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Arizona Department of Environmental Quality
Voluntary Remediation Program
ATTN: Mr. John Patricki, Project Manager
1110 West Washington Street, Mailcode 4415B-1
Phoenix, AZ 85007

August 1, 2016

Subject: Supplemental Groundwater Evaluation Work Plan for the Honeywell Deer Valley Computer Park Site, Phoenix, Arizona, VRP Site Code 502825-00

Dear Mr. Patricki,

On behalf of Honeywell International Inc. (Honeywell), CH2M HILL Engineers, Inc. has prepared the attached work plan for activities intended to enhance the conceptual site model and support the ongoing optimization efforts for the Deer Valley Computer Park site.

Please contact me or Tao Wu (Honeywell Remediation Manager) if you have any questions or would like to discuss the proposed sampling. You may reach me by telephone at (480) 295-3922 or by email at Rick.Edwards@ch2m.com, and you may reach Tao by telephone at (602) 231-2015 or by email at Tao.Wu@Honeywell.com.

Regards,
CH2M HILL Engineers, Inc.

Rick Edwards
Project Manager

cc: Tao Wu, Honeywell International Inc.

WORK PLAN

Supplemental Groundwater Evaluation Work Plan for the Honeywell Deer Valley Computer Park Site (VRP Site Code 502825-00)

Prepared for

Honeywell International Inc.

REGISTERED GEOLOGIST
CERTIFICATE NO.
53073
ERIC A.
EDWARDS
DATE SIGNED 8/1/16
ARIZONA U.S.A.
Expires 12/31/2017

August 2016

CH2M HILL Engineers, Inc.
1501 West Fountainhead Parkway
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SITE: R37553
SUBJECT: 4.04.01

Contents

Acronyms and Abbreviations

µg/L	micrograms per liter
ADWR	Arizona Department of Water Resources
AWQS	Aquifer Water Quality Standard
bgs	below ground surface
GET	groundwater extraction and treatment
gpm	gallons per minute
IDW	investigation-derived waste
LAU	lower alluvial unit
LMAU	lower portion of the middle alluvial unit
MAU	middle alluvial unit
MMAU	middle portion of the middle alluvial unit
NOI	Notice of Intent
PDB	passive diffusion bag
PID	Photoionization detector
psi	pounds per square inch
PVC	polyvinyl chloride
RAP	remedial action plan
TCE	trichloroethene
TCLP	toxicity characteristics leaching procedure
UAU	upper alluvial unit
UMAU	upper portion of the middle alluvial unit
VOCs	volatile organic compounds

SECTION 1

Introduction

CH2M HILL Engineers, Inc. (CH2M), is currently evaluating options to optimize the groundwater extraction system for the Honeywell International Inc. (Honeywell) Deer Valley Computer Park site (site) located in Phoenix, Arizona, as described in the *Aquifer Rebound Test Work Plan in Support of Groundwater Model Recalibration for Deer Valley Computer Park* (rebound test work plan) (CH2M, 2014), which was approved by the Arizona Department of Environmental Quality (ADEQ) on September 24, 2014 (ADEQ, 2014). Figure 1-1 shows the locations of wells at the site.

The primary elements of the rebound test work plan are:

1. Conduct an aquifer test at extraction well E-1 to provide data that could be used to refine the groundwater model for the site
2. Use the updated groundwater model to optimize the extraction flow rate from well E-1

CH2M has completed the aquifer test and updated the groundwater model as proposed in the rebound test work plan. Results of the modeling indicated the need for additional information, as described in Section 1.3. This work plan describes planned activities to obtain additional data that can be used to support the ongoing modeling and optimization effort. Key components of the proposed work are:

- Conduct aquifer testing at well HM-06MA to refine estimates of the hydraulic properties of the uppermost aquifer unit.
- Install a temporary well screen and packer in well E-1 and collect a depth-discrete groundwater sample from the deepest aquifer unit to assess whether it has been impacted at this location by historical site activities.
- Install a nested monitoring well downgradient of well E-1 to confirm that groundwater extraction at the site is effective at containing impacted groundwater and to provide a monitoring point for potential future changes in extraction system operation.

The organization of this work plan is as follows:

- The remainder of Section 1 provides background information including site hydrogeology (Section 1.1), the remedial action at the site (Section 1.2) and the findings from the groundwater modeling (Section 1.3).
- Section 2 describes proposed aquifer testing and groundwater monitoring activities.
- Section 3 describes proposed well installation activities.
- Section 4 describes the reporting procedures for information produced during the field activities.
- Section 5 summarizes the project team.
- Section 6 summarizes the proposed project schedule.
- Section 7 provides references used in the work plan.

1.1 Site Hydrogeology

The site is located in a relatively flat landscape setting that is underlain by a thick sequence of basin fill deposits. The deposits are classified into three hydrogeologic units based on lithology and stratigraphic position. The hydrogeologic units are named, in descending order, the upper alluvial unit (UAU), the middle alluvial unit (MAU), and the lower alluvial unit (LAU).

The UAU is bounded by the ground surface above and the top of the MAU below. This unit was once unsaturated across much of the site, but has become water-bearing again over the past decade due to regional recovery in groundwater elevation. The unit is about 400 feet thick in the vicinity of the site and is dominated by sand and gravel.

The MAU is bounded by the UAU above and the LAU below and is about 450 feet thick in the vicinity of the site. The unit is saturated and is dominated by silt and clay.

The LAU is bounded by the bottom of the MAU above. The unit is saturated and is dominated by sand and gravel.

As part of annual groundwater monitoring activities, water levels were most recently measured from site groundwater monitoring wells on September 3, 2015. The majority of site monitoring wells are screened across the UAU and the upper portion of the MAU (UMAU), with screened intervals ranging from 279 to 590 feet below ground surface (bgs). September 2015 water levels and groundwater elevation contours for these wells are shown on Figure 1-2. Water levels indicate that lateral groundwater flow in the UAU/UMAU is directed toward the north, which is consistent with previous monitoring events. Figure 1-3 shows groundwater elevations in wells screened below the UMAU in September 2015. The screened intervals in these wells range from 581 to 975 feet bgs and intersect the middle and lower portions of the MAU (MMAU and LMAU) and the LAU. Groundwater elevations were not contoured for these wells due to the small number of data points, the large difference between screened intervals, and the dissimilarity in hydraulic properties between the zones of the aquifer. However, water levels in these wells were consistently lower than levels in the UAU/UMAU, indicating a downward vertical hydraulic gradient.

1.2 Current Remedial Action

Trichloroethene (TCE) was discovered in groundwater near the site in the mid-1980s. Since that time, Honeywell has investigated groundwater conditions, has developed the remedial action plan (RAP) (RUST, 1993), and has taken steps to eliminate sources of TCE at the site. TCE is present in the UAU and MAU at concentrations exceeding the Aquifer Water Quality Standard (AWQS), but not the LAU (Figures 1-4 and 1-5). TCE has never been detected at concentrations exceeding the AWQS in the LAU.

The RAP, which was approved by ADEQ on June 22, 1994 (ADEQ, 1994), proposed the following remedial actions for the site:

- Groundwater extraction
- Treatment of the extracted groundwater to a TCE concentration of no more than 5 micrograms per liter (µg/L)
- Discharge of the treated water to the Arizona Canal (this was changed to recharge of treated groundwater in Addendum C to the RAP [E. L. Montgomery & Associates, Inc., 1995]).

A groundwater pump-and-treat system began operation in 1997. Groundwater is extracted from well E-1 at a rate of approximately 700 gallons per minute and is conveyed via an underground pipeline to a treatment plant located at 13425 North 31st Avenue. Upon reaching the treatment plant, the water is initially filtered through a de-sander, followed by a set of bag prefilters. The water is then treated by a granular-activated carbon system to remove volatile organic compounds (VOCs).

Treated water is pumped through a second set of bag filters to a network of injection wells located north of Sweetwater Avenue (Figure 1-1). Extraction well E-1 is screened throughout the MAU and into the upper LAU.

1.3 Findings of Groundwater Model

CH2M has developed a three-dimensional numerical groundwater flow and solute transport model for the site as part of ongoing efforts to optimize the remedial action. The model was most recently updated following the completion of work outlined in *Aquifer Rebound Test Work Plan in Support of Groundwater Model Recalibration for Deer Valley Computer Park*, dated August 11, 2014. A detailed description of the model development, calibration, and results will be provided after the activities described in this work plan have been completed and the model has been updated to incorporate the additional information that is generated during the activities described herein.

A key finding of the modeling work is that groundwater flow within the MAU is primarily vertical (downward) rather than horizontal. This suggests that horizontal migration of TCE within the MAU is minimal. Despite the downward gradient, the MAU is composed primarily of silt and clay and is over 400 feet thick, which likely prevents TCE from migrating into the LAU at concentrations that exceed the AWQS. This limit on downward migration is supported by TCE concentrations observed in samples collected from wells HM-16MA (MAU) and HM-18LA (LAU), located close together south of well E-2 (Figure 1-1). Table 1-1 shows the concentrations in each of these wells during the most recent groundwater sampling event, in September 2015.

Table 1-1. 2015 Trichloroethene Concentrations in Wells HM-16MA and HM-18LA
Honeywell Deer Valley Computer Park, Phoenix, Arizona

Well	Screen Interval (Feet bgs)	Trichloroethene Concentration (µg/L)
HM-16MA	677–720	210
HM-18LA	933–975	< 0.50

As shown in Table 1-1, TCE exceeds AWQS in the well screened in the middle and lower portion of the MAU but is not detected in the well screened in the LAU. This is consistent with the findings of the groundwater model as TCE has migrated into the MAU but not into the LAU.

Also consistent with the groundwater model, the lack of horizontal TCE migration within the MAU is demonstrated by TCE concentrations in wells HM-17MA and HM-19MA, which are located horizontally downgradient of well HM-16MA and are screened in similar intervals. Table 1-2 shows the concentrations in these wells during the most recent groundwater sampling event, in September 2015.

Table 1-2. 2015 Trichloroethene Concentrations in Wells HM-15MA, HM-17MA, and HM-19MA
Honeywell Deer Valley Computer Park, Phoenix, Arizona

Well	Screen Interval (Feet bgs)	Trichloroethene Concentration (µg/L)
HM-16MA	677–720	210
HM-17MA	719–761	6.3
HM-19MA	581–623	< 0.50

As in previous sampling events, TCE concentrations in HM-16MA were significantly higher than those in HM-17MA and HM-19MA during September 2015. Even though there is a northward component of groundwater flow, this distribution indicates there has been minimal horizontal migration of TCE from the area near HM-16MA toward the area near HM-17MA and HM-19MA. This is consistent with the findings of the groundwater model.

These results have multiple implications for remedial actions at the site. First, if TCE within the MAU is not migrating northward, then using extraction well E-1 as a containment system is not necessary to prevent horizontal migration of the TCE within this unit. Second, because TCE has not been detected in the LAU at concentrations above the AWQS, groundwater extraction from the LAU is also not required for this site.

Given that extraction well E-1 is screened within the MAU and LAU, the preceding discussion suggests that its operation is not necessary to maintain capture of the TCE that is present in groundwater within these units. Instead, the focus of remediation efforts should be on the UAU, where horizontal migration of TCE is more likely. During development of the groundwater model, CH2M identified data gaps regarding aquifer properties and groundwater conditions within the UAU. To address these data gaps and support the site conceptual model, additional information is required, including:

1. A better understanding of the hydraulic properties of the UAU
2. Confirmation that the UAU downgradient of well HM-06 has not been impacted by TCE or other site-related VOCs at concentrations exceeding the AWQS
3. Additional confirmation that TCE is not migrating to the LAU at concentrations that exceed the AWQS at well E-1

This work plan describes planned activities to obtain this information.

