer zone (model layer 2) for starting conditions, 5 years, 10 years, 15 years, and 20 years, respectively.
- **Figures 4-17a through 4-17e**: Scenario 2, deep aquifer zone (model layer 4) for starting conditions, 5 years, 10 years, 15 years, and 20 years, respectively.
- **Figures 4-18a through 4-18e**: Scenario 3, shallow aquifer zone (model layer 2) for starting conditions, 5 years, 10 years, 15 years, and 20 years, respectively.
- **Figures 4-19a through 4-19e**: Scenario 3, deep aquifer zone (model layer 4) for starting conditions, 5 years, 10 years, 15 years, and 20 years, respectively.
- **Figures 4-20a through 4-20e**: Scenario 4, shallow aquifer zone (model layer 2) for starting conditions, 5 years, 10 years, 15 years, and 20 years, respectively.
- **Figures 4-21a through 4-21e**: Scenario 4, deep aquifer zone (model layer 4) for starting conditions, 5 years, 10 years, 15 years, and 20 years, respectively.

The results of these simulations are summarized below:

- Under baseline conditions, the PCE plume follows the trajectory observed over the last decade plus, with shallow aquifer zone PCE discharging to springs.
- Historic average SLC-18 pumping simulated in Scenario 1 deflects groundwater flow slightly towards the northwest but does not pull a significant amount of the PCE plume into SLC-18.
- Results are similar for Scenario 3, in which University of Utah Well #1 pumping is increased with SLC-18 not pumped.
- The significant increase in pumping at SLC-18 associated with scenarios 2 and 4 results in a significant change in the deep aquifer zone groundwater flow field (**Figure sets 4-17 and 4-21**), with deep aquifer zone PCE mass drawn to the northwest towards SLC-18 and University of Utah Well #1. Shallow aquifer zone heads are lowered under these conditions as well, with simulated Scenario 4 water levels at VHA Building 7 approximately 20 feet lower than baseline conditions.

By simulating a large range of potential future pumping conditions, the future projection simulations allowed for a comparison of the resulting PCE plume trajectories that can be used to better understand potential impacts to receptors.

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Section 5

Summary

5.1 Objectives Assessment

The objectives of the groundwater modeling tasks performed for the OU1 RI and described in this report were to improve the understanding of the future fate and transport of the PCE plume under a range of potential pumping conditions, to support the continuing development and evolution of the CSM, and to assess historical flow and transport pathways associated with pumping from the SLCDPU well SLC-18. To meet these objectives, the following steps were taken:

- One groundwater flow model (the VAMC Model) was constructed based on regional and site data and previous studies and models.
- The VAMC Model represents historical conditions at OU1 and the surrounding vicinity by running in transient (time varying) mode from January 1, 1979 through September 30, 2020, using monthly stress periods.
- Hydraulic properties were estimated through a combination of historical and newly collected hydraulic testing data.
- The VAMC Model was calibrated to historical piezometric head data available from the USGS NWIS and the September 2020 synoptic round of piezometric head data collected at the site and documented in the DSR from Q3 2020 (CDM Smith 2021b).
- Model calibration was validated to the September 2011 aquifer performance test-derived drawdowns at three wells, as documented in the *Hydrogeological and Groundwater Model Summary Report for SLC-18* (MWH 2012).
- PCE transport under historical flow conditions was simulated using the January 1, 1979 to September 30, 2020 transient flow field represented by the calibrated VAMC Model.
- Present-day PCE concentration data were interpolated onto the VAMC Model and used as a starting point to simulate the fate and transport of PCE under a range of prescribed future conditions. Site data were used to implement decaying sources of PCE for these simulations.

Results of the historic PCE transport simulations are summarized below:

- SLC-18 was likely to have drawn in PCE from a VHA source between 1997 and 2004, but the PCE plume is not expected to migrate towards SLC-18 if only irrigation pumping from the University of Utah and Mount Olivet Cemetery is occurring.
- Building 7 does not appear to be a source of PCE to the water table below it. Lateral migration of PCE could have occurred in the perched zone (not modeled) and contributed to a saturated zone source in the vicinity of MW-03R.

- If a late 1970s source release is assumed, the plume does not appear to have experienced significant sorption or retardation along its flowpaths.
- The silt/clay semi-confining unit does not fully prevent the downward migration of PCE from the shallow aquifer zone to the deep aquifer zone.
- PCE mass may be migrating west of the East Bench Fault. The monitoring wells west of the fault show very low or nondetected concentrations of PCE in the shallow groundwater west of the Fault. If PCE is migrating west of the Fault, it is likely present at very low concentrations predominantly in deeper groundwater intervals.

Results of the projected PCE transport simulations are summarized below:

- Under baseline conditions, the PCE plume follows the trajectory observed over the last decade plus, with shallow aquifer zone PCE discharging to springs.
- Historic average SLC-18 pumping simulated in Scenario 1 deflects groundwater flow slightly towards the northwest but does not pull a significant amount of the present-day PCE plume into SLC-18.
- Results are similar for Scenario 3, in which University of Utah Well #1 pumping is increased with SLC-18 not pumped.
- The significant increase in pumping at SLC-18 associated with scenarios 2 and 4 results in a significant change in the deep aquifer zone groundwater flow field (**Figure sets 4-17 and 4-21**), with deep aquifer zone PCE mass drawn to the northwest towards SLC-18 and University of Utah Well #1. Shallow aquifer zone heads are lowered under these conditions as well, with simulated Scenario 4 water levels at VHA Building 7 approximately 20 feet lower than baseline conditions.

The development and application of the VAMC Model has resulted in a better understanding of the water balance, the stratigraphy, the hydraulic properties, and the impacts of pumping on the site. These insights have been incorporated into the CSM, which along with the VAMC Model, will be a valuable tool in future phases of work at the site. Overall, the objectives of the modeling have been met.

5.2 Summary

The VAMC Model was created, calibrated, and tested using available data and in accordance with the Groundwater Model QAPP (CDM Smith 2021a). The VAMC Model represents both past and current conditions well and can reproduce drawdowns measured during the 2011 SLC-18 APT documented in MWH (2012) as well as seasonal variations in piezometric heads during the early 1980s. Historic (1979-2020) PCE transport simulations indicate that SLC-18 was likely to have drawn in PCE from a VHA source between 1997 and 2004, but the PCE plume is not expected to migrate towards SLC-18 if only irrigation pumping from the University of Utah and Mount Olivet Cemetery is occurring. Future PCE transport simulations provide a range of groundwater flow fields through which PCE could travel.

Section 6

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Figures and Tables

Legend

George E. Wahlen Veterans Affairs Medical Center Boundary

Study Area Boundary

Notes:
OU = operable unit
PCE = tetrachloroethene

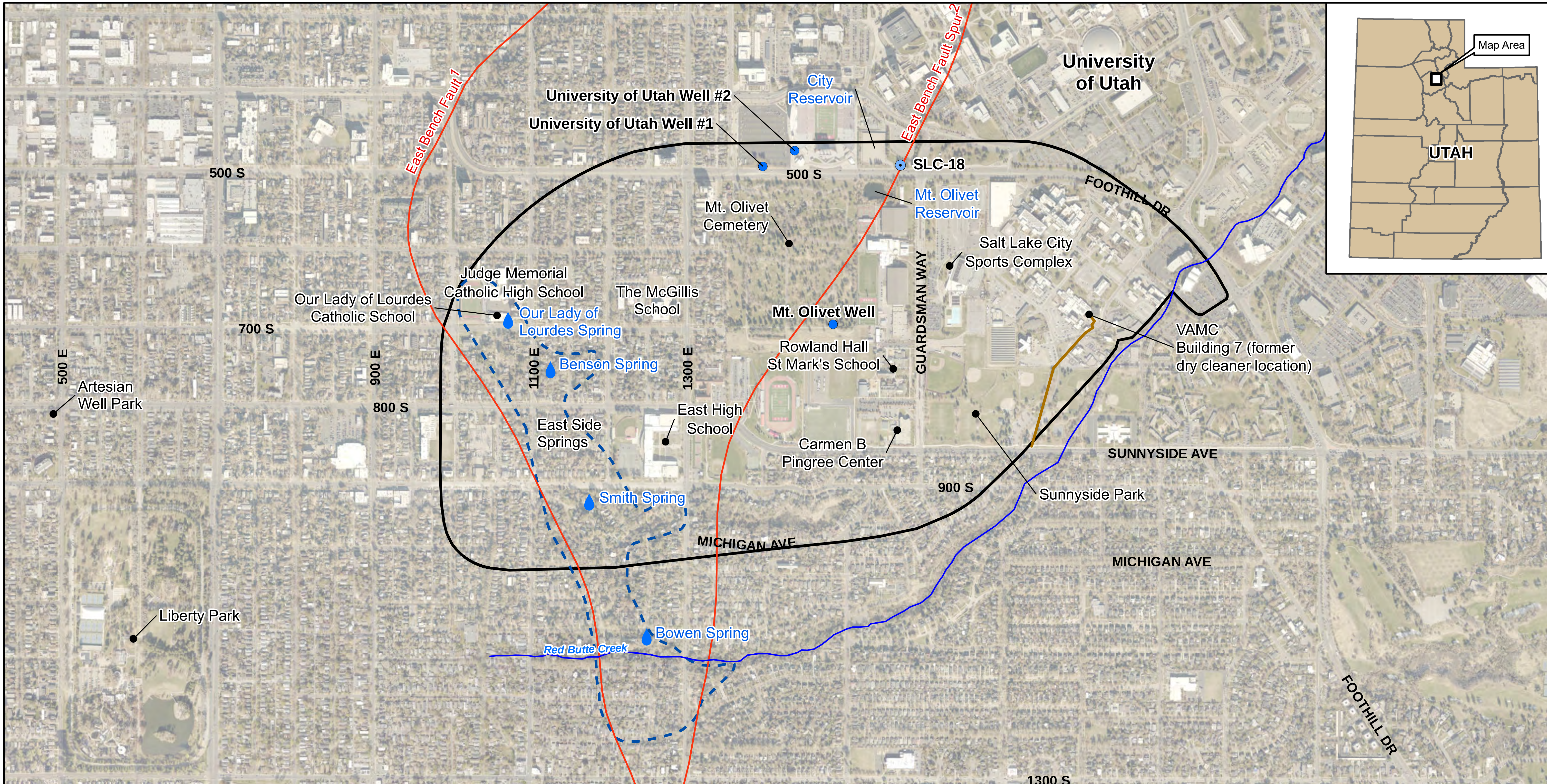
N

0 0.5 1 Miles

CDM Smith

Figure 1-1
Site Location Map

700 South 1600 East PCE Plume
Salt Lake City, Utah



Legend
- Drinking Water Supply Well
- Irrigation Well
- Spring Location
- Red Butte Creek
- Sewer Line
- Fault Line
- Study Area Boundary
- Springs Area

Notes:
(1) Location of University of Utah Well #1 is approximate; well is located less than 100 feet east of Fountain of Ute.

OU = operable unit
PCE = tetrachloroethene
VAMC = George E. Wahlen Veterans Affairs Medical Center

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N
0 500 1,000 Feet

CDM Smith

Figure 1-2
Site Features

700 South 1600 East PCE Plume
Salt Lake City, Utah

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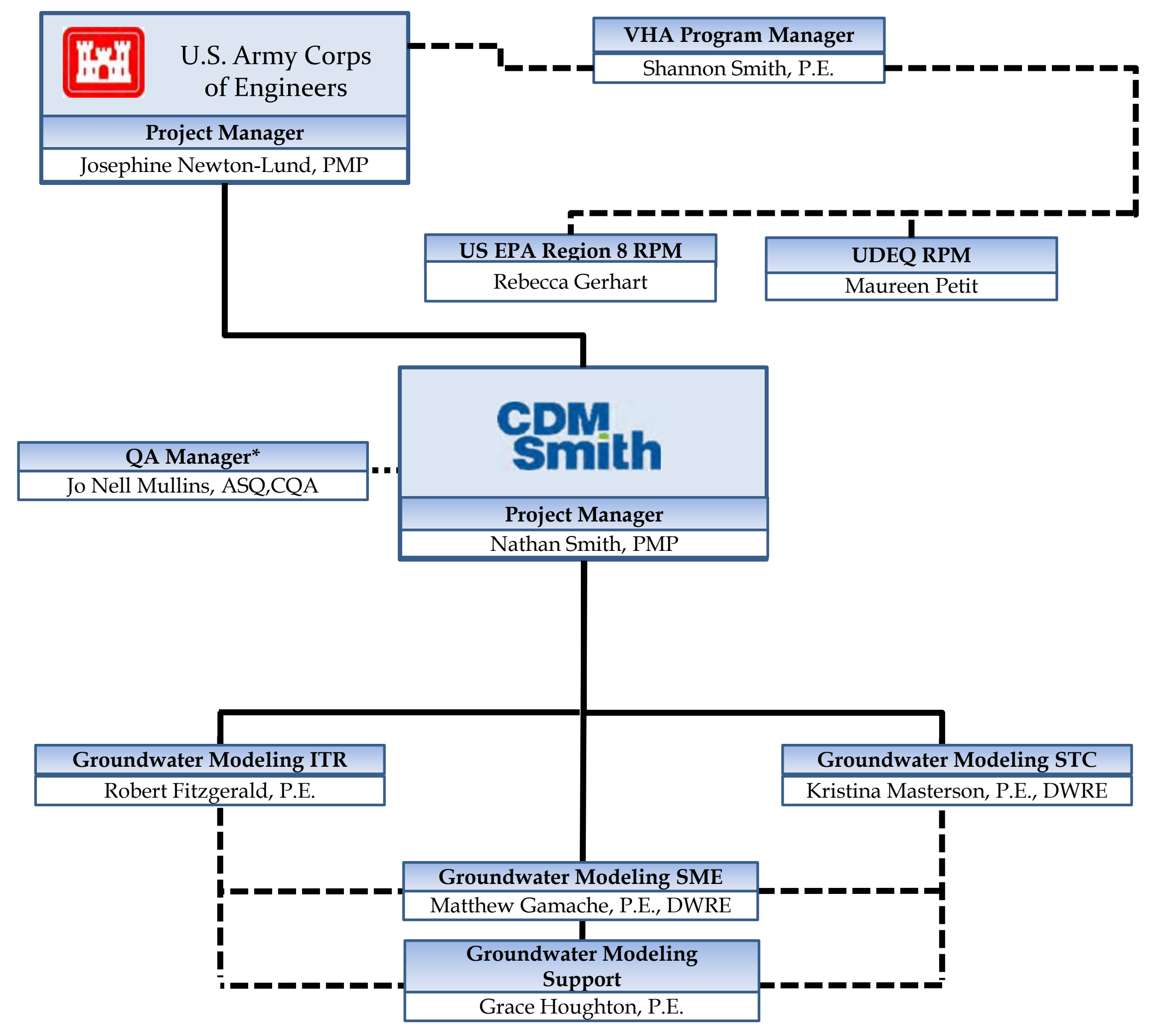


Legend

= Line of Authority
= Line of Communication
ASQ = American Society for Quality
CH = Certified Hydrogeologist
CQA = Certified Quality Auditor
DWRE = Diplomate, Water Resource Engineer
ITR = Independent Technical Reviewer

P.E. = Professional Engineer
P.G. = Professional Geologist
PMP = Project Management Professional
RPM = Remedial Project Manager
SME = Subject Matter Expert
STC = Senior Technical Consultant
UDEQ = Utah Department of Environmental Quality
U.S. EPA = U.S. Environmental Protection Agency
VHA = Veterans Health Administration

CDM Smith

Figure 1-3
Groundwater Modeling Organization Chart
700 South 1600 East PCE Plume OU1

Table 2-1
September 2020 Groundwater Elevations

Location	Sample Interval	Screen Start (ft bgs)	Screen End (ft bgs)	Top of Casing Elevation (ft amsl)[1]	Aquifer Zone	Water Level Measurement Date and Time	Water Level Depth (ft btoc)	Water Level Elevation (ft amsl)[1]
MW-01S	-	184	224	4664.80	Shallow	9/21/20 17:47	157.26	4507.54
MW-01D	-	364	404	4664.80	Deep	9/21/20 17:55	172.56	4492.24
MW-02	-	175.5	202.5	4685.24	Shallow	9/21/20 18:25	170.77	4514.47
MW-03R	A	215	220	4698.12	Shallow	9/21/20 14:54	188.25	4509.87
	B	267	272	4697.90	Deep	9/21/20 15:02	205.68	4492.22
	C	307	312	4697.92	Deep	9/21/20 14:43	205.75	4492.17
	D	359	364	4697.93	Deep	9/21/20 15:00	205.70	4492.23
MW-04	-	143	173	4656.85	Shallow	9/21/20 17:28	135.90	4520.95
MW-05R	-	198	228	4737.99	Shallow	9/21/20 12:45	214.20	4523.79
MW-06	-	100	130	4678.66	Perched	9/21/20 17:00	123.95	4554.71
MW-08	A	91	106	4539.81	Shallow	9/22/20 18:46	61.17	4478.64
	B	180	200	4539.77	Deep	9/22/20 18:49	59.74	4480.03
	C	304	309	4539.68	Deep	9/22/20 18:51	58.02	4481.66
MW-12S	-	50	60	4360.03	-	9/21/20 13:24	57.02	4303.01
MW-12D	-	88.5	93.5	4360.07	-	9/21/20 13:30	57.15	4302.92
MW-13S	-	15.5	20.5	4482.93	Shallow	9/21/20 15:11	14.31	4468.62
MW-13D	-	79	84	4482.62	Shallow	9/21/20 15:04	13.72	4468.90
MW-14S	-	4.5	14.5	4415.69	Shallow	9/21/20 14:15	5.22	4410.47
MW-14D*	-	49	54	4415.93	Shallow	9/21/20 14:25	-6.93	4422.86
MW-15S	-	52.5	55	4347.35	-	9/28/20 12:23	49.05	4298.30
MW-15D	-	69	74	4347.72	-	9/28/20 12:20	50.50	4297.22
MW-16S	-	9	19	4454.83	Shallow	9/21/20 13:54	11.23	4443.60
MW-16D	-	62	72	4454.84	Shallow	9/21/20 13:46	10.39	4444.45
MW-17S	-	6	21	4465.18	Shallow	9/21/20 14:42	5.49	4459.69
MW-17D	-	44	54	4465.69	Shallow	9/21/20 16:37	0.65	4465.04
MW-18	-	80	90	4558.76	Shallow	9/21/20 16:53	82.50	4476.26
MW-19	-	84	94	4557.16	Shallow	9/21/20 17:02	81.82	4475.34
MW-20S	-	79.5	89.5	4558.61	Shallow	9/21/20 17:11	83.93	4474.68
MW-20D	-	119	129	4558.19	Shallow	9/21/20 17:20	83.65	4474.54
MW-21	-	62	72	4563.32	Shallow	9/21/20 15:54	65.11	4498.21
MW-22	-	64	74	4562.72	Shallow	9/21/20 16:15	63.62	4499.10
MW-23	A	210	220	4711.80	Shallow	9/22/20 8:16	188.22	4523.58
	B	250	260	4711.77	Intermediate	9/22/20 8:20	197.61	4514.16
	C	348	358	4711.69	Deep	9/22/20 8:28	218.22	4493.47
MW-24	-	209.5	239.5	4709.19	Shallow	9/21/20 16:11	185.41	4523.78
MW-25	A	201	211	4702.02	Shallow	9/21/20 15:21	179.30	4522.72
	B	231	241	4702.09	Intermediate	9/21/20 15:18	184.50	4517.59
	C	307.5	317.5	4702.07	Deep	9/21/20 15:24	208.89	4493.18
MW-26	A	205	215	4712.29	Shallow	9/21/20 16:02	190.59	4521.70
	B	235	245	4712.55	Intermediate	9/21/20 15:58	195.12	4517.43
	C	315	325	4712.51	Deep	9/21/20 15:47	218.77	4493.74
	D	347.75	357.75	4712.50	Deep	9/21/20 15:54	219.50	4493.00
MW-27	-	200	220	4712.34	Shallow	9/22/20 8:37	188.15	4524.19
MW-28	-	190	210	4712.54	Shallow	9/21/20 16:17	187.02	4525.52
MW-29	A	120	130	4678.46	Perched	9/21/20 16:34	116.53	4561.93
	B	190	200	4678.45	Shallow	9/21/20 16:43	155.23	4523.22
	C	230	240	4678.68	Intermediate	9/21/20 16:27	158.52	4520.16
MW-30	A	240	250	4722.00	Intermediate	NM	NM	
	B	282	292	4721.79	Deep	NM	NM	
	C	317	327	4721.92	Deep	9/21/20 12:00	230.90	4491.02
MW-31	A	138	148	4654.27	Shallow	9/21/20 17:18	131.85	4522.42
	B	190	200	4654.39	Shallow	9/21/20 17:11	135.84	4518.55
	C	228	238	4654.35	Deep	9/21/20 17:22	148.99	4505.36
MW-32	A	114	124	4565.67	Shallow	9/21/20 18:09	84.25	4481.42
	B	170	180	4565.63	Shallow	9/21/20 18:05	83.77	4481.86
	C	260	270	4565.59	Deep	9/21/20 18:07	83.18	4482.41
MW-34	A	140	150	4623.09	Shallow	9/21/20 17:47	132.00	4491.09
	B	175	185	4622.71	Shallow	9/21/20 17:49	131.67	4491.04
	C	250	260	4622.63	Deep	9/21/20 17:53	131.22	4491.41
	D	315	325	4622.58	Deep	9/21/20 17:44	131.20	4491.38

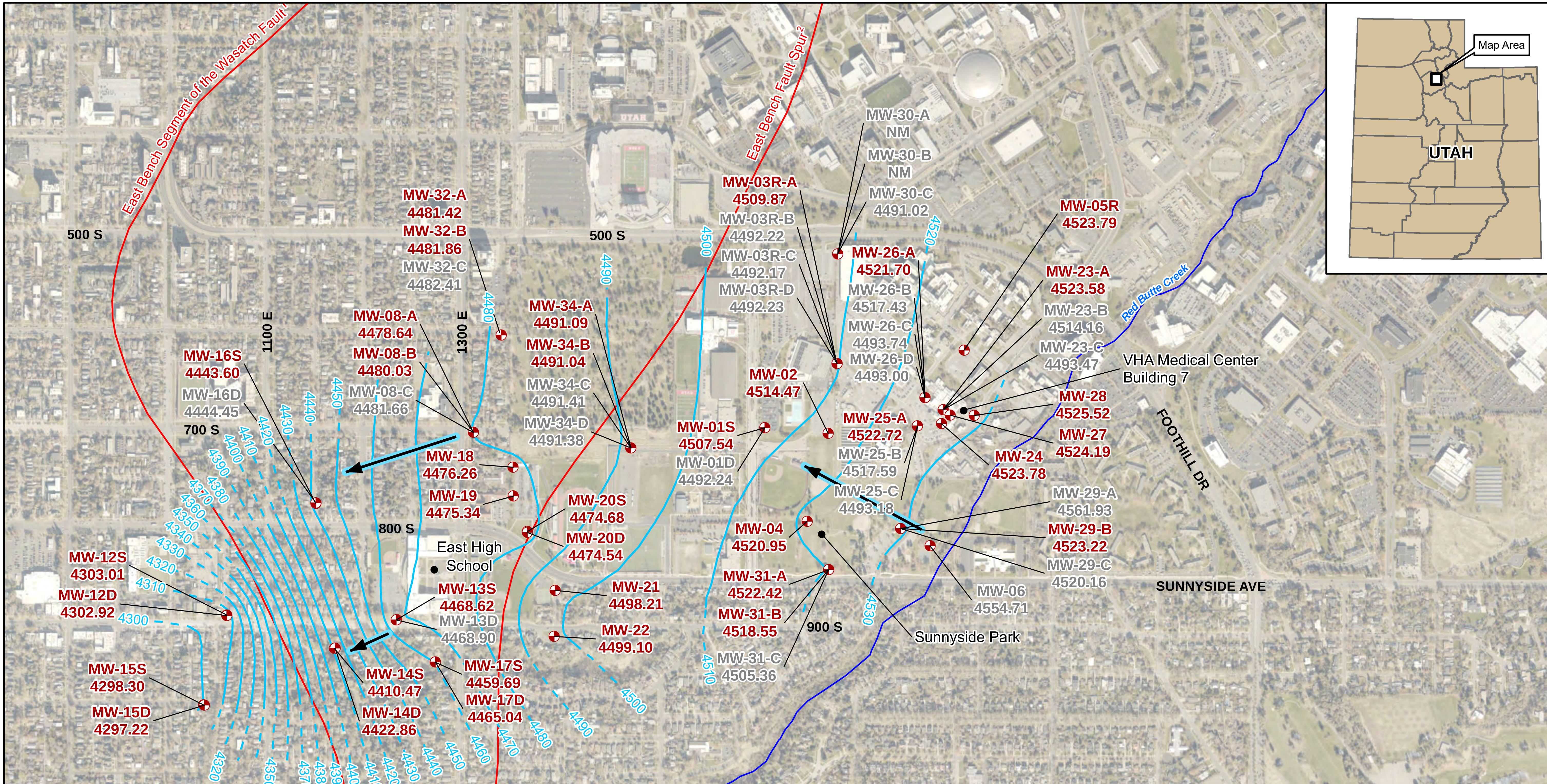
Notes:
[1] Elevations measured using NAVD 88 vertical datum
*Water level measured using pressure gauge, converted to height above top of casing (head [ft] = pressure [psi] x 2.31)

Table 2-2
Slug Test-Estimated Hydraulic Conductivity Values

Well ID	Aquifer Zone	Estimated Hydraulic Conductivity (K) (ft/day)	Lithology of the Screened Interval
MW-01S	Shallow	12.00	Silty clay with gravel, sandy clay, silty sand, clayey silt, sandy clay with gravel
MW-02	Shallow	10.08	Gravelly sand, sandy clay, sandy gravelly clay, sandy clayey gravel, sand
MW-03RA	Shallow	4.65	Silty gravel with sand, clayey gravel with sand
MW-03RB	Deep	0.75	Sandy silty clay, silty clayey gravel with sand
MW-03RC	Deep	25.00	Silty gravel with sand, gravel with silt and sand
MW-04	Shallow	6.14	Gravel with clay
MW-08A	Shallow	103.00	Clayey gravel with sand
MW-08B	Deep	51.00	Clayey gravel with sand
MW-08C	Deep	0.46	Silty gravel with sand
MW-13S	Shallow	0.01	Silty sand with gravel, clayey gravel with sand, sandy silt, clayey sand, lean clay
MW-13D	Shallow	0.13	Clayey sand with gravel, sand with silt, clayey gravel with sand
MW-13L	Deep	34.00	Sandy silt, silt with sand, gravel with sand and silt
MW-15D	Shallow	15.00	Silty gravel with sand
MW-18	Shallow	12.00	Silty gravel with sand, clayey gravel with sand, clayey sand
MW-19	Shallow	30.00	Gravelly clay with sand, clayey gravel with sand
MW-20S	Shallow	10.00	Clayey gravel with sand, silty sand with gravel, silty sand, sandy lean clay with gravel
MW-20D	Shallow	165.00	Clayey gravel with sand
MW-21	Shallow	54.00	Gravelly clay with sand, silty gravel with sand, clayey gravel with sand
MW-22	Shallow	67.00	Gravelly clay with sand, clayey gravel with sand, clayey sand with gravel
MW-26B	Intermediate	18.00	Silty sand with gravel
MW-26C	Deep	10.00	Sandy gravel, silty gravel, gravelly clay
MW-26D	Deep	39.00	Gravelly sand, gravelly clay
MW-32A	Shallow	200.00	Sandy clay, clayey gravel, sandy clay, sandy gravel with clay
MW-34A	Shallow	46.00	Silty gravel, clayey silt
MW-34B	Shallow	29.00	Silt, gravelly silt, clay
MW-34C	Deep	0.14	Silty clay, silty gravel, silty clay
MW-34D	Deep	20.00	Silty gravel, silty clay

Table 2-3
Annual Precipitation Data

Year	Precipication at the University of Utah (Inches)	Precipication at Salt Lake City Triad Center (Inches)	Precipication at Salt Lake City Airport (Inches)
1979	11.1	-	8.7
1980	22.9	-	17.2
1981	24.7	-	16.6
1982	30.9	-	22.9
1983	35.8	-	24.3
1984	23.6	-	21.6
1985	16.9	-	17.0
1986	27.5	15.5	19.5
1987	13.0	14.9	12.5
1988	13.1	12.5	9.3
1989	13.4	13.0	10.9
1990	-	11.9	10.7
1991	-	21.6	17.8
1992	-	14.8	12.1
1993	-	21.8	18.9
1994	-	17.9	15.3
1995	-	17.7	16.9
1996	-	18.1	17.3
1997	-	21.4	17.0
1998	-	28.7	23.8
1999	-	17.3	13.5
2000	-	16.6	16.4
2001	-	16.1	15.1
2002	-	9.6	10.3
2003	-	15.9	16.0
2004	-	11.4	14.9
2005	-	20.9	16.9
2006	-	17.2	16.2
2007	-	12.9	13.4
2008	-	10.8	11.8
2009	-	16.7	15.9
2010	-	19.2	18.7
2011	-	12.2	19.2
2012	-	9.9	12.7
2013	-	-	11.7
2014	-	-	14.5
2015	-	-	16.2
2016	-	-	14.9
2017	-	-	16.0
2018	-	-	13.2
2019	-	-	20.1
2020	-	-	8.6



Legend
- Monitoring Well
- Landmark
- Red Butte Creek
- Fault Line
- Groundwater Contour

Dashed Line - Inferred Extent
- Groundwater Flow Direction

Notes:
- All ground surface elevations in feet amsl
- Measurements taken September 21st through 28th 2020.
- Water levels shown in grey were not used for the generation of the potentiometric contours and are shown for information only

amsl = above mean sea level
OU = operable unit
VHA = Veterans Health Administration

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.
[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

N W E S

0 500 1,000 Feet

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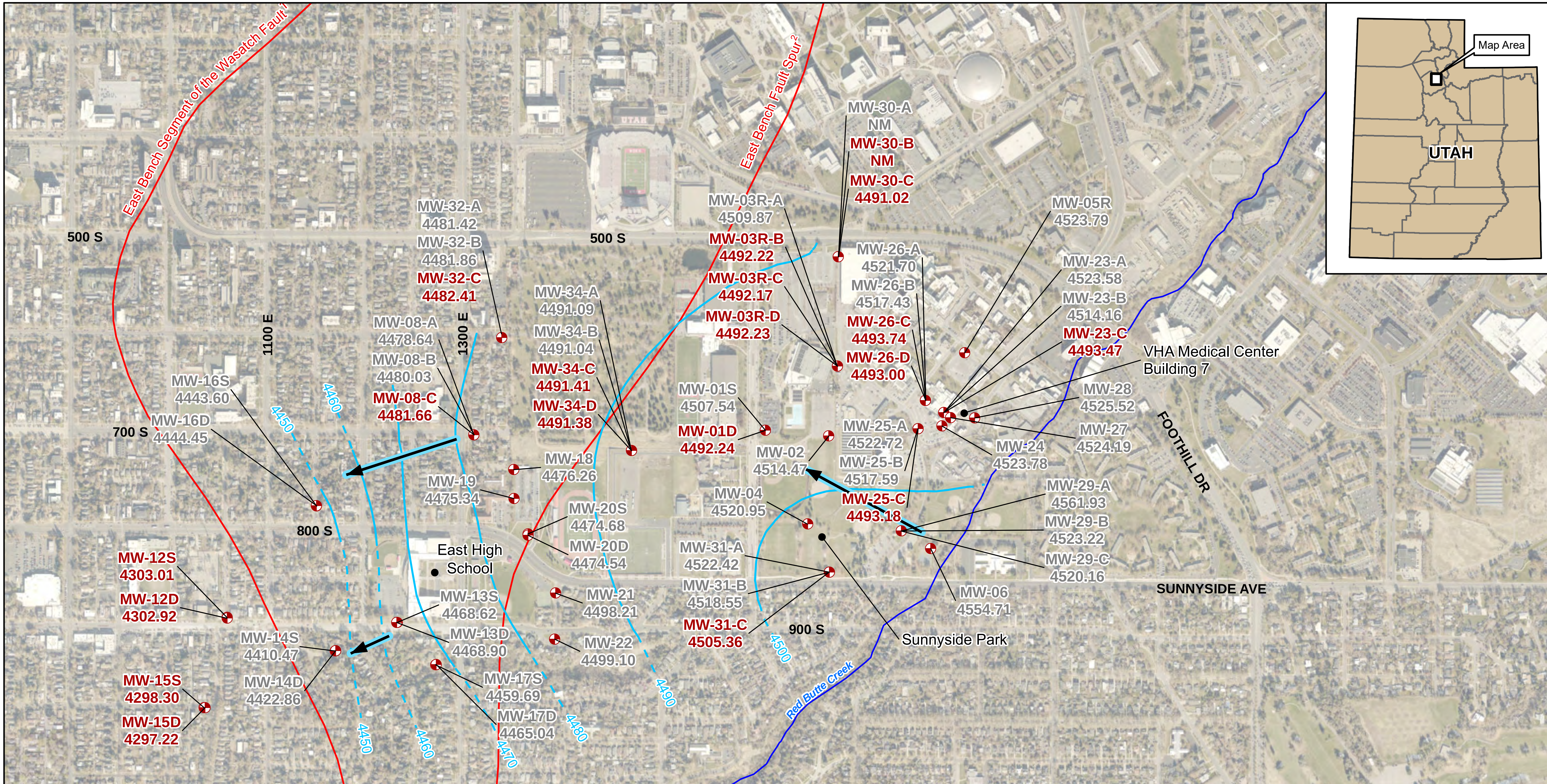
Figure 2-1
Potentiometric Groundwater Surface Map - Shallow Aquifer

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah



Legend
- Monitoring Well
- Landmark
- Red Butte Creek
- Fault Line
- Groundwater Contour
- Dashed Line - Inferred Extent
- Groundwater Flow Direction

Notes:
- All ground surface elevations in feet amsl
- Measurements taken September 21st through 28th 2020.
- Water levels shown in grey were not used for the generation of the potentiometric contours and are shown for information only

amsl = above mean sea level
OU = operable unit
VHA = Veterans Health Administration

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[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

N W E S

0 500 1,000 Feet

Figure 2-2
Potentiometric Groundwater Surface Map - Deep Aquifer

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700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: J:\238824_VA_Medical_Salt_Lake\MXD\Sampling_2021\GWMR_2021\Fig2-2_DSR_GW_B_Aquifer.mxd WAGNERA 6/1/2021 10:32:55 AM

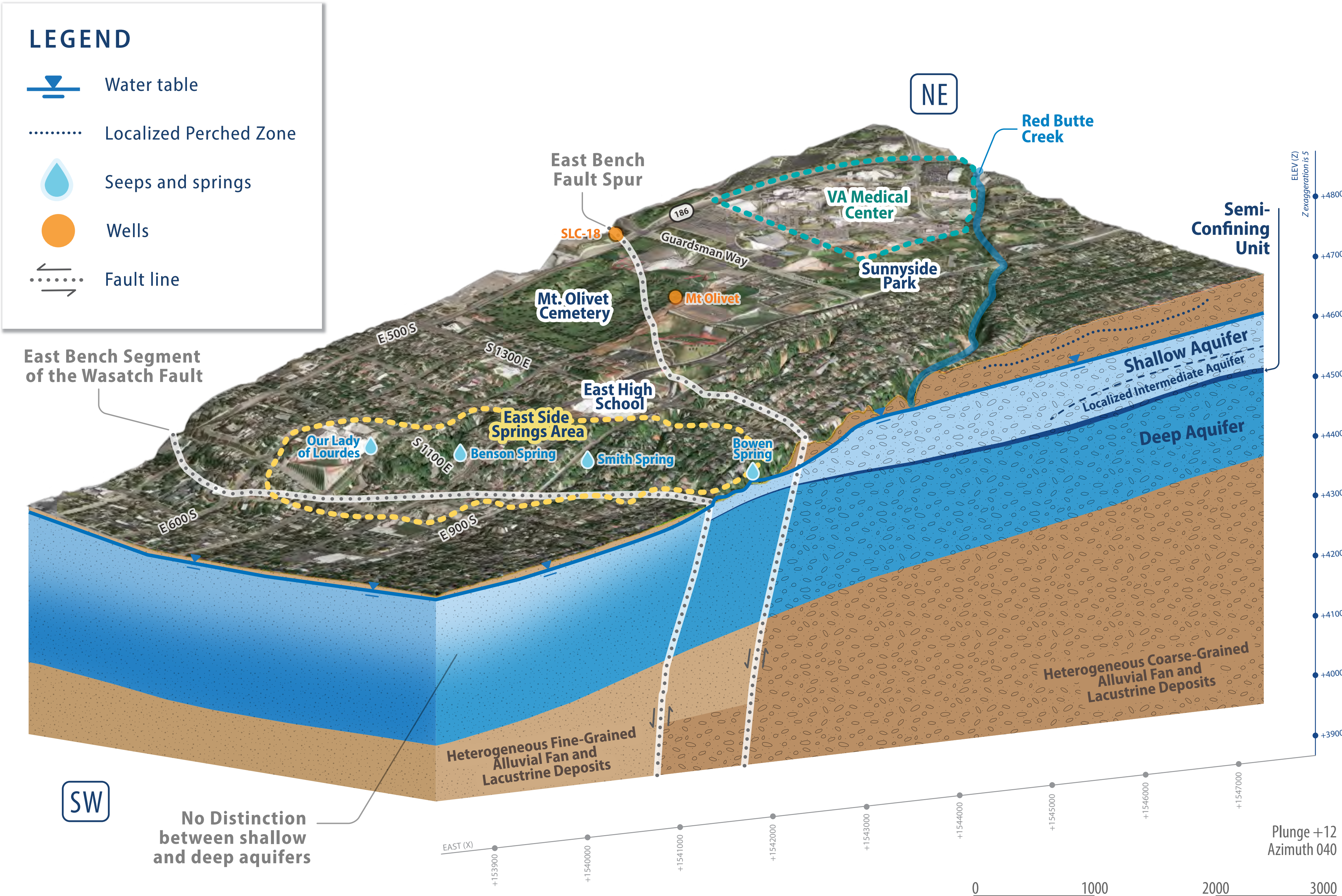
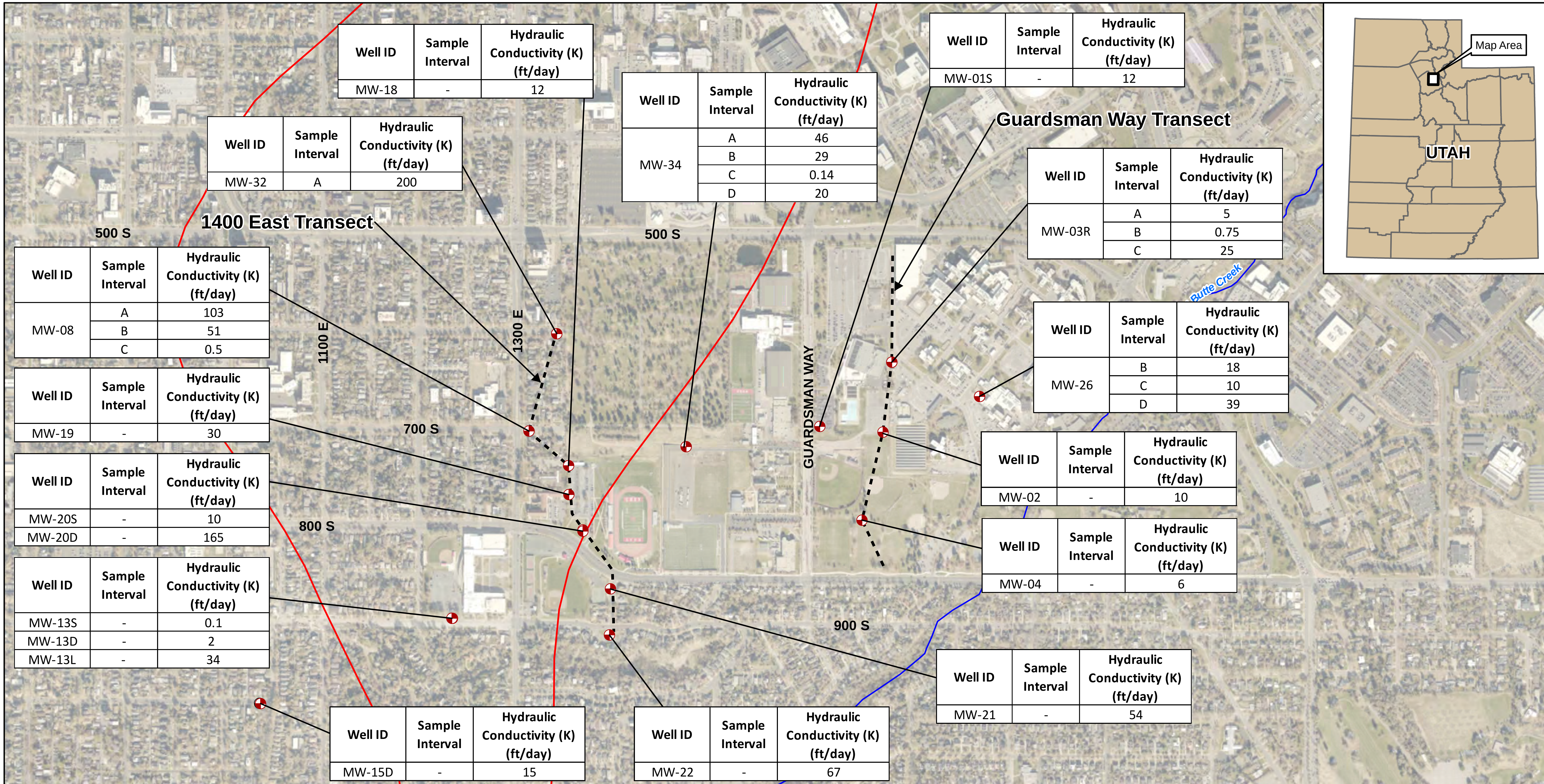


