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Optimization Work Plan

This document also serves as the Technical Report for the California Department of Public Health (CDPH)

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Jet Propulsion Laboratory (JPL)
Pasadena, California

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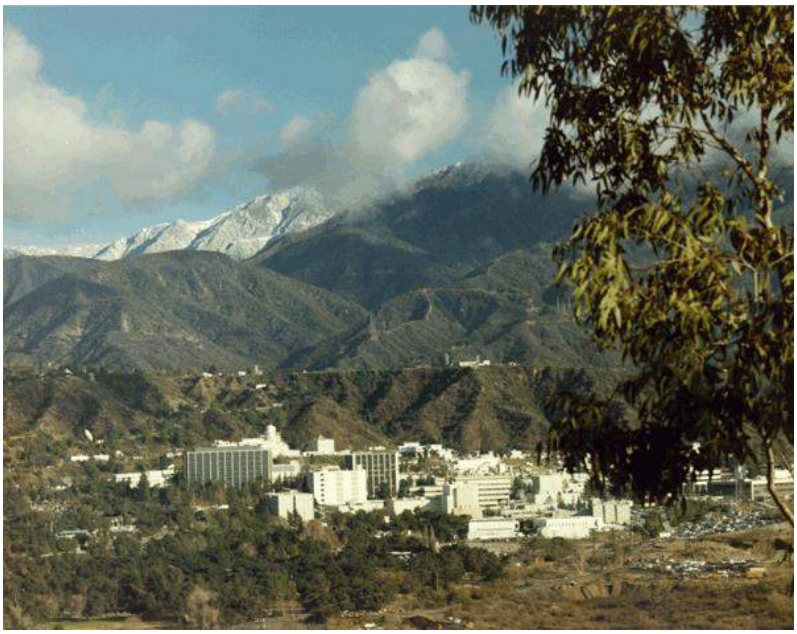

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NASA has budgeted funding for the optimization projects discussed in this work plan and has coordinated with the City of Pasadena and Lincoln Avenue Water Company on implementation issues. However, implementation of the optimization projects requires final approval of funding, as well as approvals for siting, construction, and operation. All discussion in and about the contents of this document regarding the proposed optimization projects recognizes that commencement of construction is contingent upon funding availability and receiving all necessary approvals for siting, construction, and operation.

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ABBREVIATIONS

ACP	asbestos cement (transite) pipe
amsl	above mean sea level
ANSI	American National Standards Institute
AWWA	American Water Works Association
bgs	below ground surface
Caltech	California Institute of Technology
CCR	California Code of Regulations
CDPH	California Department of Public Health
CEQA	California Environmental Quality Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CUP	Conditional Use Permit
CWC	California Water Code
DI	ductile iron
DOT	Department of Transportation
DSAL	dual swab airlift
DTSC	Department of Toxic Substances Control
DVD	Digital Video Disc
FFA	Federal Facilities Agreement
FMWD	Foothill Municipal Water District
GIS	geographic information system
gpm	gallon per minute
HGL	hydraulic grade line
hp	horsepower
HWL	high water line
IDW	investigation derived waste
IX	ion exchange
JPL	Jet Propulsion Laboratory
LAWC	Lincoln Avenue Water Company
LGAC	Liquid-phase Granular Activated Carbon
MCL	maximum contaminant level
MGD	million gallons per day
MHTS	Monk Hill Treatment System
NASA	National Aeronautics and Space Administration
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NSF	National Sanitation Foundation

OEAL	open end airlift
OU	Operable Unit
PCA	possible contaminated activities
PCE	tetrachloroethene
PLC	Programmable Logic Control
PMC	Pasadena Municipal Code
POC	point of contact
ppm	parts per million
PS	pipe segment
psi	pounds per square inch
PVC	polyvinyl chloride
PWP	Pasadena Water and Power
RBMB	Raymond Basin Management Board
RD/RA	Remedial Design/Remedial Action
ROD	Interim Record of Decision
RWQCB	Regional Water Quality Control Board
SCADA	supervisory control and data acquisition
SCE	Southern California Edison
SWA	Source Water Assessment
TCE	trichloroethylene
TDH	total dynamic head
UBC	Uniform Building Code
USA	Underground Service Alert
U.S. EPA	United States Environmental Protection Agency
USCS	Unified Soil Classification System
VFD	variable frequency drive
VOC	volatile organic compound
VWC	Valley Water Company
WDR	waste discharge requirement

1 INTRODUCTION

1.1 Project Background

The Jet Propulsion Laboratory (JPL) is a federally funded research and development center in Pasadena, California, currently operated under contract to the California Institute of Technology (Caltech) for the National Aeronautics and Space Administration (NASA). NASA has been investigating and taking actions to clean up the groundwater associated with historic waste management practices since the mid-1980s. In October 1992, the JPL site was placed on the National Priorities List (NPL) and, therefore, is subject to the provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) to regulate investigation and cleanup.

For CERCLA purposes, the JPL site has been divided into three operable units (OUs). OU-1 addresses on-facility groundwater at JPL; OU-2 addresses on-facility vadose zone soil at JPL; and OU-3 addresses off-facility groundwater adjacent to the JPL property.

The parties to the Federal Facilities Agreement (FFA) include NASA, the United States Environmental Protection Agency (U.S. EPA), the California Department of Toxic Substances Control (DTSC), and the Regional Water Quality Control Board (RWQCB). NASA is the lead federal agency, and the USEPA, DTSC, and RWQCB provide guidance and oversight to the JPL CERCLA Program. Also, because the OU-3 treatment systems provide drinking water to the local communities, the California Department of Public Health (CDPH) oversees compliance with drinking water permits for the OU-3 treatment systems.

An Interim Record of Decision (ROD [NASA, 2007c]) was finalized for OU-3 in August 2007. Two treatment systems are operated within OU-3: the Monk Hill Treatment System (MHTS), providing mid-plume cleanup, and the Lincoln Avenue Water Company (LAWC) Treatment System, providing leading edge cleanup and containment. NASA also operates a source area treatment system within the JPL fence line, providing cleanup of the area with the highest historical concentrations of chemicals. The source area system is located within OU-1 (on-facility groundwater) and is operated under a separate Interim ROD (NASA, 2007a). Remediation of on-facility soil (OU-2) was completed in 2007 (NASA, 2007b). Furthermore, results of the JPL site's first CERCLA five-year review in 2012 concluded that the OU-1 and OU-3 remedies are operating effectively and are protective of human health and the environment (NASA, 2012a). Figure 1-1 is a map showing the location of the MHTS, LAWC system, and the source area treatment system.

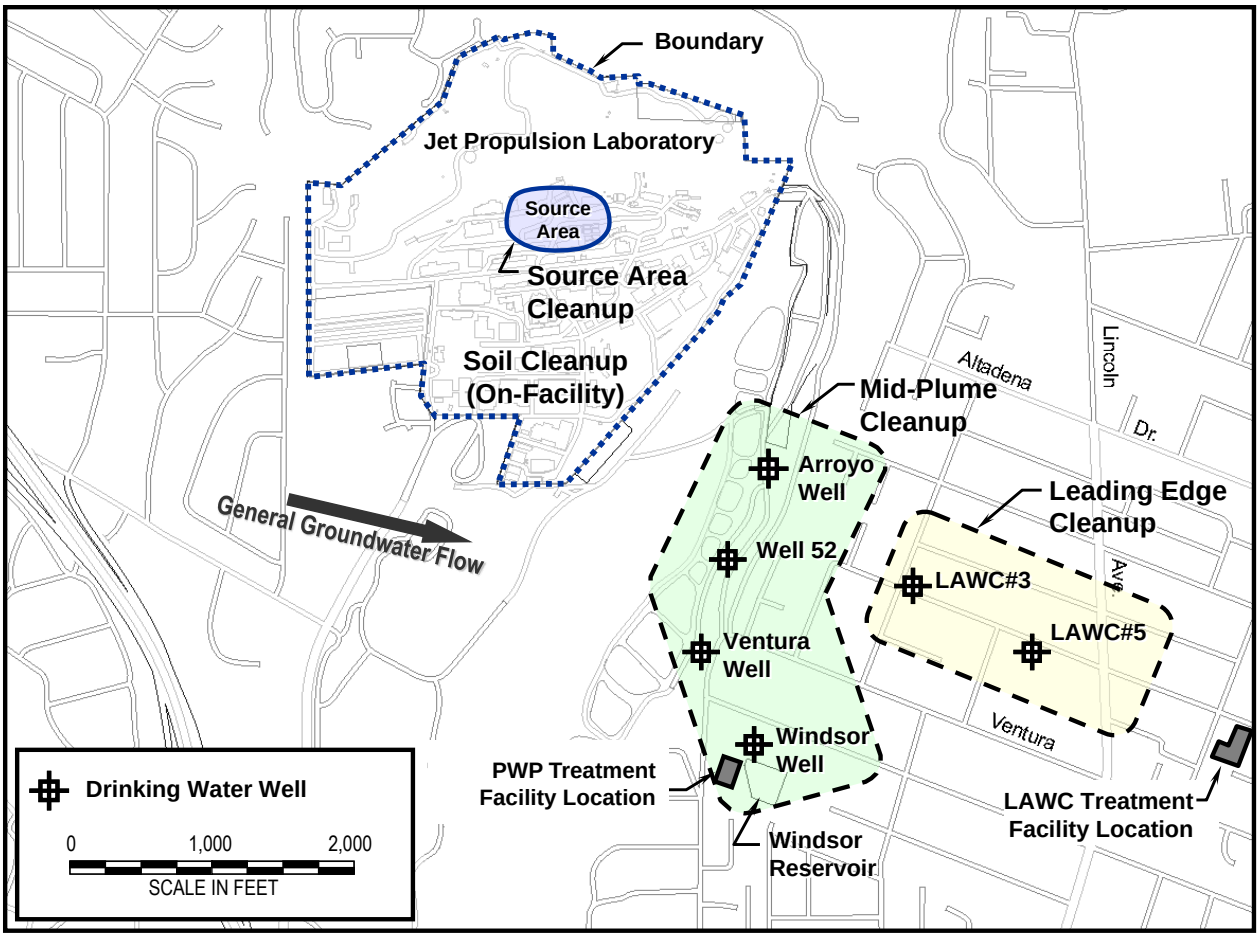

Figure 1-1. Location of the Source Area, Mid-Plume, and Leading Edge Cleanup Systems in Relation to JPL

1.1.1 Source Area Treatment (OU-1)

The OU-1 source area groundwater treatment activities consist of a 300 gallon per minute (gpm) groundwater pump and treat system with reinjection for treatment of perchlorate and volatile organic compounds (VOCs). Components of the OU-1 treatment system include liquid-phase granular activated carbon (LGAC) for VOC removal, fluidized bed reactor for biological perchlorate treatment, and filtration. A treatment system flow diagram is provided in Figure 1-2. Construction of the OU-1 treatment facility was completed in late 2004 and system operations were initiated in January 2005. Since system startup, there has been a decreasing trend in perchlorate and VOC concentrations in the extracted groundwater over the duration of system operation. As of December 2013, approximately 3,072 acre-feet of groundwater have been extracted and successfully treated by the OU-1 system and an estimated 1,774 lbs. of perchlorate and 42 lbs. of VOCs have been removed by the system (NASA, 2013a). The OU-1 system is not directly part of the optimization work described in this document, but may be used to treat some initial development wastewater generated during the installation of new wells.

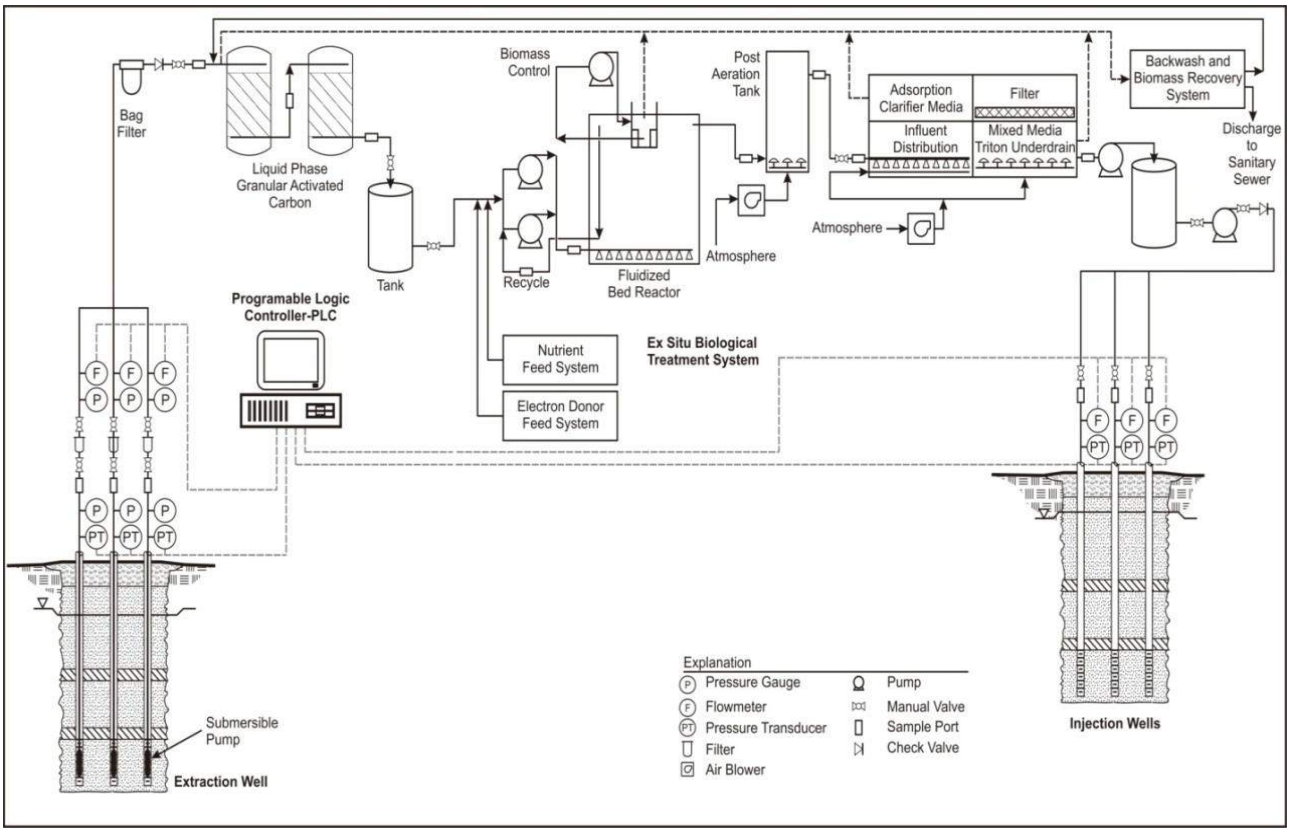

Figure 1-2. OU-1 Process Flow Diagram

1.1.2 Mid-Plume Treatment (MHTS)

The MHTS treats groundwater from four Pasadena Water and Power (PWP) production wells (Arroyo Well, Ventura Well, Well 52, and Windsor Well), providing mid-plume treatment. These drinking water wells were selected for treatment based on elevated levels of perchlorate and VOCs originating from the JPL facility. Arroyo Well, Ventura Well, and Well 52 are pumped to an equalization sump located at the Ventura Well site. Booster pumps transfer water from the sump to the treatment plant located at the Windsor site. Water from Windsor Well is pumped directly from the well to the treatment plant. The total flow capacity of the MHTS is 7,000 gpm; a treatment system flow diagram is provided in Figure 1-3. The MHTS includes three parallel cartridge filters (two active and one stand-by) for pre-filtration, four parallel pairs of lead-lag ion exchange (IX) units for perchlorate removal, five parallel pairs of lead-lag LGAC units for removal of VOCs, and disinfection required for distribution as drinking water to the City of Pasadena. The size of the distribution and treatment equipment requires routine and extensive rinsing and backwashing, creating substantial volumes of wastewater to be discharged to the Arroyo Seco spreading grounds. These discharges follow the substantive requirements of General National Pollutant Discharge Elimination System (NPDES) Permit No. CAG914001 in accordance with CERCLA Section 121(e)(1) and the approved Discharge Protocol (NASA, 2010). MHTS construction and startup activities were completed in July 2011, and the MHTS Installation Report was prepared in August 2011 (NASA, 2011). Construction completion was documented for OU-3 in a letter received from U.S. EPA Region IX on September 12, 2011 (U.S. EPA, 2011). As of December 2013, approximately 10,047 acre-feet of groundwater have been extracted and successfully treated by MHTS and an estimated 787 lbs. of perchlorate and 73 lbs. of VOCs have been removed by the system (NASA, 2013b).

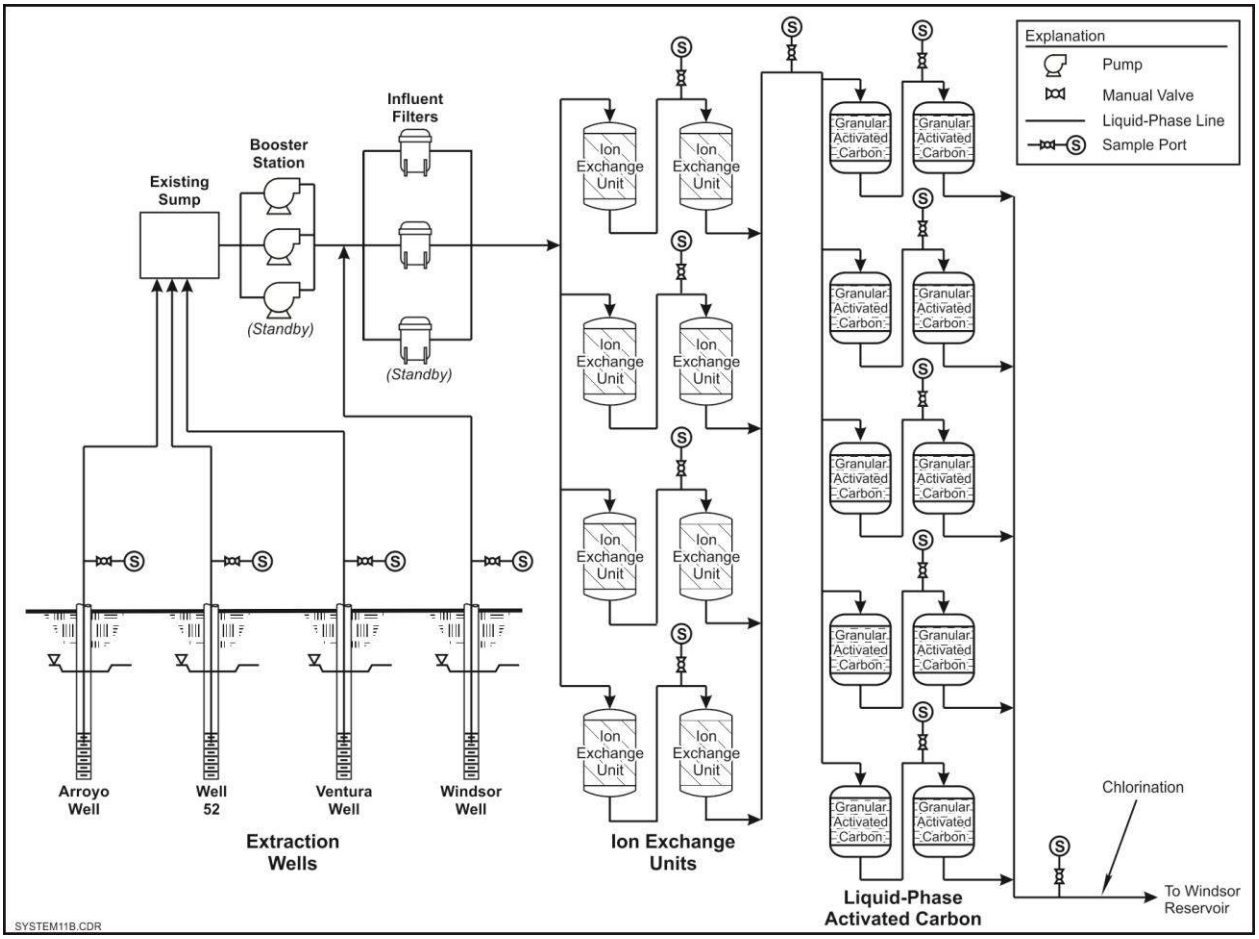

Figure 1-3. MHTS Process Flow Diagram

1.1.3 Leading Edge Treatment (LAWC)

The LAWC system treats groundwater from two LAWC production wells (LAWC#3 and LAWC#5) making up the leading edge treatment area. These drinking water wells were selected for treatment based on elevated levels of perchlorate and VOCs originating from the JPL facility. LAWC#3 and LAWC#5 are pumped directly from the well to the LAWC treatment plant. A treatment system flow diagram is provided in Figure 1-4. The LAWC system consists of two parallel bag filters for pre-filtration, one pair of lead-lag IX units for perchlorate removal, four parallel LGAC units for removal of VOCs, and disinfection prior to distribution as drinking water to LAWC customers. The total flow capacity of the LAWC system is 2,000 gpm. The LAWC treatment system was constructed in July 2004 as a time-critical removal action under CERCLA (NASA, 2004).

In August 2004, LAWC began continuous operation of the LAWC treatment system for drinking water production. LAWC is funded by NASA to operate the system. As of December 2013, approximately 18,992 acre-feet of groundwater have been extracted and successfully treated by the LAWC system and an estimated 986 lbs. of perchlorate and 216 lbs. of VOCs have been removed by the system (NASA, 2013c).

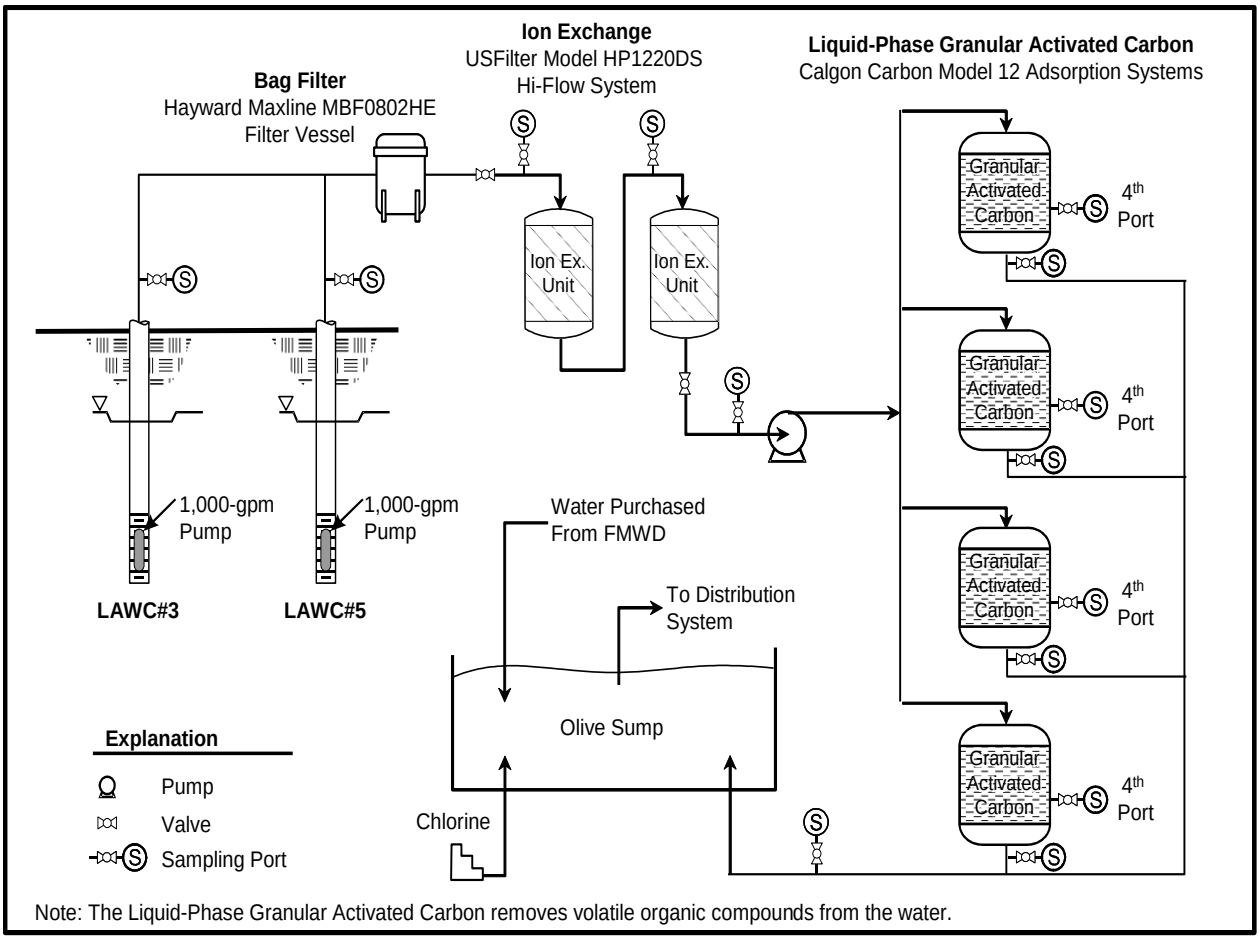

Figure 1-4. LAWC Process Flow Diagram

1.2 Objectives and Scope

The purpose of this optimization work plan is to present details of the engineering designs, construction plans and operation for the proposed OU-3 optimization to the MHTS and LAWC system. While the OU-3 systems are operating effectively, the optimization efforts are intended to improve effectiveness and reliability, and reduce life-cycle costs.

The objectives of the proposed OU-3 system optimization efforts are as follows:

- Reduce life-cycle costs associated with the MHTS and LAWC system;
- Optimize system operations and increase mass removal;
- Provide flexibility to treatment system operations;
- Improve system reliability and operability.
- Ensure three dimensional capture and containment of the JPL contaminant plumes.

This section provides an overview of the system optimization efforts for the MHTS and LAWC systems. No changes to the OU-1 treatment facility are being proposed at this time.

2.1 MHTS (Mid-Plume) Optimization

There are two optimization concepts being proposed for the MHTS to improve effectiveness and operability: a new MHTS production well and an upgrade to wastewater management infrastructure.

2.1.1 New MHTS Production Well

The new MHTS extraction well is proposed to be located on the eastern edge of the JPL East Parking Lot and adjacent to the bridle trail (Figure 2-1). NASA's annual cost to fund the MHTS is approximately $3.5M. In addition, it was estimated in the OU-3 Interim ROD (NASA, 2007c) that the MHTS will need to operate for at least 18 years to reduce aquifer concentrations to below current maximum contaminant levels (MCLs). Therefore, reducing the operational duration by a few years would have a significant impact on the life-cycle cost of the MHTS.

Based on the available groundwater data collected as part of the JPL groundwater monitoring program and NASA's understanding of capture zones of the MHTS and LAWC extraction wells, it appears that an additional extraction well located north of the Arroyo Well would provide containment of groundwater migrating downgradient from the JPL source area and limit migration toward MW-18. Modeling estimates indicated a 40% increase in mass removal when including the new well with Arroyo, Well 52, and Ventura as compared to the current MHTS well configuration of Arroyo, Well 52, Ventura, and Windsor.

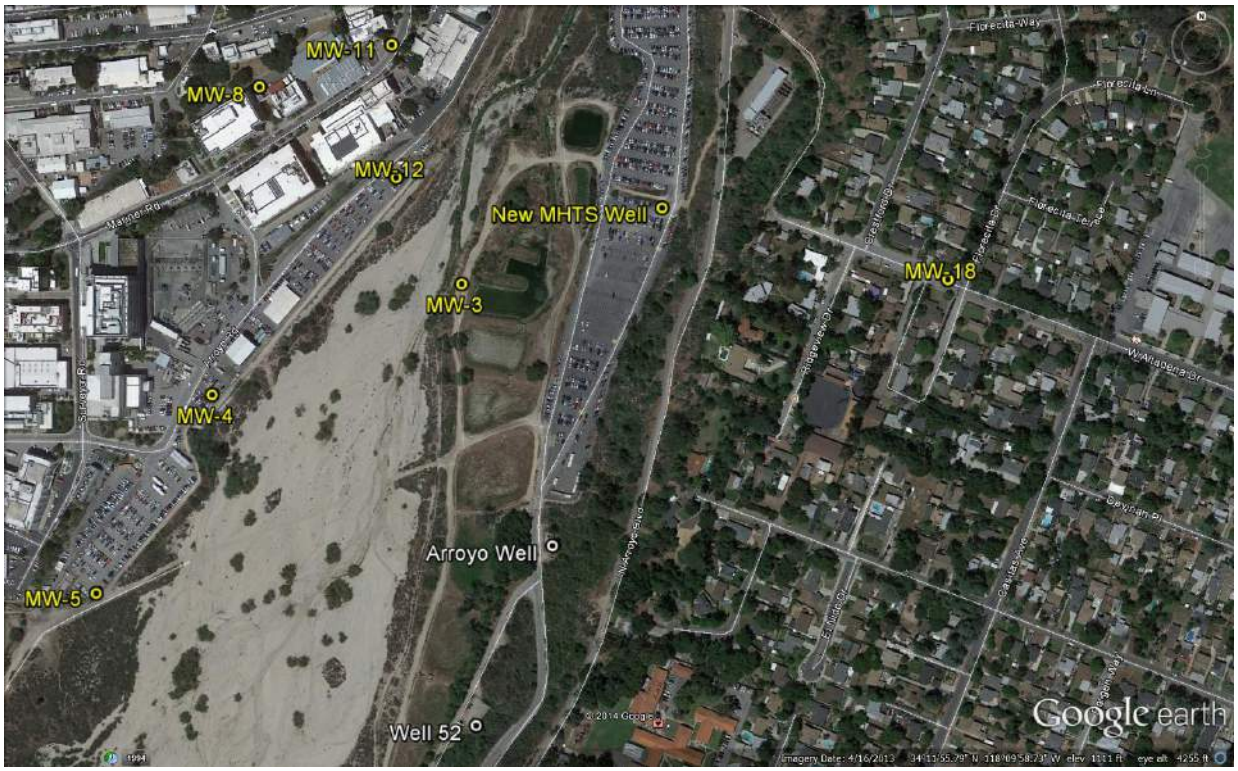

Figure 2-1. New MHTS Well Proposed Location

General Well Design – The general design parameters for the new MHTS production well include a capacity of 1,600 gpm constructed to an approximate depth of 650 feet below ground surface (bgs). The well would be constructed with 16.0-inch diameter blank casing and screen, and furnished with a 350 horsepower (hp) motor (480 volt/three-phase power) capable of a flowrate of 1,600 gpm. Required site upgrades include a pump pedestal, discharge piping, and well appurtenances; pipeline tie-in to the new PWP transmission pipeline to the MHTS; pump enclosure that includes concrete foundation and removable roof hatch, interior/exterior lighting, and low voltage power; chain link security fence and gates; switchgear (soft start), variable frequency drive (VFD), supervisory control and data acquisition (SCADA), transformer, and power connection via overhead power lines; potable water line; and asphalt paving.

After the well is installed, the results of the test pumping (i.e., pumping level, drawdown, and specific capacity), as well as seasonal and long-term static water level variations, pressure variations, system demand, and pressure characteristics will be used to design a vertical turbine pump capable of flows of 1,600 gpm. A pump design submittal generally includes the following: pump performance sheet and pump curves, sectional drawing, dimensional drawing, and motor dimensional drawings/specifications that will be reviewed by a State of California licensed civil engineer.

2.1.1.1 Location

Four potential groundwater extraction well locations were evaluated (see Appendix A), with the goal of enhancing plume containment, optimizing dissolved mass removal, and reducing life-cycle costs associated with the MHTS. MHTS Option 4 (JPL Parking Lot East) was identified as the optimal location for the new MHTS extraction well based on logistics, water supply, and plume capture. This location is within close proximity to appropriate power service and to existing transmission pipelines, appropriate site access and security, appropriate zoning, and necessary space. The location within the JPL East Parking Lot is believed to be the optimal location based on the groundwater modeling results. The new MHTS extraction well has a proposed screened interval from 300 to 650 feet bgs, consistent with the intervals of elevated chemical concentrations in nearby multi-port monitoring wells MW-3, MW-11, MW-12 and MW-18 as well as accounting for anticipated pumping water levels.

2.1.1.2 Source Water Assessment

The source water assessment (SWA) for the new MHTS extraction well follows the same procedure as the SWA documented in the *Final California Department of Public Health (CDPH) Policy Memorandum 97-500 Documentation Raymond Basin, Monk Hill Subarea* (Battelle, 2010). Most of the findings from the original SWA directly apply to the new MHTS well because the proposed location and depth of the new well falls within the area of source water originally assessed. In the original SWA, the Arroyo Well was the northern most production well considered. However, the new well will be approximately 1,000 feet north/northeast of the Arroyo Well, potentially creating a capture zone of source water not fully considered in the original SWA. To supplement the original SWA, a focused SWA has been performed as part of this document to accomplish the following:

- Review the origin of identified chemicals
- Delineate the source capture zone for the new MHTS extraction well
- Evaluate chemical concentration trends for monitoring and production wells relevant to the new well

Sections 2.3 and 2.4 of the original SWA for the Monk Hill Subarea summarized chemicals used or generated by facilities responsible for chemicals known to be in groundwater and also the vulnerability of groundwater in the Monk Hill Subarea. The findings of these sections are applicable for the proposed new well.

Once the new MHTS well is installed, additional sampling may be required to evaluate any influence from the spreading basins and stormwater runoff near the proposed well site.

Review of Origin of Identified Chemicals – The original SWA identified the JPL facility and upgradient groundwater as the two known origins of chemicals found in the source water. A variety of solvents, rocket fuel propellants, cooling-tower chemicals, and analytical laboratory chemicals were used on site for JPL operations. Until the early 1960s, seepage pits were commonly used to dispose of these wastes by infiltration into surrounding soil. Once in the soil, chemicals from the waste eventually migrated to groundwater. In addition, the Valley Water Company (VWC) wells are located upgradient of the JPL facility and historical analyses of water quality from the VWC production wells indicate the presence of certain contaminants similar to those found in groundwater beneath and downgradient of the JPL facility.

Conclusions drawn from remedial investigations and long-term monitoring findings apply to the new MHTS. In addition, conclusions from the original SWA addressing emerging contaminants and tentatively identified compounds also apply directly to the new MHTS extraction well.

Based on findings of the remedial investigations and long-term monitoring program, perchlorate and VOCs (tetrachloroethene [PCE], trichloroethene [TCE], and carbon tetrachloride) are expected to be present in groundwater near the new MHTS extraction well. Therefore, these data are evaluated in adjacent wells located within the capture zone of the new MHTS well.

Source Capture Zone Delineation – The new MHTS extraction well will be located within the Monk Hill Subarea of the Raymond Basin. While generally considered to be an unconfined aquifer, groundwater flow is modeled in layers based on the presence of relatively thin, silt rich layers that influence vertical flow. Groundwater flow in the area is primarily to the southeast. However, flow direction and elevation can be affected by production well pumping, recharge from the Arroyo Seco spreading basins, seasonal and regional recharge from precipitation, and regional groundwater flow. In the original SWA, the capture zones were delineated using the three-dimensional finite element groundwater flow model developed by NASA in 2003 (NASA, 2003). The same model was used for the new MHTS extraction well (See Appendix A).

Evaluation of Chemical Concentration Trends – The source capture zone delineation results indicate data from monitoring wells MW-18, MW-12, MW-3, and MW-11 as well as Arroyo Well should be considered in assessing chemicals and trends that might be expected in the new MHTS extraction well. VOC and perchlorate data from the deeper screened intervals (Screens 3, 4, and 5) of MW-18 and MW-12 for the past 5 years as well as data from Arroyo Well from the past 2 years are summarized in Table 2-1. Data from the deeper screened intervals of MW-3 and MW-11 were also considered, but not summarized in Table 2-1 due to sporadic and/or very low chemical concentrations.

Table 2-1. Summary of Chemical Trends for Wells near the New MHTS Extraction Well

			MW 18			MW 12			Arroyo Well[1]
			Screen 3	Screen 4	Screen 5	Screen 3	Screen 4	Screen 5	
Perchlorate (µg/L)	MCL = 6 µg/L	Detection Frequency	20/20	20/20	2/20	12/20	20/20	19/20	53/53
		Average Concentration	63	37	0.84	2.6	3.4	2.0	56.179
		Most Recent Conc.	93	15	ND	5.1	4.3	2.4	39.9
		Max. Conc.	140	67	2.7	5.5	5.2	3.6	108
		Date of Max. Conc.	08/2011	05/2010	12/2009	02/2012	02/2012	05/2008	07/2011
PCE (µg/L)	MCL = 5 µg/L	Detection Frequency	4/20	9/20	0/20	0/20	0/20	0/20	28/54
		Average Concentration	0.26	0.44	0.25	0.25	0.25	0.25	0.4037
		Most Recent Conc.	0.15	0.86	ND	ND	ND	ND	ND
		Max. Conc.	0.42	1.1	-	-	-	-	0.63
		Date of Max. Conc.	01/2008	11/2011	-	-	-	-	03/2012
TCE (µg/L)	MCL = 5 µg/L	Detection Frequency	20/20	19/20	0/20	6/20	5/20	1/20	52/54
		Average Concentration	1.3	1.1	0.25	0.34	0.30	0.25	0.7711
		Most Recent Conc.	1	0.9	ND	0.12	0.43	0.16	0.68
		Max. Conc.	3.6	1.5	-	0.72	0.53	0.16	1.07
		Date of Max. Conc.	08/2011	02/2011	-	02/2010	02/2009	09/2012	03/2011
Carbon Tetrachloride (µg/L)	MCL = 0.5 µg/L	Detection Frequency	20/20	19/20	0/20	15/20	18/20	10/20	53/54
		Average Concentration	15.7	7.8	0.25	1.1	1.1	0.5	2.65055
		Most Recent Conc.	7.4	1.9	ND	1	1.3	0.5	3.79
		Max. Conc.	43	16	-	3.9	1.8	1.1	3.89
		Date of Max. Conc.	08/2011	12/2009	-	11/2007	07/2008	07/2010	02/2012
		Gray indicates greater than or equal to 50% detection frequency.							
		Red outline indicates most recent concentration is greater than the maximum contaminant level (MCL).							

[1]Arroyo Well analytical data from August 2012

All four chemicals are frequently detected in the Arroyo Well with perchlorate and carbon tetrachloride consistently above their respective MCLs. In Arroyo Well, perchlorate concentrations have steadily decreased since 2011, likely associated with operation of the MHTS. However, carbon tetrachloride concentrations in Arroyo Well have increased slightly since 2011 and remain above the MCL. Perchlorate and carbon tetrachloride are consistently above the MCL in Screens 3 and 4 of MW-18, with both also showing an increasing trend in MW-18 (Screen 3). In MW-12, perchlorate is frequently detected but remains below the MCL. However, the trend in all three screens of MW-12 are increasing and approaching the MCL for perchlorate. Carbon tetrachloride is frequently detected in MW-12 above the MCL with an increasing trend in Screen 3.

Over the past 5 years there were no detections of PCE, TCE or carbon tetrachloride in any of the three deeper screens of MW-3 and MW-11. Perchlorate was sporadically detected in both wells but no more than three out of 20 times for any specific screen. The average perchlorate concentration across all screens for both wells is less than the MCL. The only exceedance of the MCL for perchlorate (6 µg/L) in either well occurred in 2009 with a result 7.3 µg/L in Screen 4 of MW-3.

2.1.1.3 Raw Water Quality Characterization

The goal of this raw water quality characterization is to estimate the concentrations of chemicals expected to be present in water extracted from the new MHTS extraction well. These estimates are useful in comparing existing treatment plant removal capability to the expected concentrations.

Based on the historical monitoring data presented in the SWA, estimated concentrations in the new MHTS extraction well are estimated in Table 2-2. Given the capture zone of the new MHTS extraction well draws water from similar areas as the capture zone of the Arroyo Well, it is assumed the raw water quality will most likely reflect the most recent Arroyo Well concentrations. However, given the more

northern location of the new well, water quality could be affected by the new extraction well drawing water from areas further northeast and northwest of Arroyo Well. To account for this uncertainty, in addition to the most recent Arroyo Well values, Table 2-2 also presents two possible ranges of expected chemical concentrations. The first range represents the average and maximum historical values observed in Arroyo, and the second range incorporates information from nearby wells as the weighted average and weighted maximum. The weighting reflects a scenario in which 40% of new well water matches Arroyo well water quality, 30% matches MW-18 (Screen 3) and 30% matches MW-12 (Screen 3). Concentrations from MW-11 and MW-3 are omitted from the weighting scenario since these wells were frequently non-detect and would potentially falsely lower the expected chemical concentrations. Weighting factors were adjusted to reflect different contribution scenarios from the nearby wells; however, the results remained similar to the range established using only Arroyo Well.

Table 2-2. Estimated Concentration of Chemicals in the New MHTS Extraction Well

Parameter	Assumed Quality	Range 1		Range 2	
	Arroyo Well Most Recent	Arroyo Well Average	Arroyo Well Maximum	Weighted Average	Weighted Maximum
Perchlorate (µg/L)	39.9	56.2	108	42.2	86.9
PCE (µg/L)	ND	0.40	0.63	0.31	0.45
TCE (µg/L)	0.68	0.77	1.07	0.80	1.7
Carbon Tetrachloride (µg/L)	3.79	2.65	3.89	6.09	15.6

ND = A result less than the laboratory's minimum detection limit of 0.10 µg/L

2.1.1.4 Existing Infrastructure and Design Considerations

Current analysis indicates that the new MHTS extraction well would be installed on the east side of the JPL East Parking Lot, approximately 1,030 feet north/northeast of the Arroyo Well. The proposed well will be located in a relatively flat area in the existing parking lot. This property is owned by PWP and currently leased to NASA for parking.

Three existing PWP wells are located in the Arroyo Seco: Arroyo Well, Well 52 and Ventura Well. Water extracted from these three wells is conveyed to the Ventura booster station. The booster station then pumps water to the treatment plant via a 16-inch pipeline. The exiting 16-inch pipeline is undersized considering the potential flow from all three production wells (up to 5,600 gpm). Since the MHTS was brought online in 2011, typically only two of the three Arroyo Seco production wells are operated at a time.

Groundwater from the Arroyo Well is pumped at approximately 2,200 gpm through a 12-inch pipeline south toward Well 52. Groundwater pumped from Well 52 combines with the water from the Arroyo Well and is transported to the Ventura booster station through a 16-inch pipeline. The velocity of the combined flow from Arroyo Well and the new MHTS Well (approximately 4,200 gpm) in the existing 12-inch pipeline would exceed 12 feet/second. In general, the velocity inside the pipe should range from 3 to 6.5 feet/second (McGhee, 1991). Therefore, the existing pipeline is not large enough to accommodate the additional flow from the new MHTS extraction well.

Due to the limitations with connecting a new MHTS extraction well to the existing MHTS infrastructure in the Arroyo Seco, a new pipeline will be installed from the new MHTS well to the Ventura booster station. This pipeline will allow the new MHTS Well, Arroyo Well and Well 52 to operate at the same

time at flows up to 5,600 gpm. The pipeline will consist of three sections of pipe with increasing pipe diameter to accommodate increased flow. During operation, only three of the four wells located in the Arroyo area (i.e., new MHTS Well, Arroyo Well, Well 52, and Ventura Well) can be operated at one time because the Ventura booster station has a maximum rated capacity of 5,600 gpm. Water pumped from the Ventura booster station will flow through the existing 16-inch diameter pipeline to the 24-inch MHTS influent pipeline.

The infrastructure required for the new MHTS extraction well will be coordinated closely with plans for improvements to the MHTS wastewater management infrastructure (see Section 2.1.2), as the new well would connect to this infrastructure. The new transmission pipeline will be installed along the Lower Arroyo Road (i.e., Karl Johnson Parkway). Appendix B includes the proposed pipeline routes for both the new MHTS extraction well and the wastewater management infrastructure.

Pump Sizing – The new MHTS extraction well is preliminarily sized to produce 1,600 gpm as conceptualized in meetings with PWP. The total dynamic head (TDH) must be calculated to correctly size the well pump. TDH is the amount of hydraulic head the pump must provide to deliver 1,600 gpm to the designated discharge point. TDH accounts for elevation difference, head loss due to friction through pipes, valves and fittings, and head loss through the treatment plant.

It is anticipated that the static water level in the new well will be similar to that observed in Arroyo Well. Using recent performance data from Arroyo Well and assuming 25% loss of well performance due to drawdown, the estimated pumping level for the new MHTS Well is 425 feet bgs. Table 2-3 summarizes the estimated pumping water level calculation for new well.

Table 2-3. Pumping Water Level Estimate for the New MHTS Extraction Well

Estimated Discharge	1,600 gpm
Well Performance	12 gpm per foot of drawdown
Static Water Level	257 feet bgs
Drawdown @ 1,600 gpm	134 feet
Additional Drawdown due to 25% loss Well Performance	34 feet
Estimated Pumping Water level for New Well	**425 feet bgs**

The head loss through the discharge pipeline can be calculated using the Hazen-Williams equation. The length of the discharge pipeline between the new MHTS well and the Ventura booster station is approximately 2,900 feet. The following form is used for this analysis:

$$h \quad 0.002083 \quad L\left(\frac{100}{C}\right)^{1.85} \quad \frac{gpm^{1.5}}{d^{4.8655}}$$

where

$L \quad length\ of\ pipe\ in\ feet$

$C \quad Hazen \quad Williams\ friction\ factor$

$gpm \quad gallons\ per\ minute$

$d \quad diameter\ of\ pipe\ in\ inches$

Along with the linear losses above, minor losses are also considered. Minor losses include head loss due to bends, valves, or tees. The following form is used for the minor head loss calculation:

$$h \quad Qty \quad K \quad \frac{v^2}{2g}$$

where

$Qty \quad quantity\ of\ fittings$

$K \quad resistance\ coefficient$

$v \quad velocity\ of\ water\ in\ feet\ per\ second$

$g \quad acceleration\ due\ to\ gravity \quad 32.2\ ft/s^2)$

The head loss in the pipeline due to major and minor losses is approximately 40 feet, with a 25% safety factor added to the minor loss calculation. Also, assuming a 4.33 pound per square inch (psi) pressure drop due to the combination of wells, another 10 feet of hydraulic head is included in the TDH calculation. Therefore, the TDH is estimated at 475 feet (425 + 40 + 10).

With the TDH estimated, the motor can be sized. Using the design criteria of flow rate (1,600 gpm) and TDH (475 feet), the brake hp can be calculated with the following equation:

$$P \quad \frac{Q \quad h}{3956 \quad \eta}$$

where

$P \quad Pump\ brake\ horsepower$

$Q \quad flowrate\ in\ gpm$

$h \quad total\ dynamic\ head\ in\ feet$

$\eta \quad pump\ and\ motor\ efficiency \quad as\ a\ decimal)$

Assuming a pump and motor efficiency of 80%, the brake hp with 20% safety factor equates to approximately 329 hp. Since motor sizes are supplied in standard increments, it is recommended that a 350 hp motor be installed for the well pump.

New electrical supply will be required for the new pump. The new well will require 480 volt, three-phase power. For a 350 hp motor, almost 437 Amps is required based on the following relation:

$$HP \quad I\ x\ E\ x\ 1.73\ x\ \%\ efficiency\ x\ \frac{P.F.}{746}$$

where

$HP \quad Horsepower$

I = Power (Amp)

E = 3 phase Voltage

P.F. = Power Factor = 0.9

% efficiency = 0.8

The estimated electrical load for the new MHTS extraction well is 546 Amps (270 + 25% of largest motor [80]) so a 600 amp breaker and service will be required to service the well and auxiliary loads.

