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December 15, 2021

Mr. Cory Smith
Environmental Specialist Supervisor
New Mexico Oil Conservation Division
New Mexico Energy, Minerals, and Natural Resources Department
1220 South St. Francis Drive
Santa Fe, New Mexico 87505

Subject: **Updated Pilot Testing Report**
Hilcorp Energy Company
Scott 4M
API # 30-045-34887
Incident # NCE2003650476
San Juan County, New Mexico

To Whom It May Concern:

WSP USA Inc. (WSP), on behalf of Hilcorp Lower 48 (Hilcorp), presents this *Updated Pilot Testing Repot* associated with subsurface impacts encountered at the Scott 4M (Site; Figure 1), incident number NCE2003650476. Site characterization, release description and background, and initial response and assessment activities were included in the previously submitted *Remediation Work Plan* submitted by WSP on May 29, 2020, (PO Number O547T-200501-C-1410). Hilcorp submitted the *Update Report and Updated Remediation Work Plan* on October 6, 2021, in which WSP indicated that Hilcorp would provide a report of soil vapor extraction (SVE) pilot testing results and potential existing SVE system upgrades to New Mexico Oil Conservation Division (NMOCD) by December 15, 2021. The purpose of this report is to satisfy that requirement.

SVE PILOT TEST

On September 29, 2021, and December 3, 2021, WSP conducted SVE pilot testing activities at the Site. Results from the September 29, 2021, pilot testing event were included in the previously submitted *Update Report and Updated Remediation Work Plan* on October 6, 2021. The following sections describe the additional pilot testing activities conducted within the shallow interval on December 3, 2021.

Testing was conducted to evaluate the effectiveness of the remedial technology to achieve site remediation clean up goals by evaluating the flow rate and applied vacuum required to influence the subsurface and cause volatilization of the petroleum hydrocarbons entrained in the soil. The results were used to determine specific site design radius of influence (ROI) and radius of effect (ROE). The pilot testing program was designed based on previously observed geologic conditions, surface conditions, current locations of petroleum hydrocarbon impacts, and other site-specific factors. Two tests were performed to test SVE performance within the shallow interval (5 feet to 25 feet bgs) at SVE04 and SVE05.

SVE PILOT TEST PROCEDURES

A vacuum pump on a water hauling truck was used to apply a negative pressure to each of the pilot testing wells through a manifold designed and built by WSP to control the vacuum and measure flow, vacuum, and photo-ionization detector (PID) values at the extraction wells. For the first test, SVE05 was used as the pilot testing well and SVE04, SVE06, and SVE07 were used as observation wells to collect SVE pilot test monitoring data. For the second test, SVE04 was used as the pilot testing well and SVE05, SVE06, and SVE07 were used as observation wells. SVE04 and SVE05 have a screened interval of 5 feet to 25 feet bgs and observation wells SVE06 and SVE07 have a screened interval of 7 feet to 12 feet bgs. The SVE well locations are presented on Figure 2. The following list summarizes the steps involved in the SVE pilot tests:

- Measured the distances from the extraction test well to each observation well;
- Collected background volatile organic compound (VOCs) measurements using a PID at the SVE and observation wells;

- Connected the water truck vacuum pump to the extraction well via a flexible hose and manifold. Slowly opened the valve and monitored the vacuum and flow;
- Applied a vacuum ranging from approximately 20 inches of water column (IWC) to greater than 100 IWC at the designated SVE well for each test;
- Collected at least two rounds of stabilized measurements per vacuum/flow rate. Measured the vacuum and the PID headspace at the observation wells. Collected measurements 5 to 10 minutes apart.

All test forms and graphs are provided as Enclosure A.