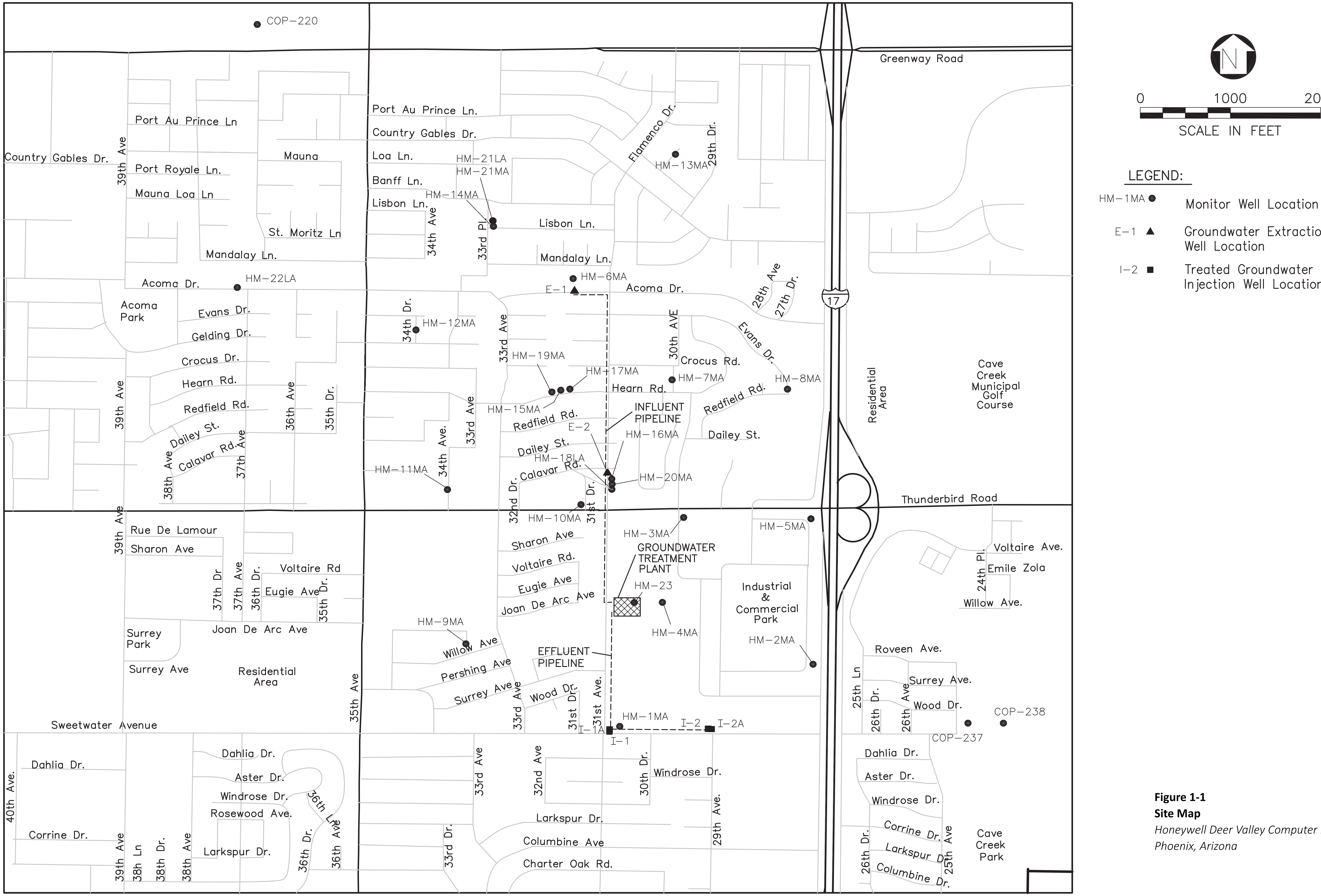

Figure 1-1
Site Map
Honeywell Deer Valley Computer Park
Phoenix, Arizona

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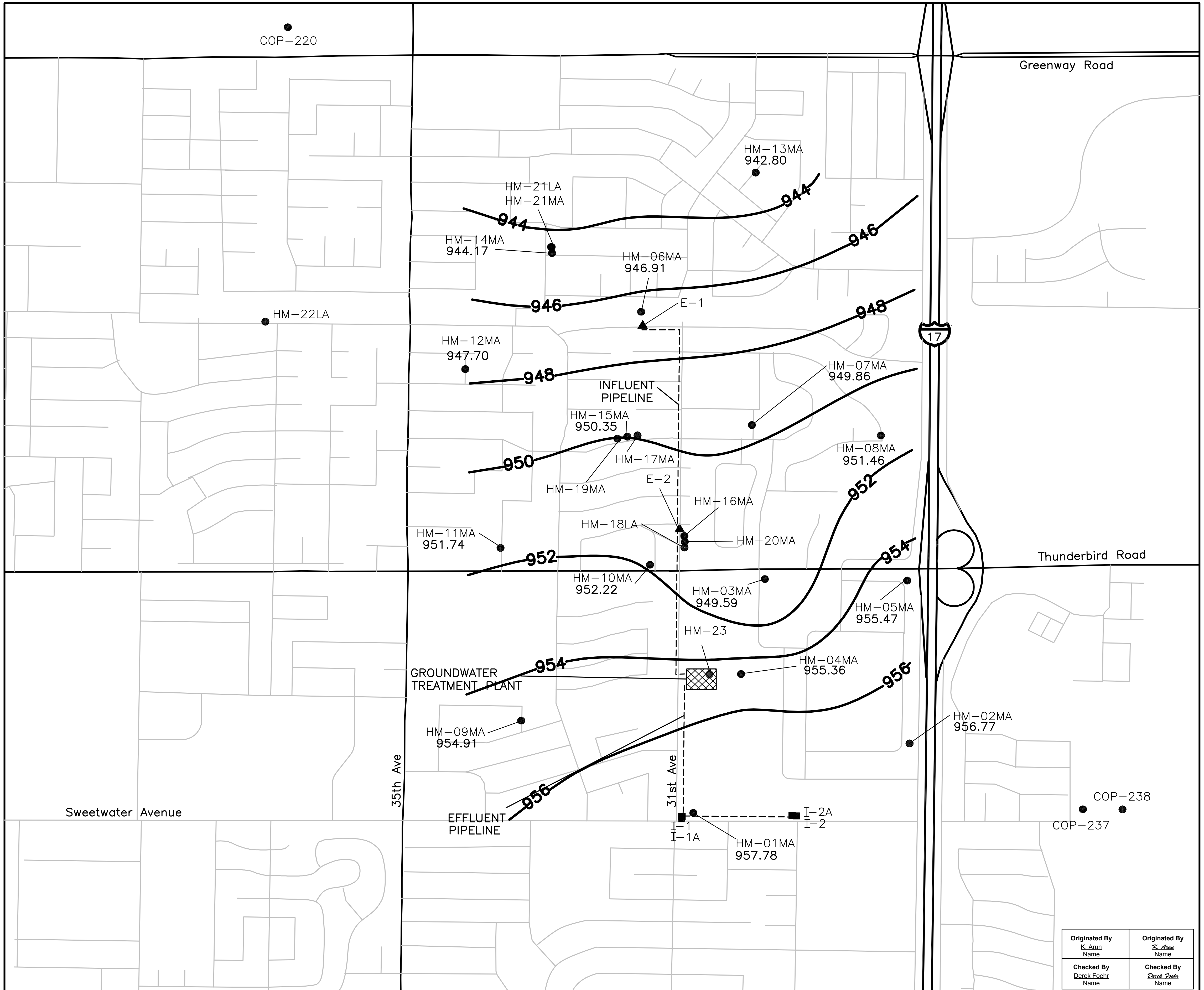

N

0 1000 2000

SCALE IN FEET

LEGEND:

HM–2MA ●	Honeywell Monitor Well Location
956.77	Static Water Level (ft AMSL)
E–1 ▲	Honeywell Groundwater Extraction Well Location
I–2 ■	Honeywell Treated Groundwater Injection Well Location
952	Groundwater Elevation Contour (ft AMSL)
*	Not used for contouring

NOTES:

1. Groundwater elevation contours were constructed with static water levels in the UAU/UMAU.
2. Groundwater elevations are only posted for wells screened in the UAU/UMAU.

Figure 1-2
September 2015 UAU/UMAU Groundwater Elevations
Honeywell Deer Valley Computer Park
Phoenix, Arizona

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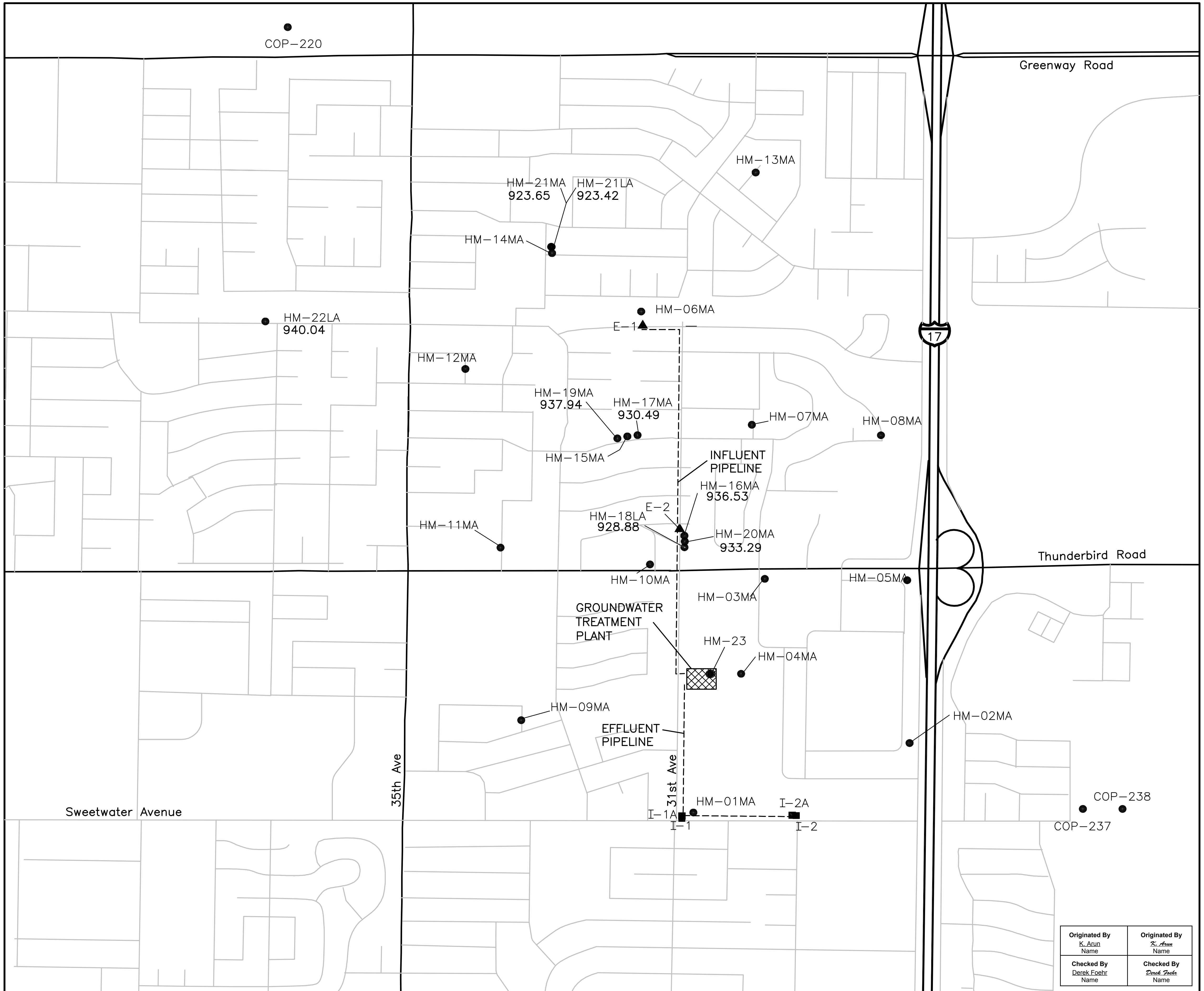

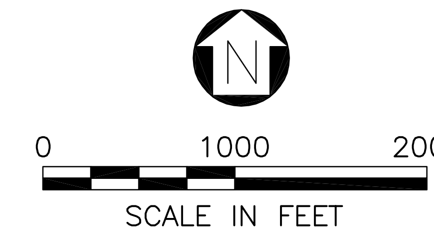

LEGEND:

- HM-19MA ● Honeywell Monitor Well Location
- 937.94 — Static Water Level (ft AMSL)
- E-1 ▲ Honeywell Groundwater Extraction Well Location
- I-2 ■ Honeywell Treated Groundwater Injection Well Location

NOTES:

1. Groundwater elevations are only posted for wells screened in the MMAU, LMAU, and LAU.
2. MMAU wells include HM-16MA and HM-19MA.
3. LMAU wells include HM-20MA and HM-21MA.
4. LAU wells include HM-18LA, HM-21LA, and HM-22LA.
5. HM-17MA is considered proximal to the LMAU.

