GW - 28

PILOT STUDY
UIC CLASS V
WELL

2019

December 13, 2019

Mr. John E. Kieling, Chief
Hazardous Waste Bureau
New Mexico Environment Department
2905 Rodeo Park Drive East, Building 1
Santa Fe, New Mexico 87505

Re: Response to Comments to the July 22, 2019 Letter of Disapproval, *Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements: Reinjection Pilot Test Work Plan*
HollyFrontier Navajo Refining LLC, Artesia Refinery
EPA ID No. NMD048918817
HWB-NRC-19-002

Dear Mr. Kieling:

This letter provides responses to the New Mexico Environment Department (NMED) letter dated July 22, 2019, regarding the April 2019 *Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements: Reinjection Pilot Test Work Plan* (Work Plan). HollyFrontier Navajo Refining LLC (HFNR) appreciates the dialogue with NMED on July 30, 2019, October 3, 2019, and November 4, 2019 to discuss the NMED's July 22, 2019 comments and clarify the objectives and assumptions of the Pilot Test. Based on these discussions, provided below are HFNR's response to each of NMED's July 22, 2019 comments (shown in *italics*).

RESPONSE TO NMED COMMENTS

<u>Comment 1</u>

The groundwater at the East Field is contaminated above the injection criteria established by NMED and Energy Minerals and Natural Resource Department Oil Conservation Division (OCD). It will be difficult to verify the effectiveness of the proposed in-situ treatment with only the proposed method, even if the constituents of concern (COCs) concentrations are reduced in-situ, it will be difficult to distinguish whether the reduction is caused by biodegradation or dilution. NMED is concerned that it may not be possible to achieve the injection criteria with the proposed in-situ bioremediation alone. The use of the proposed in-situ treatment with an aboveground treatment system (e.g., air stripper with granulated activated carbon (GAC)) would achieve the required standards and generate measurable and quantifiable data to demonstrate this. The Permittee must consider additional measures to ensure the treated groundwater will meet the injection criteria.

Response 1

HFNR understands that NMED is accepting of reinjecting extracted groundwater without ex-situ treatment other than the removal of phase-separated hydrocarbons (PSH), if present, and the addition of amendments (terminal electron acceptors) to promote in situ enhanced anaerobic bioremediation (EAB).

The stated intent of the Recovery System upgrades is to control migration of dissolved-phase impacts and PSH prior to leaving HFNR's property and to eventually stop PSH migration while allowing natural processes (i.e., natural attenuation and biodegradation) to remediate the remaining dissolved-phase hydrocarbons. The Pilot Test system selected was based on the HFNR team's experience at similar facilities with similar types of constituents and similar hydrogeologic conditions.

HFNR met with NMED and OCD representatives on multiple occasions in 2018 (as summarized in Section 2.2 of the Work Plan) and provided written documentation of regulations pertaining to groundwater reinjection on November 15, 2018. Per those discussions and correspondence, NMED and OCD agreed that treatment to regulatory levels is not required per RCRA section 3020(b), which New Mexico adopted in 20.6.2.5004A(3)(b) NMAC, since:

- It will be implemented as an Interim Measure as part of the refinery's RCRA corrective action program intended to help clean up contamination.
- The contaminated groundwater will be treated (removal of PSH and addition of terminal electron acceptors) to substantially reduce hazardous constituents prior to such reinjection, though the reduction will occur in situ as allowed by EPA and state law.
- It will protect human health and the environment through hydraulic control and reduction of contaminant levels, in conjunction with the lack of exposure pathways given that the area is within refinery property and the water-bearing zone is not a source of drinking water.

Enclosed with this letter are two case studies (Attachment A) for other refineries in West Virginia where reinjection of sulfate-amended water was used to reduce dissolved-phase hydrocarbon concentrations in situ to below regulatory levels. An overview of EAB and sulfate reduction is provided at the beginning of Case Study 1 in Attachment A. As shown on the table provided on page 3 of Case Study 1, sulfate is an effective electron acceptor for anaerobic degradation of elevated dissolved hydrocarbon concentrations (e.g., benzene) with limited potential complications compared to other electron acceptors. The use of sulfate amendments to increase the rate of anaerobic degradation of hydrocarbons in situ is well understood and proven to be successful as demonstrated by the case studies provided.