SVE TEST RESULTS

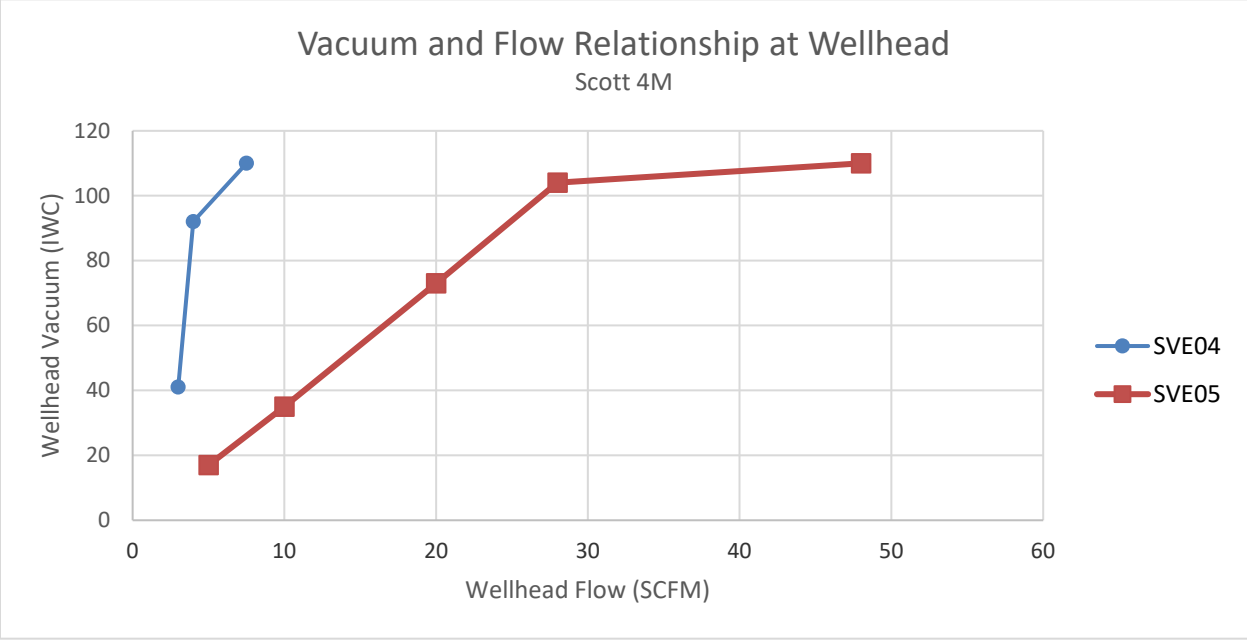
DEEP INTERVAL

Please refer to the results presented in the *Update Report and Updated Remediation Work Plan* submitted on October 6, 2021.

SHALLOW INTERVAL

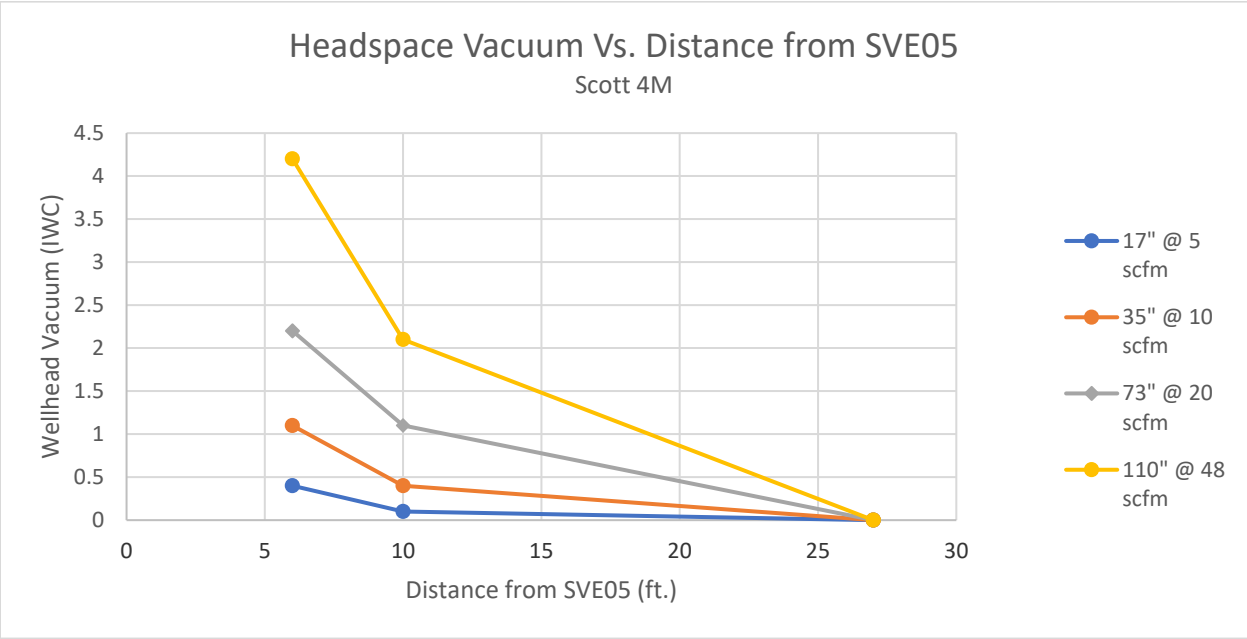
Observation wells SVE06 and SVE07 were 6 feet and 10 feet away from SVE05, respectively, for the first pilot test. Vacuum was observed in observation wells at 17 IWC applied at 5 Standard Cubic Feet per Minute (SCFM) in shallow pilot well SVE05. Observation wells SVE06 and SVE07 were 26 feet and 17 feet away from SVE04, respectively, for the second pilot test. Vacuum was not observed in the observation wells, at a maximum applied vacuum of approximately 125 IWC and a corresponding flow rate of 8 SCFM. SVE05 was able to produce 48 SCFM at the highest tested vacuum versus only 8 SCFM at the same applied vacuum in SVE04.