Figure 1-3
September 2015 MMAU, LMAU and LAU Groundwater Elevations
Honeywell Deer Valley Computer Park
Phoenix, Arizona

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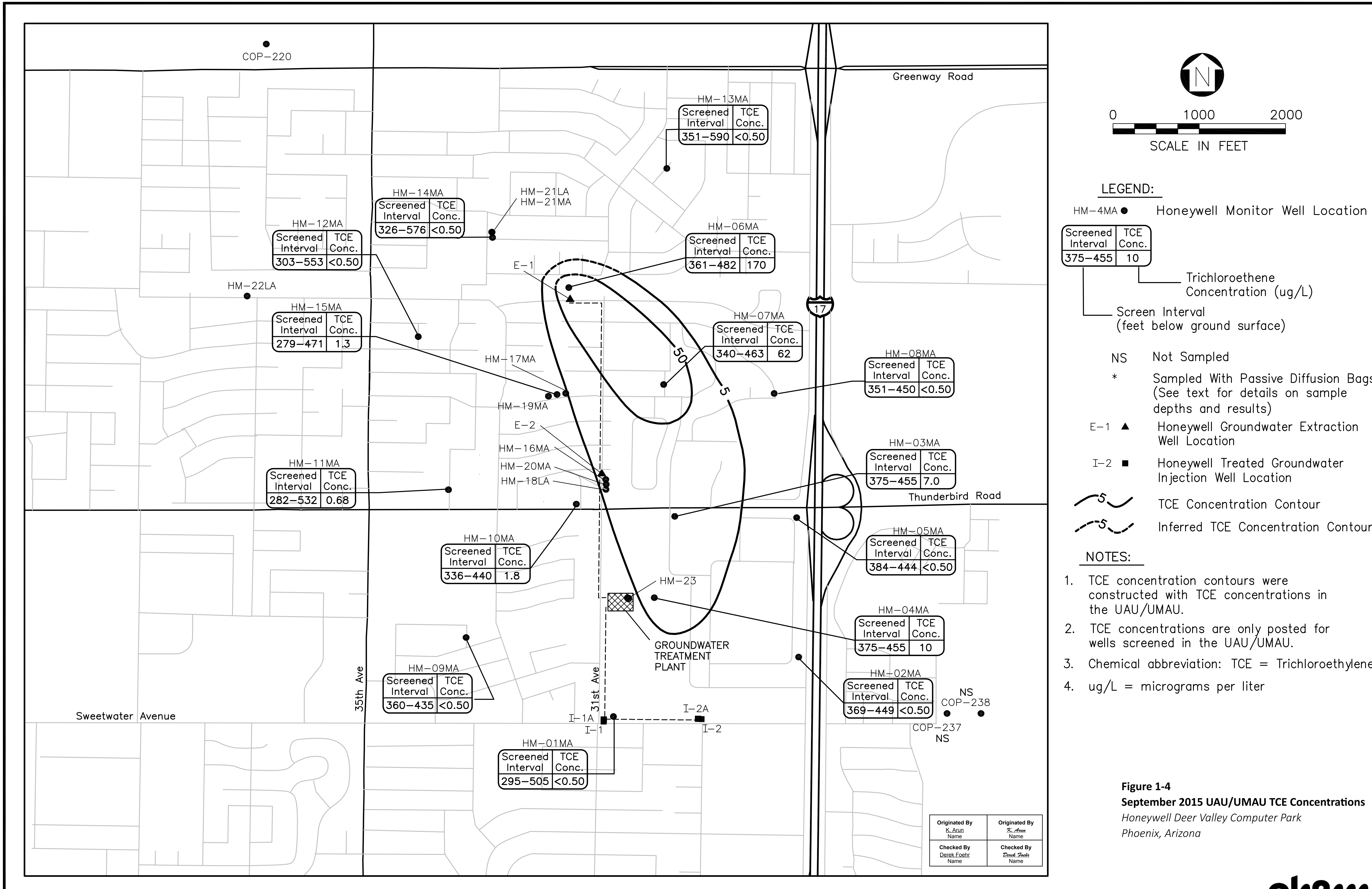

Figure 1-4
September 2015 UAU/UMAU TCE Concentrations
Honeywell Deer Valley Computer Park
Phoenix, Arizona

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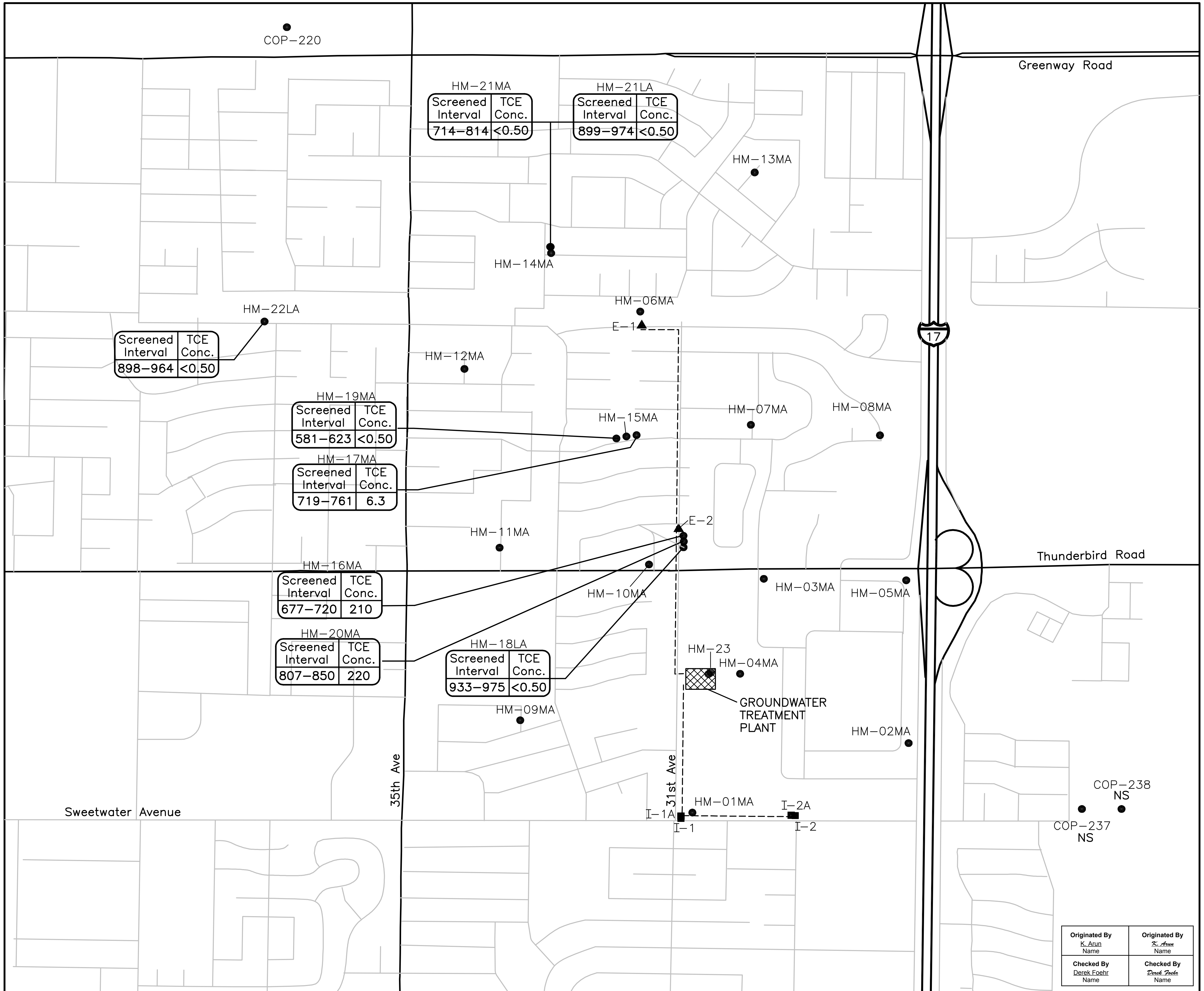

N

0 1000 2000
SCALE IN FEET

LEGEND:

HM-21MA ● Honeywell Monitor Well Location

Screened Interval	TCE Conc.
714-814	<0.50

Trichloroethene Concentration (ug/L)

Screen Interval (feet below ground surface)

E-1 ▲ Honeywell Groundwater Extraction Well Location

I-2 ■ Honeywell Treated Groundwater Injection Well Location

NOTES:

1. TCE concentrations are only posted for wells screened in the MMAU, LMAU, and LAU.
2. MMAU wells include HM-16MA and HM-19MA.
3. LMAU wells include HM-20MA and HM-21MA.
4. LAU wells include HM-18LA, HM-21LA, and HM-22LA.
5. HM-17MA is considered proximal to the LMAU.
6. Chemical abbreviation: TCE = Trichloroethylene
7. ug/L = micrograms per liter

Figure 1-5
September 2015 MMAU, LMAU and LAU TCE Concentrations
Honeywell Deer Valley Computer Park
Phoenix, Arizona

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Aquifer Testing and Groundwater Sampling

To enhance the conceptual site model and to support ongoing groundwater flow modeling and contaminant fate and transport modeling, CH2M proposes to shut down extraction well E-1 for a period of approximately 6 months, or longer, so that data can be collected to estimate the hydraulic properties of the UAU and better determine chemical properties in the UAU and LAU. The pump in E-1 will be restarted, if deemed necessary for plume containment, after the additional site characterization efforts have been completed.

During the shutdown, step-rate and constant-rate aquifer tests will be performed at well HM-06MA, a monitoring well near E-1 that is partially screened within the UAU. Groundwater samples will be collected from HM-06MA both at the beginning of the step-drawdown test and at the end of the constant-rate test. An LAU groundwater sample from E-1 will also be collected during the shutdown. The proposed shutdown, aquifer testing, and groundwater sampling are discussed in detail below. In addition to this work, CH2M also proposes to install and sample a new monitoring well, further described in Section 3.

2.1 HM-06MA Aquifer Testing and Groundwater Sampling

2.1.1 Pressure Transducer Deployment

Approximately one week before the groundwater extraction and treatment (GET) system shutdown, CH2M will deploy pressure transducers in HM-06MA and in six nearby wells to record groundwater levels during the GET shutdown and aquifer testing. Table 2-1 presents a complete list of wells that will be monitored during the GET shutdown and aquifer testing.