Regarding the statement, "It will be difficult to verify the effectiveness of the proposed in-situ treatment with only the proposed method, even if the constituents of concern (COCs) concentrations are reduced in-situ, it will be difficult to distinguish whether the reduction is caused by biodegradation or dilution," HFNR provides the following further explanation: groundwater that is extracted will be contained within a closed-loop system with no ex situ treatment other than removal of PSH (if present) and addition of the amendments (terminal electron acceptors). Thus, the water that is reinjected will have a similar concentration of dissolved hydrocarbons as the groundwater extracted from the formation. Any reduction in dissolved hydrocarbon concentrations can only be attributable to additional in situ degradation due to increased SRB activity as confirmed by the sampling program proposed in the Work Plan.

Also with respect to the statement, "The use of the proposed in-situ treatment with an aboveground treatment system (e.g., air stripper with granulated activated carbon (GAC)) would achieve the required standards and generate measurable and quantifiable data to demonstrate this," HFNR offers the following: the intent of the pilot study is to maintain anaerobic conditions in the aquifer, and to maintain that condition in the above-ground section of the closed-loop system. If the recirculated water is treated ex-situ as suggested, it will not be compatible with the anaerobic degradation approach and, in addition, the aerated water would swiftly foul injection wells and the formation without further chemical amendment. The recirculation system proposed in the Work Plan was designed to minimize any change to the redox condition of the recirculated water.

Comment 2

In Section 3.3.1 (Shallow Saturated Zone), page 8, paragraph 3, the Permittee states, "[c]oncentrations of total dissolved solids (TDS) exceeding 2,000 milligrams per liter (mg/L) and sulfate exceeding 500 mg/L have been recorded northwest (upgradient) of the Refinery." The TDS and sulfate concentrations in the groundwater samples collected from most of the wells installed in the shallow saturated zone significantly exceed the referenced concentrations in the area. For example, the TDS and sulfate concentrations in the groundwater sample collected from upgradient well UG-4 are recorded as 4,030 mg/L and 2,680 mg/L, respectively, during the April 2018 sampling event according to the 2018 Annual Groundwater Monitoring Report. Although the statement is correct, the referenced concentrations are somewhat misleading because it suggests that most of the concentrations are in close approximation to the referenced concentrations. In the revised Work Plan, clarify that a majority of the wells referenced in the northwest (upgradient) in the Refinery significantly exceed the range of concentrations provided.

Response 2

HFNR revised the range provided in the text to match the available data for the Shallow Saturated Zone and to note that the concentrations significantly exceed the Water Quality Control Commission (WQCC) standards.

<u>Comment 3</u>

In Section 3.3.2 (Valley Fill Zone), page 9, paragraph 1, the Permittee states, "[w]ells in the valley fill zone range from 40 to 60 feet bgs and the formation yields water containing TDS ranging from 500 to 1,500 mg/L." The TDS concentrations in groundwater samples collected from well MW-18B installed in the valley fill zone were recorded as being above 4,000 mg/L since 2013, exceeding the referenced range according to the 2018 Annual Groundwater Monitoring Report, submitted in February 2019. Revise the Work Plan to clarify that some wells significantly exceed the range of concentrations provided.

<u>Response 3</u>

HFNR revised the range provided in the text to match the available data for TDS in the Valley Fill Zone. Note monitoring well MW-18B is located along the eastern boundary of the Evaporation Pond and is not representative of conditions beneath the refinery.

<u>Comment 4</u>

In Section 3.3.3 (Deep Artesian Aquifer), page 9, paragraph 3, the Permittee states, "[a]vailable well completion records for irrigation well RA-4798 indicate that it is screened in the deep artesian aquifer from 840 to 850 feet bgs. Historic analytical data from this well does not indicate the presence of hydrocarbon impacts from Refinery operations." The statement is not accurate. MTBE has been detected from well RA-4798 since 2016 according to the 2018 Annual Groundwater Monitoring Report. Revise the Work Plan for accuracy.

