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California Regional Water Quality Control Board
Los Angeles Region
320 West 4th Street, Suite 200
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October 23, 2018

Subject: **Horizontal Biosparge System Construction Work Plan Addendum – Results from the Southeastern SVE Capture Zone Assessment, SFPP Norwalk Pump Station, 15306 Norwalk Boulevard, Norwalk, California**

Dear Mr. Cho,

This document is an addendum to the Horizontal Biosparge System Construction Work Plan[1] submitted on October 30, 2017 (hereafter, the "Work Plan") for the SFPP, L.P. (SFPP) Norwalk Pump Station (hereafter, the "site"), located at 15306 Norwalk Boulevard, Norwalk, California (see Figure 1). This addendum is submitted by CH2M HILL Engineers, Inc. (CH2M), now a wholly owned subsidiary of Jacobs Engineering Group Inc. (Jacobs), on behalf of Kinder Morgan, Inc. (Kinder Morgan), to the Los Angeles Regional Water Quality Control Board (Water Board). This addendum provides the results of the southeastern soil vapor extraction (SVE) capture zone assessment, which was performed to determine whether the existing southeastern SVE system (in its current configuration) is capable of sufficiently mitigating risk from offsite migration of volatile organic compound (VOC) vapors prior to initiating horizontal biosparging activities in that area of the site.

Introduction

In accordance with the Work Plan, horizontal biosparge well BS-02 was installed in the southeastern area of the site in November 2017 to treat the southeastern dissolved phase hydrocarbon groundwater plume and light non-aqueous phase liquid (LNAPL) in groundwater and soil. A Construction Completion Report documenting installation activities was submitted to the Water Board in July 2018.[2] One prerequisite of operating BS-02 established in the Work Plan was to determine whether the existing southeastern SVE system in its current configuration is capable of sufficiently mitigating risk of offsite VOC migration prior to initiating horizontal biosparging activities in the southeastern area. To complete that prerequisite, Jacobs performed a capture zone assessment on the existing SVE infrastructure and wells in the southeastern area in June 2018. This document provides the results of that assessment and recommended modifications to the SVE system required to achieve the necessary capture zone to mitigate risk of offsite VOC migration.

[1] CH2M. 2017. *Horizontal Biosparge System Construction Work Plan, SFPP Norwalk Pump Station, 15306 Norwalk Boulevard, Norwalk, California*. October 30.

[2] Jacobs. 2018. *Southeastern Horizontal Biosparge Well (BS-02) Completion Report, SFPP Norwalk Pump Station, 15306 Norwalk Boulevard, Norwalk, California.* July 12.

The following sections provide relevant site background information, a summary of the field investigation methodology, the results of the capture zone assessment, and a description of the recommended system modification.

Background Information

The entire facility on which Kinder Morgan operates is overseen by the Defense Logistics Agency Energy (formerly Defense Energy Support Center) and was formerly occupied by 12 aboveground fuel storage tanks and associated piping used to store and distribute refined petroleum products. Kinder Morgan had equipment, including a pump station, within 2 acres at the site and still maintains easements for its pipelines along the southern and eastern boundaries of the facility. The pump station was decommissioned in 2001, but three pipelines remain in service and continue to convey refined petroleum fuels including gasoline, diesel, and jet fuel. The three pipelines include two 16-inch-diameter pipelines and one 24-inch-diameter pipeline, which runs east along the southern boundary of the site (one of the 16-inch pipeline bends at the southeastern corner of the facility and continues northward within the eastern easement). The pipelines were fitted with block valves and motor-operated valves within the site. The block valve located in the south-central area of the site was historically referred to as the "intermediate 24-inch block valve." The intermediate 24-inch block valve and other motor-operated valves were removed between the third quarter 2016 and second quarter 2017. There is a block valve located offsite near the southeastern area of the site, which is still in use, and is referred to as the "southeastern 24-inch block valve" or "offsite 24-inch block valve."

Because of a historical release at the southeastern 24-inch block valve, the subsurface soil and groundwater within the uppermost semiperched groundwater zone (approximately 25 to 50 feet below ground surface [bgs]) in the southeastern area and offsite in the Holifield Park area is impacted with LNAPL and fuel-related hydrocarbons. Therefore, two total fluid extraction (TFE) wells (GMW-SF-9 and GMW-SF-10) and three dual-phase extraction wells (SVE coupled with TFE) (GMW-36, GMW-O-15, and GMW-O-18) are operated in the southeastern area to remove LNAPL, impacted groundwater, and soil vapor from the area to be treated by an onsite groundwater treatment system (GWTS) and an SVE treatment system (a regenerative thermal oxidizer [RTO]). A description and effectiveness of the sitewide GWTS and SVE system are included in the most recent quarterly remediation report.[3] Figure 2 shows the existing remediation system layout in the south-central and southeastern areas.

In December 2015, Kinder Morgan completed installation of a horizontal biosparge well, BS-01, in the south-central area as shown on Figure 2. BS-01 is constructed of 4-inch-diameter Schedule (Sch) 80 polyvinyl chloride (PVC) casing, with approximately 600 feet of screen installed 45 feet bgs. Additional details regarding the construction of the biosparge well are documented in the *Horizontal Biosparge Well and Soil Vapor Monitoring Probe Completion Report*.[4] The containerized system supplying compressed air to BS-01 is rated for a maximum capacity of 500 standard cubic feet per minute (scfm). The system includes an interlock to ensure sparging cannot occur unless the SVE system is operating.

Pilot testing of BS-01 began in early January 2016 and continued through October 2016. A comprehensive evaluation report that incorporates soil vapor and groundwater data was submitted to the Water Board in August 2017.[5] As a result of biosparge operations, LNAPL thickness was significantly reduced in 21 monitoring and remediation wells. When comparing the effectiveness of the biosparge pilot program pre- and post-initiation, the average reduction in LNAPL thickness in all wells was 1.94 feet during the 10-month pilot study, from an average of 2.15 feet in the fourth quarter 2015 to 0.21 foot. In addition, dissolved-phase TPH-g, TPH-d, benzene, and MTBE concentrations also exhibited significant reductions during the test period. Based on these results, it was determined that operation of the

[3] Jacobs. *Second Quarter 2018 Remediation Progress Report, SFPP Norwalk Pump Station, Norwalk, California*. July 12.

[4] CH2M. 2015. *Horizontal Biosparge Well and Soil Vapor Monitoring Probe Completion Report, SFPP Norwalk Pump Station, 15306 Norwalk Boulevard, Norwalk, California*. February 18.

[5] CH2M. 2017. *Evaluation Report for the South-Central Area Horizontal Biosparge Pilot Test SFPP Norwalk Pump Station, Norwalk, California*. August 3.

south-central system would continue, with expansion of the system to the southeastern area using a second horizontal biosparge well.

Therefore, following approval of the Work Plan, horizontal biosparge well (BS-02) was installed in the southeastern area of the site from November 10 to November 21, 2017. Similar to BS-01, BS-02 is constructed of a 4-inch-diameter Sch 80 PVC casing with 240 feet of screen installed 45 feet bgs. The Construction Completion Report was submitted to the Water Board in July 2018. A 175-horsepower rotary screw air compressor, enclosed in a 12-foot by 25-foot transportable container, supplying approximately 882 scfm of air at 125 pounds per square inch gauge to BS-01 and BS-02 will be installed in October 2018. The maximum biosparge flow rate will be limited to 1 standard cubic feet per minute (cfm) per foot of screen interval, which is a flow rate of 600 scfm for BS-01 and 240 scfm for BS-02. To accommodate this biosparge system flow rate, the SVE system will have to be operated at a flow rate of 1.5 times the biosparge flow rate, or at least 360 scfm, to control vapor migration.