The graph below illustrates the vacuum and flow relationships observed in each of the pilot testing wells SVE04 and SVE05. The vacuum and flow relationship was not consistent between the two test wells. Less flow was achieved in SVE04 than SVE05 at the same applied vacuum. The geologic logs indicate similar lithology in both wells and the same screened interval. Without differing geologic profiles to explain the discrepancy, it appears the well completion may be the cause of the differential. SVE wells SVE03 and SVE04 were installed as nested wells, within the same borehole so there is also potential for vertical short-circuiting, or communication between the two wells, leading to the lack of observed flow and influence.



No measurable vacuum influence was observed at values greater than 110 IWC and 7.5 SCFM for the shallow pilot test on SVE04. This lack of influence may be due to the nested configuration of the wells as indicated above in the flow versus vacuum relationship observed for this well.

The graph below illustrates that vacuum was observed during pilot testing of shallow well SVE05. Vacuum influence observations were noted at all vacuums tested at distances of 6 feet and 10 feet from SVE05. No vacuum was observed at a distance of 27 feet, but from interpolation it can be determined that vacuum would have been observed at a distance between 10 feet and 27 feet. With a higher vacuum applied of 73 IWC, a radius of 20 feet could be assumed as a conservative estimate. The anticipated radius of influence is depicted on Figure 3.



The SVE pilot test results indicate that to influence the deeper wells, at a distance of 26 feet, a vacuum blower capable of at least 50 SCFM (per SVE well) at 77 IWC would be needed, as demonstrated and calculated in the previously submitted *Update Report and Updated Remediation Work Plan* on October 6, 2021. To treat the shallow impact at a distance of 20 feet, a vacuum blower capable of at least 20 SCFM (per SVE well) at 73 IWC would be needed. It is recommended to re-drill remediation well SVE04 as a singular well for full-scale operation. Pilot test data and calculations are included in Enclosure C.

SYSTEM UPGRADE RECOMMENDATION

The pilot test to evaluate SVE application for impacted soil showed that SVE is a viable technology to remediate both the shallow and deep impacted intervals of the subsurface (surface to 45 feet bgs).

There is vacuum influence in the deeper interval, but an upgrade to a vacuum blower capable of 50 SCFM per SVE well at 77 IWC should be considered to fully address VOCs entrained to soil particles at depth with the current SVE well configuration.

Vacuum influence was also observed in the shallow interval, but an upgrade to a blower capable of 20 SCFM per SVE well at 73 IWC should be considered to fully address shallow impacts. Calculations indicate the ROE would be adequate at this distance and flow. An annual pore volume exchange rate of 2,091 was calculated, which is above industry recommended greater than 500 and a pore velocity of 57 ft/day was calculated, which is above the industry recommended more than 3 ft/day.