2.1.1.5 Nitrate Compliance

Three of the existing MHTS wells (i.e. Well 52, Ventura, and Windsor) contain nitrate levels which require blending to ensure treated water is in compliance with the drinking water MCL for nitrate of 45 mg/L. Nitrate concentrations at the new MHTS well are expected to be similar to nitrate concentrations in the Arroyo Well (approximately 15 mg/L). The City of Pasadena currently performs blending at the Windsor Reservoir in compliance with the city's existing MHTS drinking water permit (Permit Amendment: 1910124PA-003). The permit requires that "if any of the Monk Hill Wells exceeds 40 mg/L nitrate, PWP shall implement nitrate blending treatment in accordance with the approved Operations, Monitoring, and Maintenance Plan (OMMP)." PWP's current blending plan uses daily blending projections based on the most recent wellhead water quality analysis results to determine the proper flowrate is produced from each well. The flow is controlled to ensure that the blended effluent is reliably below 80% of the nitrate MCL. Compliance samples are collected at the Windsor Reservoir (PS Code: 1910124-025) on a weekly basis. Provisions are in place to ensure that if one result or the average of an initial and a confirmation result exceeds 45 mg/L, that CDPH notification and Tier 1 public notification occurs.

2.1.2 Improvements to MHTS Wastewater Management

Wastewater management at MHTS is an important aspect of operation and maintenance. The two primary sources of wastewater at the MHTS are the water produced during startup of the production wells (Arroyo Well, Well 52, Ventura Well, and Windsor Well) and the water produced during media (IX and LGAC) backwashing. The system annually generates approximately 837,000 gallons of wastewater during startup of each well and over 4 million gallons of wastewater annually during media backwashing. Sufficient storage capacity is not readily available at the MHTS for such large volumes of water. Temporary tanks are currently being used to store wastewater prior to discharge. At times, this water must be treated before being discharged to the Arroyo Seco Spreading Basins. The wastewater was successfully managed during MHTS startup and early operations; however, the effort was time consuming, labor intensive, and disruptive to plant operations. An improved approach is appropriate for long-term operation and maintenance.

Upgrades to the wastewater management at MHTS will utilize the existing Behner Plant, capable of storing large volumes of wastewater (over 500,000 gallons) and a 100 gpm package treatment plant (LGAC and IX) to treat MHTS wastewater prior to discharge to the Arroyo Seco Spreading Basins. Behner Plant details are summarized in Table 2-4.

Table 2-4. Summary of Available Data for the Behner Plant

Year Constructed	1969
24-inch Influent Pipe Invert Elevation at Plant	1157.00 feet above mean sea level (amsl)
24-inch Influent Pipe Invert Elevation at JPL East Parking Lot	1106.00 feet amsl
Flocculation Basin Capacity	500,000 gallons

2.1.2.1 Location

The Behner Plant is located approximately 1 mile from the MHTS and is a surface water treatment plant that is no longer in service. Installing dedicated pipelines for wastewater generated during media backwash and well startup to the Behner Plant would provide an effective solution for managing wastewater. Once transferred to the Behner Plant, the water could be sampled, treated (if necessary), and discharged.

2.1.2.2 Existing Infrastructure and Design Considerations

Existing pipelines associated with the MHTS and Behner Plant were approximately located using as-built drawings and geographic information system (GIS) maps provided by PWP. Media backwash water and production well startup water will be routed through a combination of new and existing pipelines from their respective locations to the Behner treatment plant as described below. The existing pipelines will be pressure tested and video inspected as necessary to confirm suitability of use for the intended application.

Backflushing of the IX resin requires 70 gpm of LGAC treated water delivered by the Windsor Well or the Ventura Booster Station. The available pressure downstream of the LGAC vessels is approximately 15 psi, or a hydraulic grade line (HGL) of 1,186 feet. The high water level (HWL) at Behner is 1,162 feet and the losses in the waste line and IX vessel are less than 1 foot. Therefore, the available pressure to perform IX backflush is sufficient (i.e., 1,186 feet 1 foot >1,162 feet) to transport water to the Behner Plant. IX resin rinsing requires 450 gpm of raw water, and there is approximately 61 psi, or an HGL of 1,289 feet, of raw water pressure available to feed the IX rinse process. The losses in the waste line and IX vessel are approximately 10 feet at 450 gpm. Therefore, the available pressure to perform IX rinse is also sufficient (1,289 feet 10 feet > 1,162 foot) to transport water to the Behner Plant.

The infrastructure required for improvements to the MHTS wastewater management infrastructure will be coordinated closely with infrastructure required for the new MHTS extraction well, as the new well would connect to the wastewater infrastructure. Appendix B includes the proposed pipeline routes for both the new MHTS extraction well and the wastewater management infrastructure.

2.1.2.3 Well Pumping Capacity

Existing pumps in Arroyo Well, Well 52 and Ventura Well are designed for discharging groundwater at the Ventura booster station, which is located in the Arroyo Seco at a lower elevation than the Behner Plant. Therefore, the pumping capacity of Arroyo Well, Well 52 and Ventura Well will decrease when discharging to the Behner Plant. Windsor Well is located at a slightly higher elevation than the Behner Plant and rerouting of pump startup water should not influence pumping capacity. Table 2-5 summarizes the estimated pumping capacity of the current PWP wells when discharging directly to the Behner Plant.

Table 2-5. Estimated Pumping Capacity of PWP Wells when Discharging Directly to the Behner Plant

Parameter	Arroyo Well	Well 52	Ventura Well	Windsor Well
Design Capacity	2,200 gpm	1,800 gpm	1,600 gpm	1,400 gpm
Total Design Head (TDH)	350 feet	300 feet	272 feet	570 feet
Current Static Water Level	213 feet bgs	111 feet bgs	182 feet bgs	185 feet bgs
Drawdown	51 feet	116 feet	50 feet	146 feet
Current Highest Discharge Elevation	1,075 feet amsl	1,075 feet amsl	1,070 feet amsl	1169 feet amsl
Behner Plant Discharge Elevation	1,162 feet amsl	1,162 feet amsl	1,162 feet amsl	1,162 feet amsl
Assumed head loss in pipelines	20 feet	22 feet	25 feet	20 feet
New TDH for Behner Plant Discharge	371 feet	336 feet	349 feet	344 feet
Estimated Pumping Capacity to Behner Plant	**2,100 gpm**	**1,600 gpm**	**1,000 gpm**	**1,400 gpm**

2.1.2.4 Estimated Total Flow to the Behner Plant

Wastewater will be generated at the MHTS during pump startup, vessel backwashing, vessel flushing, and during other service and repairs. Table 2-6 summarizes the estimated annual volumes of wastewater generated at the MHTS.

2.1.2.5 Treatment Plant at Behner Facility

A 100 gpm package treatment plant will be installed at the Behner plant to treat MHTS wastewater. Pump startup and backwashing processes will need to be coordinated so that the total flow would not exceed the Behner plant's capacity. Treated water from the package treatment plant can be discharged directly to the spreading basins utilizing existing 24-inch effluent pipeline from the Behner Plant, provided the pipe is in good condition and discharge samples meet the surface water discharge requirements. The package plant would consist of pre-filters for sediment removal, LGAC absorbers for VOC removal and IX for perchlorate removal; nitrate treatment is not expected to be needed at the Behner facility. The package treatment plant will be installed on an existing concrete pad, previously used for chemical storage at the Behner plant. The existing concrete pad is approximately 40-feet long by 24-feet wide, which will be sufficient to install the treatment vessels and filters. New pumps will be required to pump water from sedimentation basins to the package treatment plant. Two 100 gpm and 15 hp submersible pumps (one primary and one for standby) will be installed to pump the water to the new package plant. A new 4-inch pipeline will be installed from the pump station to the filter system. Figure 2-2 shows channelized flow direction from influent box to the submersible pumps. The intent of the given flow path (red arrows) is to avoid short circuiting at the pipeline influent and submersible pumps

Table 2-6. Estimated Pumping Capacity of PWP Wells when Discharging Directly to the Behner Plant

Description	Water Type	Flowrate (gpm)	Volume (gallons)	Events per Year	Annual Volume (gallons)
Arroyo Well Startup	Raw Water	2,100	279,000	1	279,000
Well 52 Startup	Raw Water	1,600	126,000	1	126,000
Ventura Well Startup	Raw Water	1,000	180,000	1	180,000
Windsor Well Startup	Raw Water	1,400	252,000	1	252,000
New MHTS Well Startup	Raw Water	2,000	360,000	1	360,000
LGAC Backwash	Potable Water	1,600	310,000	9	2,790,000
IX Blackflush	Treated LGAC Water	70	5,500	12	66,000
IX Forward Rinse	Raw Water	450	10,000	12	120,000
LGAC Disinfection	Potable Water	NA	15,000	9	135,000
IX Disinfection	Potable Water	NA	9,500	12	114,000
LGAC Post-Disinfection Flushing	Potable Water	NA	25,000	9	225,000
IX Post-disinfection Flushing	Potable Water	NA	16,000	12	192,000
Ventura Sump to Spreading Basin	Raw Water	NA	100,000	1	100,000
Servicing and Repairs	Treated Water	4,000	200,000	2	400,000
Total					**5,339,000**

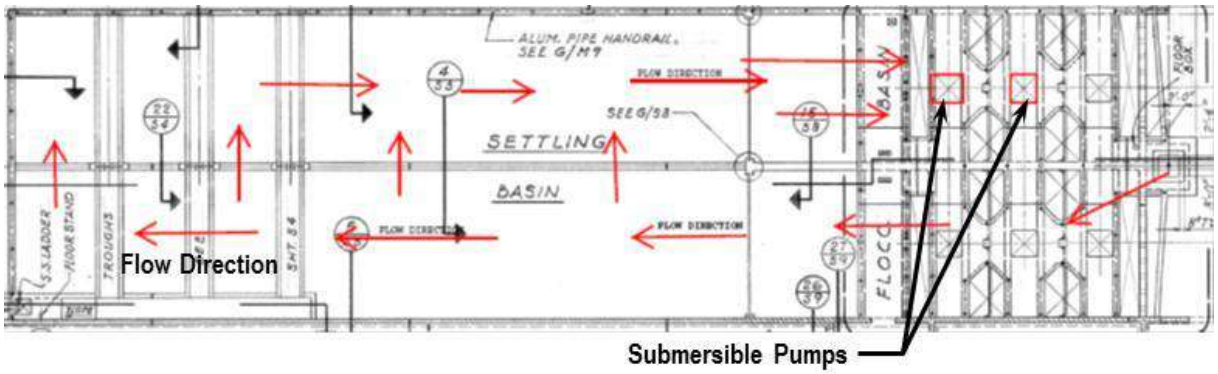

Figure 2-2. Flow Direction and Submersible Pump Locations at the Behner Plant Sedimentation Basins

2.2 LAWC (Leading Edge) Optimization

NASA's annual cost to fund the LAWC treatment system is approximately $1M. In addition, it has been estimated that the LAWC system will need to operate for at least 18 years to reduce aquifer concentrations to below current state and federal MCLs (NASA, 2007b). Installation of a new well (i.e., LAWC#6) near the current LAWC#5 serves two purposes:

1. *Improve reliability and containment*. LAWC#5 (installed in 1971) is currently the furthest downgradient containment well associated with the NASA JPL cleanup program. Concentrations of perchlorate and carbon tetrachloride have increased in samples collected from LAWC#5 since 2004, with current levels near 20 µg/L and 2 µg/L, respectively. If containment is lost, additional production wells and water companies could be impacted. A new well near LAWC#5 improves system reliability and the ability of the LAWC system to effectively contain the leading edge of the chemical plume originating from JPL.
2. *Enhance plume capture and mass removal at the leading edge of the JPL plume*. Some of the perchlorate detections near the leading edge of the JPL plume have been in the deeper portions of the aquifer, below the screened interval for LAWC#5. A new well near LAWC#5 would be screened in the deeper portions of the aquifer to better capture chemicals originating from JPL.

The new LAWC extraction well is proposed to be located at the LAWC office property, which has sufficient area to support the large footprint of well drilling equipment (i.e., drill rig, well materials, soil cuttings, etc.) required for this effort.

General Well Design – The general design parameters for the new LAWC production well include a capacity of between 1,000 to 1,800 gpm constructed to an approximate depth of 850 feet bgs. The well would be constructed of 16.0-inch diameter blank casing and screen; furnished with a 500 hp motor (480 volt/three-phase power) capable of a flowrate of 1,800 gpm. Required site upgrades include a pump pedestal, discharge piping, and well appurtenances; pipeline tie-in to the existing LAWC transmission pipeline to LAWC treatment plant; removable pump enclosure that includes concrete foundation, interior/exterior lighting, and low voltage power; switchgear (soft start), VFD, programmable logic control (PLC), transformer, and power connection via overhead power lines; potable water line; and asphalt paving.

After the well is installed, the results of the test pumping (i.e., pumping level, drawdown, and specific capacity), as well as seasonal and long-term static water level variations, pressure variations, system demand, and pressure characteristics will be used to design a vertical turbine pump capable of meeting the design flowrate. A pump design submittal generally includes the following: pump performance sheet and pump curves, sectional drawing, dimensional drawing, and motor dimensional drawings/specifications that will be reviewed by a State of California licensed civil engineer.

2.2.1 Location

The optimal location for the new LAWC extraction well was chosen based on logistics, water supply, and plume containment. Because LAWC exists within a densely populated residential area, limited open or undeveloped land is available for the construction of a new production well. The proposed location (Figure 2-3) has the required infrastructure, including appropriate power service, close proximity to existing transmission pipelines, appropriate site access and security, appropriate zoning, and necessary

space. The LAWC office location is believed to be the optimal location based on its location at the leading edge of the plume within the existing JPL chemical plume.

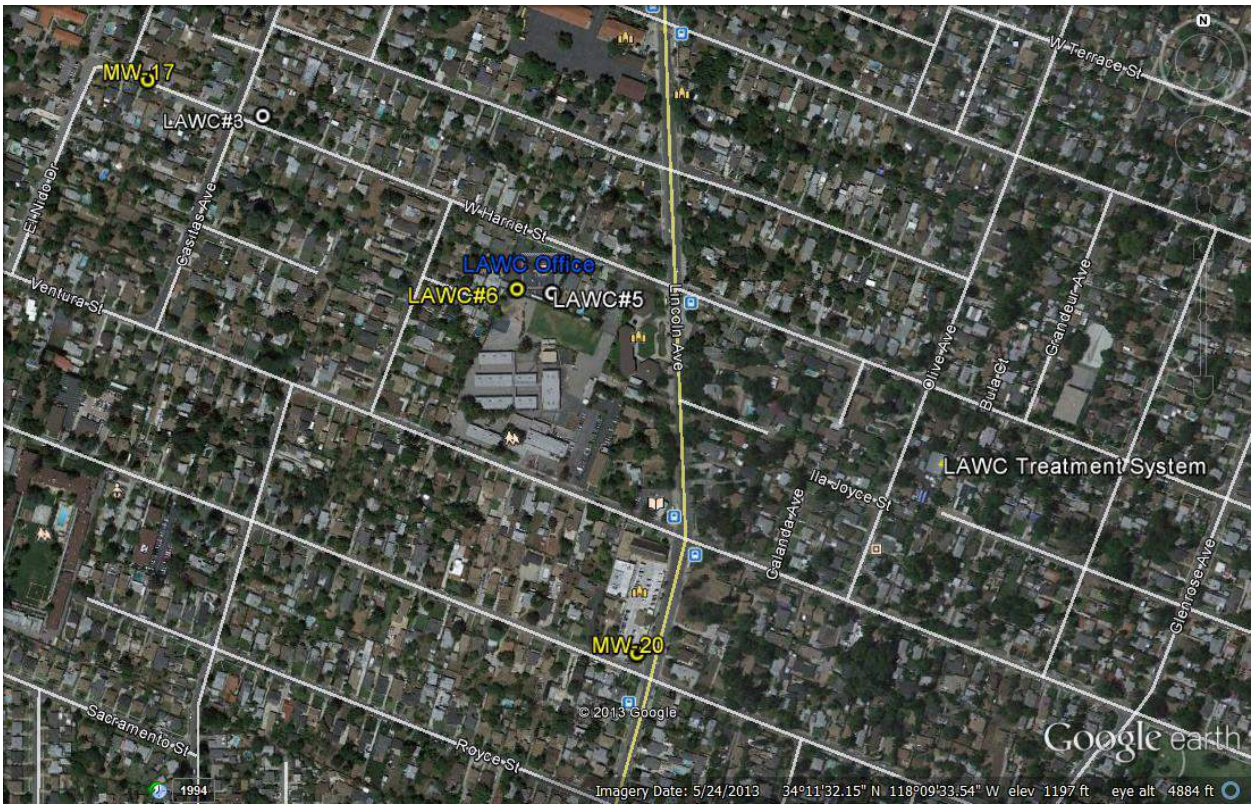

Figure 2-3. Proposed Location of New LAWC Well

Data from multi-port monitoring wells MW-17 and MW-20 indicate the presence of perchlorate in the deeper zones of the aquifer, below the current screened interval of LAWC#5, which is screened from 390 to 556 feet bgs. Therefore, the new LAWC extraction well has a proposed screened interval from 550 to 850 feet bgs, consistent with the interval of elevated chemical concentrations observed in MW-20. There is some uncertainty with placing the screen interval at this depth relative to production flowrates since no nearby production wells extract water from this depth interval in the aquifer. In addition, silt layers were observed in NASA's monitoring well MW-20 located 1,330 feet to the south/southeast of the new LAWC well which would intersect the screen interval. A more detailed evaluation of the geologic conditions is presented in Appendix C.

2.2.2 Source Water Assessment

The SWA for the new LAWC extraction well follows the same procedure as the SWA documented in the *Final California CDPH Policy Memorandum 97-500 Documentation Raymond Basin, Monk Hill Subarea* (Battelle, 2010). Given the close proximity of the proposed well to the existing well that was included in the original SWA, many of the findings from the original SWA directly apply to the new well. However, the deeper screening of the new well will create a capture zone of source water not fully considered in the original SWA. Findings from the original SWA that are independent of source water depth are considered applicable to the new LAWC extraction well. To supplement the original SWA, a focused SWA has been performed as part of this document to accomplish the following:

- Review the origin of identified chemicals;
- Delineate the source capture zone for the new LAWC extraction well;
- Evaluate chemical concentration trends for monitoring and production wells relevant to the new well.

Sections 2.3 and 2.4 of the original SWA for the Monk Hill Subarea summarized chemicals used or generated by facilities responsible for chemicals known to be in groundwater and also the vulnerability of groundwater in the Monk Hill Subarea. The findings of these sections are applicable for the proposed new well.

Review of Origin of Identified Chemicals – The original SWA identified the JPL facility and upgradient groundwater as the two known origins of chemicals found in the source water. A variety of solvents, rocket fuel propellants, cooling-tower chemicals, and analytical laboratory chemicals were used historically during JPL operations. Until the early 1960s, seepage pits were commonly used to dispose of these wastes by infiltration into surrounding soil. Once in the soil, chemicals from the waste eventually migrated to groundwater. In addition, the VWC wells represent upgradient groundwater and are located west of the JPL facility. Historical analyses of water quality from the VWC production wells indicate the presence of certain contaminants similar to those found also in groundwater beneath and downgradient of the JPL facility.

Conclusions drawn from remedial investigations and long-term monitoring findings apply to the new LAWC extraction well because data from all screening levels were included in the original SWA chemical origin and trend analysis. In addition, conclusions from the original SWA addressing emerging contaminants and tentatively identified compounds also apply directly to the new LAWC extraction well.

Based on findings of the remedial investigations and long-term monitoring program, perchlorate and VOCs (i.e., PCE, TCE, and carbon tetrachloride) are expected to be present in groundwater near the new LAWC extraction well. Therefore, these data are evaluated in adjacent wells located within the capture zone of the new LAWC well.

Source Capture Zone Delineation – The new LAWC extraction well will be located within the Monk Hill Subarea of the Raymond Basin. While generally considered to be an unconfined aquifer, groundwater flow is modeled in layers based on the presence of relatively thin, silt rich layers that influence vertical flow. Groundwater flow in the area is primarily to the southeast. However, flow direction and elevation can be affected by production well pumping, recharge from the Arroyo Seco spreading basins, seasonal and regional recharge from precipitation, and regional groundwater flow. In the original SWA, the capture zones were delineated using the three-dimensional finite element groundwater flow model developed by NASA in 2003 (NASA, 2003). The same model was used for the new LAWC extraction well (see Appendix A).

Evaluation of Chemical Concentration Trends – The source capture zone delineation results indicate data from monitoring wells MW-17, MW-20, and MW-18, as well as LAWC#3 and LAWC#5 should be considered in assessing chemicals and trends that might be expected in the new LAWC extraction well. VOC and perchlorate data from the deeper screened intervals (Screens 3, 4, and 5) of MW-17, MW-18, and MW-20, as well as LAWC#3 and LAWC#5 are summarized in Table 2-7.

Perchlorate, TCE, PCE, and carbon tetrachloride are frequently detected in LAWC#5 and LAWC#3. Perchlorate and carbon tetrachloride are frequently above their respective MCLs. In LAWC#3, perchlorate concentrations have decreased significantly since 2011, perhaps due to the operation of the MHTS. Carbon tetrachloride concentrations in LAWC#3 have been decreasing since 2006 and are

approaching the MCL. In LAWC#5, perchlorate and carbon tetrachloride concentrations have been decreasing since 2011, following a steady increase in concentrations beginning in 2004. MW-20 across all screens, MW-17 (Screen 5), and MW-18 (Screen 5) are frequently non-detect and consistently below the MCL for all four chemicals. However, perchlorate has been detected sporadically in the deeper screens of MW-20. Perchlorate is frequently detected above the MCL in MW-17 (Screen 3) and MW-18 (Screens 3 and 4). Carbon tetrachloride is also present in MW-18 (Screens 3 and 4) above the MCL. Nitrate is not anticipated to be a concern in the new LAWC extraction well as historical monitoring data from MW-17 and MW-20 show nitrate concentrations decreasing with aquifer depth.

Table 2-7. Summary of Chemical Trends for Wells near the New LAWC Extraction Well

			LAWC# 5	LAWC# 3	MW 17			MW 18			MW 20		
					Screen 3	Screen 4	Screen 5	Screen 3	Screen 4	Screen 5	Screen 3	Screen 4	Screen 5
Perchlorate (µg/L)	MCL = 6 µg/L	Detection Frequency	120/120	171/173	20/20	6/20	0/10	20/20	20/20	2/20	4/21	8/21	8/21
		Average Conc.	20.3	24	13	1.1	0.6	63	37	0.84	1.5	20	8.8
		Most Recent Conc.	26	20	8.1	2.1	ND	93	15	ND	ND	ND	ND
		Max. Conc.	44	46	33	3.8	-	140	67	2.7	13	120	57
		Date of Max. Conc.	07/2011	04/2012	11/2007	02/2011	-	08/2011	05/2010	12/2009	02/2012	02/2012	20/2012
PCE (µg/L)	MCL = 5 µg/L	Detection Frequency	32/35	28/48	3/20	0/20	0/10	4/20	9/20	0/20	5/21	0/21	0/21
		Average Conc.	0.65	0.45	0.26	0.25	0.25	0.26	0.44	0.25	0.28	0.25	0.25
		Most Recent Conc.	0.57	ND	ND	ND	ND	0.15	0.86	ND	0.28	ND	ND
		Max. Conc.	1.3	0.81	0.38	-	-	0.42	1.1	-	0.51	-	-
		Date of Max. Conc.	07/2011	10/2009	11/2007	-	-	01/2008	11/2011	-	11/2007	-	-
TCE (µg/L)	MCL = 5 µg/L	Detection Frequency	36/36	38/47	8/20	17/20	0/10	20/20	19/20	0/20	6/21	0/21	0/21
		Average Conc.	2.69	1.6	0.43	0.71	0.25	1.3	1.05	0.25	0.35	0.25	0.25
		Most Recent Conc.	2	0.8	0.2	0.59	ND	1	0.9	ND	0.5	ND	ND
		Max. Conc.	4.9	2.9	1.1	1.4	-	3.6	1.5	-	0.74	-	-
		Date of Max. Conc.	03/2011	10/2009	11/2007	10/2011	-	08/2011	02/2011	-	09/2011	-	-
Carbon Tetrachloride (µg/L)	MCL = 0.5 µg/L	Detection Frequency	36/36	37/48	11/20	0/20	0/10	20/20	19/20	0/20	0/21	0/21	0/21
		Average Conc.	2.2	1.2	0.58	0.25	0.25	15.7	7.8	0.25	0.25	0.25	0.25
		Most Recent Conc.	2.2	0.68	ND	ND	ND	7.4	1.9	ND	ND	ND	ND
		Max. Conc.	4.1	2.3	1.8	-	-	43	16	-	-	-	-
		Date of Max. Conc.	07/2011	10/2009	11/2007	-	-	08/2011	12/2009	-	-	-	-

Gray indicates greater than 50% detection frequency.

Red outline indicates most recent concentration is greater than the MCL.

* ½ PQL used for non-detect results in calculating averages; data exclude duplicate samples.

2.2.3 Raw Water Assessment

The goal of this raw water quality characterization is to estimate the concentrations of chemicals expected to be present in water extracted from the new LAWC extraction well. These estimates are useful in comparing existing treatment plant removal capability to the expected concentrations.

Based on the historical monitoring data presented in the SWA above, estimated concentrations in the new LAWC extraction well are estimated in Table 2-8. Given the close proximity of the new well to LAWC#5, it is assumed the raw water quality will most likely reflect the most recent LAWC#5 concentrations. However, given the deeper screening, water quality could be affected by the new extraction well drawing water from the areas of nearby wells identified in the SWA. To account for this uncertainty, in addition to the most recent LAWC#5 values, Table 2-8 also presents two possible ranges of expected chemical concentrations. The first range represents the average and maximum historical values observed in LAWC#5, and the second range incorporates information from nearby wells as the weighted average and weighted maximum. The weighting reflects a scenario in which 75% of new well water matches LAWC#5 water quality, 10% matches LAWC#3, 10% matches MW-18 (Screen 3) and 5% matches MW-17 (Screen 3). The weighting factors were adjusted to reflect different contribution scenarios from the nearby upgradient wells; however, the results remained similar to the range established using only LAWC#5.

Table 2-8. Estimated Concentration of Chemicals in New LAWC Extraction Well

	Assumed Quality	Range 1		Range 2	
Parameter	LAWC#5 Most Recent	LAWC#5 Average	LAWC Maximum	Weighted Average	Weighted Maximum
Perchlorate (µg/L)	**26**	20.3	44	24.5	53
PCE (µg/L)	**0.57**	0.65	1.3	0.57	1.1
TCE (µg/L)	**2**	2.69	4.9	2.33	4.4
Carbon Tetrachloride (µg/L)	**2.2**	2.2	4.1	3.37	7.7

2.2.4 Existing Infrastructure and Design Considerations

Preliminary evaluation shows that the new LAWC extraction well would be installed in the southwest corner (parking lot) of the LAWC office facility on West Harriet St., approximately 190 feet west of LAWC#5. The well will be located in a relatively flat area in the existing parking lot (see Figure 2-3). An elementary school is located south of LAWC's office parking lot separated by a chain link fence. A residential house is located approximately 20 feet away to the west. Coordination with the school district and residential community will be required prior to and during well installation activities.

An existing 8-inch pipeline from LAWC#3 and an existing 8-inch pipeline from LAWC#5 connect at the northeast corner of the LAWC office property and transition to a 12-inch pipeline that transports water approximately 2,000 feet to the LAWC treatment plant. The maximum production capacity of LAWC#3 is 900 gpm and LAWC#5 is 1,100 gpm. The flows from the new LAWC extraction well to the treatment plant can be accommodated by connecting to the existing 12-inch line at West Harriet St, or by installing a new 12-inch pipeline. Appendix D shows the existing pipelines along Harriet St. and new infrastructure associated with the new LAWC extraction well.

In general, the velocity inside the pipe should range from 3 to 6.5 feet/second (McGhee, 1991). Based on this velocity range, the existing 12-inch discharge pipeline can effectively convey up to 2,400 gpm. The current flow of 2,000 gpm through a 12-inch diameter pipeline will yield a velocity of approximately 5.6 feet/second.

Pump Sizing – The new LAWC extraction well is preliminarily sized to produce a maximum of 2,000 gpm as conceptualized in the initial meetings with LAWC. The TDH must be calculated to correctly size the well pump. TDH is the amount of hydraulic head the pump must provide to deliver 2,000 gpm to the designated discharge point. TDH accounts for elevation difference, head loss due to friction through pipes, valves and fittings, and head loss through the treatment plant.

It is anticipated that the static water level in new replacement well will be similar to that observed in LAWC#5. Using recent performance data from a nearby Pasadena Well, Windsor Well, and assuming 25% loss of well performance due to drawdown, the estimated pumping level for the new LAWC well is 555 feet bgs. Table 2-9 summarizes the estimated pumping water level calculation for the new well at LAWC facility.

Table 2-9. Pumping Water Level Estimate for the New LAWC Extraction Well

Estimated Discharge	2,000 gpm
Well Performance	9 gpm per foot of drawdown
Static Water Level	270 feet bgs
Drawdown @ 2,000 gpm	225 feet
Additional Drawdown due to 25% loss Well Performance	60 feet
Estimated Pumping Water level for New Well	**555 feet bgs**

The head loss through the discharge pipeline can be calculated using the Hazen-Williams equation (formula provided in Section 2.1.1.4). Along with the linear losses, the minor losses are also considered. Minor losses include head loss due to bends, valves, or tees.

The head loss in the pipeline due to major and minor losses is approximately 35 feet, with a 25% safety factor added to the minor loss calculation. Also, assuming a 30 psi pressure drop across the treatment plant, another 69 feet of hydraulic head is included in the TDH calculation. Therefore, the TDH is estimated at 659 feet (555 + 35 + 69).

With the TDH estimated, the motor can be sized. Using the design criteria of flow rate (2,000 gpm) and TDH (659 feet), the brake hp can be calculated using the equation provided in Section 2.1.1.4. Assuming a pump and motor efficiency of 80%, the brake hp with 20% safety factor equates to approximately 500 hp.

New electrical supply will be required for the new pump. The new well will require 480 volt power supply. Southern California Edison (SCE) supplies the power to the LAWC facility and a power pole with a transformer is located in front of the LAWC facility. LAWC has two power connections with the SCE. Per SCE, existing three-phase supply transformer is running with 70% load and can go up to 120%. The existing electric panel shows that LAWC has 600 amp switchboard and main breaker. With the addition of the new LAWC extraction well load in the system, a new 1,500 amp breaker and new meter will be needed to power both water well pumps. Therefore, the three-phase transformer located in front of the facility will need to be upgraded to take the extra load.

3 OPTIMIZATION CONSTRUCTION

Construction of the MHTS and LAWC optimization projects will be conducted in accordance with all applicable laws and regulations including an approved Accident Prevention Plan as part of the Final Remedial Design/Remedial Action (RD/RA) Work Plan (NASA, 2009). This section provides a summary of permitting, coordination, and scheduling associated with construction.

3.1 Permitting and Approvals

CERCLA Section 121(e)(1) provides that no Federal, state, or local permits shall be required for the portion of any response action conducted entirely on site. On site is defined as the "areal extent (including surface area, air, soil, and groundwater) of contamination and all suitable areas in very close proximity to the contamination necessary for implementation of the response action (U.S. EPA, 1992).

Even though CERCLA exemptions apply, various permits, or substantive requirements of permits, apply to the design and construction of the MHTS and LAWC optimization projects. These include NPDES permits from the RWQCB, drinking water permit amendments from the CDPH, and several permits and approvals from departments within the City of Pasadena (MHTS optimization) and/or the county (i.e., LAWC). PWP and LAWC will be the applicants and permit holders for any required permits. A sanitary sewer connection is not part of the optimization efforts, so a sewer discharge permit will not be required.

3.1.1 NPDES Permit

Discharges from the MHTS to the Arroyo Seco Spreading Basins currently comply with the substantive provisions of Order No. R4-2013-0043, *Waste Discharge Requirements for Discharges of Treated Groundwater from Investigation and/or Cleanup of Volatile Organic Compound Contaminated Sites to Surface Waters in Coastal Watersheds of Los Angeles and Ventura Counties* (RWQCB, 2013). The requirements contained in Order No. R4-2013-0043 are consistent with all water quality control policies, plans, and regulations in the California Water Code (CWC) and the revised *Water Quality Control Plan (Basin Plan) for the Los Angeles Region* (RWQCB, 1994). An approved Discharge Protocol (NASA, 2010) provides details regarding compliance with NPDES and RWQCB requirements. This protocol will be modified to address discharges from the Behner Plant, ensuring compliance with all substantive requirements for surface water discharges.

LAWC currently operates under RWQCB Order No. R4-2009-0047, and Monitoring and Reporting Program No. CI-9511 (RWQCB, 2009a). The LAWC system was assigned NPDES No. CAG994003 and was issued by the RWQCB on July 30, 2009 (RWQCB, 2009b). The substantive requirements of this permit (or an amended permit) would need to be followed for any discharges associated with installation, development, and test pumping associated with the new LAWC extraction well.

3.1.2 CDPH Permit Amendment

The CDPH regulates all public drinking water systems. The groundwater within the area defined as OU-3 is considered by the CDPH to be an extremely impaired drinking water source. California Code of Regulations (CCR) Title 22, Section 64560 provides the regulatory requirements associated with installation of new drinking water production wells. These regulations require submittal of a permit amendment application and technical report to CDPH, which includes:

- A source water assessment that includes delineation of the boundaries of the source area, identification of possible contaminating activities (PCAs) within the delineated source area, a determination of the PCAs to which the source is most vulnerable, and a summary of the vulnerability of the source to contamination. Much of this has already been performed as part of

permitting the MHTS and would need to be updated for the new extraction well (see section above).

- Documentation demonstrating that a well site control zone with a 50-foot radius around the site can be established for protecting the source from vandalism, tampering, or other threats.
- Design plans and specifications for the well.
- Documentation required for compliance with California Environmental Quality Act (CEQA).

The regulations also require that after CDPH has provided written or oral approval of the permit amendment application and the water system has constructed the well, both PWP and LAWC would need to submit the following items to obtain the amended permit:

- A copy of the well permit required by the county (see below);
- Department of Water Resources well completion report;
- A copy of any pump tests required by CDPH;
- Results of all required water quality analyses;
- As-built plans.

In addition, public water supply wells must be constructed in accordance with the community water system well requirements in California Department of Water Resources Bulletins 74-81 and 74-90, and be constructed in accordance with American Water Works Association (AWWA) Standard A100-06 (Water Wells). New wells must also comply with CDPH-specified minimum horizontal distances to sanitary hazards (e.g., sewer lines, manholes, septic tanks and leach lines, petroleum storage tanks, etc.).

3.1.3 Raymond Basin Management Board

The Raymond Basin Management Board (RBMB) oversees implementation of the adjudication provisions of the Raymond Basin Judgment. The RBMB consists of 16 water producers that extract water from the Raymond Basin. NASA has initiated coordination with the RBMB with respect to constructing and operating the proposed new extraction wells. Project documentation, including this optimization work plan, will be submitted to the RBMB for review. Because well construction and development require groundwater extraction, the RBMB will be notified of estimated and actual extracted groundwater quantities before and after well construction.

3.1.4 Municipal Permitting

Obtaining a Conditional Use Permit (CUP) and Building Permit from the City of Pasadena will need to be closely coordinated with PWP. NASA worked with PWP on these same permits when constructing the MHTS, so the process is understood. Even so, it can be time consuming and requires several steps, including:

- Submitting a CUP application, including an environmental assessment, tree inventory, site plan, topographic map, grading plan, elevations, landscape plan, photo renderings, and a plan for public notification.
- Conducting community meeting(s), a public comment period, and a public hearing.
- Identifying and implementing mitigation measures to address aesthetics (e.g., landscaping), biological impacts (e.g., tree protection and nesting bird season April through August), and noise exposure (e.g., restricted hours for construction and sound enclosures).
- Developing and implementing a Traffic Control Plan.

- Developing and implementing a Storm Water Protection Plan during construction.
- Developing and implementing a Construction Waste Management and Recycling Plan.

Since LAWC is not located within Pasadena City limits, the CUP process does not apply.

3.1.5 California Environmental Quality Act

A CEQA evaluation will need to be performed to comply with City of Pasadena and CDPH requirements. This will require development of two independent initial studies to evaluate the potential for adverse effects in 18 areas (aesthetics, agricultural and forestry resources, air quality, biological resources, cultural resources, geology and soils, greenhouse gas emissions, hazards and hazardous materials, hydrology and water quality, land use and planning, mineral resources, noise, population and housing, public services, recreation, transportation/traffic, utilities and service systems, and mandatory findings of significance). The Pasadena Planning and Development Department will review the initial study for the MHTS optimization and the CDPH will review the LAWC optimization to determine if significant impacts exist. Construction of the MHTS resulted in Pasadena issuing a Mitigated Negative Declaration that identified specific mitigation measures. Optimizations made to the MHTS and LAWC systems would likely result in a similar determination.

3.1.6 Los Angeles County Well Permit

As the owners and operators of the new MHTS and LAWC extraction wells, both PWP and LAWC will need to obtain a well permit from the Los Angeles County Department of Public Health. The fee for a public drinking water well is $844, plus well site plan review ($584), water supply yield evaluation ($519), and processing fee ($65). The well permit application requires supporting documentation including a written narrative of the plan, well installation diagram, and a site map (depicting roads, property lines, private sewage disposal systems, surface water features, and possible sources of contamination within 200 feet of the well site). A copy of the county well permit is provided in Appendix E.

3.2 Production Well Installations

The following sections describe the well installation activities that will be performed as part of this OU-3 optimization effort. These activities include utility survey, drilling, well installation, development and testing, and investigation derived waste (IDW) treatment and disposal. Optimization activities are similar in scope to those performed as part of NASA's regulator approved *Work Plan for Performing a Remedial Investigation/Feasibility Study at NASA JPL* (Ebasco, 1993).

3.2.1 Pre-Drilling Activities

Prior to beginning drilling, all available utility maps will be reviewed. To the extent possible, the well location will be strategically sited in the vicinity of the proposed location to avoid existing utilities. In addition, prior to performing any subsurface activities, the well location will be scanned for underground utilities using geophysical methods. The utility-locating contractor will employ several methods, including ground-penetrating radar, magnetometer, magnetic gradiometer, and/or electromagnetic imaging. As required by California State law, Underground Services Alert (USA) will be notified of the planned drilling activities. USA is a communication center that provides notice to utility owners that may potentially have underground utilities within the proposed well sites. USA requires notification a minimum of 48 hours prior to conducting any underground excavation. Following map review, geophysical utility locating, and USA clearance, the surface of the ground will be clearly marked where underground utilities are discovered. The drilling location will be selected to avoid impact to existing utilities. Prior to the initiation of drilling activities, the drilling contractor will attempt to hand auger a

pilot hole to a depth of approximately 5 feet bgs at the proposed well location to ensure that no underground utilities or obstructions are present.

3.2.2 Noise

During well installation activities, the use of machinery and/or tools will produce or emit variable sound levels and intensities. Noise monitoring and engineering controls will be utilized to comply with both city and county construction noise ordinances. The new MHTS well construction activities will comply with Pasadena Municipal Code (Title 9 – Public Peace, Morals and Welfare, Article IV – Offenses Against Public Peace, Chapter 9.36 – Noise Restrictions) and construction of the LAWC well will comply with Los Angeles County Code of Ordinances, Title 12, Environmental Protection, Chapter 12.12 – Building Construction Noise.

Pasadena Noise Regulations - During construction for the MHTS optimization activities, the use of machinery and/or tools will produce or emit variable sound levels and intensities. This section describes the regulations set forth by the Pasadena Municipal Code in regards to construction-generated noise in residential areas (PMC 9.36.110 [Construction Projects] and 9.36.120 [Construction Equipment]):

1) No person shall operate any pile driver, power shovel, pneumatic hammer, derrick power hoist, forklift, cement mixer or any other similar construction equipment within a residential district or within a radius of 500 feet therefrom at any time other than as listed below:
   a) From 7:00 a.m. to 7:00 p.m. Monday through Friday;
   b) From 8:00 a.m. 5:00 p.m. on Saturday;
   c) Operation of any of the listed construction equipment is prohibited on Sundays and holidays.

2) No person shall perform any construction or repair work on buildings, structures or projects within a residential district or within a radius of 500 feet in such a manner that a reasonable person of normal sensitiveness residing in the area is caused discomfort or annoyance at any time other than as listed below:
   a) From 7:00 a.m. to 7:00 p.m. Monday through Friday;
   b) From 8:00 a.m. to 5:00 p.m. on Saturday;
   c) Performance of construction or repair work is prohibited on Sundays and holidays.

3) The prohibition against construction on Sundays and holidays as set forth in subsection B of this section shall not apply under either of the following conditions:
   a) The construction is actually performed by an individual who is the owner or lessor of the premises and who is assisted by not more than two individuals;
   b) The person performing the construction shall have provided the building official with a petition which indicates the consent of 65% of the households residing within 500 feet of the construction site and the unanimous consent of the households adjacent to the construction site. Said petition shall be on a form promulgated by said building official and shall be accompanied by a fee, the amount of which shall be established by resolution by the city council.

4) The prohibitions of this section shall not apply to the performance of emergency work as defined in Section 9.36.020.

5) For purposes of this section, holidays are New Year's Day, Martin Luther King Jr. Day, Lincoln's Birthday, Washington's Birthday, Memorial Day, Independence Day, Labor Day, Veteran's Day, Thanksgiving Day, Day after Thanksgiving, and Christmas (Ord. 6993 §§ 1--4, 2004; Ord. 6132 § 12, 1986: Ord. 5118 § 3.00, 1973).

6) It is unlawful for any person to operate any powered construction equipment if the operation of such equipment emits noise at a level in excess of 85 dBA when measured within a radius of 100 feet from such equipment (Ord. 5118 § 3.10, 1973).

Engineering Controls

NASA will monitor noise levels and will employ, sound attenuating foam, curtains, and blankets to reduce noise emanating from construction related equipment:

Sound attenuating devices will be utilized during construction activities when the sound level exceeds 75 dB when measured at a distance of 50 feet from the equipment or powered hand tool producing the sound (Los Angeles County, California Code of Ordinances – Title 12 – Environmental Protection, Chapter 12.12 Building Construction Noise).

Los Angeles County Code - The portions of the Los Angeles County Code presented below are relevant to the LAWC new well construction:

12.12.030 Construction noise prohibited when: Except as otherwise provided in this Chapter, a person, on any Sunday, or at any other time between the hours of 8:00 p.m. and 6:30 a.m. the following day, shall not perform any construction or repair work of any kind upon any building or structure, or perform any earth excavating, filling or moving, where any of the foregoing entails the use of any air compressors; jackhammers; power-driven drill; riveting machine; excavator, diesel-powered truck, tractor or other earth moving equipment; hand hammers on steel or iron, or any other machine, tool, device or equipment which makes loud noises to the disturbance of persons occupying sleeping quarters in a dwelling, apartment, hotel, mobile home, or other place of residence (Ord. 9818 § 1, 1969: Ord. 8594 § 6, 1964).

12.12.060 Exemptions--Work by public utilities—Conditions: The provisions of Section 12.12.030 do not apply to the construction, repair or excavation by a public utility which is subject to the jurisdiction of the Public Utilities Commission as may be necessary for the preservation of life or property, and where such necessity makes it necessary to construct, repair or excavate during the prohibited hours (Ord. 8594 § 10, 1964).

Los Angeles County General Plan Noise Element - The following portions of the General Plan are relevant to the project:

Goal N-1: An environment that is protected from unacceptable levels of noise.

Policy N 1.1: Employ effective noise abatement measures to achieve acceptable levels of noise as defined by the Los Angeles County Exterior Noise Standards.

Policy N 1.2: Ensure the compatibility of land uses throughout the County to minimize excessive noise levels.

Policy N 1.3: Ensure cumulative impacts related to noise do not exceed excessive levels by utilizing development monitoring techniques.

Sensitive Receptors (LAWC) - Some land uses are considered more sensitive to noise levels than others due to the amount of noise exposure (in terms of both exposure duration and insulation from noise) and the types of activities typically involved. For instance, residential areas, schools, churches, and hospitals generally are more sensitive to noise than are commercial and industrial land uses. The LAWC facility located at 564 West Harriet Street is bordered by residential homes on the east and west sides and an

elementary school to the south. The area bounded by West Harriet Street, Lincoln Avenue, Ventura Street, and Tola Avenues includes close to 40 residential homes, an elementary school, church, and public library. The most sensitive receptors adjacent to the work area are: the home located at 577 West Calaveras Street, Franklin Elementary School located at 527 West Ventura Street, and the home at 532 Wes Harriet Street. For this reason, sound walls will be installed around the work area.

Sound Walls (LAWC) - Temporary sound walls will be installed on all sides of the work area prior to construction. The walls will be approximately 24 feet high, and will be constructed of either acoustical barrier blankets or insulated plywood panels. The walls will be used to block drilling rig and construction related noise from propagating into the surrounding areas. The sound walls will be installed at the perimeter of the work area between the noise generating equipment and the nearby sensitive receptors such as the grade school, residential homes, etc.

Acoustical barrier blanket panels are 8 feet tall by 20 feet wide, and are attached to steel frames that will be installed three panels high (i.e., 24 feet high). The panels will be supported by steel I-beams set every 10 feet and embedded 8 feet below the ground surface.

The plywood panels are 20 feet wide x 24 feet high. Each panel will be 4 inches thick and filled with R-19 insulation and held in place and supported by iron cantilever beams embedded 8 feet bgs and backfilled with rock gravel. Each panel will be anchored and tied off by a 1/4-inch cable, which will be laced through the top of the beam and the top corners of the panels.

Noise Variance (LAWC and MHTS)
The proposed MHTS and LAWC production well sites are located adjacent to or within residential neighborhoods. Constructing the new production wells will require NASA to undertake certain construction activities continuously (i.e., 24 hours per day/7 days per week). These activities include well drilling, well casing and gravel pack installation, pump development and testing. Once initiated, these activities must be performed sequentially and continuously in order to prevent the borehole walls from collapsing and compromising the integrity of well construction. These activities would be undertaken intermittently over a period of six to eight week, with the longest continuous activity (i.e. well drilling) estimated to take up to 30 days.

As stated in Section 3.2.2 above, Pasadena and Los Angeles County construction noise regulations allow construction activities during the hours of 7:00 a.m. to 7:00 p.m. Monday through Friday and 8:00 a.m. to 5:00 p.m. on Saturdays. Construction activities associated with the proposed MHTS and LAWC wells would extend beyond normal construction hours and would likely exceed noise standards for residential areas. Therefore, NASA will be requesting a variance from the Pasadena and Los Angeles county noise ordinances to allow construction of the production wells.

The Mitigated Negative Declaration resulting from the CEQA Initial Studies (see Section 3.1.5) will be provided to facilitate variance approval. NASA has proposed the use of 24-foot tall sound barrier walls to minimize construction noise for surrounding residences. Since the project sites are adjacent to or within residential neighborhoods, it is possible that construction and drilling noise will be audible at adjacent residential properties.

3.2.3 Well Drilling

The production well drilling process will consist of the following general steps: (1) drill and install a surface casing (i.e., conductor casing); (2) drill a pilot borehole to the target depth while simultaneously logging and collecting formation samples at discrete intervals to determine subsurface lithology, aquifer layers and depths as well as other stratigraphic interfaces; (3) conduct a suite a geophysical logs in the

completed pilot borehole; (4) examine and compare geophysical logs with lithologic log and results of the formation sieve analyses; (5) ream the pilot borehole to final borehole diameter; (6) design well screen (i.e., interval and aperture size) and filter pack material; (7) install well screen and blank casing to specified depths; (8) install filter pack material via tremie pipe; (9) install transition sand and cement seal to surface; (10) well development and testing. A detailed description of the above-mentioned steps is provided below.

3.2.4 Conductor Casing

A pilot hole will be augered to approximately 50 feet and a 32-inch-diameter, mild steel conductor casing will be cemented into place before drilling operations begin. The conductor casing will maintain the near surface integrity during drilling operations, and will permanently remain in the well. Following the conductor casing installation, the borehole will be drilled in stages starting with a small diameter pilot bit, followed by reaming bits until the final borehole is 26 inches in diameter. A drilling site layout diagram for the PWP drilling efforts is provided below as Figure 3-1.