Summary of the Field Investigation Methodology

The objective of the SVE system is to obtain high mass removal from the vadose zone and LNAPL smear zone above the uppermost groundwater zone. Also, the SVE system should capture vapors generated from biosparging. As such, the vapor capture zone of the SVE system should encompass those areas where LNAPL occurs, areas where high dissolved-phase hydrocarbon concentrations occur in groundwater, and the zone of influence of the newly installed biosparge well (BS-02). The approach used to evaluate the appropriate SVE capacity at the site is to assess the radius of influence (ROI) of SVE wells and determine whether the corresponding capture zone of the SVE wellfield adequately encompasses the impacted areas and the zone of influence of BS-02. Furthermore, the SVE extraction flow rates from the southeastern area will need to achieve at least 1.5 times the biosparge flow rate, as indicated above.

On June 26 and 27, 2018, Jacobs personnel conducted field testing to evaluate the SVE system operation and capabilities by observing flow and vacuum relationships for SVE wells GMW-36, GMW-O-15, and GMW-O-18. Soil hydraulic properties tests (single-well extraction) were performed by extracting vapors from each well in isolation over a prolonged duration (approximately 1 hour) to establish a relationship between flow rate and vacuum applied at each well. In addition, vacuum readings were collected at nearby groundwater extraction wells and soil vapor monitoring probes to observe induced vacuum to calculate the ROI of individual extraction wells and approximate the capture zone of the SVE system.

In addition, vacuum was measured throughout the 1,250-foot, 4-inch-diameter Sch 80 PVC conveyance header from the RTO to the SVE wellfield in the southeastern area. These data were collected to evaluate the ability of the existing header to supply adequate extraction vacuum and flow at the southeastern SVE wellfield. Vacuum was measured with Magnehelic pressure gauges of variable precision ranges (0 to 1 inch of water (in-H_2O); 0 to 5 in-H_2O; 0 to 10 in-H_2O, and 0 to 100 in-H_2O). Flow was measured with a Dwyer DS-300 flow meter installed approximately 20 feet from the SVE manifold and extraction blower. The Dwyer DS-300 provides differential pressure readings, which are converted to air flow using the following equation:[6]

$$Q(SCFM) = 128.8 \times K \times D^2 \times \sqrt{(P \times dP)/([T + 460] \times S)}$$

Where:

Q = air flow (scfm)
K = flow coefficient (0.67 for a 3-inch-diameter pipe)
D = pipe diameter (inches)
P = static line pressure (pounds per square inch, actual)
dP = differential pressure (in-H2O)
T = temperature (degrees Fahrenheit)
S = specific gravity in 60 degrees Fahrenheit

[6] Dwyer. 2004. Series DS-300 Flow Sensors, Installation and Operating Instructions Flow Calculations, Bulletin F-50.

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Results of the Capture Zone Assessment

Table 1 lists the extraction vacuum measured from each SVE well being tested, the induced vacuum measured from the surrounding observation wells, and the distance from the SVE well to the observation wells. Figure 3 presents the measured induced vacuums above 0.1 in-H_2O as a function of the distance from the SVE well being tested. Measured vacuums less than 0.1 in-H_2O (typically at greater distances) were excluded from the evaluation as they may suggest a larger ROI than what is reasonable. A logarithmic trendline of this data was generated and used to estimate the ROI of the SVE wells (Figure 3).

Table 2 displays the vacuum loss on the SVE conveyance line header from the SVE manifold to the southeastern area wellfield. The SVE conveyance line is a 4-inch Sch 80 PVC pipe with an interior 2-inch Sch 80 PVC line for the groundwater extraction system. The SVE conveyance line is approximately 1,250 feet from the SVE manifold at the treatment pad to GMW-36. The vacuum measurements during the 2-day tests (June 26 and 27, 2018) showed that there is a significant vacuum loss from 62 in-H_2O at the manifold to as little as 1.8 in-H_2O at the southeastern wellheads. The vacuum loss in the conveyance line results from the following:

- Leaks on the conveyance line (bringing in ambient air instead of vapors from the wellheads)
- Design considerations:
  - Pipe-within-pipe construction – the 2-inch line inside the 4-inch conveyance pipe design causes higher friction and decreases volume of air that passes through the 4-inch pipe
  - The 4-inch conveyance pipe would be too small even without the 2-inch pipe inside
- Entrapped condensate

After attempting to repair the leaks during the testing period, the highest vacuum achieved at the wellheads ranged from 29 to 30 in-H_2O, which is a significant increase.

GMW-36 had a measured extraction rate of 62 scfm at a vacuum of 30 in-H_2O. An induced vacuum of 0.44 in-H_2O was observed at GMW-O-15, which is approximately 55 feet from GMW-36. Assuming an effective vacuum limit of 0.1 in-H_2O, an ROI of 59 feet was estimated for GMW-36 (see Figure 3).

GMW-O-15 had a measured extraction rate of 62 scfm at 29 in-H_2O. An induced vacuum of 0.96, 0.64, and 0.22 in-H_2O was measured at GMW-O-16 (50 feet from GMW-O-15), GMW-36 (55 feet from GMW-O-15), and GMW-O-19 (92 feet from GMW-O-15), respectively. Assuming an effective vacuum limit of 0.1 in-H_2O, an ROI of 72 feet was estimated for GMW-O-15 (see Figure 3).

GMW-O-18 had a measured extraction rate of 61 scfm at 29 in-H_2O. An induced vacuum of 0.16 and 0.25 in-H_2O was observed at PZ-5 (43 feet from GMW-O-18) and GMW-O-15 (139 feet from GMW-O-18), respectively. Assuming an effective vacuum limit of 0.1 in-H_2O, an ROI of 84 feet was estimated for GMW-O-18 (see Figure 3).

Based on the ROIs of 59 feet, 72 feet, and 84 feet, the lowest measured ROI of 59 feet is used to estimate the ROI of each well for the SVE system. Figure 4 shows the capture zone coverage of the existing SVE wells, assuming three existing monitoring wells (MW-8, GMW-O-16, and GMW-O-19) will be converted to SVE wells and installation of up to three new SVE wells (VEW-3 to VEW-5) in the future. With an ROI of 59 feet, the capture zone largely encompasses the LNAPL plume, areas with elevated concentrations of dissolved-phase hydrocarbons, and the zone of influence of the new biosparge well (BS-02) at the southeastern area of the site.

The average ROI, the measured flow rates, the effective screen length (screen above the water table), and the measured vacuum are inputs in the radial flow equation[7] (see Table 3) to determine the soil permeability.

$$Ka = \frac{0.0873 * Q * \ln \frac{Ri}{Rw}}{Ha * Pw * (1 - \left(\frac{1}{Pw}\right)^2)}$$

Where:

K_a = soil permeability to air flow [darcy]
Q = air flow (scfm)
R_i = Estimated Radius of influence in feet
R_w = Radius of extraction well in inches
P_w = Vacuum/Pressure (atmosphere)
H_a = Applicable screened length in feet

Based on the field test data, Darcy's constant (K_a – soil permeability to air flow) ranged from 15.88 darcy in GMW-36 to 20.06 darcy in GMW-O-20, indicating medium sand amenable to SVE.

Using the same radial flow equation, Table 4 calculates the flow rate if vacuum loss in the SVE conveyance pipe is assumed to be minimal (50 in-H_2O at the wellheads). The corresponding extraction flow rate is calculated to be between 106 to 110 scfm.