The existing solar SVE system is successfully reducing petroleum impact, having removed almost 2 tons of vapor phase petroleum since initiation of operation. Comparing the known extent of impact relative to the location of SVE01, an ROI of approximately 16 feet is believed to be adequate to volatilize the known impact. The existing solar unit is influencing at least a portion of this area, but a definitive ROI is not available using existing monitoring locations. The existing blower, if operating on a single well at 10 SCFM and an estimated ROI of 16 feet has a calculated pore velocity of 16 ft/day, and annual air exchange of 726 pore volumes assuming the entire 45-foot vertical column is influenced. The theoretical calculation indicates the solar SVE system could be adequate in terms of volume of air

exchanged; however, the applied vacuum required to initiate influence during the pilot test indicates a higher vacuum blower may be required, with shallow screened SVE wells in the impacted area.

REMEDIATION TIMELINE

The US Army Corps of Engineers, *Soil Vapor Extraction and Bioventing – Engineer Manual,* dated June 3, 2002, states "Unless target cleanup goals are low or initial concentrations are very high, 1,000 to 1,500 pore volumes would be a good estimate of the required air exchanges." An adequately sized system can achieve 1,500 pore volume exchanges after 4 months of operation.

One strategy would be to divide the Site into several zones to reduce the flow requirements of the system and remediate each zone for a 4-month period. With 4 zones the remediation timeframe would be estimated to be 16 months. WSP will assess blower size, power options, and system configuration to further determine remediation timeframe following any additional system alterations. The SVE system will remain at the Site full time until remediation is complete.

The following timeline is proposed following submittal of this report:

- 2nd Quarter 2022: apply any upgrades to system design to achieve required flow and vacuum levels. This proposed timeline and system upgrades may be subject to equipment availability and manufacturer timeframes. The existing solar SVE system will remain in operation until that time.
- 4th Quarter 2021 through 4th Quarter 2022: Collect air samples quarterly. Once air concentrations of TVPH collected from the system become asymptotic, soil samples will be collected from the impacted area to collect soil performance samples and assess soil concentrations.
- 4th Quarter 2022: If air concentrations of TVPH have not become asymptotic, collect soil samples for performance monitoring. Evaluate soil samples and make potential SVE system adjustments;
- 1st Quarter 2023: Final site closure

Air emissions data, mass removal calculations, and system runtime will be reported quarterly. The first quarterly report (starting with the fourth quarter of 2021) will be submitted to the NMOCD within 45 days after final laboratory analytical reports are received.

Kind regards,

Josh Adams, P.G.
Associate Consultant, Geologist

Ashley Ager, M.S., P.G.
Assistant Vice President, Geologist

Robert Rebel, P.E.
Technical Principal, Lead Consultant

Figure 1 – Site Location Map
Figure 2 – As-Built Diagram
Figure 3 – Shallow Zone Estimated ROI and ROE
Enclosure A – Pilot Test Forms and Graphs

REFERENCES CITED

DiGiulio, D., Ravi, V., & Brusseau, M. (1999). Evaluation of mass flux to and from ground water using a vertical flux model (VFLUX): application to the soil vacuum extraction closure problem. Ground water monitoring & remediation, 19, 96-104. doi: 10.1111/j.1745-6592.1999.tb00210.x

The US Army Corps of Engineers, *Soil Vapor Extraction and Bioventing – Engineer Manual,* dated June 3, 2002