Table 2-1. Proposed Wells for Pressure Transducer Deployment
Honeywell Deer Valley Computer Park, Phoenix, Arizona

Well ID	Aquifer Unit	Transducer Range (psi)
E-1	MAU/LAU	50
HM-06MA	UAU/MAU	50
HM-12MA	UAU/MAU	5
HM-7MA	MAU	5
HM-13MA	UAU/MAU	5
HM-14MA	UAU/MAU	5
HM-15MA	UAU/MAU	5

psi – pounds per square inch.

The pressure transducers will be vented units and rated to allow for detection of very small changes in groundwater levels during testing. A barometric transducer vented to the atmosphere will also be deployed in one of the observation wells above the water level to record time-series barometric pressure before, during, and following testing. All transducers will be set to record instantaneous readings at 1-minute intervals for the duration of deployment.

2.1.2 System Shutdown

After pressure transducers have been deployed and are successfully recording data for approximately one week, pumping at E-1 will be terminated. The pump at E-1 will remain off during aquifer testing and sampling activities. LAU groundwater sampling of E-1 will be conducted during the shutdown and is described further in Section 2.2.

2.1.3 Step-drawdown Aquifer Test at HM-06MA

Aquifer rebound will be monitored with the installed pressure transducers following the shutdown of E-1. Based on results of previous aquifer testing at well E-1, it is assumed water levels will take approximately 3 days to recover, after which CH2M will conduct a step-drawdown aquifer test at HM-06MA. For the test, CH2M proposes the pump intake in HM-06MA be placed at the approximate boundary between the UAU and MAU, a depth of 448 feet bgs. Pumping from this depth will allow the maximum amount of drawdown within the UAU, thereby maximizing the stress on the UAU while reducing flow from the MAU.

CH2M assumes that the pumping phase of the step-drawdown test will last approximately 8 hours at a pumping rate ranging from 20 gallons per minute (gpm) to the maximum pumping rate that the well can sustain (likely 40–50 gpm). Extraction steps will be increased in 10 gpm increments every 2 hours until the maximum sustained extraction rate is attained. For the purposes of the test, the maximum sustained extraction rate is considered to be the rate at which drawdown is no greater than 10 feet above the pump intake (~438 feet bgs). Based on water levels measured in September 2015, the maximum drawdown for the test will be approximately 95 feet, although the actual drawdown will be determined based on updated water levels measured before the start of the test. As a supplement to the data collected by the pressure transducers, groundwater levels will also be manually measured throughout the test at a reasonable frequency given that driving will be required. The manual measurements will provide redundancy in case a transducer fails or is displaced during the test. Extracted groundwater will be discharged to the existing discharge line, which conveys water to the treatment plant.

2.1.4 Constant-rate Aquifer Test at HM-06MA

Once the maximum sustainable pumping rate has been achieved, extraction at this rate will continue for 48 hours. During this period, groundwater levels will continue to be recorded both manually and with transducers. As with the step-drawdown test, manual measurements will be made as frequently as practicable given the distances between monitoring wells. After 48 hours of constant-rate extraction, the pump in HM-06MA will be turned off to allow groundwater levels to recover. Monitoring of groundwater levels in the wells will continue through the aquifer recovery phase until water levels have recovered to at least 90 percent of pretest levels.

2.1.5 Collection of Samples for Chemical Analyses

In conjunction with the aquifer testing, groundwater samples for chemical analyses will be collected from HM-06MA both at the beginning of the step-drawdown test and at the end of the constant-rate test. CH2M will collect the groundwater samples using the sample pump that is installed for the pump testing in accordance with the attached standard operating procedure (Appendix A). The pump intake will be installed at a depth of 428 feet, the first sample will be collected, and then the pump intake will be lowered to 448 feet for the pump testing. This will facilitate collection of a sample that is representative of the UAU. After the testing and rebound monitoring is completed, the pump will be raised to 428 feet and the second sample will be collected. The samples will be handled under chain-of-custody procedures and analyzed by an Arizona Department of Health Services–certified laboratory for VOCs by EPA Method 8260B.

2.1.6 Aquifer Test Data Analysis

The groundwater level data resulting from aquifer testing will be processed and reformatted into appropriate input formats for the various analysis methods and software platforms that will be used to evaluate the test results. To estimate well hydraulic parameters (for example, specific capacity) and aquifer properties (for example, transmissivity, hydraulic conductivity, and groundwater storage), CH2M plans to use a combination of methods to analyze the data that result from the proposed aquifer testing program. The following steps will be employed:

1. Aquifer test data will be initially evaluated to determine whether deconvolution of the data is warranted. If deemed necessary, the USGS deconvolution spreadsheet will be used to filter "noise" from the data (http://pubs.usgs.gov/sir/2006/5024/).
2. The semianalytical model MLU for Windows, version 2.25.67 will be used to analyze both the step-drawdown and constant-rate aquifer tests (http://www.microfem.com/products/mlu.html).
3. After an initial set of hydraulic properties for the UAU has been estimated using MLU for Windows, those properties will be imported into the three-dimensional numerical groundwater flow model that has been developed for the site. The step-drawdown and constant-rate aquifer tests will then be simulated using the numerical model. An iterative approach will be used with the goal of determining a single set of hydraulic properties that can reasonably replicate data from both aquifer tests using both the numerical model and the semianalytical model. This approach of using two different and independent solution methods to analyze the same data set will provide an additional level of confidence in the results of the aquifer test analysis.

Once data analysis is complete, the site groundwater model will be refined based on the updated hydraulic properties for the UAU. The updated model will be used to identify the location for the proposed monitoring well to be installed north (downgradient) of E-1 and HM-06MA, as described in Section 3.

2.2 E-1 (LAU) Sampling

2.2.1 Packer and Sample Port Installation

Groundwater sampling of the LAU will be conducted at well E-1 in conjunction with the aquifer testing at HM-06MA. E-1 is screened within the MAU and LAU, with the unit boundary located at approximately 820 feet bgs. After E-1 is turned off at the onset of aquifer testing, the pump in the well will be removed and a temporary sampling port will be installed within the LAU section of the well as shown on Figure 2-1. The temporary port will consist of a 4-inch-inner-diameter schedule 40 well casing and 0.020-inch screen installed within the larger diameter E-1 well. The screen will be installed near the top of the LAU from approximately 840 to 880 feet bgs. An inflatable packer will be installed above the screen (near 835 feet bgs) to seal off the sampling port from the MAU.

2.2.2 LAU Groundwater Sample Collection

Following installation of the temporary sampling port in E-1, static water within the isolated LAU section of E-1 will be allowed to flush out under ambient groundwater flow. This will reduce the likelihood that the LAU sample will be impacted by VOCs that may have migrated from the MAU into the LAU within the well. Based on an assumed hydraulic conductivity within the LAU of between 10 and 75 feet per day and an assumed horizontal hydraulic gradient of 0.02, it is estimated to take between 7 and 52 days for groundwater within the LAU portion of E-1 to be flushed out by ambient groundwater flow. The actual time required may be longer than this because the flow within the well may differ from that within the aquifer.

Approximately 60 days after the LAU port is installed, a passive diffusion bag (PDB) will be installed in the well. After being allowed to equilibrate for at least 2 weeks, the PDB will be retrieved and a sample will be collected in accordance with the SOP provided in Appendix A. The sample will be handled under chain-of-custody procedures and will be analyzed for VOCs by EPA Method 8260B by an Arizona Department of Health Services–certified laboratory.

Results from the sample will affect the new well installation discussed in Section 3. If the PDB sample indicates VOC concentrations do not exceed the AWQS in the LAU, a new nested LAU well will not be installed. If VOC concentrations exceed the AWQS in the LAU, additional samples will be collected on a monthly basis for 3 months to establish a concentration trend. If concentrations decrease during the sampling period, it is possible that the VOCs observed resulted from conduit flow within well E-1 prior to installation of the packer, and therefore the presence of VOCs in the samples would not indicate that the LAU is otherwise impacted at this location. Additional efforts to confirm that the VOCs are not present in the LAU as a result of conduit flow within E-1 may also be undertaken. Details regarding these efforts will be provided to ADEQ for consideration if Honeywell believes that these actions would be beneficial.

2.2.3 Packer and Sample Port Removal

Removal of the packer and sample port and resumption of GET operations will be considered based on the results of the aquifer testing, groundwater sampling, well installation, and modeling. As discussed in Section 1.3, extracting groundwater from the MAU and LAU may not be necessary because the composition of the MAU restricts horizontal and vertical migration of TCE. As discussed in Section 2.1.6, the groundwater flow model will be updated with data obtained from the aquifer test at well HM-06MA, and used to propose the location of a new monitoring well. Part of this evaluation will include determining whether or not TCE is present in the UAU and, if it is, estimating the TCE migration velocity in the UAU under nonpumping conditions. This information will be used to estimate whether containment within the UAU is necessary, what flow rate would be required, and how long well E-1 could remain offline before TCE containment is lost. An alternate extraction scenario—such as extracting at a reduced flow rate from within the UAU—may also be developed during this evaluation.

Honeywell anticipates that resuming groundwater extraction at well E-1 at the current flow rate (on the order of 725 gpm) will not be necessary before the data collection and analysis activities described in this work plan, including the groundwater modeling, are completed. Once these activities are completed, Honeywell will make recommendations regarding future operation of the GET system, as described in Section 4. However, extraction at well E-1 may resume before these activities are completed if the evaluation indicates that continued containment under the current flow regime is necessary. Conditions that may indicate the need for continued extraction include:

- TCE is observed in E-1 within the LAU at concentrations that exceed the AWQS.
- TCE is observed in the new, downgradient monitoring well at concentrations that exceed the AWQS and would migrate downgradient without operation of E-1.
- Groundwater modeling indicates that containment of groundwater within the UAU is necessary, and that containment may be lost during the time that it takes to develop and implement an alternate pumping regime that focuses on the UAU.

Should one of these conditions occur, or a similar condition that would necessitate resuming operation of well E-1, Honeywell will communicate the condition, as well as supporting data, to ADEQ and resume operation of well E-1. The evaluation described in this work plan would continue, and additional recommendations for optimization may be made in the future based on the results.