Soil Vapor Extraction Upgrades and Installation of New Soil Vapor Monitoring Probes

To achieve sufficient soil vapor mitigation in the southeastern area, three existing groundwater monitoring wells will have to be converted to soil vapor extraction wells (MW-8, GMW-O-16, and GMW-O-19). The top of the screens for MW-8, GMW-O-16, and GMW-O-19 are located from 18 to 20 feet bgs; the bottom of the screens are located from 39.9 to 50 feet bgs, which is 16 to 18 feet below the groundwater table. Therefore, the three wells will have an applicable screen length (screen open to the vadose zone) of 12 to 14 feet, which is similar to the three existing SVE wells at the southeastern area.

Also, up to three new SVE wells will be installed (VEW-3 to VEW-5) to fully encompass the LNAPL plume, areas with elevated concentrations of dissolved-phase hydrocarbons, and the zone of influence of the new biosparge well (BS-02). The new SVE wells will be installed and constructed of 4-inch outer diameter Schedule 40 PVC casing and 0.020-inch PVC slotted screen, screened at 12 to 27 feet bgs. A filter pack will be constructed consisting of 2/12 silica quartz sand from 1 foot below the bottom of the well to at least 1 foot above the top of the screen section. Above the filter pack will be 2 feet of hydrated bentonite chips followed by cement bentonite grout to approximately 3 feet bgs. A 3-foot-wide, by 3-foot long by 3-foot-deep well vault will complete the well. Figure 5 presents a typical SVE well construction diagram.

Nested soil vapor probes at 5 and 10 feet bgs will be installed to measure the subsurface soil vapor concentrations from two offsite locations on Cheshire street (shown on Figure 4). Each vapor probe will be constructed with new ¼-inch outside diameter Teflon® tubing with a nominal 6-inch-long stainless steel (or equivalent) screen. A 1-foot-thick filter pack consisting of No. 3 sand will be placed around each screen. A 1-foot-thick dry granular bentonite will be placed on top of each filter sand pack. The boring will be backfilled to ground surface in 6-inch-thick lifts with 5-percent bentonite cement. A sampling valve will be fitted to the end of the tubing. The valve will be kept closed until purging and sampling. Each soil vapor

[7] Johnson, P.C., M.W. Kemblowski, and J.D. Colthart. 1988. Practical Screening of Models for Soil Venting Applications. In *Proceedings of NWWA/APO Conference on Petroleum Hydrocarbons and Organic Chemicals in Ground Water*. Houston, Texas.

point will be completed at the surface with a flush-mounted, traffic-rated well box. Figure 6 presents a typical soil vapor monitoring probe diagram.

To mitigate the vacuum loss in the conveyance line, the Sch 80 PVC will be replaced with high density polyethylene (HDPE) pipe, which will have minimal joint connections to minimize leakage. Most connections will be fused by a certified HDPE fusion welder. To decrease friction and increase the volume of air that passes through the conveyance line, a new dedicated 6-inch SVE header that is separate from the existing 4-inch header will also be installed. The 6-inch HDPE pipe will provide conveyance of all extracted vapors from the southeastern area. However, the existing 4-inch PVC line will remain to provide secondary containment of the 2-inch groundwater line. A condensate collection system will be installed to prevent water from being entrapped in the conveyance line. Attachment A presents a conceptual process flow diagram that includes the conveyance line upgrades.

Schedule

Jacobs anticipates installation of the new biosparge compressor system in November 2018. The biosparge compressor system is described in the Work Plan. The SVE upgrades will be completed and biosparge (BS-02) startup will occur by the end of the first quarter of 2019, with system monitoring and data analysis commencing upon startup. Evaluation reports will be prepared and submitted to the Water Board according to the schedule indicated in the Work Plan.

If you have any questions regarding this Work Plan Addendum, please contact Mr. Eric Davis, Jacobs's Project Manager, at (404) 323-1600, or Mr. Stephen Defibaugh, Kinder Morgan's Remediation Project Manager, at (714) 560-4802.

Regards,

Jacobs Engineering Group Inc.

Eric Davis, P.G.
Senior Project Manager

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Senior Technical Consultant

Attachments:

Table 1 – Radius of Influence Measurements
Table 2 – Vacuum Loss on the Southeast Soil Vapor Extraction Conveyance Line
Table 3 – Soil Permeability Calculation
Table 4 – Flow Estimate with an Assumed Vacuum of 50 Inches of Water Column

Figure 1 – Site Location Map
Figure 2 – Remediation System Layout
Figure 3 – Observed Radius of Influence
Figure 4 – Southeastern Area Biosparge and Soil Vapor Extraction Well Location Map
Figure 5 – Soil Vapor Extraction Well
Figure 6 – Soil Vapor Monitoring Probe Completion Diagram

Attachment A – Process Flow Diagram

Tables

Table 1. Radius of Influence Measurements

SFPP Norwalk Pump Station, Norwalk, California

Date	Extraction Well ID	Measured Vacuum (in. WC)	Date	Extraction Well ID	Measured Vacuum (in. WC)	Date	Extraction Well ID	Measured Vacuum (in. WC)
6/26/2018	GMW-36	30	6/27/2018	GMW-O-15	29	6/27/2018	GMW-O-18	29
Observation Well	**Measured Vacuum (in. WC)**	**Distance (feet)**	**Observation Well**	**Measured Vacuum (in. WC)**	**Distance (feet)**	**Observation Well**	**Measured Vacuum (in. WC)**	**Distance (feet)**
SVM-21 (5 ft bgs)	0.01	23	SVM-22 (5 ft bgs)	0.04	10	PZ-5	**0.16**	**43**
SVM-21 (10 ft bgs)	0.01	23	SVM-22 (10 ft bgs)	-0.03	10	GMW-O-24	-0.02	92
GMW-O-15	**0.44**	**55**	GMW-O-16	**0.96**	**50**	SVM-9 (5 ft bgs)	0.02	114
SVM-9 (5 ft bgs)	0	55	GMW-36	**0.64**	**55**	SVM-9 (14.5 ft bgs)	0.05	114
SVM-9 (14.5 ft bgs)	0.02	55	SVM-9 (5 ft bgs)	0	60	GMW-O-16	0	137
SVM-17 (5 ft bgs)	0	81	SVM-9 (14.5 ft bgs)	0.05	60	GMW-O-15	**0.25**	**139**
SVM-17 (10-ft bgs)	0	81	SVM-21 (5 ft bgs)	0.02	80	GMW-O-19	-0.04	149
MW-8	-0.04	81	SVM-21 (10 ft bgs)	0.02	80	MW-8	-0.1	159
PZ-5	0	127	GMW-O-19	**0.22**	**92**	GMW-36	0.05	162
GMW-O-18	0.04	162	SVM-23 (5 ft bgs)	0	98	--	--	--
--	--	--	SVM-23 (10 ft bgs)	0.02	98	--	--	--
--	--	--	PZ-5	0.04	114	--	--	--
--	--	--	GMW-O-18	0.04	139	--	--	--

Notes:

-- = No data available

in. WC = inches water column

ROI = radius of influence

Bolded data are used to estimate radius of influence.

Vacuum readings less than 1.0 in. WC not used to determine ROI.