Figure 2-3
Conceptual Diagram of Topography, Surface Features, Geology, and Hydrogeology

OU1 Remedial Investigation Report
700 South 1600 East PCE Plume
Salt Lake City, Utah



Well ID	Sample Interval	Hydraulic Conductivity (K) (ft/day)
MW-18	-	12

Well ID	Sample Interval	Hydraulic Conductivity (K) (ft/day)
MW-34	A	46
	B	29
	C	0.14
	D	20

Well ID	Sample Interval	Hydraulic Conductivity (K) (ft/day)
MW-01S	-	12

Well ID	Sample Interval	Hydraulic Conductivity (K) (ft/day)
MW-32	A	200

Well ID	Sample Interval	Hydraulic Conductivity (K) (ft/day)
MW-03R	A	5
	B	0.75
	C	25

Well ID	Sample Interval	Hydraulic Conductivity (K) (ft/day)
MW-08	A	103
	B	51
	C	0.5

Well ID	Sample Interval	Hydraulic Conductivity (K) (ft/day)
MW-26	B	18
	C	10
	D	39

Well ID	Sample Interval	Hydraulic Conductivity (K) (ft/day)
MW-19	-	30

Well ID	Sample Interval	Hydraulic Conductivity (K) (ft/day)
MW-02	-	10

Well ID	Sample Interval	Hydraulic Conductivity (K) (ft/day)
MW-20S	-	10
MW-20D	-	165

Well ID	Sample Interval	Hydraulic Conductivity (K) (ft/day)
MW-04	-	6

Well ID	Sample Interval	Hydraulic Conductivity (K) (ft/day)
MW-13S	-	0.1
MW-13D	-	2
MW-13L	-	34

Well ID	Sample Interval	Hydraulic Conductivity (K) (ft/day)
MW-21	-	54

Well ID	Sample Interval	Hydraulic Conductivity (K) (ft/day)
MW-15D	-	15

Well ID	Sample Interval	Hydraulic Conductivity (K) (ft/day)
MW-22	-	67

Legend
- Completed Slug Test Location
- Proposed Slug Test Location (unsuccessful)
- Monitoring Well Transect Line
- Red Butte Creek
- Fault Line

Notes:
OU = operable unit
PCE = tetrachloroethene

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Figure 2-4
Hydraulic Conductivity
from Slug Tests

700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: J:\238824_VA_Medical_Salt_Lake\MXD\Sampling_2021\GWMR_2021\Fig2-4_Hydraulic_Conductivity.mxd WAGNERA 6/1/2021

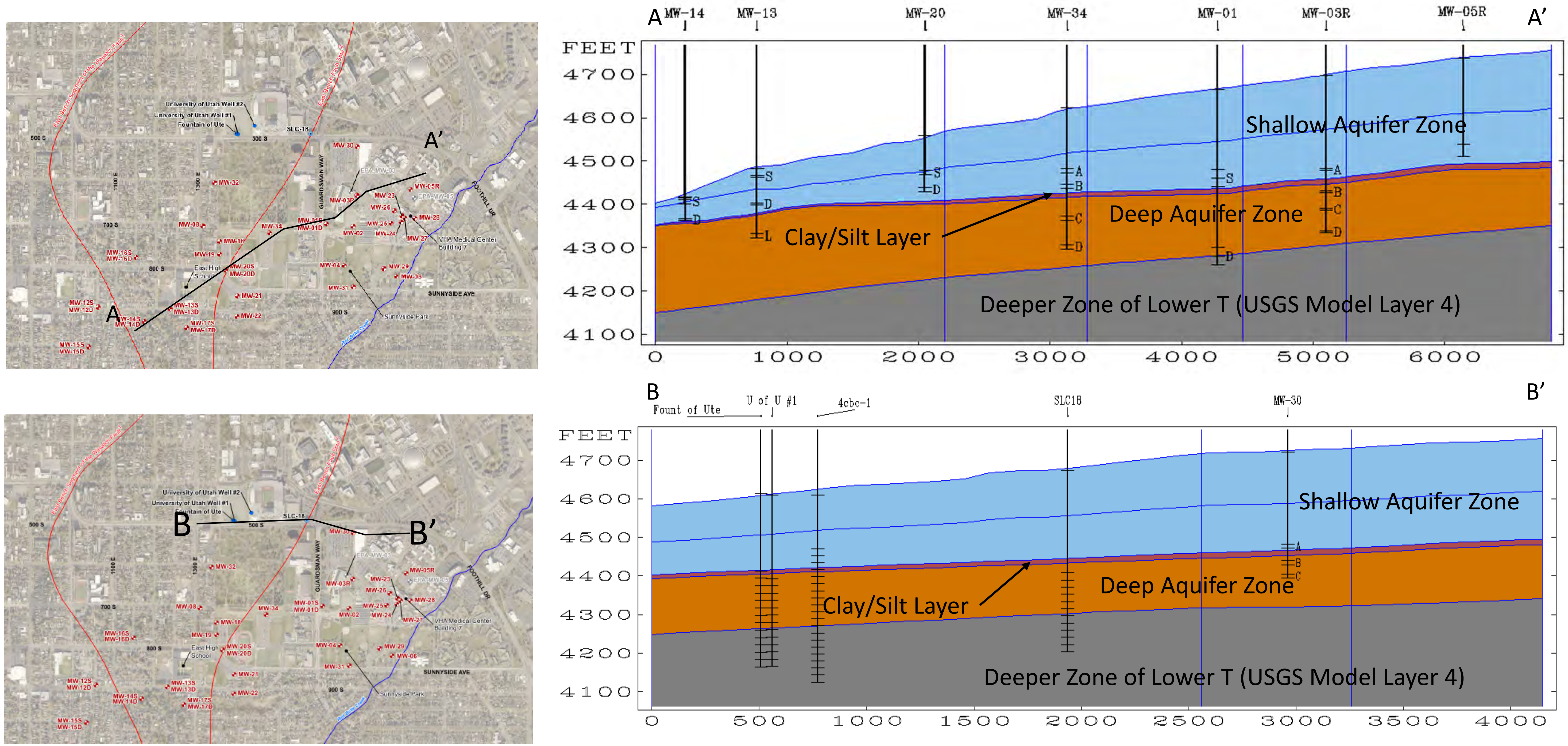

Figure 2-5
Cross Sections

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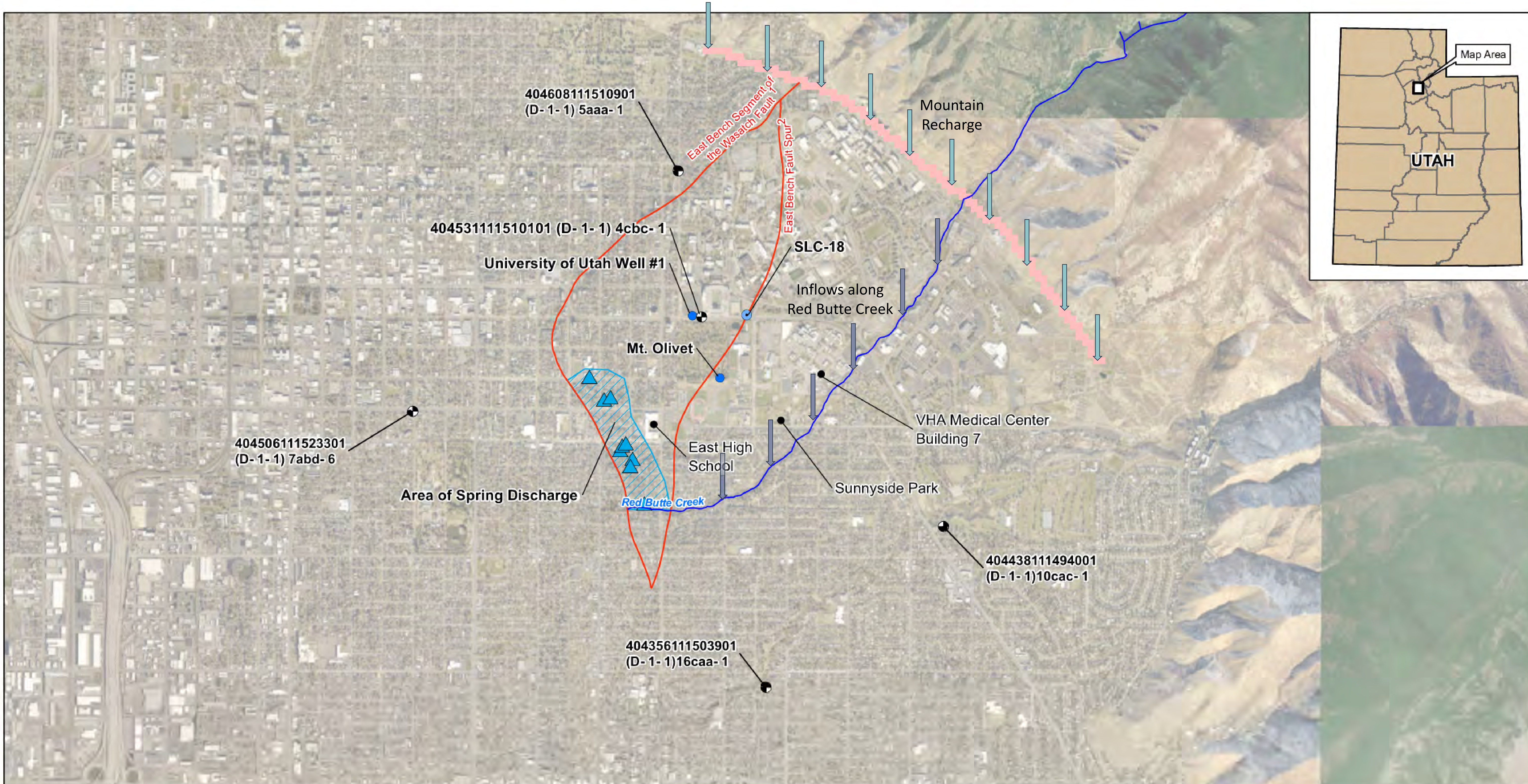
OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Model_Report_Fig\Figure_Border.mxd HoughtonG 6/4/2021



Legend

- USGS Monitoring Wells
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Springs Area
- Approximate Spring Locations
- Mountain Recharge

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.
[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

N

0 0.5 1 Miles

VHA = Veterans Health Administration

Figure 2-6
Conceptual Model Water Balance

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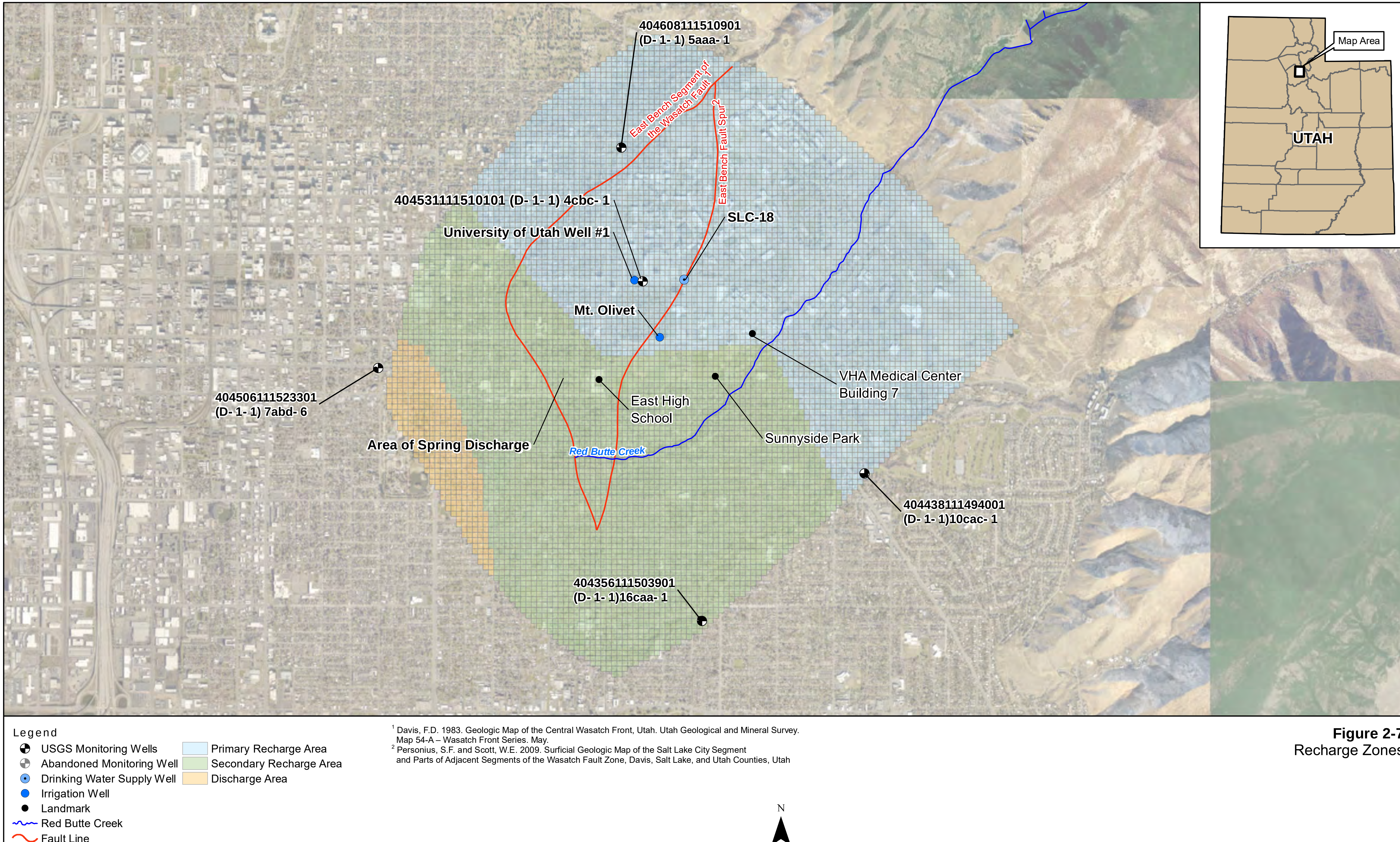
OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Model_Report_Fig\Fig2-6_Conceptual_Model_Water_Balance.mxd HoughtonG 6/4/2021



[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.
[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

Figure 2-7
Recharge Zones

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OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Model_Report_Fig\Fig2-7_Recharge_Zones.mxd HoughtonG 6/1/2021

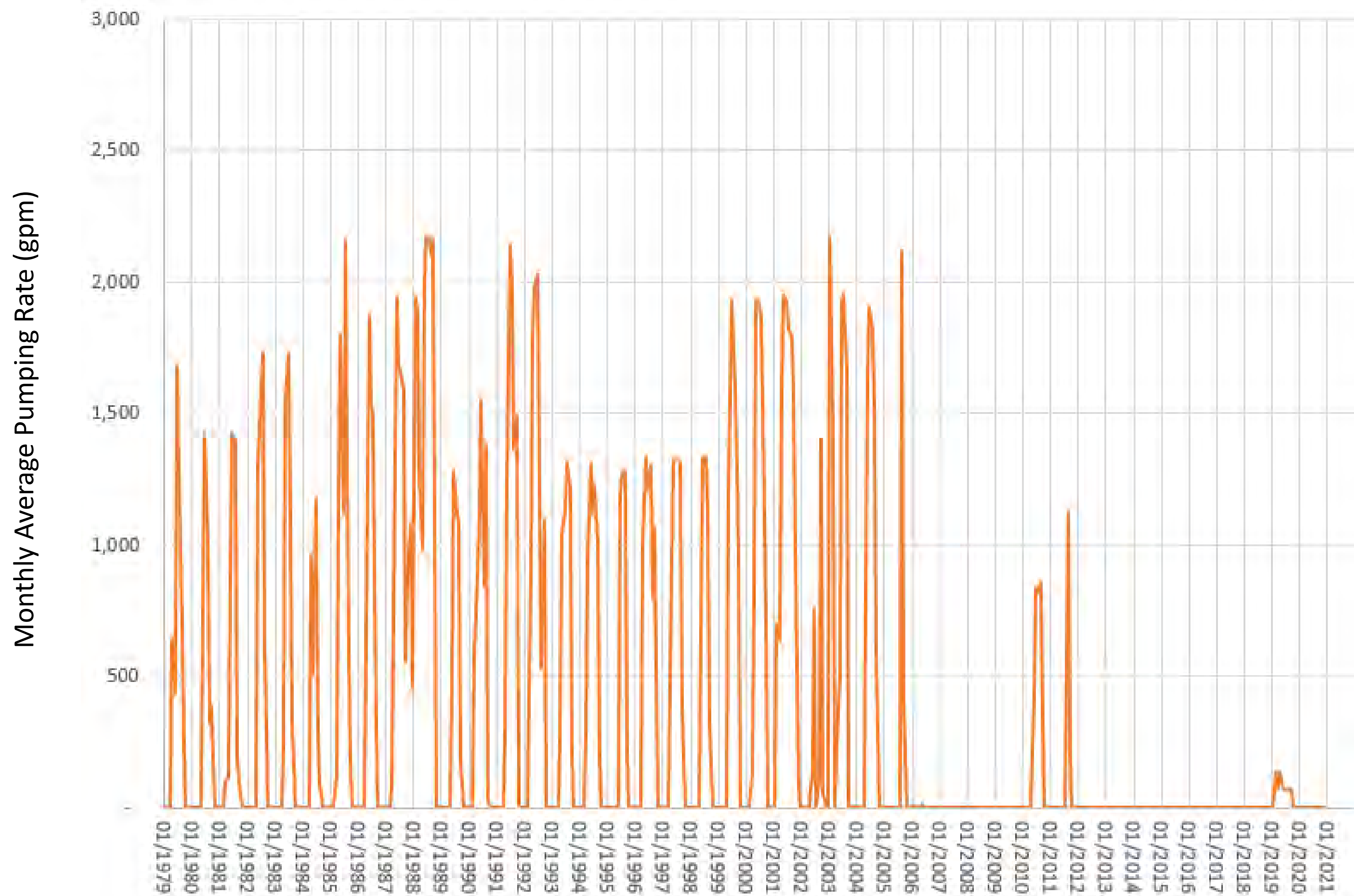


Figure 2-8
Average Monthly Pumping Rate at SLC-18

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

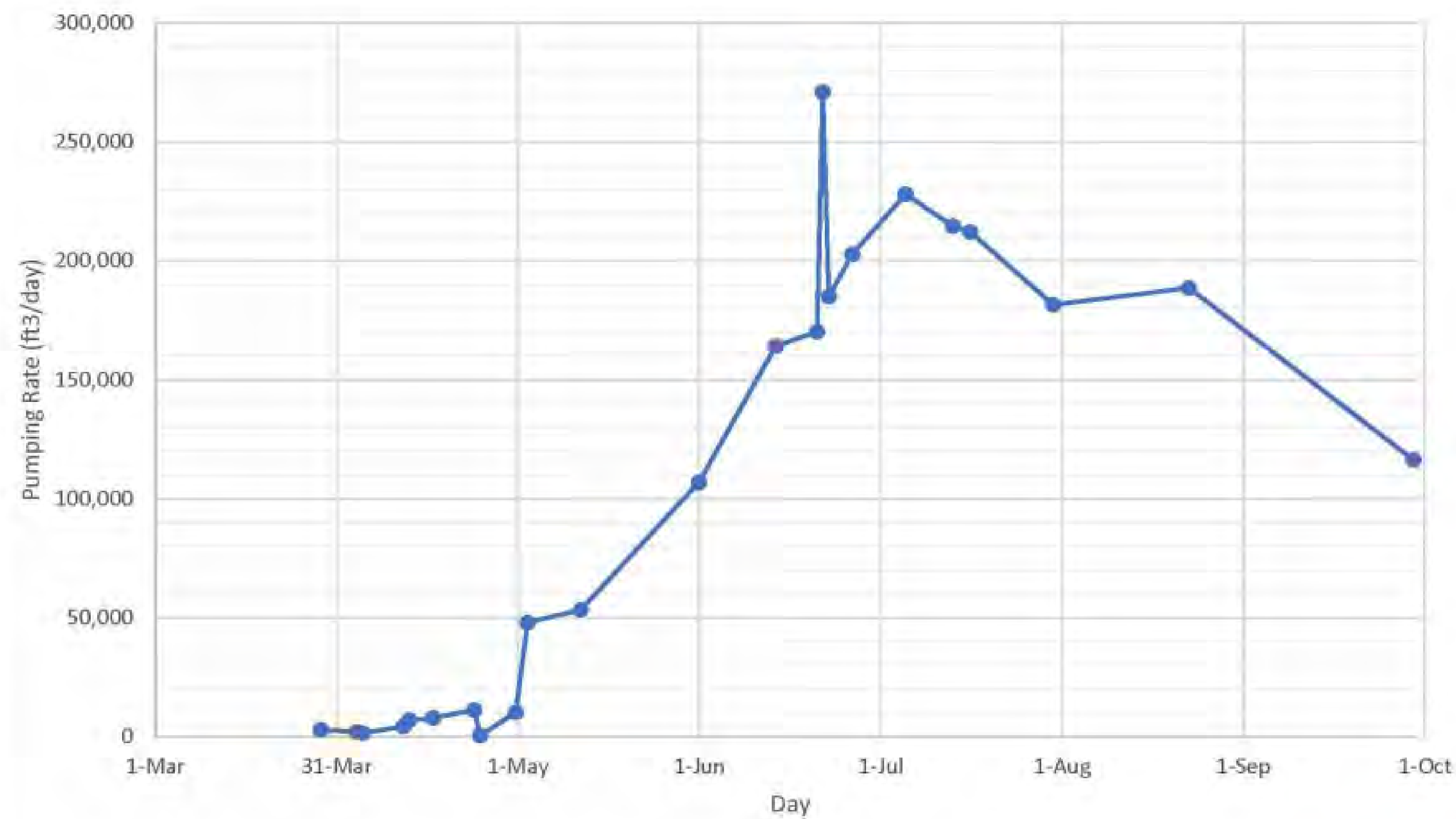


FIGURE 2. 2018 FLOW FROM UNIVERSITY WELL #1.

R·B·WHITE P.E.

Figure 2-9
University of Utah Well #1 2018 Pumping
Figure Excerpted from White (2020)

CDM Smith

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Model_Report_Fig\Figure_Border.mxd HoughtonG 6/4/2021

Table 3-1
Annual Precipitation Recharge

Year	Precipitation Recharge in the Primary Recharge Area (Inches)	Precipitation Recharge in the Secondary Recharge Area (Inches)	Precipitation Recharge in the Discharge Area (Inches)
1979	3.3	2.2	1.3
1980	6.9	4.6	2.7
1981	7.4	4.9	3.0
1982	9.3	6.2	3.7
1983	10.7	7.2	4.3
1984	7.1	4.7	2.8
1985	5.1	3.4	2.0
1986	8.3	5.5	3.3
1987	3.9	2.6	1.6
1988	3.9	2.6	1.6
1989	4.0	2.7	1.6
1990	4.5	3.0	1.8
1991	8.2	5.5	3.3
1992	5.7	3.8	2.3
1993	8.3	5.5	3.3
1994	6.8	4.6	2.7
1995	6.7	4.5	2.7
1996	6.9	4.6	2.8
1997	8.2	5.4	3.3
1998	10.9	7.3	4.4
1999	6.6	4.4	2.6
2000	6.3	4.2	2.5
2001	6.1	4.1	2.5
2002	3.7	2.4	1.5
2003	6.1	4.0	2.4
2004	4.3	2.9	1.7
2005	7.9	5.3	3.2
2006	6.6	4.4	2.6
2007	4.9	3.3	2.0
2008	4.1	2.7	1.6
2009	6.4	4.2	2.5
2010	7.3	4.9	2.9
2011	4.6	3.1	1.9
2012	4.8	3.2	1.9
2013	4.4	3.0	1.8
2014	5.5	3.7	2.2
2015	6.2	4.1	2.5
2016	5.7	3.8	2.3
2017	6.1	4.1	2.4
2018	5.0	3.4	2.0
2019	7.7	5.1	3.1
2020	3.3	2.2	1.3

Table 3-2
Simulated and Measured September 2020 Groundwater Elevations

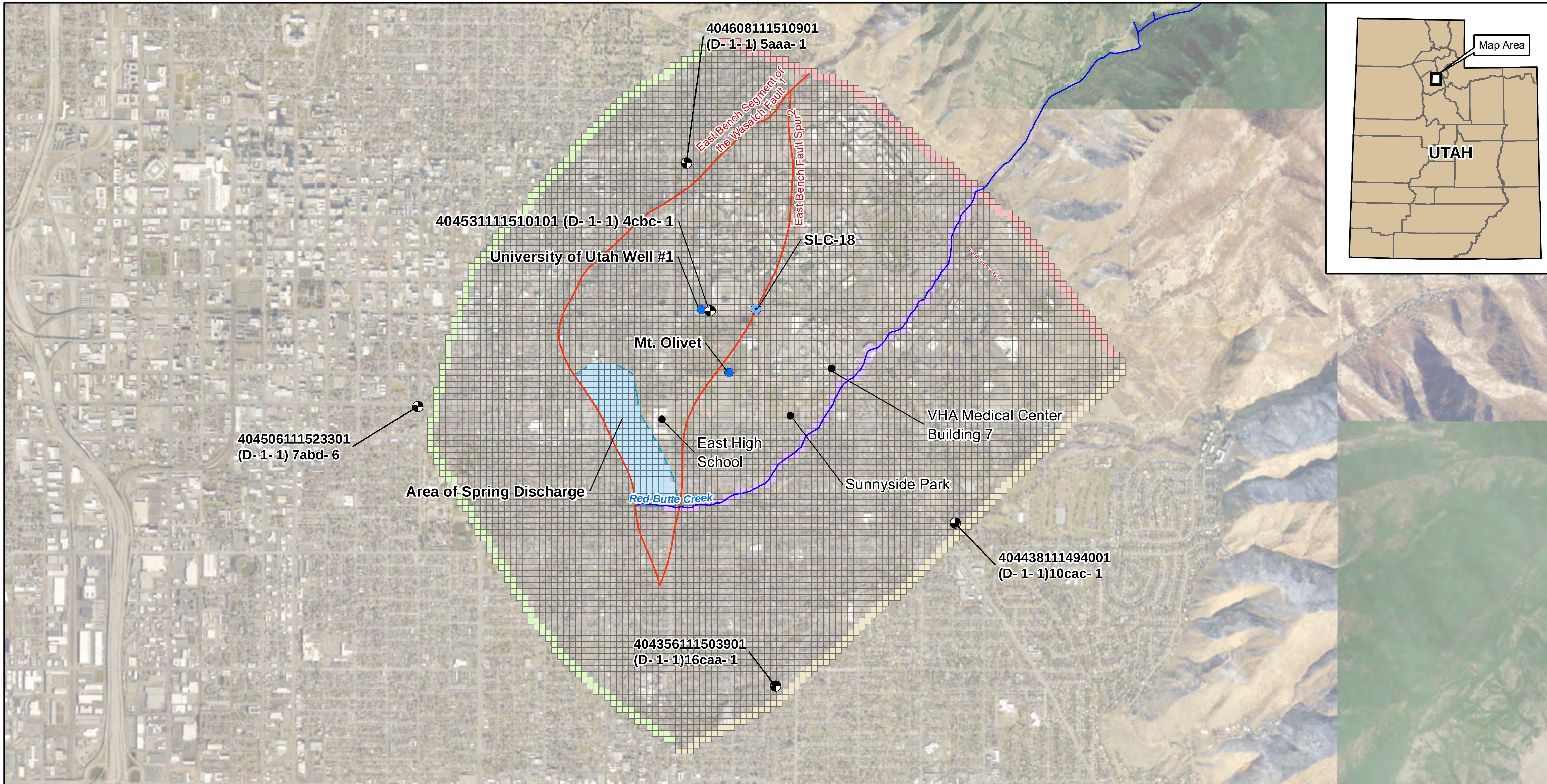
Location	Sample Interval	Aquifer Zone	Water Level Measurement Date and Time	Simulated Water Level Elevation (ft amsl)[1]	Measured Water Level Elevation (ft amsl)[1]	Simulated - Measured (Residual) (ft)
MW-01S	-	Shallow	9/21/20 17:47	4502.95	4507.54	-4.59
MW-01D	-	Deep	9/21/20 17:55	4495.39	4492.24	3.15
MW-02	-	Shallow	9/21/20 18:25	4513.01	4514.47	-1.46
MW-03R	A	Shallow	9/21/20 14:54	4512.36	4509.87	2.49
	B	Deep	9/21/20 15:02	4501.75	4492.22	9.53
	C	Deep	9/21/20 14:43	4501.75	4492.17	9.58
	D	Deep	9/21/20 15:00	4501.75	4492.23	9.52
MW-04	-	Shallow	9/21/20 17:28	4512.04	4520.95	-8.91
MW-05R	-	Shallow	9/21/20 12:45	4533.27	4523.79	9.48
MW-06	-	Perched	9/21/20 17:00	-	4554.71	-
MW-08	A	Shallow	9/22/20 18:46	4465.40	4478.64	-13.24
	B	Deep	9/22/20 18:49	4478.12	4480.03	-1.91
	C	Deep	9/22/20 18:51	4478.12	4481.66	-3.54
MW-12S	-	-	9/21/20 13:24	4298.50	4303.01	-4.51
MW-12D	-	-	9/21/20 13:30	4298.50	4302.92	-4.42
MW-13S	-	Shallow	9/21/20 15:11	4449.69	4468.62	-18.93
MW-13D	-	Shallow	9/21/20 15:04	4453.15	4468.90	-15.75
MW-14S	-	Shallow	9/21/20 14:15	4411.14	4410.47	0.67
MW-14D*	-	Shallow	9/21/20 14:25	4428.93	4422.86	6.07
MW-15S	-	-	9/28/20 12:23	4296.56	4298.30	-1.74
MW-15D	-	-	9/28/20 12:20	4296.59	4297.22	-0.63
MW-16S	-	Shallow	9/21/20 13:54	4433.82	4443.60	-9.78
MW-16D	-	Shallow	9/21/20 13:46	4447.40	4444.45	2.95
MW-17S	-	Shallow	9/21/20 14:42	4462.07	4459.69	2.38
MW-17D	-	Shallow	9/21/20 16:37	4462.07	4465.04	-2.97
MW-18	-	Shallow	9/21/20 16:53	4466.51	4476.26	-9.75
MW-19	-	Shallow	9/21/20 17:02	4465.90	4475.34	-9.44
MW-20S	-	Shallow	9/21/20 17:11	4466.47	4474.68	-8.21
MW-20D	-	Shallow	9/21/20 17:20	4466.47	4474.54	-8.07
MW-21	-	Shallow	9/21/20 15:54	4478.61	4498.21	-19.60
MW-22	-	Shallow	9/21/20 16:15	4481.48	4499.10	-17.62
MW-23	A	Shallow	9/22/20 8:16	4530.38	4523.58	6.80
	B	Intermediate	9/22/20 8:20	4510.16	4514.16	-4.00
	C	Deep	9/22/20 8:28	4510.16	4493.47	16.69
MW-24	-	Shallow	9/21/20 16:11	4530.25	4523.78	6.47
MW-25	A	Shallow	9/21/20 15:21	4526.62	4522.72	3.90
	B	Intermediate	9/21/20 15:18	4516.55	4517.59	-1.04
	C	Deep	9/21/20 15:24	4507.80	4493.18	14.62
MW-26	A	Shallow	9/21/20 16:02	4527.32	4521.70	5.62
	B	Intermediate	9/21/20 15:58	4517.37	4517.43	-0.06
	C	Deep	9/21/20 15:47	4508.72	4493.74	14.98
	D	Deep	9/21/20 15:54	4508.72	4493.00	15.72
MW-27	-	Shallow	9/22/20 8:37	4531.52	4524.19	7.33
MW-28	-	Shallow	9/21/20 16:17	4535.28	4525.52	9.76
MW-29	A	Perched	9/21/20 16:34	-	4561.93	-
	B	Shallow	9/21/20 16:43	4525.16	4523.22	1.94
	C	Intermediate	9/21/20 16:27	4514.48	4520.16	-5.68
MW-30	A	Intermediate	NM	NM		
	B	Deep	NM	NM		
	C	Deep	9/21/20 12:00	4503.15	4491.02	12.13
MW-31	A	Shallow	9/21/20 17:18	4515.81	4522.42	-6.61
	B	Shallow	9/21/20 17:11	4515.81	4518.55	-2.74
	C	Deep	9/21/20 17:22	4498.87	4505.36	-6.49
MW-32	A	Shallow	9/21/20 18:09	4469.62	4481.42	-11.80
	B	Shallow	9/21/20 18:05	4479.14	4481.86	-2.72
	C	Deep	9/21/20 18:07	4479.14	4482.41	-3.27
MW-34	A	Shallow	9/21/20 17:47	4481.10	4491.09	-9.99
	B	Shallow	9/21/20 17:49	4481.10	4491.04	-9.94
	C	Deep	9/21/20 17:53	4485.27	4491.41	-6.14
	D	Deep	9/21/20 17:44	4485.27	4491.38	-6.11

Notes:
[1] Elevations measured using NAVD 88 vertical datum
*Water level measured using pressure gauge, converted to height above top of casing (head [ft] = pressure [psi] x 2.31)

Table 3-4
Sensitivity Simulation Summary

Simulation	Model Layers Where Changes Were Made	Mean Error (Ft)	Mean Absolute Error (Ft)	Simulated Drain Outflow (MGD)	Simulated Head Difference Across Fault (Ft)[1]
Parameters: Shallow and Deep Aquifer Horizontal and Vertical Hydraulic Conductivity					
Base	--	-0.6	5.8	1.3	114.6
1: Uniform Hydraulic Conductivity East of Fault - High (Kh=50 ft/d; Kh:Kv - 100:1)	1,2 (shallow aquifer)	-25.8	25.8	2.0	114.3
2: Uniform Hydraulic Conductivity East of Fault - Low (Kh=5 ft/d; Kh:Kv - 100:1)	1,2 (shallow aquifer)	10.9	12.7	0.9	113.8
3: Multiply Kh by 1.5 (All zones, Kh:Kv - 100:1)	1,2,4 (shallow, deep aquifer)	-9.9	10.3	1.5	114.9
4: Multiply Kh by 0.5 (All zones, Kh:Kv - 100:1)	1,2,4 (shallow, deep aquifer)	22.8	23.7	0.6	113.7
5:Reduce Kh:Kv from 100:1 to 10:1 East of Fault	1,2,4 (shallow, deep aquifer)	-12.0	12.3	1.6	115.3
6: Decrease Kh east of fault from 50 ft/d to 25 ft/d (Kh:Kv - 100:1)	1,2 (shallow aquifer)	2.9	7.1	1.1	114.3
7: Increase Kh in layer 4 east of fault from 45 ft/d to 90 ft/d (Kh:Kv - 100:1)	4 (deep aquifer)	-3.7	5.6	1.3	114.3
Parameters: Drain and Fault Horizontal and Vertical Hydraulic Conductivity					
Base	--	-0.6	5.8	1.3	114.6
8: Increase Drain Conductivity from 1 ft/d to 10 ft/d	--	-0.9	6.4	1.3	114.5
9: Decrease Drain Conductivity from 1 ft/d to 0.1 ft/d	--	-0.4	6.3	1.3	115.8
10: Raise Kh of Fault everywhere by 2 (Kh:Kv - 1:1)	1 - 5	-32.6	33.0	0.5	108.4
Parameters: University of Utah Irrigation Pumping					
Base (342 gpm)	--	-0.6	5.8	1.3	114.6
11: No pumping	4	3.7	7.1	1.4	114.1
12: University well pumping x2	4	-5.3	7.3	1.2	115.1
Parameters:Groundwater Recharge					
Base	--	-0.6	5.8	1.3	114.6
13: Mountain block recharge increased by 50%	--	41.1	41.2	2.5	110.5
14: Mountain block recharge decreased by 50%	--	-33.4	33.4	0.6	117.3
15: Increase infiltration from Red Butte Creek by 50%	--	4.1	7.6	1.4	114.3
16: Decrease infiltration from Red Butte Creek Red Butte Creek by 50%	--	-6.1	7.8	1.2	115.0

(1) Measured Head Difference Across Fault (wells 14S and 15S): 112.2 ft in September 2020



Legend

- USGS Monitoring Wells
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Model Grid
- Drain Boundary Condition
- Specified Flux Boundary Condition
- Constant Head Boundary Condition
- Recharge from Red Butte Creek
- No Flow Boundary Condition

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.

[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

N

0 0.5 1 Miles

VHA = Veterans Health Administration

Figure 3-1
Model Grid and Boundary Conditions

CDM Smith

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

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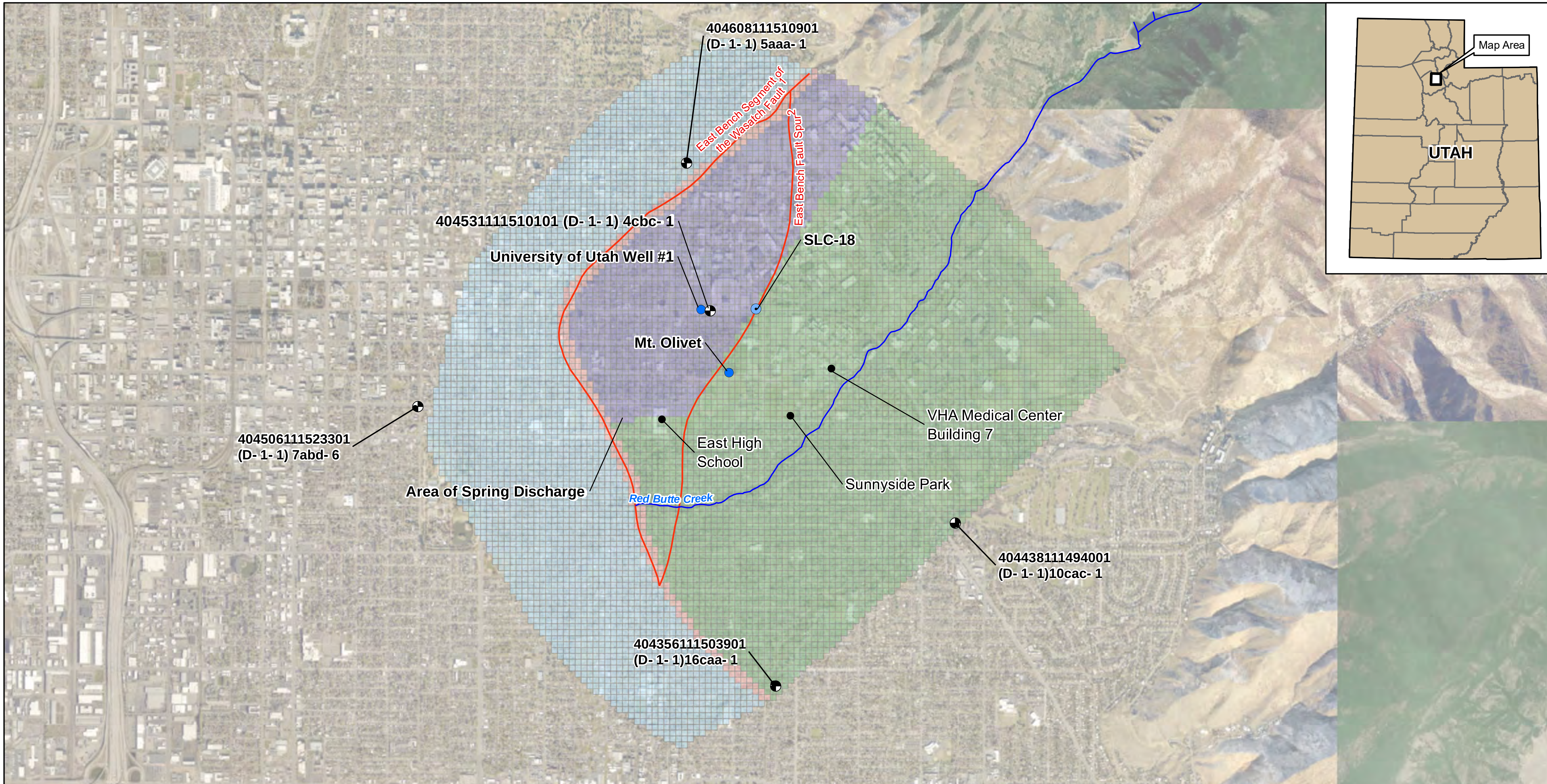


Legend

- USGS Monitoring Wells
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line

Horizontal Hydraulic Conductivity (ft/d)

- 0.1
- 5
- 15
- 50

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.
[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

N

0 0.5 1 Miles

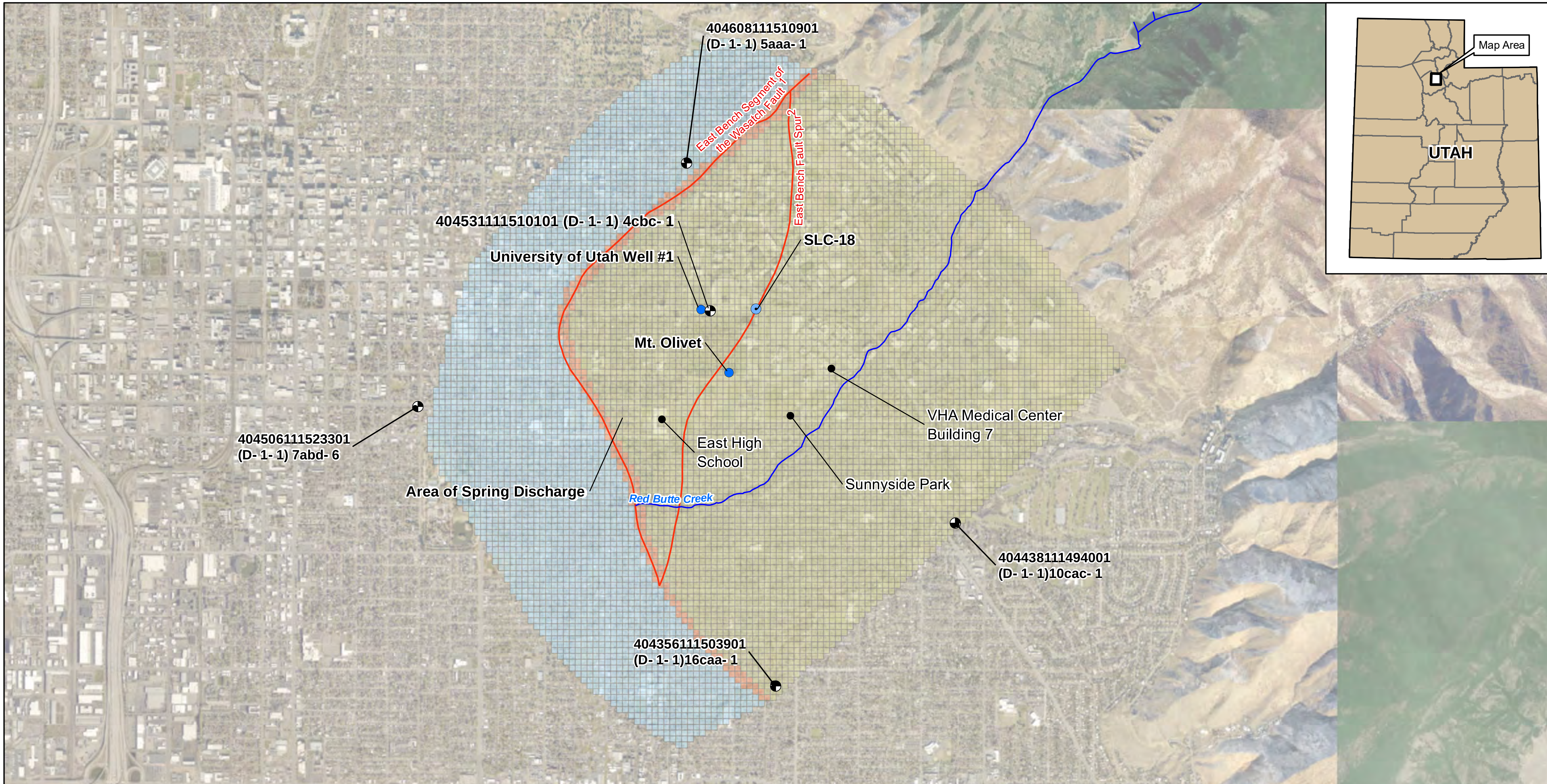
VHA = Veterans Health Administration

Figure 3-2
Model Layers 1 and 2 Properties

CDM Smith

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Model_Report_Fig\Fig3-2_Kx_Layer2.mxd HoughtonG 6/1/2021



Legend

- USGS Monitoring Wells
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line

Horizontal Hydraulic Conductivity (ft/d)

- 0.01
- 0.1
- 15

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.