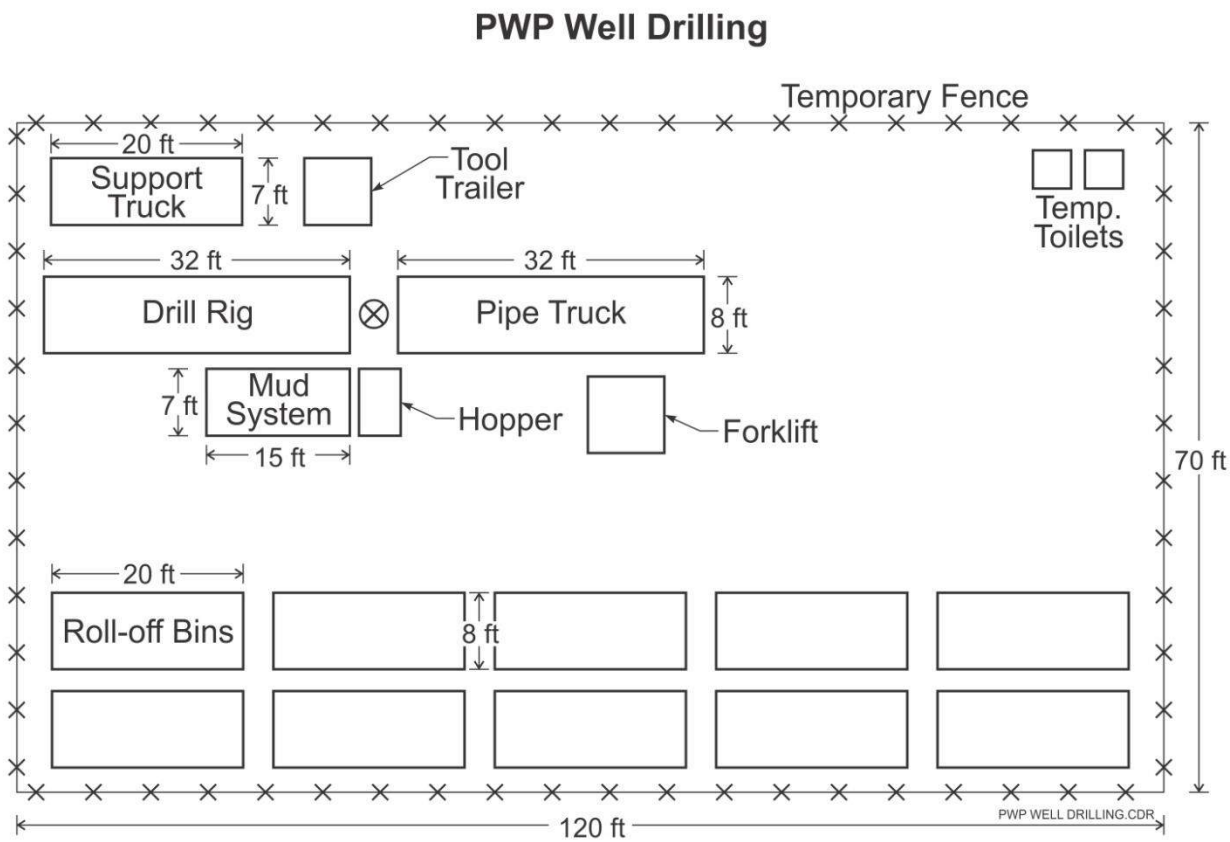

Figure 3-1. New MHTS Well Drilling Site Layout

3.2.5 Drilling Method

The pilot and reamed boreholes will be drilled utilizing the reverse circulation drilling method which is one of the most widely used production well drilling techniques in southern California. This method is ideally suited for drilling deep, large diameter drinking water well production wells. In reverse circulation rotary drilling, flow of the drilling fluid is reversed when compared with the direct rotary method. The suction end of the centrifugal pump, rather than the discharge end, is connected through the swivel to the Kelly and drill pipe. The drilling fluid and its load of cuttings move upward inside the drill pipe and are discharged by the pump into the settling pit. Centrifugal pumps with large passageways are often used to pump the drilling fluid because they can handle cuttings without excessive wear on the pump. The fluid returns to the borehole by gravity flow. It moves down the annular space between the drill pipe and borehole wall to the bottom of the hole, picks up the cuttings, and reenters the drill pipe through ports in the drill bit.

In the reverse rotary method, the drilling fluid can best be described as muddy water rather than drilling fluid; drilling fluid additives are seldom mixed with the water to make a viscous fluid. Suspended clay and silt that recirculate with the fluid are mostly fine materials picked up from the formations as drilling proceeds. Low concentrations of polymeric drilling fluids (safe for use in potable well applications) are occasionally used to reduce friction, swelling of water-sensitive clays, and water loss.

To prevent caving of the hole, the fluid level must be kept at ground level at all times, even when drilling is suspended temporarily to prevent a loss of hydrostatic pressure in the borehole. The hydrostatic pressure of the water column plus the velocity head (inertia of the water moving downward) outside the drill pipe support the borehole wall. Erosion of the wall is usually not a problem because velocity in the annular space is low.

Reverse circulation drilling is most successful in soft sedimentary rocks and unconsolidated sand and gravel where the static water level is 10 feet or more below ground level. Advantages of this method include the following:

(1) The porosity and permeability of the formation near the borehole is relatively undisturbed compared to other methods.

(2) Large-diameter holes can be drilled quickly and economically.

(3) No casing is required during the drilling operations.

(4) Well screens can be set easily as part of the casing installation.

(5) Most geologic formations can be drilled, with the exception of igneous and metamorphic rocks.

Disadvantages include the following:

(1) Large water supply is generally needed.
(2) Reverse-rotary rigs and components are usually larger and thus more expensive.
(3) Large mud pits are required.
(4) Some drill sites are inaccessible because of the rig size.
(5) For efficient operation, more personnel are generally required than for other drilling methods (Driscoll, 1989).

All drilling equipment and materials including drilling bits and pipes, drilling mud, and backfill materials will be either new or cleaned in the field using a high pressure steam cleaner. All water well drilling fluids and additives are NSF/ANSI Standard 60 certified and meet requirements for use in drinking water well drilling applications. Clean, imported water or water supplied from a nearby clean water source

(e.g., fire hydrant) will be used during drilling and well construction activities. Prior to use, a water sample will be collected from each water source. The water sample will be analyzed for perchlorate and VOCs using U.S. EPA-approved methods. A reverse circulation site layout diagram for LAWC drilling is provided as Figure 3-2 below.

During drilling and well construction, drill cuttings will be separated from the drilling fluid using a mud pit. The separated mud is recycled into the drilling process and the cuttings are stored in a roll-off bin. Additional details regarding containerization and disposal of IDW are provided in Section 3.2.9.

During pilot borehole drilling, soil samples will be collected from the mud pit for lithologic logging purposes and then disposed of with the soil cuttings. Soil samples will be logged by a field geologist under the direction of a licensed professional geologist using the Unified Soil Classification System (USCS). Drill cuttings will be evaluated after every 5 feet or less of drilling and described to document the underlying stratigraphy. Lithologic descriptions of the soil cuttings will be recorded on the field boring log form and will include the following information: physical characterization and grain-size distribution of the sample, stratigraphic boundaries, color changes, thickness of individual units, samples or cuttings collected, odor, and any other conditions encountered during drilling (i.e., changes in drilling rate, difficulties, etc.)(Ebasco, 1993). Soil boring logs will be incorporated into a bound field notebook. The field notebook will be used to document all sampling activities. These notebooks will be maintained as permanent records. Soil samples will be collected at discrete intervals for laboratory sieve analyses. This procedure is used to determine formation gradation or grain size distribution and is applied to the filter pack and well screen design. In addition, the driller will maintain a driller's log that includes penetration speed and formation material descriptions. At 100 foot intervals, the driller will check plumbness and alignment of the borehole. The drilling contractor will be required to meet alignment tolerances specified in ANSI/AWWA Standard A100-06 (AWWA, 2007).

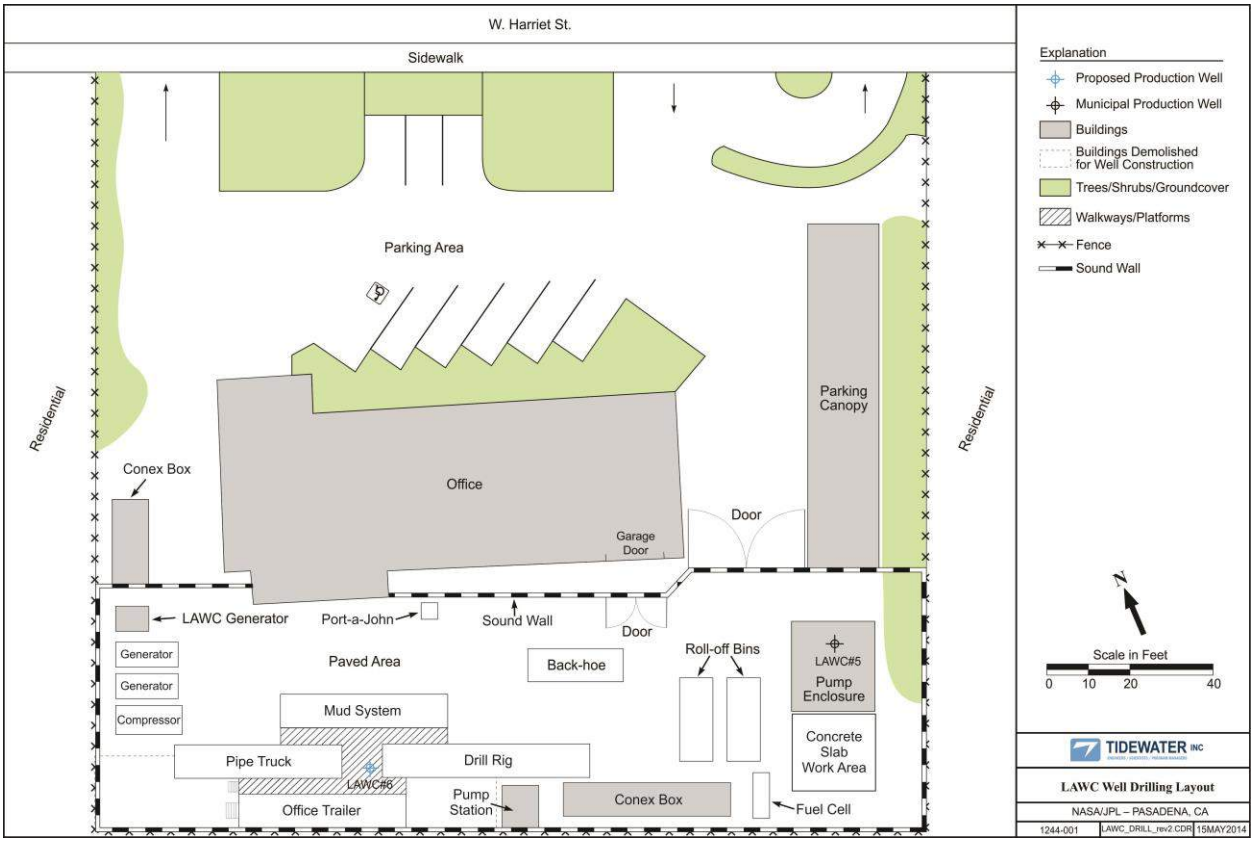

Figure 3-2. New LAWC Well Drilling Site Layout

3.2.5.1 Geophysical Logging

Upon completion of the drilling, the open borehole will be logged using geophysical methods to assist the identification of well screen depths, borehole lithologies, water-bearing intervals, and stratigraphic correlation with existing JPL monitoring wells and nearby production wells. During the geophysical logging, the sides of the open borehole will be held in place by the hydrostatic pressure of the water column, which will remain in place throughout the process. To accurately interpret results from the logging, the properties of the drilling mud or fluid will be subtracted out during analysis of the data. Proposed geophysical methods include gamma, caliper, single-point resistance, resistivity (apparent), temperature, spontaneous potential, and gyroscopic logs. The purpose and use of these methods are provided in each of the respective subsections.

3.2.5.2 Gamma Log

This method records the amount of natural gamma radiation emitted by the rocks surrounding the borehole. Clay- and shale-bearing zones often emit relatively high gamma radiation because they contain weathering products that include uranium and thorium. Clay and shale layers are aquitards and it is important to identify their locations within the aquifer to optimize the extraction of groundwater. This method is also useful to compare with the geologic log created during the drilling process.

3.2.5.3 Caliper Log

This method records borehole diameter. Changes in the borehole diameter are related to well construction, such as casing or drill-bit size, and to fracturing or caving along the borehole wall. Borehole diameter is useful in interpreting the other geophysical logs because it can affect the log

response of the other methods. Caliper logs can detect poorly consolidated sands that tend to collapse in the borehole. These sands are generally very porous, water-producing zones within the aquifer.

3.2.5.4 Single-Point Resistance Log

This method records the electrical resistance from points within the borehole to an electrical ground at the surface. Resistance typically increases with increasing grain size and decreases with increasing borehole diameter, fracture density, and dissolved-solids concentrations of the water. Single-point resistance logs require a fluid-filled borehole and are only run in the saturated zone of the aquifer. This method is useful in determining the location of water-bearing zones because fluid-filled soil pores are less resistive than solid rock or low permeability soils (e.g., clays and silts). Identifying the water-bearing zones within the aquifer will be helpful in optimizing the well construction for more efficient groundwater extraction and injection. This method is also useful to correlate with the geologic log created during the drilling process.

3.2.5.5 Resistivity (Apparent)

This method measures the electrical resistance or conductance within formations. The resistivity of a formation is affected by its lithology, water quality, and pore geometry. Both 16-inch (short normal) and 64-inch (long normal) normal resistivity measurements will be collected.

3.2.5.6 Temperature

Temperature logging is included with the suite of electric logs. The data can indicate permeable zones, flow pathways, recent recharge water, and porosity.

3.2.5.7 Spontaneous Potential Log

This method records potentials or voltages developed between the borehole fluid and the surrounding formation material and fluids. Spontaneous potential logs can be used in the determination of porous and permeable beds within the aquifer. The spontaneous potential logs are used in combination with single-point resistance logs to identify shales and sandstones (non-porous and porous, respectively) within the aquifer. This information is useful for identifying high water-bearing zones to optimize the extraction of groundwater. This method is also useful to compare with the geologic log created during the drilling process.

3.2.5.8 Gyroscopic Log

This method determines borehole alignment by calculating well attitude by sensing azimuth and inclination of the measurement sonde. The gyroscopic survey uses high-speed Litton gyros for azimuth and two accelerometers for inclination. The deviation survey uses a magnetometer for azimuth and tiltmeter to determine inclination. Plumbness and alignment of the borehole and well are very important when installing a vertical turbine pump. The log results will be plotted to demonstrate compliance with ANSI/AWWA alignment tolerances described in section 3.2.5 above.

3.2.6 Borehole Reaming

Following geophysical logging, the pilot borehole will be reamed with a larger diameter bit to the final borehole dimensions. This stage of drilling follows the same principals as described in the well drilling section above.

3.2.7 Well Construction

Following borehole reaming, the well screen and blank casing will be installed into the open borehole in 20-foot long sections. Each section will be welded at the surface and lowered into the open borehole. Centralizers will be utilized to maintain the minimum radial thickness of the annulus and ensure the well screen and blank casing are in the center of the borehole. Well screen will be placed as shown in the well

construction diagrams provided in Appendix F. Final well screen locations may be modified based on borehole logging, sieve analysis, and geophysical data. Blank casing may be installed in between screened sections based on the occurrence of fine-grained zones.

3.2.7.1 Well Casing Blank

The blank well casing will consist of 16.0-inch outer diameter, corrosion-resistant steel casing. It will be joined with the stainless steel louver screen with a dielectric coupler due to the connection between dissimilar metals.

3.2.7.2 Well Screen

The well screen will consist of 16.0-inch diameter stainless steel louver screen. The screen slot size will be determined based on a sieve analysis of the geologic formation. It will be designed to retain approximately 90% of the filter pack material after well development. The slot size for the drinking water supply well will be chosen to facilitate the flows necessary for drinking water production. Another factor selecting the slot size is analysis of drill cutting samples of the zone to be screened. Based on past drilling activities at JPL and the surrounding area, the lithology generally consists of silty to gravelly sands. Stainless steel screens best meet the characteristics of having a large percentage of non-clogging slots, are resistant to corrosion, have sufficient strength to prevent collapse, are easily developed, and prevent sand production during pumping activities.

3.2.7.3 Filter Pack

Filter-pack size will be determined by evaluating the size of the surrounding aquifer material by sieve analyses and the well screen slot size. In general, the size of the filter pack material should be large enough for adequate volumes of water to pass through, but small enough to retain the aquifer material and minimize sediment production within the well. Filter pack material (e.g., sand) is sized according to how it falls through a wire mesh, or sieve. The filter pack material will extend to 5 feet below the annular seal. The filter pack will be emplaced from the surface using the tremie method.

3.2.7.4 Seal

A 5-feet thick transition seal consisting of ¼-inch, time release coated bentonite pellets will be added on top of the filter pack. The purpose of the transition seal is to prevent the annular seal (e.g., liquid bentonite grout) from entering the filter pack. After the transition seal is in place, the annular seal will be installed. The purpose of the annular seal is to eliminate the formation of a pathway between the screened zone and potential contamination from the surface and overlying materials. The annular seal will be placed into the annular space above the transition seal to approximately the ground surface. Sealing materials will be emplaced from the surface using the tremie method. Well construction diagrams are provided in Appendix F.

3.2.8 Well Development

After completing the installation of the production well, well development will be performed to remove residual drilling fluid that forms a thin layer of mud on the sand grains of the borehole wall and filter pack material and is forced into the pore spaces and cracks in the aquifer. This process will physically commingle the sorted gravel pack with the native formation, creating a hydraulic filter around the well screen which allows efficient passage of water into or out of the well. In general, the order of the development process for the production well is as follows: drilling mud removal, mud dispersant treatment, open end airlift and dual swab airlift pumping, pump development and testing. Field notes collected during well development will be recorded on a well development log. Well development activities will be conducted in accordance with NASA's regulator approved *Work Plan for Performing a Remedial Investigation/Feasibility Study at NASA JPL* (Ebasco, 1993). The remainder of this section provides a brief discussion of each of the above well development techniques.

3.2.8.1 Primary Bail

During this process, a suction bailer is lowered into the well until it fills with water and sediment. It is then pulled to the surface and emptied. The bailer's up and down motion causes a surging action which will initiate development in the area around the screen. As a result of the surging action and mud removal, water from the aquifer will then flow towards the well and bring in more drilling fluid. This process is continued until the majority of the drilling mud is removed from inside the well.

3.2.8.2 Brush

Brushing simply involves running a hard bristle brush up and down the length of the well screen to remove fines and drilling mud embedded in the well screen. Similar to bailing, the up and down movement of the brush produces a surging effect, continuing the development process. The diameter of the brush is slightly larger than the inner diameter of the well, and will be made of hard plastic or other material that will not abrade, gouge, or otherwise damage the casing or screen of the well. Brushing the well begins at the top of the well screen and moves toward the bottom of the well in 20-foot intervals. Each 20-foot interval is brushed for 15 to 30 minutes before moving on to the next interval. Upon completion of brushing, the total depth of the well is measured to determine how much sediment has accumulated as the result of the brushing activity. Any sediment that has accumulated at the bottom of the well is removed with a bailer.

3.2.8.3 Secondary Bail

After brushing, the suction bailer is lowered into the well to remove fines and sediment that have accumulated as a result of brushing.

3.2.8.4 Mud Dispersant

Following the completion of bailing, the majority of the drilling mud has been removed from inside the well. Next, a concentrated NSF certified liquid polymer dispersant (e.g., Nu-Well 220, Aqua-Clear PFD, or equivalent) is applied to the well to facilitate removal of the residual mud and clay material present beyond the well screen and into the filter pack. The dispersant will be applied following the manufacturer's recommendations.

The mud dispersant will be mixed at the surface in a clean, graduated polymer tank. Once the mixture has been thoroughly blended, it will be applied to the screened zone via a tremie pipe. To improve the effectiveness of the mud dispersant treatment, the well will be swabbed with a dual-swab. The swabbing action ensures the distribution of the chemical treatment through the screened zone and filter pack. After completing swabbing, the well will be tagged to calculate the amount of material that has accumulated in the bottom of the well.

The bottom of the well will be bailed with a suction bailer or with an open-end airlift (OEAL) tool to remove any sediment which may have accumulated. The solids will be placed into a roll-off bin, and the water will be transferred to containment tanks. Following the completion of swabbing and bailing, the residual mud and dispersant will be removed from the well using the dual-swab airlifting (DSAL) pumping system. Additional details regarding the DSAL pumping process are provided below.

3.2.8.5 Dual-Swab Airlift Pumping

The dual-swab airlifting method is designed to dislodge debris from the casing/screen and remove it from the well. The tool consists of a vertical discharge pipe (eductor) with a smaller airline suspended down the middle of the pipe. A perforated section of pipe with two rubber swab flanges (i.e., rubber disks approximately the same size as the inside diameter of the well) is connected and located at the bottom of the eductor pipe. The swabs are primarily designed for cleaning (i.e., when raised and lowered during pumping) and stabilization of the assembly in the well. The airline discharge is installed above the surge

blocks inside the pipe. Compressed air is pumped through the airline from the surface with an air compressor and is released into the eductor pipe causing a mixture of air bubbles and water. Continued injection of compressed air causes the mixture to flow up and out of the eductor pipe. The general pumping principal is based on the difference in hydrostatic pressure inside and outside of the pipe resulting from the lower specific gravity of the mixed column of water and air bubbles. It is anticipated that the dual-swab tool will be moved up and down within the well over an approximately 10 to 15 foot interval while simultaneously pumping the well. The actual field-applied method depends upon a number of factors, including air volume, submergence (i.e., the depth below the static water level at which the air is introduced), total lift, and the cross-sectional area of the discharge or eductor pipe (i.e., diameter of discharge pipe). Generally, the larger the diameter of the eductor pipe, greater tool submergence, and higher volumes of compressed air will increase the extraction rates.

The DSAL tool is typically inserted into the well and set at the top 10 feet of the screened zone. Airlift pumping will continue at the maximum rate possible until the turbidity of the purge water decreases and will be followed by surging and swabbing of the well. This process will be repeated until turbidity does not appreciably increase as a result of surfing and swabbing of the well. Once the turbidity decreases, the airlift pumping tool will be lowered to the next 10 foot section of screen. Due to the turbidity of the airlifted water, the water will be pumped into a roll-off tank, and then transferred to a settlement or weir tank before transferring to a containment tank. The dual-swab airlift equipment will be raised and lowered throughout the screened zone. During the airlift pumping, the air supply will be periodically shut off allowing the water column to flow back through the screen. The combination of swabbing, pumping and surging enhances the removal of trapped material in the screened zone and filter-pack. Upon completion of dual-swab airlifting, a second mud dispersant treatment/dual-swab airlifting process may follow.

DSAL will be implemented in each well following the mud dispersant treatments (see Section 3.2.6.4). This technique will be performed over a 30-hour period at a maximum flowrate of 200 gpm, and will result in approximately 360,000 gallons of water and debris being removed from each well. During this initial development stage, all water removed from the wells will be routed through temporary treatment systems for sediment removal followed by treatment system processing prior to discharge. A complete description of the temporary treatment system is provided in Sections 3.2.7 and 3.2.8.

3.2.8.6 Development Pumping

After the DSAL pumping, well development pumping is performed to flush impacted fines from the surrounding gravel pack and borehole face and to consolidate the gravel pack. Development pumping consists of installing a diesel-powered vertical turbine pump into the well screened interval at a depth below the anticipated permanent production pump setting. Four 10-hour days of constant rate pumping will be performed on the drinking water supply well on consecutive days. Tables 3-1 and 3-2 summarize the duration, extraction rate, and extraction volume for the development pumping. The extraction rate for each day will vary, and increase each day from a low percentage of the expected capacity on the first day to at least 125% of the anticipated permanent discharge rate on the final day. This incremental pumping method is utilized to flush impacted fines from the gravel pack and borehole face and to consolidate the gravel pack. During each day of pump development, the sand content and turbidity will be monitored to evaluate the condition of the discharge water.

Due to the significant extraction rate and overall volume of water removed from the production wells during development pumping, the extracted water will be processed by treatment systems loaded with sacrificial media and discharged as described in Sections 3.2.7 and 3.2.8.

3.2.8.7 Test Pumping

After development pumping has been completed, aquifer test pumping is performed. Two separate well development pumping tests will be performed using the diesel powered vertical turbine test pump: a variable rate pumping test followed by a constant rate pumping test. A variable-rate (i.e., step-drawdown) pumping test will first be performed for approximately 8 hours. This test will be conducted to estimate the maximum extraction capacity of the well and the response of the aquifer system to the stresses during extraction. The extraction rate will be incrementally increased during the test once the groundwater level in the well has stabilized; reaching a maximum pumping rate that is slightly above the design flow rate. The proposed well-specific extraction rates and production volumes for the variable-rate test are summarized in Tables 3-1 and 3-2. Data collected during this test will be used to measure the hydraulic response to extraction cycles. During the pumping test, flowrates will be recorded every 10 minutes using an in-line flow totalizer. Groundwater-level measurements will be recorded using an airline and/or water level probe, and periodic measurements of sand content, and air/gas production also will be collected and recorded. These data will be used in conjunction with production rate data to estimate aquifer parameters. Groundwater-levels will continue to be recorded in the production well and in the adjacent monitoring wells after extraction during the recovery period, and the data will be used to further assist in estimating aquifer parameters.

After the completion of the step-drawdown test, and once aquifer levels have returned to static conditions, a continuous-rate pumping test will be performed on the well at its design pumping rate for 24 hours. Similar to the step-drawdown test, groundwater-level measurements will be recorded in the well throughout the test using an airline or water level probe, and periodic measurements of sand content, and air/gas production also will be collected and recorded. These data will be used in conjunction with production rate data to estimate aquifer parameters.

Due to the significant extraction rate and overall volume of water removed from the production wells during development pumping, the extracted water will be processed by treatment systems loaded with sacrificial media and discharged as described in Sections 3.2.7 and 3.2.8.

After the completion of the continuous-rate pumping test, a dynamic or pumping spinner log test will be performed which measures well hydraulics (i.e., water flow patterns) in the well.

3.2.8.8 Spinner Log

Spinner probes are commonly used in water-producing wells to measure well hydraulics (i.e., water flow patterns). A static spinner log is conducted with the well pump equipment turned off while the groundwater is under static conditions. Conversely, a dynamic spinner log is completed while the well pump is operating under normal conditions. The flow log reveals zones where water enters and exits the well screen and allows for flow contributions from individual zones to be measured and documented. Spinner log data are correlated with geophysical log data (i.e., single-point resistance log) and the lithologic log from the well installation to evaluate flow conditions within the well during static and pumping (dynamic) conditions (extraction wells only). This information is then used to identify specific zones within a well that have higher flow potential.

After well development, the test pump will be removed and the groundwater level will be allowed to re-equilibrate to static conditions. A down-hole video log of the well casing will then be taken to inspect the condition of the well casing and screen.

Table 3-1. Well Development (1,600 gpm) Production Well (PWP)

Description	Swab Airlift Rate in GPM	Hours	Airlifted Water Total (Gallons)		Day 1	Day 2	Day 3	Day 4	Step Test 8 Hour Average	Continuous Test 24 Hour + 3 hours Spinner Log	Total Volume Pumped (Gallons)
					Pump Development 10 Hours	Pump Development 10 Hours	Pump Development 10 Hours	Pump Development 10 Hours			
					0.36 x Design	0.68 x Design	1 x Design	1.27 x Design			
New PWP Well	200	30	**360,000**	Average Flow Rate:	576	1,088	1,600	2,032	1,300	1,600	**6,861,600**
Design Flow: 1,600 GPM	--			Volume:	345,600	652,800	960,000	1,219,200	624,000	2,700,000	
				Subtotal:	**3,177,600**				**3,324,000**		

Table 3-2. Well Development (1,800 gpm) Production Well (LAWC)

Description	Swab Airlift Rate in GPM	Hours	Airlifted Water Total (Gallons)		Day 1	Day 2	Day 3	Day 4	Step Test 8 Hour Average	Continuous Test 24 Hour + 3 hours Spinner Log	Total Volume Pumped (Gallons)
					Pump Development 10 Hours	Pump Development 10 Hours	Pump Development 10 Hours	Pump Development 10 Hours			
					0.36 x Design	0.68 x Design	1 x Design	1.22 x Design*			
New LAWC Well	200	30	**360,000**	Average Flow Rate:	720	1,224	1,800	2,000	1,700	1.800	**7,538,400**
Design Flow: 1,800 GPM	--			Volume:	432,000	734,400	1,080,000	1,200,000	816,000	2,916,000	
				Subtotal:	**3,446,400**				**3,732,000**		

Notes:
*Decreased flowrate from 1.27 x to 1.22 due to LAWC TP 2,000 gpm capacity.

3.2.9 PWP Purge Water Containment/Filtration

A sediment filtration and containment system will be installed at the well site (Figure 3-3) and used in conjunction with the MHTS treatment system loaded with sacrificial media to treat discharge waters. This system will be used to process development water for all stages of well development including: swab pumping (OEAL and DSAL), pump/surge development, and testing. The process flow is as follows: water will be pumped directly from the well into two 21,000 gallon containment tanks to remove sediment. Next, water will be pumped from the two tanks with high flow diesel powered pumps (i.e., 2,000 gpm max flow) to four banks of skid-mounted sand filters capable of 1,000 gpm each. Water processed by the sand filters will be pumped to MHTS via the Ventura booster station. Sand filter backwash water will be cycled back into the containment and filtration system. Well purge water will exit the sand filters and flow to the Ventura booster station through the newly installed 16-inch ductile iron (DI) pipe (PS-15), new 16-inch DI pipe (PS-11), and new 20-inch DI pipe (PS-6). The Ventura booster station will pump water to MHTS via existing pipeline connections for processing. At MHTS, two cartridge filters will be operated for sediment filtration followed by two pairs of IX vessels (perchlorate removal) and two pairs of LGAC vessels (VOC removal) loaded with sacrificial media. Both IX and LGAC vessels will be operated in lead/lag configuration with a maximum operating flowrate of 2,800 gpm (i.e., LGAC = 1,400/pair x 2 = 2,800 gpm). Treated MHTS effluent will be discharged to the sandbox, and water will gravity flow from the sandbox to the spreading basin #5 via the 30-inch Hume pipeline. Discharge samples will be collected from M001 located at the sandbox, consistent with the Discharge Protocol (NASA, 2010).

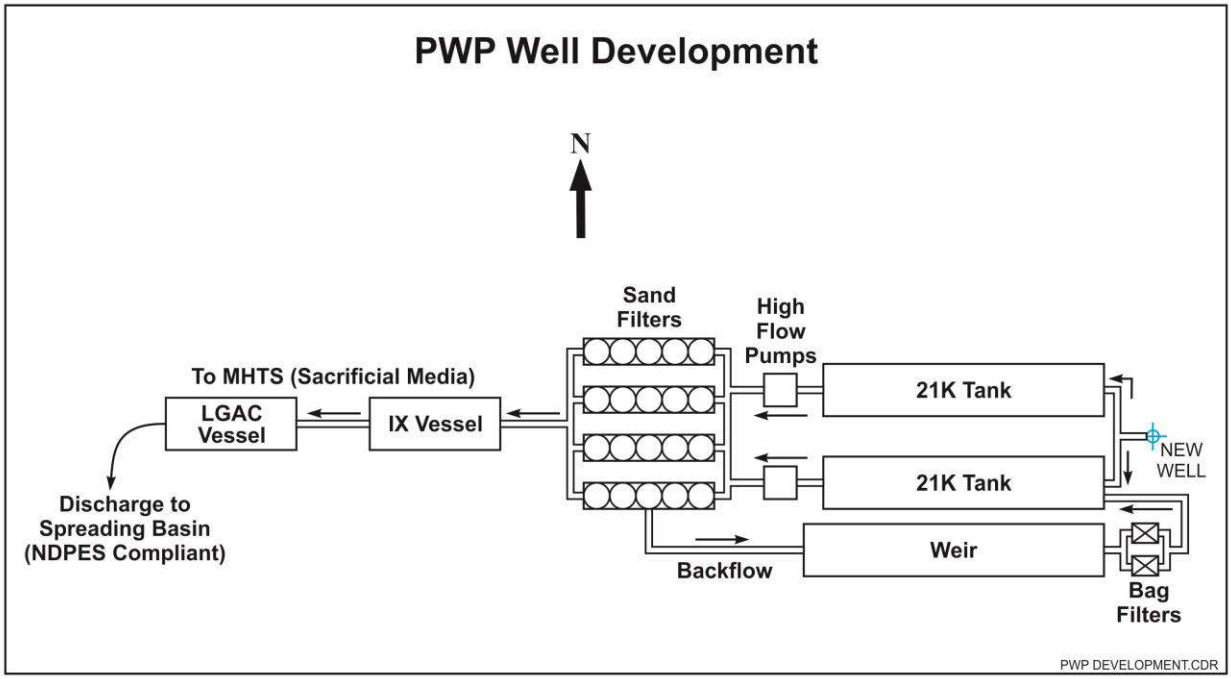

Figure 3-3. PWP Sediment Filtration

3.2.10 LAWC Purge Water Containment/Filtration

A sediment filtration and containment system will be installed at the well site (Figure 3-4) and used in conjunction with the LAWC treatment system loaded with sacrificial media to treat discharge waters.

This system will be used to process development water for all stages of well development including: swab pumping (i.e., OEAL and DSAL), pump/surge development, and testing. The process flow is as follows: water will be pumped directly from the well into four 21,000 gallon containment tanks to remove sediment. Next, water will be pumped from the two tanks with high flow pumps (i.e., 2,000 gpm max flow) to four banks of skid-mounted sand filters capable of 1,000 gpm each. Water processed by the sand filters will be pumped directly to the LAWC treatment system via the 8-inch Well No. 5 discharge line and 12-inch DI underground transmission line. Sand filter backwash water will be cycled back into the containment and filtration system. Once the water reaches the LAWC treatment plant, it will flow through the cartridge filter (sediment removal), then the IX vessel (perchlorate removal), followed by LGAC vessel (VOC removal). Treated water will be discharged directly to the storm drain which discharges to the Arroyo Seco, downstream of PWP's spreading grounds, a tributary to Los Angeles River (between Figueroa Street and Los Angeles River Estuary). Storm drain discharges will meet the substantive requirements of the General NPDES Permit No. CAG994003 and Order No. R4-2009-0047.

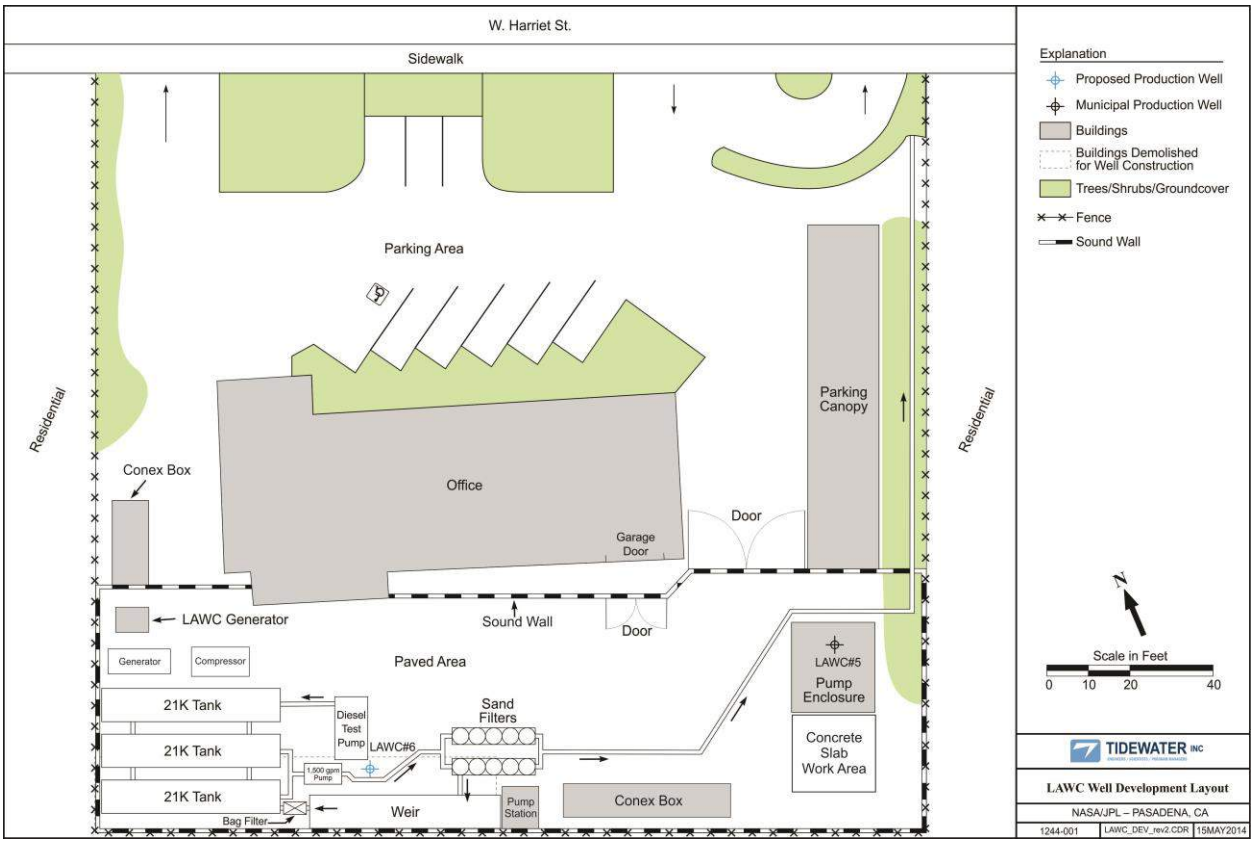

Figure 3-4. LAWC Sediment Filtration during Development

3.2.10.1 Video Survey

Upon completion of well development, a video survey will be completed in the wells to confirm the "as-built" construction of the well, to inspect for any damage (i.e., casing breaks, holes, etc.), examine the screened zone to ensure the well has been properly developed, and assess the well for potential fouling elements (e.g., biological growth, mineralization, and sedimentation). During a down-hole video survey, a camera is lowered into the well and the image is observed on a video monitor and simultaneously recorded on a DVD. The depth of the camera is superimposed onto the video image and is also recorded.

Once the log is completed, three hardcopy reports (including photos), and three color video log (DVD) copies will be obtained and stored on site.

3.2.10.2 Production Well Pump and Motor Design

Results of the test pumping (i.e., pumping level, drawdown, and specific capacity) as well as seasonal and long-term static water level variations, pressure variations, and potable system demand and pressure characteristics will be used to design a vertical turbine pump capable of their respective design flowrates. A pump design submittal generally includes the following: pump performance sheet and pump curves, sectional drawing, dimensional drawing, and motor dimensional drawings/specifications that will be reviewed by a State of California licensed civil engineer.

3.2.10.3 Production Well Pump, Motor, Installation and Testing

Prior to the installation of the new pump, well disinfection will be performed according to the American National Standards Institute (ANSI/AWWA) standard C654 well disinfection guideline. Following well disinfection, the new pump and airline will be installed into the well. All pump equipment will be disinfected as it is placed into the well. Once the pump is installed, the discharge head will be connected to the discharge piping and the premium efficiency electric motor with 120 volt space heater will be mounted. Final wellhead equipment will be installed which includes the screened and inverted casing vent, air vacuum and air release valve, and rossum sand tester. Once the pump motor has been bumped for rotation, it will be coupled, and the pump will be service ready.

3.2.11 IDW Generation, Treatment and Disposal

The primary wastes generated from implementing this optimization Work Plan include drill cuttings/mud, and decontamination rinse water. All drill cuttings and drilling mud removed from individual boreholes will be placed directly into Department of Transportation (DOT)-approved soil bins. The containers will be temporarily stored on site and labeled with the following information: date, project name and number, generator name, point of contact (POC), applicable contact numbers, contents of container, and the well identification name/number. The amount of waste generated will vary based on actual field operations. Waste samples will be analyzed for the medium-specific parameters presented in the Sampling and Analysis Plan contained within the Final RD/RA Work Plan (NASA 2009). Based on the laboratory results, the waste will be classified as hazardous or nonhazardous waste in accordance with the Code of Federal Regulations (40 CFR 261.31 to 261.33 and 261.21 to 261.24) and the 22 CCR. NASA will prepare all required waste profiles and manifests for the waste. An appropriate U.S. EPA-certified waste disposal facility will be selected and a licensed transporter will haul the waste off site for disposal. All waste transported off site will be accompanied by the appropriate hazardous or nonhazardous waste manifest, signed by a PWP or LAWC authorized representative. If the waste is characterized as hazardous, PWP and/or LAWC will be required to have a U.S. EPA identification. The disposal of waste will be in accordance with federal, state, and local laws, regulations, and instructions.

3.3 Treatment System Disinfection

As a result of utilizing the MHTS and LAWC treatment systems to process well development water, all system components will require disinfection before the systems can be placed back into service. All water mains, treatment system vessels, valve trees, Ventura sump (PWP only), appurtenances, and associated piping will be disinfected in accordance with AWWA C651-92. Disinfection of the entire MHTS system was completed in 2010 by a subcontractor. In general equipment is filled to capacity with potable water containing chlorine at concentrations of 80 ppm or greater. After 24 hours residual chlorine concentrations are measured to confirm that they are between 70 and 80 parts per million (ppm). Once confirmed, the components are flushed with potable water (to de-chlorinate the equipment) until the residual chlorine concentrations are 1.0 ppm. Flush water is dechlorinated and discharged to the spreading basin (PWP) or storm drain (LAWC), and samples will be collected and analyzed to ensure

NPDES compliance. Lastly, water samples are collected from the disinfected equipment and analyzed for total coliform and heterotrophic plate count testing on the disinfected equipment

3.4 Virgin Media Replacement

After the system has been checked and disinfected, the vessels will be ready to be filled with IX resin and LGAC. The ion exchange resin and LGAC media will be delivered to the site and installed by the treatment system vendor. The resin will be transferred to the vessels via either a vacuum or slurry; the LGAC will be transferred to the vessels as water slurry. If an air compressor is used on site during delivery of the treatment media, it will be equipped with properly operated mufflers that meet the manufacturer's specifications to minimize excess noise associated with system construction. Prior to operating the LGAC beds, the carbon media will be wetted. This step is necessary to remove air from within the pore volume of the carbon media. If this is not done, air within these pores will displace into the void spaces between the carbon particles during operation and cause high pressure drop and channeling in the vessels. A period of up to 72 hours may be required for complete wetting. After wetting, the vessels will be backwashed with potable water to remove any remaining air or carbon fines, and to segregate the carbon by size. Backwashing will be completed per the manufacturer's instructions provided in the operation and maintenance manual (NASA, 2009).

Unlike activated carbon, IX resin is supplied in the hydrated form and therefore does not require a wetting step. However, it is recommended that prior to transfer of the resin into the exchanger, the ion exchanger be filled approximately one-third full of water. This will allow proper settling of the resin as it is transferred into the exchanger. Virgin resin beds will be backflushed with potable water prior to being brought online for the first time. The reasons for backflushing before placing fresh resin online are to: (1) remove any remaining air from the bed, and (2) remove fines which can, in some cases, lead to excessive pressure drop and flow restriction. If the resin is not pre-rinsed at the vendor's facility, then it will be forward rinsed with approximately 25 bed volumes of well water after backflushing is complete. Samples will be collected upon completion of the forward rinse to evaluate nitrosamine levels before the resin is brought online.

3.5 Waste Water Management Upgrades

The following sections describe the waste water management upgrade activities that will be performed as part of this OU-3 optimization effort. These activities include installation of new piping, modification to existing piping, sump modifications, and package treatment system installation.

3.5.1 System Piping

The Behner Plant layout along with the location of influent and effluent piping at is shown in Appendix B. Extracted groundwater from the new MHTS Well, Arroyo Well, Well 52, Ventura Well, and Windsor Well will utilize a combination of newly installed and existing pipelines to pump water directly to the Behner Plant during startup and disinfection operations. The same series of pipelines from MHTS to Arroyo and Arroyo to Behner will be used to send backwash water from MHTS to the Behner Plant.

The pipelines required to connect the MHTS to the Behner plant to improve wastewater management are as follows (*all pipeline (PS-1, 2, etc.) and Sheet # references can be viewed in detail in Appendix B):*

- At the Windsor Well, a new 12-inch DI pipe (PS-1) will be installed to connect the Windsor Well to the existing 16-inch steel pipe (PS-2). A new 12-inch tie in will be installed to route water from the 12-inch MHTS effluent line to the existing 16-inch steel pipeline. A new 12-inch DI pipe (PS-3) will be installed between the existing 16- and 12-inch ACP and PVC pipelines (Sheet 2). Pipe segment 7 extending from Windsor Avenue to the Ventura Booster will need to be evaluated again through pressure testing and video inspection to confirm suitability of use.

- Water will be routed through the existing 12-inch line (PS-4) that runs to the Ventura site. This pipeline was pressure tested in 2008 and is in good condition. A new 12-inch DI pipeline (PS-5) will be installed by connecting the existing 12-inch DI pipeline (PS-4) and existing 16-inch steel pipeline (PS-12) as shown in sheet 3.
- Existing 16-inch steel pipeline (PS-12) that previously delivered water from Well 52 and Arroyo Well to Ventura Booster station will be capped and blind flanged. PS-12 will be repurposed and used to discharge pump start up water from Windsor Well and backwash water from the MHTS towards Well 52 and finally to the Behner treatment plant. This pipe will also convey pump startup water from the remaining wells to the Behner plant. A new 10-inch DI pipe (PS-7) will be connected with the new 12-inch DI pipeline (PS-5) as shown in sheet 3.
- Existing 12-inch DI pipeline (PS-8) that discharges water from Arroyo Well towards Well 52 connects with the existing 16-inch steel pipeline (PS-12) after Well 52 combines at Lower Arroyo Road (i.e., Karl Johnson Parkway) as shown in sheet 4. This section of PS-12 will also be re-purposed and will be used to carry pump start up and backwash water.
- From Arroyo Well to the Behner treatment plant, a new 12-inch DI pipeline (PS-18) will be installed along the base of the hill to discharge pump start up water from all existing wells, the new well, and backwash water from MHTS (Sheet 5).
- A new 12-inch DI pipeline (PS-14) will be installed from new pipe (PS-15) to discharge the new MHTS well's pump waste into the new 12-inch DI pipeline (PS-17) with necessary operating valves around Arroyo Well site as shown in sheet 5.

The existing 24-inch pipeline running to the Arroyo Seco Spreading Basins will be used to discharge treated water from the packaged treatment plant, consistent with the substantive provisions of RWQCB Order No. R4-2013-0043.

3.5.2 Packaged Treatment Plant Equipment

The 100 gpm package treatment plant will consist of two IX vessels and two LGAC vessels operated in a lead/lag configuration. All exposed vessels, piping, equipment, and new facilities shall be a neutral (or earth-toned) color to help the Behner system blend with the existing area views. Design information for the proposed treatment equipment is provided in the following subsections. Available design drawings and an O&M Plans are provided in Appendix G.

3.5.2.1 Feed Pumps

Two feed (sump) pumps, approximately 15 hp, will be installed to transfer water out of the sump, across the treatment vessels and associated piping, valves, and fittings, and into the designate effluent pipeline for transportation to the Arroyo Seco Spreading Basin. One pump will be operational with the second one in standby mode serving as a backup. The feed pumps will be installed so that pumping of settled solids or sludge is minimized.