Table 2. Vacuum Loss on the Southeast Soil Vapor Extraction Conveyance Line

SFPP Norwalk Pump Station, Norwalk, California

Distance from SVE Manifold (feet)	Measured Vacuum (in. WC) 6/26/2018	Comments	Distance from SVE Manifold (feet)	Measured Vacuum (in. WC) 6/26/2018	Comments	Distance from SVE Manifold (feet)	Measured Vacuum (in. WC) 6/27/2018	Comments	Distance from SVE Manifold (feet)	Measured Vacuum (in. WC) 6/27/2018	Comments	Distance from SVE Manifold (feet)	Measured Vacuum (in. WC) 6/27/2018	Comments
0	62		0	60		0	62		0	62		0	61	
327	46		327	52		327	52		327	53		327	53	
348	41		348	50		348	49		348	50		348	50	
612	30		612	44		612	42		612	44		612	44	
620	27	Drawing in	620	43		620	40	Drawing in	620	43		620	43	
814	21	ambient air	814	40	Made repairs	814	36	ambient air	814	40	Made repairs	814	39	
820	18	from the leg of	820	39	on the	820	35	from the leg of	820	38	on the	820	38	
1006	13	the	1006	36	conveyance	1006	31	the	1006	36	conveyance	1006	35	
1013	10	conveyance	1013	34	line to	1013	30	conveyance	1013	34	line to	1013	34	
1202	3.8	line to	1202	31	GMW-SF-9	1202	26	line to	1202	31	GMW-SF-9	1202	31	
1205	2.4	GMW-SF-9	1205	30		1205	26	GMW-SF-9	1205	30		1205	30	
1208	1.9		1208	30		1208	25		1208	30		1208	30	
@ GMW-36	1.8		@ GMW-36	30		@ GMW-36	--		@ GMW-36	--		@ GMW-36	--	
@ GMW-O-15	--		@ GMW-O-15	--		@ GMW-O-15	24		@ GMW-O-15	29		@ GMW-O-15	--	
@ GMW-O-18	--		@ GMW-O-18	--		@ GMW-O-18	--		@ GMW-O-18	--		@ GMW-O-18	29	

Notes:

-- = No data available

in. WC = inches water column

SVE = soil vapor extraction

Table 3. Soil Permeability Calculation

SFPP Norwalk Pump Station, Norwalk, California

Well ID	Q (SCFM)	DTP (feet below top of casing)	DTW (feet below top of casing)	Casing Elevation (feet bgs)	DTP (feet bgs)	DTW (feet bgs)	TOS (feet bgs)	BOS (feet bgs)	H	Ha	Rw	Ri	V	Pw (atm)	X1	X2	Ka (Darcy)
Southeastern Soil Vapor Extraction Wells - Estimated 71 feet Radius of Influence																	
GMW-36	62	--	35.2	-2.2	--	33.0	20	50	30.0	13.0	2.03	59	30	0.93	-5.853	-0.165	15.88
GMW-O-15	62	31.7	31.8	0.0	31.7	31.8	20	50	30.0	11.7	2.03	59	29	0.93	-5.853	-0.159	18.34
GMW-O-18	61	31.3	31.3	0.0	31.3	31.3	20.8	40.4	19.6	10.5	2.03	59	29	0.93	-5.853	-0.159	20.06

Notes:

DTP and DTW based on April 2018 gauging data.

Highlighted cells – Based on October 2017 gauging data.

SVE Darcy Calculator using radial flow equation:

Q = Flow in cubic feet per minute

DTP = Depth to product in feet below top of casing

DTW = Depth to water in feet below top of casing

TOS = Top of screen (feet bgs)

BOS = Bottom of screen (feet bgs)

H = Constructed screened length in feet

H_a = Applicable screened length in feet

R_w = Radius of extraction well in inches

R_i = Estimated Radius of influence in feet

V = Vacuum in extraction well in inches of water

X1= ln (R_i/R_w)

X2= 1-(1/P_w)^2

Ka = soil permeability to air flow (darcy)

Pw = Vacuum/Pressure (atm)

atm = atmosphere

$$Ka = \frac{0.0873 * Q * \ln \frac{Ri}{Rw}}{Ha * Pw * (1 - \left(\frac{1}{Pw}\right)^2)}$$

Soil Type	Ka (Darcy)
Coarse Sand	100-1000
Medium Sand	1-100
Fine Sand	0.1-1.0
Silts/Clays	<0.1

Table 4. Flow Estimate with an Assumed Vacuum of 50 Inches of Water Column

SFPP Norwalk Pump Station, Norwalk, California

Well ID	Ka (Darcy)	DTP (feet below top of casing)	DTW (feet below top of casing)	Casing Elevation (feet bgs)	DTP (feet bgs)	DTW (feet bgs)	TOS (feet bgs)	BOS (feet bgs)	H	Ha	Rw	Ri	V	Pw (atm)	X1	X2	Q (SCFM)
Southeastern Soil Vapor Extraction Wells - Estimated 71 feet Radius of Influence																	
GMW-36	15.88	--	35.2	-2.2	--	33.0	20	50	30.0	13.0	2.03	59	**50**	0.88	-5.853	-0.300	106
GMW-O-15	18.34	31.7	31.8	0.0	31.7	31.8	20	50	30.0	11.7	2.03	59	**50**	0.88	-5.853	-0.300	110
GMW-O-18	20.06	31.3	31.3	0.0	31.3	31.3	20.8	40.4	19.6	10.5	2.03	59	**50**	0.88	-5.853	-0.300	108

Notes:

DTP and DTW based on April 2018 gauging data.

Highlighted cells – Based on October 2017 gauging data.

Bolded numbers are assumed.

SVE Darcy Calculator using radial flow equation:

Q = Flow in cubic feet per minute

DTP = Depth to product in feet below top of casing

DTW = Depth to water in feet below top of casing

TOS = Top of screen (feet bgs)

BOS = Bottom of screen (feet bgs)

H = Constructed screened length in feet

H_a = Applicable screened length in feet

R_w = Radius of extraction well in inches

R_i = Estimated Radius of influence in feet

V = Vacuum in extraction well in inches of water

Pw = Vacuum in atmosphere.

X1= ln (R_i/R_w)

X2= 1-(1/P_w)^2

$$Ka = \frac{0.0873 * Q * \ln \frac{Ri}{Rw}}{Ha * Pw * (1 - \left(\frac{1}{Pw}\right)^2)}$$

Soil Type	k (Darcy)
Coarse Sand	100-1000
Medium Sand	1-100
Fine Sand	0.1-1.0
Silts/Clays	<0.1