[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

N

0 0.5 1 Miles

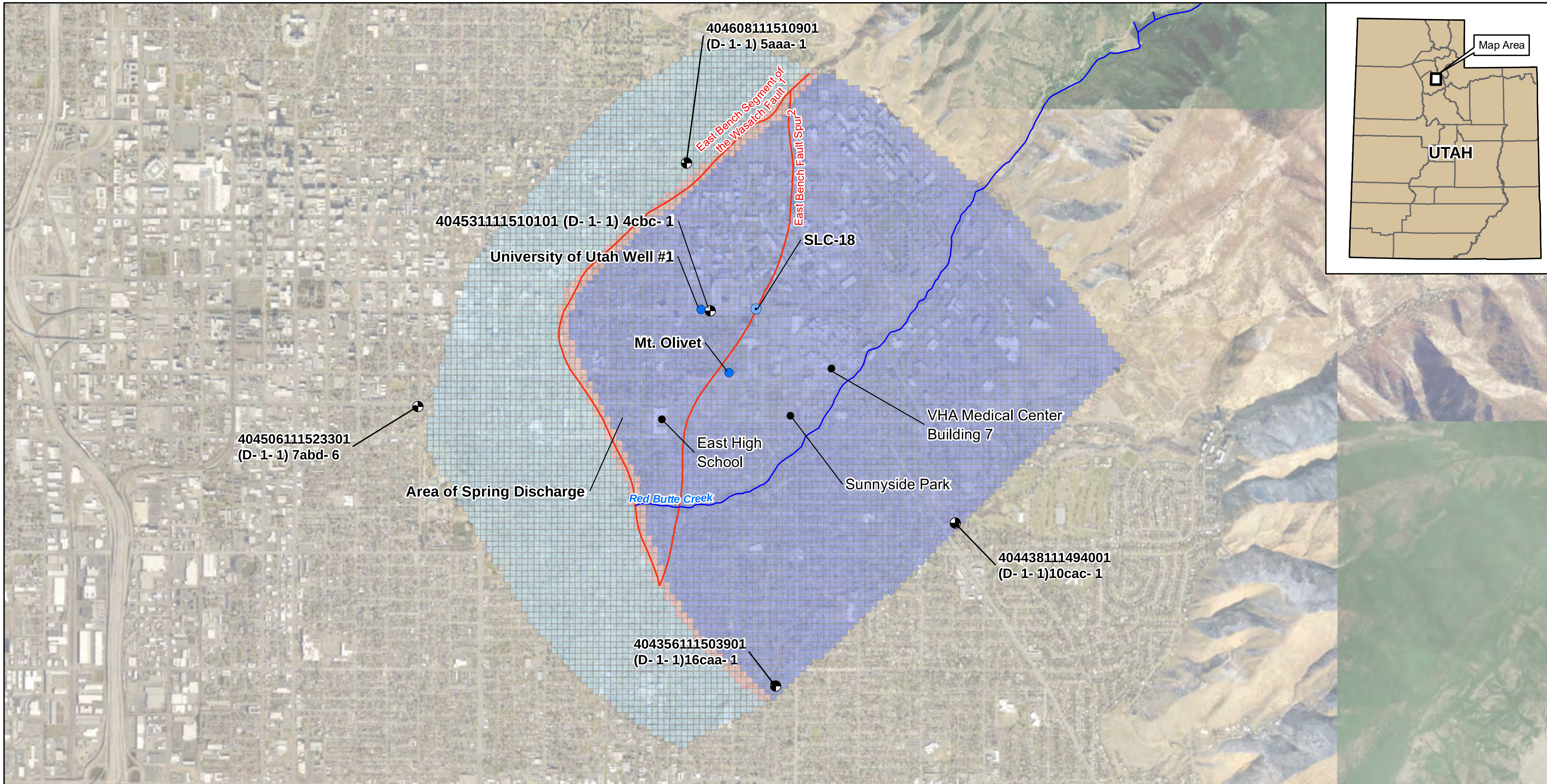
VHA = Veterans Health Administration

Figure 3-3
Model Layer 3 Properties

CDM Smith

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Model_Report_Fig\Fig3-3revKx_Layer3.mxd HoughtonG 6/1/2021



Legend

USGS Monitoring Wells
Abandoned Monitoring Well
Drinking Water Supply Well
Irrigation Well
Landmark
Red Butte Creek
Fault Line

Horizontal Hydraulic Conductivity (ft/d)
0.1
15
45

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.
[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

N
0 0.5 1 Miles

VHA = Veterans Health Administration

Figure 3-4
Model Layer 4 Properties

CDM Smith

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Model_Report_Fig\Fig3-4_Kx_Layer4.mxd HoughtonG 6/1/2021

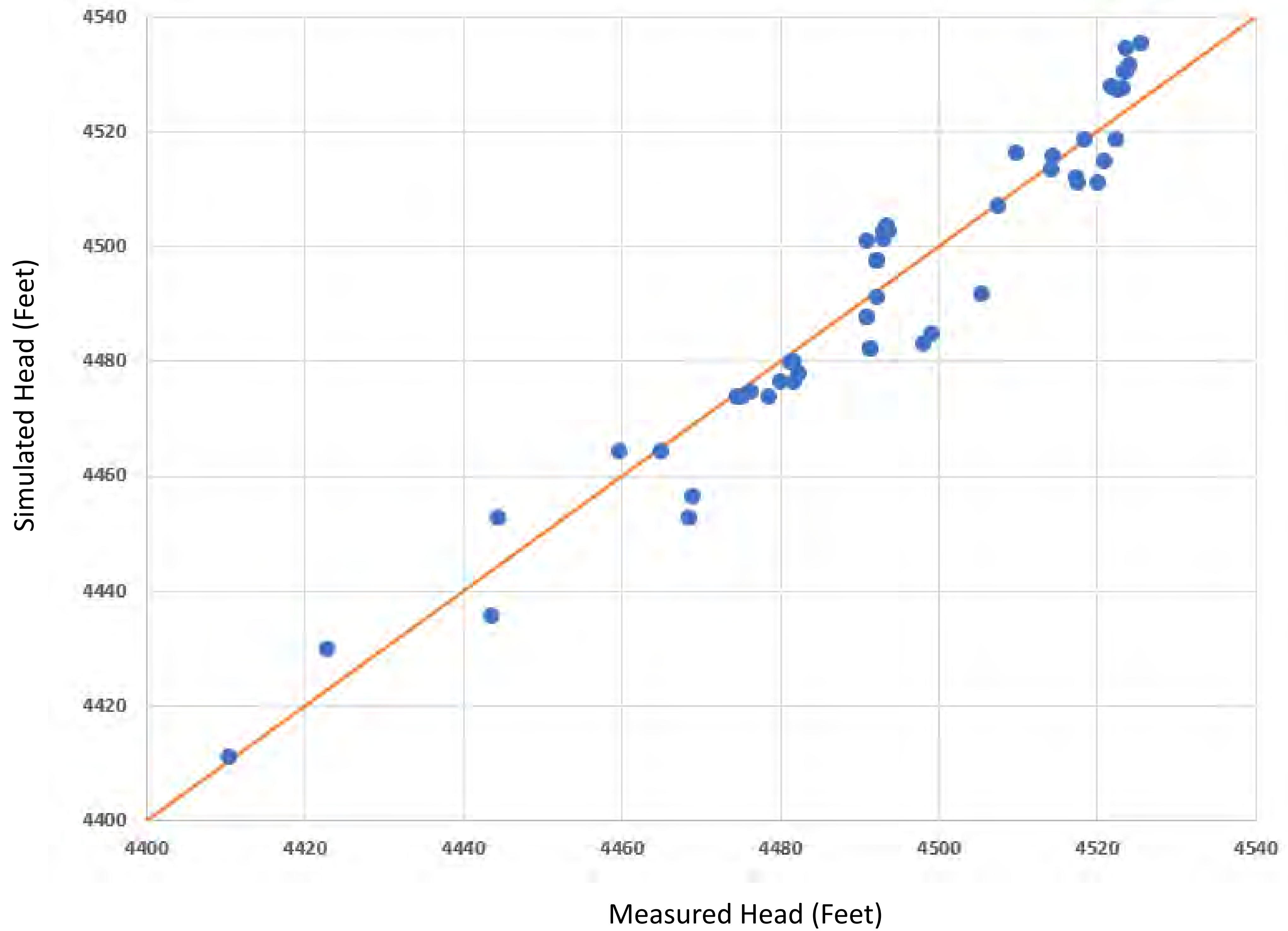
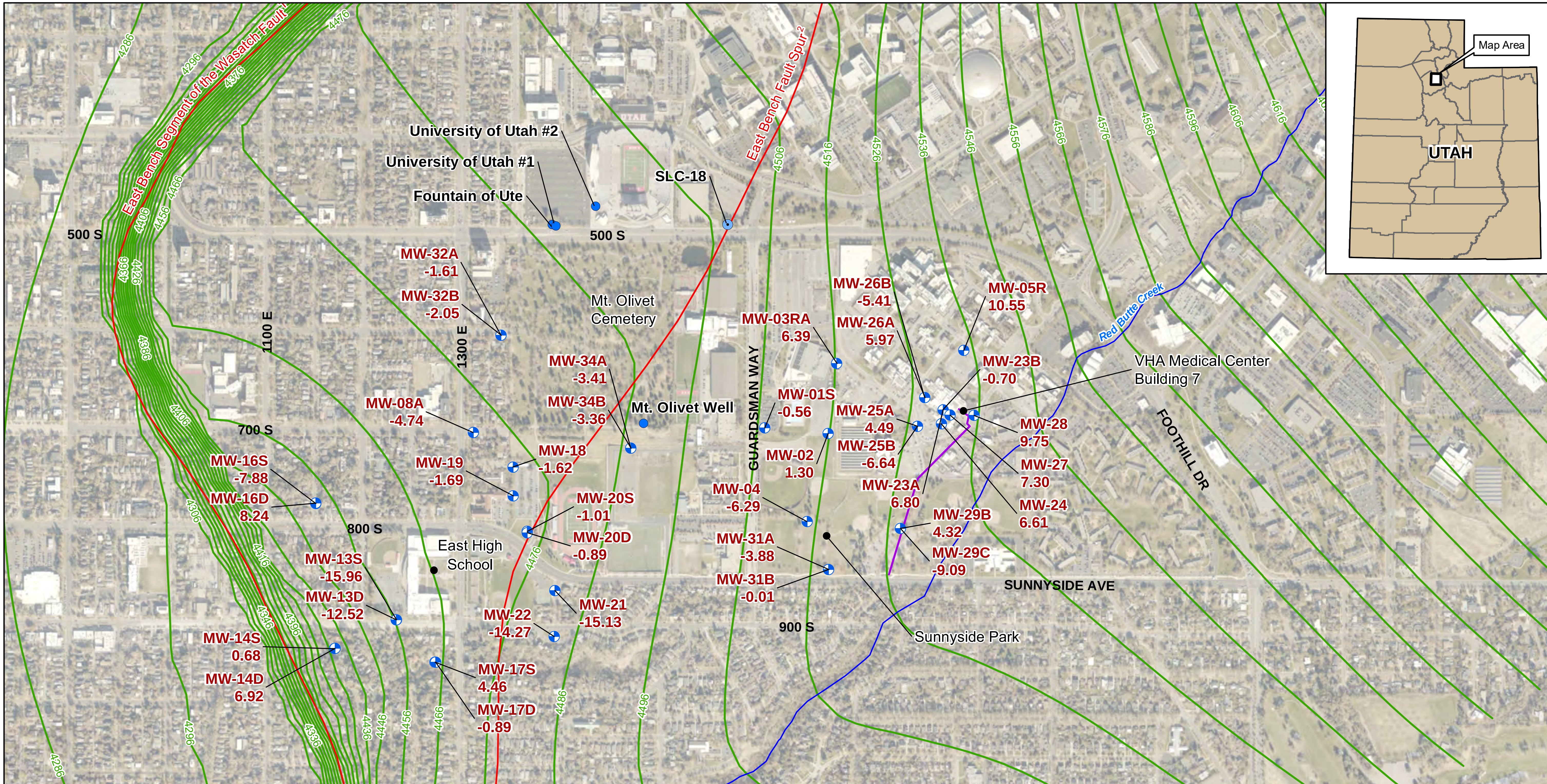


Figure 3-5
September 2020 Calibration Scatterplot

CDM Smith

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah



Legend
- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Model Simulated Shallow Contour (Layer 2)
- 0 Residual (Simulated - Measured) (feet)

Notes:
- Measured heads from September 2020.

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.
[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

0 500 1,000 Feet

CDM Smith

Figure 3-6
Shallow Zone Head Residuals

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Model_Report_Fig\Fig3-6_Shallow_Residuals_Run75.mxd HoughtonG 6/14/2021 9:19:57 AM

Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Model Simulated Deep Contour (Layer 4)
- **0** Residual (Simulated - Measured) (feet)

Notes:
- Measured heads from September 2020.

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.
[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

0 500 1,000 Feet

CDM Smith

Figure 3-7
Deep Zone Head Residuals

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Model_Report_Fig\Fig3-7_Deep_Residuals_Run75.mxd HoughtonG 6/14/2021 9:24:23 AM

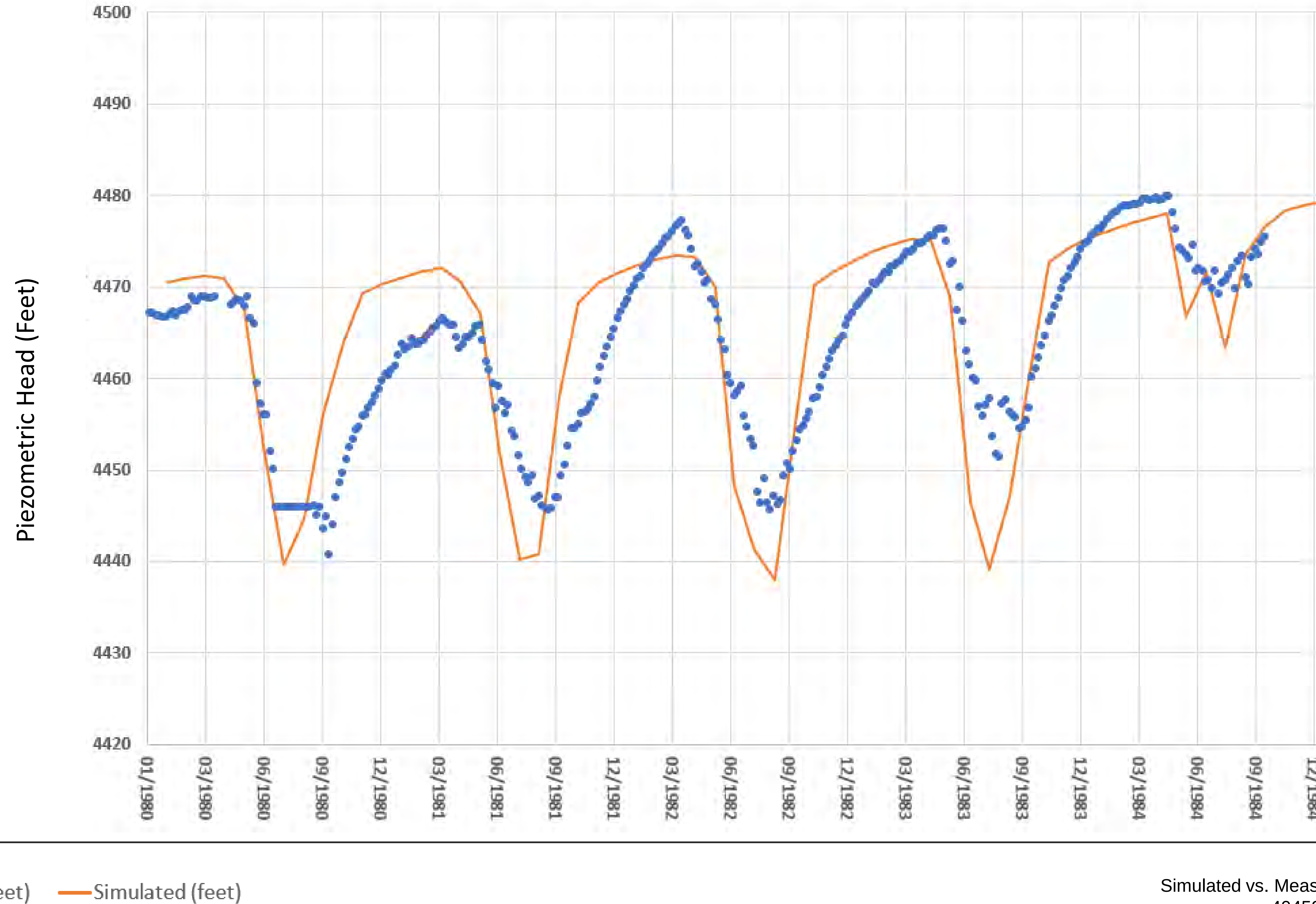


Figure 3-8
Simulated vs. Measured Heads at USGS Well
404531111510101(D-1-d)4cbc-1

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

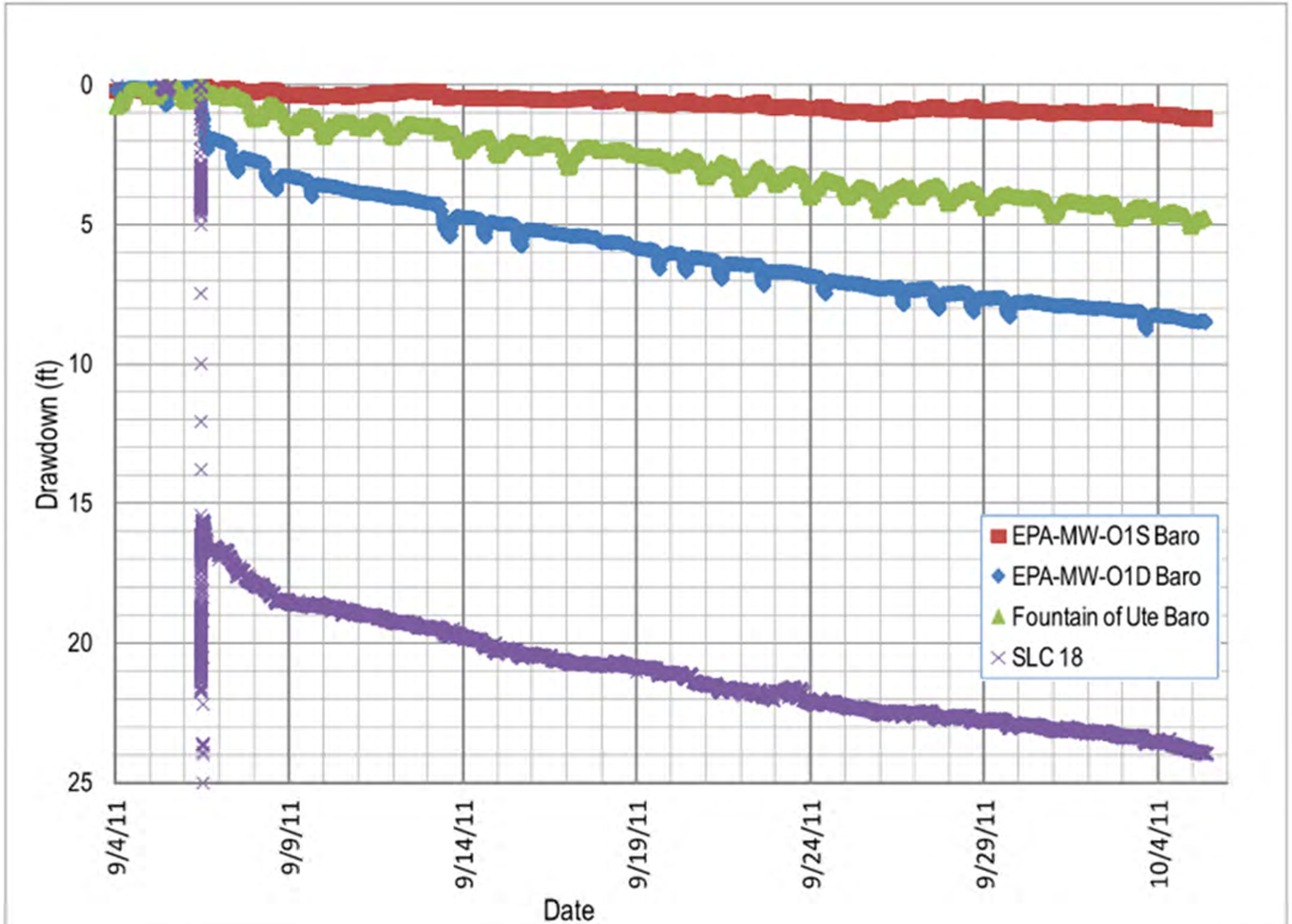


Figure A.1: Drawdown Responses at Pumping and Observation Wells

Figure 3-9
September 2011 Aquifer Performance Test Results
Figure Excerpted from MWH (2012)

CDM Smith

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

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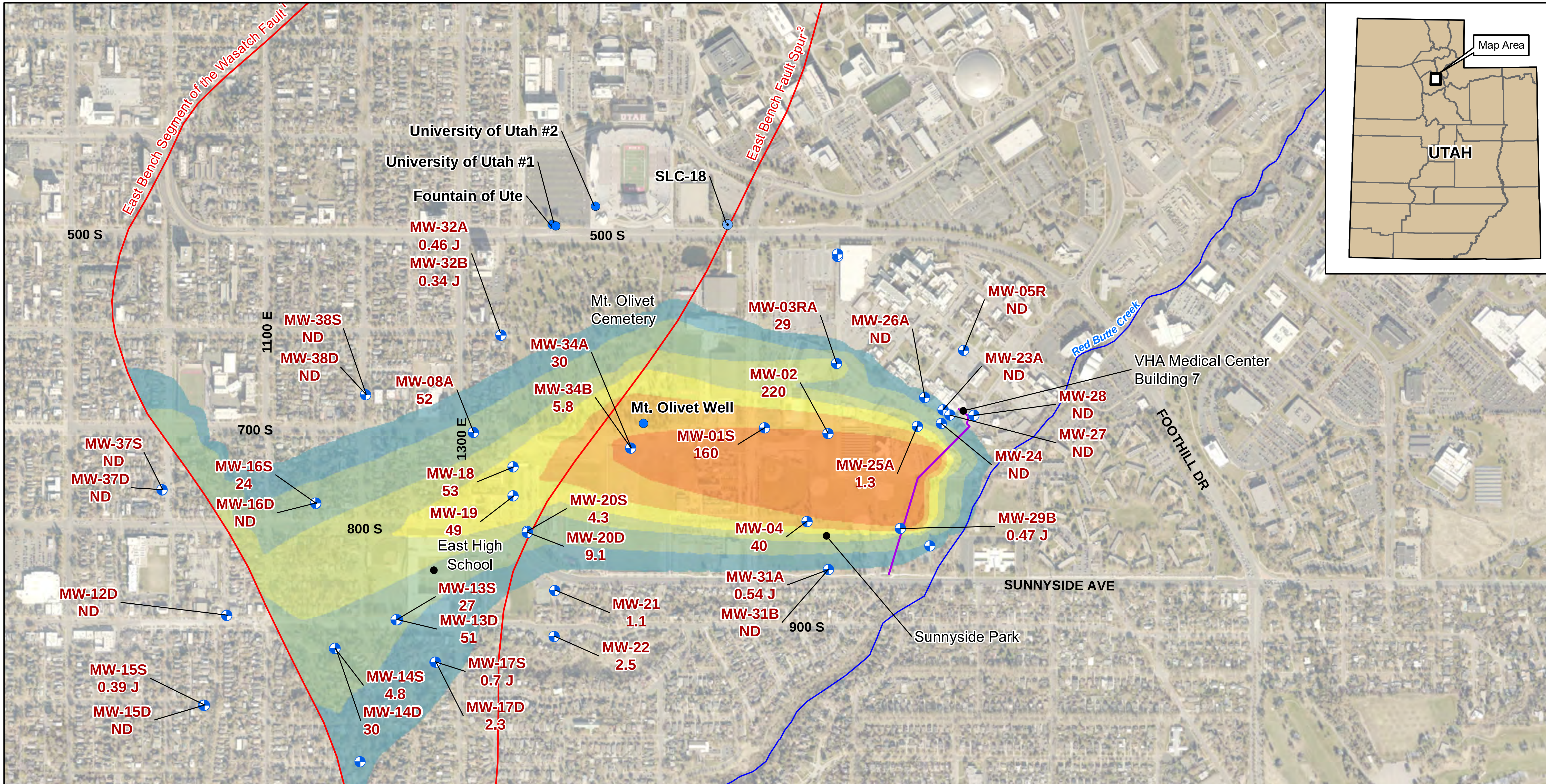

Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line

PCE (ug/L)
< 1
1 - 5
5 - 25
25 - 50
50 - 100
100 - 200
>200

Notes:
- Measured PCE concentrations are from December 2020.

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.

[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

N E S W

0 500 1,000 Feet

CDM Smith

Figure 4-1
Simulated PCE Concentrations, September 2020
Shallow Aquifer

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

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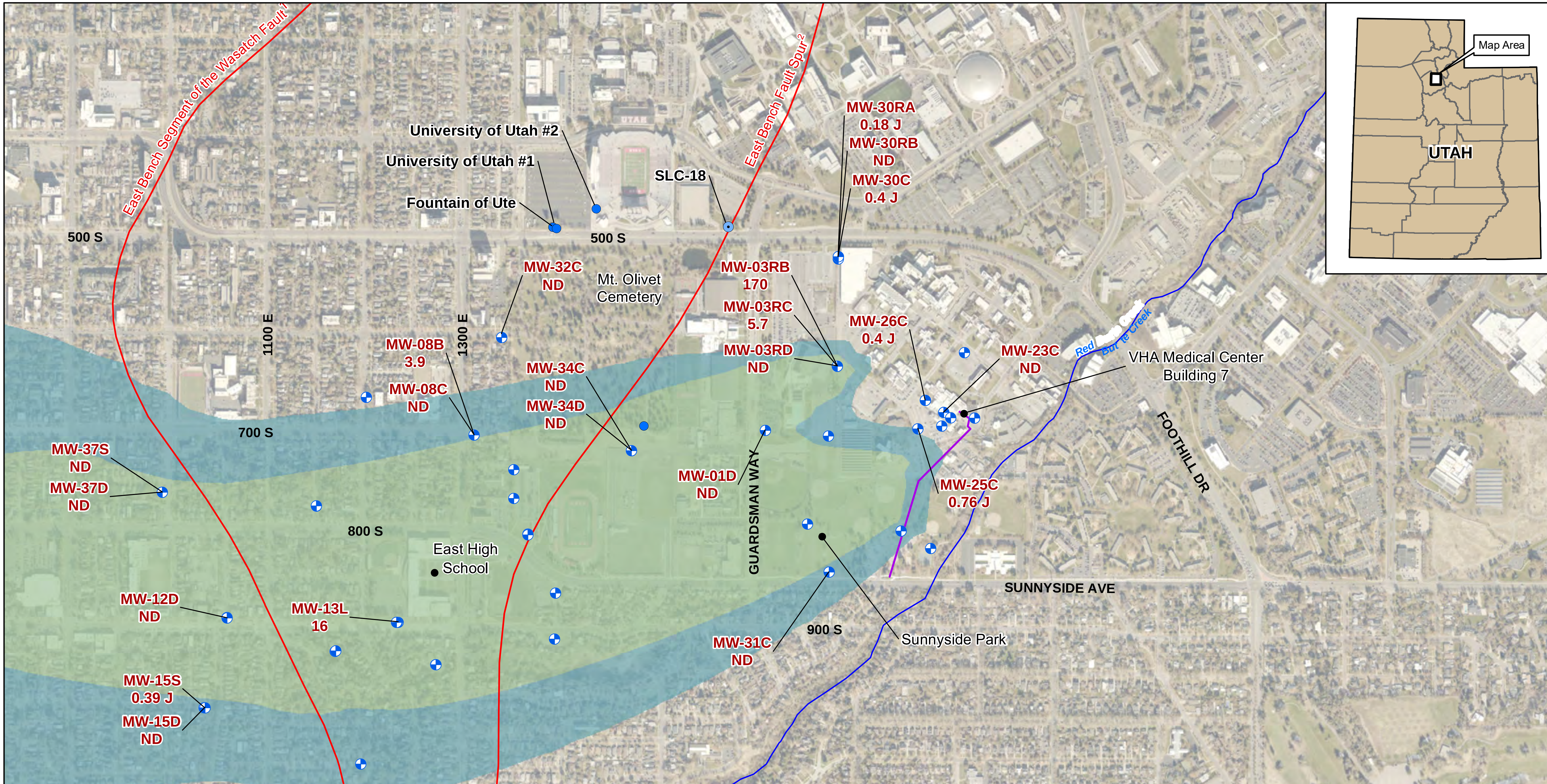


Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line

PCE (ug/L)
< 1
1 - 5
5 - 25
25 - 50
50 - 100
100 - 200
>200

Notes:
- Measured PCE concentrations are from December 2020.

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.
[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

N
W E
S

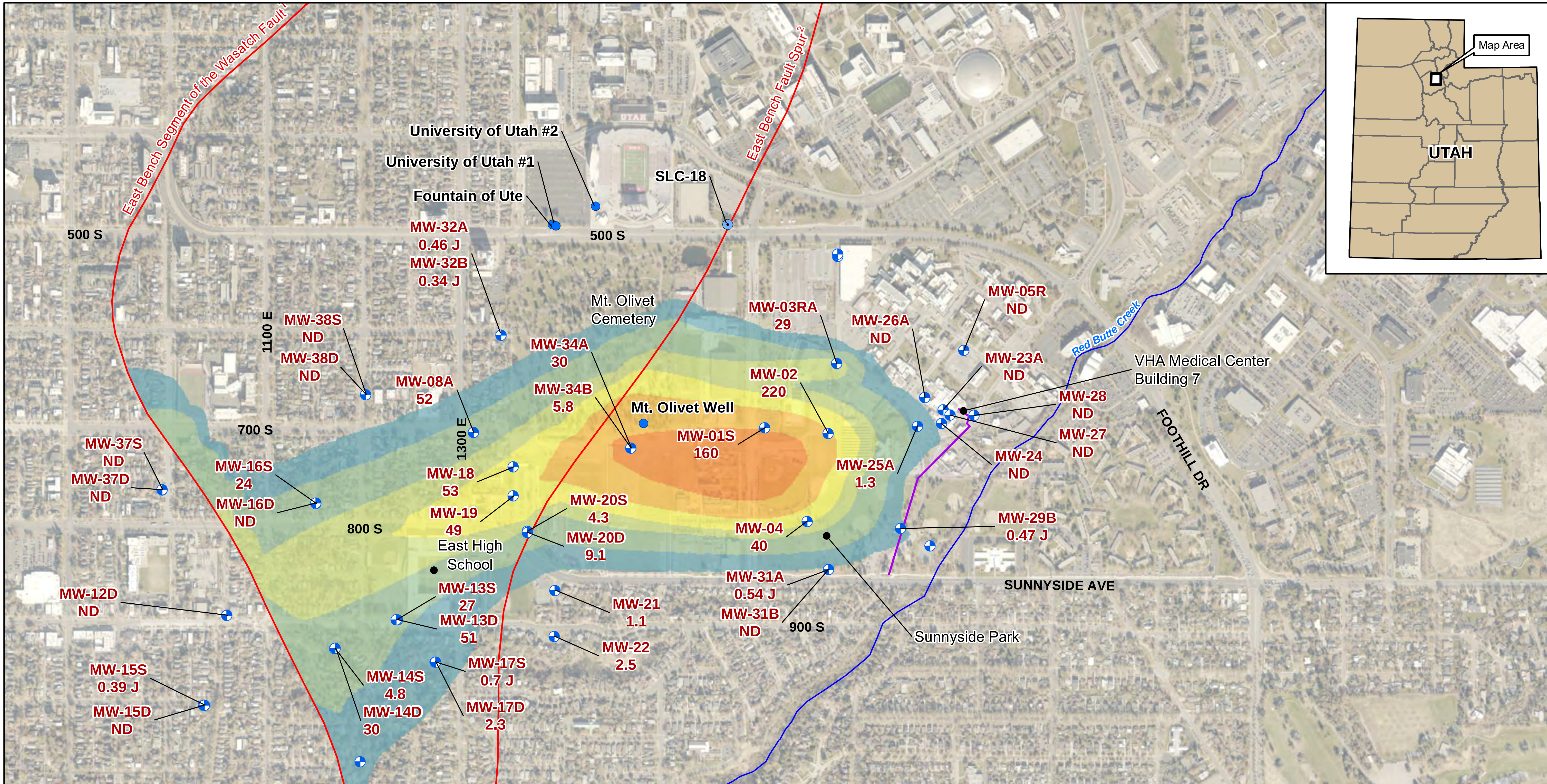
0 500 1,000 Feet

CDM Smith

Figure 4-2
Simulated PCE Concentrations, September 2020
Deep Aquifer

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: C:\Projects\Missouri_Drought_Plan\GIS\mxd\Fig4-2_DSR_GW_B_Aquifer_Concentrations_Sep2020_T23.mxd HoughtonG 8/16/2021 7:55:31 PM



Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line

PCE (ug/L)
< 1
1 - 5
5 - 25
25 - 50
50 - 100
100 - 200
>200

Notes:
- Measured PCE concentrations are from December 2020.

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.
[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

N E S W

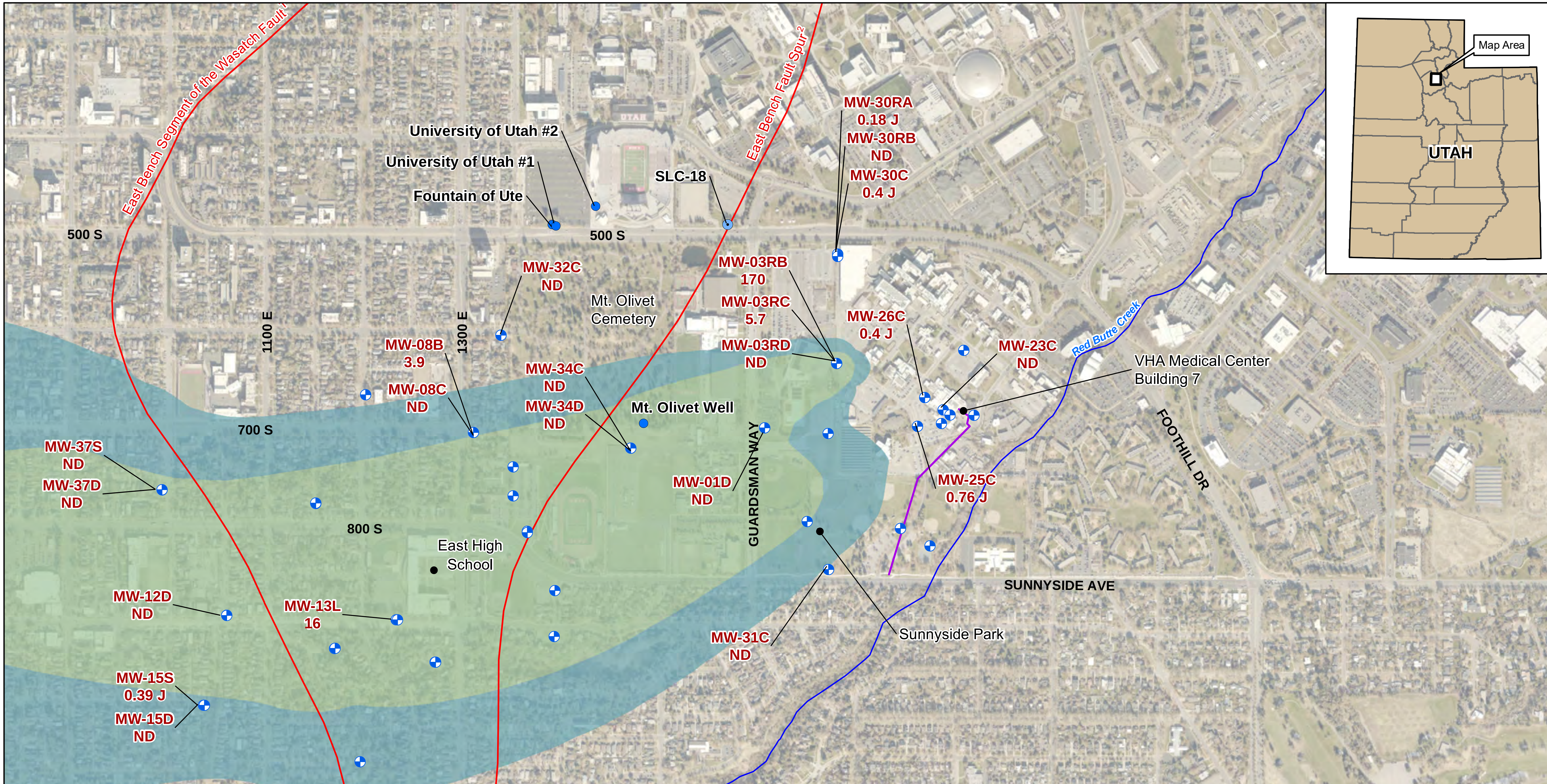
0 500 1,000 Feet

Figure 4-3
Simulated PCE Concentrations, September 2020
Continuous Shallow Aquifer Source Through 2015
Shallow Aquifer

CDM Smith

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Model_Report_Fig\Fig4-3_Shallow_Aquifer_Concentrations_Sept2020_T20.mxd HoughtonG 8/17/2021 7:46:51 AM



Legend

- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line

PCE (ug/L)

- < 1
- 1 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 200
- >200

Notes:
- Measured PCE concentrations are from December 2020.