<u>Response 4</u>

HFNR submitted the report titled *Evaluation of Methyl Tert-Butyl Ether (MTBE) in Groundwater* on September 13, 2019. The report included a summary of historical use and storage of MTBE at the Refinery and provided a more detailed summary of MTBE detections in wells near the Refinery including supporting data. Based on that data, HFNR does not believe that the MTBE detected in RA-4798 can be conclusively attributed to historic refinery operations. No other dissolved volatile organic compounds (VOCs) have been detected in groundwater samples collected from RA-4798. Because MTBE is more recalcitrant and mobile than other VOCs, there are numerous potential sources of MTBE upgradient of RA-4798 in addition to the Refinery that may be the source of the detected concentrations.

HFNR revised Section 3.3.3, page 9, paragraph 3 to state, “Analytical data from this well does not indicate the presence of hydrocarbon impacts from Refinery operations. MTBE has been detected in RA-4798 at levels below the WQCC standard, but these detections cannot be attributed to historical Refinery operations based on all available data.”

Comment 5

Section 4.1 (Test Location), page 10, paragraph 1 states that "[t]o test recovery and injection efficiency in areas that are representative of the conditions that will be addressed by the full scale system, HFNR is planning to perform that pilot test in the East field near existing wells KWB-5 and MW-131. The area around these wells [KWB-5 and MW-131] contains PSH and dissolved-phase constituents at concentrations of the same magnitude or higher than what is expected to be recovered by the enhanced recovery system." In the revised Work Plan, address the following:

a. *NMED is concerned that the proposed Pilot Test wells KWB-5 and MW-131 may not be representative of conditions where the full-scale system is proposed (i.e., at the Eastern Boundary and East Field) to be installed. COC analytical groundwater data in the proposed Pilot Test wells are lower than the groundwater analytical results in the groundwater monitoring wells at the eastern refinery boundary. The difference is significant enough that the results from the Pilot Test may skew the design of the full scale system and may not translate to wells with significantly higher contaminant concentrations. In the revised Work Plan discuss the conditions in the proposed Pilot Test area compared to the eastern refinery boundary area and discuss how the Pilot Test results are expected to scale up.*

b. *The sulfate level in well MW-131 was recorded as 15.5 mg/L during the October 2017 sampling event, which is exceptionally low compared to the rest of the wells in the vicinity: therefore, it is not representative of site conditions. The low groundwater sulfate level in the Pilot Test location is misleading and may overstate success and a possibly false demonstration of the injection criteria being met by the proposed amendment in a full-scale system. If sulfate reducing bacteria (SRB) are present in the aquifer and favorable conditions are met, the sulfate groundwater concentrations in the East Field generally exceed the theoretical demands required to reduce all organic constituent concentrations below the screening levels. Since the injection fluid for the full-scale system will be a mixture of groundwater extracted from the trenches at Bolton Road, the sulfate level in the injection fluid of the full-scale system will likely exceed the required sulfate demand. Sulfate is abundant at the site; therefore, amending the system with sulfate does not appear to be necessary to attain the injection criteria. Provide more discussion for the basis of the proposed sulfate biostimulation and how it will help to attain the injection criteria in the revised Work Plan.*

Response 5

a. Based on discussions with the NMED and OCD during the October 3, 2019 meeting, and a subsequent conference call with NMED on November 4, 2019, HFNR proposes moving one of the Pilot Test locations from near KWB-5 to near RW-19 as described in the revised Work Plan. The Pilot Test location near RW-19 is within the East Field adjacent to the Refinery eastern fence line. Regarding the statement, "COC analytical groundwater data in the proposed Pilot Test wells are lower than the groundwater analytical results in the groundwater monitoring wells at the eastern refinery boundary," HFNR notes the following: benzene concentrations in the East Field are greater than those in wells located further downgradient along the refinery boundary (i.e., along Bolton Road), as shown on the attached benzene isoconcentration map[1] (Figure 1). The refinery property boundary extends to the east of the main refinery plant and fence line as shown on Figures 1 and 2. The proposed Pilot Test areas are representative of the overall conditions across the dissolved hydrocarbon plume.