Figures

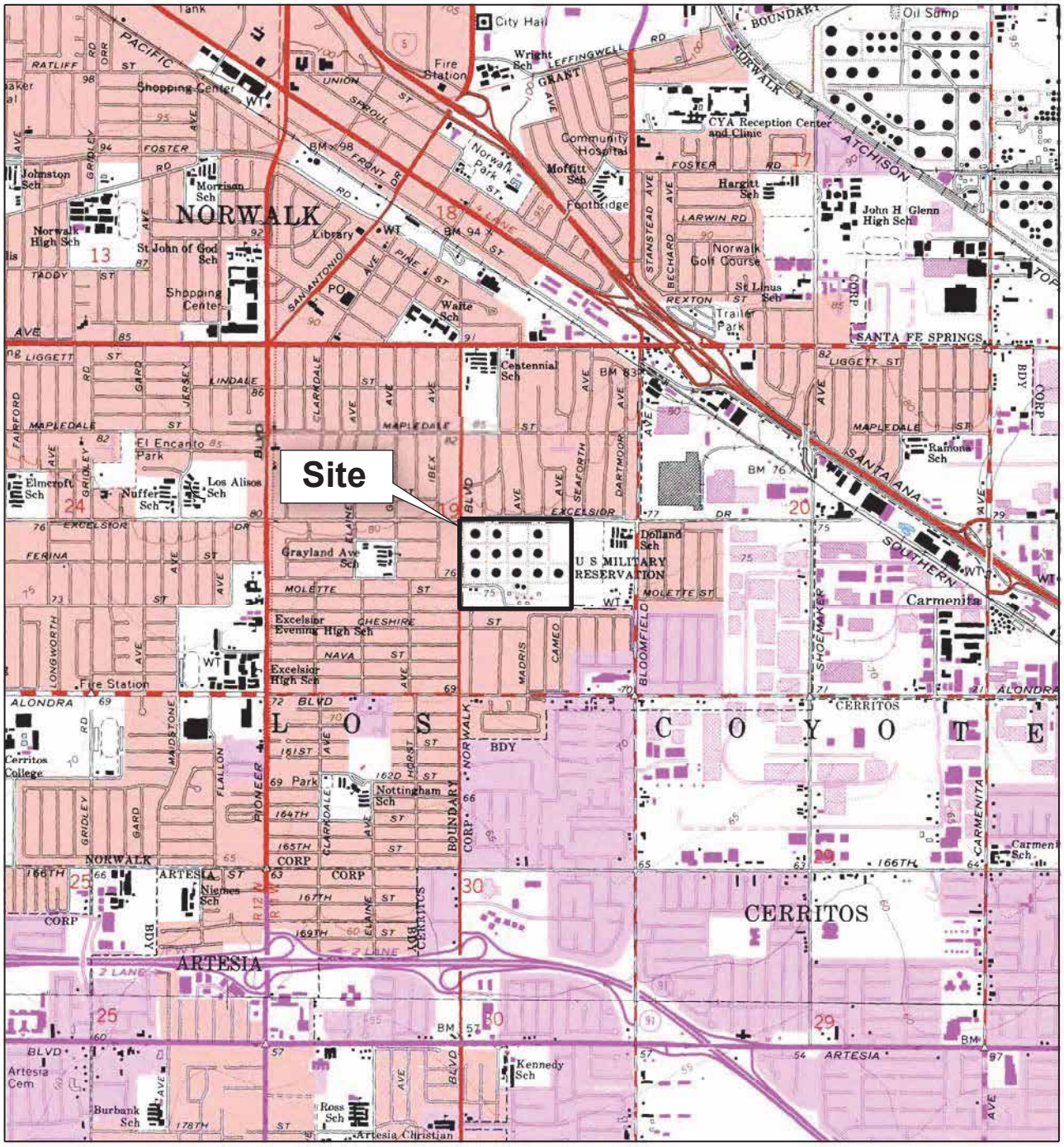

Figure 1. Site Location Map
SFPP Norwalk Pump Station
Norwalk, California

BASEMAP MODIFIED FROM U.S.G.S. 7.5 MINUTE QUADRANGLE MAP
LOS ALAMITOS 1964, CALIFORNIA. PHOTO-REVISED 1981.
WHITTIER 1965, CALIFORNIA. PHOTO-REVISED 1981.

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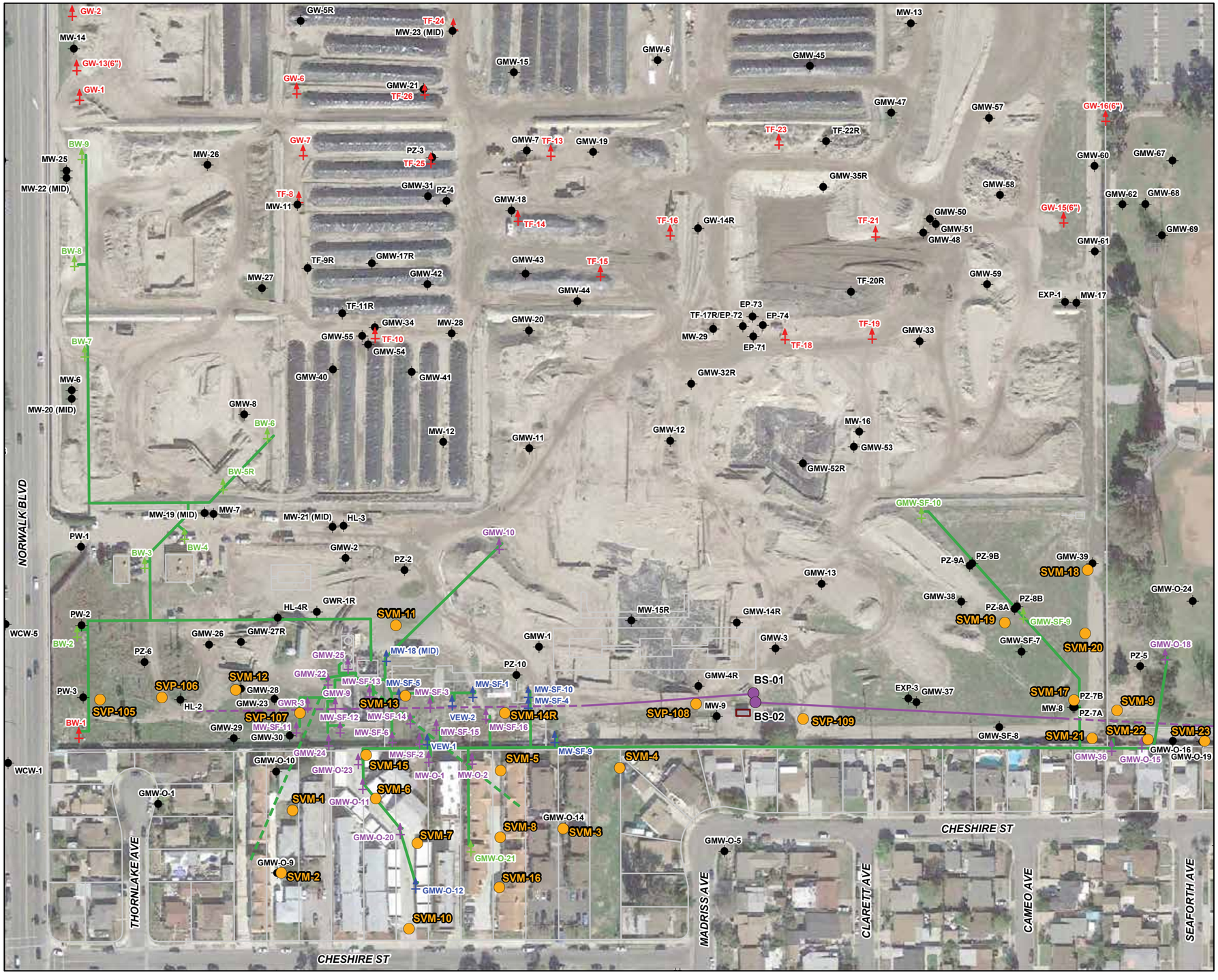

LEGEND

- Soil Vapor Probe/Soil Vapor Monitoring Probe
- Horizontal Biosparge Well Entry Point
- Existing Groundwater Monitoring Well
- Existing Remediation Well
- Kinder Morgan Combined Soil Vapor and Total Fluids Extraction Wells
- Kinder Morgan Soil Vapor Extraction Wells
- Kinder Morgan Total Fluids and/or Groundwater Extraction Wells
- Kinder Morgan Remediation Piping Layout (Above Ground and Below Ground)
- Horizontal Vapor Extraction Well Piping
- Horizontal Biosparge Well (Dashed Line Depicts Approximate Lateral Extent of Well Screen)
- Air Compressor System

Imagery Source:
Google Earth October 18, 2016.