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.
[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

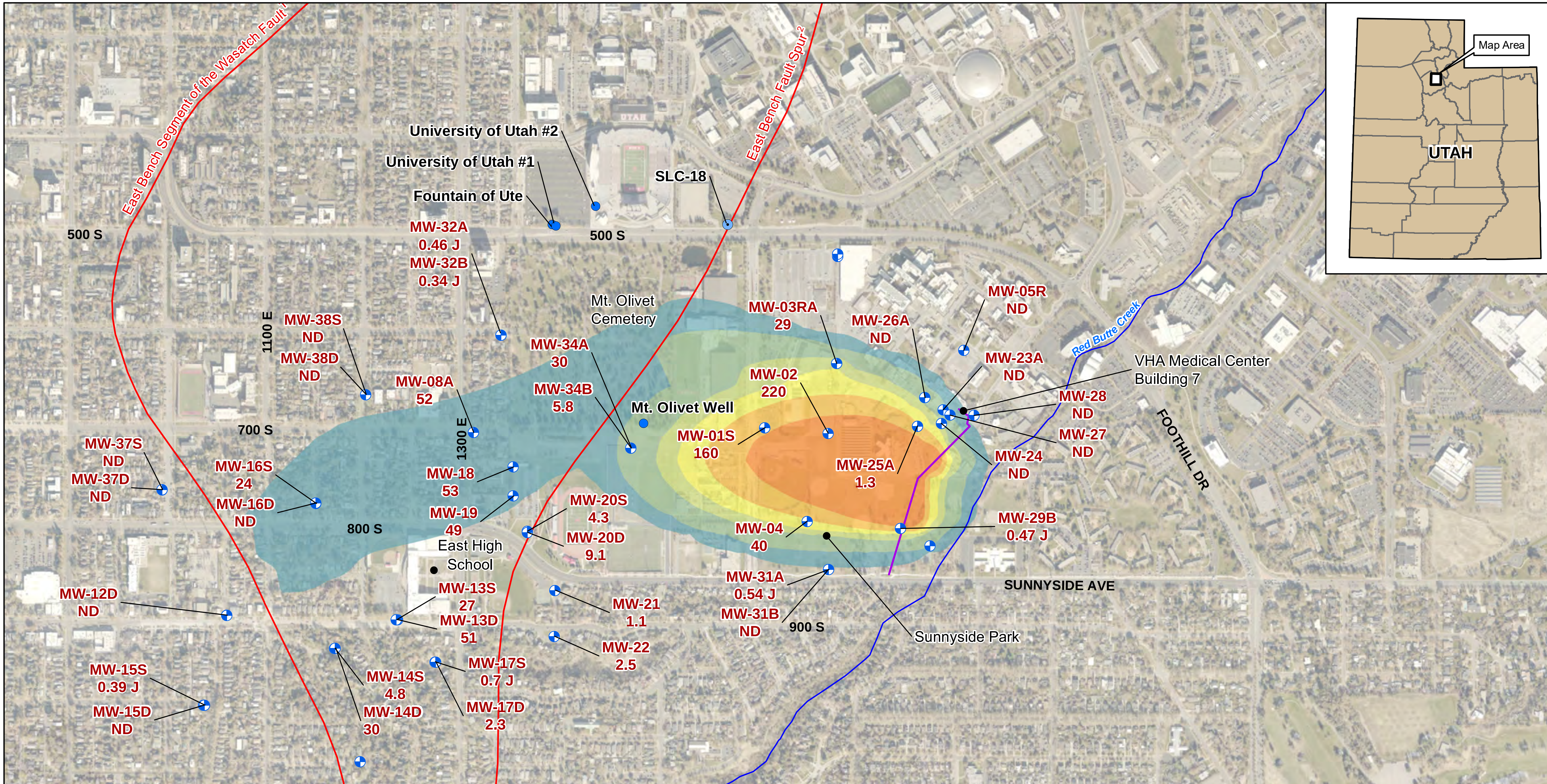
VHA = Veterans Health Administration

Figure 4-4
Simulated PCE Concentrations, September 2020
Continuous Shallow Aquifer Source Through 2015
Deep Aquifer

CDM Smith

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Model_Report_Fig\Fig4-4_Deep_Aquifer_Concentrations_Sept2020_R75T26.mxd HoughtonG 8/17/2021 9:21:24 AM



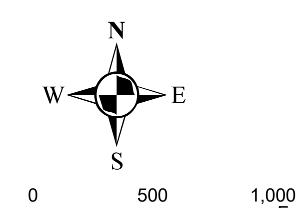
Legend
- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line

PCE (ug/L)
- < 1
- 1 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 200
- >200

Notes:
- Measured PCE concentrations are from December 2020.

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.
[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

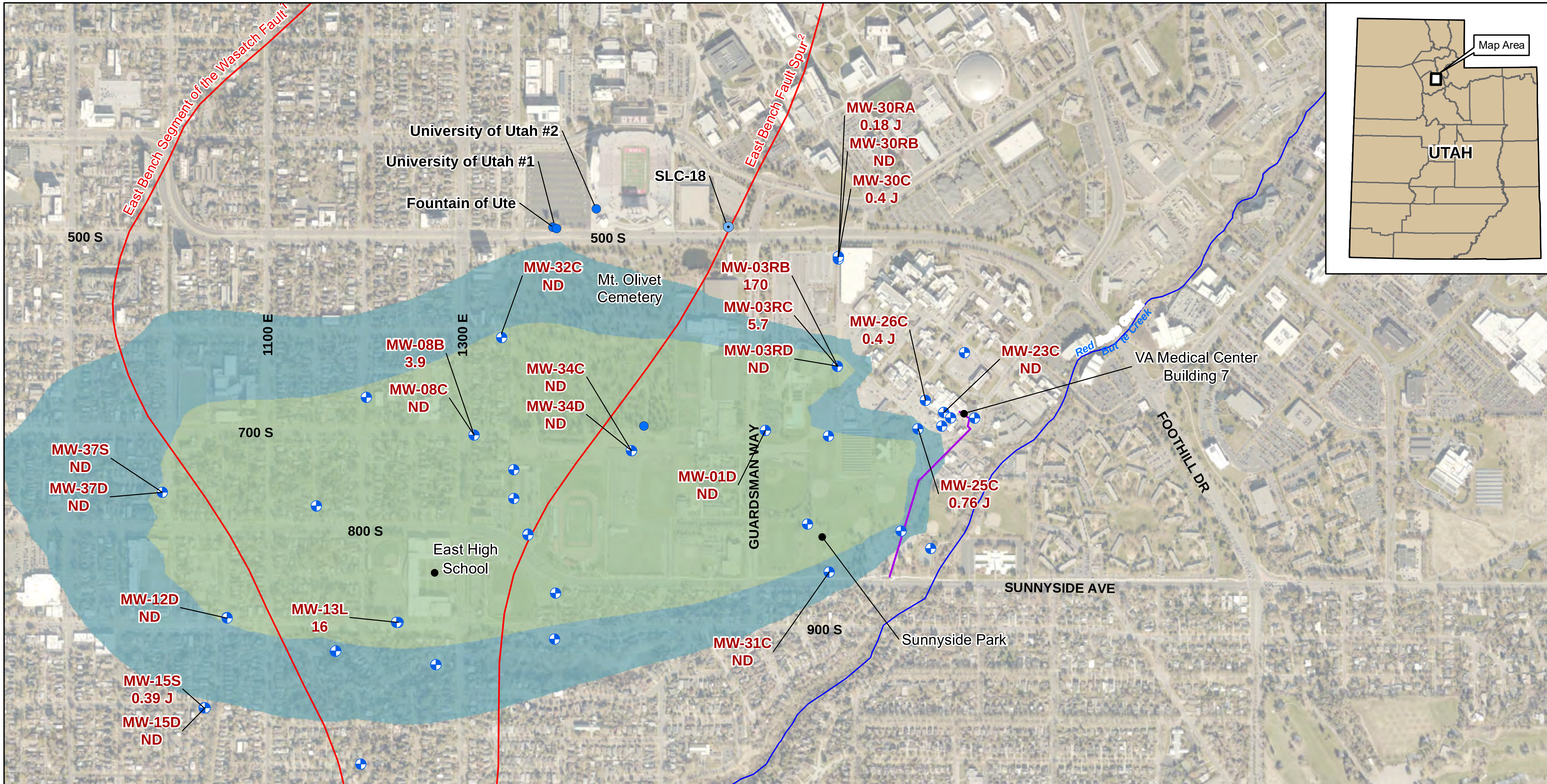


CDM Smith

Figure 4-5
Simulated PCE Concentrations, June 1990
Shallow Aquifer

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Model_Report_Fig\Fig4-5_Shallow_Aquifer_Concentrations_June1990_T14.mxd HoughtonG 7/19/2021 8:26:41 AM



Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line

PCE (ug/L)

- < 1
- 1 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 200
- >200

Notes:
- Measured PCE concentrations are from December 2020.

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.
[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

N S W E

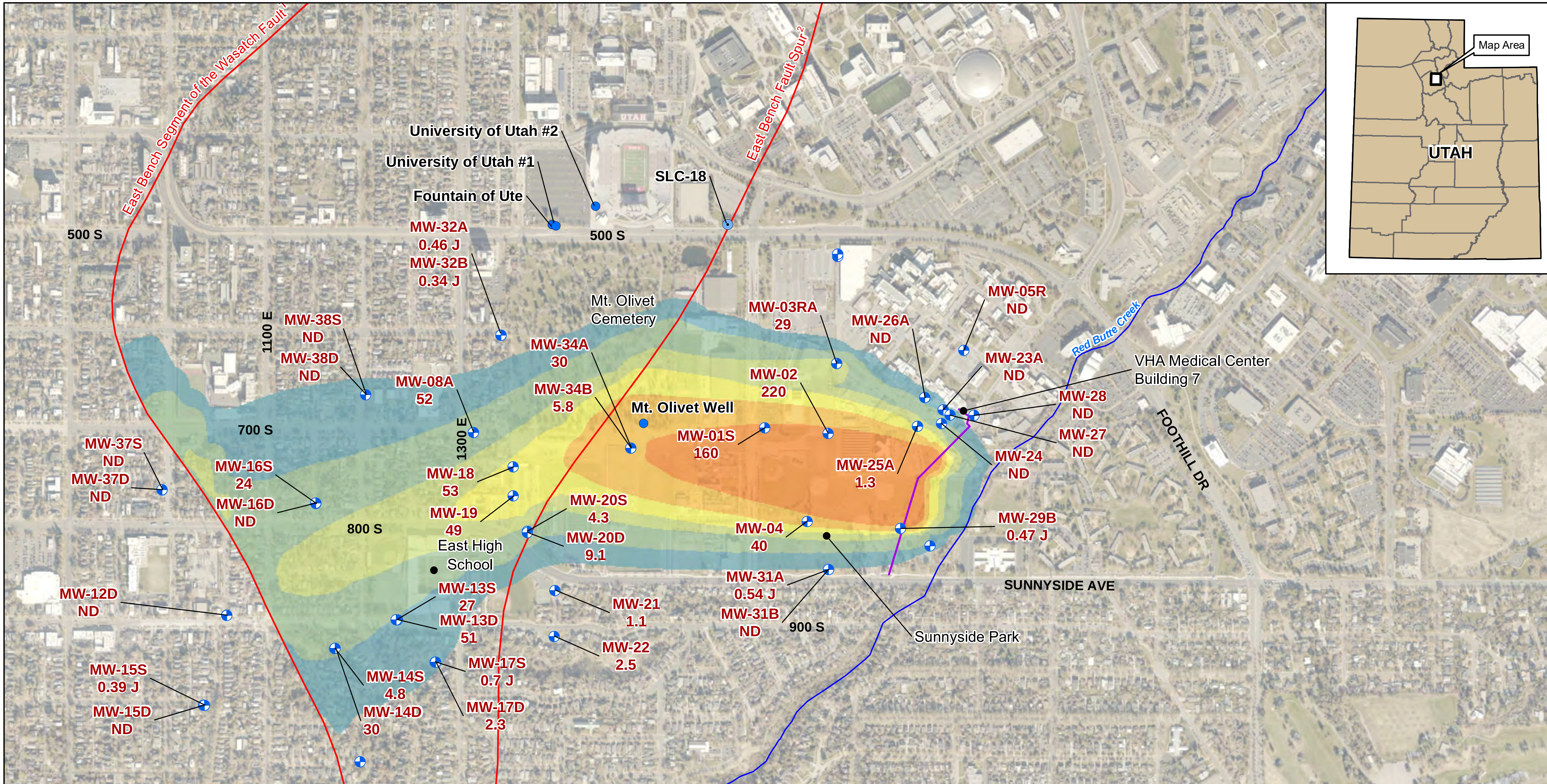
0 500 1,000 Feet

CDM Smith

Figure 4-6
Simulated PCE Concentrations, June 2004
Deep Aquifer

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Model_Report_Fig\Fig4-6_Deep_Aquifer_Concentrations_June2004_Run75T23.mxd HoughtonG 8/16/2021 8:38:36 PM



Notes:
- Measured PCE concentrations are from December 2020.

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.
[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

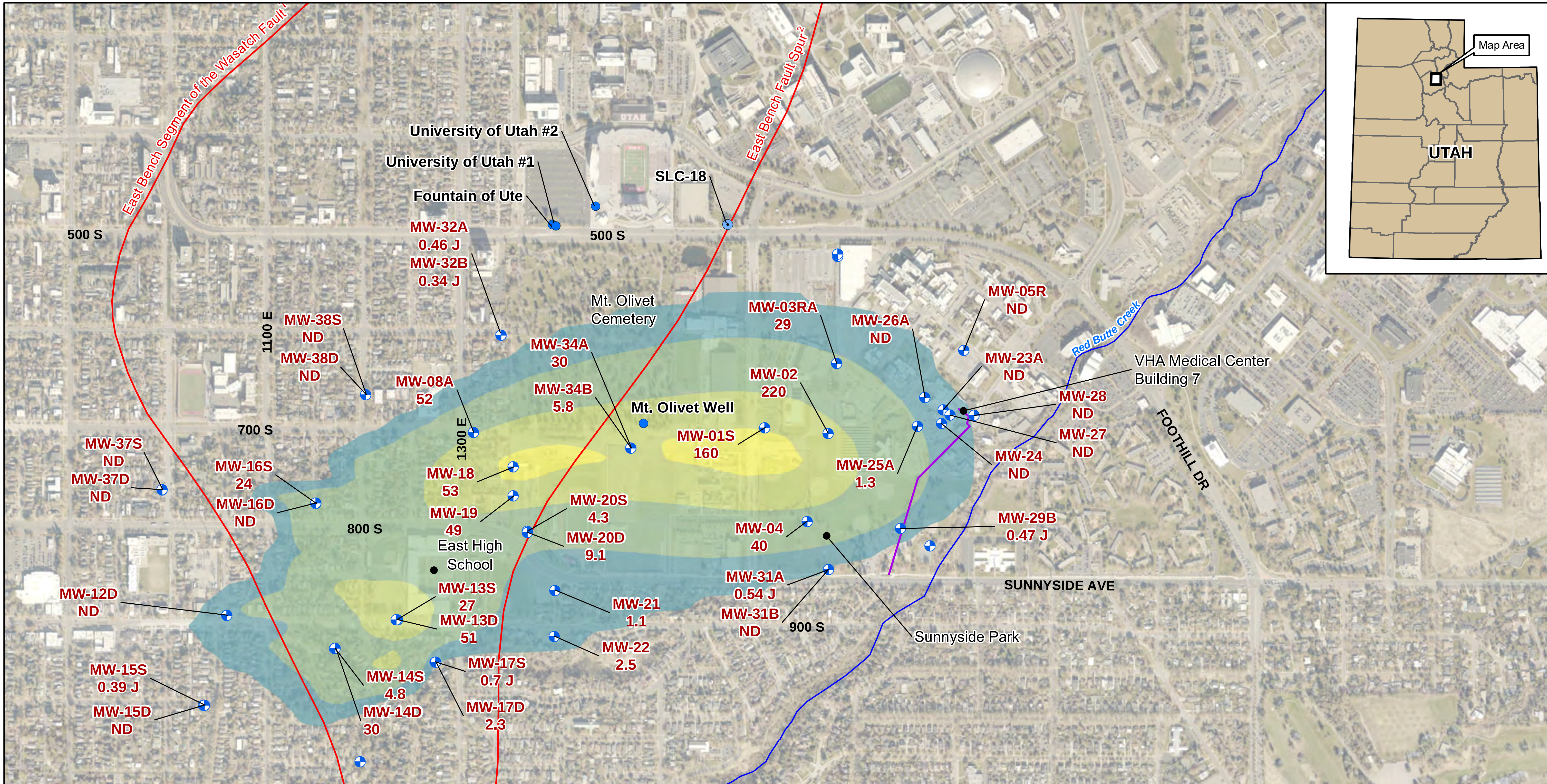
VHA = Veterans Health Administration

Figure 4-7
Simulated PCE Concentrations, June 2010
Shallow Aquifer

CDM Smith

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Model_Report_Fig\Fig4-7_Shallow_Aquifer_Concentrations_June2010_T14.mxd HoughtonG 7/19/2021 8:20:35 AM



Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line

PCE (ug/L)

- < 1
- 1 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 200
- >200

Notes:
- Measured PCE concentrations are from December 2020.

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.
[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

N E S W

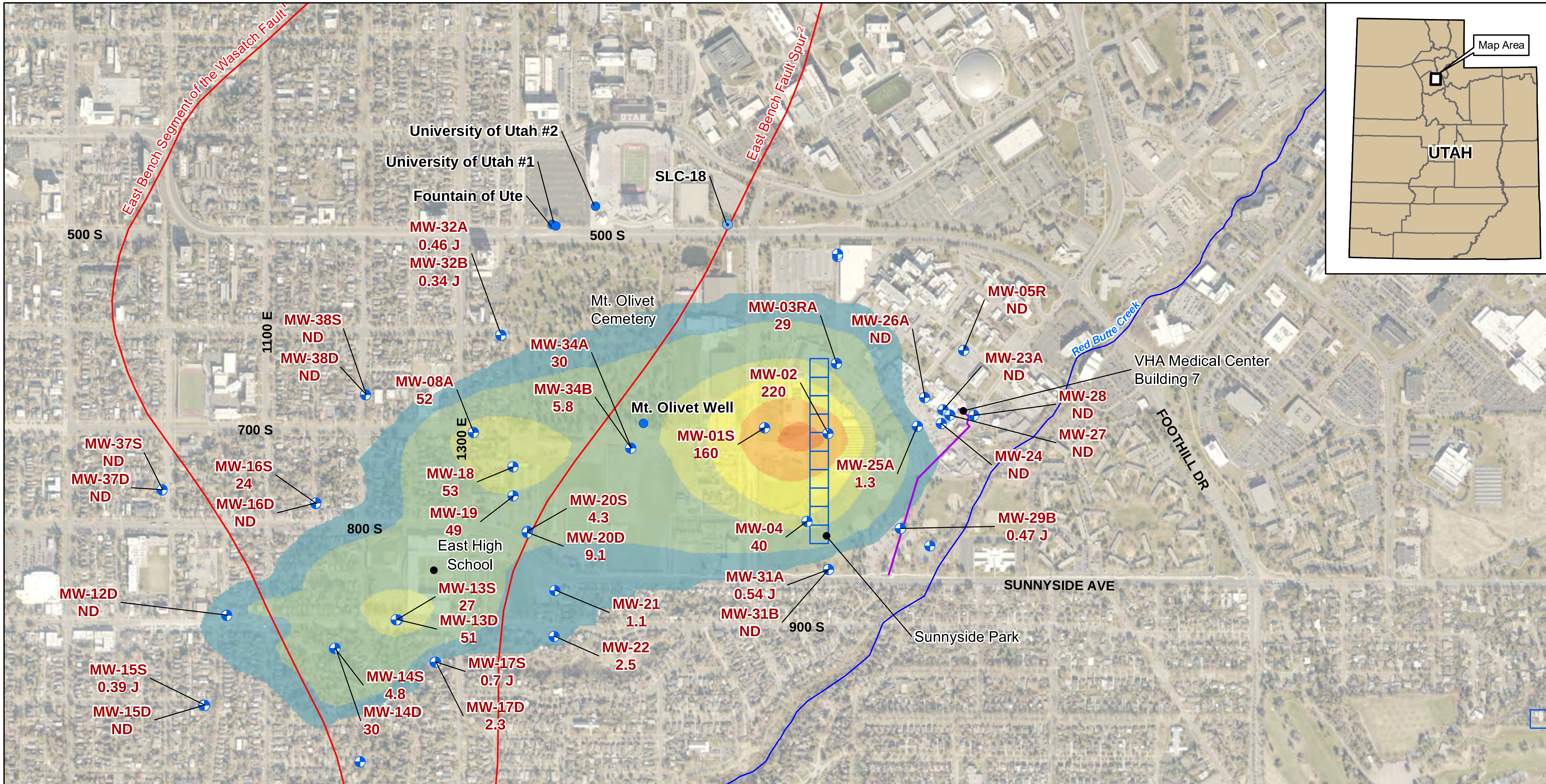
0 500 1,000 Feet

CDM Smith

Figure 4-8
Starting PCE Concentrations
Shallow Aquifer, Model Layer 1

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Model_Report_Fig\Fig4-8_Starting_Concentrations_Layer1.mxd HoughtonG 8/18/2021 2:37:55 PM



Legend

Symbol		PCE (ug/L)
Monitoring Well		< 1
Abandoned Monitoring Well		1 - 5
Drinking Water Supply Well		5 - 25
Irrigation Well		25 - 50
Landmark		50 - 100
Red Butte Creek		100 - 200
Fault Line		>200
Sewer Line		
Decaying Source Location		

Notes:
- Measured PCE concentrations are from December 2020.

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.
[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

N E S W

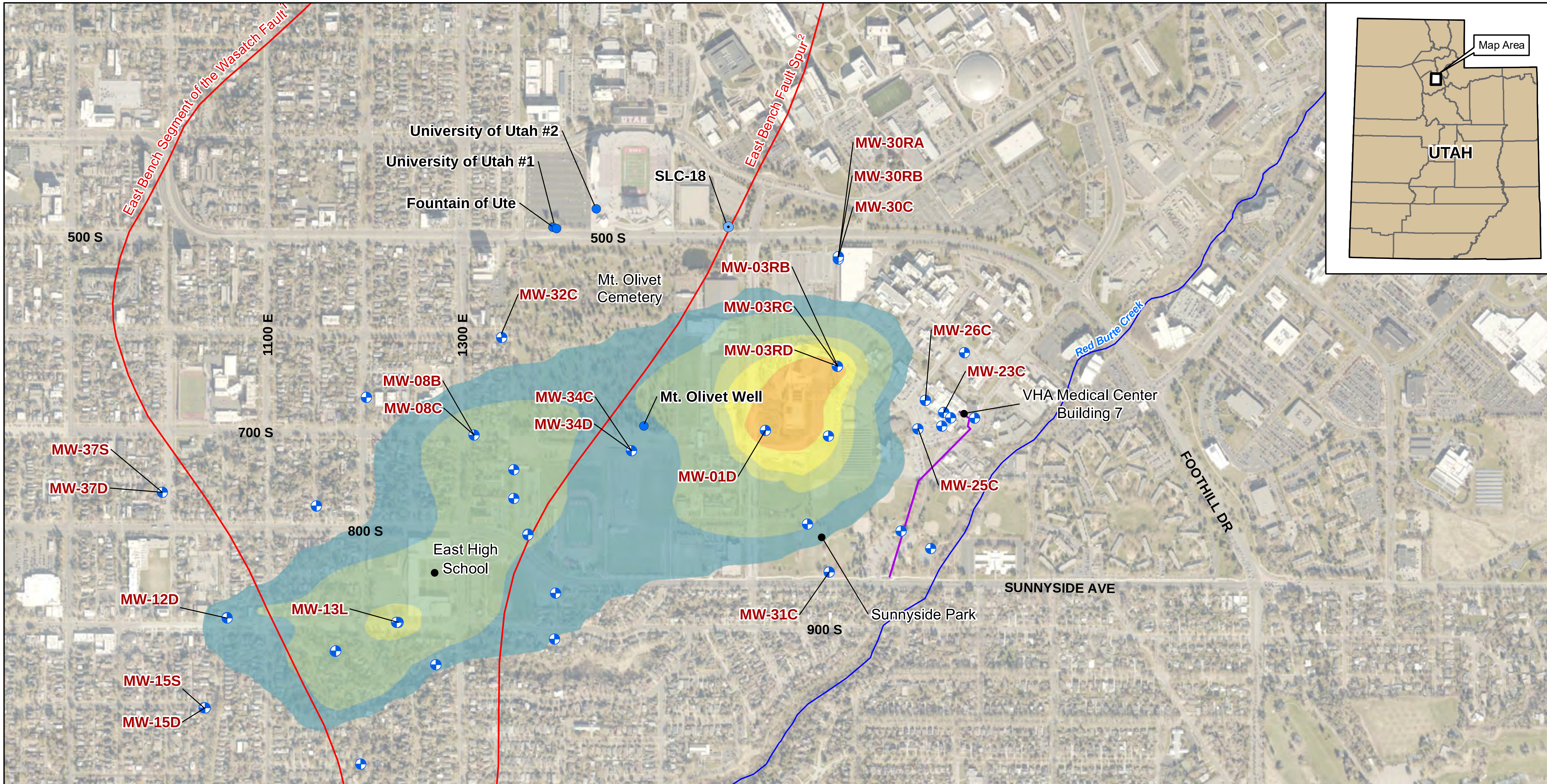
0 500 1,000 Feet

Figure 4-9
Starting PCE Concentrations
Shallow Aquifer, Model Layer 2

CDM Smith

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Model_Report_Fig\Fig4-9_Starting_Concentrations_Layer2.mxd HoughtonG 8/18/2021 2:39:50 PM



Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line

PCE (ug/L)
< 1
1 - 5
5 - 25
25 - 50
50 - 100
100 - 200
>200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.

[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

N W E S

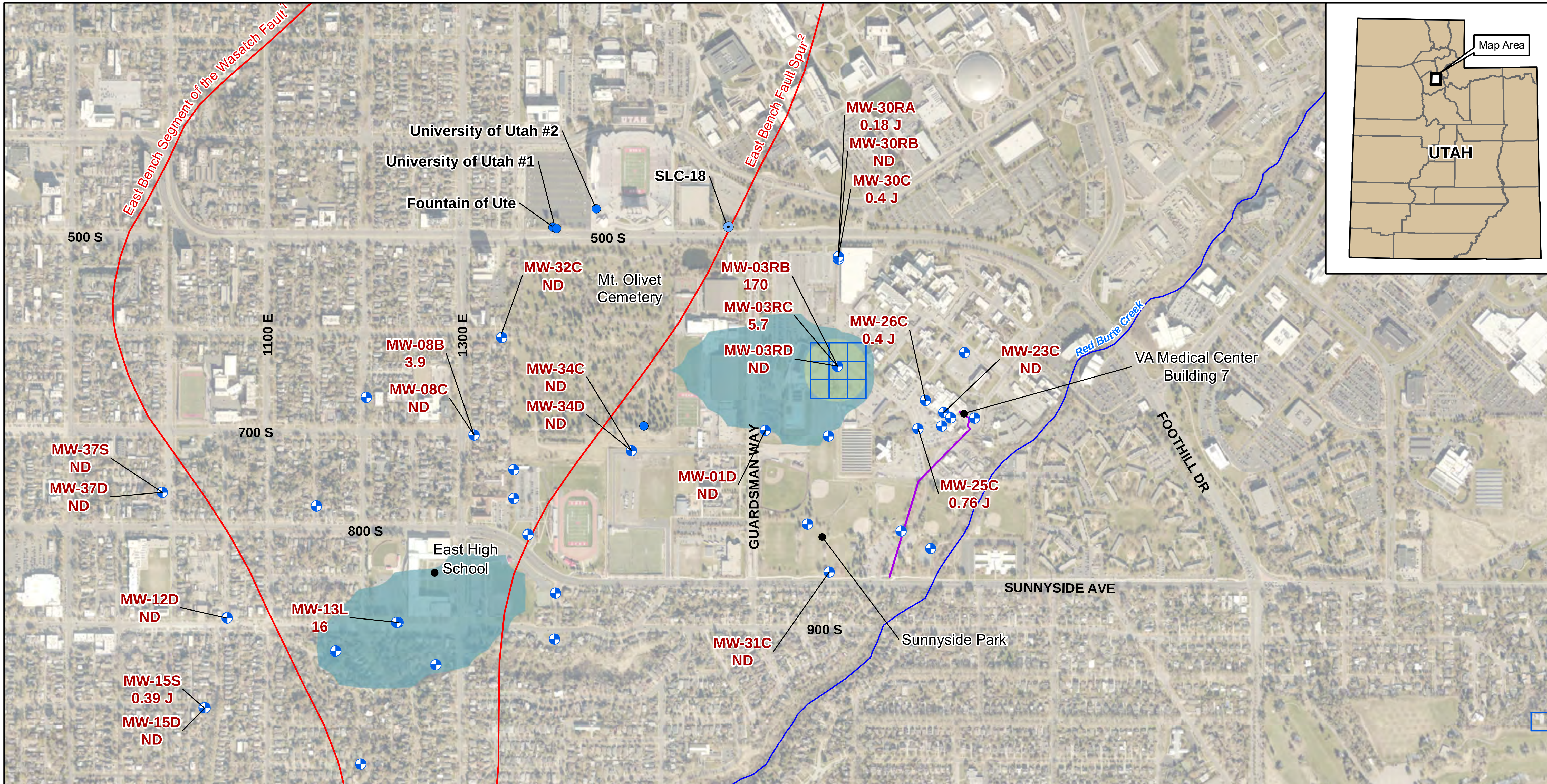
0 500 1,000 Feet

Figure 4-10
Starting PCE Concentrations
Aquitard, Model Layer 3

CDM Smith

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Model_Report_Fig\Fig4-10_Starting_Concentrations_Layer3.mxd HoughtonG 8/18/2021 2:36:55 PM



Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Decaying Source Location

PCE (ug/L)

- < 1
- 1 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 200
- >200

Notes:
- Measured PCE concentrations are from December 2020.

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.
[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

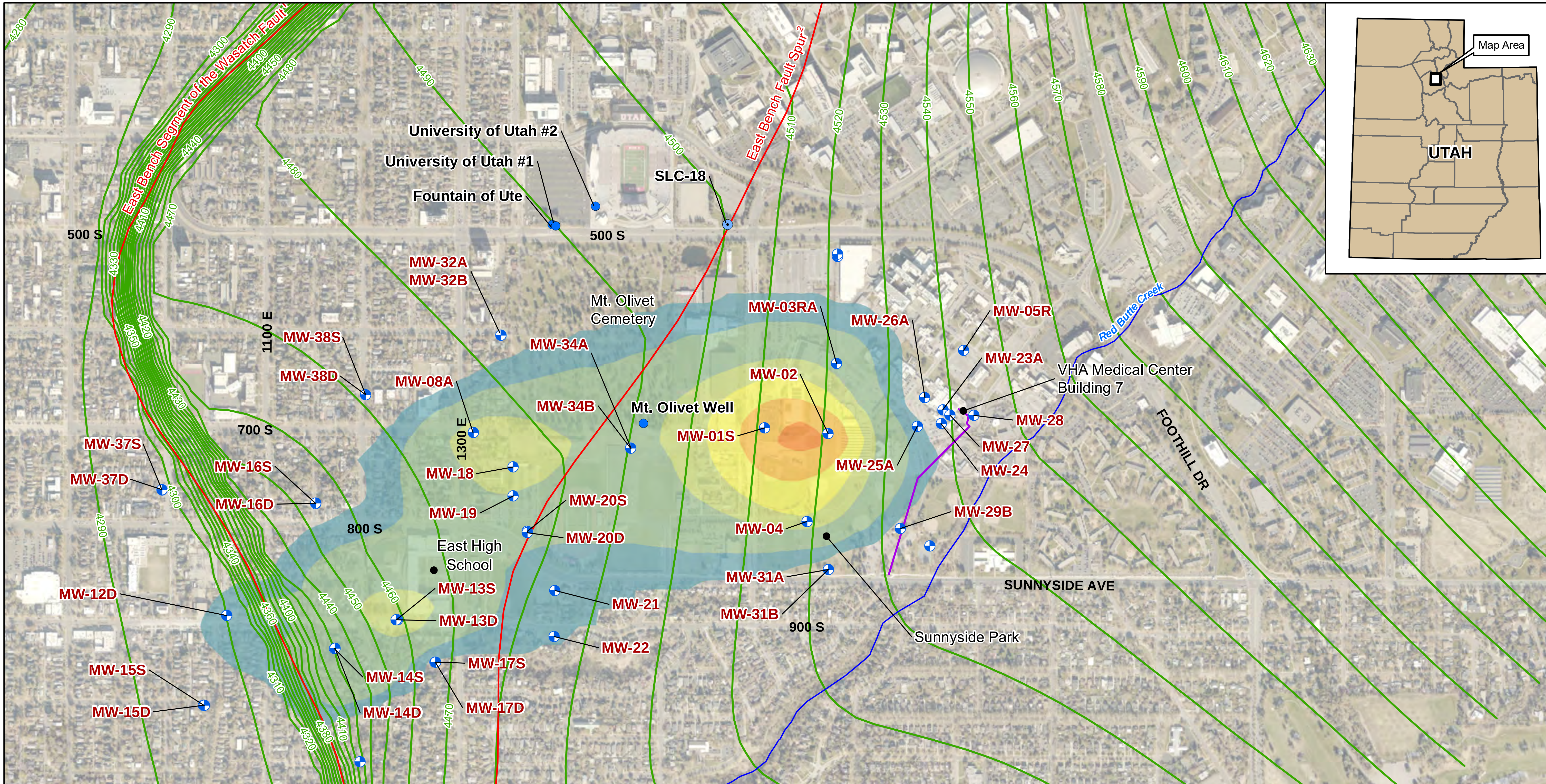
N
W E
S

0 500 1,000 Feet

Figure 4-11
Starting PCE Concentrations
Deep Aquifer, Model Layer 4

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Model_Report_Fig\Fig4-11_Starting_Concentrations_Layer4.mxd HoughtonG 8/18/2021 2:33:15 PM



Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)
< 1
1 - 5
5 - 25
25 - 50
50 - 100
100 - 200
>200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.

[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

N W E S

0 500 1,000 Feet

Figure 4-12a

Future Conditions - Initial PCE Concentrations

Shallow Aquifer

Baseline: Average Conditions for Last Ten Years

CDM Smith

OU1 700 South 1600 East PCE Plume

Salt Lake City, Utah

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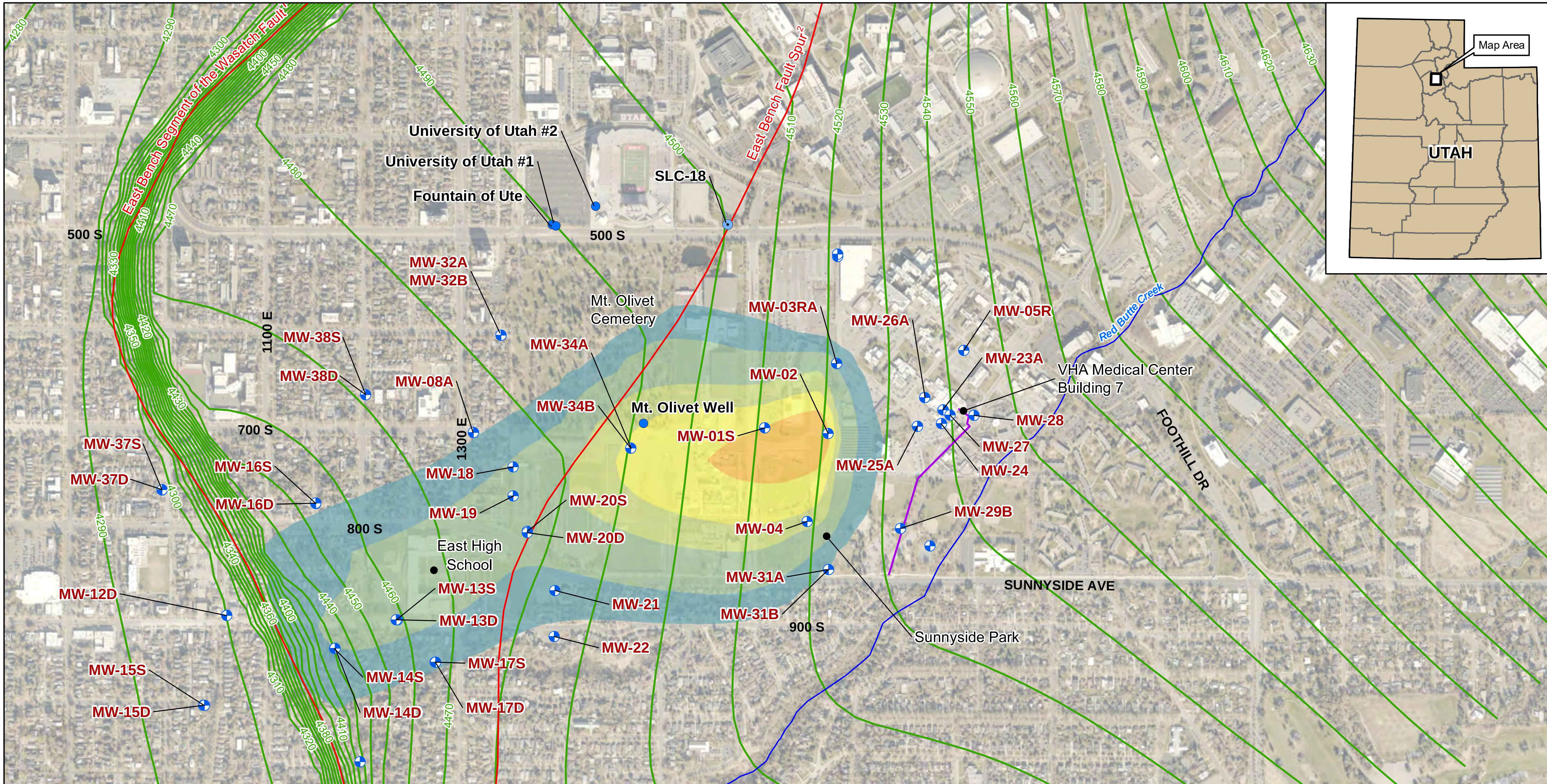


Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)

- < 1
- 1 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 200
- >200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.

[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

N S E W

0 500 1,000 Feet

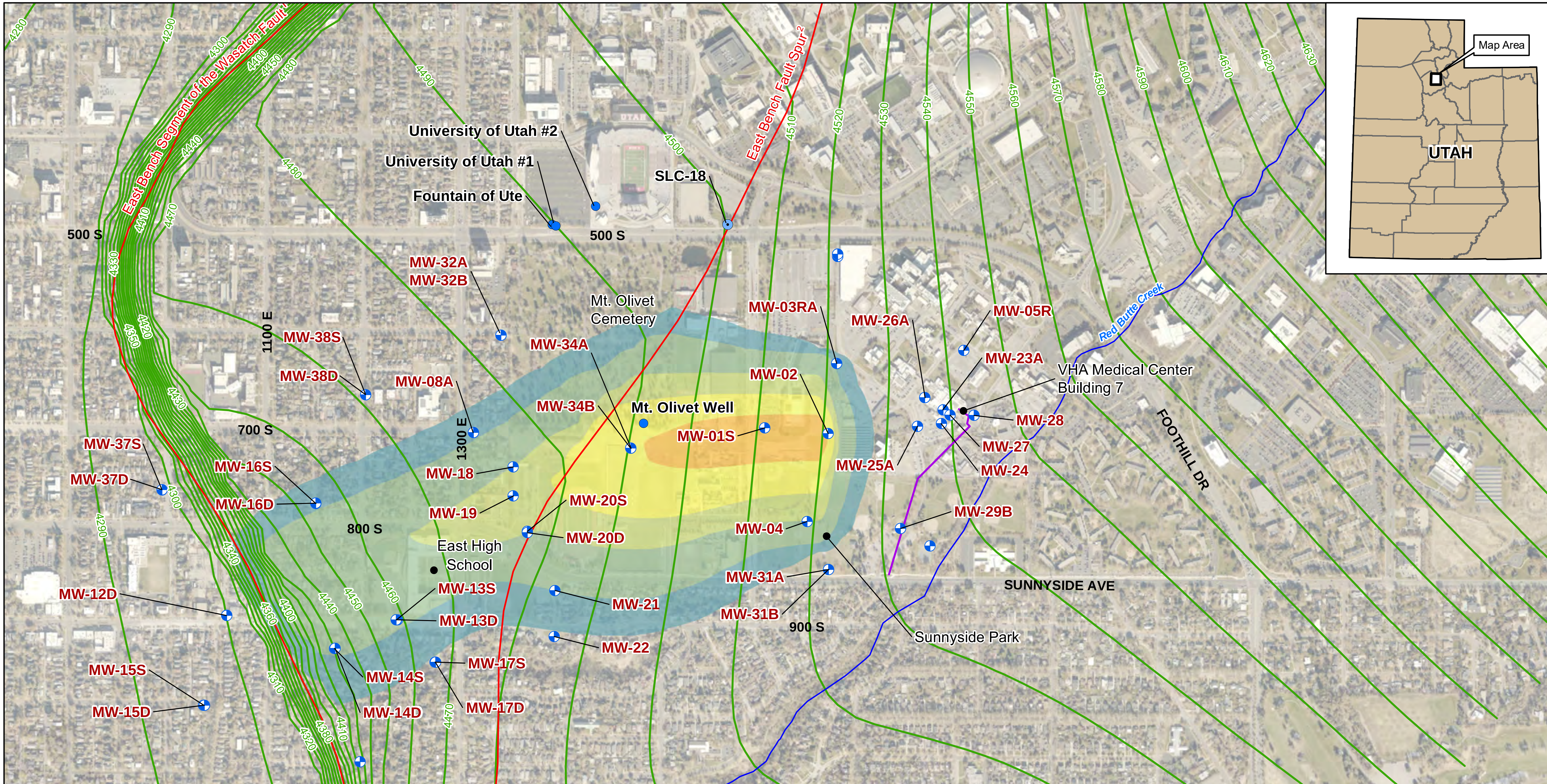
Figure 4-12b

Future Conditions - Simulated 5 Year PCE Concentrations
Shallow Aquifer
Baseline: Average Conditions for Last Ten Years

CDM Smith

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Future_Simulation_Base_Conditions\Shallow_Aquifer_Concentrations_Future1_5yr.mxd HoughtonG 8/17/2021 9:57:48 AM



Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)

- < 1
- 1 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 200
- >200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.