3.5.2.2 Vessel Inlet Water Filter

The inlet water filter system will be a duplex (two vessel) filter or similar. Each filter will be designed with a minimum 150 gpm capacity, and two filters will operate in parallel under normal flow conditions. Each filter will contain a trade size #2 bag filter with a maximum 10 micron to prevent particles from building up in the media treatment vessels downstream. Each vessel will be approximately 8 inches in diameter and 40-inches tall. They will be constructed of carbon steel with a stainless steel strainer basket to support the filter bag and rated at 150 psi at 400°F. The filter vessels will have a full diameter top access port secured by heavy duty closure bolts. The expected pressure drop is approximately 5 psi through the clean filter and 25 psi through the dirty filter.

3.5.2.3 Ion Exchange Inlet Header Piping

Following the filtration stage, the water will be directed to a fixed bed IX vessel pair. The IX system header piping will be a 3-inch carbon steel pipe with an epoxy based interior lining. Influent flow rates to the treatment vessels will be adjusted manually.

3.5.2.4 Ion Exchange Vessels

The ion exchange system will consist of two IX-48s or similar water treatment system vessels. The system will be arranged with one parallel pairs of vessels, operated in a lead/lag configuration. Each vessel will be 4 foot in diameter with an overall height of approximately 8 feet, and will be constructed of carbon steel. The interior surfaces of each vessel will be lined to inhibit corrosion and extend vessel life. The structural aspects of the vessels will be sufficient to meet the Uniform Building Code (UBC) requirements for Seismic Zone 4.

Each vessel will be designed with the necessary piping connections for operation of the vessels in a lead/lag configuration, as well as for backwashing of the vessels. Conical strainers will be installed on the effluent end of each vessel to provide protection of downstream equipment in the case of an unexpected release of media. Each vessel will also be provided, at a minimum, with one 18-inch man way for access.

The pair of IX vessels will be designed with a maximum treatment capacity of 200 gpm. The pressure drop across the IX vessels will be approximately 20 psi at 100 gpm. Each individual IX vessel will contain approximately 53 cubic feet of perchlorate-specific IX resin.

3.5.2.5 GAC System Inlet Header Piping

Following IX treatment, the water will be directed to a fixed bed GAC system. The GAC system header piping will be a 3-inch carbon steel pipe with an epoxy based interior lining. All flow rates to individual vessels will be adjusted manually.

3.5.2.6 GAC System Vessels

The GAC system will consist of two carbon adsorption system vessels. The system will be arranged with a pair of vessels, each operated in a lead/lag configuration. Each vessel will be approximately 4 feet in diameter with an overall height of approximately 10 feet, and will be constructed of carbon steel. The interior surfaces of each vessel will be lined to inhibit corrosion and extend vessel life. The structural aspects of the vessels will be sufficient to meet the UBC requirements for Seismic Zone 4.

Each vessel will be designed with the necessary piping connections for operation of the vessels in a lead/lag configuration, as well as for backwashing of the vessels. Conical strainers will be installed on the effluent end of each vessel to provide protection of downstream equipment in the case of an unexpected release of LGAC media. Each vessel will also be provided, at a minimum, with one 20-inch man way for access.

The pair of LGAC vessels will be designed with a maximum treatment capacity of 200 gpm. The pressure drop across the LGAC vessels will be approximately 20 psi at 100 gpm. Each individual LGAC vessel will contain approximately 2,000 pounds of carbon.

3.5.2.7 Instrumentation and Controls

Instrumentation associated with the package treatment system equipment primarily includes flow meters, pressure gauges, level switches, and ruptures disks. Flow meters will be installed on the influent and effluent of the treatment system to monitor flow and keep accurate discharge totals. All flow control through the system will be manually adjusted using the appropriate flow control valves.

The process piping and vessel will be equipped with pressure gauges to indicate the water pressure entering each pair of treatment vessels (IX and LGAC). The pressure gauges will have a range of 1 to 100 psi and will be used to monitor pressure across the vessels.

3.6 Coordination and Site Logistics

3.6.1 Project Coordination

If appropriate, site work on Pasadena property will be conducted in accordance with the *Use Agreement and Right-of-Entry for Environmental Actions* between the City of Pasadena and NASA (2003). The City of Pasadena is required by its own ordinances to go through several permitting processes (see Section 3.1.4), and NASA will provide technical support to the City for this permitting.

NASA will provide funds to install and operate the new LAWC well. NASA and LAWC will work collaboratively to oversee and manage construction activities.

3.6.2 Special Considerations

Three large-scale construction efforts will be underway in and around the Arroyo Seco in the coming years. These include the City of Pasadena's Hahamongna Watershed Park Master Plan, the Devil's Gate Reservoir Sediment and Removal Management Project, and the Foothill Municipal Water District's Recycled Water Project. Project planning and coordination will be necessary to ensure OU-3 optimization activities seamlessly integrate with these projects.

The City of Pasadena's Hahamongna Watershed Park Master Plan includes the following improvements: the JPL east parking lot will be converted to spreading basins and park area; construction of the north perimeter trail bridge crossing, public parking lot, public restrooms, roadway, and Altadena/Altacrest drain improvements. In addition to these improvements, PWP plans a series of diversion and dam structure construction in the upper Arroyo Seco north of the JPL Bridge and the installation of pipelines at the Arroyo booster station.

The Los Angeles County Department of Public Works will be completing the Devil's Gate Reservoir Sediment Removal and Management Project to remove sediment that accumulated behind Devil's Gate dam as a result of the 2009 Station Fire and subsequent rain events. Approximately 68% of the watershed tributary to Devil's Gate Reservoir (approximately 100% of the undeveloped portion) was burned, making sediment deposition inevitable during subsequent storm events. The storms that occurred in the two wet seasons after the fire increased sediment accumulation in the reservoir by more than one million cubic yards. This major sediment inflow significantly reduced the reservoir's capacity and also buried a large portion of the reservoir vegetation, although significant amounts of vegetation, including numerous mature willow trees remain present. In its current condition, the reservoir no longer has the capacity to safely contain another major debris event; and the outlet works have a risk of becoming clogged and inoperable. The goal of the Devil's Gate Sediment Removal and Management Project is to restore flood control capacity to the facility and establish a reservoir configuration more suitable for routine maintenance activities including sediment management. Primary project objectives include (LA County Department of Public Works, 2013):

- Reducing flood risk to the communities downstream of the reservoir adjacent to the Arroyo Seco by restoring reservoir capacity for flood control and future sediment inflow events;
- Supporting sustainability by establishing a reservoir configuration more suitable for routine maintenance activities including sediment management;

- Removing sediment in front of the dam to facilitate an operational reservoir pool to reduce the possibility of plugging the outlet works with sediment or debris during subsequent storm events;
- Supporting dam safety by removing sediment accumulated in the reservoir in a timely manner to ensure the ability to empty the reservoir in the event of a dam safety concern;
- Delivering the sediment to placement or reuse facilities that are already prepared and designated to accept material without native vegetation and habitat removal.

The Foothill Municipal Water District (FMWD) Recycled Water Project plans to develop a recycled water system that increases stormwater and urban runoff capture, and recharges the local groundwater basin. FMWD is pursuing the construction of a 0.25 million gallons per day (MGD) membrane bioreactor facility adjacent to the La Cañada United Methodist Church, near the intersection of Oak Grove Drive and Berkshire Place located in La Cañada Flintridge, CA. This facility will produce recycled water that will be designated for indirect potable reuse. The recycled water will help to replenish the Raymond Groundwater Basin and allow FMWD to obtain pumping credits to distribute to five of its eight member agencies. This project is estimated to yield on average 318 acre-feet annually (FMWD, 2013).

OU-3 optimization activities will require planning, scheduling, and coordination with other planned projects to ensure projects do not interfere with one another. Once a construction schedule is established project managers from other ongoing projects will be notified and coordinated with appropriately.

3.6.3 As-Built Records

A topographic site survey was completed by a California-licensed surveyor in 2011 following construction of the MHTS. The survey was used to prepare as-built drawings for the project. A survey will be completed after the OU-3 optimizations to document the locations of the wells and any new underground pipelines and utilities. As-built drawings generated during the construction will also be documented in the final surveyor plans. Survey records and as-built drawings will be provided to PWP and LAWC.

3.6.4 Utility Clearance

A subsurface geophysical survey was completed in conjunction with the topographic survey in June 2005. Specifically, the subsurface geophysical survey included locating utilities and underground structures within the proposed footprint of the MHTS, delineating underground utilities at various locations along the northern portion of the site, and performing two seismic P-wave refraction lines and two ReMi lines in the area of the proposed MHTS. The purpose of the surveys was to provide information regarding underground structures in the area of planned improvements, and to obtain seismic data to be used in the design of the treatment plant facility. Additional geophysical surveys were also conducted in 2008 in conjunction with the pipeline video logging, and in 2009 prior to completion of landscaping activities at the Windsor site. Information obtained from these surveys was used in developing the MHTS optimization design.

As required by California State law, any areas requiring digging during construction will be clearly marked, and a utility clearance will be requested by contacting USA at (800)-422-4133 at least 2 days prior to starting construction activities at the site.

3.6.5 Waste Management

The primary wastes generated from construction and operation of the OU-3 optimizations will include the following:

- Sediment from production well drilling,
- Water from purging the production wells,
- Excavated soil from installation of pipelines,
- Spent ion exchange resin and LGAC media,
- New GAC and resin fines, and
- Treated waste water from startup, and periodic maintenance (i.e., backwashing vessels).

The amount of waste generated will vary based on actual field operations. Wastewater will be sampled and discharged in accordance with all permit requirements. Solid wastes will be characterized and classified as hazardous or nonhazardous waste based on the laboratory results in accordance with the Code of Federal Regulations (40 CFR 261.31 to 261.33 and 261.21 to 261.24) and the 22 CCR. An appropriate U.S. EPA-certified waste disposal facility and licensed transporter will be selected for off-site waste transportation and disposal. All waste transported off site will be accompanied by the appropriate hazardous or non-hazardous waste manifests. The disposal of waste will be in accordance with Federal, state, and local laws, regulations, and instructions.

3.7 Project Schedule

OU-3 optimization design and construction permitting is expected to be completed by February 2015. All permits from the City of Pasadena should be secured by that time. In order to minimize traffic impacts in the area, mobilization for the OU-3 optimizations will be coordinated with the activities described in Section 3.6.2 above. OU-3 optimization construction is scheduled to begin in March 2015 and may take 10 to 12 months for completion. An anticipated project schedule is included in Appendix H.

3.8 Performance Monitoring

Following installation of the proposed new extraction wells at LAWC and MHTS, performance monitoring data will be evaluated as part of existing CERCLA documentation. Specifically, quarterly groundwater monitoring reports will evaluate chemical concentrations and trends, as well as groundwater elevations, based on results of monitoring from the JPL groundwater monitoring network. In addition, LAWC treatment system and MHTS performance will be documented in the annual progress report prepared for each system. The annual progress reports will include three-dimensional capture zone analysis, consistent with EPA guidance (EPA, 2008).

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APPENDIX A
Technical Memorandum Groundwater Modeling

Introduction

This technical memorandum was prepared for the U.S. Army Corps of Engineers (USACE) and the National Aeronautics and Space Administration (NASA), under Contract No. W9128F-09-D-0005 (Task Order 0015) with USACE Omaha District. This memorandum provides a summary of groundwater modeling efforts designed to evaluate potential locations and associated pumping rates for new Monk Hill Treatment System (MHTS) and Lincoln Avenue Water Company (LAWC) groundwater extraction wells.

A calibrated, steady-state groundwater flow model was developed for NASA as part of the Jet Propulsion Laboratory (JPL) Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Program to evaluate treatment alternatives and groundwater flow in the Monk Hill Subarea.[1] The JPL Groundwater Model utilizes FEFLOW software, a finite-element three-dimensional saturated flow and transport code. The JPL model was used to perform the simulations documented in this technical memorandum.

The MHTS removes volatile organic compounds (VOCs) and perchlorate from groundwater extracted from four production wells with a design treatment capacity of 7,000 gallons per minute (gpm). The MHTS is implemented as a remedial action under the CERCLA program at JPL. The objective of the groundwater modeling associated with the new MHTS extraction well is to identify a location that maximizes plume containment and dissolved mass removal, with the goal of reducing the operational duration of the MHTS and LAWC Treatment System.

LAWC operates two groundwater production wells for potable water supply (LAWC#3 and LAWC#5). The associated LAWC treatment plant removes VOCs and perchlorate from groundwater extracted from the two wells with a design treatment capacity of 2,000 gpm. The objective of the groundwater modeling associated with the new LAWC extraction well is to maximize plume containment and dissolved chemical mass removal, while supplementing the production capacity of the LAWC.

Background

An important consideration for evaluating the need and location of additional production wells is the presence of elevated dissolved chemical concentrations in LAWC#5 and the deeper screens of MW-18 and MW-20. Table 1 presents laboratory results for perchlorate at these locations during quarterly sampling in 2010, 2011, and the first three quarters of 2012.[2] Figure 1 shows the current (August/September 2012) spatial distribution of the dissolved perchlorate plume originating from NASA JPL.

Perchlorate concentrations in MW-18 Screens 3 and 4 began increasing in 2004 and are now well above maximum contaminant level (MCL) with a statistically significant increasing trend. Perchlorate concentrations in MW-18 Screens 1, 2, and 5 have consistently been near the detection limit and below MCLs. The new MHTS extraction well is intended to capture dissolved chemicals migrating from the JPL source area toward MW-18.

LAWC#5 is currently the furthest downgradient containment well associated with the NASA JPL cleanup program. Concentrations of perchlorate have increased in samples collected from LAWC#5 since 2004, with current levels near 30 µg/L. In addition, dissolved perchlorate concentrations in MW-20 Screens 3, 4, and 5 were detected in January/February 2012 at 12.6, 123 and 57 µg/L, respectively, but decreased below the MCL by April/May 2012. Elevated detections of perchlorate also have been observed in MW-20 Screens 4 and 5 in April/May 2010 and

[1] NASA. 2003. *JPL Groundwater Modeling Report, National Aeronautics and Space Administration, Jet Propulsion Laboratory, Pasadena, California*. December.
[2] NASA, 2012. *Technical Memorandum Second Quarter 2012 Groundwater Monitoring Summary*, National Aeronautics and Space Administration Jet Propulsion Laboratory, Pasadena, California. August.

Table 1. Recent Dissolved Perchlorate Concentrations in the LAWC Wells, MW-18, and MW-20

Sampling Event	LAWC #3	LAWC #5	MW-18		MW-20				
			Screen 3	Screen 4	Screen 1	Screen 2	Screen 3	Screen 4	Screen 5
Feb/Mar 2010	34 (Feb 2)	NA	45.1	58.8	<1.0	3.0 J	<1.0	<1.0	<1.0
Apr/May 2010	<4.0 (May 24)	NA	62.4	67.2	<1.0	2.9	1.7	37.3	11.5
Aug/Sep 2010	34 (Sep 7)	NA	65.1	54.5	<1.0	2.5	<1.0	<1.0	<1.0
Nov/Dec 2010	40 (Nov 30)	NA	65.2	30	<1.0	2.7 J	<1.0	<1.0	<1.0
Feb/Mar 2011	42 (Mar 15)	21 (Mar 11)	53.5	46.8	<1.0	3.8	<1.0	<1.0	<1.0
Apr/May 2011	46 (Apr 5)	32 (Apr 12)	54.8	38.3	<1.0	2.8	<1.0	15.1	4.2
Aug/Sep 2011	37 (Sep 9)	30 (Sep 9)	144	10.9 J	1.3 J	2.5 J	<1.0	<1.0	<1.0
Nov/Dec 2011	26 (Dec 6)	29 (Dec 6)	110	11.6	<1.0	2.5	<1.0	<1.0	<1.0
Jan/Feb 2012	18 (Feb 14)	27 (Feb 14)	126	16.5	1.7	5.2	12.6	123 J	56.5
Apr/May 2012	14	32	64.4	47.3	<1.0	6.4	<1.0	<1.0	<1.0
Aug/Sep 2012	20	26	93	15	1.6 J	3.2 J	<4.0	<4.0	<4.0

Notes: All concentrations reported in g/L.
J - Perchlorate concentration is an estimated value
Bold highlight indicates chemical exceeds the California MCL of 6.0 g/L.
NA – data not available.

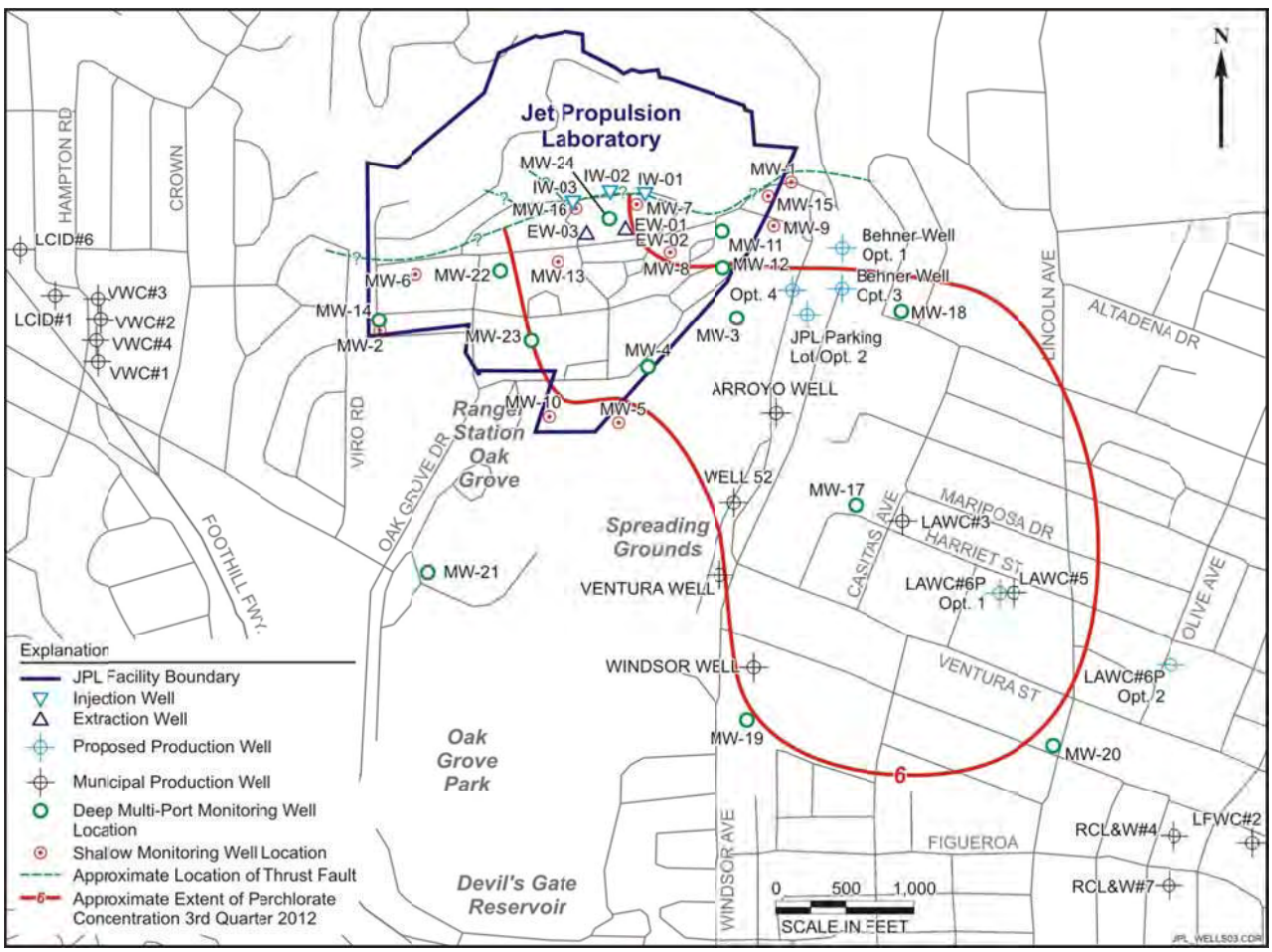


Figure 1. Site Map Showing the Extent of Third Quarter 2012 Perchlorate Concentrations in Groundwater at Levels Greater than the California MCL and Potential Locations of New LAWC and MHTS Extraction Wells.

April/May 2011. Therefore, data show that perchlorate is sporadically detected in the deeper portions of the aquifer downgradient of LAWC#5; however, perchlorate has not been detected above 4 µg/L in the Rubio Cañon Land and Water (RCL&W) Association wells that are located downgradient of MW-20. These deeper screens in MW-20 are located below the screened interval of LAWC#5, so the new LAWC extraction well is proposed to be screened in this deeper portion of the aquifer.

Proposed Well Locations and Characteristics

The new MHTS extraction well conceptual design consists of a 16-inch diameter well, constructed to a depth of 550 feet below ground surface (bgs) with a 300-foot screened interval from 250 to 550 feet bgs. The well will be designed with a production capacity of 2,000 gpm. The proposed new MHTS well locations are shown in Figure 1 and include the following:

- ***MHTS Option 1: Behner Well North***. This location is in the northern portion of the Behner Treatment Plant property, roughly 1,500 feet north-northeast of the Arroyo well.
- ***MHTS Option 2: JPL Parking Lot West***. This location is on the western edge of the JPL parking lot, roughly 925 feet north-northeast of the Arroyo well.
- ***MHTS Option 3: Behner Well South***. This location is along the southern edge of the Behner Treatment Plant property, roughly 1,150 feet north-northeast of the Arroyo well.
- ***MHTS Option 4: JPL Parking Lot East***. This location is on the eastern edge of the JPL parking lot, roughly 1,000 feet north-northeast of the Arroyo well.

The new LAWC production well conceptual design consists of a 16-inch diameter well, constructed to a depth of 824 feet bgs with a 200-ft screened interval from 624 to 824 feet bgs. The well will be designed with a peak capacity of 2,000 gpm. The proposed new LAWC well locations are shown in Figure 1 and include the following:

- ***LAWC Option 1: LAWC Office (LAWC #6P Opt. 1)***. This location is roughly 200 feet upgradient and to the west of LAWC#5 within the LAWC office property.
- ***LAWC Option 2: LAWC Treatment System (LAWC #6P Opt. 2)***. This location is roughly 1,400 feet east-southeast and downgradient of LAWC#5 within the LAWC treatment plant property.

Surface water discharge and subsurface inflow from the Arroyo Seco accounts for an estimated average of over 800 acre-ft per year (roughly 500 gpm) of water entering the basin (over 8% of the entire JPL Groundwater Model inflow).[1] This inflow results in elevated groundwater levels in MW-1, MW-15, and MW-9 (located near the mouth of the Arroyo Seco discharge) and a southerly groundwater flow direction immediately downgradient of the mouth of the Arroyo Seco. Model simulations performed to evaluate the MHTS Option 1 (Behner Well North) location indicated that the capture zone consists largely of this water from the north discharging from the mouth of the Arroyo Seco (Figure 2), and does not capture the JPL source area. This finding, in addition to the MHTS Option 1 (Behner Well North) location being outside the known perchlorate plume, suggests this proposed location is situated too far to the north to provide optimal plume containment and mass removal; therefore, it was not considered as a viable location.

It should be noted that the JPL Groundwater Model contains an artificial flow barrier located just south of the mouth of the Arroyo Seco that extends from northwest to southeast, between the two Behner Well locations. This flow barrier was implemented via a low hydraulic conductivity unit designed to restrict flow and mimic the elevated groundwater levels in the upgradient groundwater monitoring wells (MW-1, MW-15, and MW-9). This flow barrier affects the modeled capture zones of the proposed well locations to some degree, causing particle tracking pathways to be routed around the flow barrier due to restricted flow through the barrier. However, the conceptual site model supports a significant discharge volume from the mouth of the Arroyo Seco, and suggests the Behner Well North location will extract a significant volume of water discharging from the Arroyo Seco.

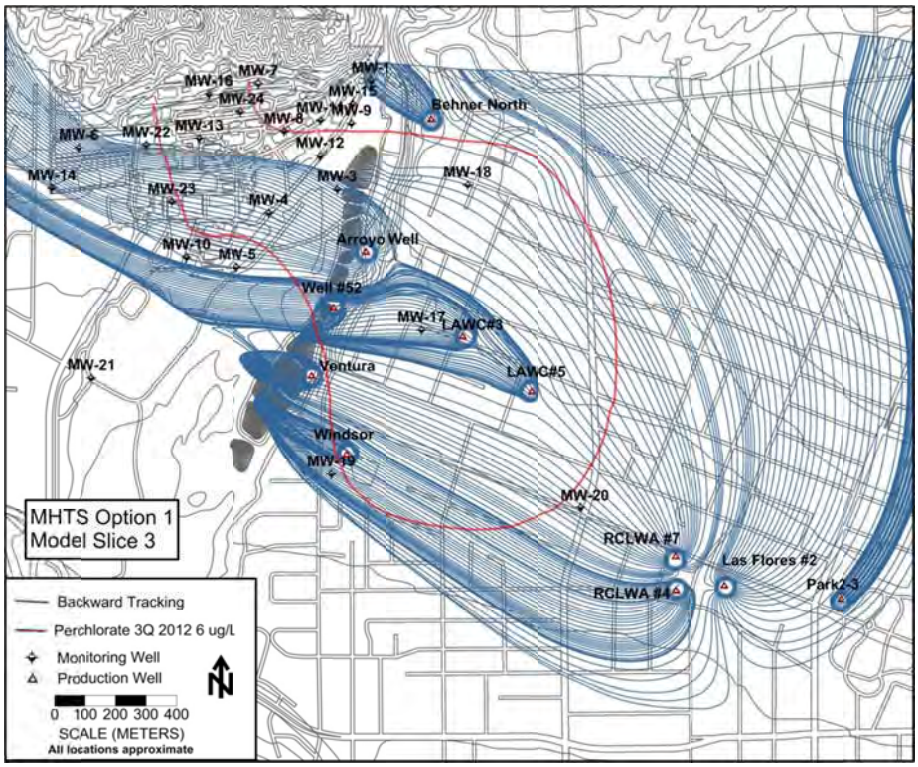


Figure 2. MHTS Option 1 (Behner Well North) Modeling Results in Model Slice 3

Model simulations performed to evaluate the proposed locations for the new LAWC well indicated the LAWC #6P Opt. 1 (LAWC Office) appears to be the most suitable location for the placement of an additional extraction well, considering NASA's goals of plume containment and mass removal. Installation of a new LAWC well at the LAWC #6P Opt. 2 (LAWC treatment plant) location would serve as a viable option for production capacity, but is not optimal for preventing migration of perchlorate contamination toward MW-20; this proposed location lies outside the current extent of the dissolved perchlorate plume and may pull clean groundwater from the north and dissolved mass from inside the plume toward the east. Accordingly, the LAWC #6P Opt. 2 location was not considered a viable option for this modeling effort, and the LAWC #6P Opt. 1 location was used as the chosen location for the new LAWC extraction well (referred to as LAWC#6P in the remainder of this document).

MHTS Mass Removal Estimate

Average well-specific perchlorate concentrations from the Arroyo Well, Well 52, and Ventura Well, and the December 2010 perchlorate concentration from the Windsor well were used to estimate perchlorate mass removal rates under the current pumping scheme. In addition, a similar mass removal estimate was performed for a proposed pumping scenario including the Arroyo Well, Well 52, and the new MHTS well. A conservative estimate for the dissolved perchlorate concentration (86.9 µg/L) was assumed for the proposed new MHTS well, consistent with range of estimates documented in Technical Memorandum No. 1 and concentrations observed in Screen 3 of nearby MW-18 from the four most recent quarterly monitoring events. As shown in Table 2, the total extraction rate is roughly 500 gpm higher in the proposed pumping scenario including the new MHTS well. The proposed pumping scenario removes roughly twice as much mass per year compared to current pumping scheme, due primarily to the higher chemical concentrations estimated in the new MHTS extraction well. This analysis shows that MHTS mass removal can be optimized by increasing the extraction rate in the proposed new well and reducing extraction in wells with lower perchlorate concentrations (i.e., Ventura Well and Windsor Well).

Table 2. Summary of Mass Removal Estimates

Well	Average Annual Extraction Rate (gpm)	Average Perchlorate Conc (µg/L)	Mass Removed (lbs/yr)
Simulation 1 – Historical Extraction Rates			
Arroyo	1,832	49.0[A]	394
Well 52	755	15.7[B]	52.0
Ventura	403	4.82[C]	8.52
Windsor	353	5.34[D]	8.27
Total	3,343	--	463
Simulation 2 – Proposed Extraction Rates			
New MHTS Well	1,250	86.9[E]	477
Arroyo	1,832	49.0[A]	394
Well 52	755	15.7[B]	52.0
Total	3,837	--	923

[A]Average concentration from PWP monitoring from September 2011 through August 2012.
[B]Average concentration from PWP IX System monitoring from January 20, 2011 to May 17, 2011.
[C]Average concentration from PWP monitoring from October 2011 through August 2012.
[D]Concentration from PWP IX System monitoring on December 21, 2010.
[E]Estimated weighted maximum concentration from Technical Memorandum No. 1.

Modeling Simulations/Results

The JPL Groundwater Model[2] was used to perform a baseline simulation representing current conditions, and to perform three sets of three simulations designed to evaluate plume containment with various placement options and extraction rates for the proposed new extraction wells. In each set of simulations, three potential new MHTS well locations (Options 2, 3, and 4) were evaluated. A summary of these simulations is presented in Table 3.

Table 3. Summary of Groundwater Modeling Simulations

No.	Description	Average Annual Extraction Rate (gpm)				Notes
		LAWC#3	LAWC#5	LAWC#5R	New MHTS Well	
1	Baseline	755	494	0	0	Arroyo, Well 52, Ventura, Windsor, RCLWA, LFWC at historical rates
2	LAWC#6P and New MHTS Well Operating - Low	500	0	750	500	Arroyo, Well 52, RCLWA, LFWC at historical rates. Ventura and Windsor not operating.
3	LAWC#6P and New MHTS Well Operating - High	500	0	1,250	1,250	Arroyo, Well 52, Windsor, RCLWA, LFWC at historical rates. Ventura and Windsor not operating.
4	LAWC#5, LAWC #6P and New MHTS Well Operating	500	500	750	1,250	Arroyo, Well 52, Windsor, RCLWA, LFWC at historical rates. Ventura and Windsor not operating.

Results are presented for groundwater flow model Slices 3, 4 and 5, which correlate to the deeper aquifer where elevated levels of chemicals have been detected in MW-18 and MW-20.

Simulation No. 1 – Baseline

The baseline simulation was performed using historical average yearly production rates between 2005 and 2011. Figure 3 shows the capture zones generated in slices 3, 4, and 5 for the baseline simulation. The results show that the initial row of Pasadena wells does not provide containment to the north of the Arroyo Well, and the potential exists for dissolved chemicals to migrate from the JPL source area downgradient toward MW-18. The results also indicate that the LAWC wells provide containment of groundwater originating in the JPL source area, but show there is minimal containment of groundwater in slice 5 beneath the LAWC#3 and LAWC#5, due in large part to the relatively shallow completion of these wells relative to nearby monitoring wells and the depth of bedrock.

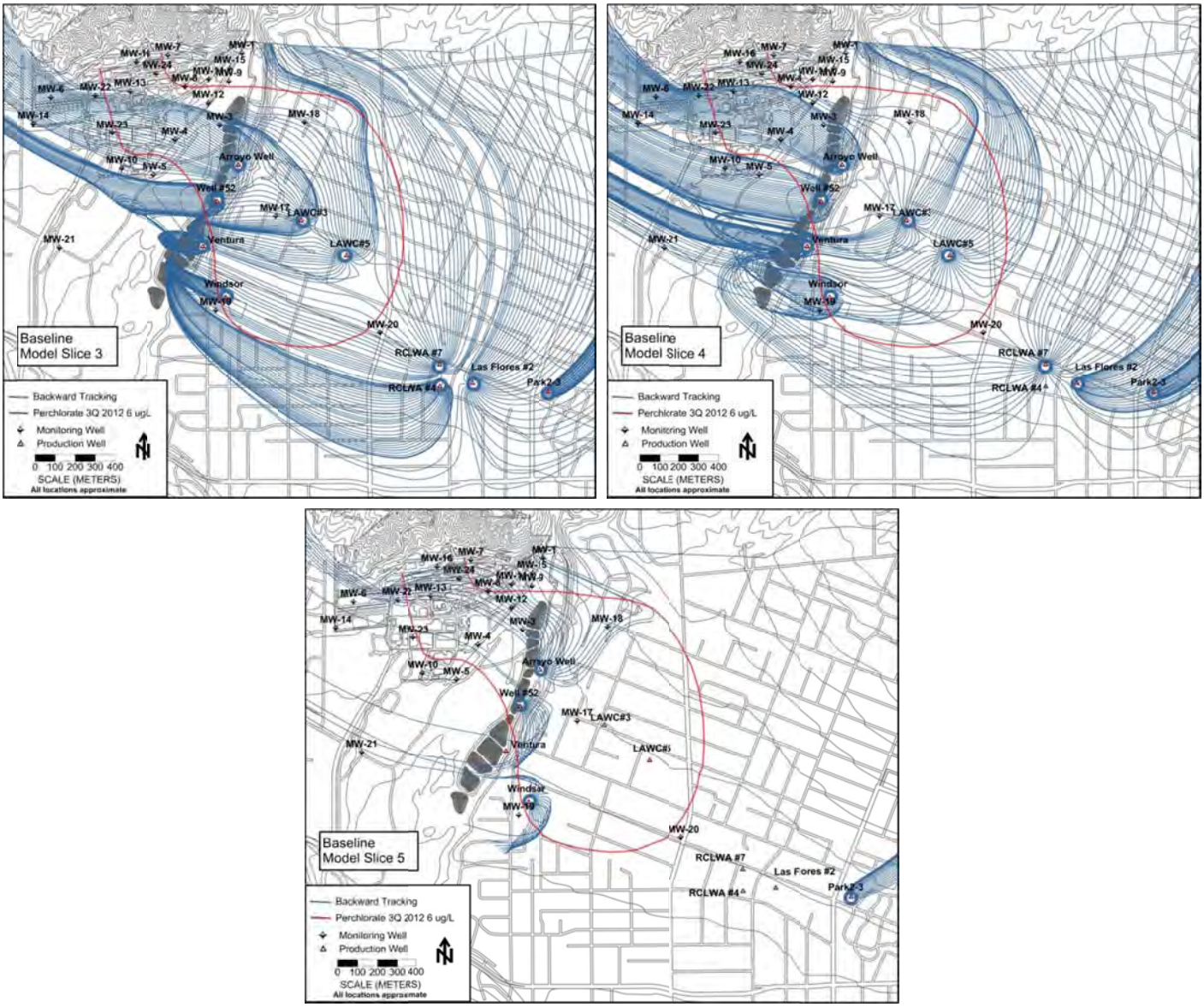


Figure 3. Simulation No. 1: Baseline Modeling Results in Model Slices 3, 4, and 5

Simulation No. 2a – LAWC #6P and MHTS Option 2: JPL Parking Lot West with Low Extraction Rate

Simulation No. 2a was performed using the extraction rates outlined in Table 3 with the JPL Parking Lot West location for the new MHTS well; the new MHTS well and LAWC#6P are operating at a low extraction rate. Figure 4 shows the capture zones generated in slices 3, 4, and 5 for Simulation No. 2a. The simulations show that the JPL Parking Lot West well location will provide more containment of the source area compared to the baseline simulation, thus minimizing the potential for downgradient migration toward MW-18. However, it appears the capture zone is affected by inflow from the mouth of the Arroyo Seco and the artificial flow barrier located to the north of this well, as indicated by the absence of a northerly component of the capture zone. The results also indicate that without LAWC#5 operating, there is less shallow containment of the plume to the north of the LAWC wells. However, the operation of LAWC#6P provides more containment at depth compared to the baseline simulation.

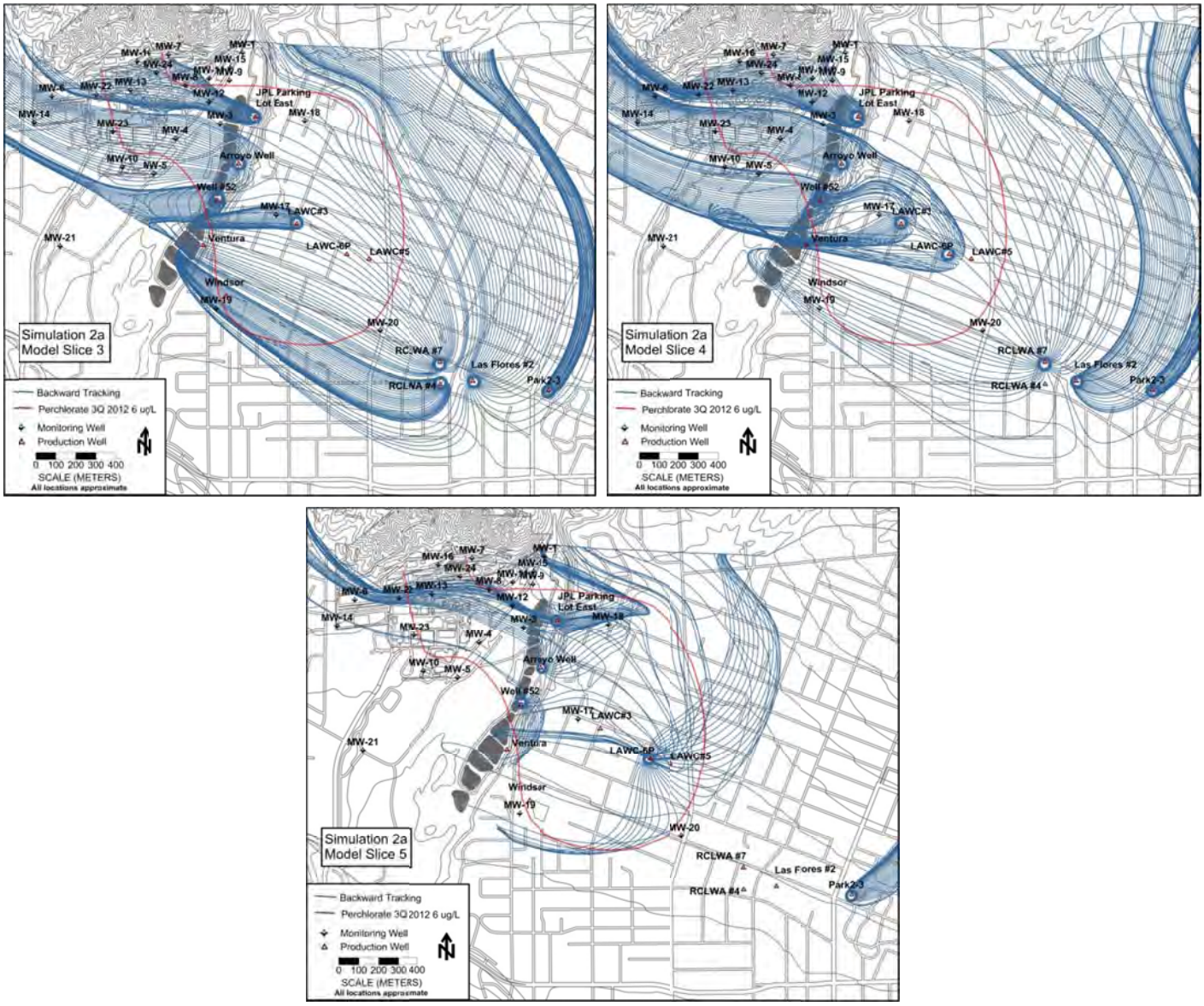


Figure 4. Simulation No. 2a Results (LAWC#6P and MHTS Option 2: JPL Parking Lot West) in Model Slices 3, 4, and 5

Simulation No. 2b – LAWC #6P and MHTS Option 3: Behner Well South with Low Extraction Rate

Simulation No. 2b was performed using the extraction rates outlined in Table 3 with the Behner Well South location for the new MHTS well; the new MHTS well and LAWC#6P are operating at a low extraction rate. Figure 5 shows the capture zones generated in slices 3, 4, and 5 for Simulation No. 2b. The simulations show that the Behner Well South well location will provide more containment of the source area compared to the baseline simulation, thus minimizing the potential for downgradient migration toward MW-18. However, it is evident the capture zone is affected by the artificial flow barrier located to the north of this well, as indicated by the absence of a northerly component of the capture zone. The results also indicate that without LAWC#5 operating, there is less shallow containment of the plume to the north of the LAWC wells. However, the operation of LAWC#6P provides more containment at depth compared to the baseline simulation.

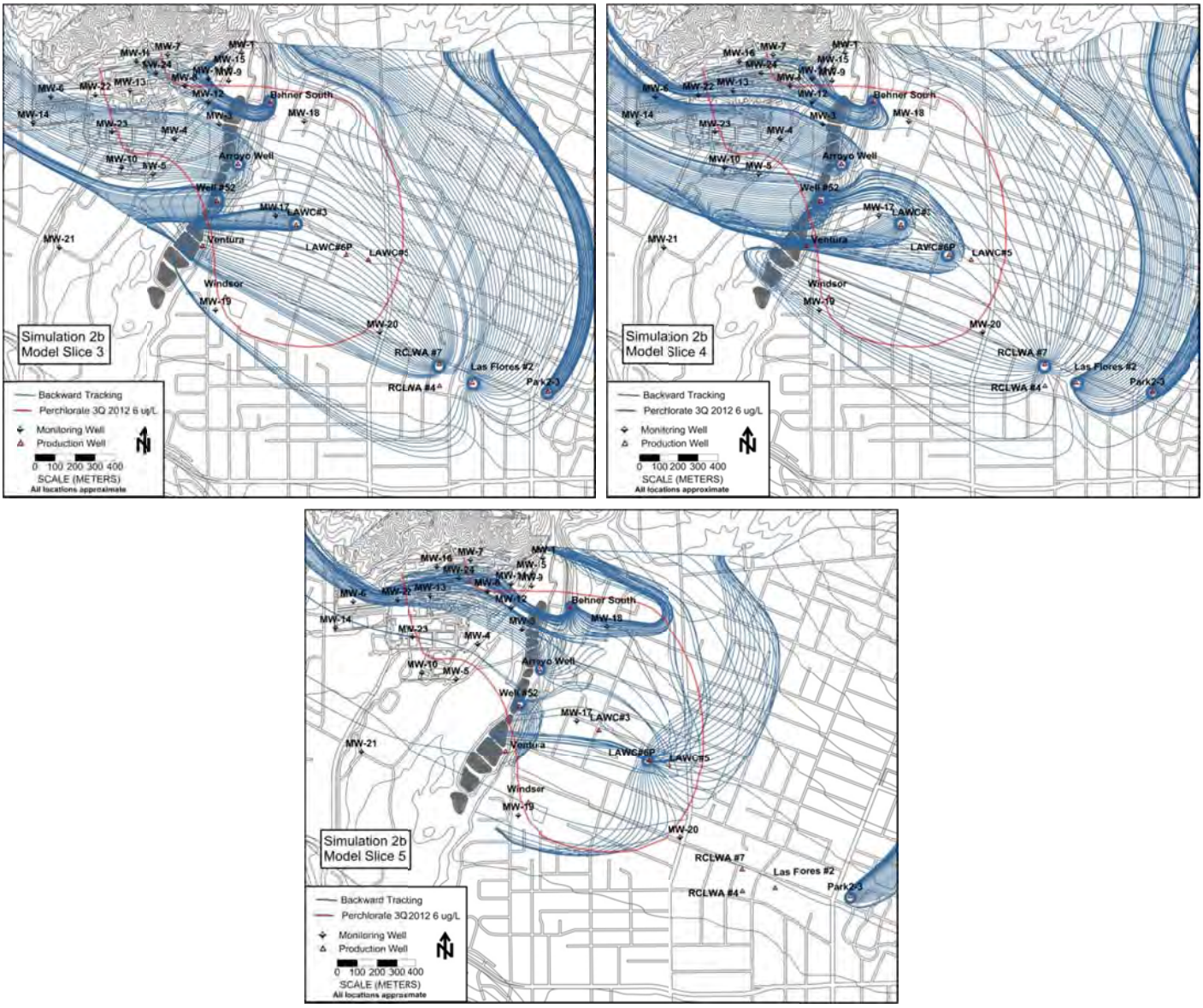


Figure 5. Simulation No. 2b Results (LAWC#6P and MHTS Option 3: Behner Well South) in Model Slices 3, 4, and 5

Simulation No. 2c – LAWC #6P and MHTS Option 4: JPL Parking Lot East with Low Extraction Rate

Simulation No. 2c was performed using the extraction rates outlined in Table 3 with the JPL Parking Lot East location for the new MHTS well; the new MHTS well and LAWC#6P are operating at a low extraction rate. Figure 6 shows the capture zones generated in slices 3, 4, and 5 for Simulation No. 2c. The simulations show that the JPL Parking Lot East location will provide more containment of the source area compared to the baseline simulation, thus minimizing the potential for downgradient migration toward MW-18. The JPL Parking Lot East location is not as affected by the artificial flow barrier as the JPL Parking Lot West location, and appears to better contain groundwater in the source area compared to this location. The results also indicate that without LAWC#5 operating, there is less shallow containment of the plume to the north of the LAWC wells. However, the operation of LAWC#6P provides more containment at depth compared to the baseline simulation.

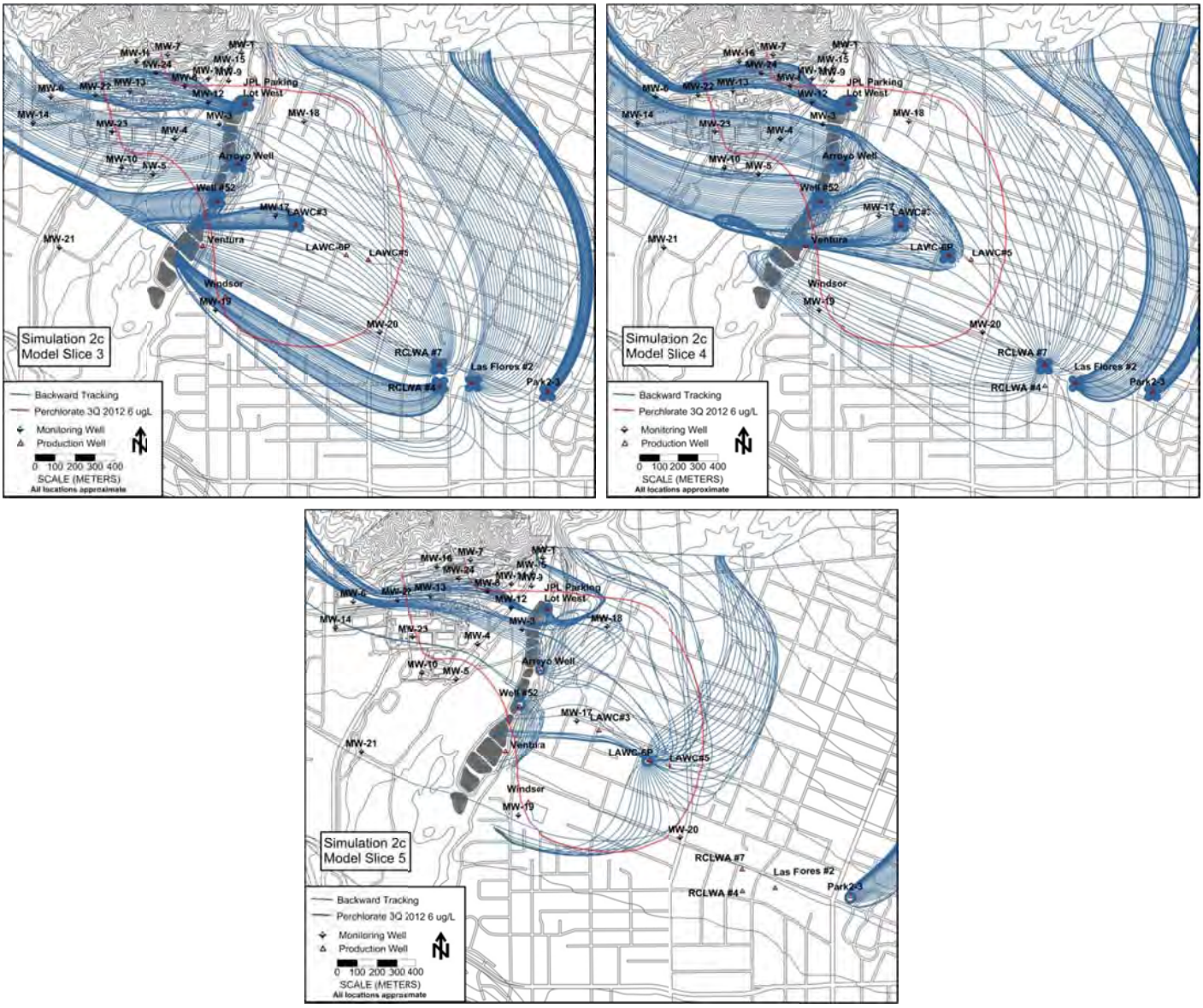


Figure 6. Simulation No. 2c Results (LAWC#6P and MHTS Option 4: JPL Parking East Parking Lot) in Model Slices 3, 4, and 5

Simulation No. 3a – LAWC #6P and MHTS Option 2: JPL Parking Lot West with High Extraction Rate

Simulation No. 3a was performed using the extraction rates outlined in Table 3 with the JPL Parking Lot West location for the new MHTS well; the new MHTS well and LAWC#6P are operating at a high extraction rate. Figure 7 shows the capture zones generated in slices 3, 4, and 5 for Simulation No. 3a. The simulations show that the JPL Parking Lot West well location will provide more containment of the source area compared to the baseline simulation, thus minimizing the potential for downgradient migration toward MW-18. Similar to Simulation No. 2a (low extraction rate simulation) the capture zone is affected by inflow from the mouth of the Arroyo Seco and the artificial flow barrier located to the north of this well. The JPL Parking Lot West location capture zone is slightly wider than in the low extraction rate simulation. The results also indicate that without LAWC#5 operating, there is less shallow containment of the plume to the north of the LAWC wells. The operation of LAWC#6P provides more containment at depth compared to the baseline simulation, and the higher extraction rate in this well results in a wider capture zone compared to the low extraction rate simulation.