N

0 75 150 300

Feet

1 inch = 150 feet

Figure 2. Remediation System Layout
SFPP Norwalk Pump Station
Norwalk, California

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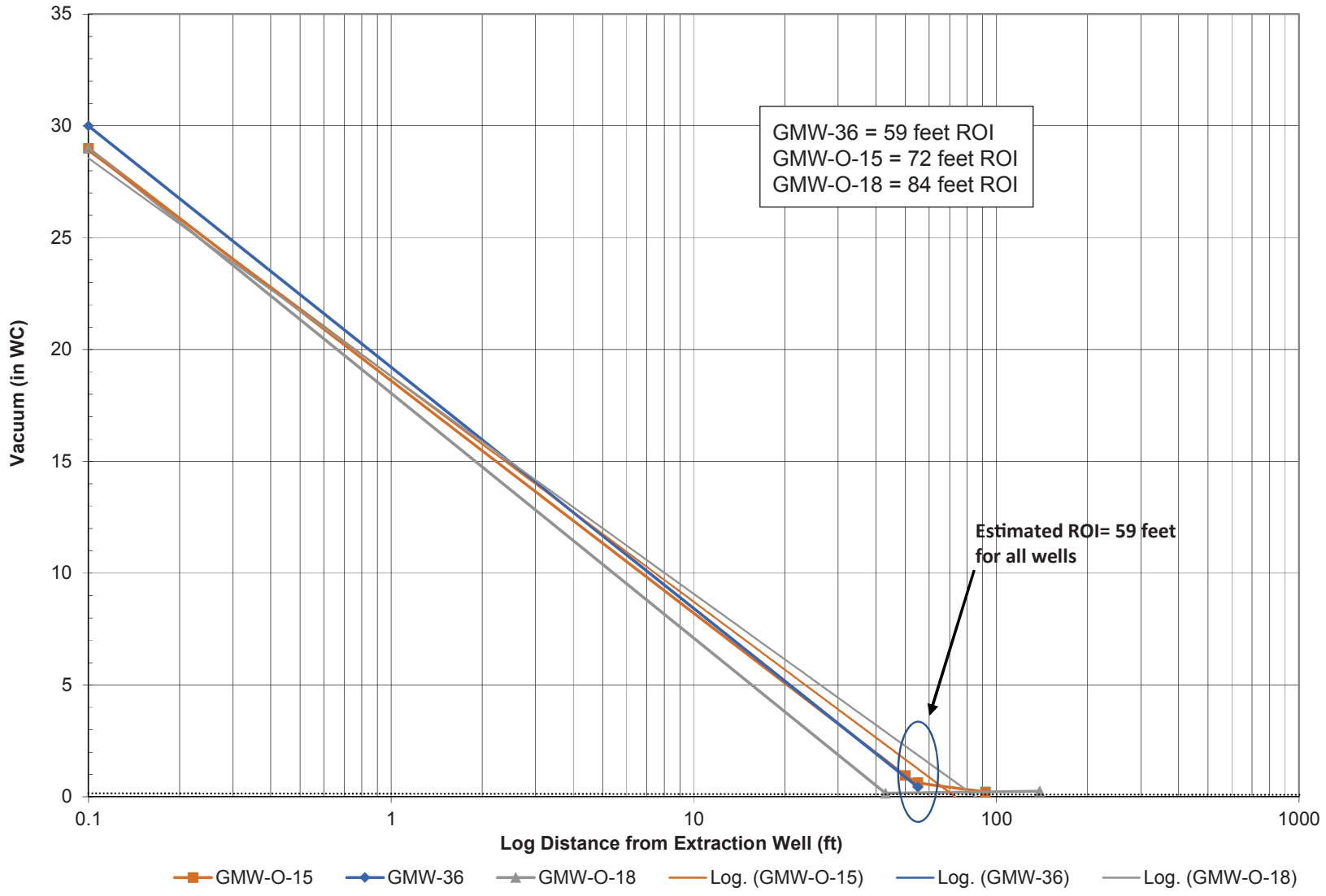
R:\ENBG\00_PROJ\K\KINDERMORGAN\NORWALK\MAPFILES\2018\FIGURE_2_REMEDIATION_SYSTEM_LAYOUT.MXD AESPEJO 2/15/2018



Note:
ROI - Radius of Influence
Trendline Equation for:
GMW-36: y = -4.685ln(x) + 19.213
GMW-O-15: y = -4.38ln(x) + 18.806
GMW-O-18: y = -4.229ln(x) + 18.816

Figure 3. Observed Radius of Influence
SFPP Norwalk Pump Station
Norwalk, California

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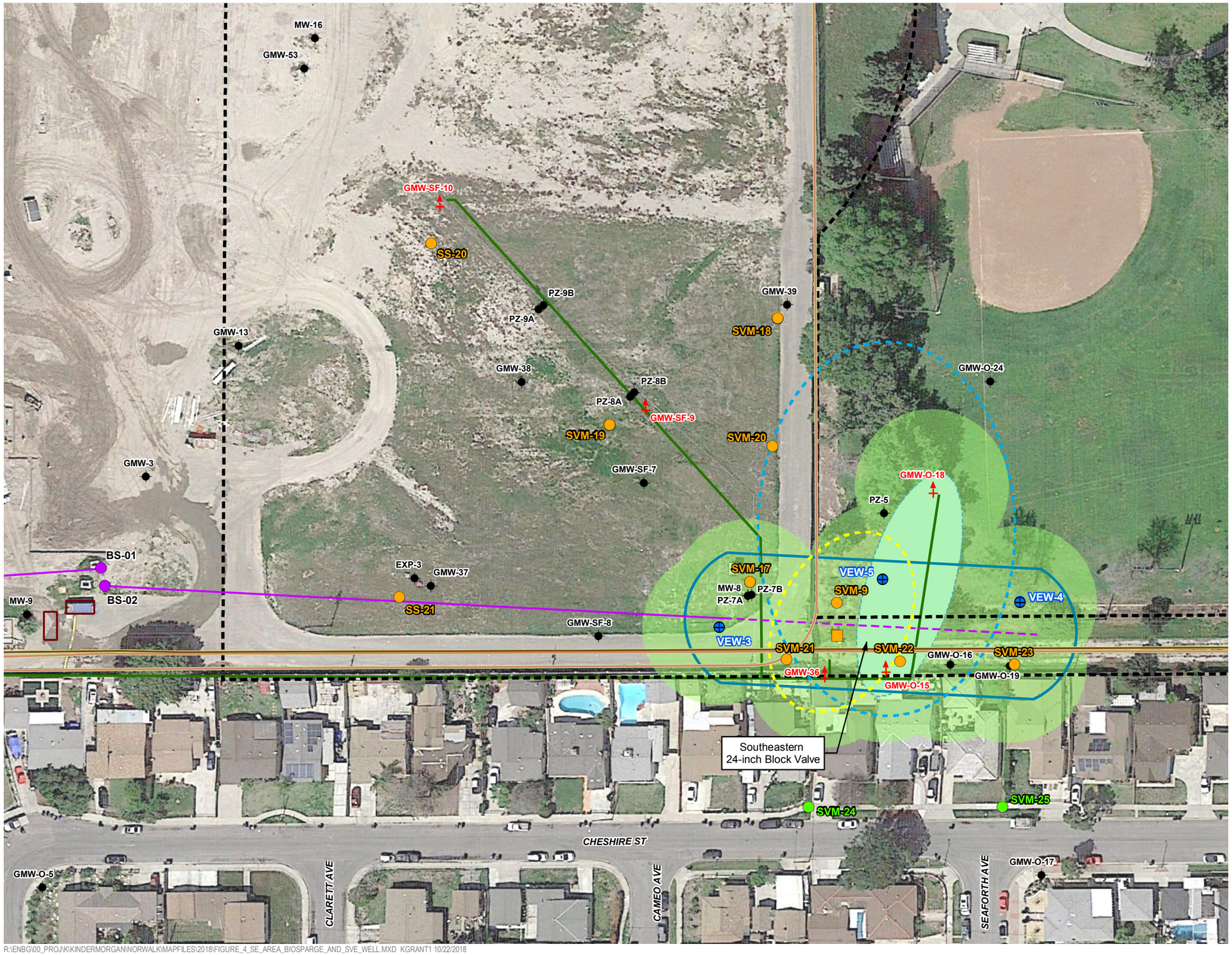
AX0828181154SCO