FIGURES

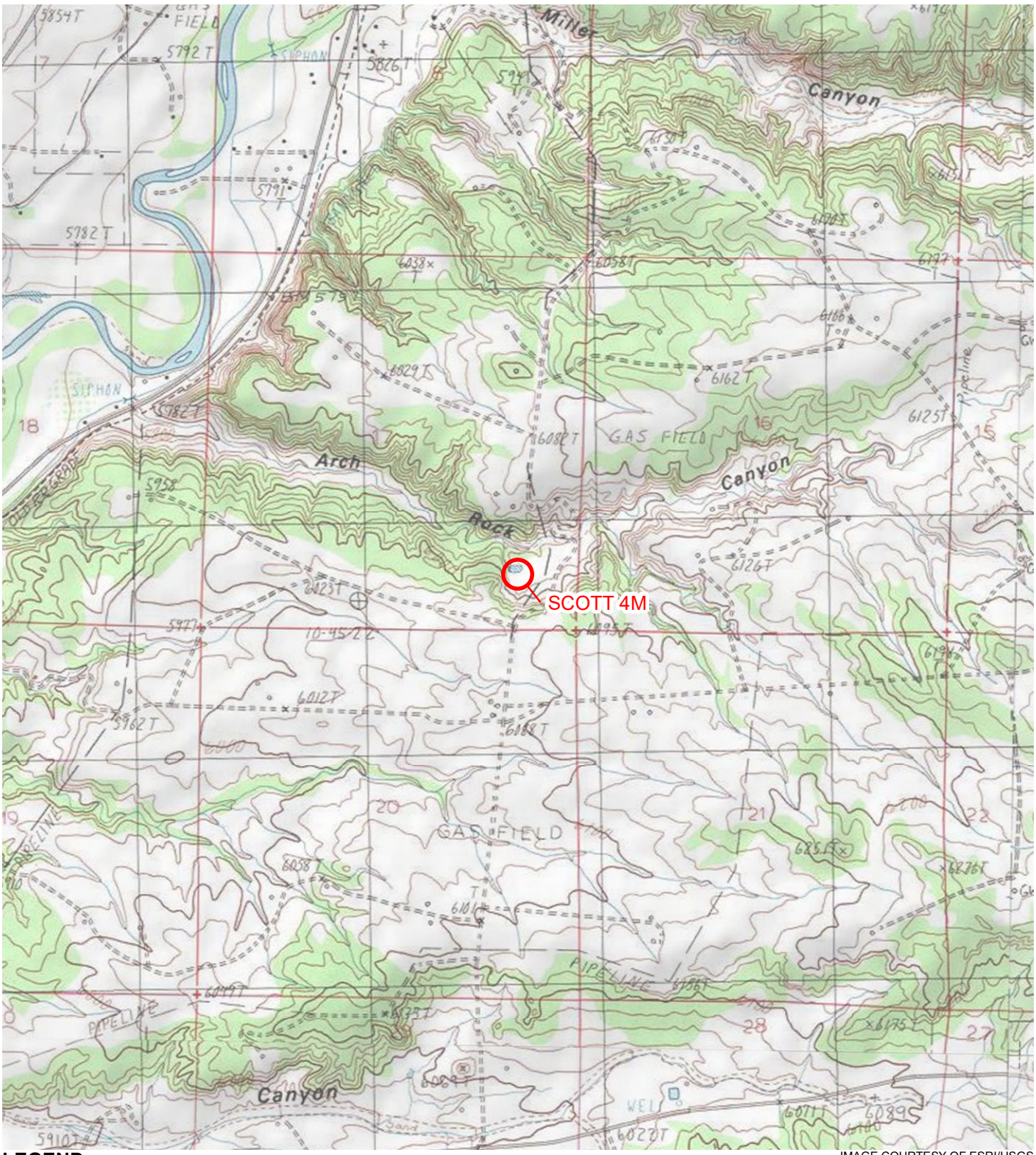


IMAGE COURTESY OF ESRI/USGS

LEGEND

SITE LOCATION

0 2,000 4,000

Feet

N

NEW MEXICO

FIGURE 1
SITE LOCATION MAP
SCOTT 4M
UNIT P SEC 17-T31N-R10W
SAN JUAN COUNTY, NEW MEXICO
HILCORP ENERGY COMPANY

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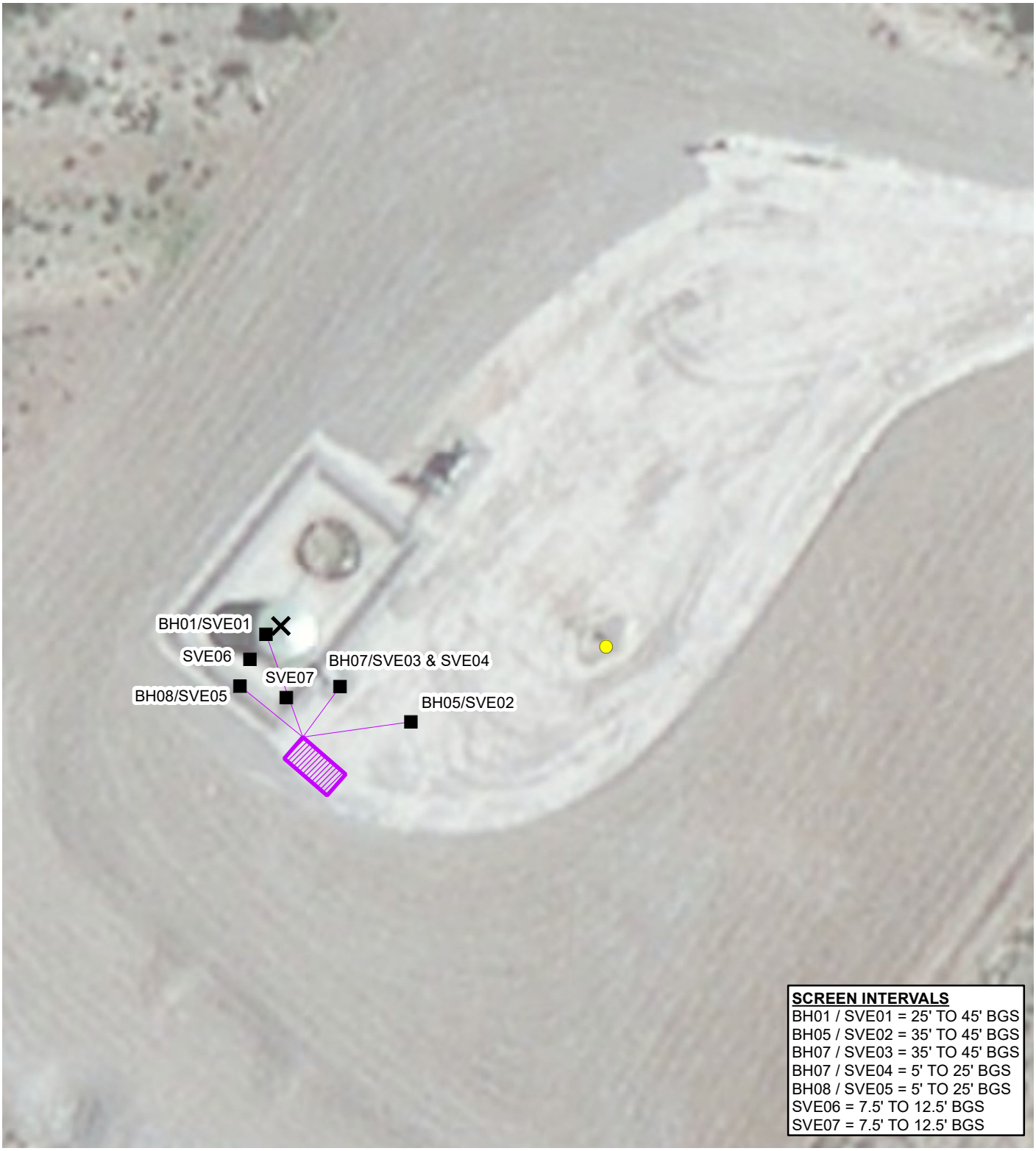

LEGEND

- RELEASE LOCATION
- SVE WELL
- WELLHEAD
- REMEDIATION SYSTEM PIPING
- SOLAR SVE SKID

0 40 80
Feet

N

BGS: BELOW GROUND SURFACE
SVE: SOIL VAPOR EXTRACTION

FIGURE 2
AS-BUILT DIAGRAM
SCOTT 4M
SESE SEC 17-T31N-R10W
SAN JUAN COUNTY, NEW MEXICO
HILCORP ENERGY COMPANY

wsp

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FIGURE 3
SHALLOW ZONE ESTIMATED ROI AND ROE
SCOTT 4M
SESE SEC 17-T31N-R10W
SAN JUAN COUNTY, NEW MEXICO
HILCORP ENERGY COMPANY

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ENCLOSURE A – PILOT TEST FORMS AND GRAPHS