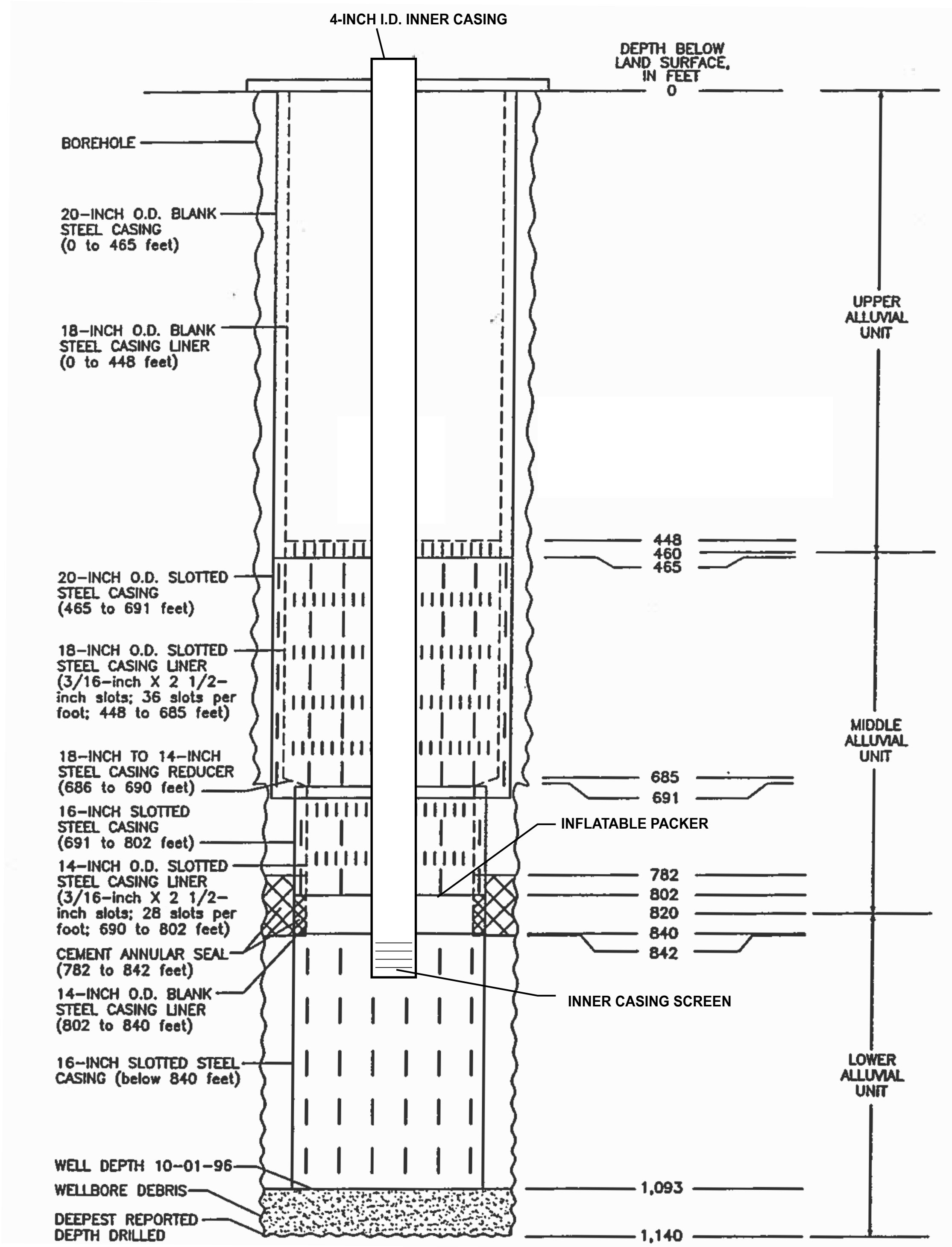

Figure 2-1
Proposed Configuration for Well E-1 Sampling
Honeywell Deer Valley Computer Park
Phoenix, Arizona

Monitoring Well Installation

Nested monitoring wells will be installed in a single borehole north of extraction well E-1 at a location based on the results of the activities outlined in Section 2. As discussed in Section 4, CH2M will present the ADEQ with a technical memorandum summarizing the completed aquifer testing and groundwater sampling activities, and will subsequently meet with the ADEQ to discuss the well installation plans. At a minimum, nested well screens will be installed within the UAU and MAU. A third well screen located within the LAU will also be installed if VOC concentrations exceed the AWQS in the LAU groundwater sample that will be collected from E-1. The purpose of the new well is to confirm that VOCs have not migrated beyond the predicted capture zone of extraction well E-1. The well can also be used in the future to monitor downgradient concentrations during proposed changes in the extraction regime.

3.1 Project Planning

Several tasks are required prior to mobilization, including Blue Stake notification, utility location, receipt of a City of Phoenix Construction Permit, and submittal of a Notice of Intent (NOI) form to the Arizona Department of Water Resources (ADWR). Some of these tasks will be performed by the well installation contractor.

3.1.1 ADWR Notice of Intent

An NOI to Drill an Environmental Well form must be submitted to ADWR and a Drill Card received by the driller prior to the commencement of drilling activities. The NOI submittal consists of the form, well construction diagrams, and a fee payment of $150 per well. Proposed well information will be provided to the drilling contractor, who will obtain the appropriate ADWR permit. This process is typically rapid and may be accomplished within a few days.

3.1.2 Utility Locating

The boring location requires a Blue Stake ticket as well as clearance by a private utility locator using geophysical methods to locate subsurface utilities. CH2M will mark the drilling location in white paint prior to proceeding with utility clearances. The drilling contractor will manage utility clearances and provide copies of clearances to CH2M prior to mobilization.

3.1.3 City of Phoenix Construction Permit

CH2M will obtain a permit from the City of Phoenix to install the well within the right-of-way. Obtaining the permit will require:

- Three copies of a construction drawing showing a plan view of the well construction, a cross section of the proposed well, and a detail of the wellhead
- Completion of the “Monitoring Wells in Right-Of-Way Checklist”
- Completion of the “Prelog Administrative Review” form
- Associated review fees, permit fee, and cash bond

3.1.4 Public Notice

Honeywell will provide notification of drilling activities to residents adjacent to the proposed well location by mailing a flier containing a description of the proposed work, anticipated work hours and duration, a map showing the proposed well location, and contact information if residents are interested in obtaining additional information. The flier will be distributed approximately 14 days prior to commencement of work.

3.2 Drilling

The drilling will be conducted using a rig that is in good working order and has been cleaned of visible grease, oil, and other contamination prior to mobilization to the site. The rig will be inspected by CH2M before work is initiated to assess and direct repair of any leaks of fuels or lubricants.

3.2.1 Drilling Method

Drilling will be conducted using either mud-rotary or sonic drilling methods. The final selection of method will partially depend on whether or not a well will be installed within the LAU. If the LAU well is necessary, mud rotary drilling methods will be used. Drilling will consist of advancing a pilot hole to total depth (920 feet) then reaming out the hole to a larger diameter to a depth of 620 feet (the bottom depth for the MAU well). The driller would then remove cuttings that may have partially filled the pilot hole to facilitate well installation in the LAU.

If the LAU well is not necessary, sonic drilling methods will be employed. Drill casing will be telescoped down to total depth, starting with 10-inch and ultimately reducing to 6-inch-diameter casing.

3.2.2 Soil Sampling

CH2M will collect two soil samples from within the saturated zone of each stratigraphic unit to provide data that can be used to support modeling and optimization efforts. Analyses will include the following:

- Total and effective porosity
- Bulk density
- Fraction of organic content
- Magnetic susceptibility
- Soil oxidant demand

Measurements of porosity, bulk density, and fraction organic content will be used to support groundwater modeling for the site. Magnetic susceptibility will be used to evaluate the potential for abiotic degradation of VOCs due to the presence of magnetite in the alluvial materials. Soil oxidant demand will be measured to provide data that could be used if in situ chemical oxidation is considered in the future.

Each sample container will be labeled with a sample identification number, site name, sampler's initials, date and time of sample collection, preservative, and the parameters to be analyzed. After sample collection, each sample will be logged on a chain-of-custody form and packaged to prevent damage during shipment. The samples, along with the corresponding chain-of-custody form, will be shipped to the laboratory for analysis.

3.2.3 Soil Logging

Lithologic observations will be recorded on CH2M's standard boring log forms or using P-log software on hand-held personal data acquisition devices. The field scientist will note soil attributes such as color, particle size, consistency, moisture content, structure, plasticity, odor (if obvious) and organic content (if visible). Soil cuttings will be described using ASTM D2488. Photoionization detector (PID) readings obtained from the soil cuttings during drilling will also be recorded on the boring log forms, and the initial depth at which groundwater is encountered will be noted, if it can be determined. Lithologic logs will be prepared upon completion of drilling.

3.2.4 Air Monitoring Activities

A PID will be used during the drilling activities to check for hazardous environments and protect workers (for example, identify the need for personal protective equipment upgrades). Specific procedures and requirements for air monitoring are described in the health and safety plan for the site.

3.2.5 Equipment Decontamination

Drilling equipment brought to the site will be free of heavy mud, oil, or other contamination. Down-hole drilling equipment will be decontaminated before and after drilling by the subcontractor using the following procedure:

1. Brush or spray equipment with nonphosphate detergent and potable water solution
2. Rinse equipment with potable water
3. Rinse a second time with potable water
4. Air-dry equipment

Decontamination may be done on a temporary or portable decontamination pad to be located at the equipment staging area.

3.2.6 Field Equipment and Forms

Types of field equipment required include soil logging equipment, safety equipment, and field forms. Examples of equipment expected to be needed to complete the work described in this work plan are described below.

3.2.6.1 Field Equipment

- Paper towels
- Liquid hand soap
- Nitrile gloves
- Ziploc bags
- Trash bags
- Cooler for drinking water
- Ice and drinking water
- Water proof pens
- Water level indicator
- Stainless steel or plastic bowls
- Stainless steel or plastic spoons
- Clear glass jars

3.2.6.2 Safety Equipment

- Health and safety plan
- Traffic cones
- Safety glasses
- Hardhat
- Safety vest
- Steel toed boots
- Ear plugs (disposable)
- First aid kit
- Bloodborne pathogen kit
- Fire extinguisher (should also be one in each of the subcontractor’s vehicles)

- Work gloves (leather or cotton)
- Organic vapor monitoring device (for example, PID)

3.2.6.3 Field Forms

- Labels for waste containers
- Field log book
- Boring logs for adjacent wells
- Blue Stake ticket numbers for each location
- Contact list
- Copy of ASTM D2488 procedures for identifying soils
- Blank soil boring logs
- Blank bid schedules or daily quantity tracking forms
- Daily tailgate health and safety briefing forms and safe behavior observation forms
- Health and safety self-assessment checklists

3.3 Well Installation and Development

3.3.1 Well Casing and Screen

Each monitoring well will be constructed using 2-inch-internal-diameter Schedule 80 polyvinyl chloride (PVC) casing and will include a 20-foot interval of Schedule 80 PVC factory-slotted well screen. All connections will be flush joint threaded. Screens will be placed from 400–420 feet bgs (UAU), 600–620 feet bgs (MAU), and 860–880 feet bgs (LAU, if necessary). Table 3-1 summarizes well construction materials, and Figure 3-1 shows a proposed construction diagram.

Table 3-1. Summary of Proposed Well Construction
Honeywell Deer Valley Computer Park, Phoenix, Arizona

Well Port	Proposed Screen Interval (Feet bgs)	Proposed Screen Slot Size (Inches)	Proposed Filter Pack Sand Size
UAU	400–420	0.045	10-20
MAU	600–620	0.015	20-40
LAU (if needed)	860–880	0.045	10-20

3.3.2 Well Completion Materials

The annular space between the well casings and the borehole wall will be filled with a combination of filter pack, bentonite seal, and cement-bentonite grout. The wells will be installed such that the UAU, MAU, and LAU are hydrologically separated from each other to prevent migration of contaminants between units.

3.3.3 Filter Pack

Each well screen will be surrounded by a filter pack consisting of Colorado silica sand. Sand will be placed through a tremie pipe from the bottom to approximately 5 feet above the top of each screen. Each filter pack will be placed at a uniform rate without segregation or bridging of material. The top of the sand pack will be tagged to verify its depth during placement. The contractor will record the volume of the filter pack emplaced surrounding each well screen. Potable water may be used, with the approval of the field geologist, to emplace the filter packs, as long as no contaminants are introduced to the subsurface.

3.3.4 Bentonite Seal and Annular Grout

A bentonite seal at least 5 feet thick will be placed on top of each filter pack.

The bentonite seal requirements are as follows:

- Only 100 percent sodium bentonite will be used. Bentonite pellets coated in isopropanol are not acceptable.
- Bentonite must be in pellet or tablet form. The use of granular bentonite or bentonite chips is not acceptable.
- A setup time of at least 1 hour is required before grouting to allow the bentonite to hydrate.

A cement-bentonite grout mixture will be placed between each bentonite seal and filter pack and from the top of the shallowest bentonite seal to approximately 1 foot below the ground surface. The annular grout requirements are as follows:

- The cement-bentonite grout slurry will be composed of the following proportions:
  - One 94-pound bag of neat portland cement (conforming to ASTM C150, B: Type I and Type II)
  - Not more than 4 to 5 pounds of 100 percent sodium bentonite powder
  - Not more than 6 gallons of potable water
- The seal will be emplaced using a method (for example, tremie) that forces grout upward from the bottom of the interval that is being sealed.
- In cases where a well and filter pack are being installed on top of a grout seal, the seal will be allowed to set prior to continuing with installation.