R:\ENBG\00_PROJ\K\KINDERMORGAN\NORWALK\MAPFILES\2018\FIGURE_4_SE_AREA_BIOSPARGE_AND_SVE_WELL.MXD KGRANT1 10/22/2018

LEGEND

- Proposed Soil Vapor Extraction Well Location
- Proposed Soil Vapor Monitoring Probe Location
- Horizontal Biosparge Well Entry Point
- Eastern Soil Vapor Monitoring Probe Location
- Estimated Location of Cathodic Protection Well
- Existing Groundwater Monitoring Well
- Existing Remediation Well
- KMEP Remediation Piping Layout (Above Ground and Below Ground)
- 16" Pipline (approximate)
- 24" Pipeline (approximate)
- Eastern 15-Acre Parcel Boundary
- Horizontal Biosparge Well (Dashed Line Depicts Approximate Lateral Extent of Well Screen)
- Approximate Extent of Dissolved Phase in Groundwater
- Inferred Historical Extent of LNAPL Zone (Smear Zone) from LNAPL Characterization Work Plan (AMEC Geomatrix, 2010)
- Estimated Extent of Measurable LNAPL on Groundwater. Based on April 2017 Semiannual Groundwater Monitoring Event. Dashed Where Inferred.
- Air Compressor System
- Estimated Zone of Influence
- Estimated Radius of Influence - 59 feet

Imagery Source:
Google Earth March 29, 2018.

N

0 37.5 75 150
Feet

1 inch = 75 feet

Figure 4. Southeastern Area Biosparge and Soil Vapor Extraction Well Location Map
SFPP Norwalk Pump Station
Norwalk, California

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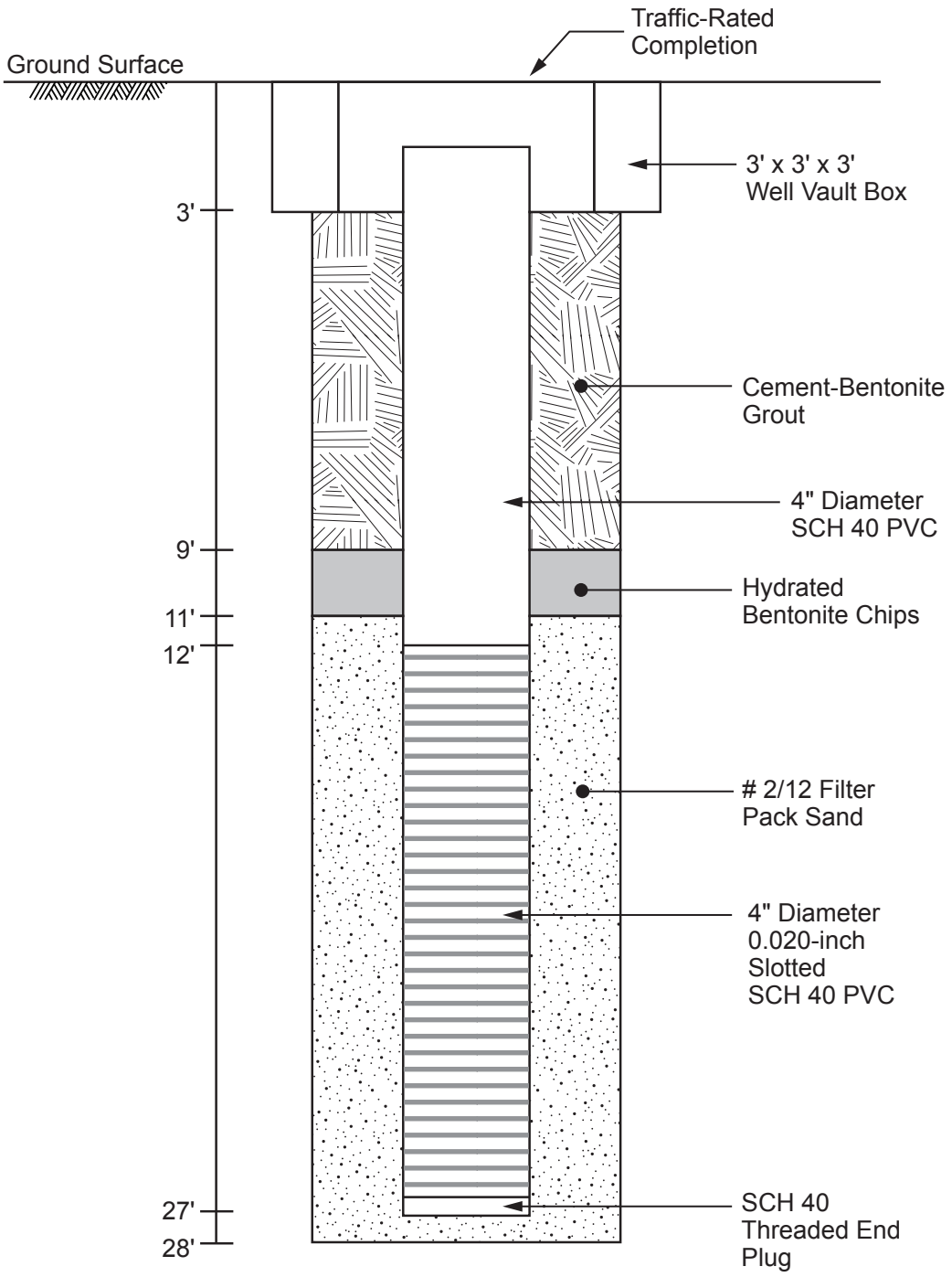

Not to Scale

Figure 5. Soil Vapor Extraction Well
SFPP Norwalk Pump Station
Norwalk, California