The Pilot Test results should provide a range of sulfate concentrations that are effective in enhancing SRB activity and reducing hydrocarbon concentrations. As hydrocarbon impacts are similar throughout the dissolved phase plume, these results can be used in the design and operation of the full-scale system. The Pilot Study is intended to demonstrate reduction in hydrocarbon concentrations while maintaining sulfate concentrations at 500 mg/L, which is the initial target sulfate demand based on the HFNR team's experience at similar sites. Target concentrations for the full-scale system will be based on the results of the Pilot Test but are expected to be similar to the initial target concentration of the Pilot Test. The actual amount of sulfate amendment in the full-scale system will also be adjusted based on actual conditions observed during operation of the system. The remedial timeframe may vary as it will be proportional to the mass of hydrocarbons in the targeted zone.

b. Regarding the perspective that sulfate concentrations in MW-131 are "exceptionally low compared to other wells in the vicinity," HFNR provides the following further information: sulfate concentrations are depressed within the dissolved hydrocarbon plume across the southern refinery, as shown on Figure 2. Historical sulfate concentrations in wells MW-48, MW-64, MW-65, MW-66, MW-102, MW-107, KWB-5, KWB-10R, and RW-15C are generally consistent with or less than the noted sulfate concentrations in MW-131 as shown on Figures 2 and 3. Further, sulfate has either not been detected or detected at low estimated J-flag concentrations in some of these wells during recent groundwater monitoring events.

Sulfate concentrations are significantly lower in wells with dissolved hydrocarbon impacts across the East Field compared to other site wells with no dissolved hydrocarbon

[1] Benzene is representative of the dissolved hydrocarbons in the Shallow Saturated Zone because it is the most prevalent dissolved hydrocarbon in shallow groundwater beneath and downgradient of the refinery property. Other dissolved hydrocarbons present in the Shallow Saturated Zone have a similar distribution to dissolved benzene but smaller lateral extent. TPH DRO and GRO are present in shallow groundwater upgradient, crossgradient, and downgradient of the Facility. Naphthalene was used as an indicator compound for TPH DRO and GRO and demonstrated a smaller lateral extent than benzene.

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impacts as shown on Figures 1 and 2. While not a direct measurement, the inverse correlation of sulfate and dissolved benzene concentrations shown on these figures is a primary line of evidence that SRB are actively degrading the hydrocarbon plume in the East Field, and that more robust degradation is limited by the depressed sulfate concentrations within these areas. The addition of sulfate will stimulate additional SRB activity, which will increase the hydrocarbon attenuation and desorption rates. In typical unconsolidated aquifers the majority of the hydrocarbon mass is adsorbed to the soil. The provided case studies show the initial response to sulfate addition is an increase in dissolved hydrocarbon concentrations that is associated with SRBs actively desorbing hydrocarbons (substrate) from the formation matrix as these microbes live on the outside of soil particles near adsorbed hydrocarbons. The desorbed hydrocarbons are then degraded in the dissolved-phase. This process demonstrates how the proposed biostimulation is more efficient in reducing hydrocarbon concentrations by increasing the bioavailability of electron acceptors to the adsorbed hydrocarbons in an aquifer than traditional “pump and treat” and in situ chemical oxidation (ISCO) processes that only rely on solubility of the individual hydrocarbon compounds to address the adsorbed hydrocarbons.

The Pilot Test is intended to be a controlled study that will demonstrate the applicability and effectiveness of EAB of hydrocarbons in the Shallow Saturated Zone (i.e., proof of concept). The design and layout of the full-scale system will be reviewed and modified as necessary based on the results of the Pilot Test. The Pilot Test results will also be used to estimate sulfate nutrient demand and remedial timeframes of the full-scale system. The use of a mixture of groundwater from the East Field and Bolton Road in the full-scale system would involve adjusting the amendment dosing throughout operation to ensure sulfate is present throughout the targeted formation (initial goal is to maintain approximately 500 mg/L in targeted formation but will be adjusted based on estimated sulfate demand). The sulfate demand is expected to decrease over time as the relative concentrations of the more degradable hydrocarbon compounds (e.g., BTEX) decrease with respect to the total remaining hydrocarbons.

As stated in Response 1, the injection criteria for the proposed injection system is to remove PSH (if present) and add amendments (terminal electron acceptors) to reduce hydrocarbons in situ by EAB.