3.3.5 Surface Completion

The wells will be completed in a 12-inch-diameter, traffic-rated, flush-mounted vault surrounded by a concrete pad. A watertight expanding-rubber-seal-type locking cap and will be provided for each well to prevent water infiltration from the surface. The identity of the well will be permanently marked on the casing cap.

3.3.6 Well Development

The monitoring wells will be developed by airlifting sediment after a waiting period of at least 24 hours following well construction and annular seal placement. Each port of the well will be developed until the water is clear of drilling mud. Material generated during the surging will be transferred to a portable tank located at the groundwater treatment plant. Investigation-derived waste (IDW) water generated during well development will be containerized and disposed of as described in Section 3.4.

3.3.7 Well Surveying and Completion Diagram

Following surface completion, the new monitoring wells will be surveyed by a licensed surveyor for well datum elevation and location. All existing site monitoring and extraction wells will also be resurveyed at this time. In addition to a lithologic log, a well completion diagram will be also prepared. It will include the following information:

- Well identification
- Drilling method
- Installation date(s)
- Elevations of ground surface and the measuring point
- Total boring depth
- Lengths and descriptions of the screens and casings

- Lengths and descriptions of the filter packs, bentonite seals, and grout
- Depth to groundwater in the constructed wells

3.4 Investigation-derived Waste Management

IDW generated during well installation will include soil, drilling mud, development water, and decontamination water. Soil will be containerized in a roll-off bin staged near the drilling area. Each bin will be moved to the groundwater treatment plant once it is full, and another bin will be delivered to the drilling site. CH2M will collect composite samples from each roll-off bin (the sample for VOCs will be collected as four individual aliquots from each bin, which will be composited at the laboratory). Soil samples will be analyzed for VOCs using EPA Method 8260B, SVOCs using EPA Method 8270 SIM, the toxicity characteristics leaching procedure (TCLP) for the eight Resource Conservation and Recovery Act (RCRA) metals using EPA Methods 6010B (arsenic, barium, cadmium, chromium, lead, selenium, and silver), 7470A (mercury), and 1311 (TCLP preparation); and pH using EPA Method SW-9045C. It is assumed that the soil cuttings will be characterized as nonhazardous waste and will transported to an appropriate facility for disposal.

A sample of the drilling mud will be collected when the drilling enters the lowest unit that will be encountered (the LAU, unless an LAU well is not installed, in which case the lowest unit would be the MAU). The sample will be analyzed for the same parameters as the soil cuttings on a 24-hour-turnaround basis. It is anticipated that the mud will be characterized as nonhazardous waste and will be transported to a landfill for disposal once the well is installed.

Water generated during drilling activities will be containerized in a portable tank and transported to the groundwater treatment plant. CH2M will collect a grab sample from the portable tank to be analyzed for VOCs using EPA Method 8260B. Assuming that the water is characterized as nonhazardous waste, the water will be discharged to the ground at the groundwater treatment plant.

All waste storage containers must be labeled with a “Pending Analysis” label. Each label must have the following information:

- Date of waste generation
- Generator name (in this case, Honeywell)
- Contact person (CH2M representative)
- Contact phone number

Used personal protective equipment and consumable supplies will be double-bagged and disposed of as municipal waste.

3.5 Recordkeeping

All field and sampling activities will be recorded in a bound field notebook. Entries will be dated, legible, written in permanent ink, and contain accurate and inclusive documentation of project activities. Entries will include, but not be limited to, observations, descriptions of problems encountered, sample identification information, and changes made to the procedures described in this work plan. At a minimum, field notes must include descriptions of the work activities including:

- Date of entry
- Project name and location
- Time that work starts every day
- Summary of weather conditions
- Daily progress of work activities, and equipment and personnel onsite

- Work operations, sequencing, staging, etc.
- Summaries of meetings and actions recommended to be performed
- Sampling and testing activities
- Deviations from plans (sampling analysis plan, quality assurance project plan, work plan, etc.)
- Decisions made regarding defective work or corrective measures implemented, or both
- Testing equipment and personnel
- Calibration of test equipment
- Start time and duration of downtime resulting from equipment breakdown, weather, or emergencies, etc.
- Description of materials delivered to the site, including quality control data provided by the suppliers
- Observations, inspections, and records of general quality control activities
- Maintenance and inspection of waste disposal areas

Field sampling information obtained during sampling will be entered into the logbook. This includes the sample identification, location, depth, date and time of sample collection, parameters requested for analysis, field measurement and calibration data, analysis data and methods, sample distribution and transport, and field observations.

Samples collected for waste profiling will be documented using IDW waste profiling forms.

Field staff will record (in a field notebook and on the IDW tracking forms) the number of bins, size of bin, and tanks delivered to the site, when the waste containers are demobilized, and date of sampling notifications.

Corrections in the logbooks will be made by striking out the incorrect entry with a single line so that the original entry is not obliterated. The person making the correction will also initial and date the crossed-out entry. The correct entry will then be made below the crossed-out entry. The bottom of each page of the field notebook will be signed or initialed, and each entry dated in order to show that notes are being taken on a daily basis. A line-through will be placed on any portion of a field notebook that is unused.

3.6 Groundwater Sampling

Following installation and development, the new monitoring wells will be sampled quarterly for one year using PDBs. After one year, the new monitoring wells will be sampled annually as part of the routine groundwater monitoring program for the site. Sampling will be conducted in accordance with the *Deer Valley Computer Park Annual Groundwater Sampling Field Instructions* (CH2M, 2012). Routine groundwater monitoring for the site, which involves sampling all site monitoring wells annually, will continue unchanged, although Honeywell may make recommendations for optimization of the monitoring program in the future.

The LAU port installed in well E-1 is not intended to be part of the routine groundwater monitoring program at the site. The configuration and use of well E-1 may change based on the evaluation described in this work plan.

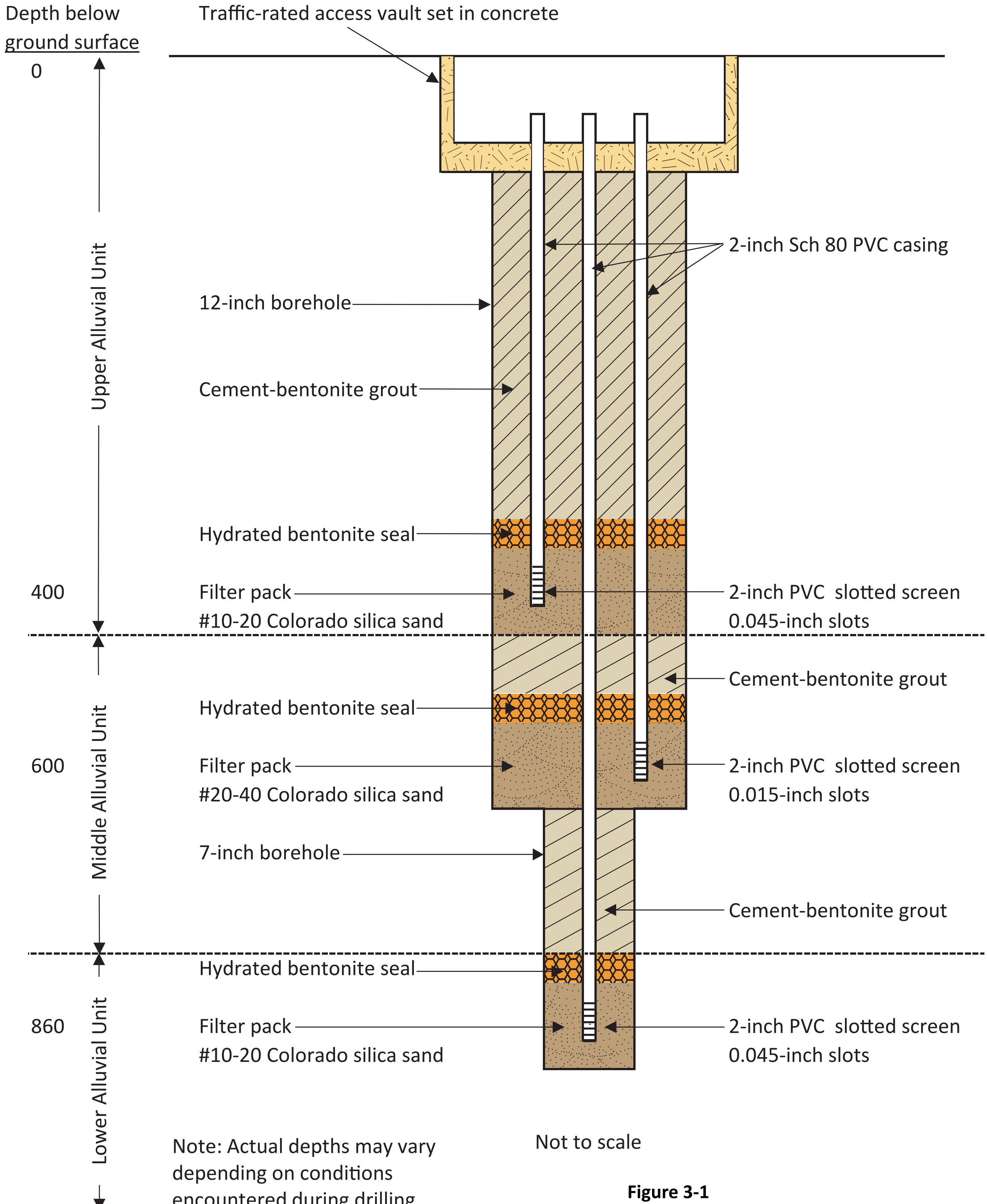

Figure 3-1
Proposed Well Construction Diagram
Honeywell Deer Valley Computer Park
Phoenix, Arizona

Reporting

Three separate documents will be generated as a result of the field activities described above. CH2M will initially prepare a technical memorandum after aquifer testing and groundwater sampling has been completed that summarizes the activities and their results. Results presented in the memorandum will provide the basis for determining both the location of the new groundwater monitoring well and the units that it screens. CH2M will meet with the ADEQ to discuss installation of the new wells in light of these results prior to proceeding with installation activities.

CH2M will prepare a second technical memorandum after the new monitoring wells have been installed to document the drilling and well installation activities. The memorandum will include a boring log and well completion diagram for the new wells. Analytical results from the first quarterly PDB sampling event of the new wells will also be included in this report along with results for the soil samples collected during drilling. Subsequent sampling results of the new monitoring wells will be presented in the annual groundwater monitoring report.

Data collected during both phases of field activities will be used to update the three-dimensional numerical groundwater model that is currently under development for the site. After the model has been updated to incorporate the recently generated information, CH2M will prepare an additional report detailing model development, calibration, and results. This report will provide a recommendation regarding future operation of the GET system on this basis of the updated modeling results, historical data, and new data collected as part of the activities described in this work plan.

Project Team

Project roles and pertinent contact information for individuals involved in this project are listed in Table 5-1.

Table 5-1. Project Team
Honeywell Deer Valley Computer Park, Phoenix, Arizona

Position	Name and Contact Information
Arizona Department of Environmental Quality Project Manager	John Patricki Office: 602-771-4397
Honeywell Remediation Manager	Tao Wu Office: 602-231-2015
Project Manager	Rick Edwards/PHX Office: 480-295-3922 Mobile: 480-570-7162
Health and Safety	Jeff Hilgaertner/PHX Mobile: 714-552-1971 Occupational Health Nurse 866-893-2514
Local Site Contact	Tom Kearsley/PHX Office: 602-231-4091 Mobile: 480-747-1531
Senior Technical Consultant	John Tunks /DEN Office: 720-286-5271 Mobile: 303-931-6138
Subject Matter Expert	Peter Lawson /RDD Office: 530-229-3383 Mobile: 530-949-0870
Project Hydrogeologist	Darren Meadows/SLC Office: 385-474-8570 Mobile: 775-219-9716
Field Team	Ramzi Ramzi Mobile: (619) 241-5856
Environmental Manager	Gretchen Engel/PHX Office: 480-295-3923 Mobile: 928-242-3700

SECTION 6

Schedule

Table 6-1 summarizes the proposed timing of activities associated with aquifer testing and well installation. The schedule is subject to change depending on variables such as the time required for permitting and the availability of subcontractors. Honeywell will provide notice to ADEQ prior to initiating field activities.