[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

N
W E
S

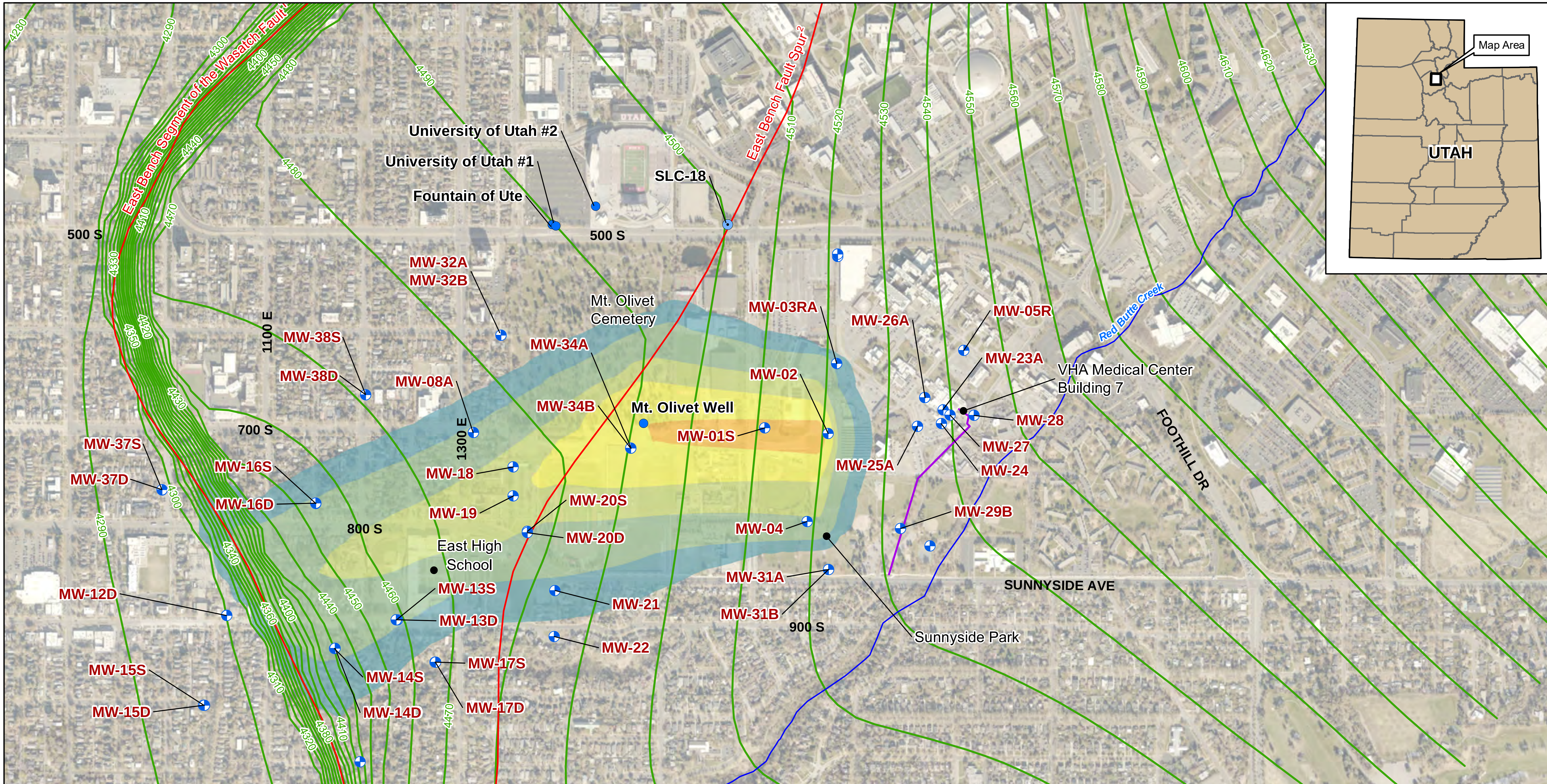
0 500 1,000 Feet

CDM Smith

Figure 4-12c
Future Conditions - Simulated 10 Year PCE Concentrations
Shallow Aquifer
Baseline: Average Conditions for Last Ten Years

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Future_Simulation_Base_Conditions\Shallow_Aquifer_Concentrations_Future1_10yr.mxd HoughtonG 8/17/2021 9:58:06 AM



Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)

- < 1
- 1 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 200
- >200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.

[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

N E S W

0 500 1,000 Feet

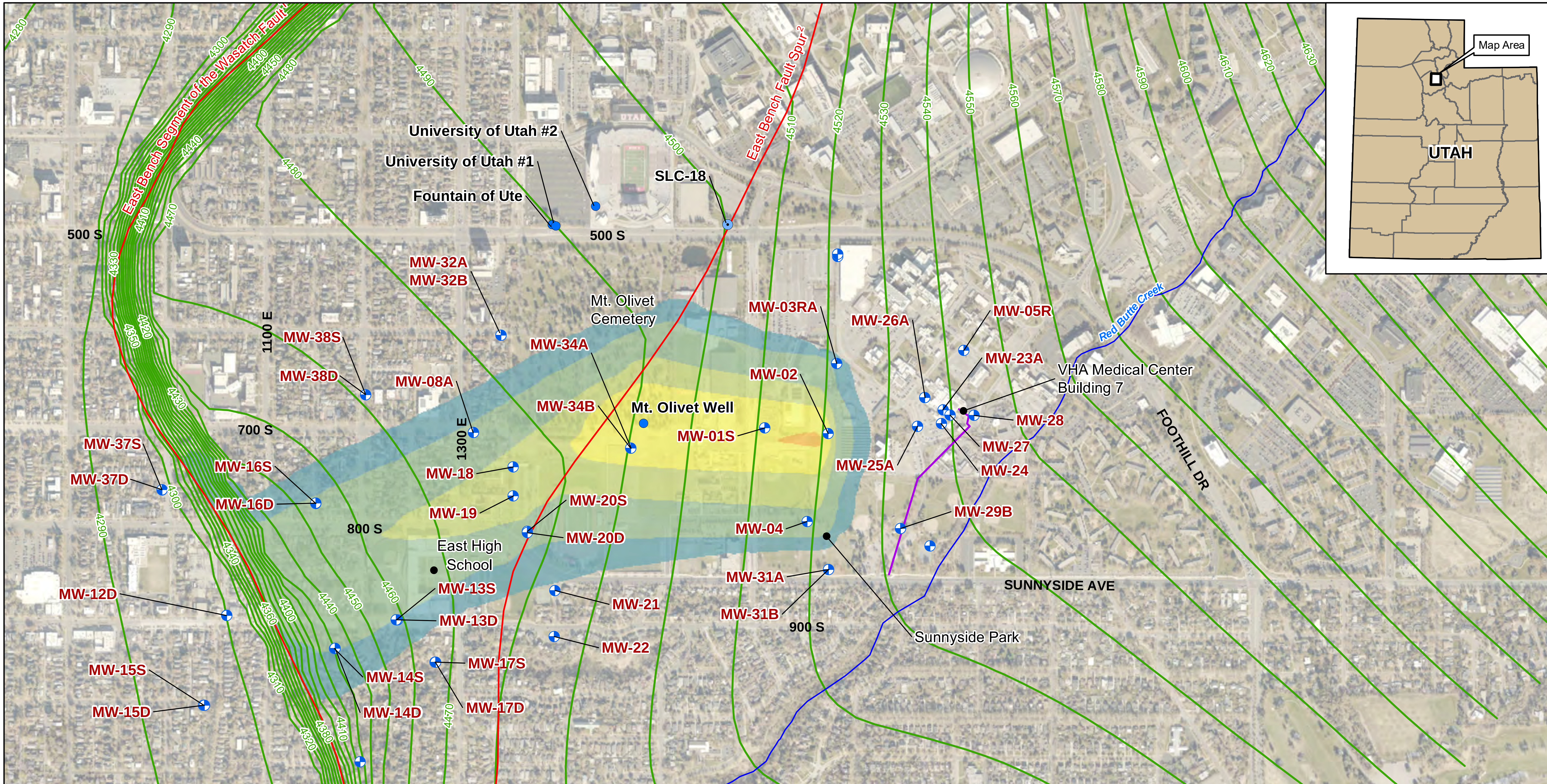
Figure 4-12d

Future Conditions - Simulated 15 Year PCE Concentrations
Shallow Aquifer
Baseline: Average Conditions for Last Ten Years

CDM Smith

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Future_Simulation_Base_Conditions\Shallow_Aquifer_Concentrations_Future1_15yr.mxd HoughtonG 8/17/2021 9:54:55 AM



Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)
< 1
1 - 5
5 - 25
25 - 50
50 - 100
100 - 200
>200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.

[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

N W E S

0 500 1,000 Feet

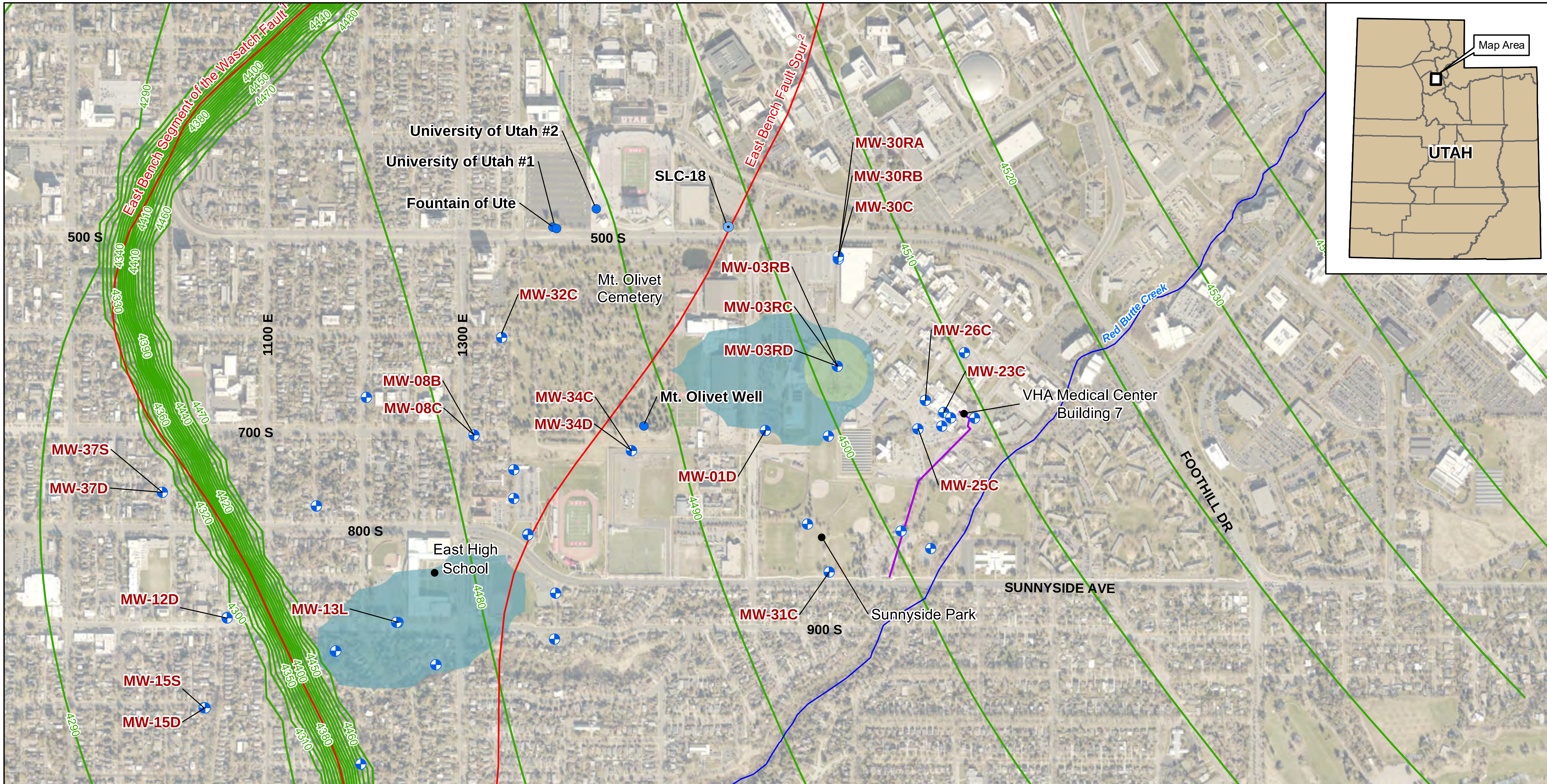
CDM Smith

Figure 4-12e

Future Conditions - Simulated 20 Year PCE Concentrations
Shallow Aquifer
Baseline: Average Conditions for Last Ten Years

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Future_Simulation_Base_Conditions\Shallow_Aquifer_ConcentrationsT4_Future1_20yr.mxd HoughtonG 8/18/2021 1:25:51 PM



Legend
- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)
- < 1
- 1 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 200
- >200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.
[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

0 500 1,000 Feet

N S E W

Figure 4-13a
Future Conditions - Initial PCE Concentrations
Deep Aquifer
Baseline: Average Conditions for Last Ten Years

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Future_Simulation_Base_Conditions\Deep_Aquifer_ConcentrationsT4_Future1_Initial.mxd HoughtonG 8/18/2021 2:46:36 PM

Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)

- < 1
- 1 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 200
- >200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.
[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

N
W E
S

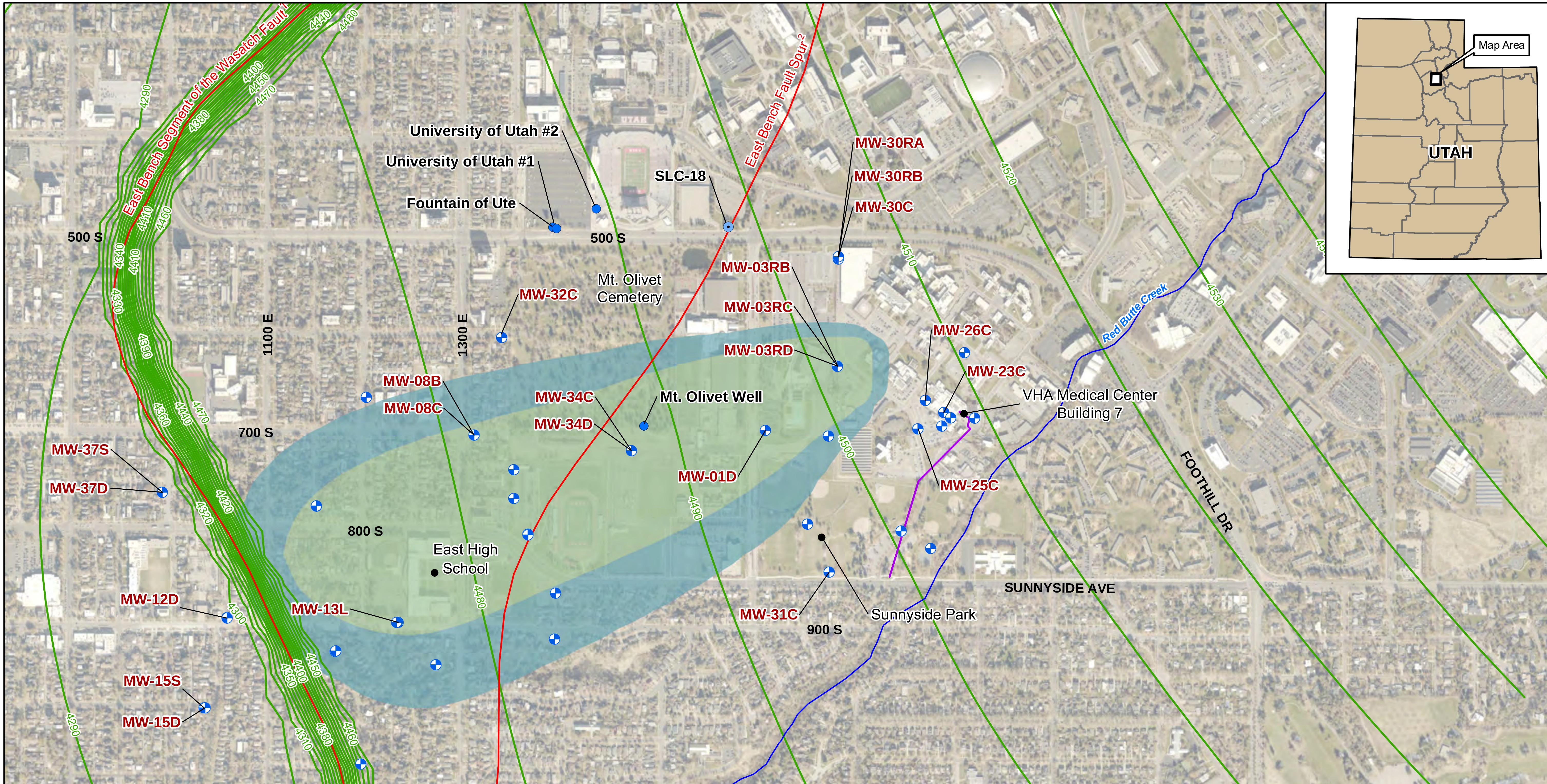
0 500 1,000
Feet

CDM Smith

Figure 4-13b
Future Conditions - Simulated 5 Year PCE Concentrations
Deep Aquifer
Baseline: Average Conditions for Last Ten Years

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Future_Simulation_Base_Conditions\Deep_Aquifer_ConcentrationsT4_Future1_5yr.mxd HoughtonG 8/17/2021 9:03:02 AM



Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)

- < 1
- 1 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 200
- >200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.

[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

Figure 4-13c
Future Conditions - Simulated 10 Year PCE Concentrations
Deep Aquifer
Baseline: Average Conditions for Last Ten Years

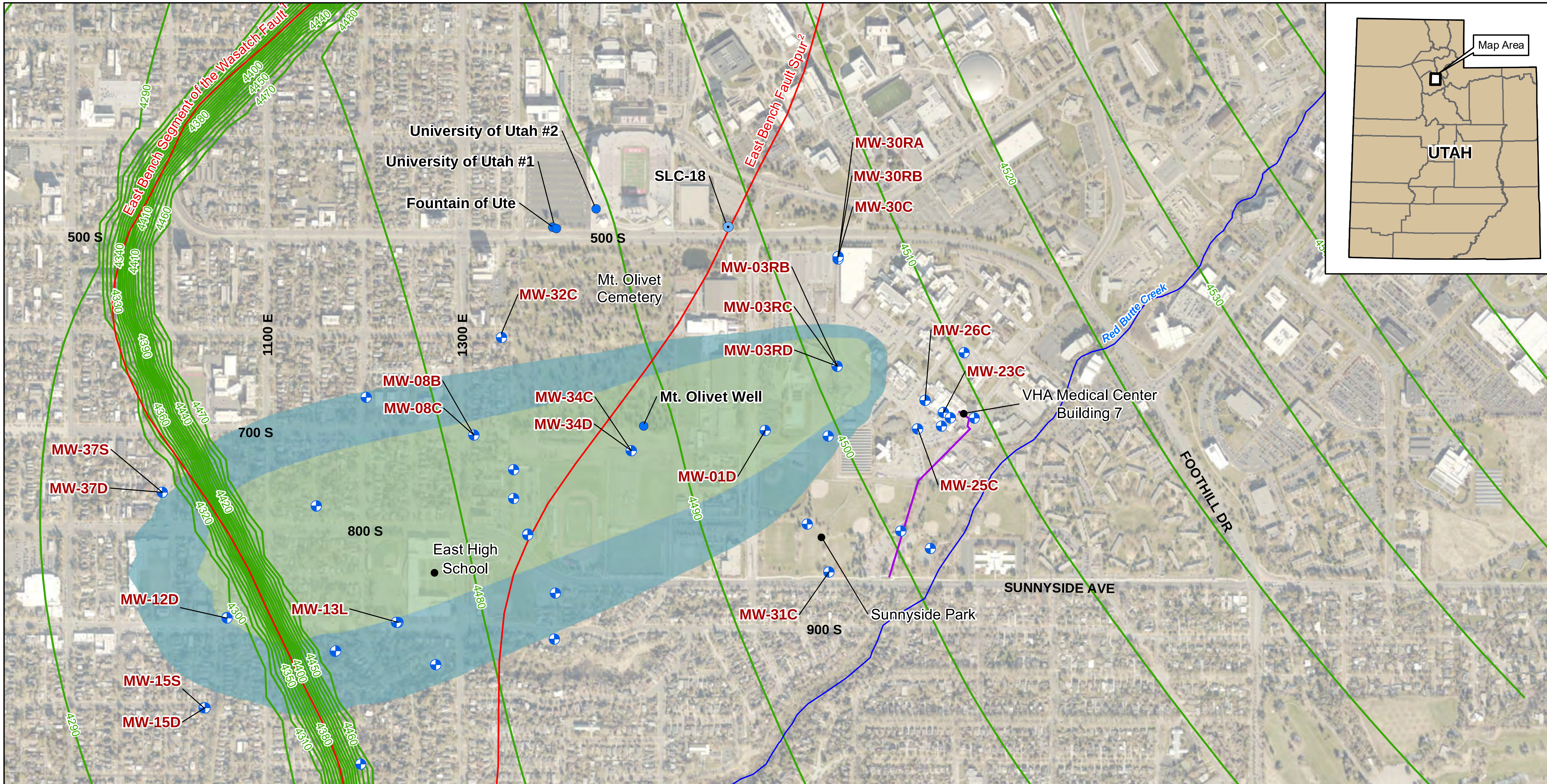
N W E S

0 500 1,000 Feet

CDM Smith

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Future_Simulation_Base_Conditions\Deep_Aquifer_ConcentrationsT4_Future1_10yr.mxd HoughtonG 8/17/2021 9:03:26 AM



Legend

Monitoring Well		PCE (ug/L)	
Abandoned Monitoring Well			< 1
Drinking Water Supply Well			1 - 5
Irrigation Well			5 - 25
Landmark			25 - 50
Red Butte Creek			50 - 100
Fault Line			100 - 200
Sewer Line			>200
Head Contour (10-ft)			

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.
[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

Figure 4-13d
Future Conditions - Simulated 15 Year PCE Concentrations
Deep Aquifer
Baseline: Average Conditions for Last Ten Years

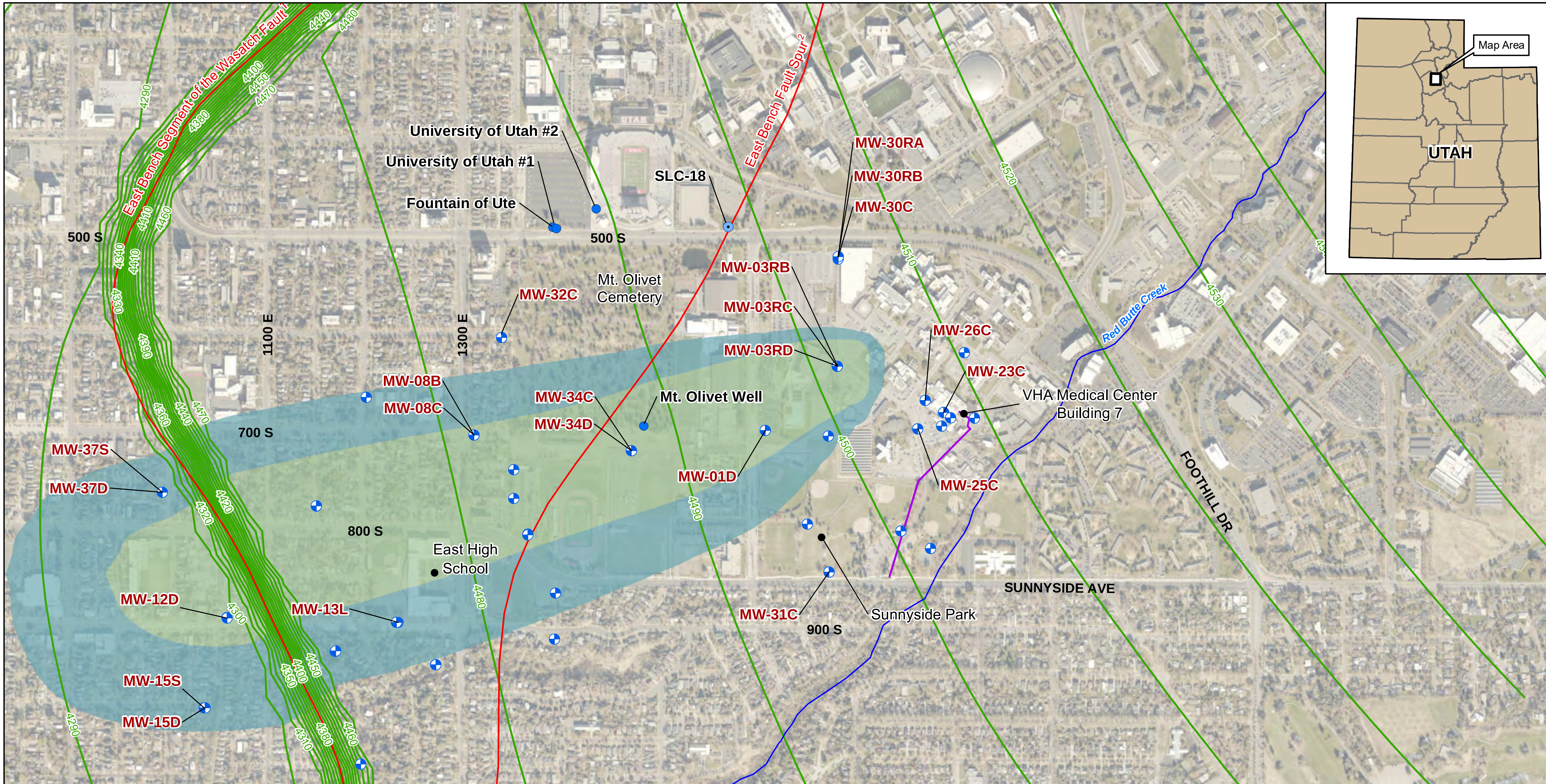
N W E S

0 500 1,000 Feet

CDM Smith

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Future_Simulation_Base_Conditions\Deep_Aquifer_ConcentrationsT4_Future1_15yr.mxd HoughtonG 8/17/2021 9:03:52 AM



Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)
< 1
1 - 5
5 - 25
25 - 50
50 - 100
100 - 200
>200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.
[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

Figure 4-13e
Future Conditions - Simulated 20 Year PCE Concentrations
Deep Aquifer
Baseline: Average Conditions for Last Ten Years

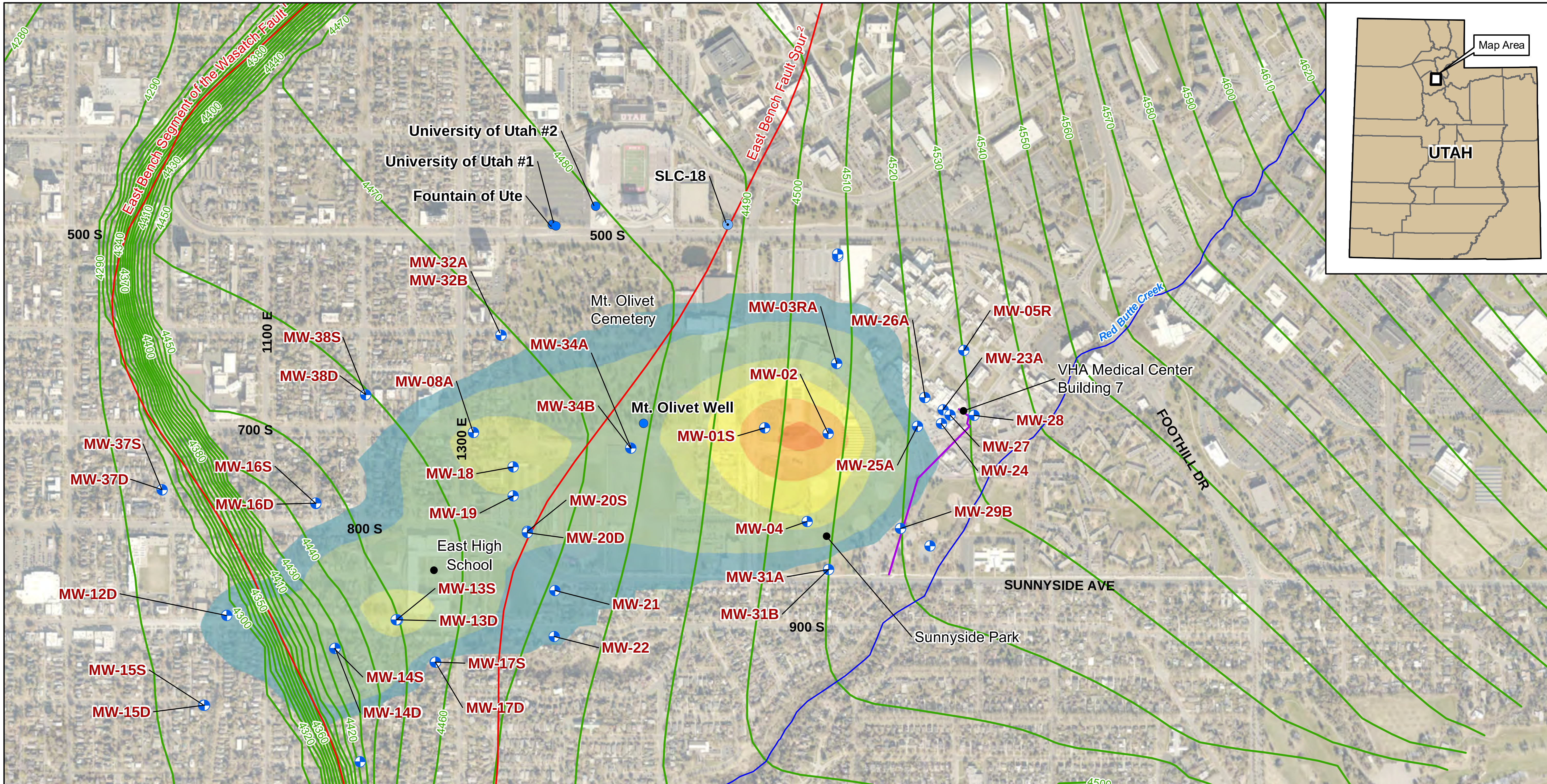
N E S W

0 500 1,000 Feet

CDM Smith

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Future_Simulation_Base_Conditions\Deep_Aquifer_ConcentrationsT4_Future1_20yr.mxd HoughtonG 8/17/2021 9:04:09 AM



Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)

- < 1
- 1 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 200
- >200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.

[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

N S W E

0 500 1,000 Feet

CDM Smith

Figure 4-14a

Future Conditions - Initial PCE Concentrations

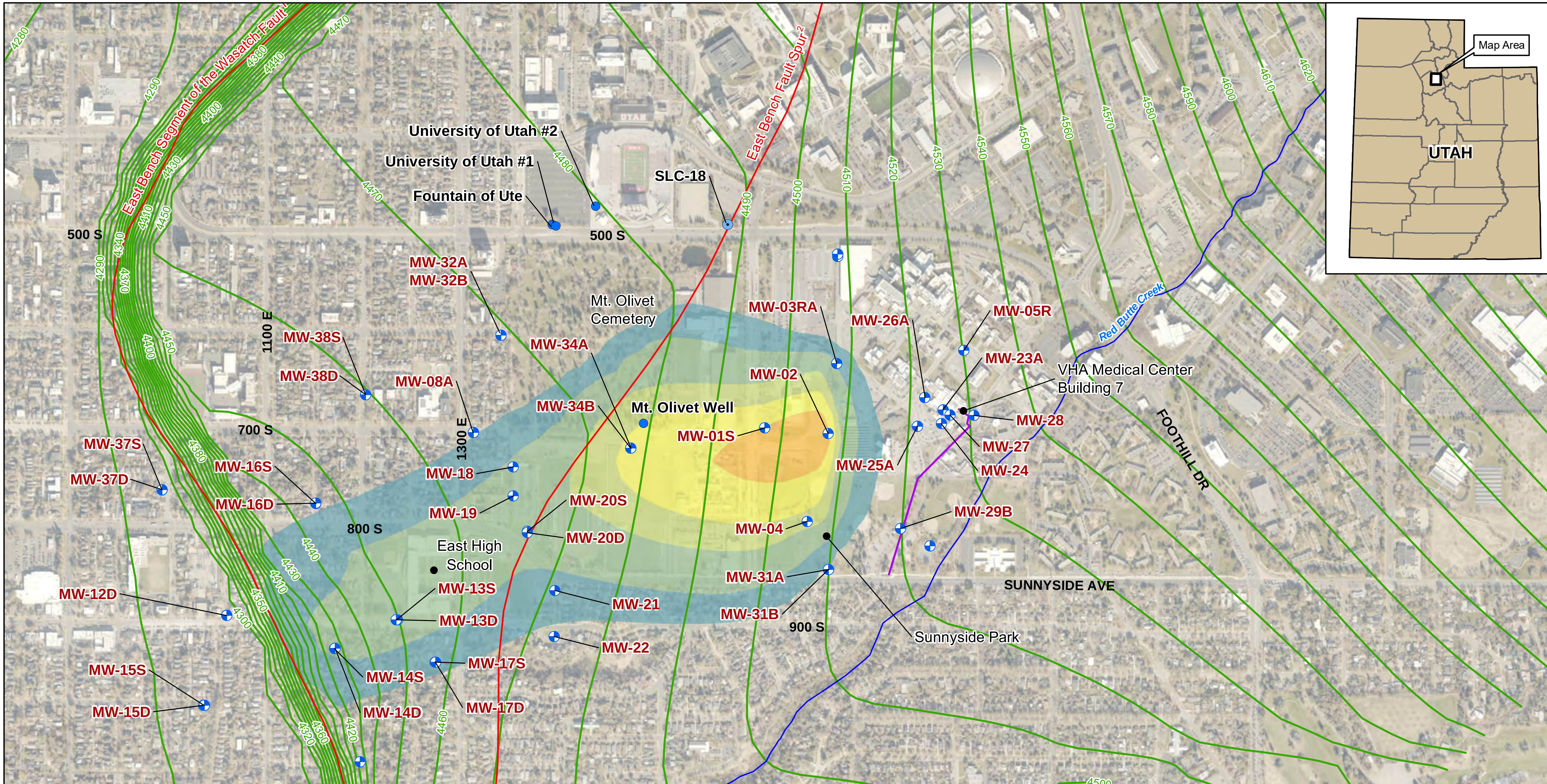
Shallow Aquifer

Scenario 1: Historic SLC-18 Pumping

OU1 700 South 1600 East PCE Plume

Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Future_Simulation_Base_Conditions\Shallow_Aquifer_ConcentrationsT4_Future2_Initial.mxd HoughtonG 8/17/2021 10:31:26 AM



Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)
< 1
1 - 5
5 - 25
25 - 50
50 - 100
100 - 200
>200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.

[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

N
W E
S

0 500 1,000 Feet

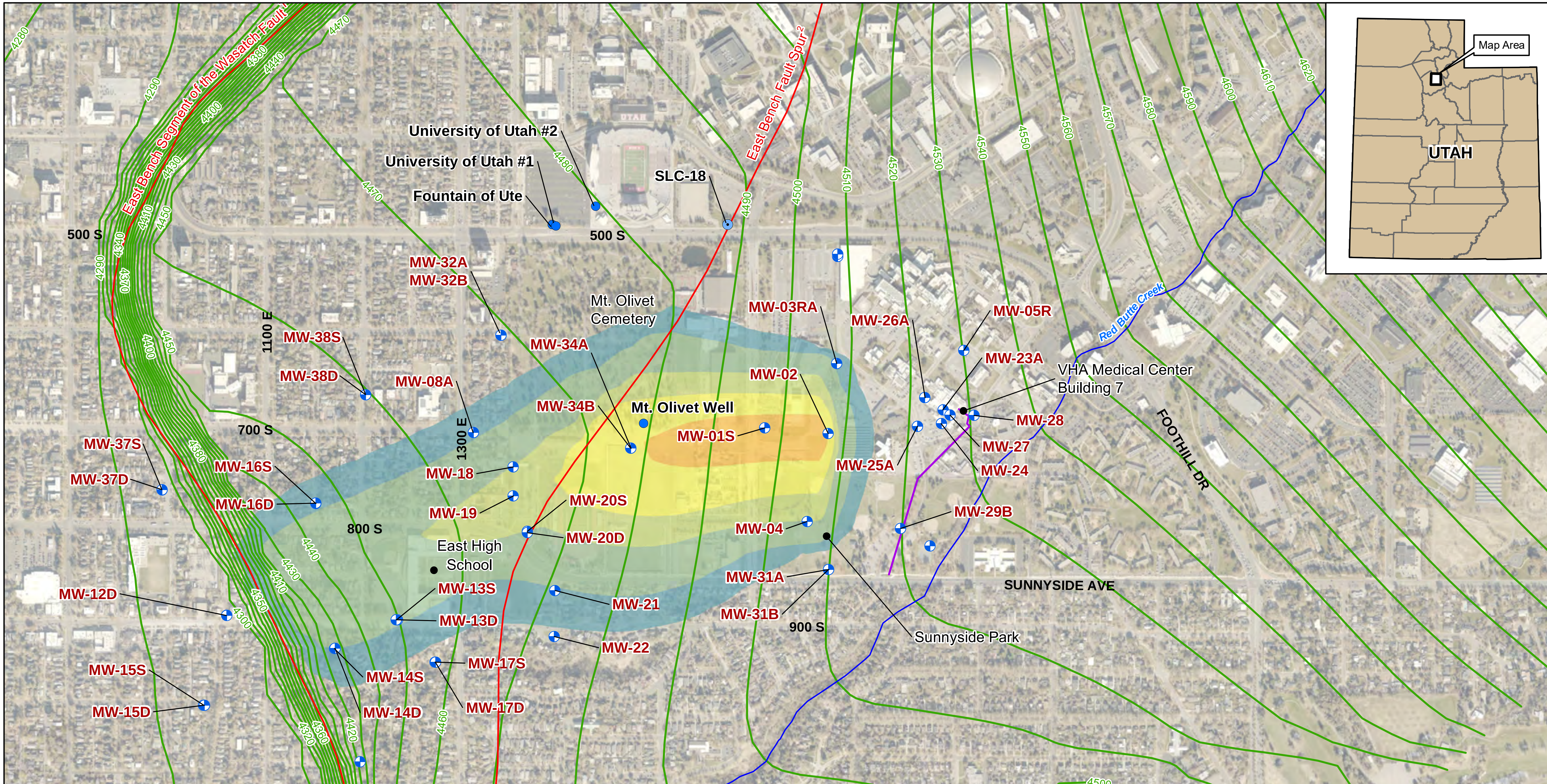
CDM Smith

Figure 4-14b

Future Conditions - Simulated 5 Year PCE Concentrations
Shallow Aquifer
Scenario 1: Historic SLC-18 Pumping

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Future_Simulation_Base_Conditions\Shallow_Aquifer_ConcentrationsT4_Future2_5yr.mxd HoughtonG 8/17/2021 10:34:52 AM



Legend

Symbol	PCE (ug/L)
Monitoring Well	< 1
Abandoned Monitoring Well	1 - 5
Drinking Water Supply Well	5 - 25
Irrigation Well	25 - 50
Landmark	50 - 100
Red Butte Creek	100 - 200
Fault Line	>200
Sewer Line	
Head Contour (10-ft)	

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.
[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

N W E S

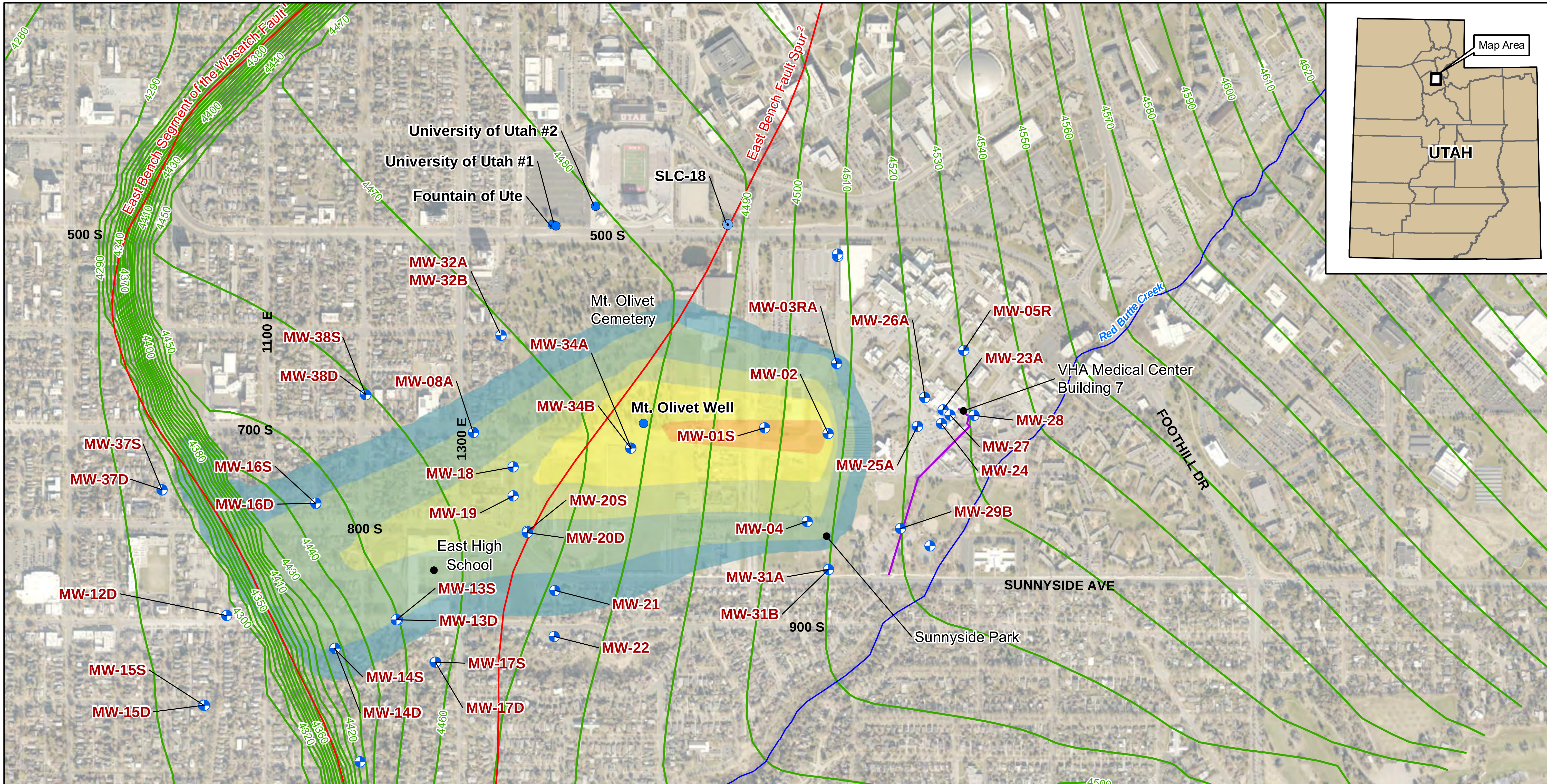
0 500 1,000 Feet

Figure 4-14c
Future Conditions - Simulated 10 Year PCE Concentrations
Shallow Aquifer
Scenario 1: Historic SLC-18 Pumping

CDM Smith

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Future_Simulation_Base_Conditions\Shallow_Aquifer_ConcentrationsT4_Future2_10yr.mxd HoughtonG 8/17/2021 10:34:26 AM



Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)

- < 1
- 1 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 200
- >200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.