<u>Comment 6</u>

In Section 4.1 (Test Locations), page 10, paragraph 1, the Permittee states, "[t]he two proposed pilot test locations provide the opportunity to test injection, amendment, and recovery in two of the primary soil types (gravel and silty sand) in which the full-scale system will also be installed." The Permittee must explain why KWB-5 is considered to be a "target zone with more *gravel" when the KWB-5 well log does not include gravel in the soil type description. If available, provide additional soil boring logs that are pertinent to the discussion and demonstrate that the two different soil types are present in the Pilot Test area in the revised Work Plan.*

Response 6

As described in this section of the Work Plan, an initial evaluation is to be performed prior to installation of Pilot Test wells (discussed further in Comment 7) to confirm (1) the presence of gravel through gamma logging and potentially exploratory borings and (2) confirm or adjust the location/design of the pilot test wells based on the results. In the revised Work Plan, HFNR moved the Pilot Test location from near KWB-5 to near RW-19 based on a conference call with NMED on November 4, 2019. The well log for RW-19 indicates gravel is present at this location and an initial evaluation as described in Section 4.1 of the revised Work Plan will be completed at this location.

Comment 7

In Section 4.1 (Test Locations), page 10, paragraph 2, the Permittee states, "[t]he exact location of the injection, monitoring, and recovery wells will be determined after completion of gamma logging of the existing well in the area around KWB-5 and MW-131 ." The Permittee must include the gamma logging data, the potential figures generated from the data results and include a discussion of the data and the results in the Pilot Test report.

Response 7

HFNR will include the gamma logging data, figures generated from the data results, and a discussion of the data and the results in the Final Investigation Report (Pilot Test report). HFNR revised the Work Plan to indicate that the requested items will be included in the Pilot Test report. If the evaluation directs the placement to be different from the chosen areas, these will be noted as deviations in the Pilot Test report.

Comment 8

In Section 4.1 (Test Locations), page 10, paragraph 2, the Permittee states, "[d]ue to the heterogeneous nature of the shallow geology in this area, some additional exploratory borings may be installed to further characterize the lithology in the area near well KWB-5 and MW-131. The final locations of wells to be used in each of the two pilot test areas will be adjusted with the intent of having all wells within each pilot test area screened within the same, continuous coarse-grained lithology zone, to the degree feasible on the heterogeneous nature of the shallow geology. One pilot test area will target zones with more gravel (KWB-5) and the other pilot test area will target zones with more silty sand (near MW-131)." The Permittee must provide all boring logs for the additional exploratory borings, including borings that were not converted to wells. The *additional borings are subject to soil sampling and must also include analysis for VOCs, total petroleum hydrocarbons (TPH as diesel-range organics (DRO), gasoline-range organics (GRO), and oil-range organics (ORO)) and metals analyses, at a minimum. The data must be included in the Pilot Test report. While the Permittee's intent is to conduct the test in two lithologic zones, it appears the gravel zone may not be present in well KWB-5 (see Comment 5a). The Permittee will not be able to extrapolate the data to the full-scale system, if the test is conducted as proposed.*

Response 8

See response to Comment 6 (not 5a) regarding gravel in the vicinity of KWB-5 and the new Pilot Test location near RW-19 in the revised Work Plan. HFNR will provide boring logs for all exploratory borings including borings that are not converted to wells.

The East Field where the Pilot Test is planned has never been used for any industrial purposes. Constituents present in the groundwater in the areas around the proposed Pilot Test locations migrated from the refinery laterally via the Shallow Saturated Zone as described in previous investigation reports. Any unexpected hydrocarbon impacts as well as the smear zone can and will be noted using standard field screening techniques (i.e. visual, olfactory, and/or PID screening). HFNR understands based on discussions during the October 3, 2019 meeting with NMED and OCD that soil samples collected from borings installed at locations with no historical industrial activity will be submitted for laboratory analysis of total petroleum hydrocarbons (TPH) as diesel-range organics (DRO), gasoline-range organics (GRO), and oil-range organics ORO), and the Work Plan has been revised accordingly.