Table 6-1. Proposed Schedule
Honeywell Deer Valley Computer Park, Phoenix, Arizona

Activity	Start Date	End Date
Notify adjacent residents of aquifer testing	9/15/2016	9/15/2016
Install transducers	9/17/2016	9/18/2016
Turn off extraction well E-1 pump, install LAU sampling port and packer	9/29/2016	9/30/2016
Conduct step test of HM-06MA	10/3/2016	10/3/2016
Conduct constant-rate test of HM-06MA	10/4/2016	10/6/2016
Analyze aquifer test data, update groundwater model	10/6/2016	11/4/2016
Sample E-1 LAU	12/15/2016	12/29/2016
Submit aquifer testing technical memorandum and propose location and screened units for new monitoring well	1/27/2017	1/27/2017
Notify adjacent residents of new monitoring well	3/6/2017	3/6/2017
Install new monitoring well	3/20/2017	4/7/2017
Sample new monitoring well	4/10/2017	4/24/2017
Submit well installation technical memorandum	6/30/2017	6/30/2017
Submit groundwater modeling report	8/4/2017	8/4/2017

Notes:

LAU = lower alluvial unit.

SECTION 7

References

Arizona Department of Environmental Quality (ADEQ). 1994. Letter of Determination for the Remedial Action Plan for the *Groundwater Remediation in the Vicinity of Deer Valley Computer Park*, dated September 1993. June 22.

Arizona Department of Environmental Quality (ADEQ). 2014. Approval of *Aquifer Rebound Test Work Plan in Support of Groundwater Model Recalibration,* Honeywell Deer Valley Computer Park, 13425 N 31st Avenue, Phoenix, Arizona 85029, Site Code: 502825-00. September 24.

CH2M. 2012. *Deer Valley Computer Park Annual Groundwater Sampling Field Instructions*. October.

CH2M. 2014. *Aquifer Rebound Test Work Plan in Support of Groundwater Model Recalibration*. August 11.

E. L. Montgomery & Associates, Inc. 1995. Addendum C to the *Remedial Action Plan for Groundwater Remediation in the Vicinity of Deer Valley Computer Park*. March.

RUST. 1993. *Remedial Action Plan for Groundwater Remediation in the Vicinity of Deer Valley Computer Park*. September.

Appendix A
Standard Operating Procedures

Decontamination of Personnel and Equipment

I. Purpose

To provide general guidelines for the decontamination of personnel, sampling equipment, and monitoring equipment used in potentially contaminated environments.

II. Scope

This is a general description of decontamination procedures.

III. Equipment and Materials

- Demonstrated analyte-free, deionized ("DI") water (specifically, ASTM Type II water or lab-grade DI water)
- Potable water; must be from a municipal water supplier, otherwise an analysis must be run for appropriate volatile and semivolatile organic compounds and inorganic chemicals (e.g., Target Compound List and Target Analyte List chemicals)
- 2.5% (W/W) Liquinox® and water solution
- Concentrated (V/V) pesticide grade isopropanol (DO NOT USE ACETONE)
- Large plastic pails or tubs for Liquinox® and water, scrub brushes, squirt bottles for Liquinox® solution, methanol and water, plastic bags and sheets
- DOT approved 55-gallon drum for disposal of waste
- Personal Protective Equipment as specified by the Health and Safety Plan
- Decontamination pad and steam cleaner/high pressure cleaner for large equipment

IV. Procedures and Guidelines

A. Personnel Decontamination

To be performed after completion of tasks whenever potential for contamination exists, and upon leaving the exclusion zone.

1. Wash boots in Liquinox® solution, then rinse with water. If disposable latex booties are worn over boots in the work area, rinse with Liquinox® solution, remove, and discard into DOT-approved 55-gallon drum.
2. Wash outer gloves in Liquinox® solution, rinse, remove, and discard into DOT-approved 55-gallon drum.

3. Remove disposable coveralls (“Tyveks”) and discard into DOT-approved 55-gallon drum.
4. Remove respirator (if worn).
5. Remove inner gloves and discard.
6. At the end of the work day, shower entire body, including hair, either at the work site or at home.
7. Sanitize respirator if worn.

B. Sampling Equipment Decontamination—Groundwater Sampling Pumps

Sampling pumps are decontaminated after each use as follows.

1. Don phthalate-free gloves.
2. Spread plastic on the ground to keep equipment from touching the ground
3. Turn off pump after sampling. Remove pump from well and remove and dispose of tubing. Place pump in decontamination tube.
4. Turn pump back on and pump 1 gallon of Liquinox® solution through the sampling pump.
5. Rinse with 1 gallon of 10% isopropanol solution pumped through the pump. (DO NOT USE ACETONE). (Optional)
6. Rinse with 1 gallon of tap water.
7. Rinse with 1 gallon of deionized water.
8. Keep decontaminated pump in decontamination tube or remove and wrap in aluminum foil or clean plastic sheeting.
9. Collect all rinsate and dispose of in a DOT-approved 55-gallon drum.
10. Decontamination materials (e.g., plastic sheeting, tubing, etc.) that have come in contact with used decontamination fluids or sampling equipment will be disposed of in either DOT-approved 55-gallon drums or with solid waste in garbage bags, dependent on Facility/project requirements.

C. Sampling Equipment Decontamination—Other Equipment

Reusable sampling equipment is decontaminated after each use as follows.

1. Don phthalate-free gloves.
2. Before entering the potentially contaminated zone, wrap soil contact points in aluminum foil (shiny side out).
3. Rinse and scrub with potable water.
4. Wash all equipment surfaces that contacted the potentially contaminated soil/water with Liquinox® solution.
5. Rinse with potable water.
6. Rinse with distilled or potable water and isopropanol solution (DO NOT USE ACETONE). (Optional)
7. Air dry.
8. Rinse with deionized water.

9. Completely air dry and wrap exposed areas with aluminum foil (shiny side out) for transport and handling if equipment will not be used immediately.
10. Collect all rinsate and dispose of in a DOT-approved 55-gallon drum.
11. Decontamination materials (plastic sheeting, tubing, etc.) that have come in contact with used decontamination fluids or sampling equipment will be disposed of in DOT-approved 55-gallon drums or with solid waste in garbage bags, dependent on facility/project requirements.

D. Health and Safety Monitoring Equipment Decontamination

1. Before use, wrap soil contact points in plastic to reduce need for subsequent cleaning.
2. Wipe all surfaces that had possible contact with contaminated materials with a paper towel wet with Liquinox® solution, then a towel wet with methanol solution, and finally three times with a towel wet with distilled water. Dispose of all used paper towels in a DOT-approved 55-gallon drum or with solid waste in garbage bags, dependent on facility/project requirements.

E. Sample Container Decontamination

The outsides of sample bottles or containers filled in the field may need to be decontaminated before being packed for shipment or handled by personnel without hand protection. The procedure is:

1. Wipe container with a paper towel dampened with Liquinox® solution or immerse in the solution AFTER THE CONTAINERS HAVE BEEN SEALED. Repeat the above steps using potable water.
2. Dispose of all used paper towels in a DOT-approved 55-gallon drum or with solid waste in garbage bags, dependent on facility/project requirements.

F. Heavy Equipment and Tools

Heavy equipment such as drilling rigs, drilling rods/tools, and the backhoe will be decontaminated upon arrival at the site and between locations as follows:

1. Set up a decontamination pad in area designated by the facility
2. Steam clean heavy equipment until no visible signs of dirt are observed. This may require wire or stiff brushes to dislodge dirt from some areas.

V. Attachments

None.

VI. Key Checks and Items

- Clean with solutions of Liquinox®, Liquinox® solution (optional), and distilled water.
- Do not use acetone for decontamination.
- Drum all contaminated rinsate and materials.
- Decontaminate filled sample bottles before relinquishing them to anyone.

Passive Diffusion Bag Sampling for VOCs from Monitoring Wells

I. Purpose and Scope

This procedure presents general guidelines for the collection of groundwater samples from monitoring wells using passive diffusion bag (PDB) sampling procedures. The supplier of the PDB samplers and PDB sampler hardware should be consulted for procedures specific to the type of sampler and hardware assembly being used.

II. Equipment and Materials

- Water-level indicator
- Pre-filled passive diffusion bags (various lengths and sizes)
- Disposable straws
- Protective mesh sleeves
- Pre-measured harnesses, stainless steel hanger assembly, including weights
- 2-gallon resealable plastic bags for storing dedicated PDB hardware
- Well-construction information
- Sample containers
- Shipping supplies (labels, coolers, and ice)
- Field book
- Air monitoring and personal protective equipment

III. Procedures and Guidelines

A. Setup and Deployment of the PDB Samplers

Field personnel shall wear latex or nitrile gloves while setting up and handling the PDB sampler. Do not expose PDB samplers to areas where there are exhaust fumes or other potential sources of contamination.

1. Review project requirements and well construction information (as necessary) to determine the placement depth of the PDB sampler
2. Open the well and begin screening breathing zone with air monitoring device until sampling is complete, in accordance with the HASP.
3. Measure the depth to groundwater in each monitoring well following the SOP for *Water-Level Measurements*. Record the measurement and ensure that the planned placement depth is completely below the water level.

4. Slide the PDB sampler into a clean, protective mesh sleeve.
5. Attach a pre-measured suspension harness to the well head to secure the PDB sampler during deployment. Next, attach the pre-measured harness and a stainless-steel weight to the PDB sampler.
6. Slowly lower the stainless-steel weight, PDB sampler, and line into the well casing until the line holding the PDB sampler is taut.
7. Close and lock the well casing.

B. PDB Sampler Equilibration and Sample Recovery

For VOC sampling, the PDB sampler should be left in the well for a period of at least two weeks (14 days) prior to retrieval.

Field personnel shall wear chemical resistant gloves when handling the PDBs and collecting samples. Gloves shall be replaced after the sampler has been pulled out of the well but prior to sample collection. PDB sample recovery should be conducted as follows:

1. Open the well and begin screening breathing zone with the air monitoring device until sampling is complete, in accordance with the HASP.
2. Slowly remove the PDB sampler from the well by pulling up the weighted line. Avoid exposing the sampler to heat or agitation.
3. Examine the exterior of the sampler for tears in the membrane material. Make a detailed observation in the field notes of any residues or discoloration on the exterior of the sampler. Water from samplers in which the membrane has been damaged cannot be submitted for analysis.
4. Remove the sampler from the weighted line. Discard the rope and decontaminate the weight, harness, and/or hangar assembly for future use. If pre-measured and dedicated harnesses, weights, and/or hangar assemblies are used, they should be placed back into the well casing.
5. To minimize cross contamination, remove any excess liquid from the exterior of the sampler by wiping off the PDB sampler with a paper towel.
6. To transfer the water from the sampler to sample containers, hold the PDB vertically and poke into the PDB near the bottom with the pointed end of a clean disposable straw. Fill the sample containers through the straw.
7. Immediately upon collection, all samples for chemical analysis are to be placed in a closed container on ice unless it is not possible to do so. Although unusual and uncommon, there may be instances where it is not possible to have containers with ice at the sample location. In these instances, the samples should be placed on ice as soon as practical and during the time between collection and placing the samples on ice, the samples should be kept as cool as possible.
8. Any unused water in the PDB sampler should be transferred to a 55-gallon drum and managed per project requirements.
9. Dispose of the PDB sampler membrane, rope, and gloves in accordance with project requirements.

IV. Attachments

None.