ENCLOSURE A

SOIL VAPOR EXTRACTION PILOT TEST
SCOTT 4M

HILCORP ENERGY COMPANY

Date : 12/3/2021 Test Well Diam. 2"

Extraction Test Well
SVE05

Pilot Test Extraction Well					Observation Wells			Observation Wells		
Time	Wellhead Vacuum (in. wc)	Wellhead Vacuum (in. Hg)	Well Flow (scfm)	PID at Stack (ppm)	**SVE06**	**SVE07**	**SVE04**	**SVE06**	**SVE07**	**SVE04**
					Distance From Test Well (feet)			Distance From Test Well (feet)		
					6	**10**	**27**	**6**	**10**	**27**
					Vacuum (in. wc)			PID Measurement (ppm)		
8:05	0.0	0.0			0.0	0.0	0.0	8.7	0.0	0.0
9:55	17	1.3	5	108	0.4	0.2	0.0			
10:00	17.3	1.3	5	136	0.4	0.1	0.0			
10:05	17.2	1.3	5	173	0.4	0.1	0.0			
10:10	35.54	2.6	10	169	1.0	0.4	0.0			
10:15	35.9	2.6	10	198	1.1	0.4	0.0			
10:20	35.9	2.6	10	209	1.1	0.4	0.0			
10:25	73.2	5.4	20	215	2.2	1.1	0.0			
10:30	73.6	5.4	20	231	2.3	1.0	0.0			
10:35	73	5.4	20		2.2	1.1	0.0			
10:40	104.8	7.7	28	213	3.0	1.5	0.0			
10:45	104.7	7.7	28	220	3.0	1.5	0.0			
10:50	>110	>8	48		4.2	2.1	0.0			

Notes:
ND - not detected
in. wc - inches of water column
in. Hg - inches of mercury
ppm - parts per million
PID - photoionization detector
fpm - feet per minute
scfm - standard cubic feet per minute
NM - not measured

RADIUS OF EFFECT CALCULATIONS

SOIL VAPOR EXTRACTION PILOT TEST
SCOTT 4M
HILCORP ENERGY COMPANY

Site Specific Information

Test Well	SVE05		
SVE Screen Length (H)	20	ft	
Soil Type	sandy silt		
Porosity (n)	20%	percent	

Test Specific Information

Radius of Influence (ROI)	20		
Flow Rate	20	SCFM	(maximum measured flow)
Wellhead Vacuum	73	IWC	

Calculations

Total Volume (ft^3)	25,133	= PI * ROI * ROI * H
Volume Pore Space (ft^3)	5,027	= Total Volume * n
Pore Volume Exchange Rate	0.17	days
Annual Pore Volume Exchanges	2,091	>500 Required
Velocity at ROI (ft/min)	0.040	= Flowrate/(2*PI * ROI* H * n)
Velocity at ROI (ft/day)	57	> 3 ft/day recommended

Conclusions

Vacuum influence was observed at 10 feet but not at a distance of 27 feet. From interpolation it can be assumed that vacuum would have been observed at 20 feet at a wellhead vacuum of 73 IWC. Assuming a radius of influence (ROI) of 20 feet, the radius of effect (ROE) was evaluated using annual pore volume exchange and velocity, both of these are within established guidance values.

Notes:

*Current SVE Research indicates that is it desirable to achieve pore-gas velocities throughout the treatment zone in excess of 0.001 cm/sec or ~3 ft/day (DiGiulo and Ravi 1999)
ft - feet
ROI - radius of influence
IWC - inches water column
min - minute
s - second
SCFM - standard cubic feet per minute

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State of New Mexico
Energy, Minerals and Natural Resources
Oil Conservation Division
1220 S. St Francis Dr.
Santa Fe, NM 87505

CONDITIONS

Action 67317

CONDITIONS

Operator:	OGRID:
HILCORP ENERGY COMPANY 1111 Travis Street Houston, TX 77002	372171
	Action Number: 67317
	Action Type: [UF-GWA] Ground Water Abatement (GROUND WATER ABATEMENT)

CONDITIONS

Created By	Condition	Condition Date
nvelez	Accepted for the record. See App ID 124691 for most updated status.	10/3/2022