Comment 9

In Section 4.2 (Dissolved-Phase Conditions), page 10, bullet item 2, the Permittee states that "[b]ackground sulfate concentrations west of the Refinery appear to range between 1,000 and 2,000 mg/L, while sulfate concentrations within the hydrocarbon plume below the East Field range from 10 to 100 mg/L, and are non-detect in some wells." Wells UG-I, UG-2, and UG-3R were not intended to be utilized for background and were originally installed to monitor contamination migrating on to the Refinery property. It has been discussed several times that background at the site is not achievable and that only a baseline can be established with the current conditions of the site. The baseline conditions must be established specific to the East Field relevant to the areas of the Pilot Test and full-scale remediation system. Revise all sections that refer to "background" and replace with the term "baseline".

Response 9

HFNR revised the word “background” to “upgradient” for similar instances throughout the Work Plan. The intent in the referenced sentence was to describe the distribution and magnitude of sulfate concentrations within and outside of the dissolved hydrocarbon plume to demonstrate the inverse correlation of sulfate and dissolved hydrocarbon concentrations which is a primary line of evidence that biodegradation of hydrocarbons is occurring via sulfate reduction. The term “baseline” in the Pilot Test will be relevant to the baseline groundwater quality evaluation described in Section 5.2.1 of the Work Plan.

Comment 10

Section 4.2 (Dissolved-Phase Conditions), page 11, bullet item 1, states, "[t]he inverse concentration correlation indicates SRBs are utilizing sulfate to degrade hydrocarbons in both dissolved and adsorbed phases (note that the sulfate demand of dissolved-phase concentrations is too low to exceed the background supply of sulfate)." The Permittee has not demonstrated that there is a correlation between the SRB and the degradation of hydrocarbons in both the dissolved and adsorbed phase and there is no data to support this statement. Therefore, groundwater samples must be collected from wells within the East Field to determine the concentrations of sulfide and sulfate and the population of the SRB. Since the Work Plan is developed based on the assumption that SRB play a vital role in hydrocarbon degradation, the presence of SRB and the occurrence of sulfate reduction must be demonstrated prior to Pilot Test start up. Include SRB sampling and evaluation in the revised Work Plan. Sampling of the SRB population must be conducted throughout the duration of the Pilot Test.

Response 10

Section 4.2 of the Work Plan provides a list of primary and secondary lines of evidence that indicate SRBs are actively utilizing sulfate to degrade hydrocarbons in the Shallow Saturated Zone (i.e, sulfate reduction is occurring). These lines of evidence are consistent with sulfate reduction as detailed in the December 2013 EPA Office of Solid Waste and Emergency Response document *Introduction to In Situ Bioremediation of Groundwater* (542-R-13-018). Qualitative and quantitative data associated with lines of evidence have been provided to NMED in numerous reports, including the Annual Groundwater Monitoring Reports that were submitted in February of each calendar year. Figures 1 and 2 were developed for this letter to visually demonstrate the inverse relationship of benzene and sulfate concentrations as an example of a primary line of evidence that sulfate reduction is occurring.

Sampling for SRBs is neither practical nor effective in demonstrating that sulfate reduction is occurring as (1) the process of sampling, shipping, and laboratory analysis reduces anaerobic populations in samples due to exposure to oxygen, light, and temperature changes, and (2) the vast majority of the microbial population are attached to the formation matrix (soil particles) and not suspended or free "swimming" in the groundwater[2]. The ratio of attached to suspended microbial populations in an aquifer can range between 59:1 and 1657:1[3]. Based on discussion with NMED and OCD during the October 3, 2019 meeting, HFNR understands that qualitative field testing for the presence of SRBs is acceptable to address NMED's request for SRB sampling. HFNR revised to the Work Plan to include field testing for SRBs during baseline sampling and at a selected frequency throughout the Pilot Test for qualitative purposes only. The SRB sampling results can be used as one of the multiple lines of evidence to evaluate the Pilot Test results but will not be the primary or the sole criterion for evaluating sulfate reduction.