[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

N W E S

0 500 1,000 Feet

CDM Smith

Figure 4-14d

Future Conditions - Simulated 15 Year PCE Concentrations
Shallow Aquifer
Scenario 1: Historic SLC-18 Pumping

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

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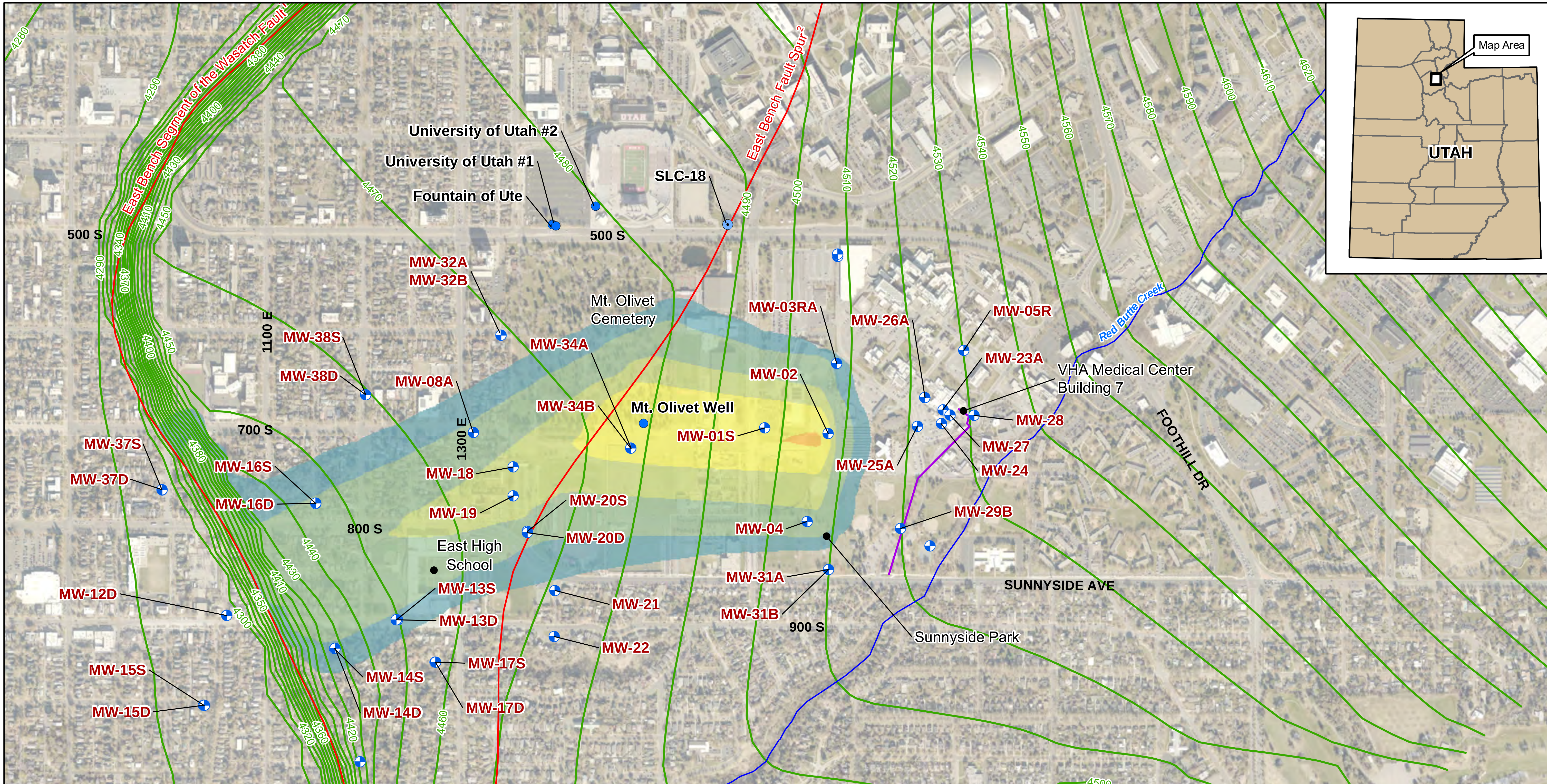

Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)

- < 1
- 1 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 200
- >200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.

[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

0 500 1,000 Feet

N S E W

Figure 4-14e

Future Conditions - Simulated 20 Year PCE Concentrations
Shallow Aquifer
Scenario 1: Historic SLC-18 Pumping

CDM Smith

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

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Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)

- < 1
- 1 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 200
- >200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.
[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

N W E S

0 500 1,000 Feet

Figure 4-15a
Future Conditions - Initial PCE Concentrations
Deep Aquifer
Scenario 1: Historic SLC-18 Pumping

CDM Smith

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

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Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)

- < 1
- 1 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 200
- >200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.

[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

N W E S

0 500 1,000 Feet

Figure 4-15b

Future Conditions - Simulated 5 Year PCE Concentrations
Deep Aquifer
Scenario 1: Historic SLC-18 Pumping

CDM Smith

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Future_Simulation_Base_Conditions\Deep_Aquifer_ConcentrationsT4_Future2_5yr.mxd HoughtonG 8/17/2021 10:50:31 AM

Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)

- < 1
- 1 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 200
- >200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.
[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

0 500 1,000 Feet

Figure 4-15c
Future Conditions - Simulated 10 Year PCE Concentrations
Deep Aquifer
Scenario 1: Historic SLC-18 Pumping

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Future_Simulation_Base_Conditions\Deep_Aquifer_ConcentrationsT4_Future2_10yr.mxd HoughtonG 8/17/2021 10:50:14 AM

Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)

- < 1
- 1 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 200
- >200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.
[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

0 500 1,000 Feet

Figure 4-15d
Future Conditions - Simulated 15 Year PCE Concentrations
Deep Aquifer
Scenario 1: Historic SLC-18 Pumping

CDM Smith

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Future_Simulation_Base_Conditions\Deep_Aquifer_ConcentrationsT4_Future2_15yr.mxd HoughtonG 8/18/2021 9:22:18 AM

Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)

- < 1
- 1 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 200
- >200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.
[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

N W E S

0 500 1,000 Feet

Figure 4-15e
Future Conditions - Simulated 20 Year PCE Concentrations
Deep Aquifer
Scenario 1: Historic SLC-18 Pumping

CDM Smith

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

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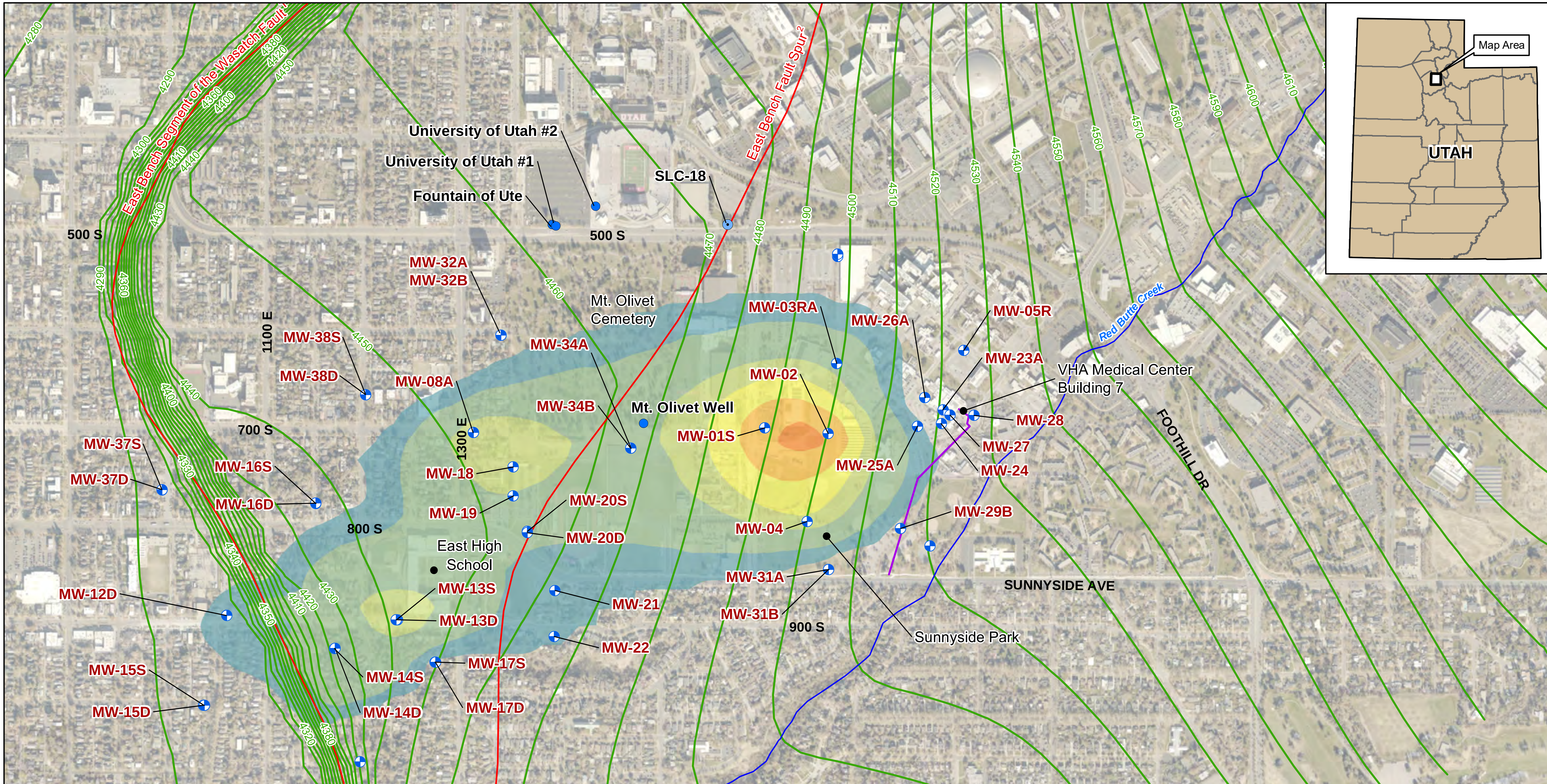

Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)

- < 1
- 1 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 200
- >200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.

[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

N E S W

0 500 1,000 Feet

Figure 4-16a

Future Conditions - Initial PCE Concentrations
Shallow Aquifer
Scenario 2: Maximum (Water Right) SLC-18 Pumping

CDM Smith

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

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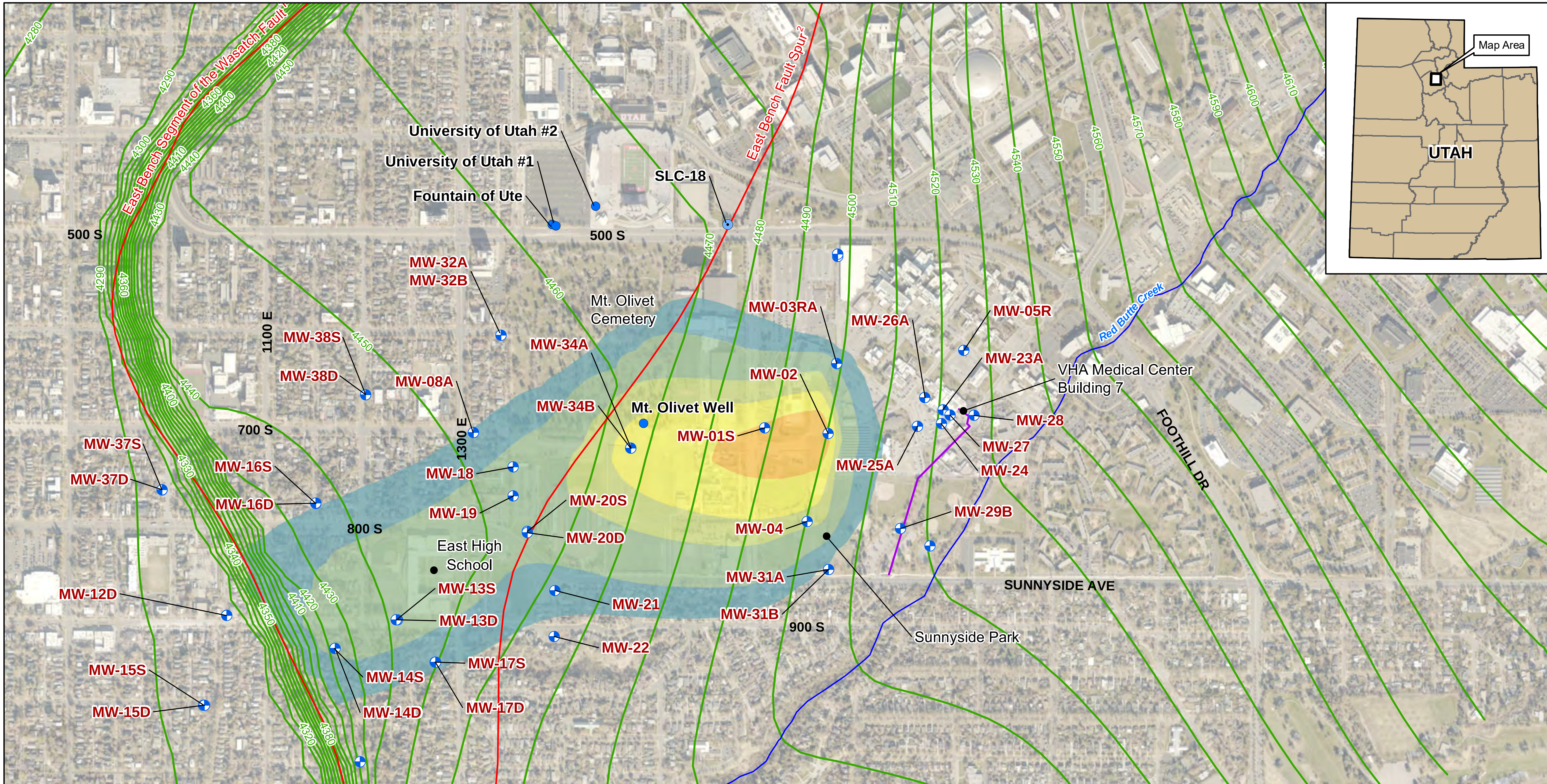

Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)

- < 1
- 1 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 200
- >200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.

[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

0 500 1,000 Feet

Figure 4-16b

Future Conditions - Simulated 5 Year PCE Concentrations
Shallow Aquifer
Scenario 2: Maximum (Water Right) SLC-18 Pumping

CDM Smith

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

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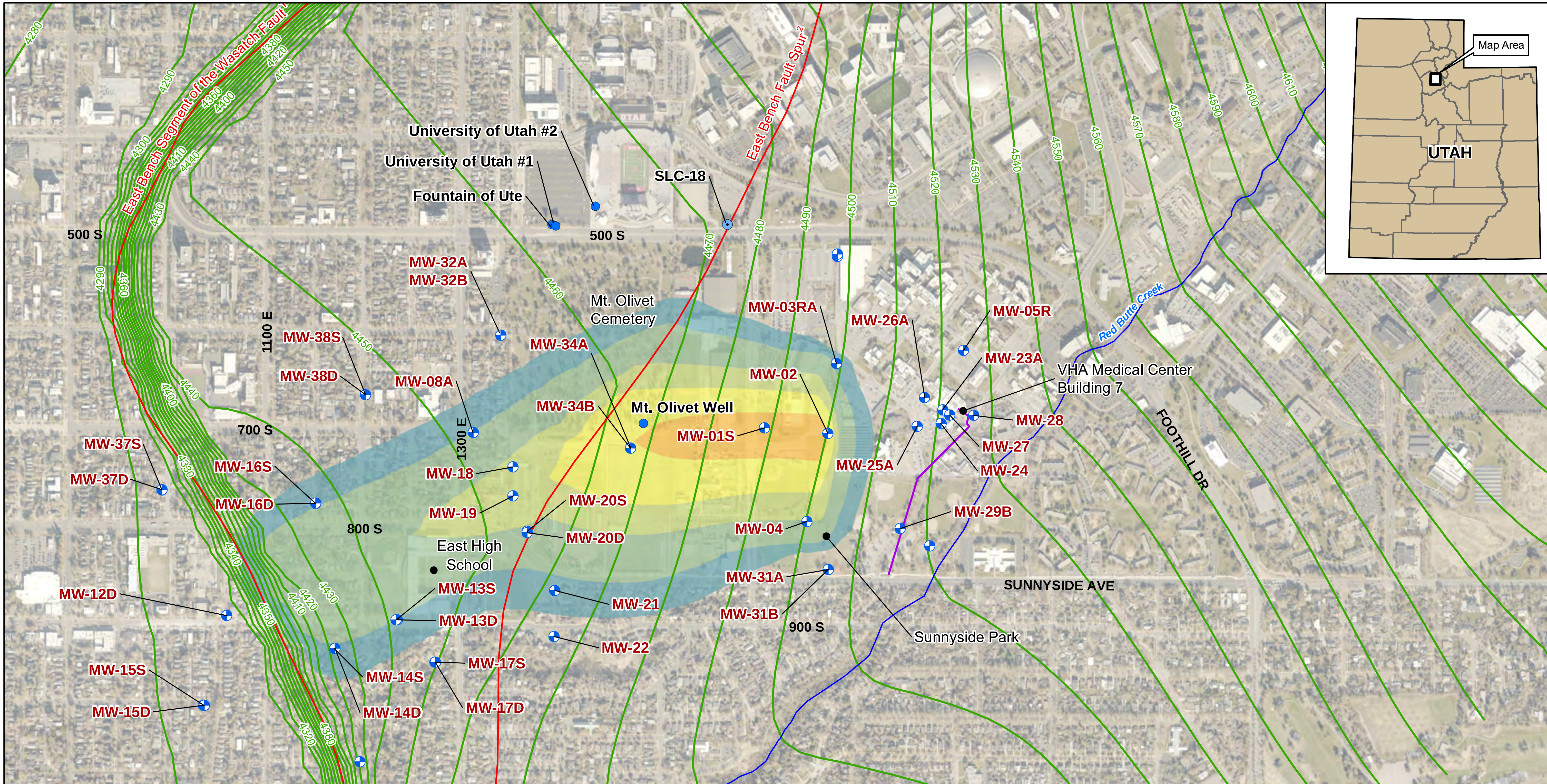

Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)

- < 1
- 1 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 200
- >200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.

[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

N W E S

0 500 1,000 Feet

CDM Smith

Figure 4-16c

Future Conditions - Simulated 10 Year PCE Concentrations
Shallow Aquifer
Scenario 2: Maximum (Water Right) SLC-18 Pumping

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

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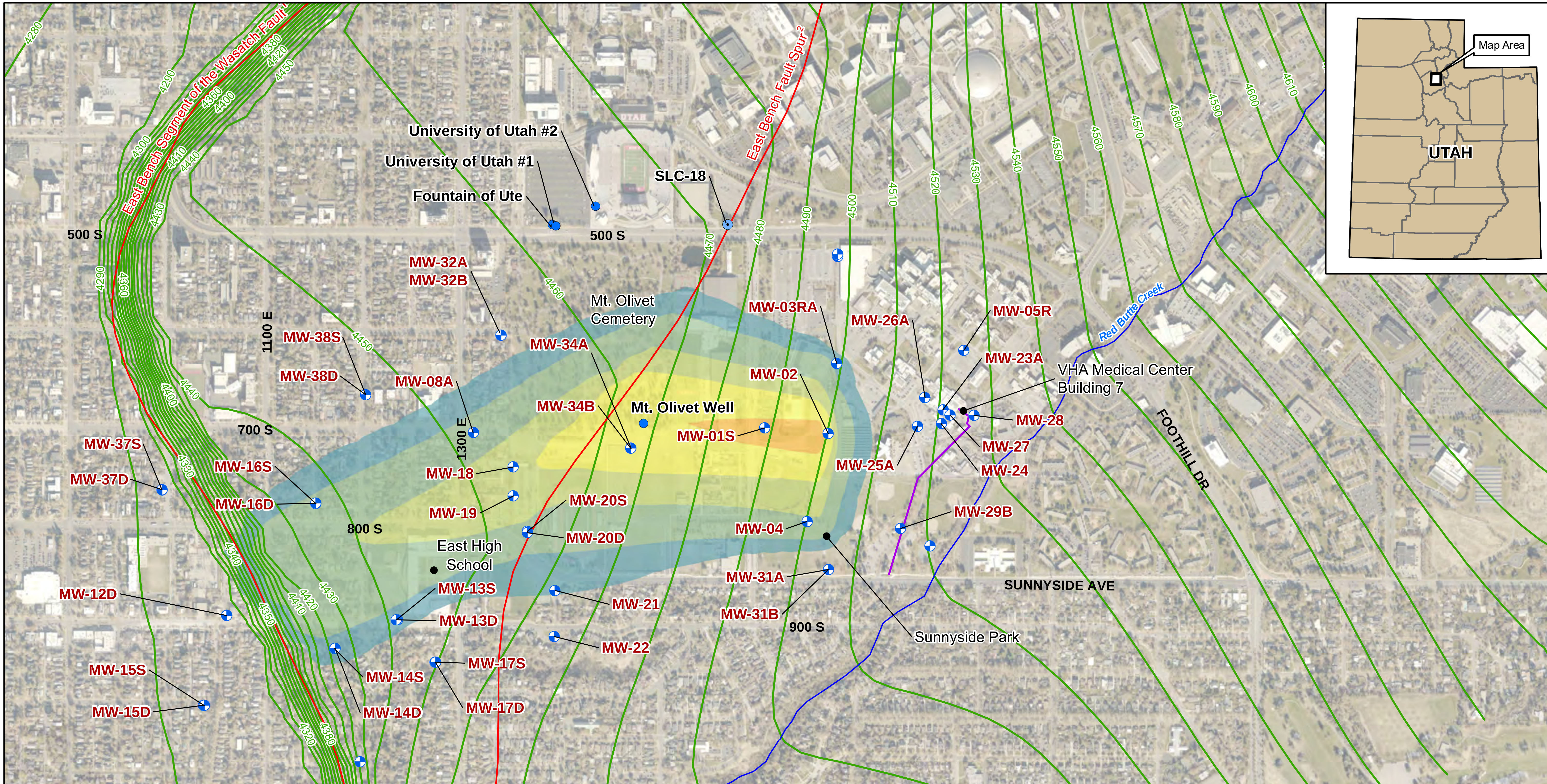


Legend
- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)
< 1
1 - 5
5 - 25
25 - 50
50 - 100
100 - 200
>200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.
[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

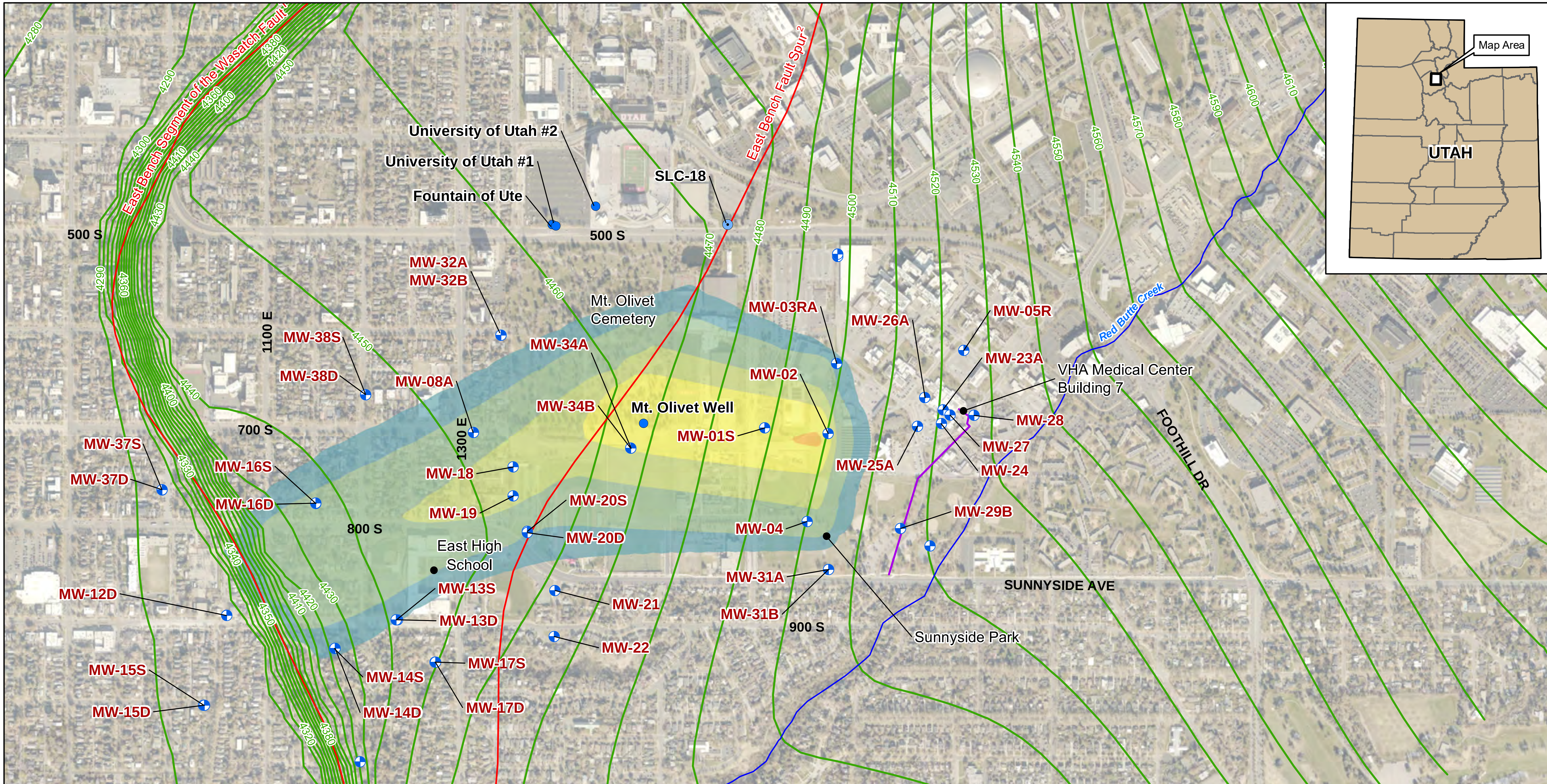
0 500 1,000 Feet

Figure 4-16d
Future Conditions - Simulated 15 Year PCE Concentrations
Shallow Aquifer
Scenario 2: Maximum (Water Right) SLC-18 Pumping

CDM Smith

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Future_Simulation_Base_Conditions\Shallow_Aquifer_ConcentrationsT4_Future3_15yr.mxd HoughtonG 8/17/2021 2:21:21 PM



Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)

- < 1
- 1 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 200
- >200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.

[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

N W E S

0 500 1,000 Feet

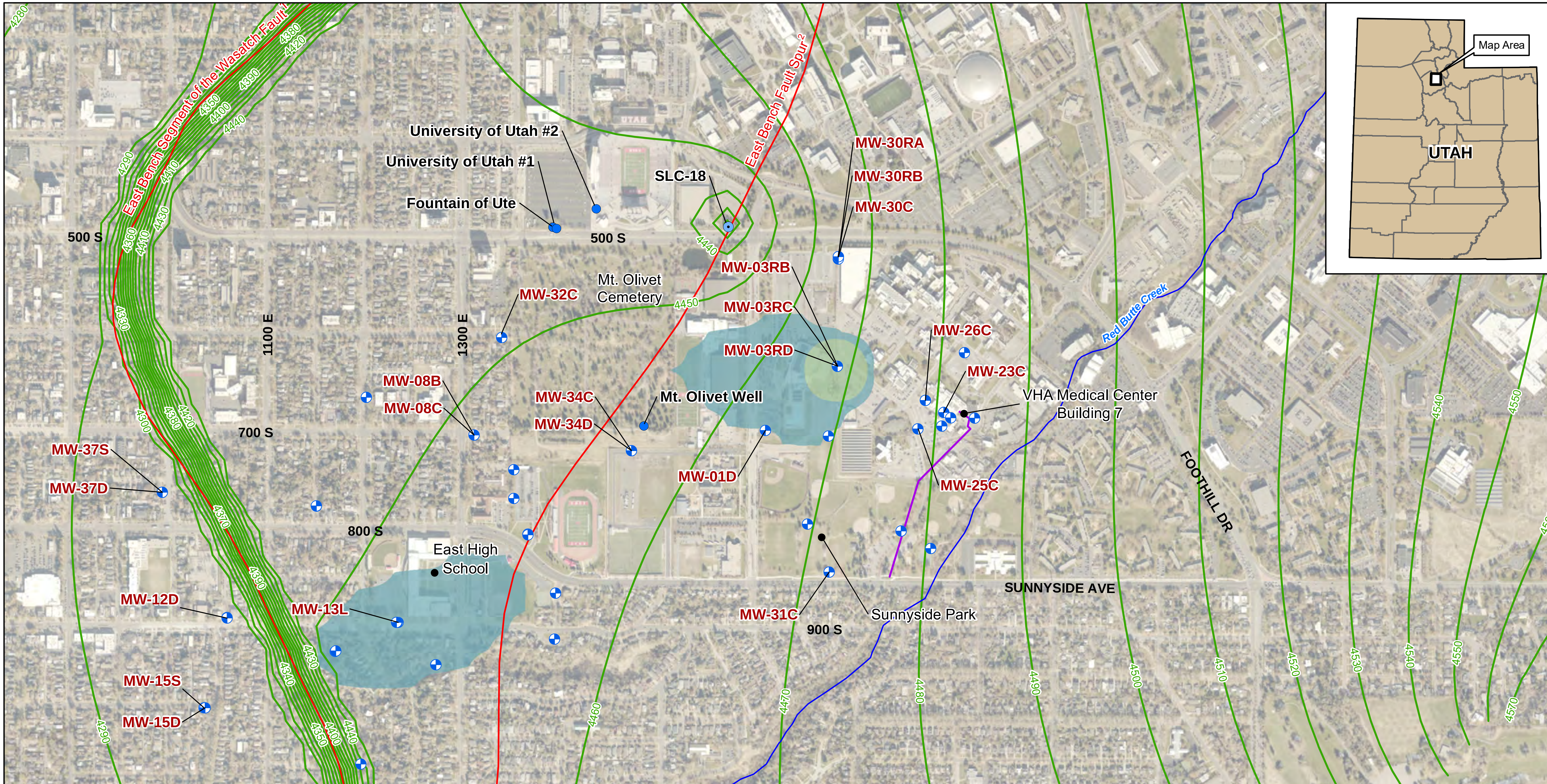
Figure 4-16e

Future Conditions - Simulated 20 Year PCE Concentrations
Shallow Aquifer
Scenario 2: Maximum (Water Right) SLC-18 Pumping

CDM Smith

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Future_Simulation_Base_Conditions\Shallow_Aquifer_ConcentrationsT4_Future3_20yr.mxd HoughtonG 8/17/2021 2:21:38 PM



Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)

- < 1
- 1 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 200
- >200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.
[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

N E S W

0 500 1,000 Feet

Figure 4-17a
Future Conditions - Initial PCE Concentrations
Deep Aquifer
Scenario 2: Maximum (Water Right) SLC-18 Pumping

CDM Smith

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

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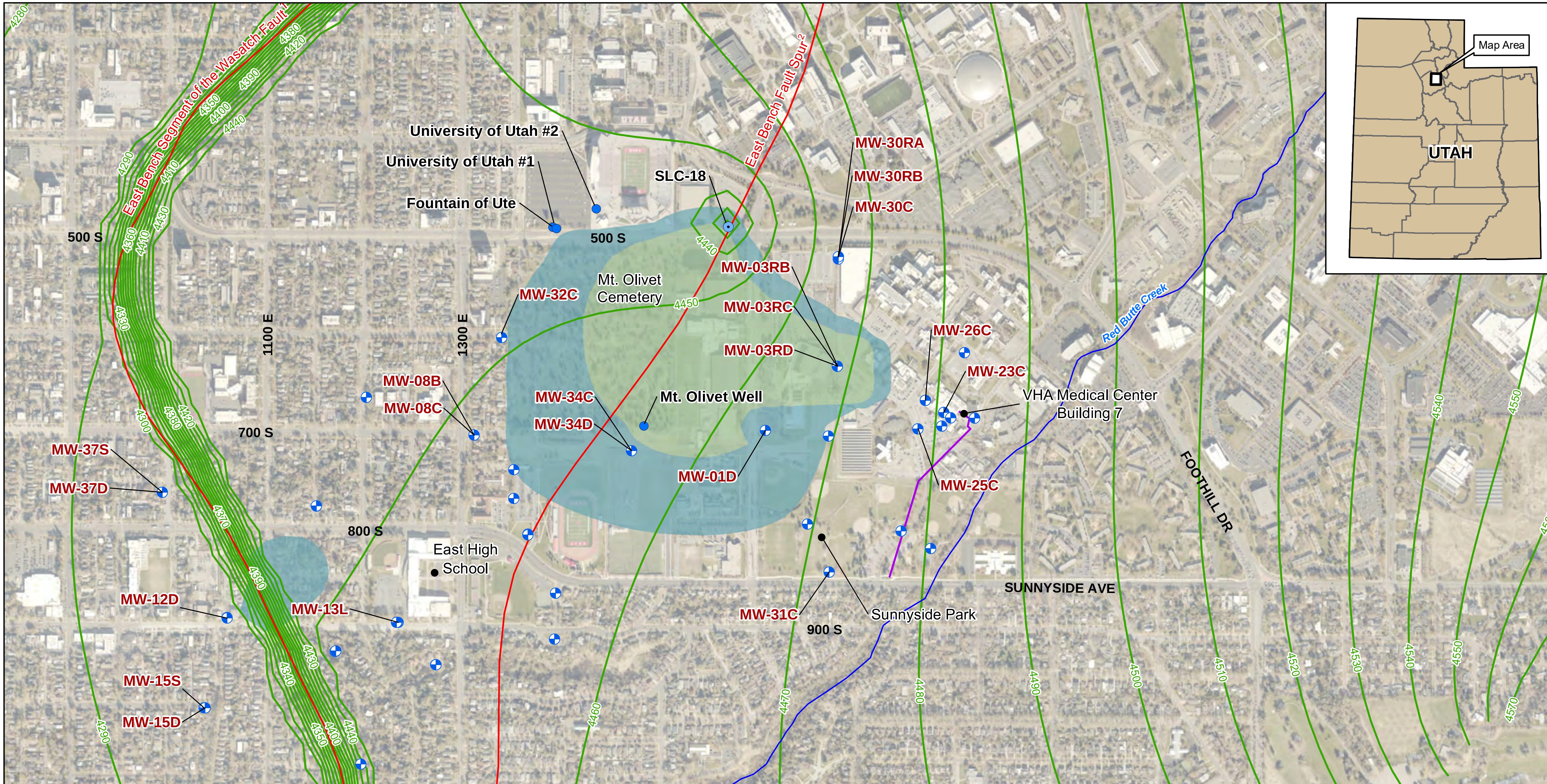


Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)

- < 1
- 1 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 200
- >200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.
[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

N W E S

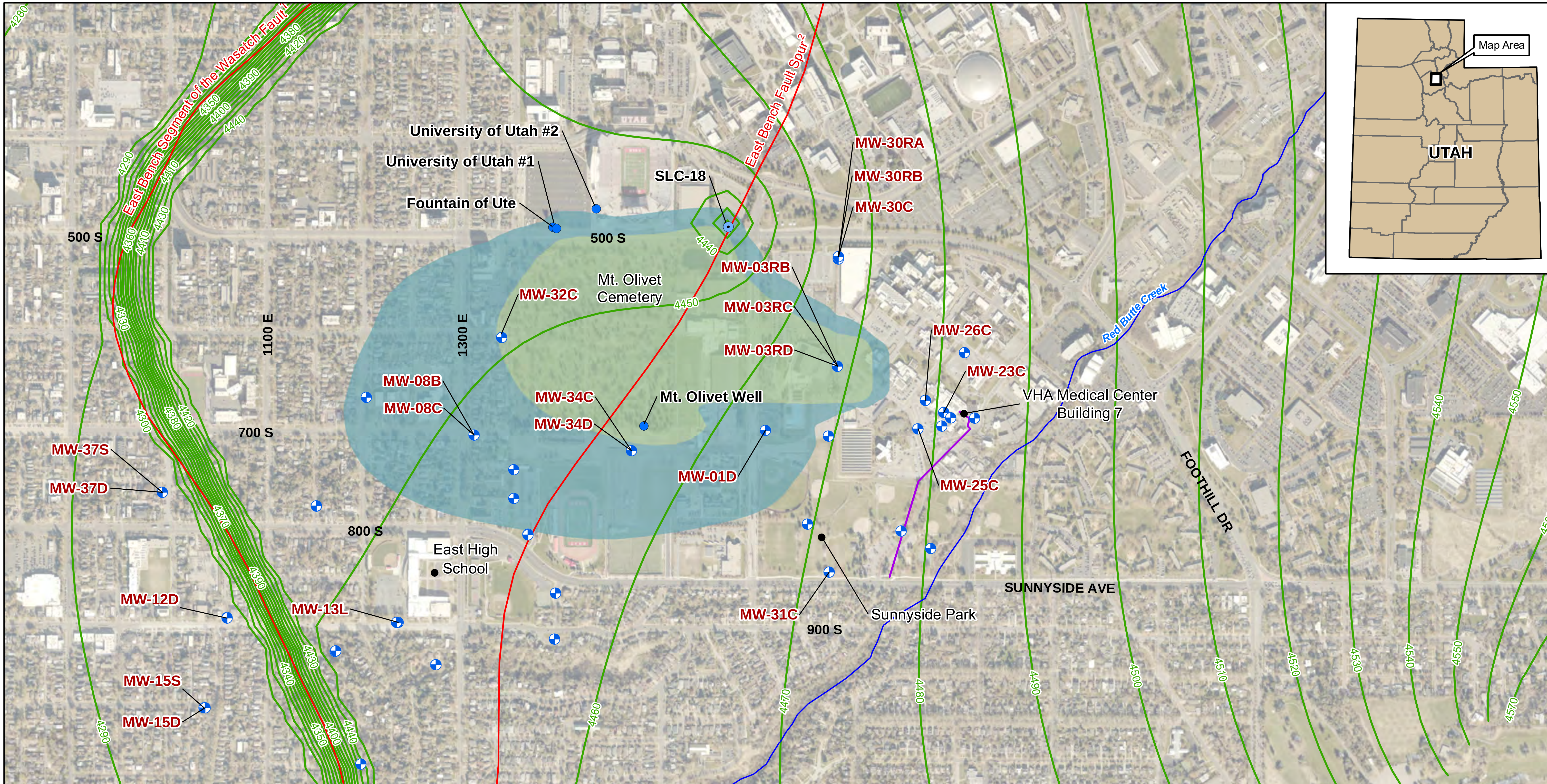
0 500 1,000 Feet

CDM Smith

Figure 4-17b
Future Conditions - Simulated 5 Year PCE Concentrations
Deep Aquifer
Scenario 2: Maximum (Water Right) SLC-18 Pumping

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Future_Simulation_Base_Conditions\Deep_Aquifer_ConcentrationsT4_Future3_5yr.mxd HoughtonG 8/17/2021 2:53:51 PM



Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)

- < 1
- 1 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 200
- >200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.