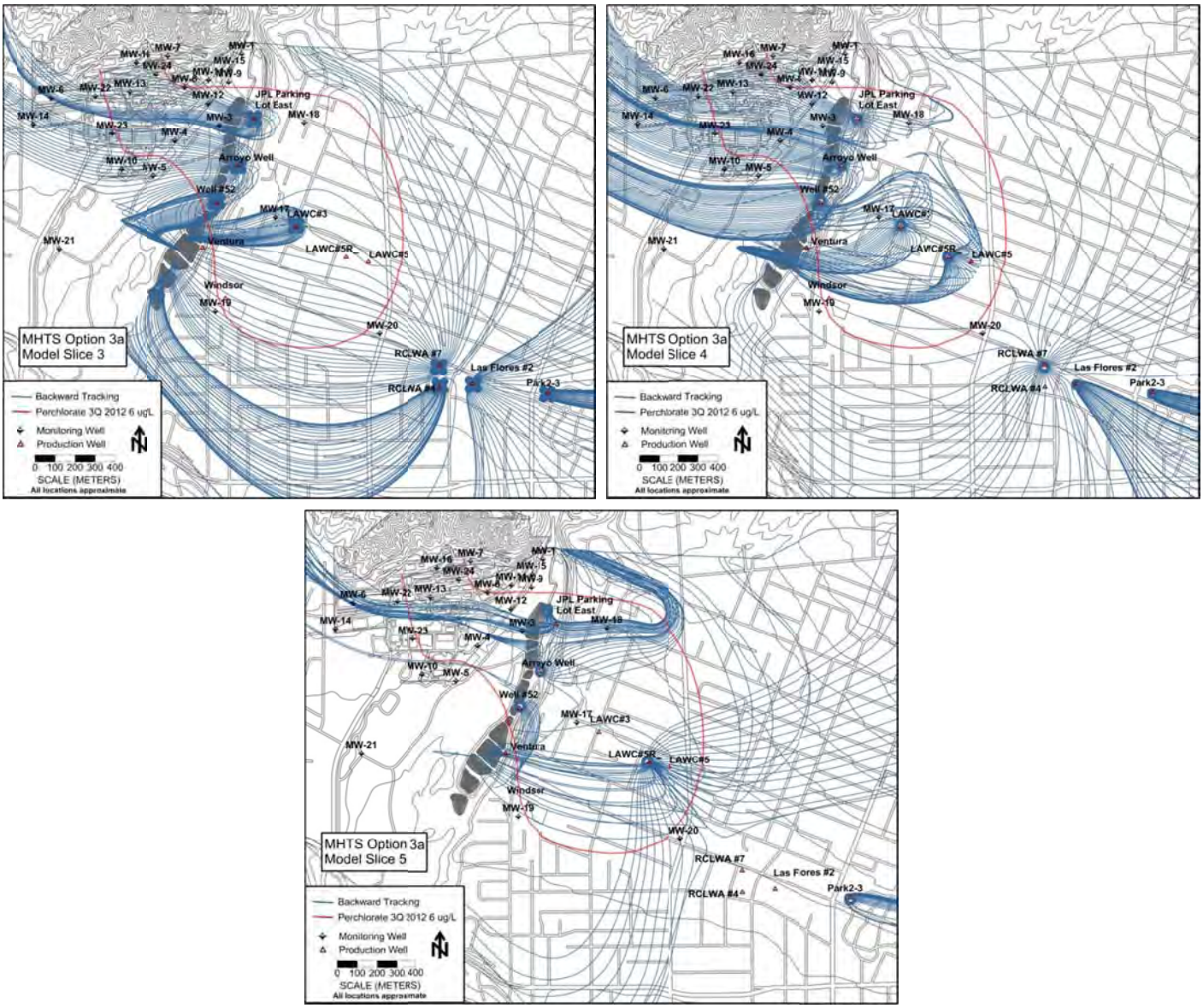


Figure 7. Simulation No. 3a Results (LAWC#6P and MHTS Option 2: JPL Parking Lot West) in Model Slices 3, 4, and 5

Simulation No. 3b – LAWC #6P and MHTS Option 3: Behner Well South with High Extraction Rate

Simulation No. 3b was performed using the extraction rates outlined in Table 3 with the Behner Well South location for the new MHTS well; the new MHTS well and LAWC#6P are operating at a high extraction rate. Figure 8 shows the capture zones generated in slices 3, 4, and 5 for Simulation No. 3b. The simulations show that the Behner Well South well location will provide more containment of the source area compared to the baseline simulation, thus minimizing the potential for downgradient migration toward MW-18. Similar to Simulation No. 2b (low extraction rate simulation) the capture zone is affected by inflow from the mouth of the Arroyo Seco and the artificial flow barrier located to the north of this well. The Behner Well South location capture zone is slightly wider than in the low extraction rate simulation. The results also indicate that without LAWC#5 operating, there is less shallow containment of the plume to the north of the LAWC wells. The operation of LAWC#6P provides more containment at depth compared to the baseline simulation, and the higher extraction rate in this well results in a wider capture zone that contains more groundwater to the east and south compared to the low extraction rate simulation.

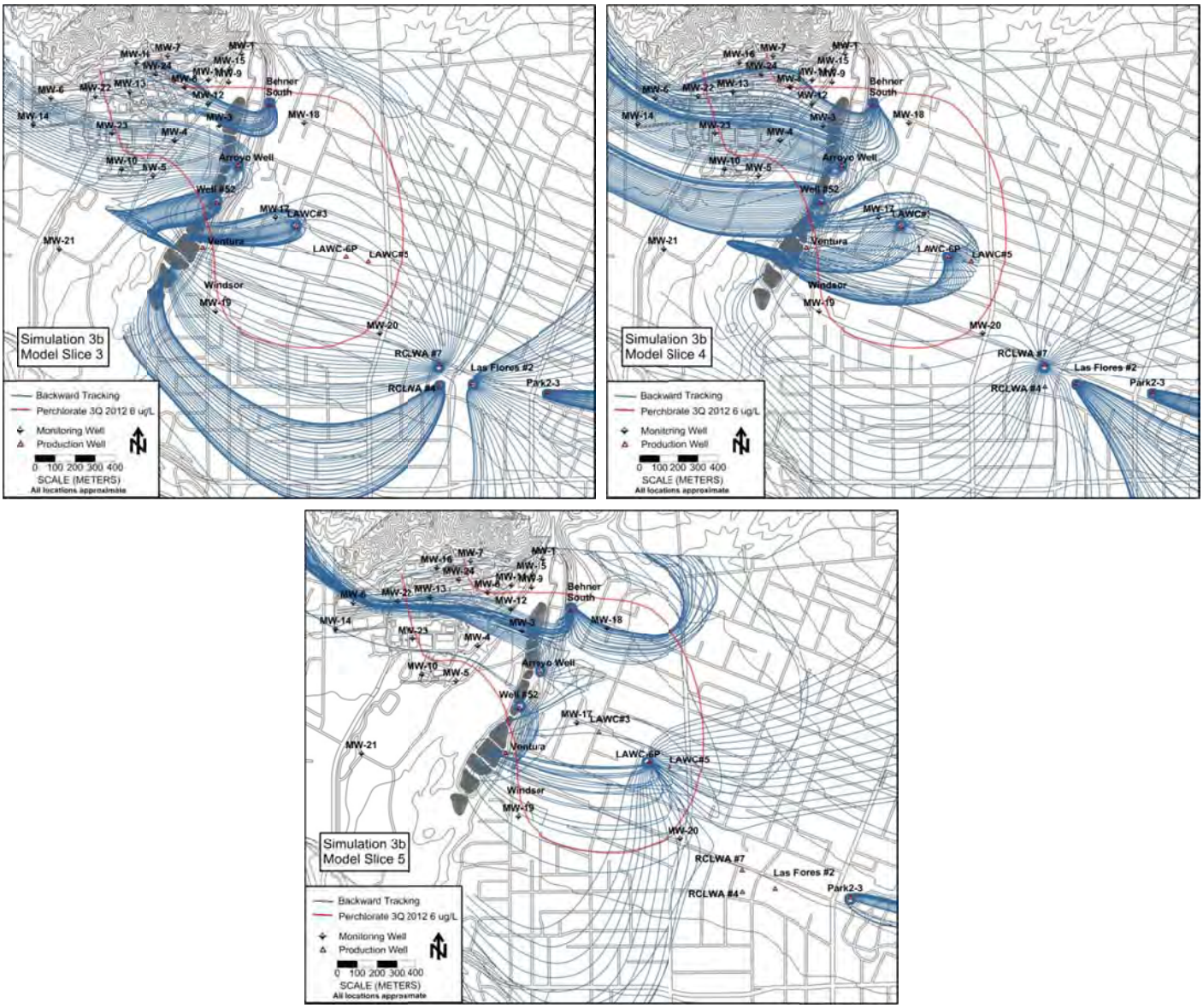


Figure 8. Simulation No. 3b Results (LAWC#6P and MHTS Option 3: Behner Well South) in Model Slices 3, 4, and 5

Simulation No. 3c – LAWC #6P and MHTS Option 4: JPL Parking Lot East with High Extraction Rate

Simulation No. 3c was performed using the extraction rates outlined in Table 3 with the JPL Parking Lot East location for the new MHTS well; the new MHTS well and LAWC#6P are operating at a high extraction rate. Figure 9 shows the capture zones generated in slices 3, 4, and 5 for Simulation No. 3c. The simulations show that the JPL Parking Lot East well location will provide more containment of the source area compared to the baseline simulation, thus minimizing the potential for downgradient migration toward MW-18. The JPL Parking Lot East location is not as affected by the artificial flow barrier as the JPL Parking Lot West location, and appears to better contain groundwater in the source area compared to this location. The JPL Parking Lot East location capture zone is slightly wider than in the low extraction rate simulation. The results also indicate that without LAWC#5 operating, there is less shallow containment of the plume to the north of the LAWC wells. The operation of LAWC#6P provides more containment at depth compared to the baseline simulation, and the higher extraction rate in this well results in a wider capture zone that contains more groundwater to the east and south compared to the low extraction rate simulation.

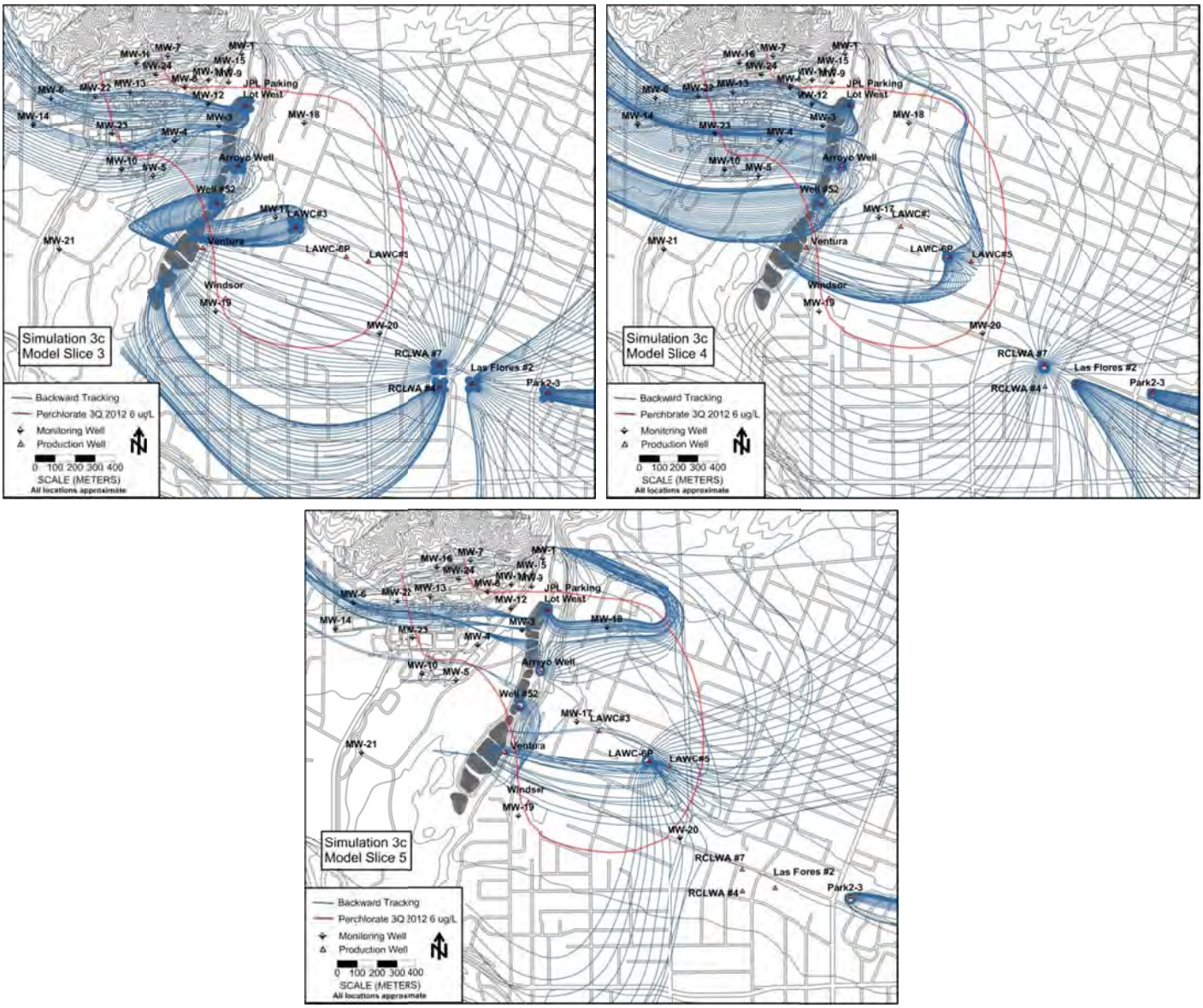


Figure 9. Simulation No. 3c Results (LAWC#6P and MHTS Option 3: JPL Parking Lot East) in Model Slices 3, 4, and 5

Simulation No. 4a – LAWC #6P, LAWC #5, and MHTS Option 2: JPL Parking Lot West with High Extraction Rate

Simulation No. 4a was performed using the extraction rates outlined in Table 3 with the JPL Parking Lot West well location for the new MHTS well; the new MHTS well is operating at a high extraction rate, and LAWC#5 and LAWC#6P are both operating. Figure 10 shows the capture zones generated in slices 3, 4, and 5 for Simulation No. 4a. The simulations show that the JPL Parking Lot West location will provide more containment of the source area compared to the baseline simulation, thus minimizing the potential for downgradient migration toward MW-18. The capture zone is affected by inflow from the mouth of the Arroyo Seco and the artificial flow barrier located to the north of this well. The results also indicate that with LAWC#5 operating, there is more shallow containment of the plume to the north of the LAWC wells. The operation of LAWC#6P provides more containment at depth compared to the baseline simulation, and at depth this well contains more groundwater to the east and south due to operation of LAWC#5.

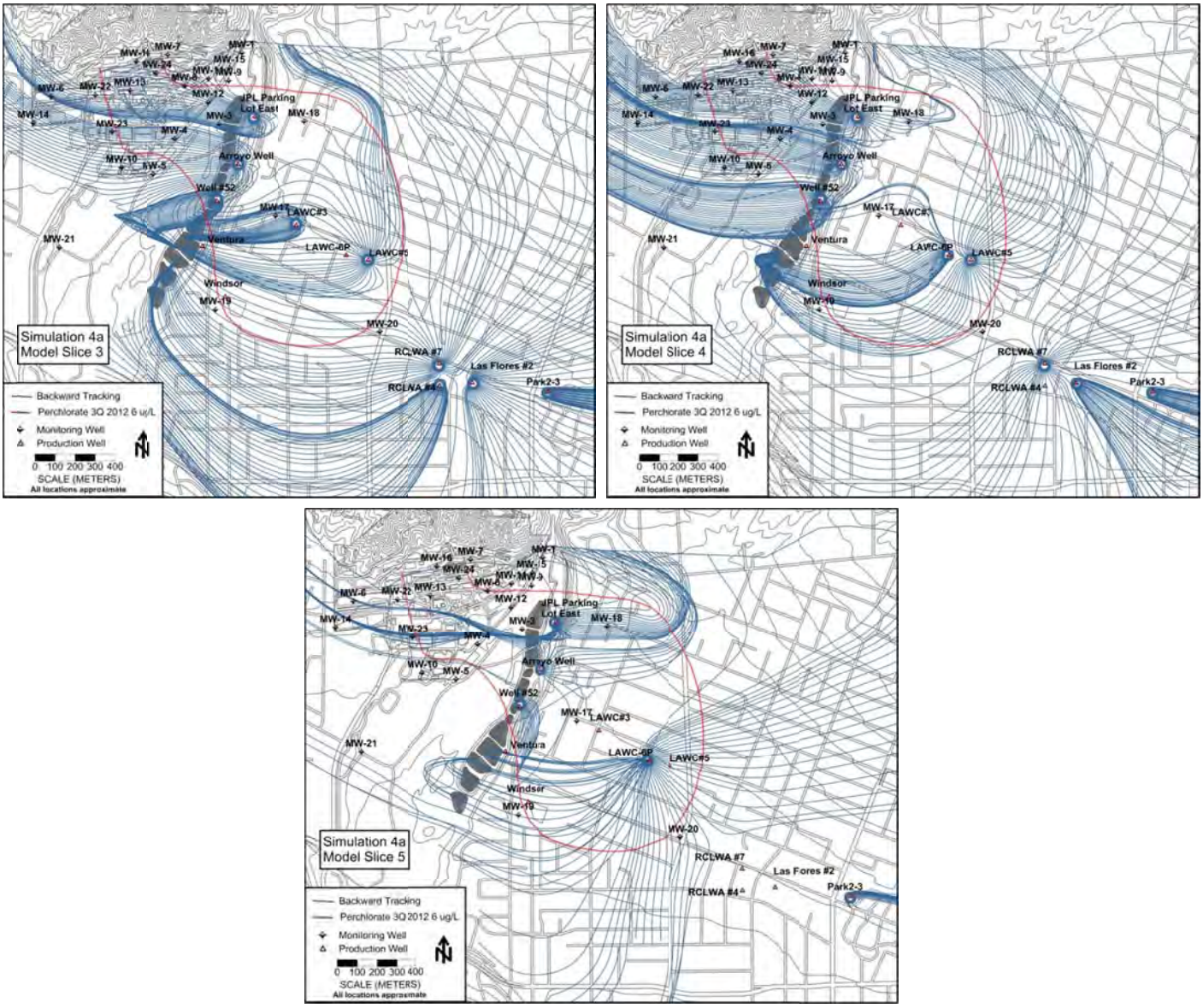


Figure 10. Simulation No. 4a Results (LAWC#6P, LAWC#5, and MHTS Option 2: JPL Parking Lot West) in Model Slices 3, 4, and 5

Simulation No. 4b – LAWC #6P, LAWC #5, and MHTS Option 3: Behner Well South with High Extraction Rate

Simulation No. 4b was performed using the extraction rates outlined in Table 3 with the Behner Well South well location for the new MHTS well; the new MHTS well is operating at a high extraction rate, and LAWC#5 and LAWC#6P are both operating. Figure 11 shows the capture zones generated in slices 3, 4, and 5 for Simulation No. 4b. The simulations show that the Behner Well South well location will provide more containment of the source area compared to the baseline simulation, thus minimizing the potential for downgradient migration toward MW-18. Similar to Simulations No. 2b and No. 3b, the Behner Well South capture zone is affected by inflow from the mouth of the Arroyo Seco and the artificial flow barrier located to the north of this well. The results also indicate that with LAWC#5 operating, there is more shallow containment of the plume to the north of the LAWC wells. The operation of LAWC#6P provides more containment at depth compared to the baseline simulation, and at depth this well contains groundwater to the east and south due to operation of LAWC#5.

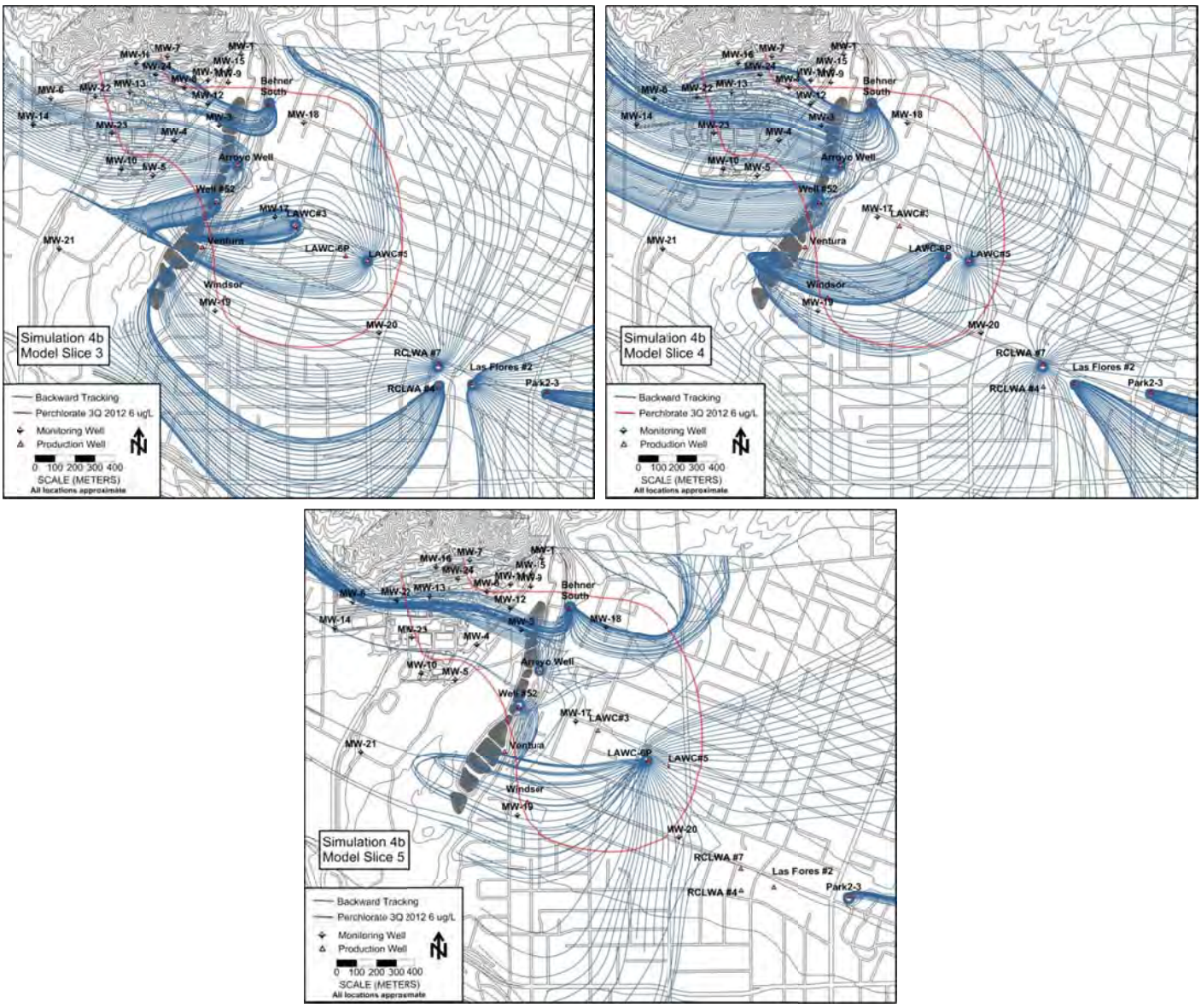


Figure 11. Simulation No. 4b Results (LAWC#6P, LAWC#5, and MHTS Option 3: Behner Well South) in Model Slices 3, 4, and 5

Simulation No. 4c – LAWC #6P, LAWC #5, and MHTS Option 4: JPL Parking Lot East with High Extraction Rate

Simulation No. 4c was performed using the extraction rates outlined in Table 3 with the JPL Parking Lot East well location for the new MHTS well; the new MHTS well is operating at a high extraction rate, and LAWC#5 and LAWC#6P are both operating. Figure 12 shows the capture zones generated in slices 3, 4, and 5 for Simulation No. 4c. The simulations show that the JPL Parking Lot East well location will provide more containment of the source area compared to the baseline simulation, thus minimizing the potential for downgradient migration toward MW-18. The capture zone is not as affected by inflow from the mouth of the Arroyo Seco and the artificial flow barrier located to the north of this well compared to the JPL Parking Lot West location. The results also indicate that with LAWC#5 operating, there is more shallow containment of the plume to the north of the LAWC wells. The operation of LAWC#6P provides more containment at depth compared to the baseline simulation, and at depth this well contains more groundwater to the east and south due to operation of LAWC#5.

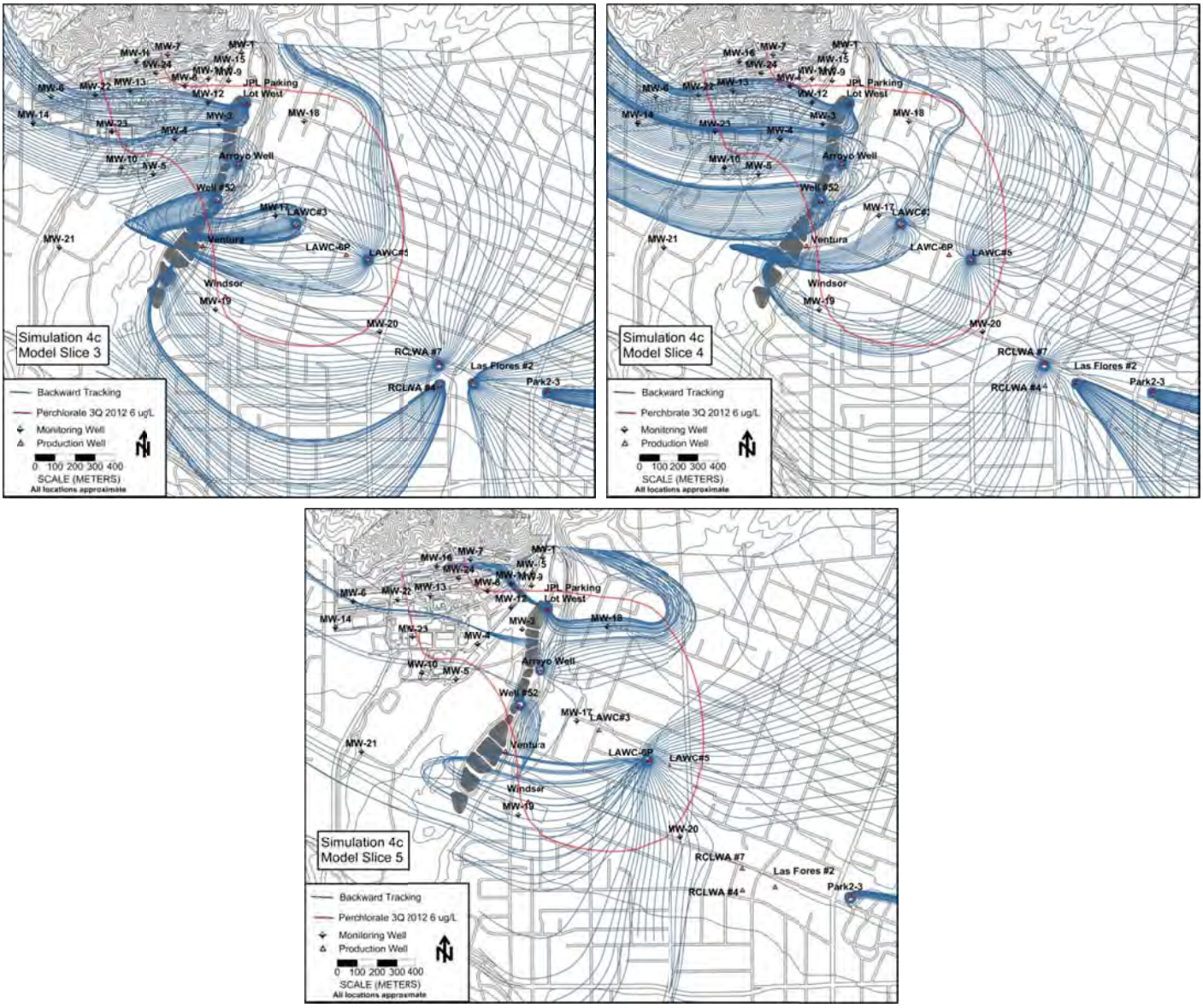


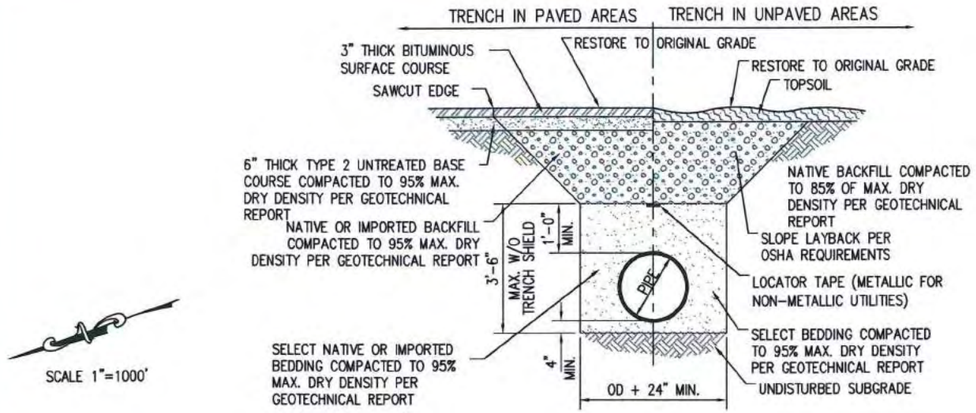
Figure 12. Simulation No. 4c Results (LAWC#6P, LAWC#5, and MHTS Option 4: JPL Parking Lot East) in Model Slices 3, 4, and 5

Conclusions

Based on the simulations documented in this technical memorandum, the following conclusions are noted:

- Surface water discharge and subsurface inflow from the Arroyo Seco accounts for a significant volume of water entering the Monk Hill Subarea, and has resulted in historically high groundwater levels in nearby monitoring wells and a southerly groundwater flow direction in the vicinity of these wells. A new MHTS well placed in the vicinity of the mouth of the Arroyo Seco (e.g., Behner Well North location) will likely contain a significant portion of "clean" groundwater discharging from the Arroyo Seco and will not provide optimal containment of JPL source area groundwater.
- The artificial flow barrier included in the groundwater flow model to account for the Arroyo Seco inflow significantly affects particle tracking results in the area of the proposed MHTS wells, particularly wells situated farther to the north.
- MHTS mass removal can be optimized by installing a new extraction well in an area of elevated dissolved chemical concentrations in groundwater and reducing extraction in areas of lower dissolved concentrations in groundwater. Addition of a new MHTS well at one of the proposed locations in place of the Windsor and Ventura wells can nearly double the current mass removal rate.
- The JPL Parking lot locations appear to be better locations for the new MHTS extraction well as opposed to the Behner property locations, and will likely collect less "clean" groundwater from the mouth of the Arroyo Seco than the Behner Well North and South locations. Modeling results suggest the JPL Parking Lot East location is the optimal location for placement of the new MHTS well. Installation of a new MHTS well at this location would provide effective containment of source area groundwater, and minimize downgradient chemical migration toward MW-18.
- Modeling results suggest LAWC#6P will provide plume containment at depth, thus minimizing downgradient migration toward the RCL&W Association production wells. Results from soil and geophysical logging during well installation should be used to design the optimal screen placement of this well.
- LAWC#5 should be operated in conjunction with LAWC#6P to provide optimal containment at the leading edge of the dissolved chemical plume.

APPENDIX B
Pipeline Routes and Specifications (MHTS)



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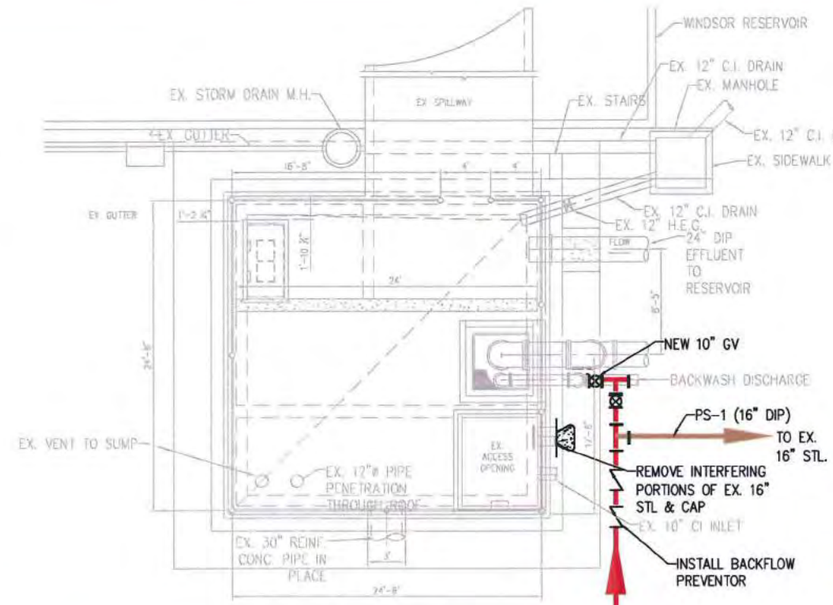
TYPICAL TRENCH DETAIL
NOT TO SCALE



SAND BOX PLAN
SCALE: 3/16"=1'-0"

LEGEND

- NEW RAW WATER PIPE TO VPS
- EXISTING RAW WATER PIPE TO MHTS
- NEW WASTE COLLECTOR FOR BWTP
- NEW PUMP WATER TO BWTP
- EXISTING MAIN CONVERTED TO WASTE COLLECTOR TO BWTP
- TREATED WASTEWATER FOR RECHARGE

NOT FOR CONSTRUCTION

REVISION		
NO.	DESCRIPTION	DATE

APPROVED BY:
CHRISTOPHER SHEM HAWES RCE 68578 — DATE
APPROVED: — DATE
APPROVED: — DATE

PLANS PREPARED BY:
CIVILTEC engineering inc.
General Civil, Municipal, Water and Wastewater Engineering, Planning, Construction Management and Surveying
118 West Lime Avenue
Monrovia, Ca. 91016
Phone: (626) 357-0588
Fax: (626) 303-7957

TIDEWATER INC. ENGINEERS / SCIENTISTS / PROGRAM MANAGERS

CITY OF PASADENA INCORPORATED JUNE 1886

DATE	SCALE	PASADENA WATER & POWER CITY OF PASADENA	SHEET NO 1 OF 6 SHEETS
DEC. 2013	AS SHOWN	MHTS UTILITY PIPELINE AND PRODUCTION WELL CONCEPTS GENERAL SITE PLAN	WORK ORDER — / FILE NUMBER —
DRAWN BY CIVILTEC			
DESIGNED BY CIVILTEC/BD			
CHECKED BY CIVILTEC/CSH			
SUBMITTED BY CIVILTEC			
FIELD BOOKS	CALC BOOKS	APPROVED / APPROVED	REVISION

a:\2012\2012165.00-TIDEWATER-MHTS UTILITY PIPELINE AND PRODUCTION WELL CONCEPTS\AUTOCAD DWG\WELL PLANS\WELL PRNG PLANS\SHT 01-T1

SCALE 1"=20'

WINDSOR WELL HEAD
SEE DETAIL

WINDSOR WELL

NEW 12" DIP (PS-1)

NEW VALVES FOR BACKWASH TIE-IN DISCONNECT CUT & CAP EX. 16" STL

EXISTING WINDSOR RESERVOIR

EX. 12" DIP PLANT INFLUENT

CITY OF PASADENA BOUNDARY

EXIST. 16" STEEL (PS-2)

CUT & CAP SALVAGE EX. GATE VALVE

NEW 12" DIP (PS-3)

EX. 12" DIP (PS-4)

EXIST. 16" STL

WINDSOR AVENUE

EX. TREATMENT PAD

EX. 24" DIP PLANT EFFLUENT

EX. 24" DIP PLANT INFLUENT

EX. 10" DIP BACKWASH SUPPLY

EX. 4" GSP FIRE SERVICE

4" PVC FIRE SERVICE

2" GSP UTILITY WATER

EX. 10" DIP BACKWASH DISCHARGE

8" DIP FIRE SERVICE

AMMONIA SAMPLING VAULT

AMMONIA INJECTION VAULT

AQUA AMMONIA STORAGE AREA

CHLORINE GAS STORAGE AREA

EX. ACCESS OPENING

WINDSOR WELL BUILDING

WATER VAULT

EX. SANDBOX

2" PVC PIPE FOR PUMP WATER LUBE LINE

45°-2" PVC ELBOW

90°-2" PVC ELBOW

EX. 30" WATER

EX. 12" DI WATER

EX. ¾" ELEC. CONDUIT

EX. 1" ELEC. CONDUIT

TO WINDSOR WELL BLDG

EXISTING WINDSOR WELL

NEW 12" NIBCO ANGLE VALVE

NEW 12" PIPE

EXISTING EDGE OF PAVEMENT

TO EX. 16" STL

NORTH

WELL PIPING LAYOUT

SCALE: 1/2"=1'-0"

250 HP MOTOR US MOTORS

REPLACE EXISTING SPOOL W/ NEW SPOOL WITH 12" OUTLET, INSTALL 12" NIBCO VALVE AND CONNECT NEW PIPE TO NIBCO VALVE

NEW 12" PIPE (PS-1)

EXISTING TREMIE PIPE

PUMP COLUMN=10"

EX. STEEL CASING=20"

1 1/4" PVC STILLING WELL FOR WELL LEVEL TRANSDUCER

STATIC WATER LEVEL=220' bgs

WELL LEVEL TRANSDUCER (LIT-102)

OPERATIONAL WATER LEVEL=366' bgs

PUMP BOWEL CHRISTENSEN 12CHC (9 STAGE)

PUMP INLET DEPTH = 397'

WELL PIPING SECTION

SCALE: 1/2"=1'-0"

NOT FOR CONSTRUCTION

REVISION		
NO.	DESCRIPTION	DATE

REGISTERED PROFESSIONAL ENGINEER — CHRISTOPHER SHEM HAWES — No. 69578 Exp. 06/30/10 — CIVIL — STATE OF CALIFORNIA

APPROVED BY:
CHRISTOPHER SHEM HAWES 69578 RCE — DATE
APPROVED: — DATE
APPROVED: — DATE

PLANS PREPARED BY:
CIVILTEC engineering inc.
General Civil, Municipal, Water and Wastewater Engineering, Planning, Construction Management and Surveying
118 West Lime Avenue
Monrovia, Ca. 91016
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Fax: (626) 303-7957

TIDEWATER INC — ENGINEERS / SCIENTISTS / PROGRAM MANAGERS

CITY OF PASADENA — INCORPORATED JUNE 1886

DATE DEC. 2013	SCALE AS SHOWN	PASADENA WATER & POWER CITY OF PASADENA	SHEET NO 2 OF 6 SHEETS
DRAWN BY CIVILTEC		MHTS UTILITY PIPELINE AND PRODUCTION WELL CONCEPTS	WORK ORDER – / FILE NUMBER –
DESIGNED BY CIVILTEC/BD		WINDSOR WELL HEAD – SITE LAYOUT	
CHECKED BY CIVILTEC/CSH			
SUBMITTED BY CIVILTEC			
FIELD BOOKS	CALC BOOKS	APPROVED / APPROVED	REVISION

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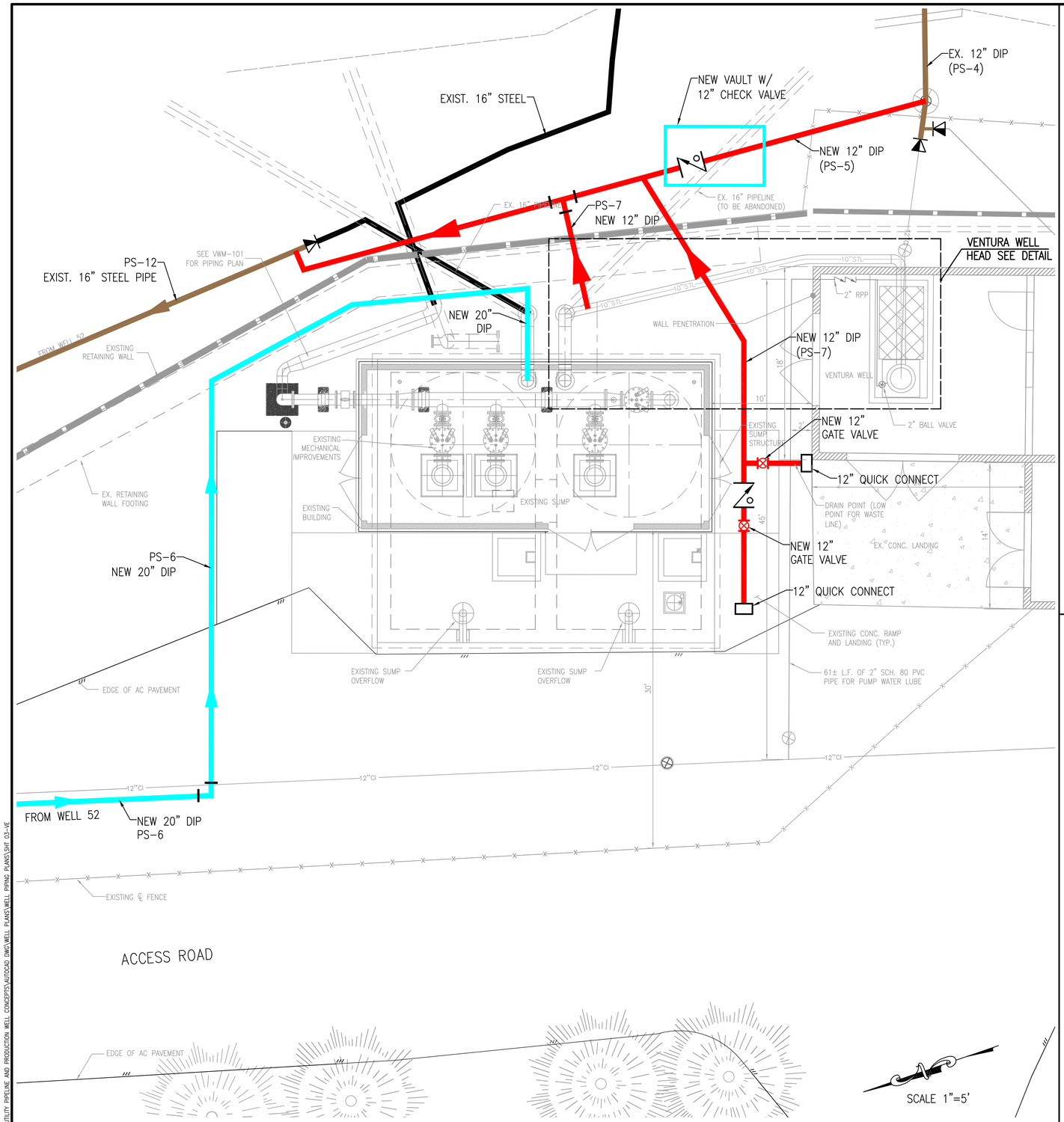

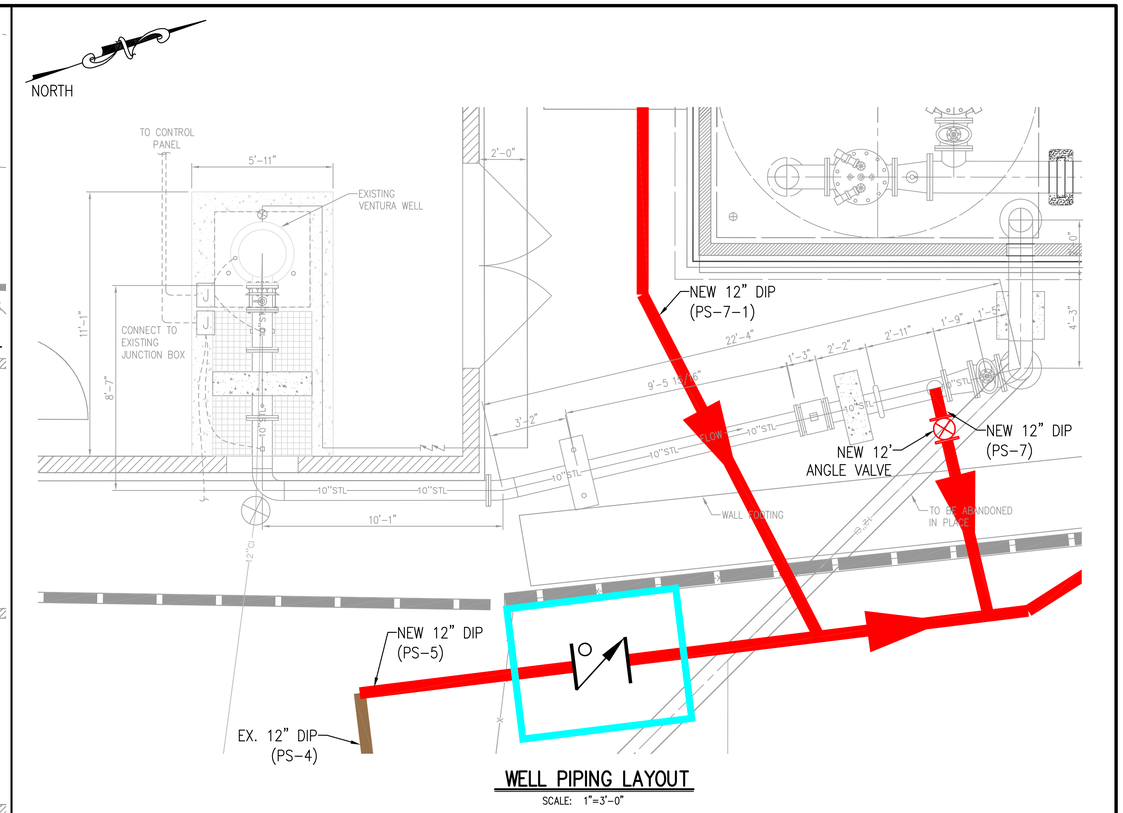

WELL PIPING LAYOUT

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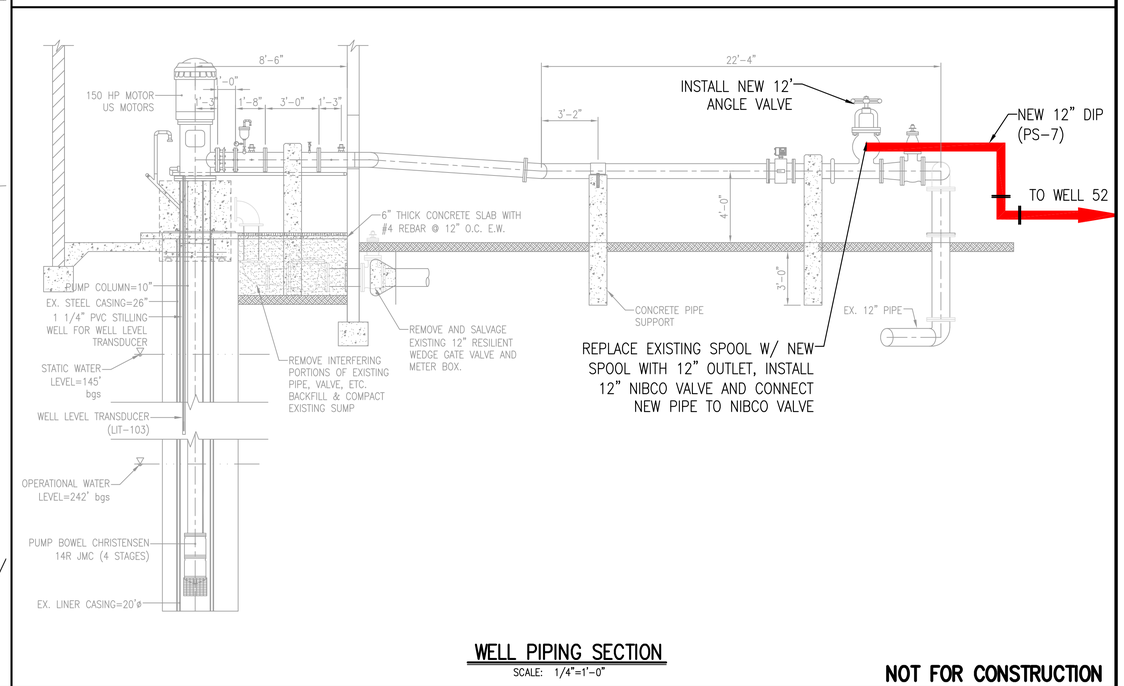