V. Key Checks and Preventative Maintenance

- Carefully handle the PDB samplers during setup and retrieval as to avoid damage to the sampler membranes or cross contamination.
- Do not expose PDB samplers to areas where there are exhaust fumes or other fumes.
- Determine depths for PDB sampler installation prior to field mobilization.
- When possible, use pre-filled PDB samplers filled by the laboratory and pre-measured harnesses for PDB samplers.
- Do not use water from PDB samplers for laboratory analysis if the PDB sampler membrane is damaged.
- Decontaminate the weight, harness, and/or hangar assembly for future use if dedicated equipment is not used.
- For VOC analysis, PDB samplers will require at least two weeks between deployment and sample recovery.

Well-Volume Groundwater Sampling from Monitoring Wells

I. Purpose and Scope

This procedure presents general guidelines for collecting groundwater samples from monitoring wells using the well-volume approach. The procedure **does not** address purging and sampling using "low-flow" techniques. Operations manuals should be consulted for specific calibration and operating procedures.

II. Equipment and Materials

- Adjustable-rate positive-displacement pump, submersible pump, or peristaltic pump
- Bailers (Teflon or stainless steel) and nylon cord, if applicable
- Horiba® U-22 or equivalent water quality meter to monitor pH, specific conductance, turbidity, dissolved oxygen, oxidation-reduction potential (ORP), and temperature
- Air monitoring equipment
- Personal protective equipment
- Flow-through cell with inlet/outlet ports and watertight ports for each probe
- Generator or alternate power source depending on pump type
- Water-level indicator
- Disposable Teflon, Teflon-lined polyethylene tubing or polyethylene tubing for metals and other inorganics
- Plastic sheeting
- Well-construction information
- Calibrated container and stopwatch to determine flow rate
- Purged water containers
- Sample containers
- Waste container labels
- In-line disposable 0.45-µm filters (QED® FF8100 or equivalent)
- Shipping supplies (labels, coolers, and ice)
- Aluminum foil
- Field book

<u>Note: bailers and peristaltic pumps should only be used when site access or other limitations prevent the use of sampling pumps</u>

III. Procedures and Guidelines

A. Setup and Purging

1. Obtain information on well location, diameter(s), depth, and screened interval(s), and the method for disposal of purged water.
2. A pump will be used for well purging if the well yield is adequate; otherwise, a bailer may be used depending on project requirements.
3. Sampling equipment will be cleaned and decontaminated prior to sampling in accordance with the Decontamination of Personnel and Equipment SOP.
4. Instruments are calibrated according to manufacturer's instructions.
5. The well number, site, date, and condition are recorded in the field logbook.
6. Plastic sheeting is placed on the ground, and the well is unlocked and opened.
7. Open the well and begin screening breathing zone with air monitoring device until sampling is complete, in accordance with the HASP.
8. Water level measurements are collected in accordance with the *Water Level Measurement* SOP. **Do not measure the depth to the bottom of the well at this time; this reduces the possibility that any accumulated sediment in the well will be disturbed**. Obtain depth to bottom information from well construction log.
9. Calculate the volume (V) of water in a well casing as follows:

$$V = 0.041\ d^2h$$

where: V = volume of water in well (gallons)

d = diameter of well in <u>inches</u>

h = height of water column in <u>feet</u>

The volume of water in common well casing diameters may be calculated as follows:

2-inch diameter well:

0.163 gal/ft x ___ (linear feet of water) = gallons

4-inch diameter well:

0.653 gal/ft x ___ (linear feet of water) = gallons

6-inch diameter well:

1.469 gal/ft x ___ (linear feet of water) = gallons

10. Attach tubing, support cable or rope, and air line (if applicable) to the pump. The support line should bear the weight of the pump. Set the pump intake near the top of the water column. This is done so that the purging will “pull” water from the formation into the screened area of the well and up through the casing so that the entire static volume can be removed. It is recommended that the pump not be lowered more than 3 to 5 feet into the water column. If the recharge rate is faster than the pumping rate and no observable drawdown occurs, the pump should be raised until the intake is within 1 foot of the top of the water column. Conversely, if

the pumping rate exceeds the recharge rate, the pump must be lowered as needed to accommodate the drawdown.

11. If an electric submersible pump is to be used in a large diameter well (greater than 4 inches), a pump shroud should be used to direct the flow of water across the pump motor. Failure to use a shroud in this situation can lead to overheating of the motor and potential loss of volatiles from the pump discharge.

12. Generators and fuel, if used, must be located at least 30 feet downwind from the well to avoid exhaust fumes contaminating the samples.

13. If a bailer is being used, it should be removed from its protective covering and attached to a cord compatible with the site contaminants. The bailer should be lowered into the top of the water column, allowed to fill, and removed. It is critical that bailers be slowly and gently immersed into the top of the water column, particularly during final stages of purging, to minimize turbidity and disturbance of volatile organic constituents. The use of bailers for purging and sampling is discouraged because the correct technique is highly operator dependent and improper use may result in an unrepresentative sample.

14. Insert the water quality measurement probes into the flow-through cell and place in a shaded area. The purged groundwater must enter the flow through the cell by the lower port and exit via the upper port. Wrap exposed tubing and the flow through cell in aluminum foil to minimize heat loss/gain due to environmental conditions. Field parameters including pH, ORP, turbidity, dissolved oxygen, specific conductance, and temperature are measured and recorded in the field logbook.

15. A minimum of three well volumes must be purged (up to 5 well volumes may be purged if water quality parameters do not stabilize) prior to sampling. In low-yielding wells, if the well is purged dry, it is not necessary to remove a minimum of three well volumes; however, the well should be allowed to recover sufficiently to allow collection of all samples.

16. During purging, the field parameters must be measured frequently (every 5 minutes) until the parameters have stabilized. Field parameters are considered stable when measurements meet the following criteria:

    - pH: within 0.1 pH units
    - Specific conductance: within 3 percent
    - Dissolved oxygen: within 10 percent
    - Turbidity: within 10 percent for values greater than 5 NTU; if 3 turbidity values are less than 5 NTU, consider the values as stabilized
    - ORP: within 10 mV

17. Temperature: within 3 percent

B. Sample Collection

Once purging is complete the well is ready to sample. The pump should be allowed to operate at the same rate as the purge cycle until sampling begins, whereupon the discharge should be reduced to 0.1 L/m.

Samples will be placed in sample containers that have been cleaned to laboratory standards and are preserved in accordance with the analytical method. The containers are typically pre-preserved, if required.

The steps to be followed for sample collection are as follows:

1. The cap is removed from the sample bottle, and the bottle is tilted slightly.
2. The sample is slowly poured from the bailer or discharged from the pump so that it runs down the inside of the sample bottle with a minimum of disturbance. The pumping rate should be reduced to approximately 100 ml per minute when sampling VOCs.
3. Inorganics, including metals, may be collected and preserved in the filtered form as well as the unfiltered form. Disposable in-line filters (0.45 micron filter), connected to the end of the sample tubing, are typically used for field filtration. Samples are field filtered as the water is being placed into the sample container. If a bailer is used, filtration may be driven by a peristaltic pump.
4. Adequate space is left in the bottle to allow for expansion, except for VOC vials, which are filled to the top with a positive meniscus. VOC vials should be capped slowly to prevent introduction of air bubbles in the sample. Once capped, the VOC vial should be inverted and tapped to detect the presence of air bubbles.
5. The bottle is capped and clearly labeled.
6. Immediately upon collection, all samples for chemical analysis are to be labeled and placed on ice.
7. If the sample tubing or bailer is dedicated, it is returned to the well and the well is capped and locked. Nondedicated equipment is cleaned and decontaminated in accordance with the *Decontamination of Personnel and Equipment* SOP.

The following information, at a minimum, will be recorded in the log book:

1. Sample identification (site name, location, and project number; sample name/number and location; sample type and matrix; time and date; sampler's identity)
2. Sample source and source description
3. Field observations and measurements (appearance, volatile screening, field chemistry, sampling method), volume of water purged prior to sampling, number of well volumes purged, and field parameter measurements
4. Sample disposition (preservative; laboratory name, date and time sent; laboratory sample number, chain-of-custody number, sample bottle lot number)

IV. Attachments

None.

V. Key Checks and Preventative Maintenance

- Use of peristaltic pumps and bailers should be avoided, if possible.
- Allow the field parameters to stabilize within the specified criteria as much as possible.
- Fill bottles for VOC samples first.
- Be sure the sample identification is properly specified.

- Maintain field equipment in accordance with the manufacturer's recommendations. This may include, but is not limited to:
  - Inspect sampling pump regularly and replace as warranted
  - Bring supplies for replacing the bladder and "O" rings if using a positive-displacement bladder pump
  - Inspect tubing regularly and replace as warranted
  - Inspect air/sample line quick-connects regularly and replace as warranted
  - Verify battery charge, calibration, and proper working order of field measurement equipment prior to initial mobilization and daily during field efforts

Water-Level Measurements

I. Purpose and Scope

The purpose of this procedure is to provide a guideline for the measurement of the depth to groundwater in piezometers and monitoring wells, even where a second phase of floating liquid (e.g., gasoline) is encountered, and on staff gauges in surface-water bodies. This SOP includes guidelines for discrete measurements of static water levels and does not cover the use of continuously recording loggers.

II. Equipment and Materials

- Electronic water-level meter (Solinst® or equivalent) with a minimum 100-foot tape; the tape should have graduations in increments of 0.01 foot or less
- Interface probe (Solinst® Model 122 Interface Meter or equivalent)

III. Procedures and Guidelines

Verify that the unit is turned on and functioning properly. Slowly lower the probe on its cable into the piezometer or well until the probe just contacts the water surface; the unit will respond with a tone or light signal. Note the depth from a reference point indicated on the piezometer or well riser. Typically, this is the top of the PVC casing. If no reference is clearly visible, measure the depth to water from the northern edge of the PVC casing. If access to the top of the PVC casing is difficult, sight across the top of the locking casing adjacent to the measuring point, recording the position of the cable when the probe is at the water surface.

Measure the distance from this point to the closest interval marker on the tape, and record the water level reading in the logbook. Water levels will be measured to the nearest 0.01 foot. Also when specified in the project plans, measure and record the depth of the piezometer or well. The depth of the piezometer or well may be measured using the water-level probe with the instrument turned off.

Free product light or dense nonaqueous phase liquid may be present in the piezometer or well. If the presence of free product is suspected, the thickness of the product should be determined using appropriate equipment (e.g., Solinst® Model 122 Interface Meter). The depth to water also is determined with this equipment, and the water-level meter should not be used in the piezometer or well as long as product is present. Typically, a constant sound is emitted from the device when free product is encountered and an alternating on/off beep sound is emitted when water is encountered.

The apparent elevation of the water level in the well or piezometer is determined by measuring both the apparent depth to water and the thickness of free product. The corrected water-level elevation is calculated by the following equation:

$$WL_c = Wl_a + (\text{Free-product thickness} \times 0.80)$$

Where

WL_c = corrected water-level elevation

Wl_a = apparent water-level elevation

0.80 = typical value for the density of petroleum hydrocarbon products

If free product is detected on the surface of the water in the piezometer or well, the value of sampling should be reconsidered because of the potential for contaminating the sampling equipment.

Staff gauges may be installed in some surface-water bodies. These facilities typically are constructed by attaching a calibrated, marked staff gauge to a wood or metal post, driving the post into the bottom of the surface-water body, and surveying the elevation of the top of the post to a resolution or 0.01 foot. The elevation of the water in the surface-water body then can be determined by reading off the distance the water level is from the top of the post. A shield or other protection may be needed to calm the fluctuations in water level if the gauge is installed at a location exposed to wind or wave.

IV. Attachments

None.

V. Key Checks

- Before each use, verify that the battery is charged by pressing the test button on the water-level meter.
- Verify that the unit is operating correctly by testing the probe in distilled or deionized water. Leave the unit turned off when not in use.