[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

N W E S

0 500 1,000 Feet

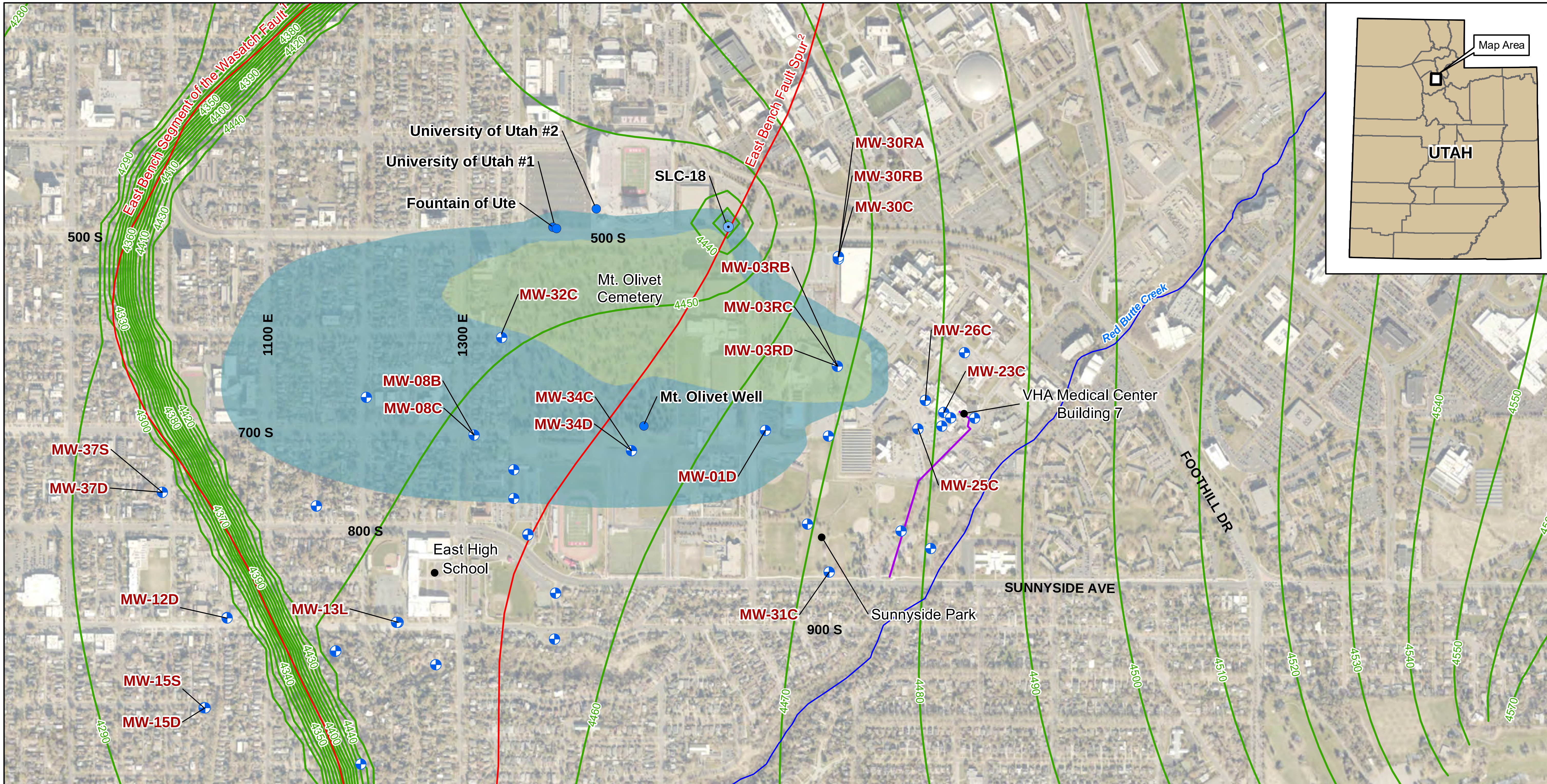
CDM Smith

Figure 4-17c

Future Conditions - Simulated 10 Year PCE Concentrations
Deep Aquifer
Scenario 2: Maximum (Water Right) SLC-18 Pumping

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Future_Simulation_Base_Conditions\Deep_Aquifer_ConcentrationsT4_Future3_10yr.mxd HoughtonG 8/17/2021 2:54:13 PM



Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)

- < 1
- 1 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 200
- >200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.
[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

Figure 4-17d
Future Conditions - Simulated 15 Year PCE Concentrations
Deep Aquifer
Scenario 2: Maximum (Water Right) SLC-18 Pumping

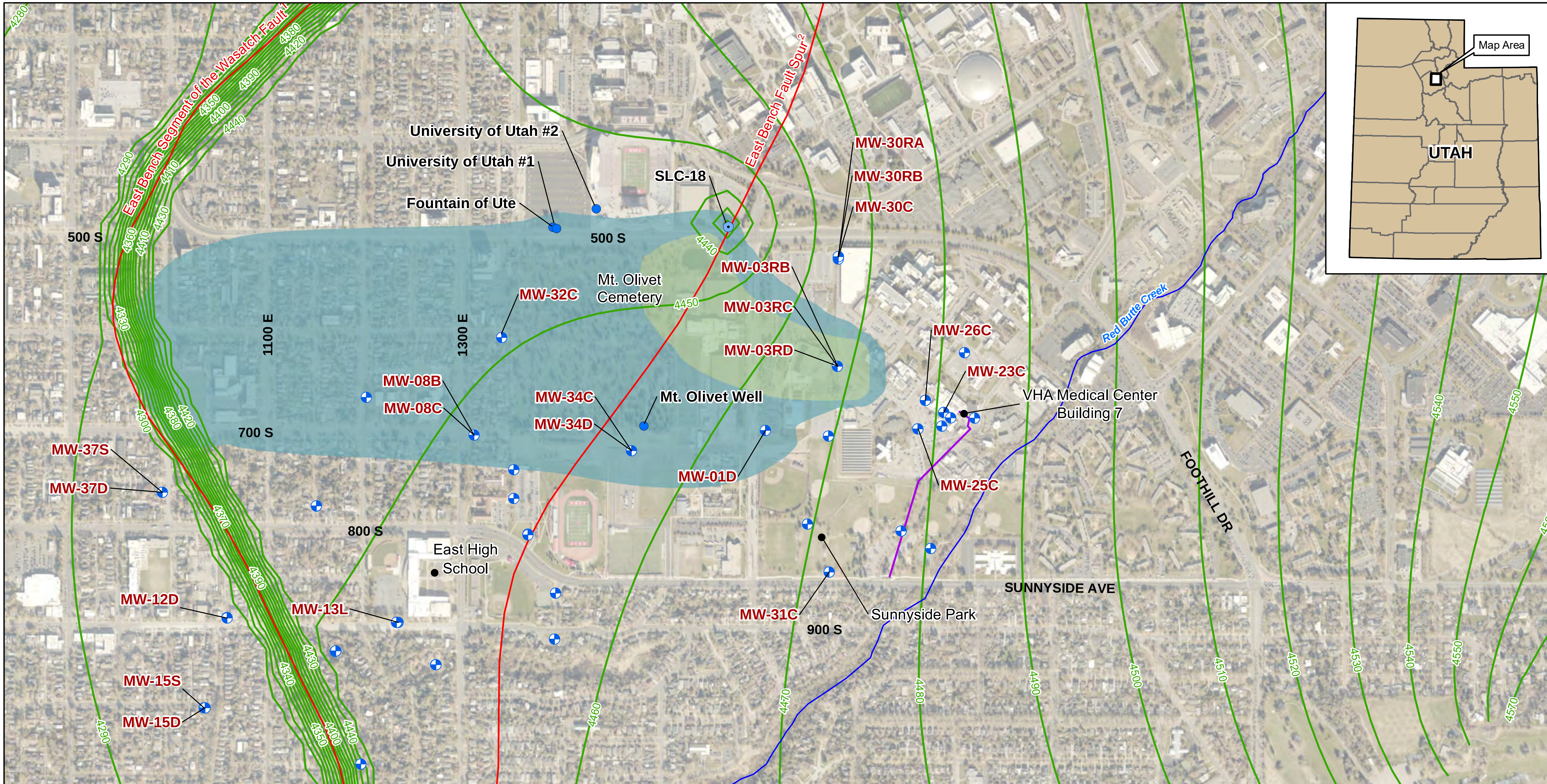
N
W E
S

0 500 1,000 Feet

CDM Smith

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Future_Simulation_Base_Conditions\Deep_Aquifer_ConcentrationsT4_Future3_15yr.mxd HoughtonG 8/17/2021 2:54:55 PM



Legend

Monitoring Well	
Abandoned Monitoring Well	
Drinking Water Supply Well	
Irrigation Well	
Landmark	
Red Butte Creek	
Fault Line	
Sewer Line	
Head Contour (10-ft)	

PCE (ug/L)
- < 1
- 1 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 200
- >200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.

[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

Figure 4-17e
Future Conditions - Simulated 20 Year PCE Concentrations
Deep Aquifer
Scenario 2: Maximum (Water Right) SLC-18 Pumping

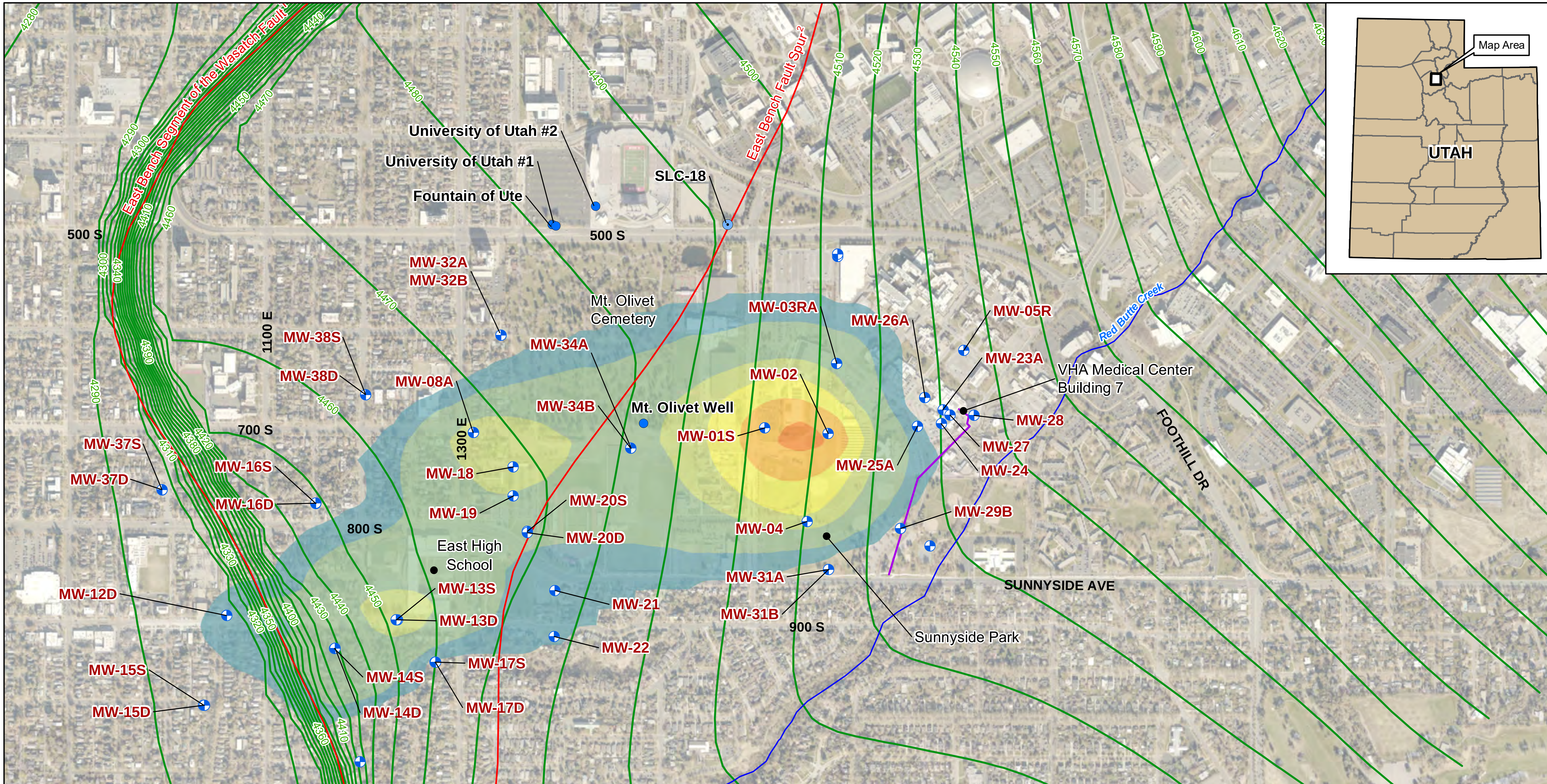
N W E S

0 500 1,000 Feet

CDM Smith

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Future_Simulation_Base_Conditions\Deep_Aquifer_ConcentrationsT4_Future3_20yr.mxd HoughtonG 8/17/2021 2:54:31 PM



Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)

- < 1
- 1 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 200
- >200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.

[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

0 500 1,000 Feet

Figure 4-18a

Future Conditions - Initial PCE Concentrations

Shallow Aquifer

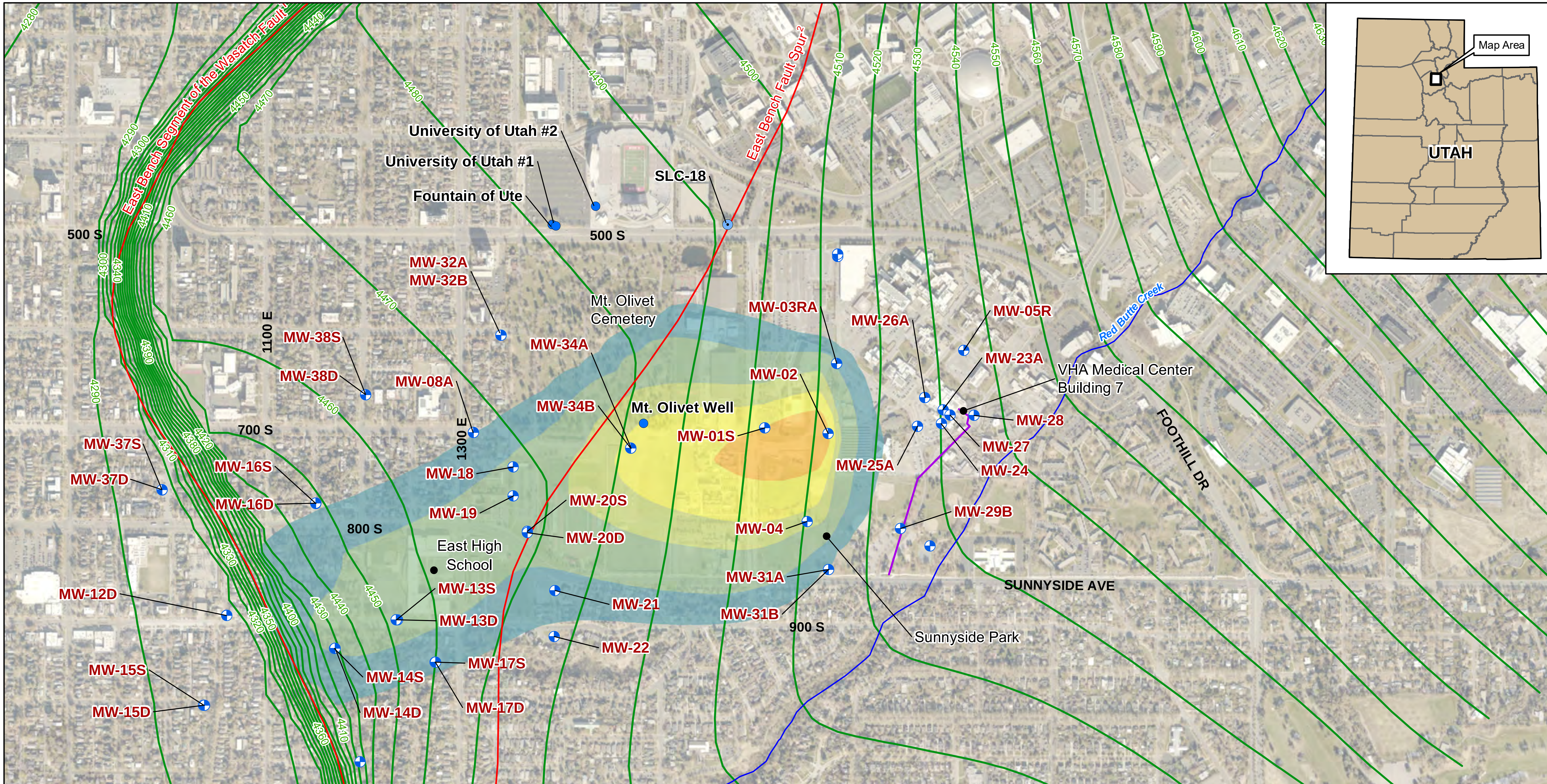
Scenario 3: Proposed University Irrigation Pumping

CDM Smith

OU1 700 South 1600 East PCE Plume

Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Future_Simulation_Base_Conditions\Shallow_Aquifer_ConcentrationsT4_Future4_Initial.mxd HoughtonG 8/17/2021 3:36:17 PM



Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)
< 1
1 - 5
5 - 25
25 - 50
50 - 100
100 - 200
>200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.

[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

N E S W

0 500 1,000 Feet

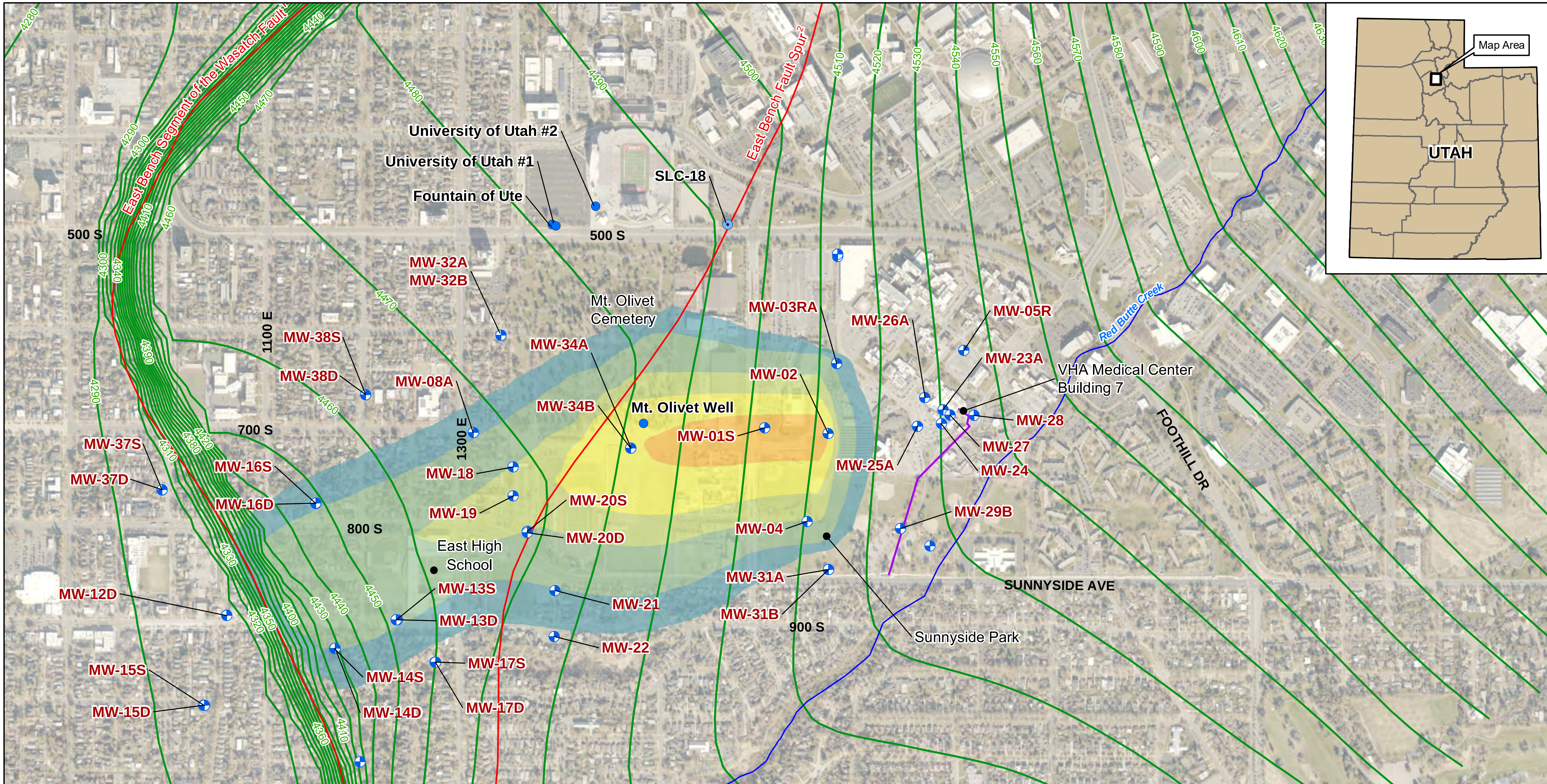
Figure 4-18b

Future Conditions - Simulated 5 Year PCE Concentrations
Shallow Aquifer
Scenario 3: Proposed University Irrigation Pumping

CDM Smith

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Future_Simulation_Base_Conditions\Shallow_Aquifer_ConcentrationsT4_Future4_5yr.mxd HoughtonG 8/17/2021 3:35:57 PM



Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)

- < 1
- 1 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 200
- >200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.
[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

N W E S

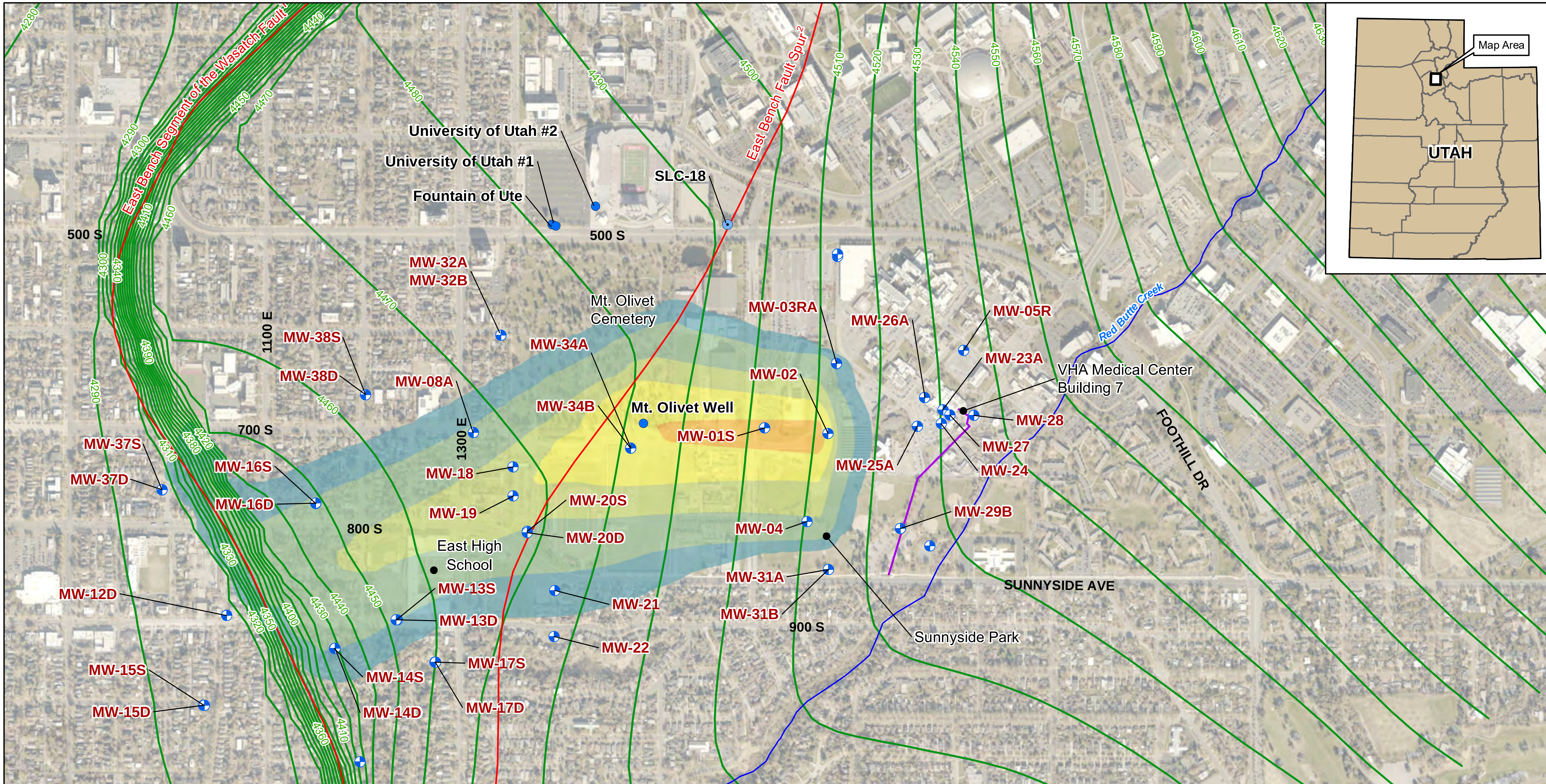
0 500 1,000 Feet

Figure 4-18c
Future Conditions - Simulated 10 Year PCE Concentrations
Shallow Aquifer
Scenario 3: Proposed University Irrigation Pumping

CDM Smith

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Future_Simulation_Base_Conditions\Shallow_Aquifer_ConcentrationsT4_Future4_10yr.mxd HoughtonG 8/17/2021 3:35:34 PM



Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)

- < 1
- 1 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 200
- >200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.
[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

N E S W

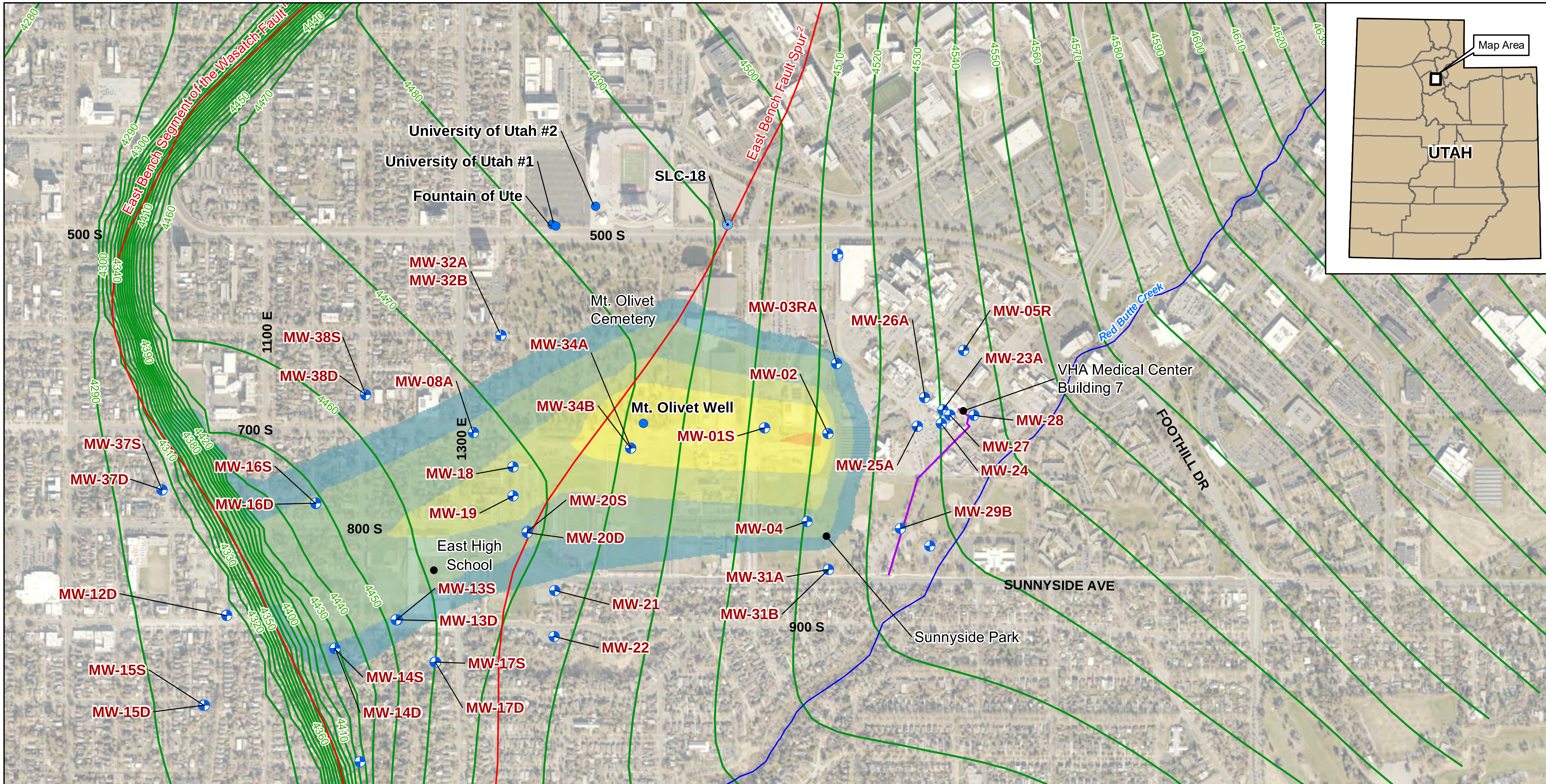
0 500 1,000 Feet

CDM Smith

Figure 4-18d
Future Conditions - Simulated 15 Year PCE Concentrations
Shallow Aquifer
Scenario 3: Proposed University Irrigation Pumping

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Future_Simulation_Base_Conditions\Shallow_Aquifer_ConcentrationsT4_Future4_15yr.mxd HoughtonG 8/17/2021 3:35:16 PM



Legend
- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)
< 1
1 - 5
5 - 25
25 - 50
50 - 100
100 - 200
>200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.
[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

N E S W

0 500 1,000 Feet

Figure 4-18e
Future Conditions - Simulated 20 Year PCE Concentrations
Shallow Aquifer
Scenario 3: Proposed University Irrigation Pumping

CDM Smith

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Future_Simulation_Base_Conditions\Shallow_Aquifer_ConcentrationsT4_Future4_20yr.mxd HoughtonG 8/18/2021 1:29:36 PM

Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (/ugL)
< 1
1 - 5
5 - 25
25 - 50
50 - 100
100 - 200
>200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.

[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

N E S W

0 500 1,000 Feet

Figure 4-19a

Future Conditions - Initial PCE Concentrations

Deep Aquifer

Scenario 3: Proposed University Irrigation Pumping

CDM Smith

OU1 700 South 1600 East PCE Plume

Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Future_Simulation_Base_Conditions\Deep_Aquifer_ConcentrationsT4_Future4_Initial.mxd HoughtonG 8/18/2021 2:51:37 PM

Legend

Monitoring Well		PCE (ug/L)	
Abandoned Monitoring Well			< 1
Drinking Water Supply Well			1 - 5
Irrigation Well			5 - 25
Landmark			25 - 50
Red Butte Creek			50 - 100
Fault Line			100 - 200
Sewer Line			>200
Head Contour (10-ft)			

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.

[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

Figure 4-19b

Future Conditions - Simulated 5 Year PCE Concentrations
Deep Aquifer
Scenario 3: Proposed University Irrigation Pumping

N W E S

0 500 1,000 Feet

CDM Smith

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Future_Simulation_Base_Conditions\Deep_Aquifer_ConcentrationsT4_Future4_5yr.mxd HoughtonG 8/17/2021 3:19:03 PM

Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)
< 1
1 - 5
5 - 25
25 - 50
50 - 100
100 - 200
>200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.

[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

N W E S

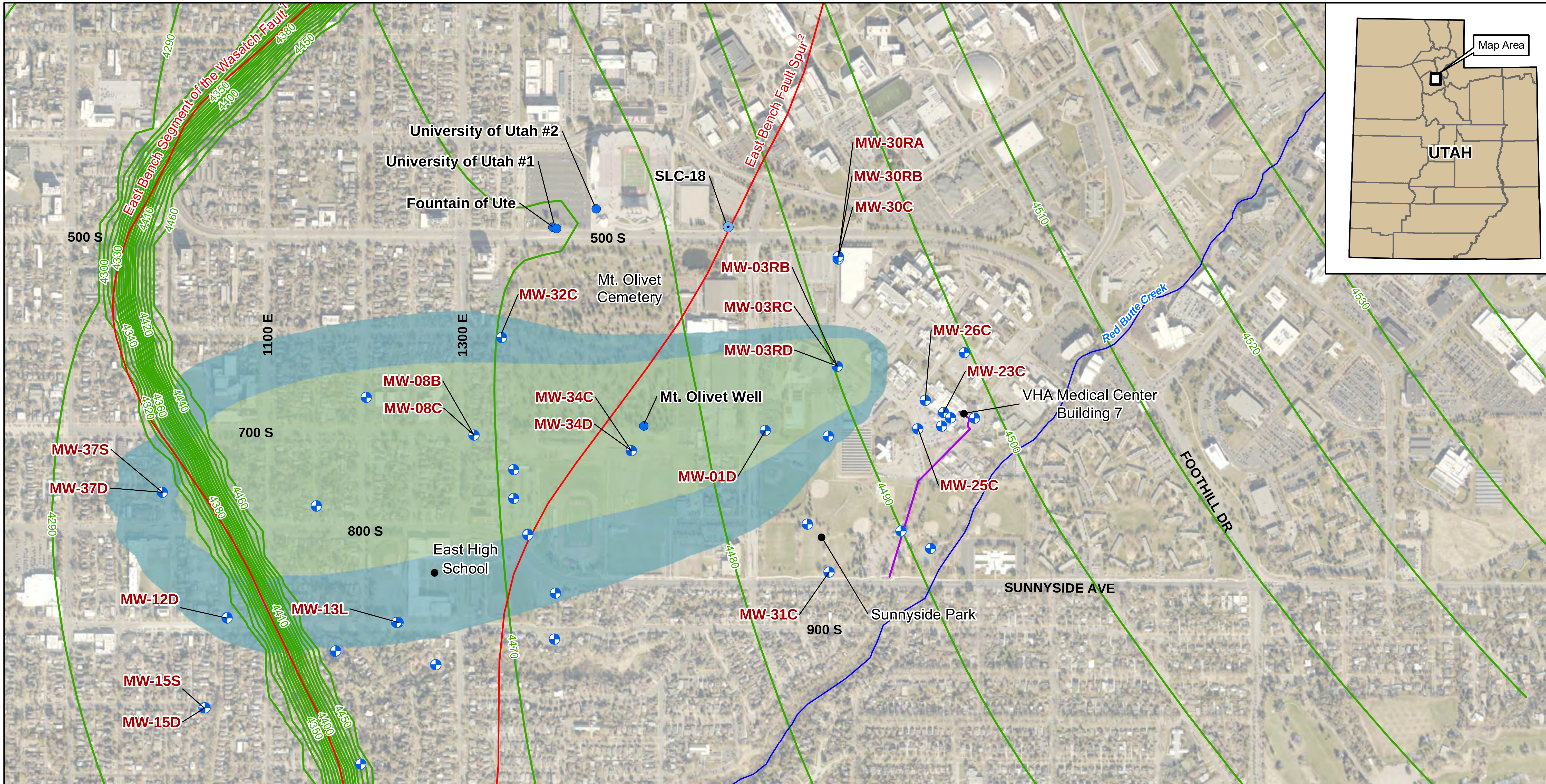
0 500 1,000 Feet

Figure 4-19c
Future Conditions - Simulated 10 Year PCE Concentrations
Deep Aquifer
Scenario 3: Proposed University Irrigation Pumping

CDM Smith

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Future_Simulation_Base_Conditions\Deep_Aquifer_ConcentrationsT4_Future4_10yr.mxd HoughtonG 8/17/2021 3:18:49 PM



Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)

- < 1
- 1 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 200
- >200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.

[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

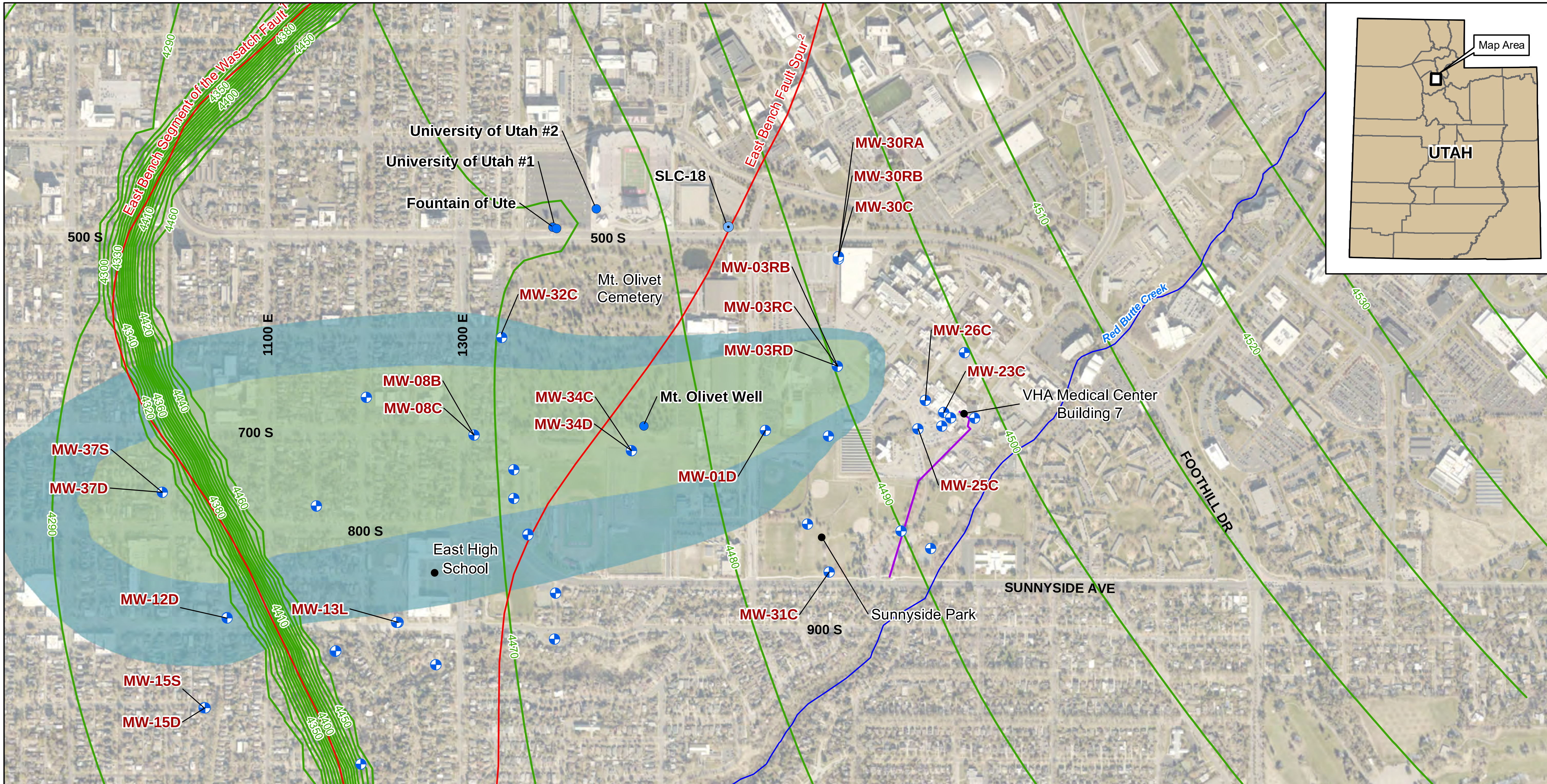
Figure 4-19d
Future Conditions - Simulated 15 Year PCE Concentrations
Deep Aquifer
Scenario 3: Proposed University Irrigation Pumping

0 500 1,000 Feet

CDM Smith

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Future_Simulation_Base_Conditions\Deep_Aquifer_ConcentrationsT4_Future4_15yr.mxd HoughtonG 8/17/2021 3:18:33 PM



Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)
< 1
1 - 5
5 - 25
25 - 50
50 - 100
100 - 200
>200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.