WELL PIPING SECTION

SCALE: 1/4"=1'-0"

NOT FOR CONSTRUCTION

REVISION		
NO.	DESCRIPTION	DATE

REGISTERED PROFESSIONAL ENGINEER — CHRISTOPHER SHEM HAWES — No. 69578 Exp. 06/30/10 — CIVIL — STATE OF CALIFORNIA

APPROVED BY:
CHRISTOPHER SHEM HAWES 69578 RCE — DATE
APPROVED: — DATE
APPROVED: — DATE

PLANS PREPARED BY:
CIVILTEC engineering inc.
General Civil, Municipal, Water and Wastewater Engineering, Planning, Construction Management and Surveying
118 West Lime Avenue
Monrovia, Ca. 91016
Phone: (626) 357-0588
Fax: (626) 303-7957

TIDEWATER INC ENGINEERS / SCIENTISTS / PROGRAM MANAGERS

CITY OF PASADENA INCORPORATED JUNE 1886

DATE	DEC. 2013
SCALE	AS SHOWN
DRAWN BY	CIVILTEC
DESIGNED BY	CIVILTEC/BD
CHECKED BY	CIVILTEC/CSH
SUBMITTED BY	CIVILTEC
FIELD BOOKS	
CALC BOOKS	

PASADENA WATER & POWER
CITY OF PASADENA

MHTS UTILITY PIPELINE AND PRODUCTION WELL CONCEPTS
VENTURA WELL PIPING PLAN

APPROVED | APPROVED

SHEET NO 3 OF 6 SHEETS

WORK ORDER –
FILE NUMBER –
REVISION

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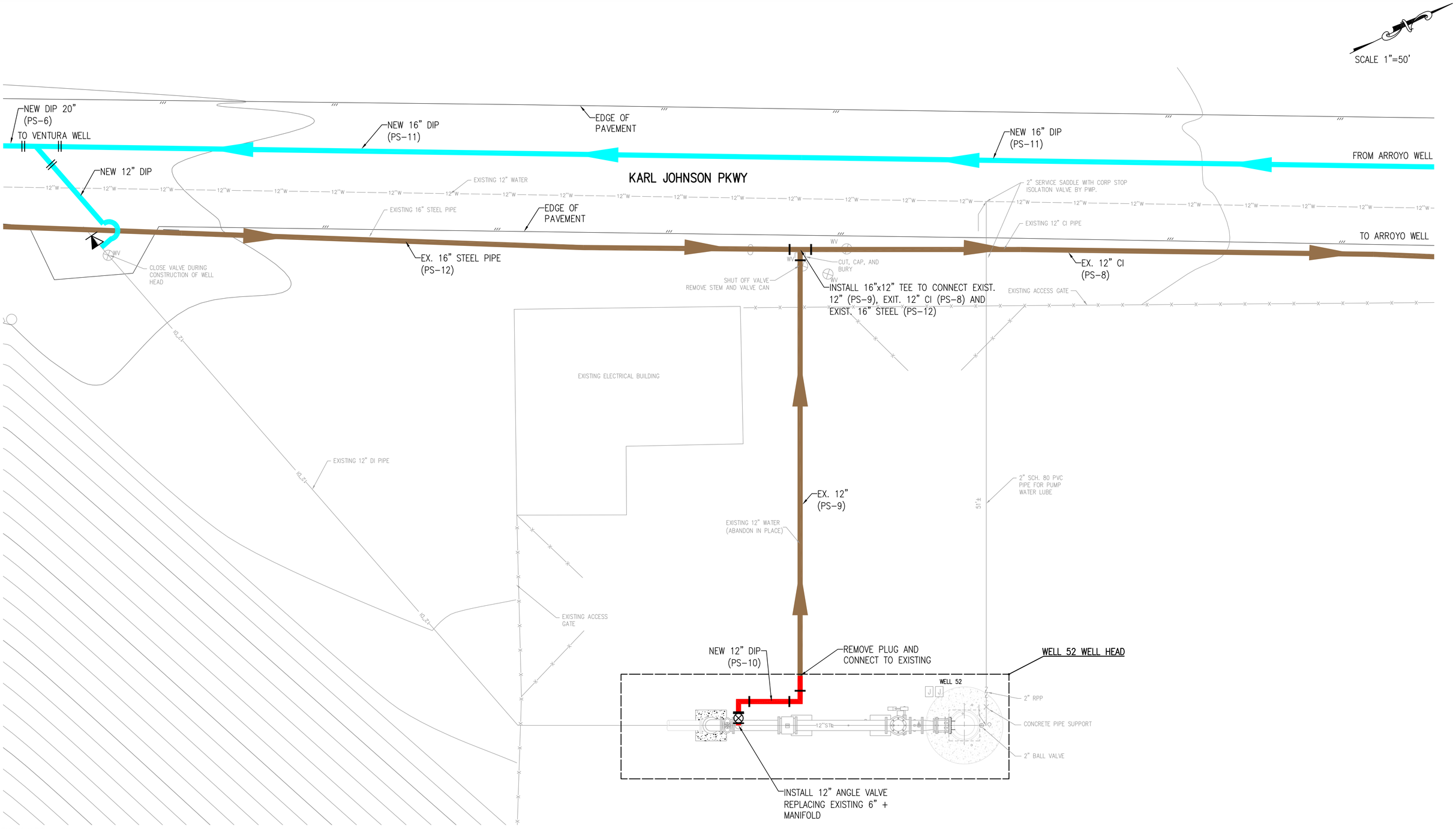

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REGISTERED PROFESSIONAL ENGINEER — CHRISTOPHER SHEM HAWES — No. 69578 Exp. 06/30/10 — CIVIL — STATE OF CALIFORNIA

APPROVED BY:

69578
CHRISTOPHER SHEM HAWES RCE — DATE

APPROVED: — DATE

APPROVED: — DATE

PLANS PREPARED BY:

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General Civil, Municipal, Water and Wastewater Engineering, Planning, Construction Management and Surveying

118 West Lime Avenue
Monrovia, Ca. 91016
Phone: (626) 357-0588
Fax: (626) 303-7957

TIDEWATER INC ENGINEERS / SCIENTISTS / PROGRAM MANAGERS

CITY OF PASADENA INCORPORATED JUNE 1886

DATE	DEC. 2013
SCALE	AS SHOWN
DRAWN BY	CIVILTEC
DESIGNED BY	CIVILTEC/BD
CHECKED BY	CIVILTEC/CSH
SUBMITTED BY	CIVILTEC
FIELD BOOKS	
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PASADENA WATER & POWER
CITY OF PASADENA

MHTS UTILITY PIPELINE AND PRODUCTION WELL CONCEPTS
WELL 52 – SITE LAYOUT

APPROVED | APPROVED

SHEET NO 4 OF 6 SHEETS

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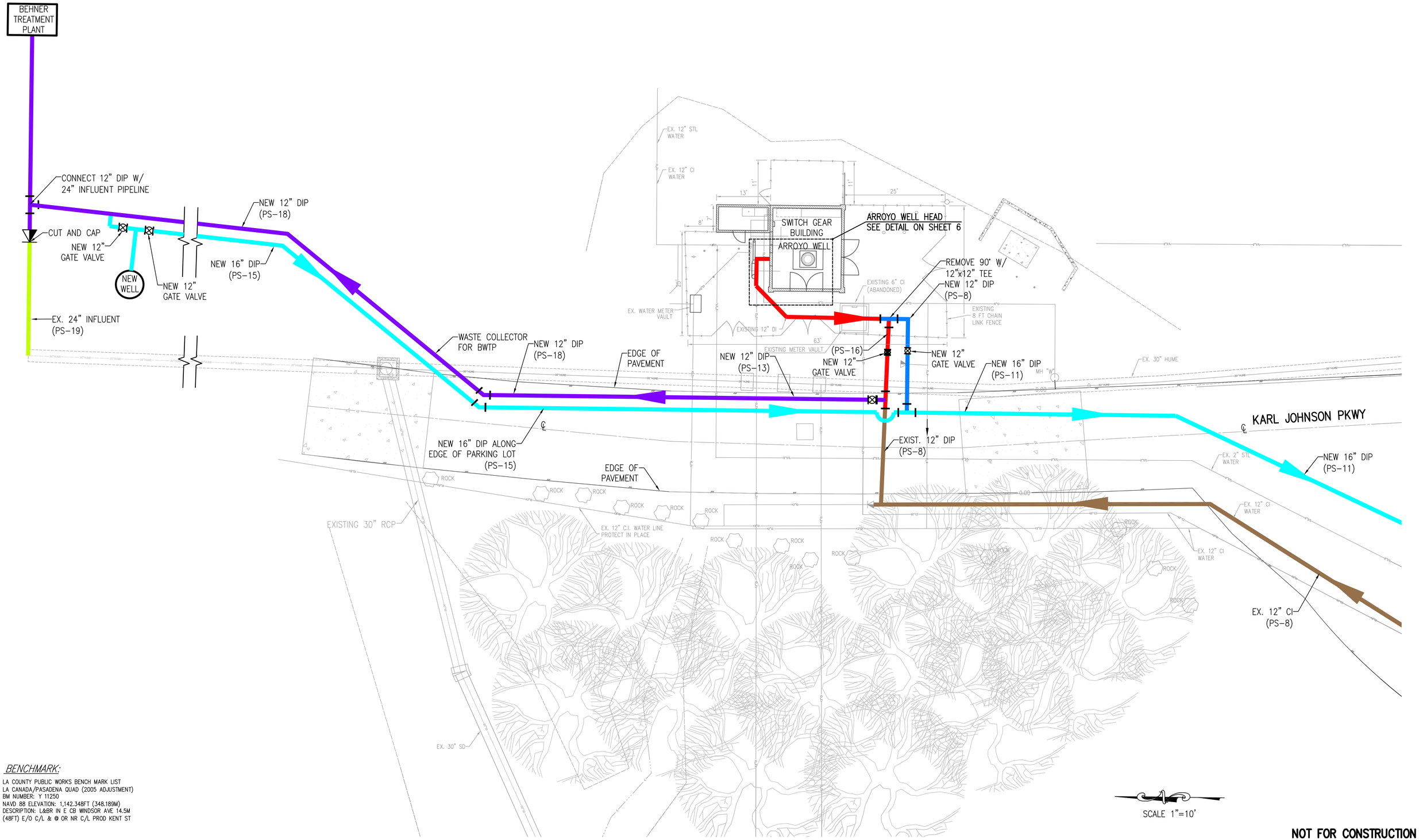

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LA COUNTY PUBLIC WORKS BENCH MARK LIST
LA CANADA/PASADENA QUAD (2005 ADJUSTMENT)
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REVISION		
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REGISTERED PROFESSIONAL ENGINEER — CHRISTOPHER SHEM HAWES — No. 69578 Exp. 06/30/10 — CIVIL — STATE OF CALIFORNIA

APPROVED BY:
CHRISTOPHER SHEM HAWES 69578 RCE — DATE
APPROVED: — DATE
APPROVED: — DATE

PLANS PREPARED BY:
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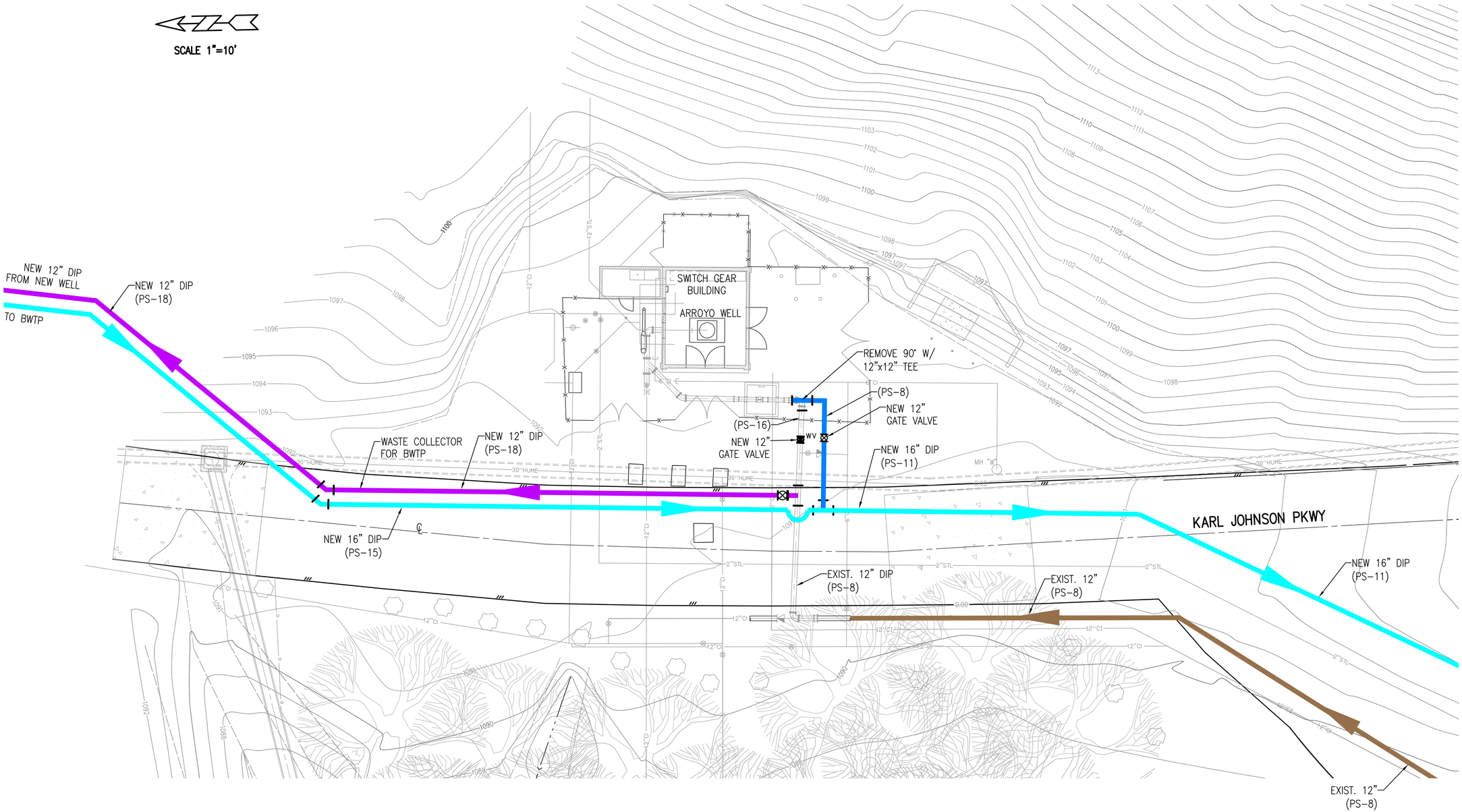

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CHRISTOPHER SHEM HAWES 69578 RCE — DATE
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APPROVED: — DATE

PLANS PREPARED BY:
CIVILTEC engineering inc.
General Civil, Municipal, Water and Wastewater Engineering, Planning, Construction Management and Surveying
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APPENDIX C
Geological Evaluation

Geologic Review
of
Proposed Pasadena Water and Power
and
Lincoln Avenue Water Company Production Well Locations

1. Introduction

The Jet Propulsion Laboratory (JPL) is a federally-funded research and development center in Pasadena, California, currently operated under contract with the California Institute of Technology (Caltech) for National Aeronautics and Space Administration (NASA). JPL's primary activities include the exploration of the earth and solar system by automated spacecraft and the design and operation of the Global Deep Space Tracking Network.

Located in Los Angeles County, JPL adjoins the incorporated cities of La Cañada Flintridge and Pasadena, and is bordered on the east by the unincorporated community of Altadena. JPL encompasses approximately 176 acres of land and more than 150 buildings and other structures. Of the JPL facility's 176 acres, approximately 156 acres are federally owned. The remaining land is leased for parking from the City of Pasadena and the Flintridge Riding Club. Development at JPL is primarily located in two regions, an early-developed northeastern area and a later-developed southwestern area. Figure 1 presents a map showing the JPL facility and surrounding areas.

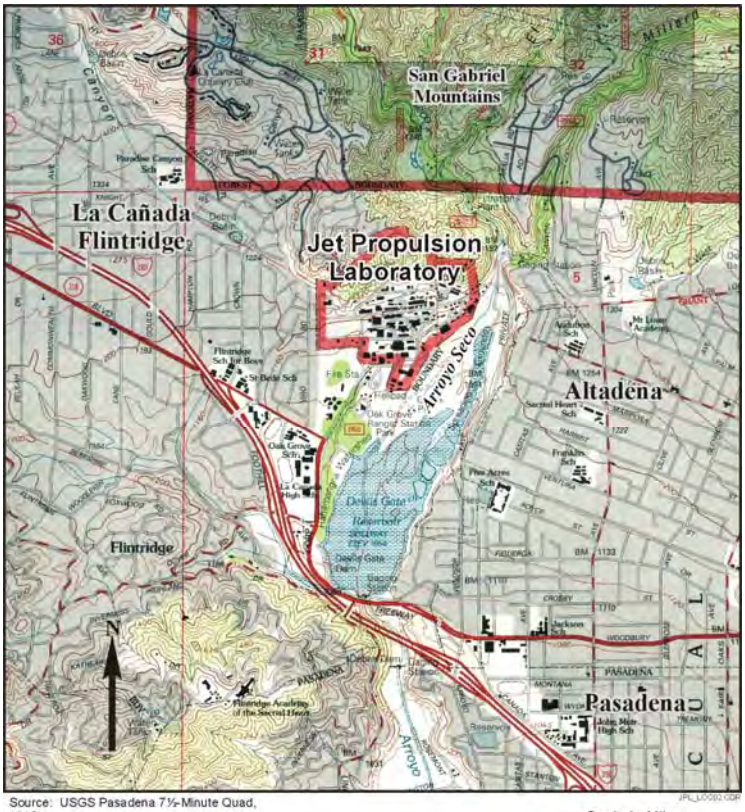

Figure 1. Map of JPL and the Surrounding Area

This technical memorandum provides the results of a geologic records review associated with the installation of two new extraction wells. The purpose of this review is to determine bedrock depth,

lithology, and the presence of faulting at the two proposed extraction well locations. The first well named "New MHTS Well" is located 1,030 feet north of the Arroyo Well and second well named "New LAWC Well" is located at the Lincoln Avenue Water Company. The well locations are presented in Figures 2 and 3, respectively. The purpose of the well installations is to enhance perchlorate and VOC mass removal as well as improving reliability of the respective treatment systems. Both systems are operating as part of NASA's Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Program at the Jet Propulsion Laboratory in Pasadena, California. JPL was placed on the National Priorities List (NPL) in 1992 and is subject to regulation under CERCLA.[1]

Figure 2. New MHTS Well Location

[1] 47189-47187 Federal Register, 1992, Vol. 57, No. 199.

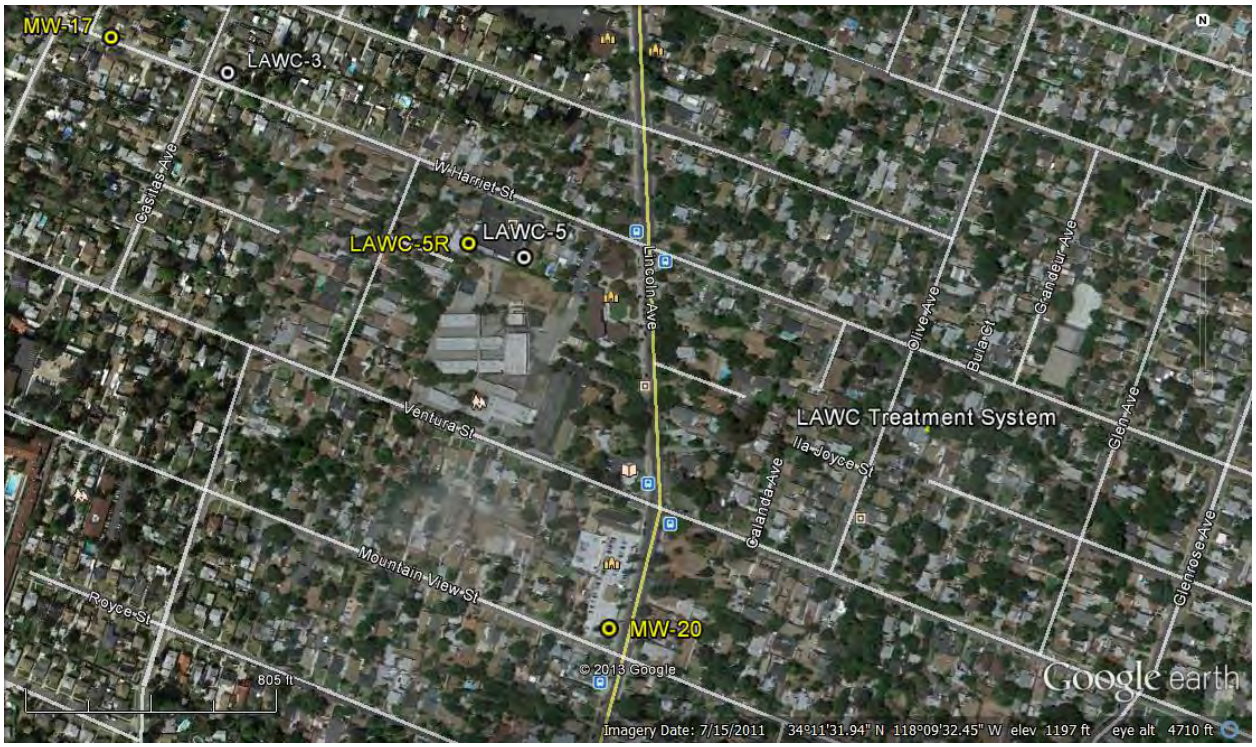

Figure 3. New LAWC Well Location

2. Site Geology

JPL is located immediately south of the southwestern edge of the San Gabriel Mountains (Figure 1). The San Gabriel Mountains, together with the San Bernardino Mountains to the east and the Santa Monica Mountains to the west, make up a major part of the east-west trending Transverse Ranges province of California. This province is dominated by east-west trending folds, reverse faults, and thrust faults indicating a history dominated by north-south compressional deformation.

The San Gabriel Mountains are primarily composed of crystalline basement rocks. These rocks range in age from Precambrian to Tertiary and include various types of diorites, granites, monzonites, and granodiorites with a complex history of intrusion and metamorphism (Dibblee, 1982). Periodic tectonic uplift of the San Gabriel Mountains has occurred during the past 1 to 2 million years. This uplift is responsible for the present topography of the area (Smith, 1986). Most of this uplift has occurred along north- to northeast-dipping reverse and thrust faults located along the south to southwest edges of the San Gabriel Mountains. This system of faults along the southern edge of the San Gabriel Mountains is referred to as the Sierra Madre Fault system.

The Sierra Madre Fault system separates the San Gabriel Mountains to the north from the San Gabriel Valley to the south. The San Gabriel Valley contains distinct groundwater basins, including the Raymond Basin, where JPL is located. The Raymond Basin is bordered on the north by the San Gabriel Mountains, on the west by the San Rafael Hills, and on the south and east by the Raymond Fault (Figure 4). The Raymond Fault is a steep, north-dipping reverse fault that lies south of the topographic front of the San Gabriel Mountains.

The stratigraphic record of the Raymond Bain prior to the Tertiary period is incomplete. Sediments representing the time period between formation of the crystalline basement complex and sedimentary

rocks of early to middle Tertiary are not present. A generalized stratigraphic column of the Raymond Basin is shown in Figure 4.

The oldest non-crystalline rocks in the Raymond Basin are in the Topanga Formation. The Topanga Formation comprises a very small part of a fault block in the southwestern corner of the Raymond Basin (Figure 5). The formation consists of well-bedded and well-indurated shales, sandstones and conglomerates.

Deposited uncomformably on top of the Topanga Formation and the crystalline basement complex is the Pleistocene Older Alluvium. The Older Alluvium is the result of alluvial-plain deposition and is typified by poorly sorted to unsorted, yellowish- to reddish-brown, coarse-grained clastic material derived primarily from the San Gabriel Mountains. The material in these deposits ranges from silt to boulders over 3 feet in diameter.

The alluvial deposits may be associated with braided-river environments, intermittent stream action, and periodic flooding. Sediments deposited by the action of streams typically show abundant scour-and-fill structures and crudely developed near-horizontal bedding. The maximum thickness of the Older Alluvium beneath JPL is estimated at over 800 feet.

Lying unconformably upon all underlying units are the unweathered sediments of the Recent (Holocene) Younger Alluvium. The Younger Alluvium is found primarily in the stream beds of the major streams that traverse the basin and consists primarily of light-gray coarse-grained sands, silts, gravel, and boulders. The Younger Alluvium ranges in thickness from a few inches to roughly 150 feet (DWR, 1969).

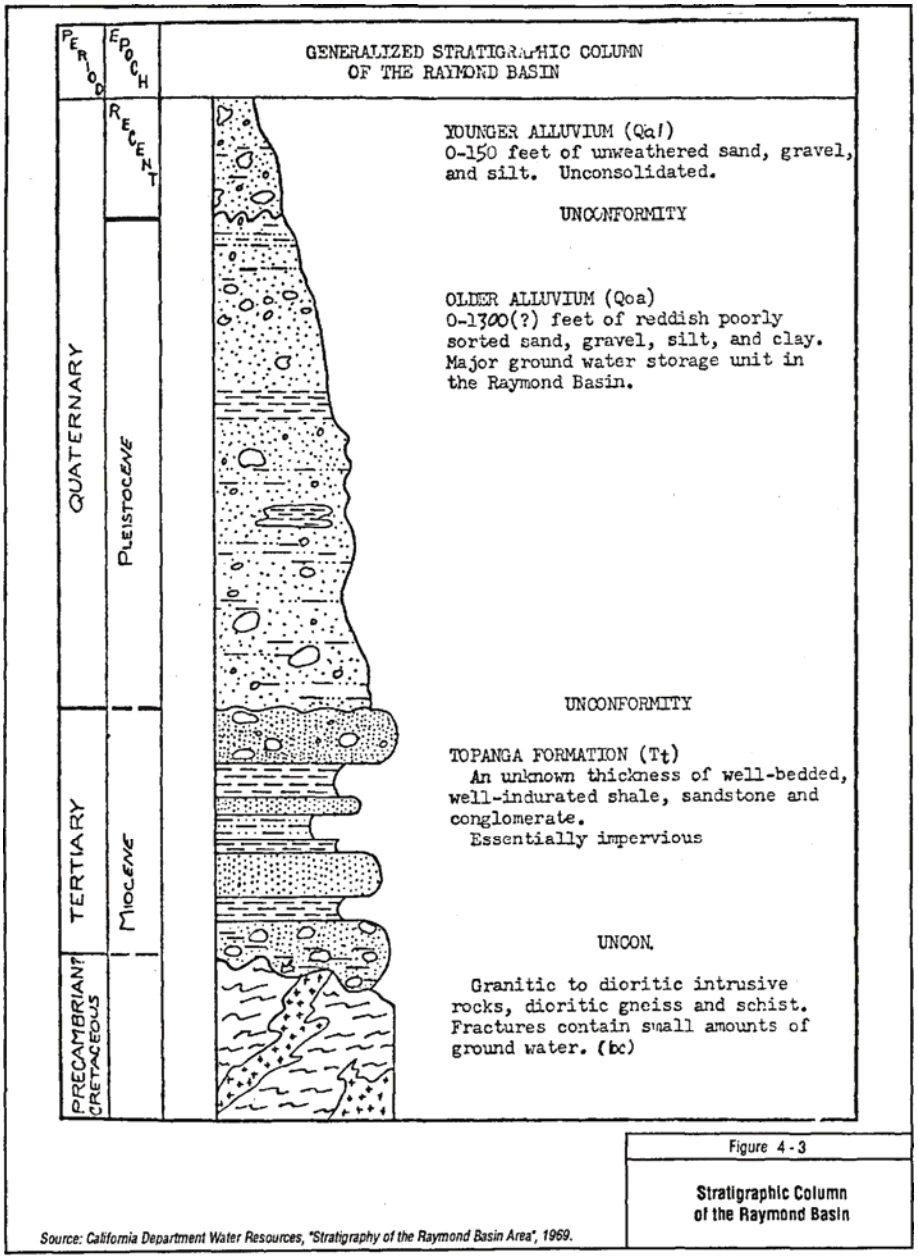

Figure 4. Stratigraphic Column of the Raymond Basin

3. Hydrogeology

The Raymond Basin provides an important source of potable groundwater for many communities in the area around JPL, including Pasadena, La Cañada-Flintridge, San Marino, Sierra Madre, Altadena, Alhambra, and Arcadia. The JPL CERCLA site is located in the Monk Hill Subarea of the Raymond Basin.

The northwest portion of the San Gabriel Valley, near JPL, is composed of about 1,500 to 2,000 feet of Cenozoic alluvial-fan deposits that unconformably overlie the crystalline basement complex exposed in the San Gabriel Mountains (Smith, 1986). These alluvial deposits typically consist of poorly sorted, coarse-grained sands and gravels, with some finer sand and silty material. Clasts within the alluvial deposits range from silt size to boulders more than 3 feet in diameter.

The Older Alluvium deposits beneath JPL comprise the local groundwater reservoir. The Older Alluvium deposits throughout the basin have historically provided virtually all of the groundwater produced in the region. The City of Pasadena operates several municipal water production wells in the Monk Hill Subbasin that extract groundwater strictly from the saturated sections of the Older Alluvium.

The northernmost part of JPL consists of Gould Mesa, a flat-topped southern promontory of the San Gabriel Mountains that rises above the main part of the JPL complex. Elevation of the JPL site varies from 1,075 feet in the southern portion to 1,550 feet along the northern portion of the site at Gould Mesa. The remainder of JPL is moderately sloped and has been graded extensively throughout its development. The Arroyo Seco Creek intermittently flows through the Arroyo Seco wash on the eastern side of JPL. Within the Arroyo Seco, a series of surface impoundments are used as surface water collection and spreading basins for groundwater recharge.

Surface runoff on JPL is generally from north to south. There are no permanent surface water bodies within the boundaries of JPL. Surface water runoff from the mountains to the north is collected and transmitted by an underground storm-drain system through the developed southern portion of the site and is then discharged into the Arroyo Seco.

North of the JPL Thrust Fault, groundwater primarily occurs in joints and fractures in the bedrock. Because the bedrock is of low porosity, it is considered non-water bearing. South of the JPL Thrust Fault, groundwater occurs in alluvial deposits.

The aquifer below JPL consists of four layers that are separated by noncontiguous, low permeability silt layers (Figure 6). Layer 1 consists of the upper 75 to 100 feet of saturated alluvium. Layer 2 underlies Layer 1 and is about 150 to 200 feet thick. Layer 3 is about 200 to 300 feet thick and generally overlies crystalline basement rock beneath JPL. Layer 4 occurs only at the far eastern end of JPL, is about 150 feet thick, and rests on crystalline basement rocks.

Depth to groundwater at JPL ranges from 22 feet below ground surface (bgs) to 270 feet bgs. This wide range of depth to water is attributed to steep topography in the northern part of the site and to seasonal groundwater recharge. The depth to groundwater under most of the JPL complex averages approximately 200 feet.

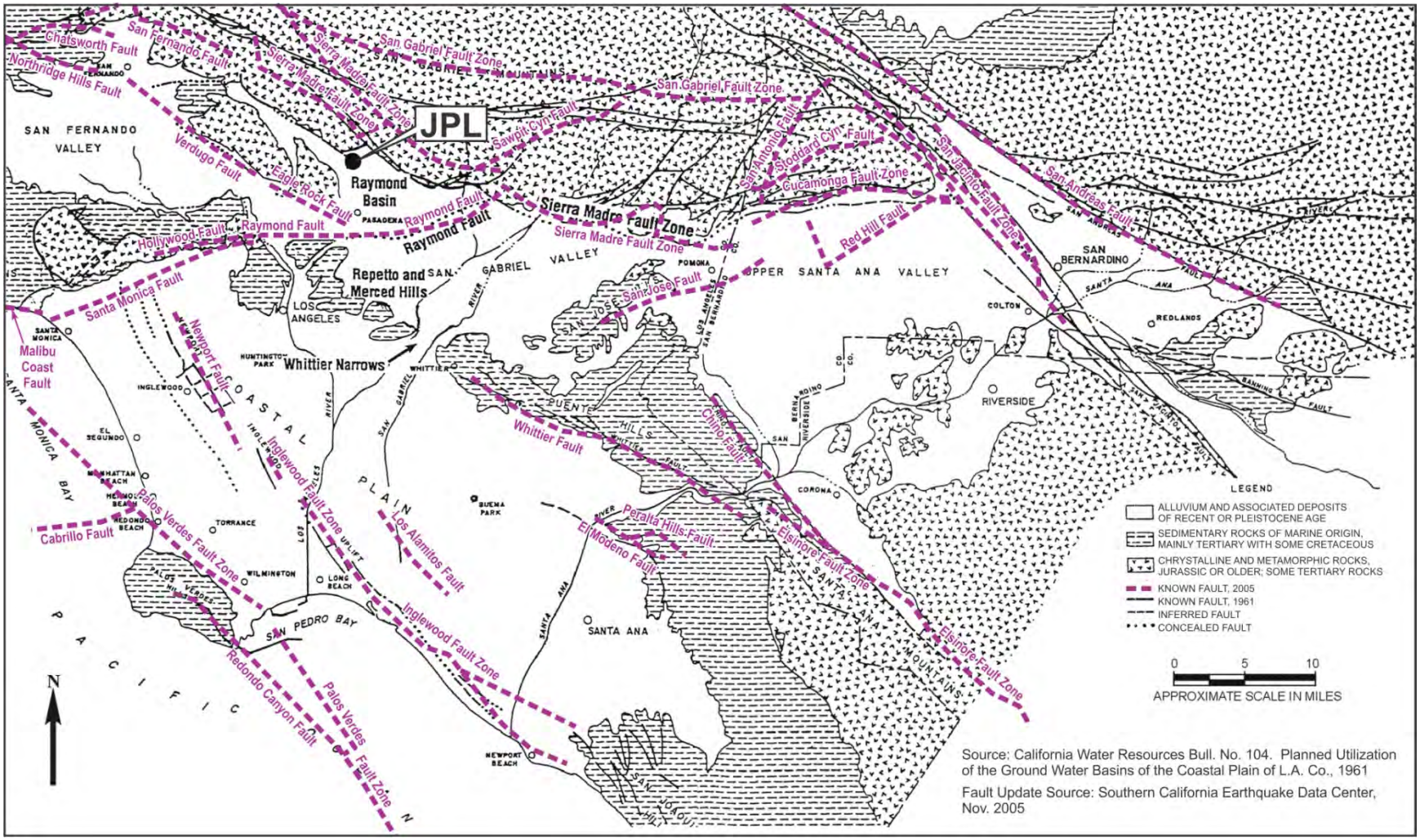

Figure 5. Map of Regional Geology and Physiology

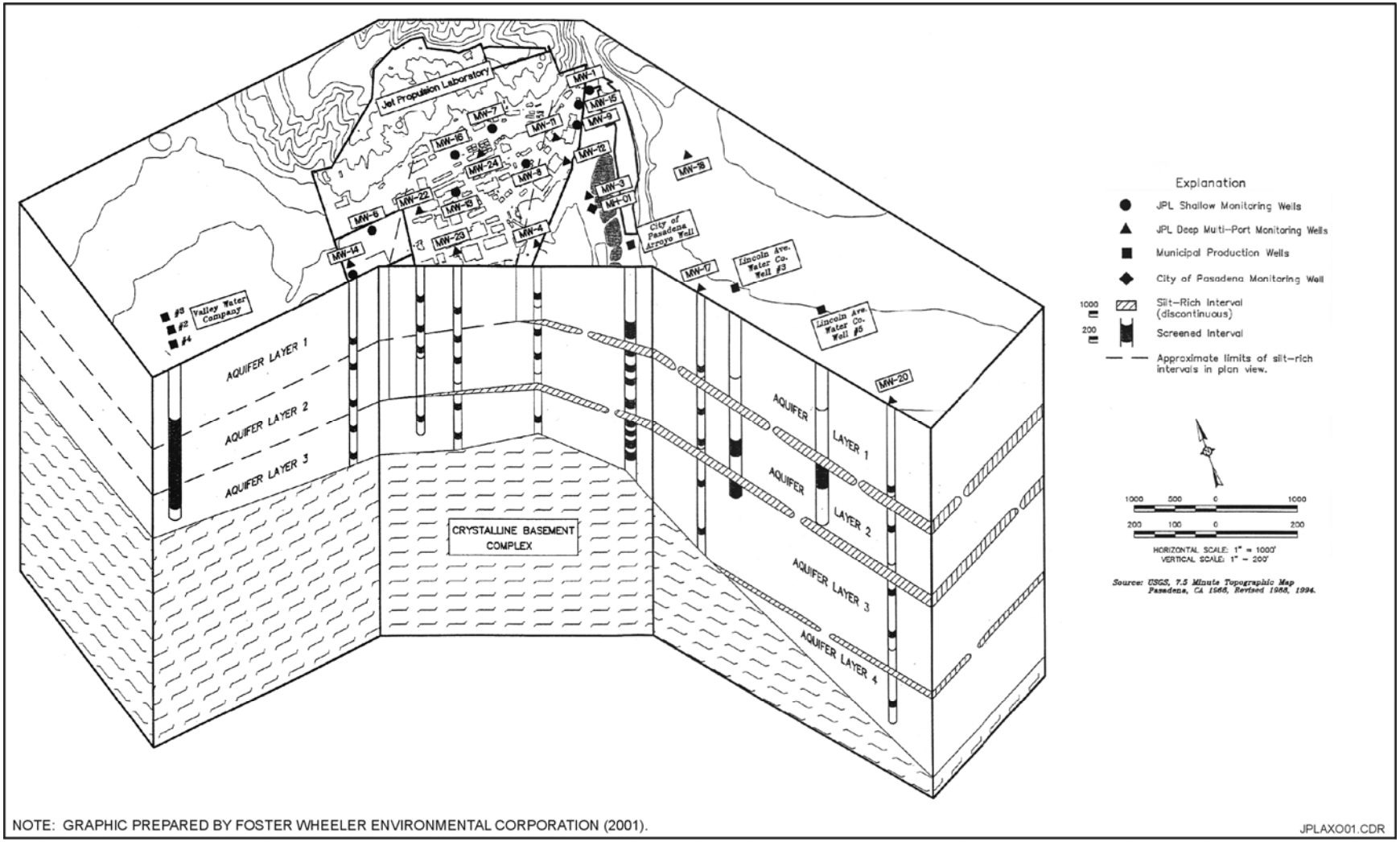

Figure 6. Conceptual Model of JPL Aquifer Layers

4. New MHTS Well

The new MHTS well will be installed approximately 1,030 north/northeast of the Arroyo Well along the east side of the JPL east parking lot (see Figure 2). Nearby NASA groundwater monitoring wells include: MW-3 located approximately 635 feet to the west; MW-12 located over 800 feet to the west/northwest; and MW-18 located approximately 845 feet to the east.

Plate 3 of the California Department of Conservation Division of Mines and Geology – DMG Open-File Report 86-4[2], and Figure 3-8 "Contours of Crystalline Basement Complex Surrounding the JPL Site"[3] were used to generate the bedrock contour map presented in Figure 7. A surface geologic map of the north half of the Pasadena quadrangle, which includes JPL, was produced by the California Division of Mines and Geology (Smith, 1986). The geologic formations present within the subject area, as described by the California Division of Mines and Geology, are included in Figure 8. Also shown in Figure 8 are the locations of the cross sections A-A' (Figure 9) and E-E' (Figure 10). These geologic cross sections depict the new MHTS Well relative to bedrock elevations, lithology, aquifer layers, and screened zones of nearby monitoring and production wells.

The lithology at this location is expected to be unconsolidated alluvium consisting of sand, gravel, boulders, and some silt and clay layers. A review of nearby monitoring well and production well boring logs show that bedrock was encountered during drilling at MW-3, Arroyo Well, and MW-12 at elevations of approximately 376 feet above mean sea level (amsl)(i.e. 724 feet bgs), 430 feet amsl (i.e. 660 feet bgs), and 456 feet amsl (i.e. 646 feet bgs), respectively. One thing to note is that a thrust fault was inferred at MW-12[4] (Figure 9) and was interpreted to run west towards MW-23 and to the east/northeast towards the spreading grounds. This eastern portion of the thrust fault has not been confirmed by another well or boring. Taking into consideration that bedrock was not encountered during drilling at MW-18 (total depth 825 feet bgs or 400 feet amsl), and that vertical offset of the thrust fault at MW-12 is roughly 60 feet, the bedrock may be at a depth of 653 -753 feet bgs or 360 – 460 feet amsl. If vertical offset of the fault is not present, then bedrock is anticipated at 713 – 813 feet bgs or 300 – 400 feet amsl (Table 1). Therefore, bedrock is expected to be deeper than the bottom of the new MHTS well and will likely be constructed entirely in unconsolidated alluvium. If bedrock is encountered during pilot hole drilling at an unexpectedly shallow depth (i.e., < 600 feet bgs), a different production well location may have to be identified to the south.

The new extraction well is proposed to be 16-inches in diameter and installed to a depth of 650 feet bgs with a screened interval of 300 – 650 feet bgs (463 - 813 feet amsl). The screened interval was designed to intersect targeted zones in MW-18 (Screens 3 and 4), MW-12 (Screens 2, 3, and 4), and the Arroyo Well where perchlorate and VOC's have been detected[5] as shown in Figures 9 and 10.

It is anticipated that the static water level in new well will be identical to the static water level in the Arroyo Well due to the close proximity of the new MHTS Well. The static water level at Arroyo Well

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[2] California Department of Conservation Division of Mines and Geology – DMG Open-File Report 86-4, Geology of the North Half of the Pasadena Quadrangle, Los Angeles County, California. Plate 3: Structural Contour Map of the Top of Crystalline Basement Rocks, North Half of the Pasadena Quadrangle, Los Angeles, California D.P. Smith and E.C. Sprotte, 1986

[3] Figure 3-8 "Contours of Top of Crystalline Basement Complex Surrounding the JPL Site" Final Remedial Investigation Report for Operable Units 1 and 3: On Site and Off-Site Groundwater, NASA/JPL, Pasadena, CA; August 1999

[4] Figure 3-3 "Contours of Top of Crystalline Basement Complex Surrounding the JPL Site" Final Remedial Investigation Report for Operable Units 1 and 3: On Site and Off-Site Groundwater, NASA/JPL, Pasadena, CA; August 1999

[5] Tidewater 2012. Technical Memorandum No. 1 New MHTS Extraction Well

was observed at 219 feet bgs in October 2012 and 213 feet bgs in April 2013. During the 24 hour pumping test (October 2010), the pumping level was recorded as low as 241 feet bgs at 2,220 gallons per minute (gpm). Since the new well will be located to the north of the Arroyo Well, the new well site will be about 25 feet higher than the Arroyo Well. Assuming 25% loss of well performance due to additional drawdown, the estimated pumping water level for new well will be 425 feet bgs at an elevation of 688 feet amsl. It should be noted that this is a conservative estimate considering the design pumping flowrate will be 1,600 gpm which is 600 gpm less than the Arroyo Well. If similar drawdown occurs at the design flowrate, then the pumping level will be below the top of the screened zone at 813 feet amsl. If the well is furnished with a VFD, the pump could be operated at a lower flowrate to maintain a higher pumping water level.

Table 1. Bedrock Depth and Elevations (New MHTS Well)

	MW-3	MW-12	Arroyo Well	MW-18	New MHTS Well
Surface Elevation (ft amsl)	1100.00	1102.42	1092.71	1225.40	1113.00
Bedrock (ft bgs)	724.00	650.00	660.00	NE	NA
Bedrock (ft amsl)	376.00	452.42	432.71	NE	NA
Bedrock Estimated (ft bgs)	NA	NA	NA	> 825.4	713-813
Bedrock Estimated (ft amsl)	NA	NA	NA	< 400	300-400
Vertical Fault Offset (MW-12) ft	NA	60.00	NA	NA	NA
Bedrock Estimated (ft bgs) w/fault	NA	NA	NA	NA	653-753
Bedrock Estimated (ft amsl) w/fault	NA	NA	NA	NA	360-460

Notes:

NE = Not Encountered

NA = Not Applicable

5. New LAWC Well

The new LAWC well is proposed to be installed at the LAWC office property, approximately 190 feet upgradient of LAWC #5 (see Figure 3). Nearby NASA groundwater monitoring wells include: MW-17 located approximately 1,400 feet to the northwest and MW-20 located approximately 1,340 feet to the south/southeast.

The lithology at this location is expected to be unconsolidated alluvium consisting of sand, gravel, boulders, and some silt and clay layers. A review of nearby monitoring well and production well boring logs show that bedrock was encountered during drilling at MW-17 at a depth of 821.5 feet bgs (369.5 feet amsl). Bedrock was not encountered at LAWC #3, LAWC #5, and MW-20 at total drilling depths of 601 feet bgs (604 feet amsl), 588 feet bgs (618 feet amsl), and 1,008 feet bgs (157 feet amsl), respectively. The bedrock elevation at the new LAWC well location is estimated at a depth of 904 – 1,004 feet bgs (200 - 300 feet amsl) as shown in Table 2. Therefore, the well will likely be constructed entirely in unconsolidated alluvium.