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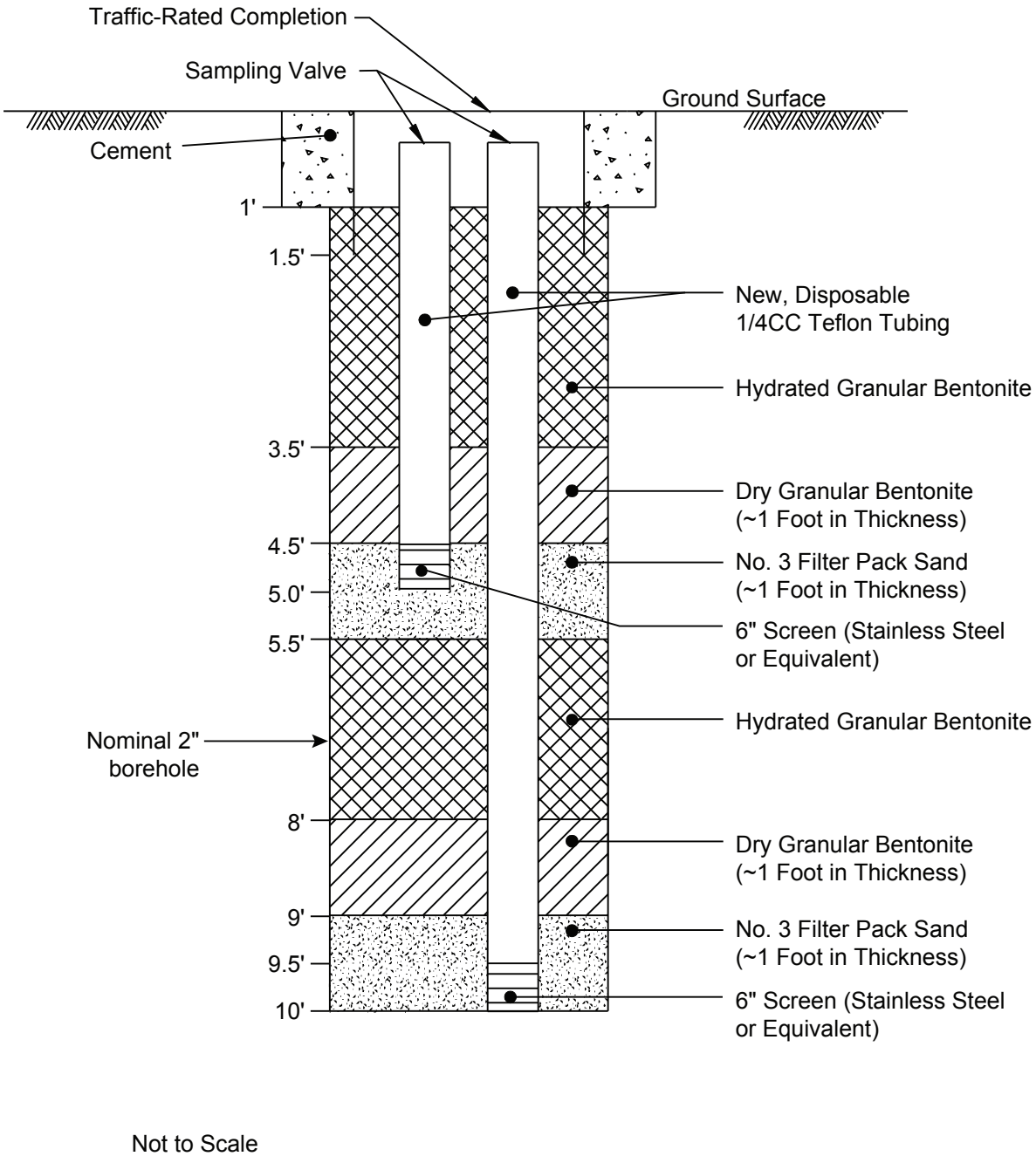


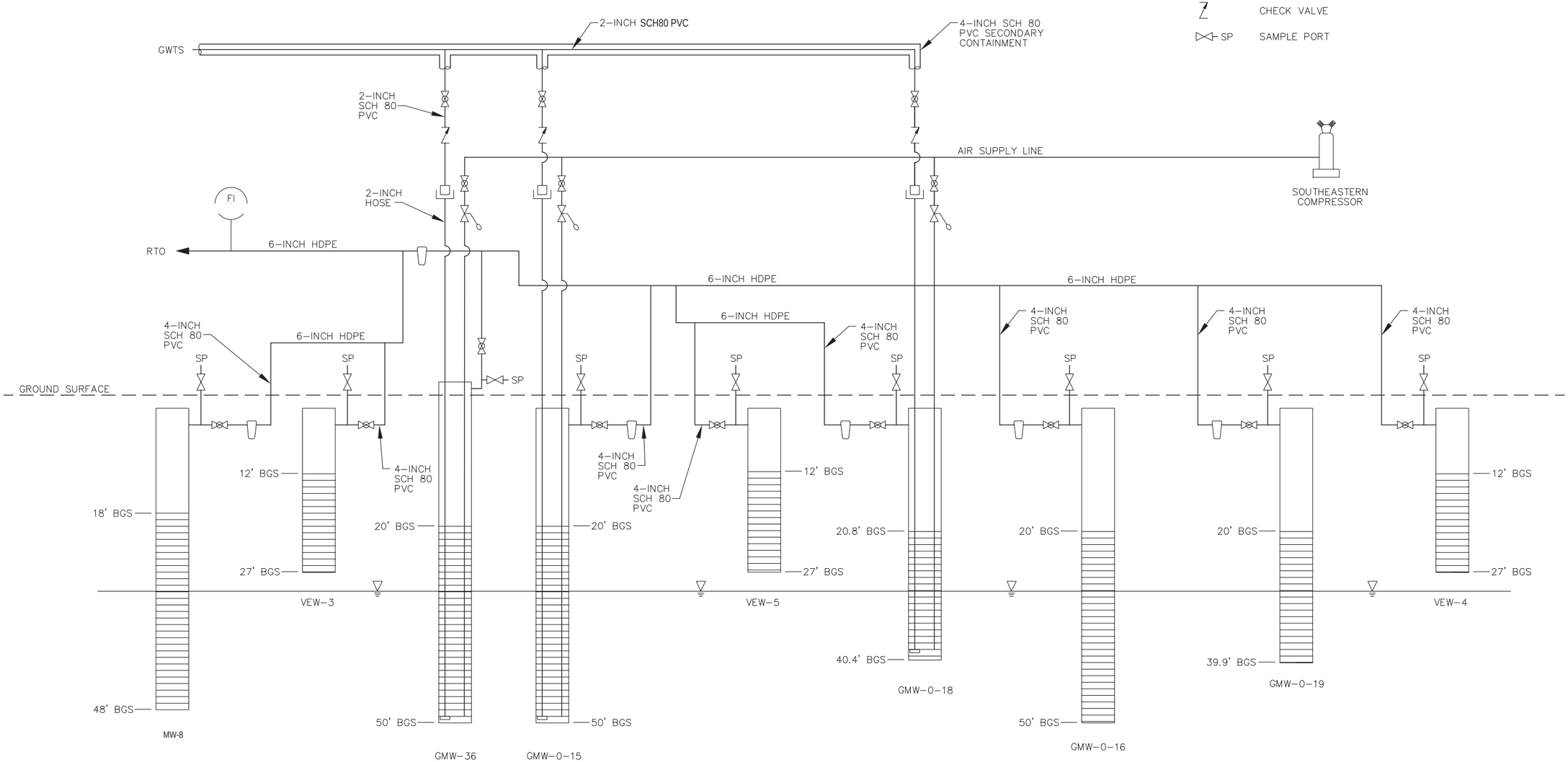
Not to Scale

Figure 6. Soil Vapor Monitoring Probe Completion Diagram
SFPP Norwalk Pump Station
Norwalk, California

Attachment A
Process Flow Diagram

LEGEND

39.9' BGS	FEET BELOW GROUND SURFACE
FI	DSD-300-6 FLOW SENSOR
	CONDENSATE COLLECTION
	BALL VALVE
	CAMLOCK CONNECTION
	FLOAT VALVE
	CHECK VALVE
SP	SAMPLE PORT



BID DRAWING

NO.	DESCRIPTION	DATE	DR	CHK	APVD
DSGN	REVISION		D. BAYLIS	XXX	APVD

BY APVD

2600 MICHELSON DRIVE, SUITE 500
IRVINE, CALIFORNIA 92612
PHONE: (949) 224-7500

SFPP NORWALK PUMP STATION
15306 NORWALK BOULEVARD
KINDER MORGAN, INC.
NORWALK, CALIFORNIA

JACOBS

PROCESS FLOW DIAGRAM

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	AUGUST 2018
PROJ	SFPP NORWALK
DWG	P-01
SHEET	4 of 8