[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

Figure 4-19e

Future Conditions - Simulated 20 Year PCE Concentrations
Deep Aquifer
Scenario 3: Proposed University Irrigation Pumping

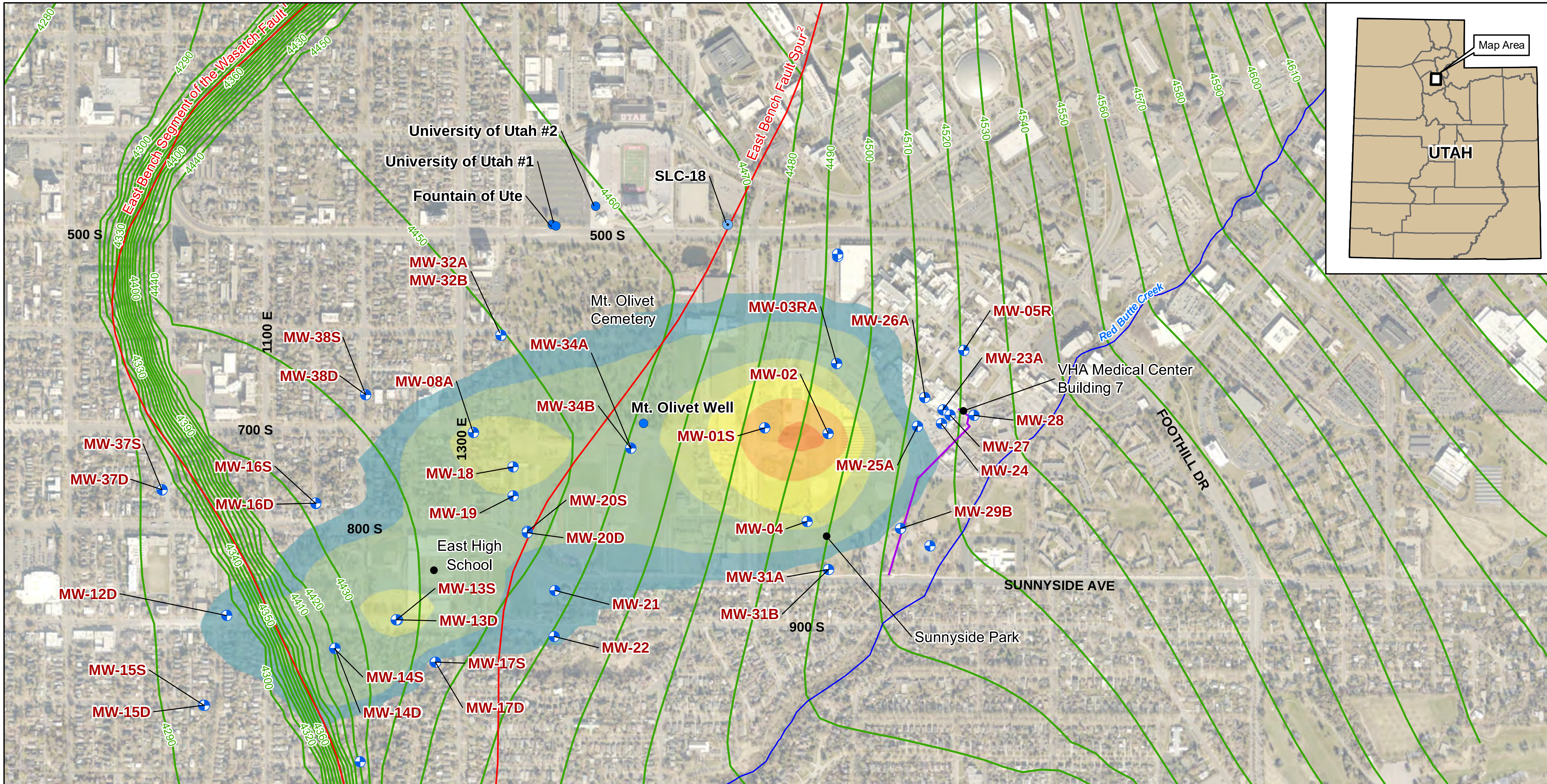
N W E S

0 500 1,000 Feet

CDM Smith

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Future_Simulation_Base_Conditions\Deep_Aquifer_ConcentrationsT4_Future4_20yr.mxd HoughtonG 8/17/2021 3:18:12 PM



Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)

- < 1
- 1 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 200
- >200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.
[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

N E S W

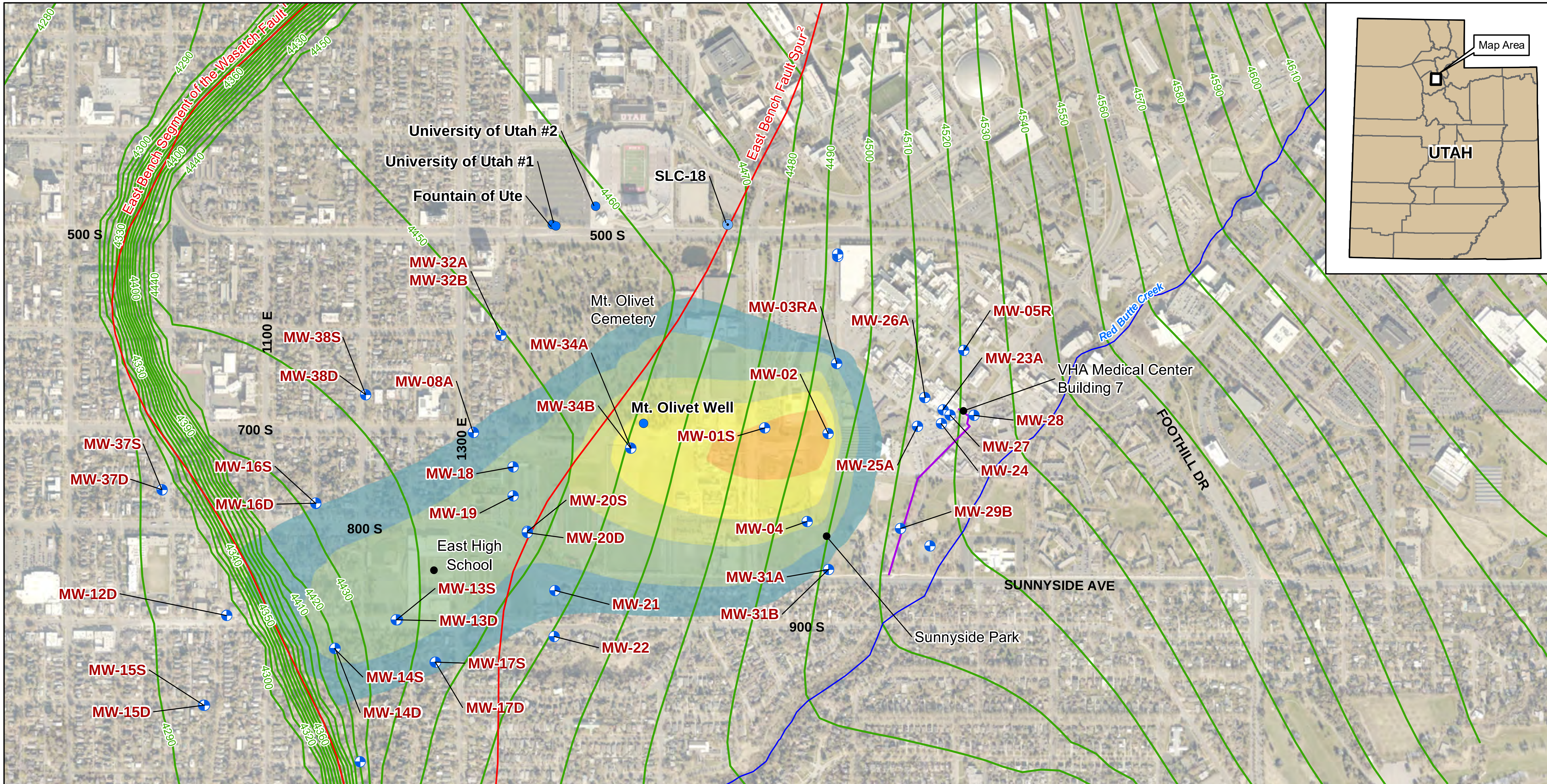
0 500 1,000 Feet

CDM Smith

Figure 4-20a
Future Conditions - Initial PCE Concentrations
Shallow Aquifer
Scenario 4: Proposed University Irrigation Pumping and Maximum (Water Right) Pumping at SLC-18

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Future_Simulation_Base_Conditions\Shallow_Aquifer_ConcentrationsT4_Future5_Initial.mxd HoughtonG 8/17/2021 4:21:55 PM



Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)

- < 1
- 1 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 200
- >200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.

[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

N E S W

0 500 1,000 Feet

CDM Smith

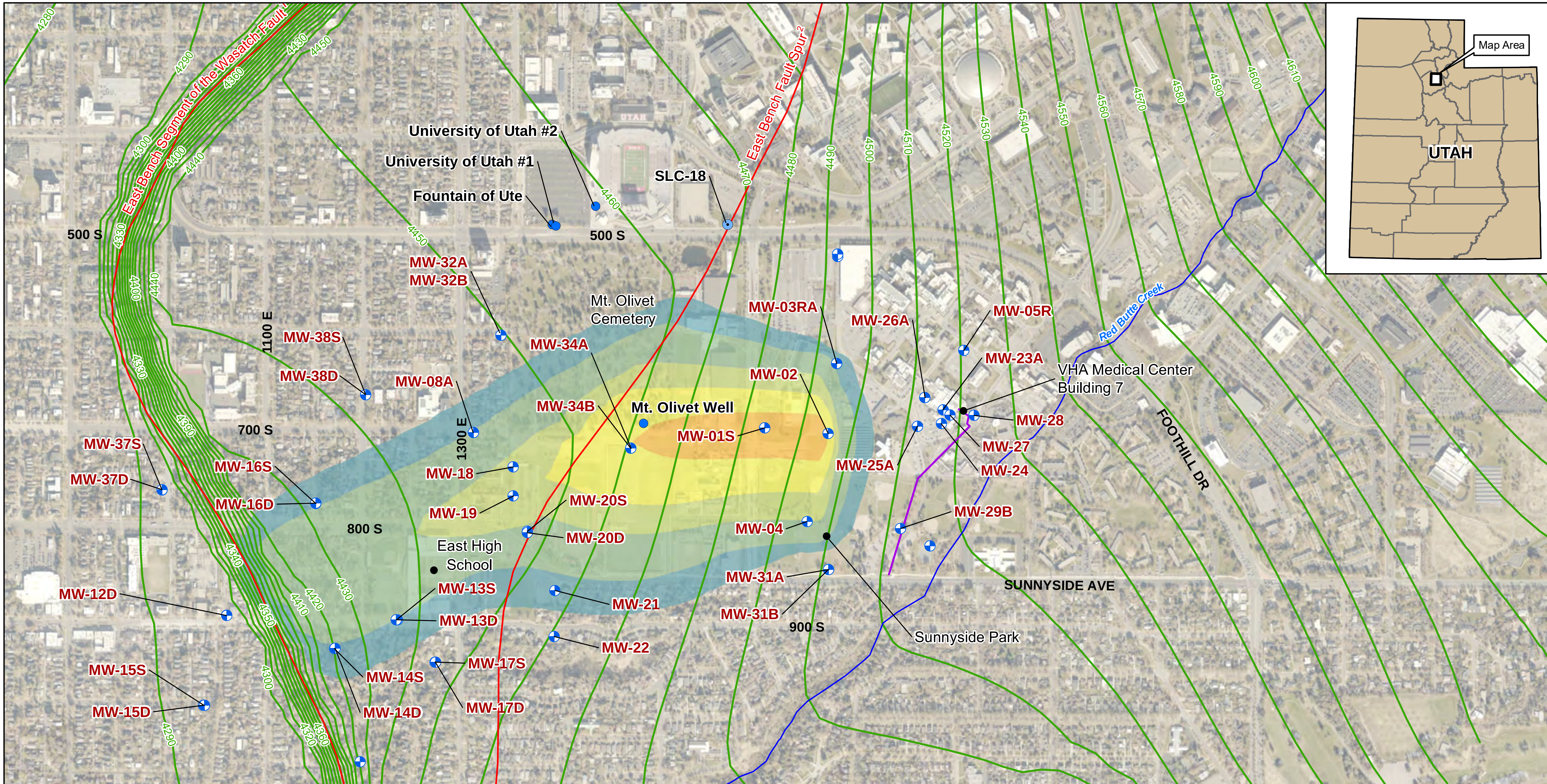
Figure 4-20b

Future Conditions - Simulated 5 Year PCE Concentrations Shallow Aquifer

Scenario 4: Proposed University Irrigation Pumping and Maximum (Water Right) Pumping at SLC-18

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Future_Simulation_Base_Conditions\Shallow_Aquifer_ConcentrationsT4_Future5_5yr.mxd HoughtonG 8/17/2021 4:22:26 PM



Legend
- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)
- < 1
- 1 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 200
- >200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.

[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

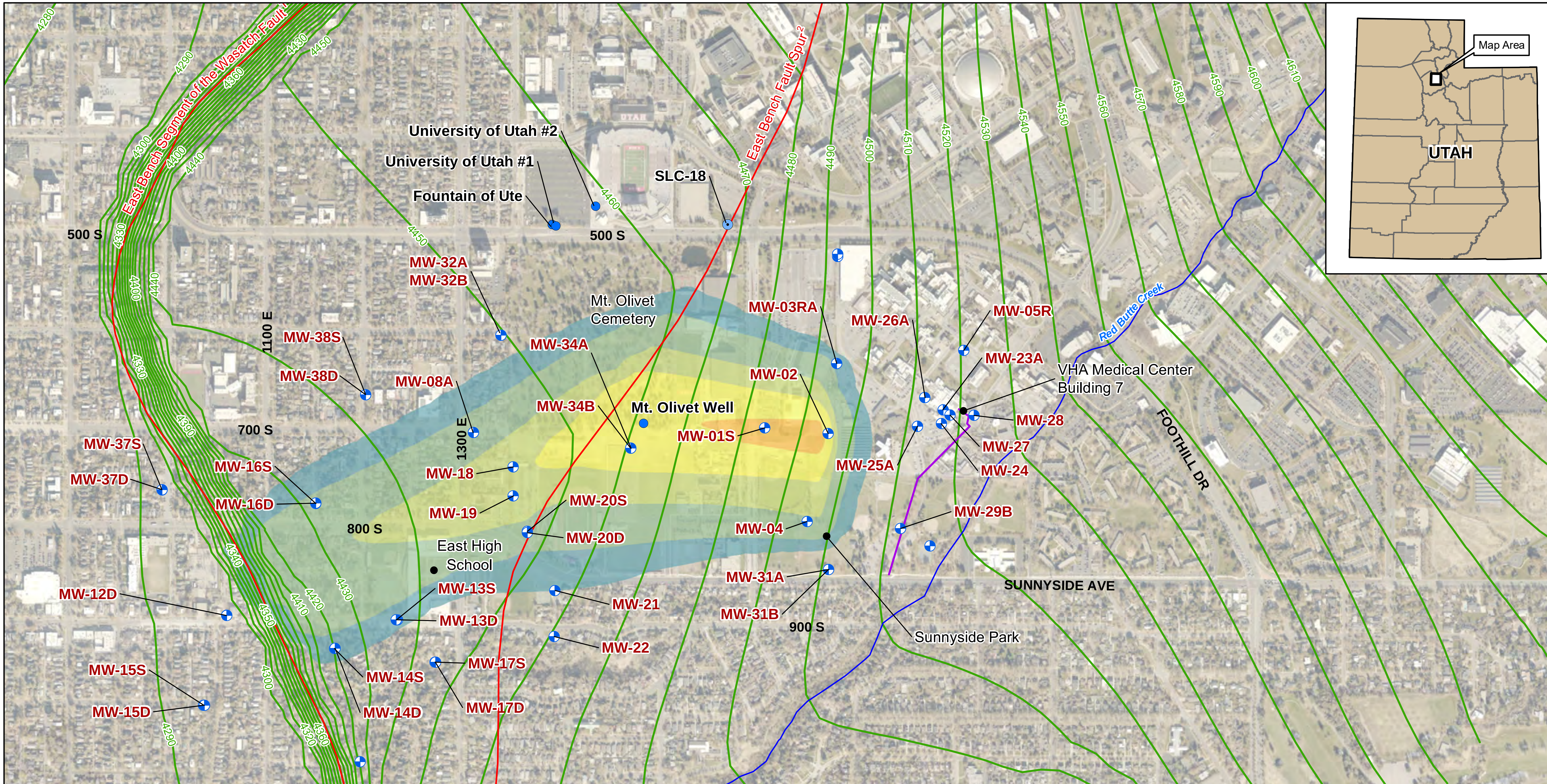
0 500 1,000 Feet

Figure 4-20c
Future Conditions - Simulated 10 Year PCE Concentrations
Shallow Aquifer
Scenario 4: Proposed University Irrigation Pumping
and Maximum (Water Right) Pumping at SLC-18

CDM Smith

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Future_Simulation_Base_Conditions\Shallow_Aquifer_ConcentrationsT4_Future5_10yr.mxd HoughtonG 8/17/2021 4:22:46 PM



Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)

- < 1
- 1 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 200
- >200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.
[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

N E S W

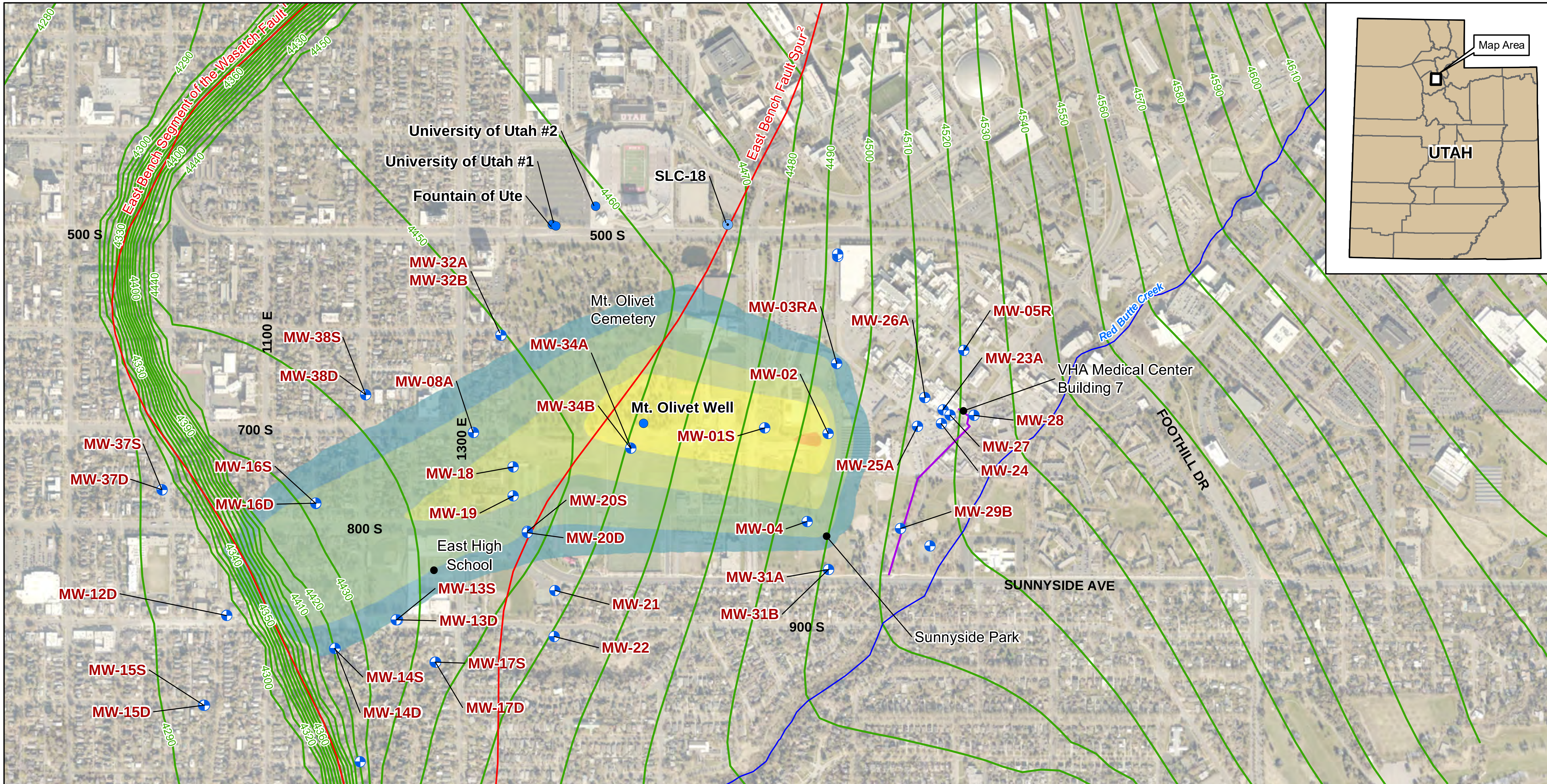
0 500 1,000 Feet

CDM Smith

Figure 4-20d
Future Conditions - Simulated 15 Year PCE Concentrations
Shallow Aquifer
Scenario 4: Proposed University Irrigation Pumping
and Maximum (Water Right) Pumping at SLC-18

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Future_Simulation_Base_Conditions\Shallow_Aquifer_ConcentrationsT4_Future5_15yr.mxd HoughtonG 8/18/2021 9:30:05 AM



Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)

- < 1
- 1 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 200
- >200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.

[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

N E S W

0 500 1,000 Feet

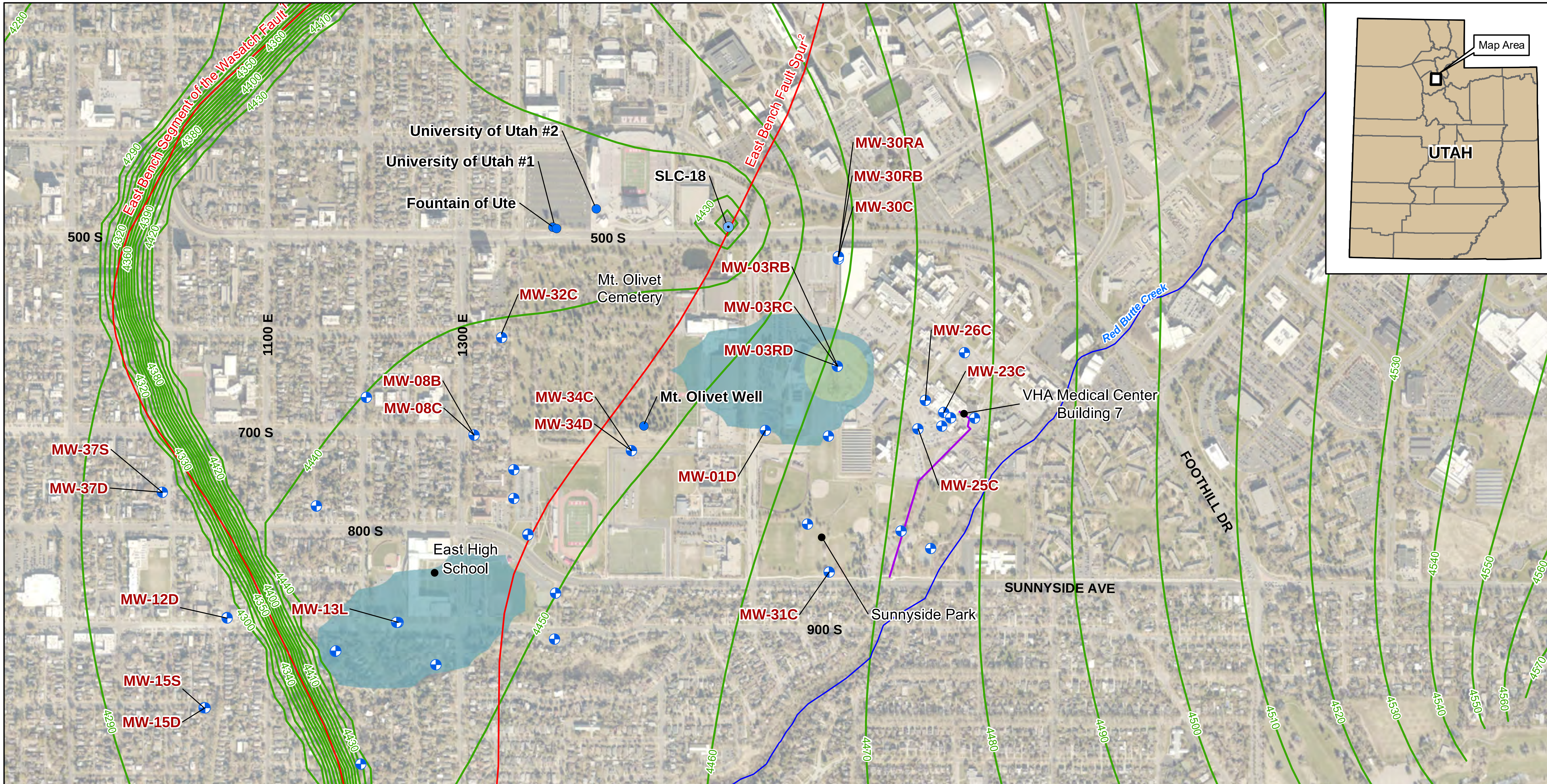
CDM Smith

Figure 4-20e

Future Conditions - Simulated 20 Year PCE Concentrations
Shallow Aquifer
Scenario 4: Proposed University Irrigation Pumping and Maximum (Water Right) Pumping at SLC-18

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Future_Simulation_Base_Conditions\Shallow_Aquifer_ConcentrationsT4_Future5_20yr.mxd HoughtonG 8/17/2021 4:23:26 PM



Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)

- < 1
- 1 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 200
- >200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.

[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

N W E S

0 500 1,000 Feet

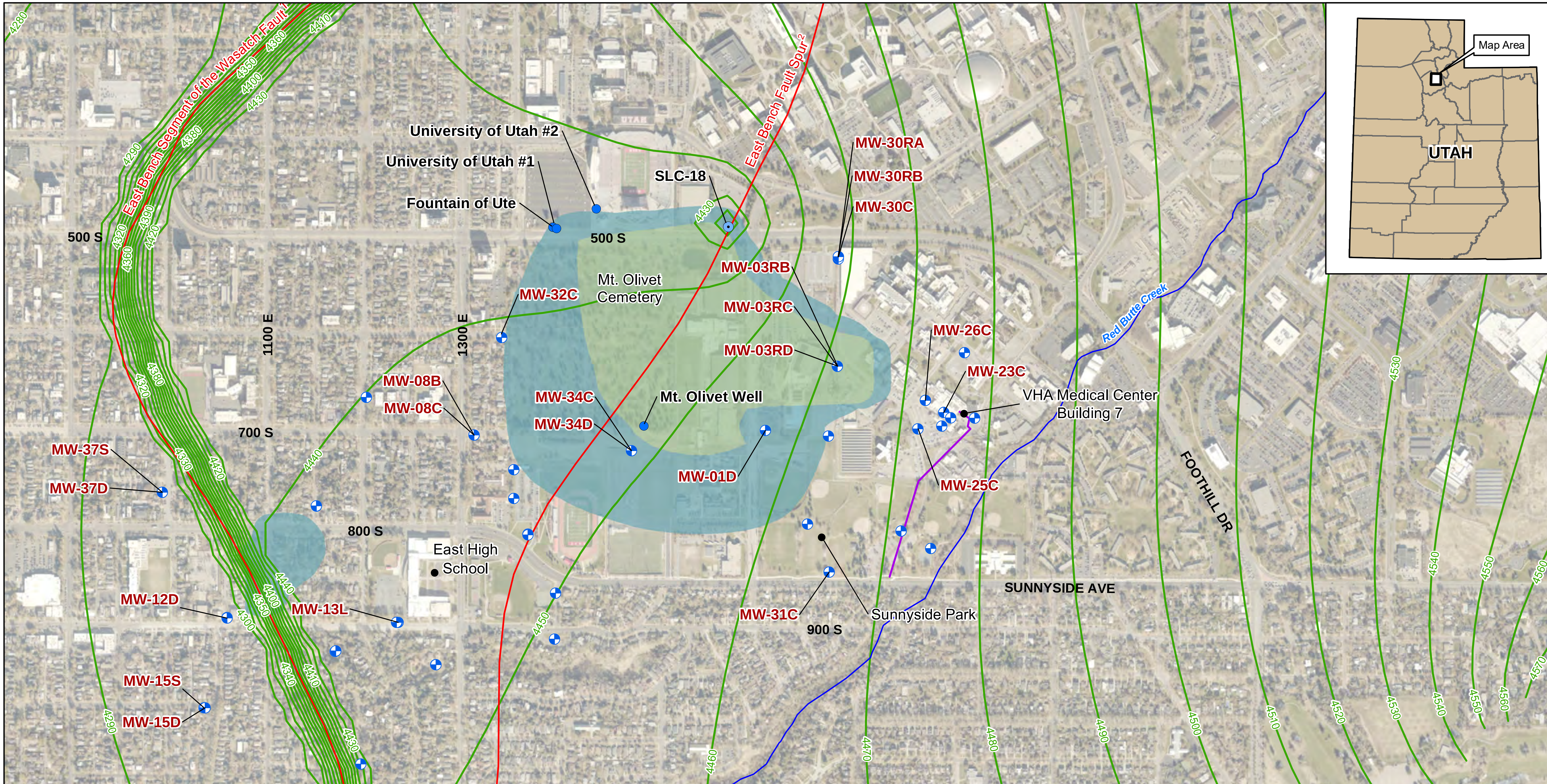
Figure 4-21a

Future Conditions - Initial PCE Concentrations
Deep Aquifer
Scenario 4: Proposed University Irrigation Pumping and Maximum (Water Right) Pumping at SLC-18

CDM Smith

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Future_Simulation_Base_Conditions\Deep_Aquifer_ConcentrationsT4_Future5_Initial.mxd HoughtonG 8/18/2021 2:48:45 PM



Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)
< 1
1 - 5
5 - 25
25 - 50
50 - 100
100 - 200
>200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.
[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

N W E S

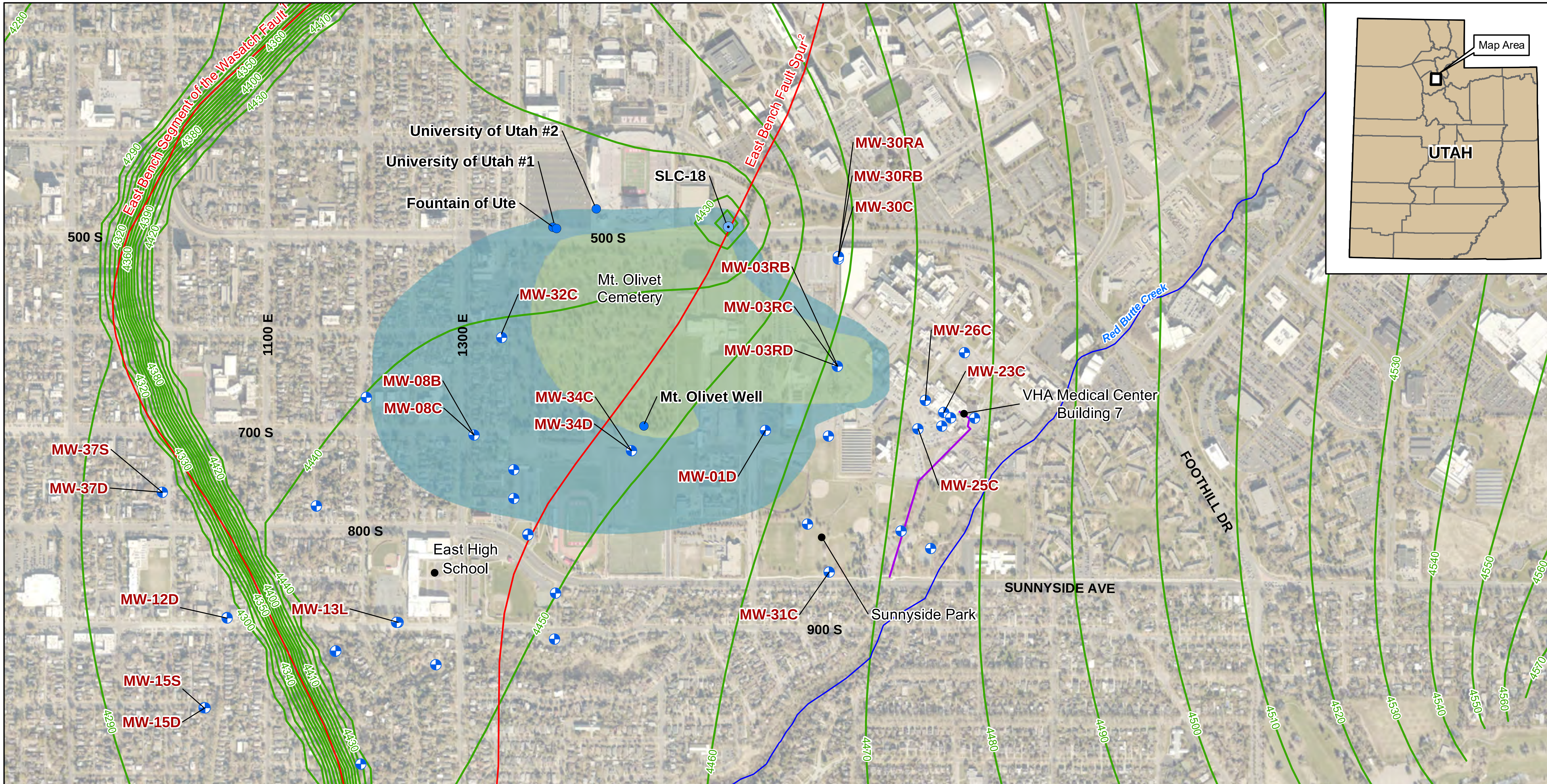
0 500 1,000 Feet

CDM Smith

Figure 4-21b
Future Conditions - Simulated 5 Year PCE Concentrations
Deep Aquifer
Scenario 4: Proposed University Irrigation Pumping
and Maximum (Water Right) Pumping at SLC-18

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Future_Simulation_Base_Conditions\Deep_Aquifer_ConcentrationsT4_Future5_5yr.mxd HoughtonG 8/17/2021 5:22:07 PM



Legend

	PCE (ug/L)
Monitoring Well	< 1
Abandoned Monitoring Well	1 - 5
Drinking Water Supply Well	5 - 25
Irrigation Well	25 - 50
Landmark	50 - 100
Red Butte Creek	100 - 200
Fault Line	>200
Sewer Line	
Head Contour (10-ft)	

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.
[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

N W E S

0 500 1,000 Feet

Figure 4-21c
Future Conditions - Simulated 10 Year PCE Concentrations
Deep Aquifer
Scenario 4: Proposed University Irrigation Pumping
and Maximum (Water Right) Pumping at SLC-18

CDM Smith

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

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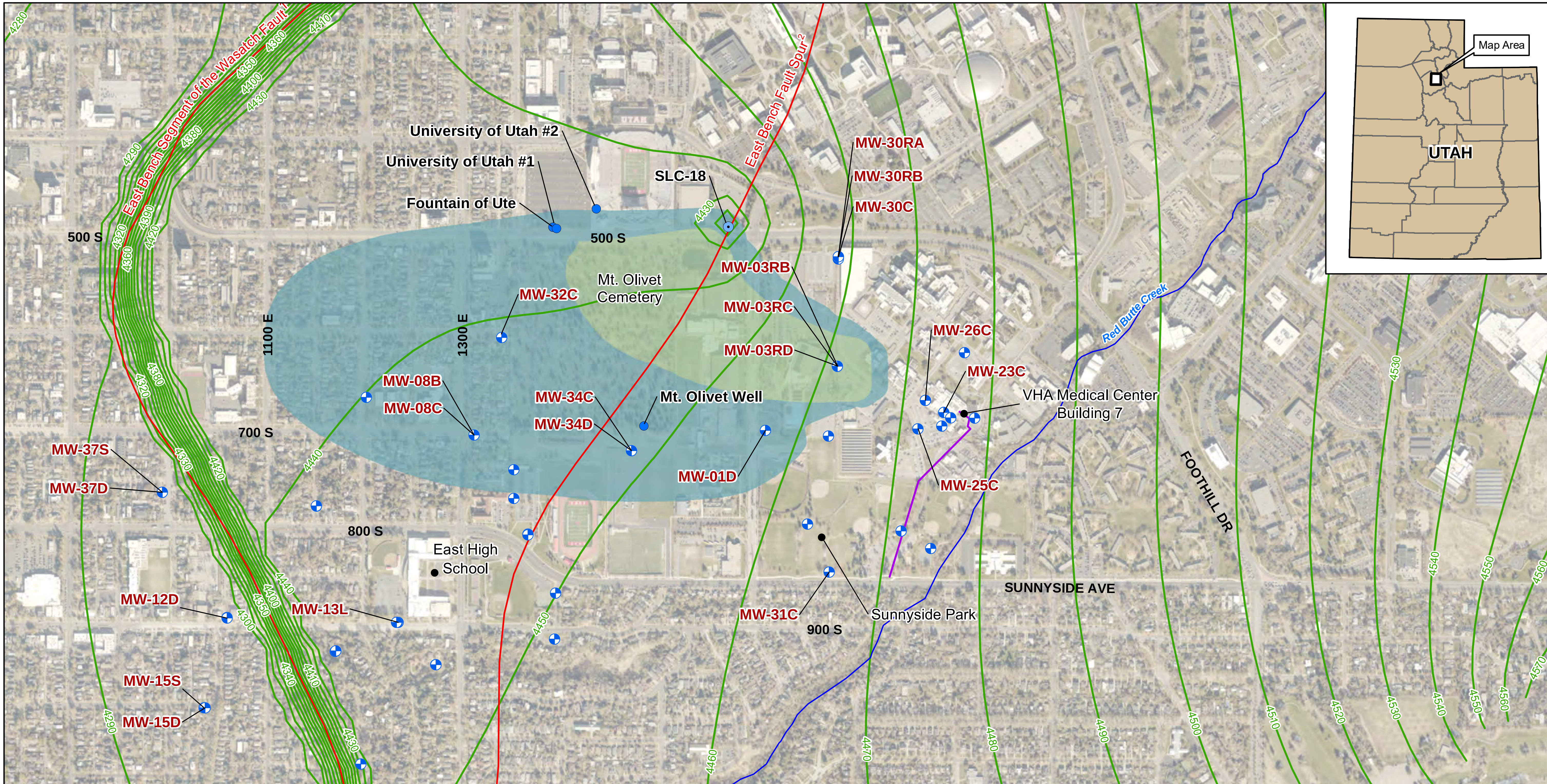

Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)

- < 1
- 1 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 200
- >200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.
[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

N W E S

0 500 1,000 Feet

Figure 4-21d

Future Conditions - Simulated 15 Year PCE Concentrations
Deep Aquifer
Scenario 4: Proposed University Irrigation Pumping
and Maximum (Water Right) Pumping at SLC-18

CDM Smith

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

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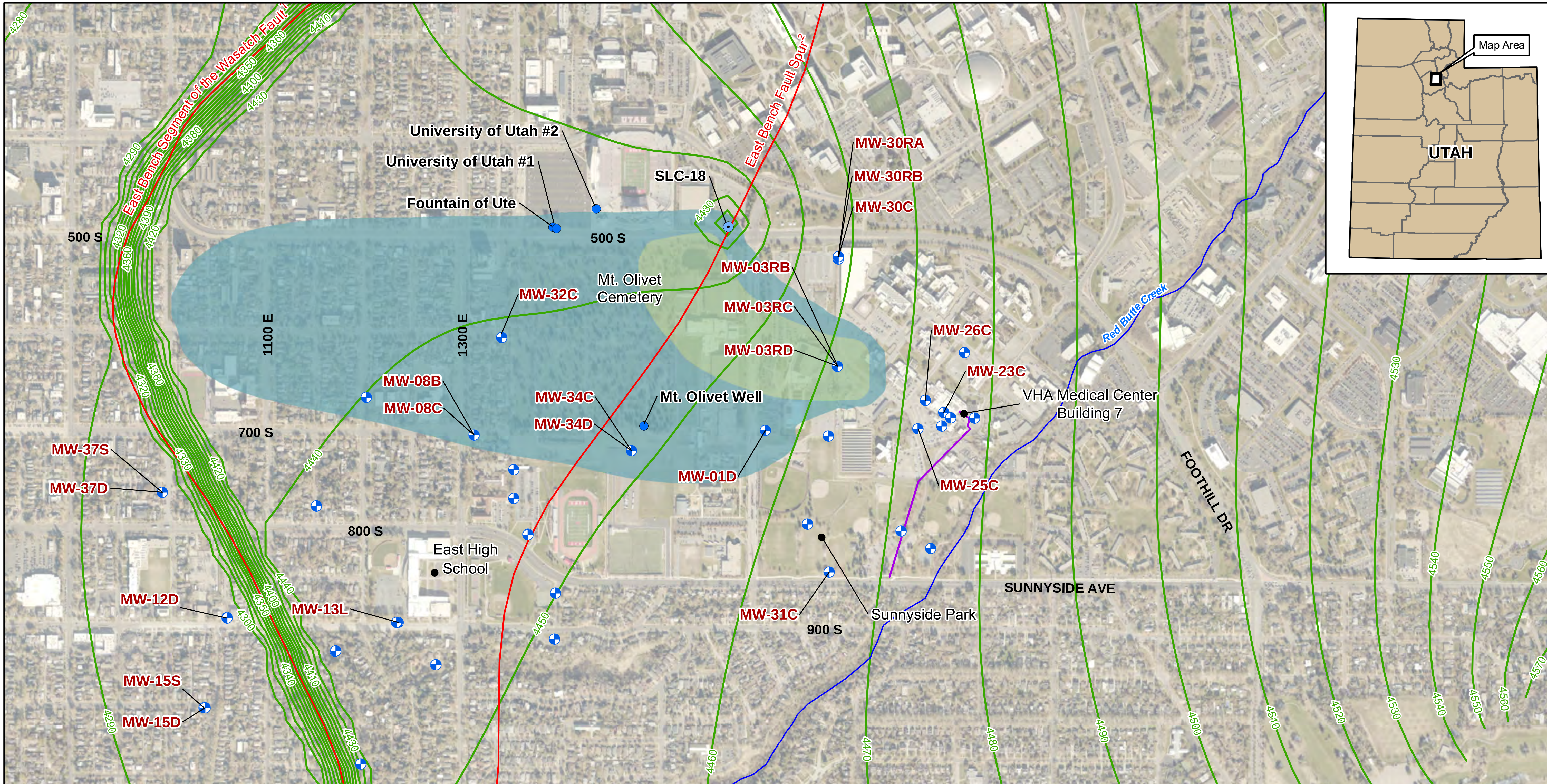

Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Landmark
- Red Butte Creek
- Fault Line
- Sewer Line
- Head Contour (10-ft)

PCE (ug/L)

- < 1
- 1 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 200
- >200

[1] Davis, F.D. 1983. Geologic Map of the Central Wasatch Front, Utah. Utah Geological and Mineral Survey. Map 54-A – Wasatch Front Series. May.
[2] Personius, S.F. and Scott, W.E. 2009. Surficial Geologic Map of the Salt Lake City Segment and Parts of Adjacent Segments of the Wasatch Fault Zone, Davis, Salt Lake, and Utah Counties, Utah

VHA = Veterans Health Administration

Figure 4-21e
Future Conditions - Simulated 20 Year PCE Concentrations
Deep Aquifer
Scenario 4: Proposed University Irrigation Pumping and Maximum (Water Right) Pumping at SLC-18

N W E S

0 500 1,000 Feet

CDM Smith

OU1 700 South 1600 East PCE Plume
Salt Lake City, Utah

File Path: E:\Salt_Lake_PCE\GIS\mxd\Future_Simulation_Base_Conditions\Deep_Aquifer_ConcentrationsT4_Future5_20yr.mxd HoughtonG 8/17/2021 5:21:25 PM