Table 2. Bedrock Depth and Elevations (New LAWC Well)

	MW-17	LAWC#3	LAWC#5	MW-20	New LAWC Well
Surface Elevation (ft amsl)	1190.99	1202.70	1203.90	1164.89	1204.00
Bedrock (ft bgs)	821.50	NE	NE	NE	NA
Bedrock (ft amsl)	369.49	NE	NE	NE	NA
Bedrock Estimated (ft bgs)	NA	803-903	904-1004	> 1008	904-1004
Bedrock Estimated (ft amsl)	NA	300-400	200-300	< 157	200-300

Notes:

NE = Not Encountered

NA = Not Applicable

Figure 8, described in section 4, presents the transect location of cross section B-B' (Figure 11). This geologic cross section depicts the new LAWC well relative to bedrock elevations, lithology, aquifer layers, and screened zones of nearby monitoring and production wells.

Data from multi-port monitoring wells MW-17 and MW-20 indicate the presence of perchlorate in the deeper zones of the aquifer, below the current screened interval of LAWC#5, which is screened from 390 to 556 feet bgs (647.9 – 813.9 feet amsl). A screened interval between 624 and 824 feet bgs would likely intersect the zone of elevated chemical concentrations observed in MW-20.

It is anticipated that the static water level in new replacement well will be similar to that observed in LAWC#5. Using recent performance data from a nearby Pasadena Well, Windsor Well, and assuming 25% loss of well performance due to drawdown, the estimated pumping level for new LAWC well is 555 feet bgs (at 2,000 gpm). Ideally, the flowrate for the new LAWC well will be between 1,000 and 1,500 gpm (or greater), however this well will be installed in a deeper portion of the aquifer where pumping characteristics are unknown. The new LAWC well will be screened in aquifer Layer number 3. During the Remedial Investigation, Foster Wheeler stated pumping of the Pasadena wells (i.e. Arroyo, Well 52, Ventura, and Windsor) have a very significant impact on the potentiometric surface in aquifer Layer 3. When only the Pasadena wells are pumping, a cone of depression in the potentiometric surface extended a great distance. The cone of depression developed in Layer 3 during pumping of the Pasadena wells is much deeper, and broader than is developed in the other layers. Deeper and broader cones of depression will typically form in aquifers under confining or semi-confining conditions. Foster Wheeler also noted that pumping of the Lincoln Avenue Water Company well No. 3 has little impact on the hydraulic head in Layer 3 in well MW-17, located less than 500 feet away.

In addition, NASA's monitoring well MW-20 boring log shows an abundance of fine-grained sediments throughout the entire boring which will likely impact extraction flowrates from the new well. With that said, California's Groundwater Bulletin 118 Hydrologic Region South Coast Raymond Groundwater Basin reported Municipal/Irrigation well yields between 10 and 3,620 gpm with an average of 1,880 gpm based on 27 Well Completion Reports.[6] To ensure adequate production capacity and mass removal, it's

[6] California Department of Water Resources, California's Groundwater Bulletin 118 Hydrologic Region South Coast Raymond Groundwater Basin: http://www.water.ca.gov/pubs/groundwater/bulletin_118/basindescriptions/4-23.pdf

recommended that the new LAWC Well screen interval be from 550 – 850 feet bgs (354 – 654 feet amsl) which overlaps the bottom portion of LAWC#5's screen.

6. Conclusion

This technical memorandum presented the results of a geologic records review associated with the installation of two new extraction wells (New MHTS Well and New LAWC Well). The purpose of the review was to determine bedrock depth, lithology, and the presence of faulting at the two proposed well locations. It was determined that drilling of each borehole would not encounter bedrock and that both of the wells would likely be constructed entirely in unconsolidated alluvium. A thrust fault was inferred at MW-12 (Figure 9) and was interpreted to run west towards MW-23 and to the east/northeast towards the spreading grounds. This eastern portion of the thrust fault has not been confirmed by another well or boring, however it is not anticipated to be encountered during the drilling of the New MHTS Well. There was no indication of faults present in the vicinity of the proposed LAWC well location, and will be confirmed during drilling. Both of the proposed wells are expected to be drilled and completed to the design specifications outlined in the optimization work plan.[7]

[7]NASA. OU-3 Optimization Work Plan. 2013

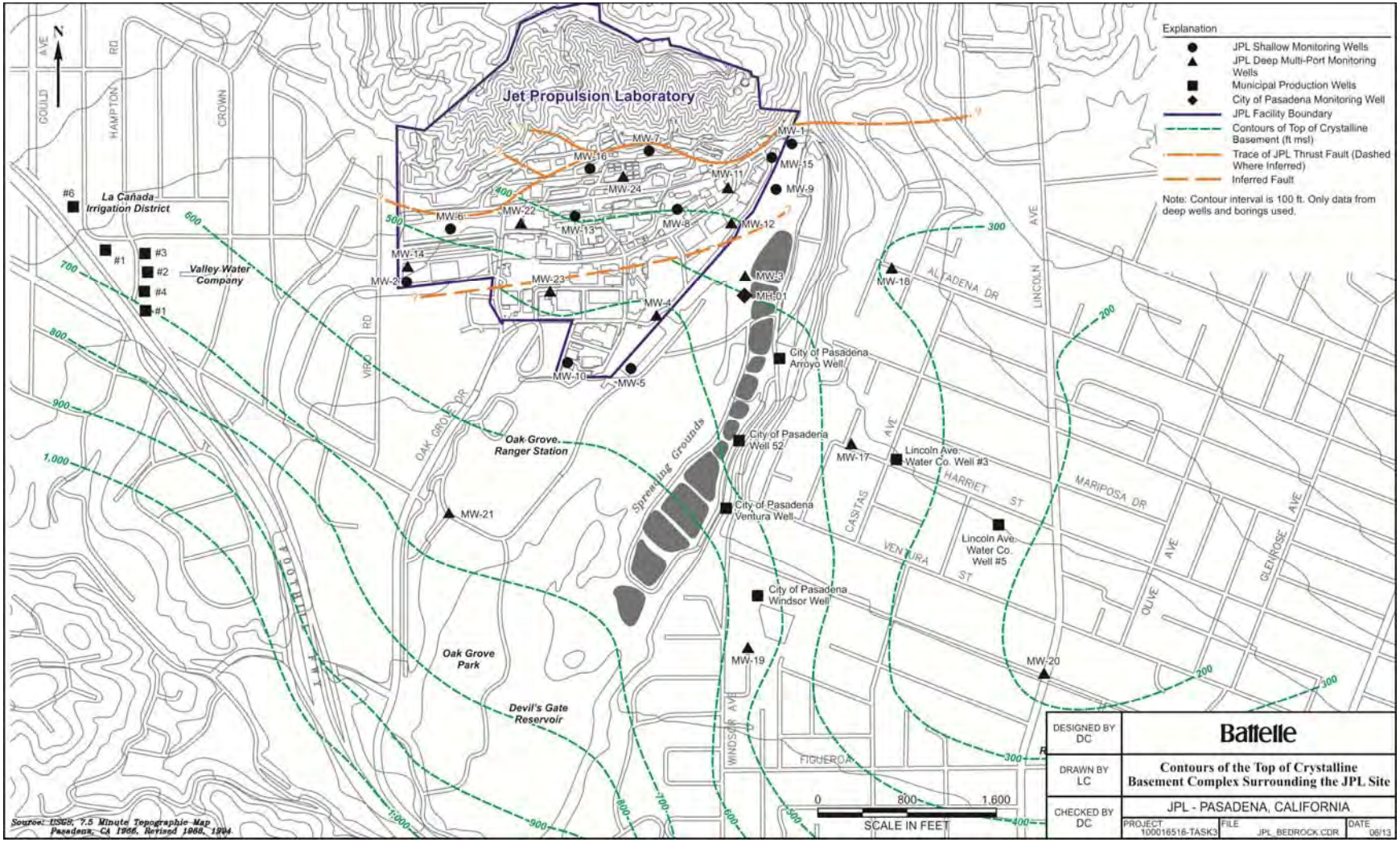


Figure 7. Contours of the Top of Crystalline Basement Complex Surrounding the JPL Site

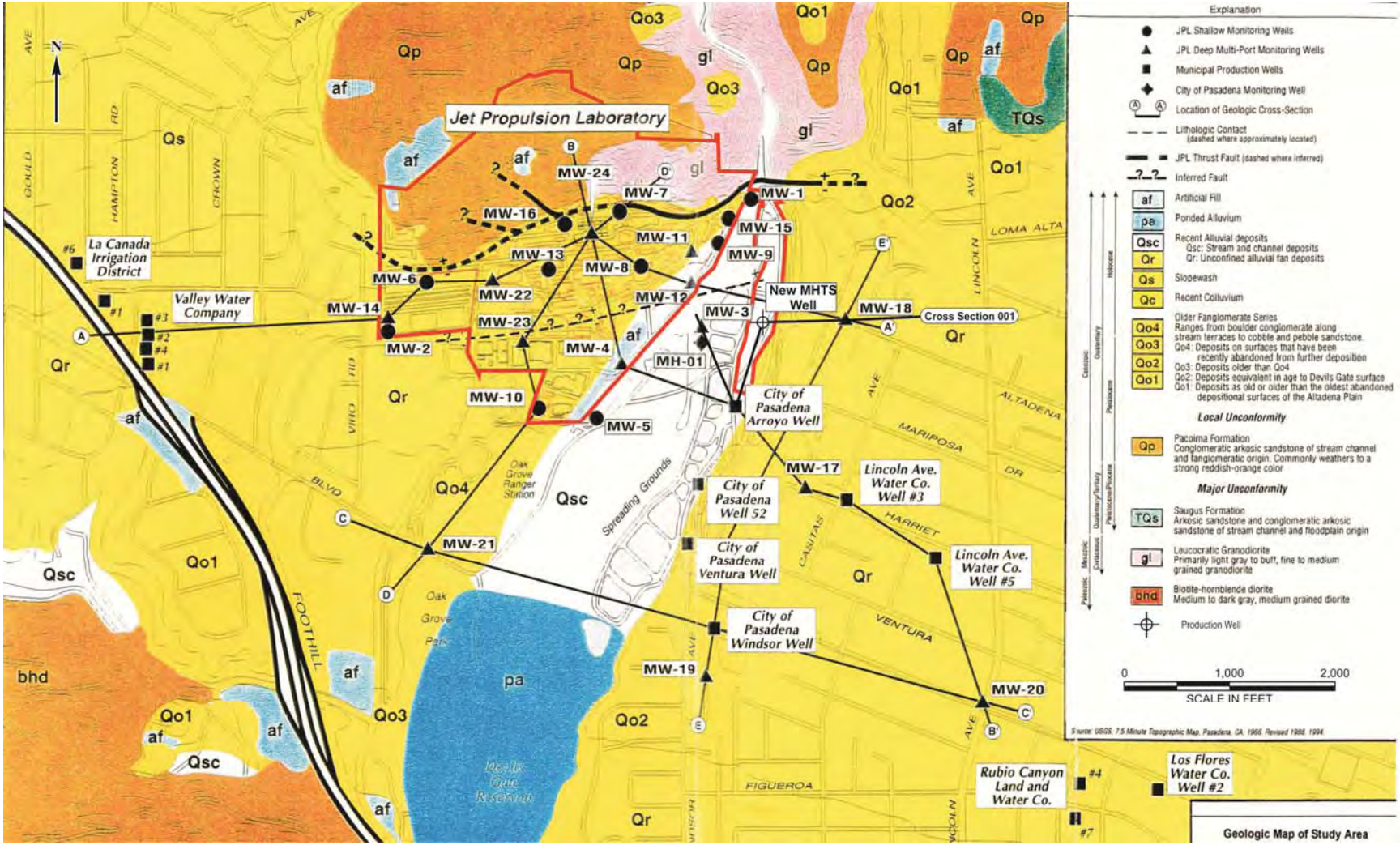


Figure 8. Geologic Map of Study Area

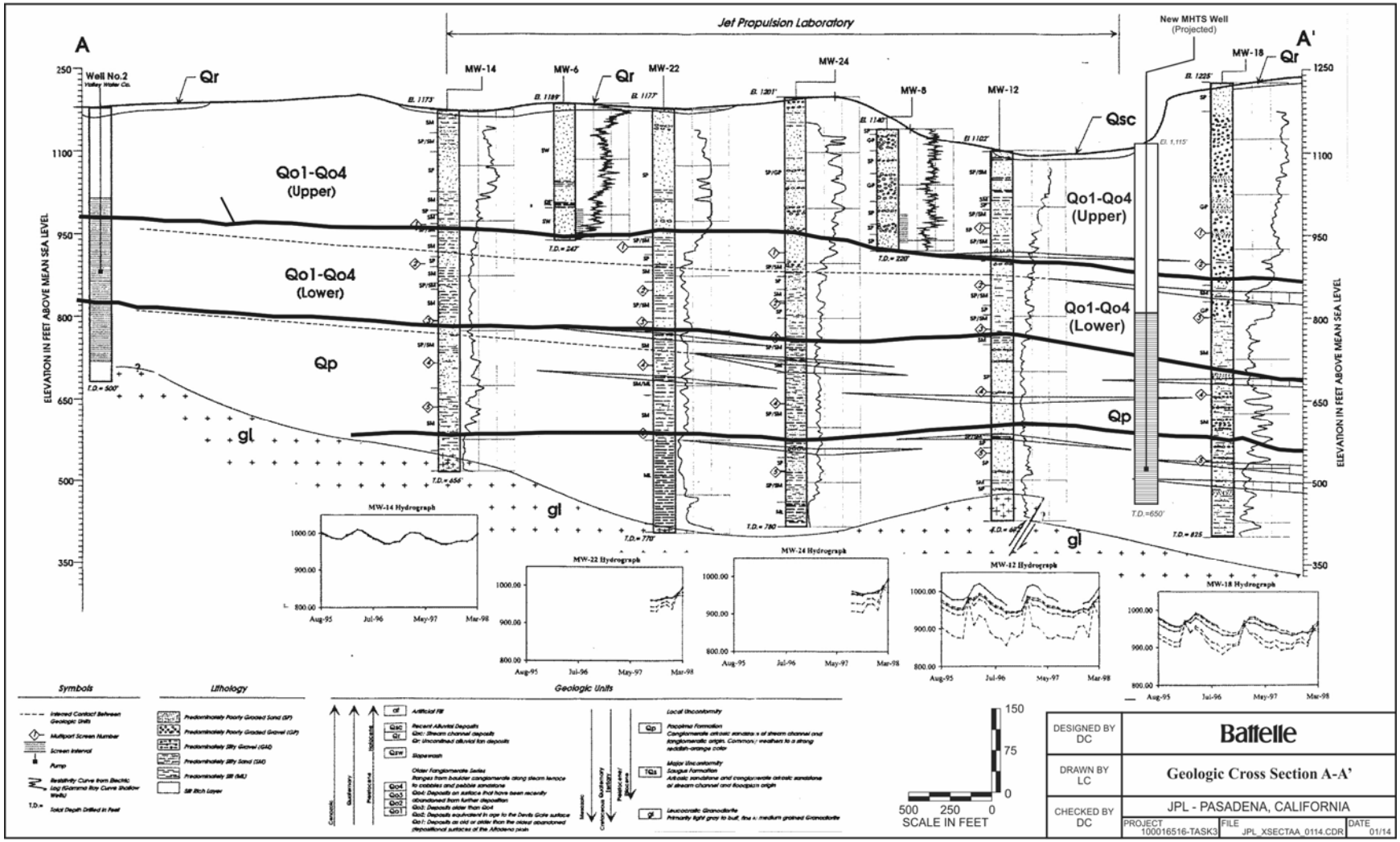


Figure 9. Geologic Cross Section A-A'

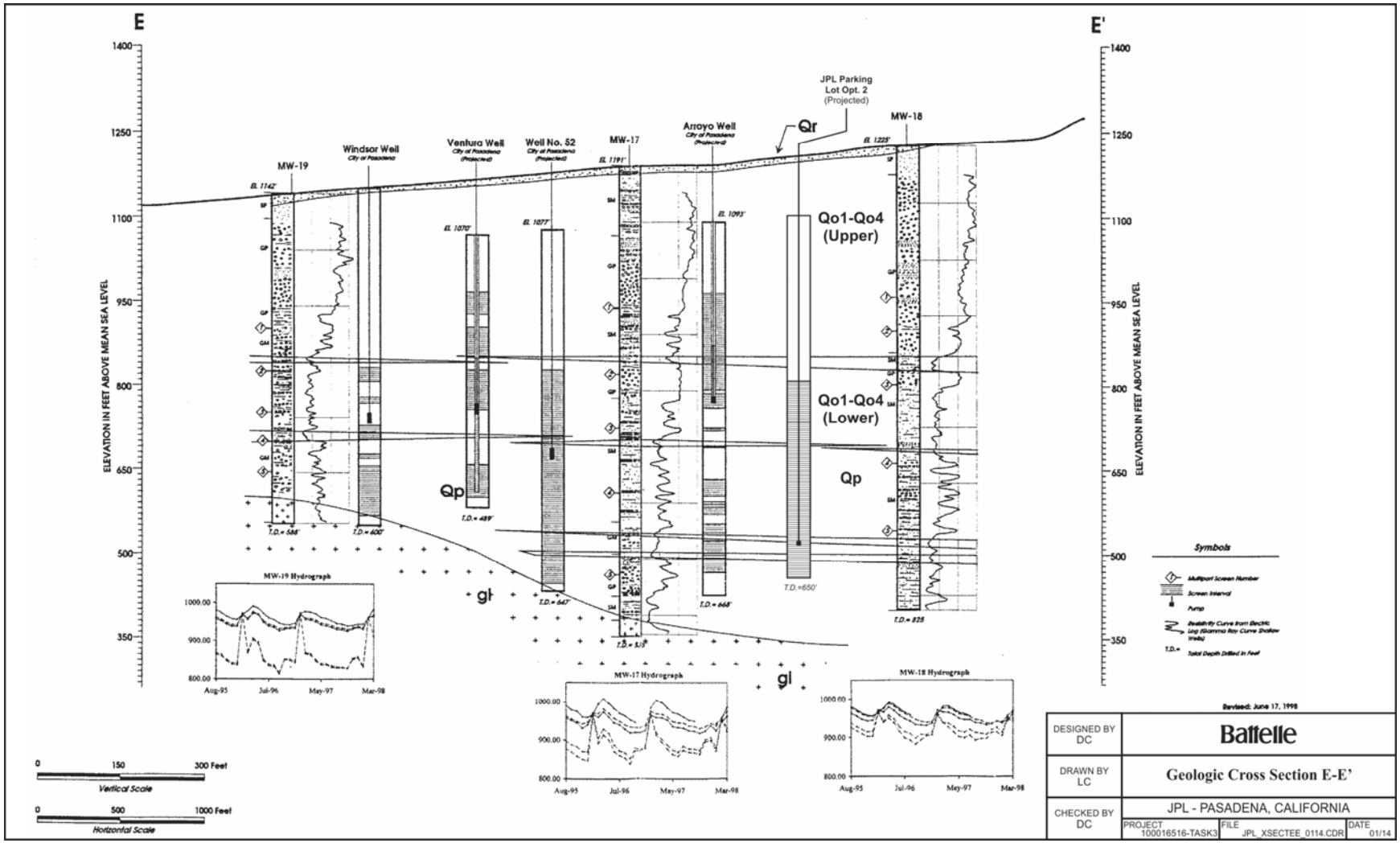


Figure 10. Geologic Cross Section E-E

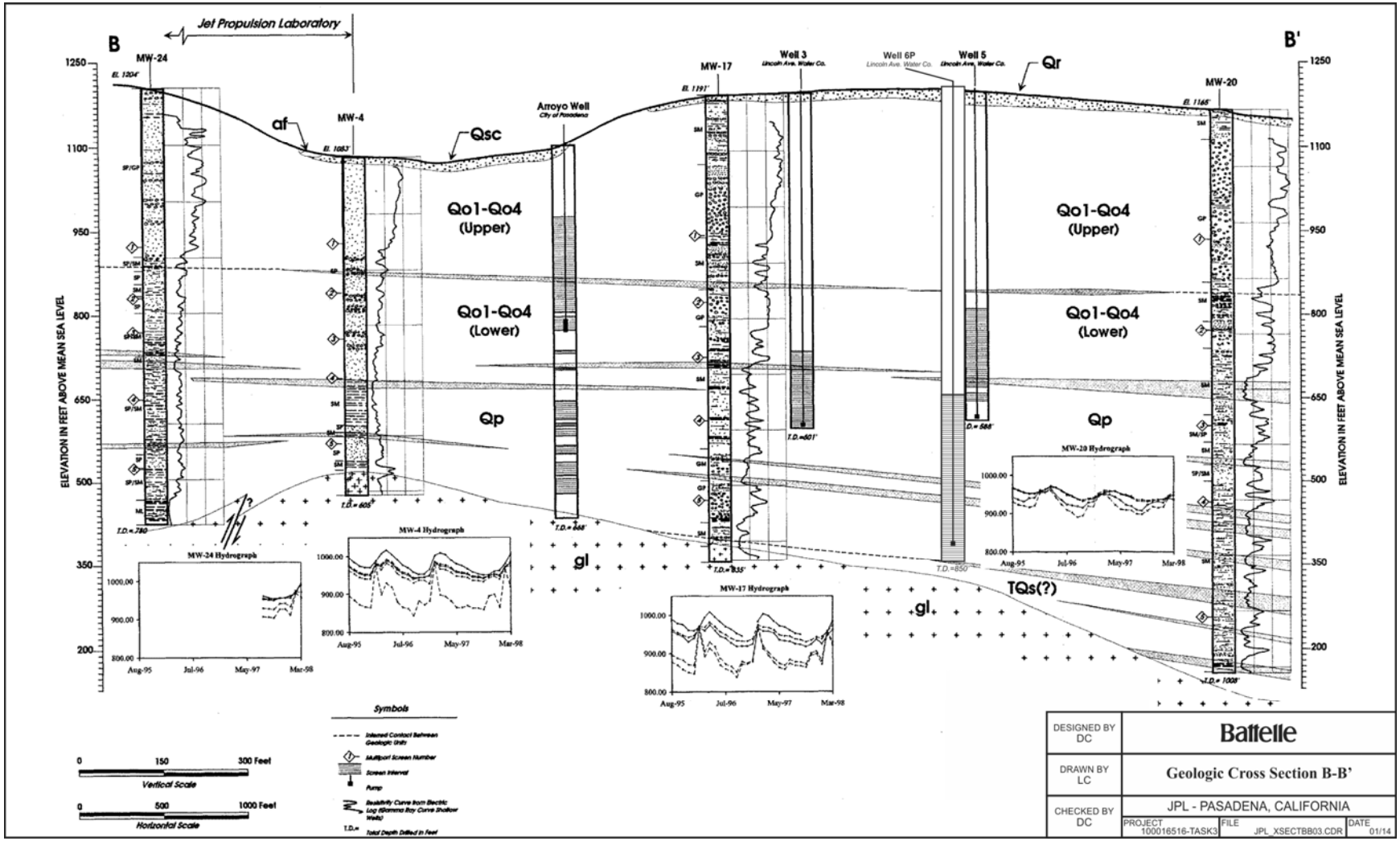
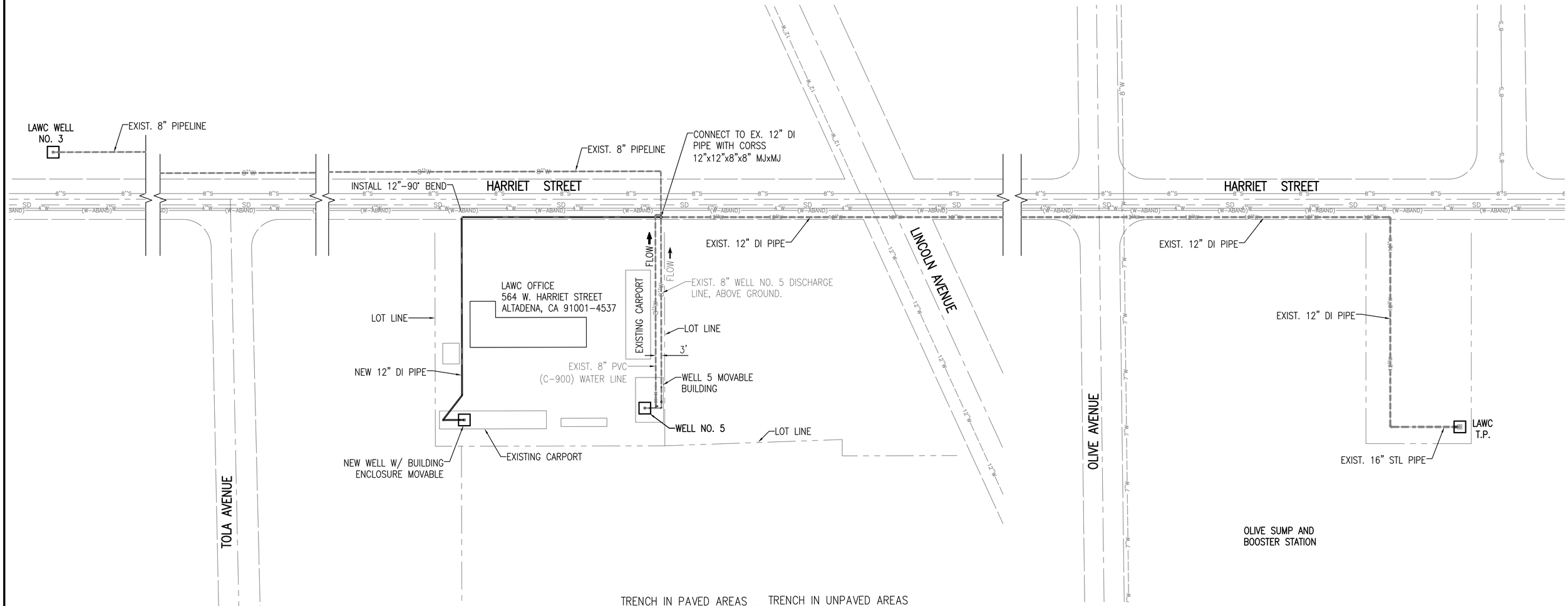
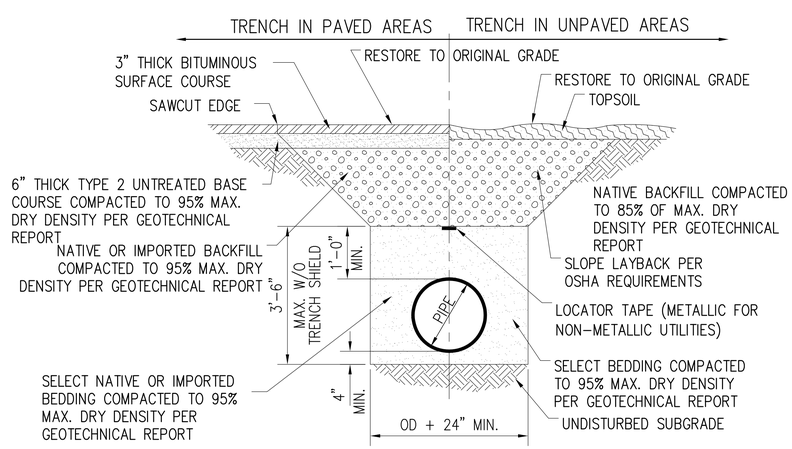


Figure 11. Geologic Cross Section B-B

APPENDIX D
Pipeline Routes and Specifications (LAWC)





TYPICAL TRENCH DETAIL

NOT TO SCALE

SCALE: 1"=40'

NOT FOR CONSTRUCTION

1-800-227-2600 DIGALERT
UNDERGROUND SERVICE ALERT
PLAY IT SAFE DIAL BEFORE YOU DIG!
AT LEAST TWO WORKING DAYS PRIOR TO EXCAVATING

REFERENCES

NO.	DESCRIPTION	APP.	DATE

APPROVED BY:
XXXXX
CIVILTEC ENGINEERING, INC. RCE DATE
APPROVED BY:
(CITY OR AGENCY) DATE

PLANS PREPARED BY:
CIVILTEC engineering inc.
General Civil, Municipal, Water and Wastewater Engineering, Planning, Construction Management and Surveying
118 West Lime Avenue
Monrovia, Ca. 91016
Phone: (626) 357-0588
Fax: (626) 303-7957

TIDEWATER INC
ENGINEERS / SCIENTISTS / PROGRAM MANAGERS
3761 Attucks Drive
Powell, Ohio 43065
Phone: (614) 792-2896
Tidewater, Inc. holds SBA 8(a) certification
We are headquartered in Columbia, Maryland

LINCOLN AVENUE WATER COMPANY

LAWC NEW PRODUCTION WELL CONCEPTS

EXHIBIT A

DESIGN: BD	CHECKED: CSH	DRAWN: JT
DESIGN DATE: DECEMBER 2012	JOB NO. 2012165.00	SHEET 1 OF 1

H:\2012\2012165.00-TIDEWATER-WHTS UTILITY PIPELINE AND PRODUCTION WELL CONCEPTS\AUTOCAD DWG\CONCEPTS\2012165 WELL 5 DETAIL.DWG 108

APPENDIX E
Los Angeles County Well Permit

ENVIRONMENTAL HEALTH

Drinking Water Program

5050 Commerce Drive, Baldwin Park, CA 91706
Telephone: (626) 430-5420 • Facsimile: (626) 813-3013 • Email: waterquality@ph.lacounty.gov
http://publichealth.lacounty.gov/eh/ep/dw/dw_main.htm

Service Request Application

SERVICE	FEE	QTY	TOTALS
PRODUCTION WELLS □ residential drinking water, □ public/municipal, □ irrigation, □ cathodic			
□ Construction	$ 844.00	×	= $
□ Decommission □ Renovation	$ 1103.00	×	= $
NON-PRODUCTION WELLS □ Construction, □ Decommission □ monitoring, □ piezo, □ injection, □ water extraction, □ sparge, □ test			
each well, first 24 wells	$ 519.00	×	= $
each additional well starting with the 25th	$ 130.00	×	= $
CPT/HYDROPUNCH/SOIL BORINGS INTO GROUNDWATER *(contact the Drinking Water Program for projects of 25 borings or more)*	$ 130.00	×	= $
GEOTHERMAL HEAT EXCHANGE WELLS	$ 519.00	×	= $
WELL SITE PLAN REVIEW	$ 584.00	×	= $
WATER SUPPLY YIELD EVALUATION commercial facility	$ 1038.00	×	= $
WATER SUPPLY YIELD EVALUATION residential (1-4 service connections)	$ 844.00	×	= $
WATER SUPPLY YIELD EVALUATION Public Water Systems (5 or more service connections)	$ 519.00	×	= $
WATER TREATMENT SYSTEM EVALUATION	$ 519.00	×	= $
WATER SAMPLING commercial food service facility for USDA certification	$ 714.00	×	= $

Applications are nontransferable. Field Personnel cannot accept payments. DO NOT SEND CASH.
Make checks or money orders payable to:

LOS ANGELES COUNTY DEPARTMENT OF PUBLIC HEALTH

Allow **10** business days for work plan review and response. Cancellations of service requests are subject to a $65.00 processing fee plus additional plan review fees (hourly rate as applicable).

WORK SITE ADDRESS CITY ZIP CROSS STREET/PARCEL# DATE

All application status inquiries should be emailed to waterquality@ph.lacounty.gov *with the work site address above.*

CONTACT OFFICE	DEPARTMENT STAMP
	DATE: CHECK #
	RECEIPT # AMOUNT: $
SITE/PERMIT# INSPECTOR:	

Revised: October 2012

ENVIRONMENTAL HEALTH

Drinking Water Program

5050 Commerce Drive, Baldwin Park, CA 91706
Telephone: (626) 430-5420 • Facsimile: (626) 813-3013 • Email: waterquality@ph.lacounty.gov
http://publichealth.lacounty.gov/eh/ep/dw/dw_main.htm

Well Permit Application

WORK SITE ADDRESS	CITY	ZIP	NUMBER OF WELLS	START DATE

OWNER		EMAIL	
ADDRESS	CITY	ZIP	TELEPHONE

DRILLER	PROJECT CONTACT	C-57 LICENSE NUMBER
ADDRESS	CITY	ZIP
EMAIL	TELEPHONE	MOBILE

CONSULTANT	PROJECT CONTACT	PROJECT MANAGER
ADDRESS	CITY	ZIP
EMAIL	TELEPHONE	MOBILE

ATTACH ALL SUPPORTING DOCUMENTS, INCLUDING:

☐ written narrative describing work plan details

☐ vertical well diagram detailing depths, sizes, thicknesses, and materials of: (1) the casing, (2) the annular (sanitary) seal, (3) the screens/slotting, and (4) any pertinent geological features

☐ scaled drawing of roads, property lines, private sewage disposal systems, surface water features, blue line streams, and other possible sources of contamination within 200 feet of the well site

FOR WELL DECOMMISSION: ☐ well construction logs, ☐ the method of assessment, ☐ type and amount of sealant, and ☐ the method of upper seal pressure application (including PSI and time applied)

PRODUCTION WELLS	
☐ PUBLIC (MUNICIPAL UTILITY)	☐ PRIVATE RESIDENCE
☐ IRRIGATION	☐ CATHODIC PROTECTION
☐ GEOTHERMAL HEAT EXCHANGE	
☐ OTHER _____	
NAME OF C-57 LICENSEE	
SIGNATURE	

NON-PRODUCTION WELLS	
☐ MONITORING	☐ PIEZOMETER
☐ INJECTION	☐ WATER EXTRACTION
☐ AIR SPARGE	☐ TEST HOLE (PRE-PRODUCTION)
☐ HYDROPUNCH	☐ CONE PENETROMETER (CPT)
☐ SOIL BORING INTO GROUNDWATER	
NAME OF APPLICANT	
SIGNATURE	

BY SIGNING ABOVE, I HEREBY AGREE TO COMPLY IN EVERY RESPECT WITH ALL THE REGULATIONS, ORDINANCES, AND LAWS OF THE STATE OF CALIFORNIA, THE COUNTY OF LOS ANGELES, THE DEPARTMENT OF PUBLIC HEALTH, AND THE ENVIRONMENTAL HEALTH DRINKING WATER PROGRAM.

Revised: October 2012

ENVIRONMENTAL HEALTH

Drinking Water Program

5050 Commerce Drive, Baldwin Park, CA 91706
Telephone: (626) 430-5420 • Facsimile: (626) 813-3013 • Email: waterquality@ph.lacounty.gov
http://publichealth.lacounty.gov/eh/ep/dw/dw_main.htm

Well Permit Approval

TO BE COMPLETED BY APPLICANT:

WORK SITE ADDRESS	CITY	ZIP	EMAIL ADDRESS FOR WELL PERMIT APPROVAL

NOTICE:

- WORK PLAN APPROVALS ARE VALID FOR 180 DAYS. 30 DAY EXTENSIONS OF WORK PLAN APPROVALS ARE CONSIDERED ON AN INDIVIDUAL (CASE-BY-CASE) BASIS AND MAY BE SUBJECT TO ADDITIONAL PLAN REVIEW FEES (HOURLY RATE AS APPLICABLE).
- WORK PLAN MODIFICATIONS MAY BE REQUIRED IF WELL AND GEOLOGIC CONDITIONS ENCOUNTERED AT THE SITE INSPECTION ARE FOUND TO DIFFER FROM THE SCOPE OF WORK PRESENTED TO THE DEPARTMENT OF PUBLIC HEALTH—DRINKING WATER PROGRAM.
- THIS WELL PERMIT APPROVAL IS LIMITED TO COMPLIANCE WITH THE CALIFORNIA WELL STANDARDS AND THE LOS ANGELES COUNTY CODE AND DOES NOT GRANT ANY RIGHTS TO CONSTRUCT, RENOVATE, OR DECOMMISSION ANY WELL. THE APPLICANT IS RESPONSIBLE FOR SECURING ALL OTHER NECESSARY PERMITS SUCH AS WATER RIGHTS, PROPERTY RIGHTS, COASTAL COMMISSION APPROVALS, USE COVENANTS, ENCROACHMENT PERMISSIONS, UTILITY LINE SETBACKS, CITY/COUNTY PUBLIC WORKS RIGHTS OF WAY, ETC.
- ALL FIELD WORK MUST BE CONDUCTED UNDER THE DIRECT SUPERVISION OF A PROFESSIONAL GEOLOGIST LICENSED IN THE STATE OF CALIFORNIA.
- THIS PERMIT IS NOT COMPLETE UNTIL ALL OF THE FOLLOWING REQUIREMENTS ARE SIGNED BY THE DEPUTY HEALTH OFFICER. WORK SHALL NOT BE INITIATED WITHOUT A WORK PLAN APPROVAL STAMPED BY THE DEPARTMENT OF PUBLIC HEALTH—DRINKING WATER PROGRAM.
- **NOTIFY THE DRINKING WATER PROGRAM BY EMAIL 3 BUSINESS DAYS BEFORE WORK IS SCHEDULED TO BEGIN.**

TO BE COMPLETED BY DEPARTMENT OF PUBLIC HEALTH—DRINKING WATER PROGRAM:

☐ WORK PLAN INCOMPLETE; SUBMIT THE FOLLOWING:	☐ WORK PLAN APPROVED Los Angeles County Drinking Water stamp	DATE: ADDITIONAL APPROVAL CONDITIONS:

☐ ANNULAR SEAL FINAL INSPECTION REQUIRED		☐ WELL COMPLETION LOG REQUIRED	
DATE ACCEPTED:	REHS signature	DATE ACCEPTED:	REHS signature

☐ WATER QUALITY—BACTERIOLOGICAL STANDARDS REQUIRED		☐ WATER QUALITY—CHEMICAL STANDARDS REQUIRED	
DATE ACCEPTED:	REHS signature	DATE ACCEPTED:	REHS signature

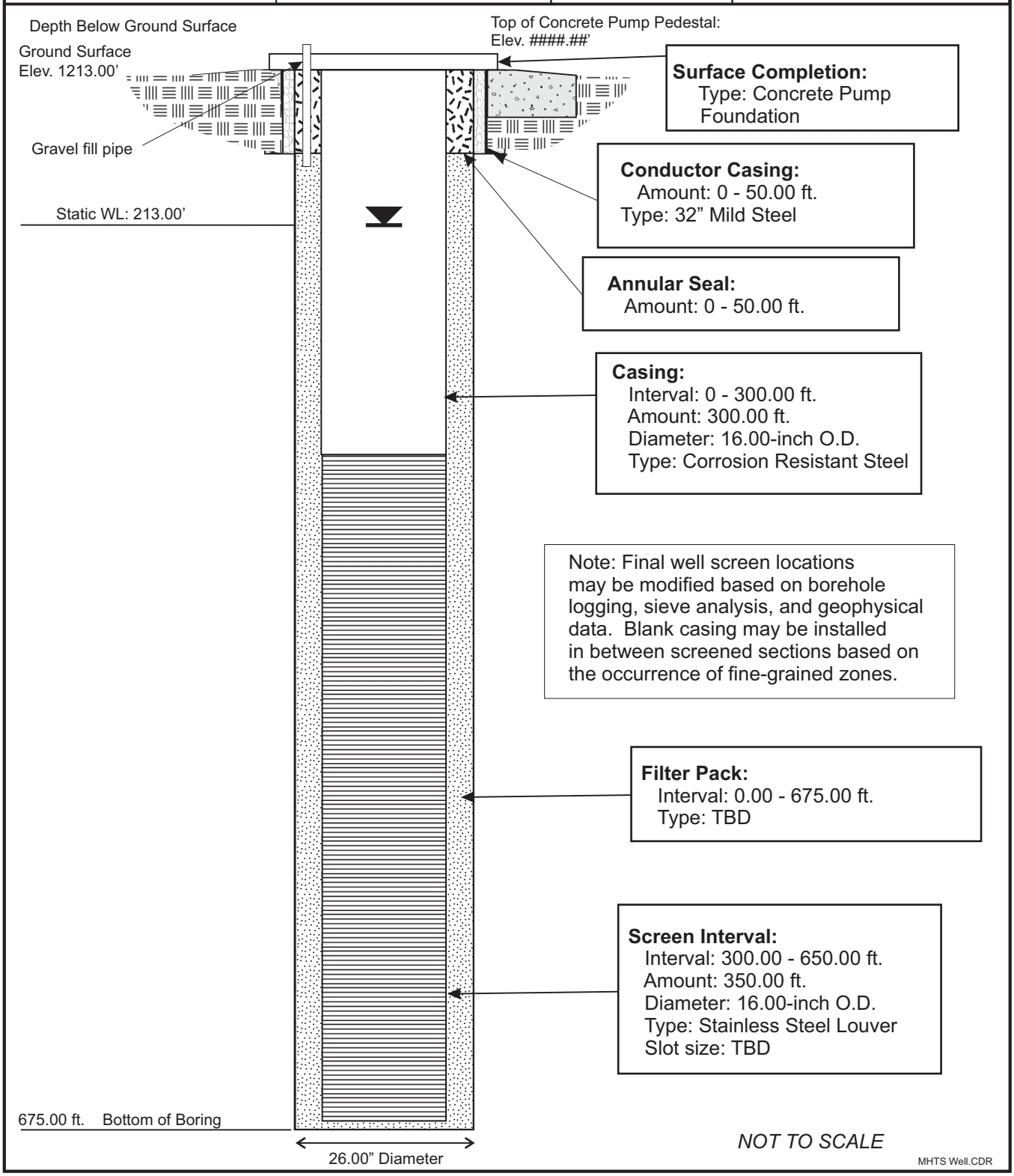
☐ WATER SUPPLY YIELD REQUIRED		☐ OTHER REQUIREMENT	
DATE ACCEPTED:	REHS signature	DATE ACCEPTED:	REHS signature

Revised: October 2012

APPENDIX F
Well Construction Diagrams

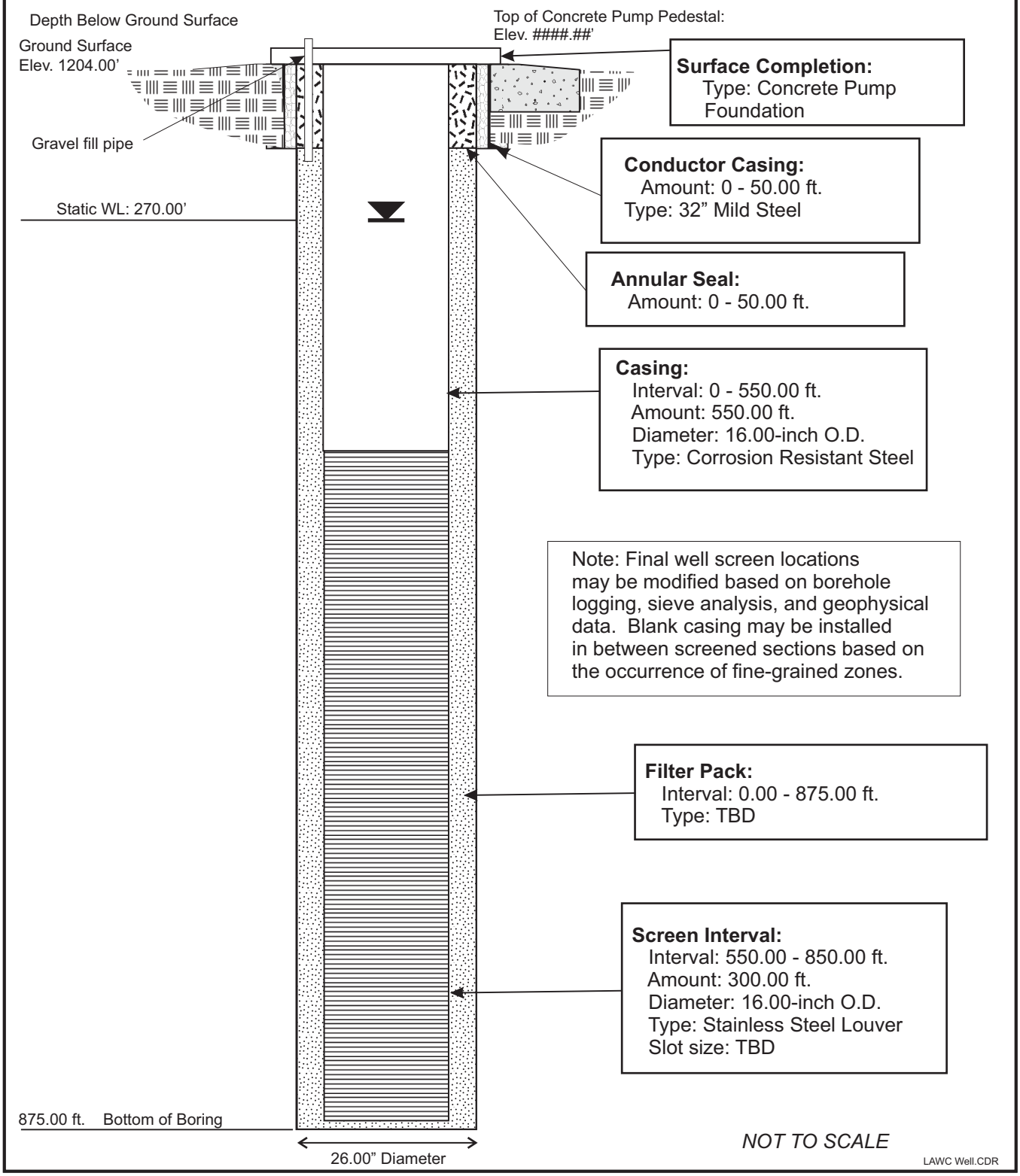
Well Diagram
Altadena, California
New MHTS Well

State Well ID#: Not Assigned	Site: City of Pasadena	Well #: MHTS Well	Northing:
Drilling Contractor:	Well Diameter: 16.00-inch	Install Dates:	Easting:
Reviewed by: D. Conner	Installer/Welder:	Geologist: D. Conner	Surface Elevation: 1213.00 feet amsl



Well Diagram
Altadena, California
New LAWC Well

State Well ID#: Not Assigned	Site: Lincoln Avenue Water Co.	Well #: LAWC #6	Northing:
Drilling Contractor:	Well Diameter: 16.00-inch	Install Dates:	Easting:
Reviewed by: D. Conner	Installer/Welder:	Geologist: D. Conner	Surface Elevation: 1204.00 feet amsl



APPENDIX G
Behner Treatment Plan Operations and Maintenance Manual

Introduction

This O&M Manual was developed in order to provide guidance for utilizing the Behner sump and packaged treatment system to manage the MHTS wastewaters. By utilizing the 525,000 gallon capacity of the Behner sump and a 100 gpm treatment system the MHTS wastewater can be efficiently stored, treated, and discharged in accordance with appropriate surface water discharge requirements.

Wastewater management at MHTS is an important aspect of operation and maintenance. The two primary sources of wastewater at the MHTS are the water produced during startup of the production wells (Arroyo Well, Well 52, Ventura Well, and Windsor Well) and the water produced during media (ion exchange and LGAC) backwashing. Annually, the system generates approximately 1.5 million gallons of wastewater during startup of each well (combined annual wastewater discharges during well startup are between 5 and 10 million gallons) and over 4 million gallons of wastewater annually during media backwashing. Table 1 summarizes the general details of the Behner sump.

Table 1. Summary of available data for the Behner Plant.

Year Constructed	1969
24-inch Influent Pipe Invert Elevation at Plant	1157.00 feet above mean sea level (amsl)
24-inch Influent Pipe Invert Elevation at JPL East Parking Lot	1106.00 feet amsl
Flocculation Basin Dimensions	Two Basins, 30-feet long x 19.5-feet wide x 12-feet deep
Flocculation Basins Volume	105,000 gallons
Sedimentation Basins Dimensions	Two Basins, 117-feet long x 20-feet wide x 12-feet deep
Sedimentation Basins Volume	420,000 gallons
Total Volume	525,000 gallons

Overview

Using the Behner Plant for MHTS wastewater management will require manual operations and coordination at production wells and the MHTS system.

Well Pump Capacity – Existing pumps in Arroyo Well, Well 52 and Ventura Well are designed for discharging groundwater at the Ventura Booster Station, which is located in the Arroyo Seco at a lower elevation than the Behner Plant. Therefore, the pumping capacity of Arroyo Well, Well 52 and Ventura Well will decrease when discharging to the Behner Plant. Windsor Well is located at a slightly higher elevation than the Behner Plant and rerouting of pump startup water should not influence pumping capacity. Table 2 summarizes the estimated pumping capacity of the PWP wells when discharging directly to the Behner Plant.

Table 2. Estimated pumping capacity of PWP wells when discharging directly to the Behner Plant.

Parameter	Arroyo Well	Well 52	Ventura Well	Windsor Well
Design Capacity	2,200 gpm	1,800 gpm	1,600 gpm	1,400 gpm
Total Design Head (TDH)	350 feet	300 feet	242 feet	560 feet
Current Highest Discharge Elevation	1,091 feet amsl	1,075 feet amsl	1,075 feet amsl	1170 feet amsl
Behner Plant Discharge Elevation	1,157 feet amsl	1,157 feet amsl	1,157 feet amsl	1,157 feet amsl
Assumed head loss in pipelines	20 feet	22 feet	25 feet	20 feet
New TDH	436 feet	404 feet	349 feet	567 feet
Estimated Pumping Capacity to Behner Plant	1,550 gpm	700 gpm	1,000 gpm	1,400 gpm

Estimated Total Flow To the Behner Plant – Wastewater will be generated at the MHTS during pump start up, vessel backwashing, vessel flushing, and other service and repairs. Table 3 summarizes the estimated annual volumes of wastewater generated at the MHTS.

Table 3. Estimated pumping capacity of PWP wells when discharging directly to the Behner Plant.

Description	Water Type	Flowrate (gpm)	Volume (gallons)	Events per Year	Annual Volume (gallons)
Arroyo Well Start-Up	Raw Water	1,550	279,000	1	279,000
Well 52 Start-Up	Raw Water	700	126,000	1	126,000
Ventura Well Start-Up	Raw Water	1,000	180,000	1	180,000
Windsor Well Start-Up	Raw Water	1,400	252,000	1	252,000
New MHTS Well Start-Up	Raw Water	2,000	360,000	1	360,000
LGAC Backwash	Potable Water	1,600	310,000	9	2,790,000
IX Blackflush	Treated LGAC Water	70	5,500	12	66,000
IX Forward Rinse	Raw Water	450	10,000	12	120,000
LGAC Disinfection	Potable Water	NA	15,000	9	135,000
IX Disinfection	Potable Water	NA	9,500	12	114,000
LGAC Post-Disinfection Flushing	Potable Water	NA	25,000	9	225,000
IX Post-disinfection Flushing	Potable Water	NA	16,000	12	192,000
Servicing and Repairs	Treated Water	4,000	200,000	2	400,000
Total					5,239,000

Package Treatment System – A 100 gpm package treatment plant is installed at the Behner Plant to treat production well wastewater and MHTS wastewater. The package treatment system consists of influent sump pumps (15HP) located within the Behner sump two IX vessels and two GAC vessels operated in a lead/lag configuration. Treated water from the package treatment plant will be discharged directly to the spreading basins utilizing existing 24-inch effluent pipeline from the Behner sump. Attachment A provides an O&M plan and general design drawings specific to the package treatment system utilized prior to discharge.

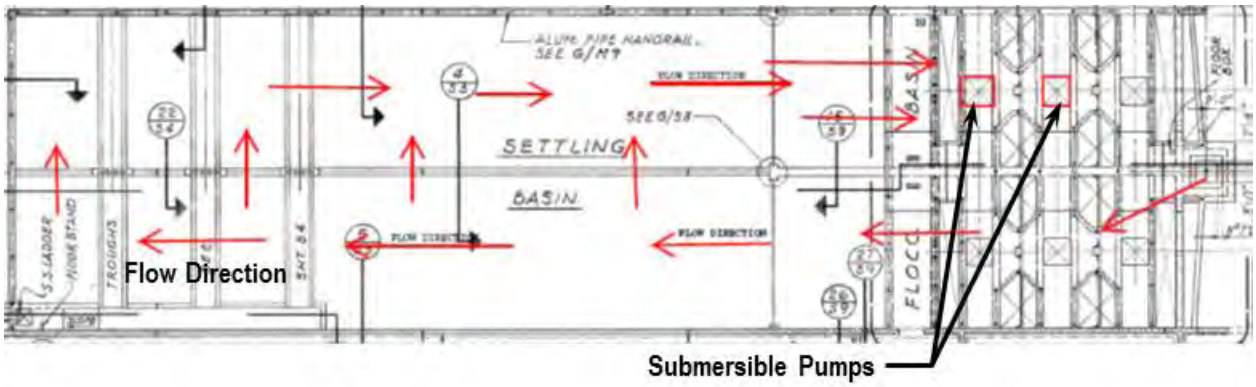


Figure 1. Flow direction and submersible pump locations at the Behner Plant sedimentation basins.

Pumping Operations

The following sections will summarize the different operating scenarios for pumping wastewater to the Behner sump and detail the treatment process at the packaged treatment system. These operations will require open communication between two or more operators at all times.

Arroyo Well Startup – During normal operating conditions the Arroyo well pumps into the Ventura booster station to be lifted through the MHTS. When well startup, disinfection, and pump to waste is underway follow the below guidelines:

1. Open appropriate valves leading from Arroyo well to Behner sump so that flow can only be directed into the Behner sump.
2. The valve leading to Ventura booster must be closed and the bypass to waste valve must be opened. Double check all valves to ensure that the well pump will not be "dead headed" against a closed valve.
3. Manually start the Arroyo well and monitor flows and pressure at the well. Monitor flow into the Behner sump paying very close attention to the water level.

Well 52 Startup – During normal operating conditions Well 52 pumps into the Ventura booster station to be lifted through the MHTS. When well startup, disinfection, and pump to waste is underway follow the below guidelines:

1. Open appropriate valves leading from Well 52 to Behner sump so that flow can only be directed into the Behner sump.
2. The valve leading to Ventura booster must be closed and the bypass to waste valve must be opened. Double check all valves to ensure that the well pump will not be "dead headed" against a closed valve.
3. Manually start the Well 52 and monitor flows and pressure at the well. Monitor flow into the Behner sump paying very close attention to the water level.

Ventura Well Startup – During normal operating conditions the Ventura well pumps into the Ventura booster station to be lifted through the MHTS. When well startup, disinfection, and pump to waste is underway follow the below guidelines:

1. Open appropriate valves leading from the Ventura well to Behner sump so that flow can only be directed into the Behner sump.
2. The valve leading to Ventura booster must be closed and the bypass to waste valve must be opened. Double check all valves to ensure that the well pump will not be "dead headed" against a closed valve.
3. Manually start the Ventura well and monitor flows and pressure at the well. Monitor flow into the Behner sump paying very close attention to the water level.

Windsor Well Startup – During normal operating conditions Windsor well pumps directly into the MHTS. When well startup, disinfection, and pump to waste is underway follow the below guidelines:

1. Open appropriate valves leading from Windsor well to the sand box so that flow can be directed into the Behner sump.
2. The valve leading from Windsor to MHTS must be closed and the bypass to waste valve must be opened. Double check all valves to ensure that the well pump will not be "dead headed" against a closed valve.
3. Manually start the Windsor well and monitor flows and pressure at the well. Monitor flow into the sand box and Behner sump paying very close attention to the water levels.

New MHTS Well Startup – During normal operating conditions the New MHTS well pumps into the Ventura booster station to be lifted through the MHTS. When well startup, disinfection, and pump to waste is underway follow the below guidelines:

1. Open appropriate valves leading from the New MHTS well to Behner sump so that flow can only be directed into the Behner sump.
2. The valve leading to Ventura booster must be closed and the bypass to waste valve must be opened. Double check all valves to ensure that the well pump will not be "dead headed" against a closed valve.
3. Manually start the New MHTS well and monitor flows and pressure at the well. Monitor flow into the Behner sump paying very close attention to the water level.

LGAC Backwash – Backwash water from the MHTS LGAC vessels leaves the treatment system via the 10" waste line to the sand box. Previously particulate filtration was used prior to discharge to the sand box. When utilizing the Behner plant pre-filtering discharge water will *not* be required, backwash water will leave the 10" waste line and connect to the Behner plant at the sand box. Follow all appropriate backwash procedures as outlined in the Calgon O&M Manual. Water levels at the Behner Plant must be monitored closely to ensure capacity.

IX Backflush – Backflush water from the MHTS IX vessels leaves the treatment system via the 10" waste line to the sand box. Previously particulate filtration was used prior to discharge to the sand box. When utilizing the Behner plant pre-filtering discharge water will *not* be required, backwash water will leave the 10" waste line and connect to the Behner plant at the sand box. Follow all appropriate backflush procedures as outlined in the Calgon O&M Manual. Water levels at the Behner Plant must be monitored closely to ensure capacity.

IX Forward Rinse – Forward Rinse water from the MHTS IX vessels leaves the treatment system via the 10" waste line to the sand box. Previously particulate filtration was used prior to discharge to the sand box. When utilizing the Behner plant pre-filtering discharge water will *not* be required, backwash water will leave the 10" waste line and connect to the Behner plant at the sand box. Follow all appropriate backflush procedures as outlined in the Calgon O&M Manual. Water levels at the Behner Plant must be monitored closely to ensure capacity.

LGAC & IX Disinfection – After disinfection has taken place of the LGAC or IX vessels all water should be diverted through the 10" waste line to the sand box and on to the Behner plant for treatment. Water levels at the Behner Plant must be monitored closely to ensure capacity.

LGAC & IX Post Disinfection Flushing –Water used to flush disinfected vessles should be diverted throught the 10" waste line to the sand box and on to the Behner plant for treatment levels at the Behner Plant must be monitored closely to ensure capacity.

Service and Repairs – Water produced at the MTHS plant or at and of the MTHS production wells should pumped to the Behner Plant for treatment whenever possible. Water levels at the Behner Plant must be monitored closely to ensure capacity.

Treatment/Discharge Operations

The following section details the discharge protocol to the spreading basin.

Discharge Requirements – Waste waters discharged at the MHTS are regulated under the General NPDES Permit No. CAG914001 (Order No. R4-2007-0022). Currently, NASA complies the substantive requirements of General NPDES Permit No. CAG914001 in accordance with CERCLA section 121(e)(1) when discharging water from the MHTS to the Arroyo Seco Spreading Basins. A Discharge Protocol[1] was developed to ensure each MHTS discharge complies with the substantive requirements of Order No. R4-2007-0022. Discharges associated with the MHTS will continue to be performed in accordance with the MHTS Discharge Protocol.

Discharges from the Behner sump will only be conducted after water has been processed through the package treatment system or confirmation sampling of water within the sump has proven that all discharge requirements will be met without additional treatment.

Waste Disposal

Solid Waste Disposal – Pre-filters and spent media will require disposal or regeneration as part of the operations of the packaged treatment system. Pre-filters should be dried and containerized in 55-gallon drums and sampled once the drum has become full. Media will require change outs after contaminants have broken through the lead vessel. Change out procedures are detailed in Attachment A.

Sediment Waste Disposal –Settled solids in the sedimentation basin will be collected and transported off-site for disposal as needed. Loading frequency will depend on the amount of solids in the sedimentation basins. An existing 8-inch pipeline at the sedimentation basin will be used to collect settled solids. This pipeline is connected to an existing manhole located in front of the control building. Solids will be removed at the manhole utilizing a vacuum truck. Prior to sediment removal and disposal appropriate confirmation sampling must be performed in accordance with U.S. EPA guidelines.

[1] NASA. 2010. *Discharge Protocol, Monk Hill Treatment System Protocol for Discharge to Arroyo Seco, National Aeronautics and Space Administration, Jet Propulsion Laboratory, Pasadena*, California. April.

Attachment A

Behner Treatment System O&M Manual

1.0 INTRODUCTION

This manual covers a general description of the equipment and operating procedures for the Behner Package Treatment System. To achieve this, the systems equipment must be properly handled and maintained to obtain the desired results. Failure to do so can cause premature equipment malfunctions and/or undesirable System performance.

The installation contractor is fully responsible for proper inspection, handling and installation, of the equipment, and shall insure that quality workmanship practices and construction procedures are followed throughout.

Section 1.4 provides helpful information for the receiving, unloading, handling and installation of the Carbon System equipment.

1.1 IMPORTANT MESSAGES AND WARNINGS

This Manual should be in the possession of the personnel who operate and maintain the treatment system. The purpose of this manual is for instruction and to advise operators and maintenance personnel.

Failure to properly follow instructions, failure to take notice of warnings, and failure to take proper precautions and preventive measures may be dangerous and could cause serious injury, equipment damage, and environmental problems.

Mechanical modifications or substitutions of parts on equipment that may affect structural or operational safety shall not be made without prior manufacturer's approval or engineer's advice. Modifications other than those approved may defeat protective features originally designed into the equipment and its controls; and therefore, shall not be made.

1.2 RECEIVING

Immediately upon receipt and prior to removal from the truck trailer, railcar or shipping container, inspects all equipment for damage. Claiming any damage that may have occurred in transit should be filed promptly with the delivering carrier. The unloading operation should be delayed until the carrier's representative has completed his inspection of the damaged equipment, otherwise a damage claim may not be honored. The inspection should include as a minimum:

1. External surface damage.
2. Damage such as broken nozzles, valves, pipes, underdrain, etc.
3. Equipment damage at contact points.
4. Unpacking and inspection of all packaged equipment and accessories.
5. Internal lining.

1.3 UNLOADING AND HANDLING

When unloading and handling the treatment system equipment, extreme care should be taken as not to damage it.

Regardless of the type of equipment being handled, certain precautionary measures must be implemented such as:

1. Insure the lifting equipment can withstand the total intended load.
2. Always use lifting eyes and brackets.
3. Never position the lifting equipment where damage to the equipment load may occur.
4. When using a forklift, make sure the forks are long enough to extend past the intended load. This prevents accidental punctures on the underside of the equipment crates, boxes and skids that may damage the equipment itself.
5. Use spreader bars.
6. Do not slide, drag or push equipment across surfaces. Always lift to move into position.
7. Do not roll, drop or throw equipment or accessories.
8. Lifting cables and/or straps must not be attached to, or permitted to come in contact with nozzles, flanges, gussets, pipes, shafts, painted surfaces, or any other accessory that may be damaged by contact.
9. When equipment is being lifted, proper rigging practices should be observed and a guide- line should be attached to prevent impact damage caused by swinging into contact with other object.
10. Never set on or roll over an equipment fitting and never use a fitting as a lifting point.
11. Prevent tools, hooks, etc. from striking the Carbon System equipment.

1.5 ASSEMBLY INSTRUCTIONS

The treatment system will be shipped pre-assembled to the greatest extent possible. The attached drawing shows the system after assembly. The piping module skid and vessel skids have drilled holes for placement and mounting. The site foundation should be level, but most importantly flat. Check to see if any bolts that may have come loose during shipment, if so, tighten them. The internal nozzles have been shipped installed. Be sure to use proper flange tightening procedures when assembling all piping.

The treatment system should be assembled in the following order:

1. Mark the foundation with guide-lines in order to place the vessels in a straight line.
2. Located the vessels spaced as shown on drawing.
3. Place the piping module appropriately between the face piping connections.
4. If alignment is off, make sure the vessels and piping module are level and in the correct positions. Some shimming of the vessels and piping module may be required.
5. Bolt Tanks to the piping module (bolt loosely until system is fully assembled).
6. If alignment is acceptable, tighten all the bolts.
7. Secure the vessels and piping module to the foundation.
8. Assembly is complete.

2.0 EQUIPMENT DESCRIPTION

2.1 GENERAL DESCRIPTION

The Package Treatment System consists of two ion exchange (IX) absorber vessels and two granular activated carbon (GAC) absorber vessels, face piping, and piping module with support skid. The piping system comes complete with influent, effluent, backwash, air vent line, carbon fill, carbon removal, compressed air, and sampling connections.

The carbon steel vessels are vertical cylindrical pressure vessels with elliptical tops and bottoms manufactured for a maximum operating pressure of 75 PSIG. The absorbers are designed for down flow operation with a specially designed underdrain collection system to maximize the utilization of media as well as allow for efficient and rapid removal of the spent media.

The treatment vessels are designed with sufficient free board volume to allow for full fluidization during back washing of the media bed during start up and in the event an unacceptable pressure drop develops across the bed due to any filterable solids entering the vessels.

The process and utility piping to operate the system are mounted on the vessels and piping module. The piping options include valving to operate both sets of vessels in parallel or series (lead/lag) flow configuration. Each vessel has its own media fill, discharge and vent lines. The process piping is equipped with pressure gauges and sample ports at the inlet and outlet of each vessel. Compressed air connections are provided for use during media transfer.

2.2 PROCESS DESCRIPTION

The Package Treatment System is designed to remove perchlorate and volatile organic compounds (VOCs) from contaminated feed water using IX and GAC media. The feed water to be treated will be pumped from the Behner sump at a controlled rate through the absorbers in a series configuration.

A pre-filter will be required to remove any suspended solids from the feed water prior to entering the treatment system.

Each IX vessel shall contain approximately 53 cubic feet of perchlorate specific resin, which will provide sufficient contact time at the design flow rate to remove the perchlorate in the feed water.

Each GAC vessel shall contain approximately 2,000 lb of GAC, which will provide sufficient contact time at the design flow rate to remove the VOCs in the feed water.

Feed water enters the treatment system from the top and flows down through the media. The treated water is collected in the underdrain system.

When piped in the series configuration and the lead absorber becomes saturated (exhausted) it's taken off-line for replacement of the spent media. The feed water is directed to the second absorber, allowing the system to remain in service. With the addition of utility water, the spent media is pneumatically displaced as slurry to a bulk transport trailer. The dewatered spent media is reactivated or disposed of.

To refill the absorber with fresh media, the new media in the trailer is slurried, using clean water, pressurized up to 15 psig and then transferred to the empty absorber.

Once the fresh media is placed in the vessel, it must be soaked and backwashed before the appropriate valves will be opened, placing the vessel with the fresh media in the secondary position.

2.3 OPERATING CONDITIONS

The design operating conditions and characteristics for this system are as follows:

Maximum flow rate:	200 gpm per vessel
Maximum Pressure:	75 psig
Maximum Temperature:	150°F
GAC media content:	2,000 lb. /vessel
IX media content:	53 ft^3 /vessel

2.4 GENERAL PROCESS COMMENTS

OPERATIONAL CHANGES

Optimum operation of the system is obtained if changes to the system occur slowly. Rapid changes in flow will cause upsets to the absorbers, which could adversely affect the operation. Valves should be closed slowly at all times to reduce the chance of shock or “water-hammer”.

3.0 START-UP

3.1 SAFETY

Any piece of equipment can be dangerous if operated improperly. Safety is ultimately the responsibility of those operating and maintaining the equipment. All personnel operating and maintaining the treatment system and its proper implementation must be familiar with all of the system components, and observe all OSHA, federal, state and local safety codes and requirements.

Failure to properly follow instructions and failure to take proper safety precautions is dangerous and can cause serious personal injury, needless equipment damage, and unnecessary environmental harm. Mechanical modifications and/or substitutions of parts on equipment that will affect structural, operational, or environmental safety should not be made. Modifications that may defeat protective features originally designed into the equipment and control; and therefore, should not be made.

The following is a partial list of precautions to follow but in no case is the list exhaustive nor is it intended to be. Operators and maintenance personnel should expand on this list after first reviewing the entire system and its operation with the appropriate health and safety authorities.

- Keep areas clean. A clean work area is a much safer area.
- Keep all equipment guards in place. If removed to service the equipment, make sure the guards are replaced properly.
- Wear eye and face protection around rotating and pumping equipment and whenever working around or handling chemicals. Be especially cautions for splash when disconnecting piping, valves and fittings.
- Wear ear protection if necessary.
- Wear proper apparel. Do not wear loose clothing, or jewelry, which could be caught in machinery.
- Wear a proper respirator around chemicals and in areas where vapors and/or gases may be present.
- Non-skid foot wear is recommended and always wear protective gloves when feasible.
- Make sure all personnel are familiar with OSHA approved MSDS Sheets for all hazardous materials they may come in contact with.

STAY ALERT

WATCH WHAT YOU ARE DOING

USE COMMON SENSE

DO NOT PERFORM OPERATION OR MAINTENANCE FUNCTIONS WHEN YOU ARE TIRED OR GROGGY

DO NOT ATTEMPT TO SERVICE OR OPERATE MACHINERY YOU ARE NOT FULLY FAMILIAR WITH

DO NOT TAKE CHANCES

ASK FOR ASSISTANCE IF IN DOUBT

DO NOT TRY TO DO IT ALONE

THINK BEFORE YOU ACT AND BE CAREFUL

3.2 OXYGEN DEMAND CREATED BY GAC IN CONFINED VESSELS

Research efforts have confirmed that wet granular activated carbon confined in large vessels creates an oxygen demand, which is hazardous to human health and can cause death unless proper safety precautions are observed.

Studies conducted have shown that low oxygen content exists in vessels containing wet carbon. Laboratory experiments conducted since that time also have revealed that commercial activated carbons in a wet or moist condition will lower the oxygen content of an isolated space. Preliminary indications of this research are:

1. The phenomenon occurs with wet activated carbon of all common types.

2. The rate of oxygen uptake naturally varies with the degree of exposure of the wet carbon to the air. Thus, it is relatively rapid in a drained bed.

3. There is some indication of a limit to carbon's capacity for oxygen, but until more is known, it would be prudent to assume that all carbon (fresh, used, reactivated) will also exhibit this characteristic. Similarly, although these tests were run with water, it should be assumed that the phenomenon will occur in other liquid and vapor systems.

NOTE:

ALL CONFINED SPACES, INCLUDING THOSE CONTAINING ACTIVATED CARBON, SHOULD BE PRESUMED TO BE HAZARDOUS. APPROPRIATE SAFETY MEASURES SHOULD ALWAYS BE TAKEN BEFORE ENTERING, AS WELL AS WHEN WORKERS ARE IN A CONFINED SPACE. OSHA REGULATIONS APPLICABLE TO RESPIRATORY PROTECTION IN OXYGEN-DEFICIENT ATMOSPHERES SHOULD BE STRICTLY FOLLOWED.

3.3 FILLING THE VESSELS

BULK BAGS

When filling the absorbers with Bulk Bags the following steps are to be followed:

1. Remove the manway cover in absorber head (top).
2. Open Vent Valve.
3. Make certain all remaining valves are closed.
4. Fill each absorber to approximately half capacity with water.
5. Carefully empty the bulk bags into the absorbers. After media, check the water level. If media is above the water level, add more water as necessary. Media should always be placed into the vesselr with a water cushion.
6. After all media has been loaded, fill the vessel with water and reinstall the manway cover.
7. With the media bed totally covered with water, let media soak approximately 24 hours to totally dissipate air from the media with vent line open.

SLURRY

IX and GAC are transferred into the vessels from a bulk pneumatic trailer as slurry through the transfer lines on the vessels. The vessels must have a water cushion before media is transferred. The trailer must be filled with water prior to beginning the transfer sequence. The bulk pneumatic trailer is then pressurized to 30 psig. Slowly fully open the appropriate medai slurry inlet line. While transferring the media, the vent lines shall be fully open. All other valves should be in the closed position. The media must be soaked for approximately 24 hours with the vent line open to totally dissipate air from the media.

3.4 INITIAL BACKWASH

The absorbers must be backwashed after soaking and prior to being placed in service, to remove carbon fines, entrapped air and to fully stratify the carbon bed. To backwash the adsorption tank, the procedure is described below.

EACH ABSORBER SHOULD BE BACKWASHED SEPARATELY.

At the start of backwash all valves in the adsorption system are closed. To initiate backwash, follow valve sequences provided by the system manufacture.

3.5 PLACING THE SYSTEM IN OPERATION

ADSORPTION SYSTEM START-UP

To put the adsorption system on-stream, the procedure is described below.

The feed to the adsorption system is provided by the user's feed pump. The pump must be started and brought up to operating conditions prior to placing the adsorption system in operation. When this has been accomplished, the pump discharge valve is slowly opened. Initially, all valves in the adsorption system are closed. For normal operation through the absorbers, the valve sequencing is as follows:

START-UP PROCEDURE FOR OPERATION IN PARALLEL

With feed pump connected to influent line and all valves closed:

1. Slowly open influent valve.

2. Manually vent air within the absorber through the vent valve open on all vessels.

3. Once no air is observed discharging through the vent valve (all water), slowly close the vent valves.

4. Refer to System Flow Diagram and General Arrangement Drawings for the desired valve sequence to put the system in operation, remembering to operate each valve slowly.

Normal operation requires no further changes until breakthrough occurs.

Occasionally, particulate builds up on the carbon and it becomes necessary to backwash the units. Refer to Section 3.6 if this happens.

3.6 BACKWASH

If the pressure drop across an absorber becomes too high (doubling clean bed pressure drop), backwashing may be necessary. To backwash an adsorption tank, the procedure is described below.

It is the operator's responsibility to backwash an absorber and provide ample water for backwashing. The water should be clean water should not exceed the flow rate stated in 2.3 Operating Conditions.

EACH ABSORBER SHOULD BE BACKWASHED SEPARATELY.

1. Isolate the vessel to be backwashed from the process stream.

2. To initiate backwash, follow the valve sequence and flow diagram.

3. Backwash for 10 - 15 minutes.

4. Make sure backwash valves are open for entire cycle.

5. If pressure drop is still unacceptable, repeat or call system manufacture.

3.7 SPENT MEDIA REMOVAL

When the lead absorber becomes saturated (exhausted) it is taken off-line for replacement of the spent carbon. The feed water is directed to the second absorber, allowing the system to remain in service. The lead absorber is then pressurized up to 30 psig with air. With the addition of utility water, the spent media is pneumatically displaced as slurry to a bulk transport trailer by slowly opening the slurry outlet valve. To remove 2,000 pounds of carbon approximately 1,000 gallons of water is required to keep the spent media in slurry to facilitate removal. This will help prevent line clogging.

To refill the absorber with fresh media see Section 3.3.

4.0 TROUBLESHOOTING

The following tables list malfunctions, probable causes, and in most cases, possible corrective action to take for the problem at hand. By no means is this list complete. It is intended only as a guide for the maintenance personnel to help them in properly identifying and isolating equipment malfunctions. If in doubt as to the actual cause of a malfunction, consult the factory or nearest equipment representative for assistance.

ADSORPTION SYSTEM:

MALFUNCTION	PROBLEM CAUSE	CORRECTION ACTION
High pressure drop across absorber	Bed not flooded Bed air bound	Check to see that the air release valve is operating. Make sure there is a constant flow before valve closes.
	Feed pump pressure too high	Throttle feed pump
	Improper valving	Check valve sequence (see Figure 1). Check for obstructions in transfer lines.
	Particulate build-up on carbon bed	Backwash per Section 3.6
Leaking flange	Loose bolts	Tighten bolts
Discharge Water From the Backwash/Vent Outlet Line	Broken Rupture Disk	Replace Rupture Disk

MALFUNCTION	PROBLEM CAUSE	CORRECTION ACTION
Leaking Pressure Relief Valve	Leaking or broken Relief Valve	Check to see is carbon has collected on the valve seat. Replace Relief Valve
Carbon in the effluent	Internal mechanical failure	To confirm, open effluent sample valve. Collect 1 qt. Effluent sample to check for carbon. If the test confirms internal failure, call manufacture.
Premature breakthrough	Change of influent concentrations	Confirm by checking influent and effluent samples before changing carbon
	Siphoning air in	Check Air Release/Vacuum Relief Valve for correct operation
	Background TOC Colloids	Change carbon
Sudden high contamination level in effluent	Check heel due to improper carbon change-out	Call Manufacture
Frozen lines, broken gauges and valves	Cold weather	Insulate piping and or heat trace process. Call Manufacture
System bacteria infections	Disinfect System	Call Manufacture

5.0 SYSTEM MONITORING

It is responsibility of the user to monitor the treatment system during operation. Spent media must be properly profiled according to all applicable regulations prior to reactivation.

The following is a suggested format for an operating log. This list is meant as a suggestion only and is by no means complete. Record each day the following items for each individual media vessel:

1. Record all equipment maintenance, calibrations, system cleaning, repairing and any parts replacement.

2. Record any unusual occurrences, shutdowns, breakdowns, etc.

3. Record the date and time when each item is logged.

4. Record the pressure drop across the system daily to indicate if any foreign objects have entered the system.

6.0 GENERAL SYSTEM INFORMATION

6.1 TEMPORARY SHUTDOWNS:

For shutdown or intermittent operation, the treatment system should remain completely full of water and the inlet and outlet should be sealed either by a valve or a cap. Prior to restarting the unit, the treatment system should be backwashed using two to three bed volumes of water. Failure to backwash may result in a temporary presence of contaminated water at the outlet of the absorber.

6.2 EXTENDED SHUTDOWNS:

If the treatment system is shut down for an extended period of time, the following procedure should be followed to reduce potential degradation of bed life.

Backwash the vessels using two - three bed volumes of water. Drain the vessel of all water. There should be no free standing water left in the vessel. All valves, manways, and vents shall be tightly sealed for the duration of the shutdown to eliminate any supply of oxygen that would promote biological growth. Prior to re-commissioning the units, follow the start-up instructions included.

6.3 EMERGENCY PROCEDURES

In the event something should occur to cause a shutdown of an absorber, the operation shall be switched over to the other absorber and steps shall be taken immediately to remedy the situation.

If a major leak or failure occurs which would cause the Treatment System to be inoperative, then the feed to the system should be shut down immediately. If repairs are beyond the scope of the plant operators, the manufacturer’s customer service department should be contacted immediately.

7.0 MAINTENANCE

7.1 MINOR MAINTENANCE

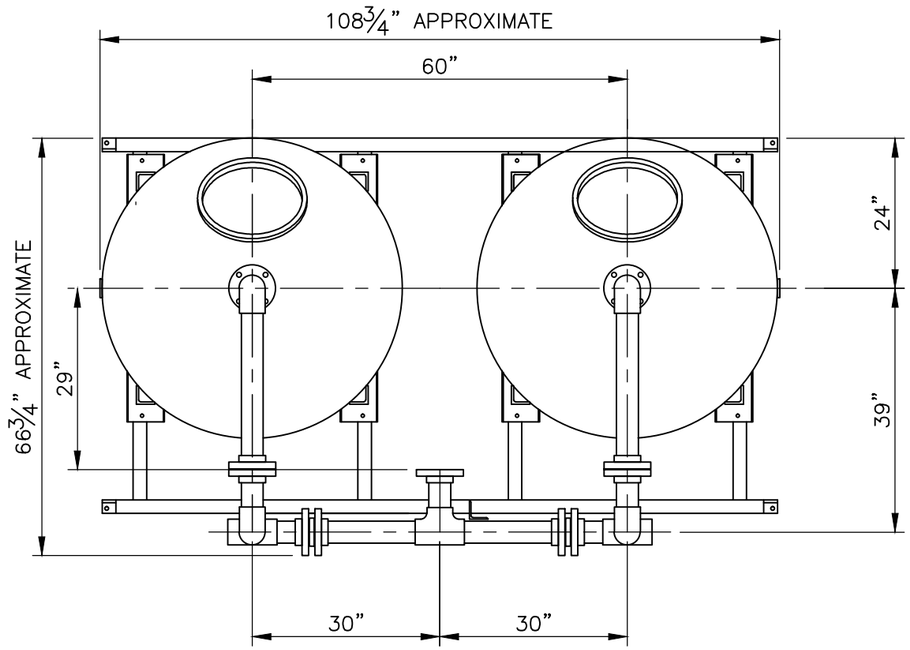
Minor maintenance is that maintenance to be performed by the plant to ensure continuous and effective operation. This maintenance includes visual check of pressure gauges and adjustments to valves and regulators, tightening flanges and connections to eliminate leakage, backwashing, etc.

7.2 MAJOR MAINTENANCE

Major maintenance is that effort needed to repair or replace equipment in order to continue system operation. The need for major maintenance would result from a major malfunction causing the system to be inoperative. Major maintenance also refers to system design changes and/or maintenance requiring downtime.

7.3 SPARE PARTS

For specific information on part numbers, please refer to the manufacturer's data sheets.



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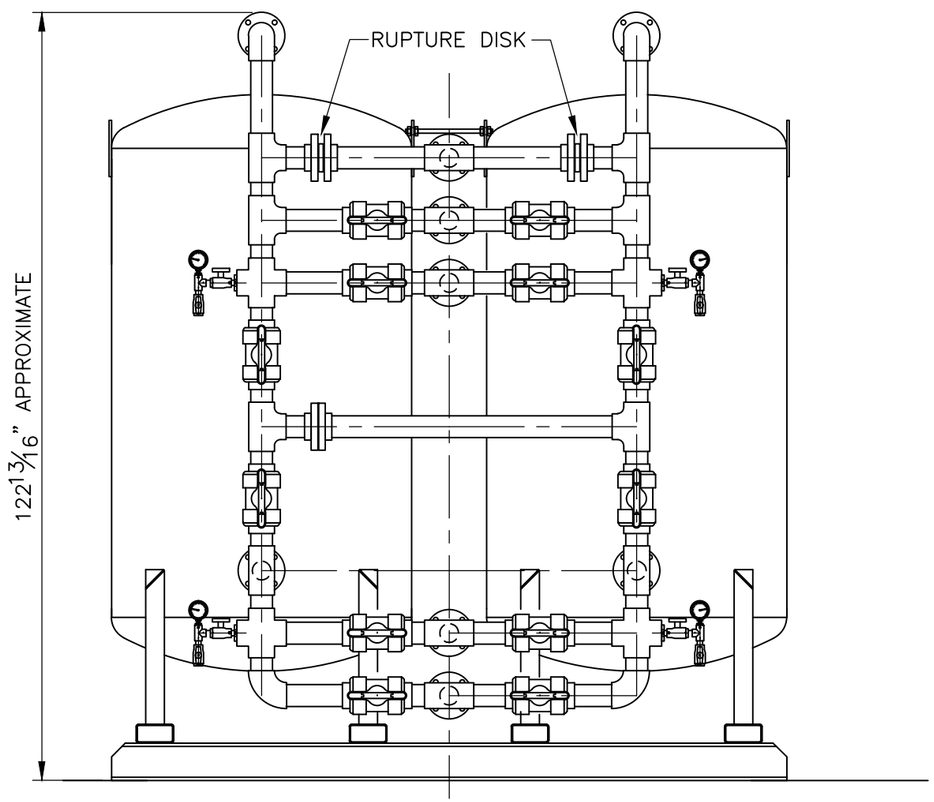

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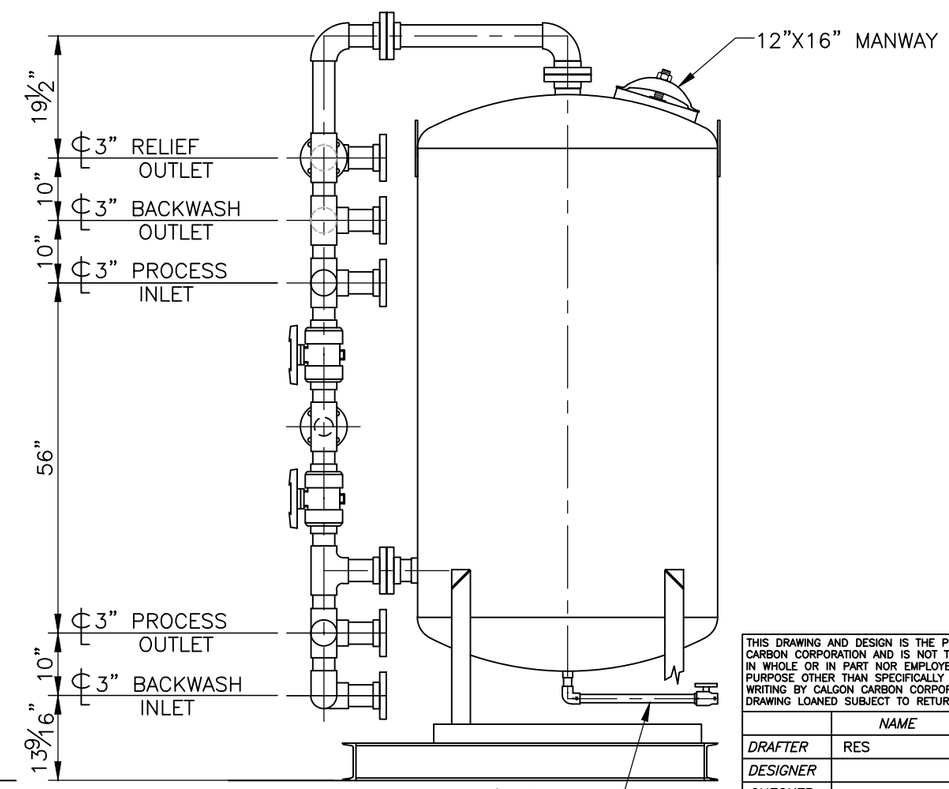

RIGHT ELEVATION

NOTES:

1. SEE SYSTEM DATA BLOCK FOR DESIGN CONDITIONS.
2. MEDIA:
   TYPE: TBD
   MESH: TBD
   QUANTITY: 2000 LB. EACH VESSEL
3. ALL PIPING AND FITTINGS TO BE SCHEDULE 80 PVC UNLESS OTHERWISE NOTED.
4. FLANGED CONNECTIONS ARE 150#.
5. P.I. ASSEMBLY SHIPPED LOOSE.

SYSTEM DATA		
MAX. OPER. PRESS.	75	PSIG
MAX. OPER. TEMP.	140	°F
DESIGN FLOW	65	GPM
BACKWASH FLOW	100	GPM
EMPTY VESSEL WT.	1300	LB
SYSTEM EMPTY WT.	3,350	LB
SYSTEM OPER. WT.	16,950	LB

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	NAME	DATE
DRAFTER	RES	11/21/2012
DESIGNER		
CHECKER		
APPROVAL		
PROJECT No.	P-IS-12125	

REV	DESCRIPTION	APP	DATE

REVISIONS

TOLERANCES (unless otherwise specified)

ANGULAR	±0°30'	DECIMAL (2 PLACES)	±.010
FRACTIONAL	±1/16"	DECIMAL (3 PLACES)	±.005
DECIMAL (1 PLACE)	±.015	DECIMAL (4 PLACES)	±.0005

CalgonCarbon

CLIENT: NASA-PWP

TITLE: ION EXCHANGE SYSTEM MD-72, W/SKID, 3" PVC PIPING GENERAL ARRANGEMENT

DWG. Size: B | SHEET No.: 1 OF 1 | SCALE: NTS

DWG. No.: GA-001 | REV.: A

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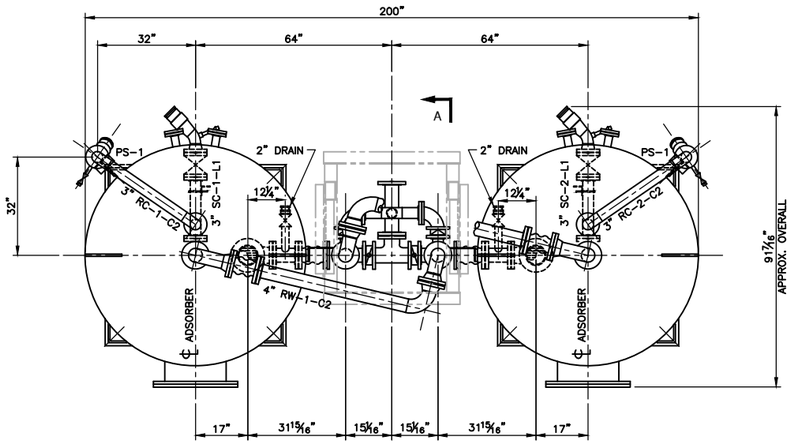
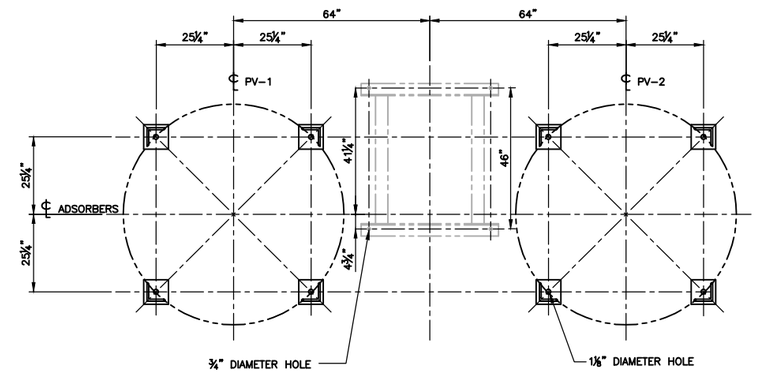
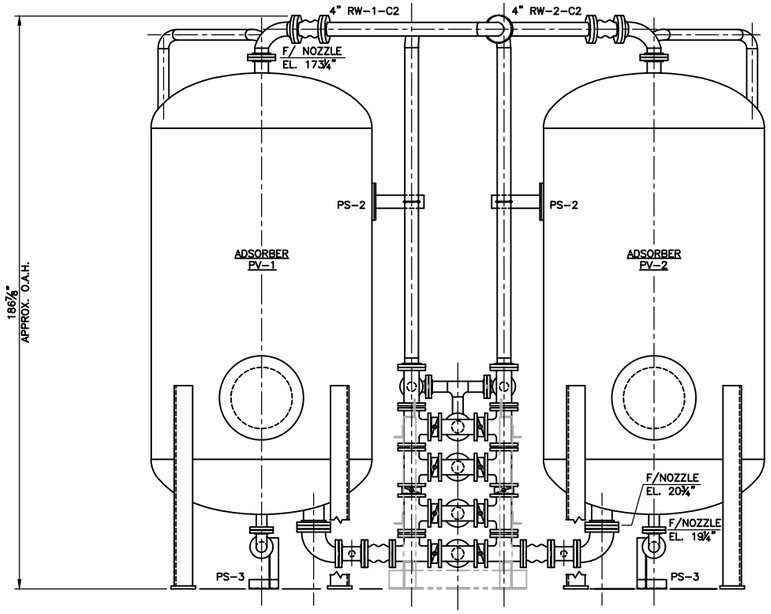


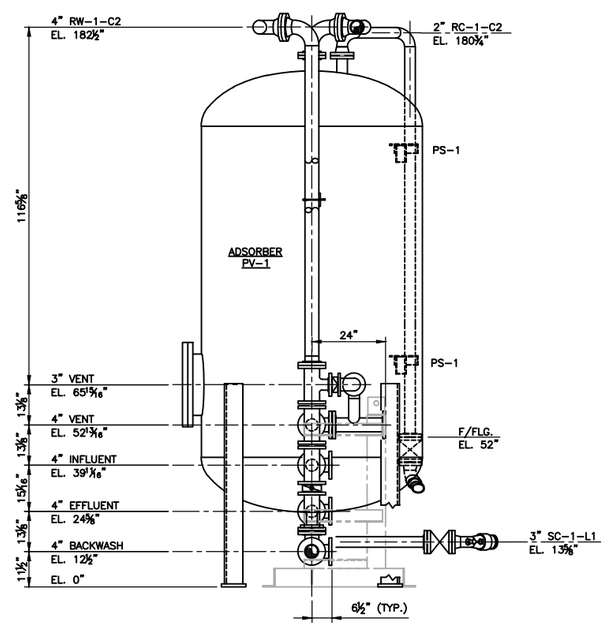
PLAN



ANCHOR BOLT PLAN



ELEVATION



SECTION A-A

REV	DESCRIPTION	APP	DATE
2	REDRAWN	RES	4/7/09

REVISIONS

TOLERANCES (unless otherwise specified)

ANGULAR	±0°30'	DECIMAL (2 PLACES)	±.010
FRACTIONAL	±1/16"	DECIMAL (3 PLACES)	±.005
DECIMAL (1 PLACE)	±.015	DECIMAL (4 PLACES)	±.0005

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	NAME	DATE
DRAFTER	RES	04-07-2009
DESIGNER		
CHECKER		
APPROVAL		
PROJECT No.	STANDARD	

CalgonCarbon

CLIENT

TITLE
MODULAR ADSORBER SYSTEM
(2) 6 FT. DIA. VESSELS
GENERAL ARRANGEMENT

DWG. Size	SHEET No.	SCALE
D	1 OF 1	NONE

DWG. No. 90951575 REV. 2

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APPENDIX H
Project Schedule

OU-3 Optimization Construction Schedule

Item Number	Activity	Duration (Calendar Days)
	MHTS Well Installation	100
1	Geophysical Utility Clearance	4
2	Mobilization	2
3	Prep Work for Supply Well Drilling	0
4	Containment Delivery (Solids)	2
5	Supply Well Drilling	11
6	Supply Well Construction	4
7	Containment and Filtration Delivery (Liquid)	4
8	Supply Well Development	18
9	Supply Well Aquifer Testing and Sampling	3
10	Supply Well Pump House Construction	7
11	Electrical Power Supply (Transformers and Switchgear)	4
12	Fence and Gate Construction	4
13	Supply Well Pump and Motor Installation	4
14	Supply Well Testing and Sampling	1
15	Well Disinfection	2
16	Demobilization	6
	MHTS System	77
17	Sacrificial Media Operation (Development and Testing)	32
18	Sacrificial Media Removal	4
19	System and Distribution Piping Disinfection	11
20	Bacteriological Testing	4
21	Virgin Media Loading	4
22	Bacteriological Testing	4
23	MHTS Returned to Service	0
	Behner Treatment Plant Upgrades	200
24	Geophysical Utility Clearance	4
25	Mobilization	4
26	Windsor Site Pipeline Installation and Tie In	3
27	Windsor Site Pipeline Installation and Tie In	3
28	Windsor Pipeline Pressure Testing	3
29	Ventura Pipeline Installations	11
30	Ventura Pipeline Installations	11
31	Ventura to Well 52 Pipeline Installation	25
32	Ventura Pipeline Pressure Testing	4
33	Well 52 Pipeline Installations	4
34	Well 52 Pipeline Installation	4
35	Well 52 Install 16" x 12" TEE	4
36	Well 52 to Arroyo Pipeline Installation	18
37	Well 52 Pressure Testing	4
38	Arroyo Pipeline Installation	4
39	Arroyo Pipeline Installation	4

Item Number	Activity	Duration (Calendar Days)
40	Arroyo Pipeline Installation	4
41	Arroyo 16" x 16" x 12" TEE, 12" x 12" x 12" TEE and BF	4
42	Arroyo Pipeline Installation	4
43	New MHTS Well to Arroyo Pipeline Installation	18
44	Arroyo Hillside Pipeline Installation	11
45	Arroyo Pipline Pressure Testing	4
46	Waste Collector Pipeline Installation	11
47	Behner Treatment Plant Pipeline Tie Ins	3
48	Package Treatment Plant Installation	4
49	Behner Pressure Testing	4
50	Package Treatment Media Loading	2
51	Startup Testing	1
	LAWC Well Installation	109
52	Geophysical Utility Clearance	2
53	Mobilization	5
54	Prep Work for Supply Well Drilling	0
55	Sound Panel Installation	1
56	Containment Delivery (Solids)	1
57	Supply Well Drilling	18
58	Supply Well Construction	11
59	Containment and Filtration Delivery (Liquid)	2
60	Supply Well Development	18
61	Supply Well Aquifer Testing and Sampling	4
62	Supply Well Pump House Construction	4
63	Supply Well Conveyance Piping Construction	11
64	Electrical Power Supply (Transformers and Switchgear)	4
65	Supply Well Pump and Motor Installation	1
66	Supply Well Testing and Sampling	2
67	Well Disinfection	4
68	Demobilization	4
	LAWC Treatment System	63
69	Sacrificial Media Operation (Development and Testing)	25
70	Sacrificial Media Removal	4
71	System and Distribution Piping Disinfection	4
72	Bacteriological Testing	4
73	Virgin Media Loading	4
74	Bacteriological Testing	4
75	LAWCTS Returned to Service	0
	Estimate to Complete	**200**