Sulfide is an end product of sulfate reduction, but it precipitates with ferrous iron and is effectively immobilized or is transient[4,5]. However, HFNR revised the Work Plan to include the analysis of sulfide during baseline sampling and at a selected frequency throughout the Pilot Test. Note the presence of black particulates in and/or slightly grey turbid purge water observed within the hydrocarbon plume during groundwater sampling activities (noted on Table 2 in Annual Groundwater Monitoring Reports) is an indication of iron sulfide precipitants. The sulfide results can be used as one of the multiple lines of evidence to evaluate the Pilot Test results, but will not be the primary or the sole criterion for evaluation of sulfate reduction.

<u>Comment 11</u>

Section 4.2 (Dissolved-Phase Conditions), page 11, paragraph 1, states, "[i]n addition to bioavailable sulfate, nitrogen in the form of ammonia will be added to the system to amend the two most likely rate-limiting nutrients." The screening level for nitrate concentration in groundwater is 10 mg/L. Verify that the ammonia amendment will not cause nitrate exceedances and provide a more detailed basis for amending with ammonia in the revised Work Plan.

<u>Response 11</u>

The addition of a nitrogen source was proposed to boost the indigenous microbial population growth based on the HFNR team's experience at other similar facilities with similar COCs and similar geology. However, the nitrogen source will only be added if it is determined that there is insufficient nitrogen present in the Shallow Saturated Zone (i.e., total Kjeldahl nitrogen <10 mg/L). The application rate of the nitrogen source (ammonia) generally decreases over time as the indigenous microbial population stabilizes. Under anaerobic conditions, ammonia cannot oxidize to nitrate due to the lack of oxygen. There is minor potential for nitrification within wells

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[2] Griebler, C. and T. Lueders. Microbial Biodiversity in Groundwater Ecosystems. *Freshwater Biology* 54 (2009): 649-677.
[3] Griebler C., Mindl B., Slezak D. & Geiger-Kaiser M. Distribution Patterns of Attached and Suspended Bacteria in Pristine and Contaminated Shallow Aquifers Studied with an In Situ Sediment Exposure Microcosm. *Aquatic Microbial Ecology* 28, (2002): 117–129
[4] Office of Solid Waste and Emergency Response, United States Environmental Protection Agency. December 2013. *Introduction to In Situ Bioremediation of Groundwater*. 542-R-13-018.
[5] R. Kolhatkar and M. Schnobrich. Land Application of Sulfate Salts for Enhanced Natural Attenuation of Benzene in Groundwater: A Case Study. *Monitoring & Remediation* 37, no. 2, Spring 2017: 43–57.

that are screened across variable redox conditions, but the resulting nitrate concentrations would be significantly below 10 mg/L and would be swiftly reduced by the anaerobic formation. In addition, there is limited potential for downgradient migration of minor quantities of nitrogen or nitrate past the Pilot Test recovery wells.

Comment 12

Section 5.2.1 (Baseline Groundwater Quality Evaluation), page 13, bullet item 4, states,

"[m]onitored natural attenuation (MNA) laboratory-measured parameter concentrations: sulfate, total Kjeldahl nitrogen (TKN), total organic carbon (TOC), alkalinity, ferrous iron, and magnesium." Discuss the basis for monitoring TKN in the response letter. Since the dissolved phase hydrocarbon is to be primarily degraded by SRB, measurement of SRB and sulfide concentrations must also be included (see Comment 10). In addition, since the proposed MNA parameters are unlikely to provide accurate information regarding the distribution of amendments in the vicinity of the injection wells, a tracer must be included during the initial stage of the injection process and the tracer level must be monitored. Revise the Work Plan accordingly.

Response 12

TKN is a measure of all forms of nitrogen present in the analyzed media (in this case, groundwater). The analysis of TKN in the Pilot Test monitoring program was included to ensure that data necessary to evaluate all potential limiting constituents is collected.

As described in Response 10, HFNR revised the Work Plan to include qualitative field testing for SRBs and laboratory sampling for sulfide during baseline sampling and at a selected frequency throughout the Pilot Test.

HFNR believes that the distribution of amendments in the vicinity of the injection wells can be reliably determined from the proposed testing procedure. The well layout, monitoring frequency, and monitoring parameters have been selected to ensure changes in water table elevation, PSH thickness, and constituent concentration can be observed and compared between locations and over time. As described in Section 5.2.7 of the Work Plan, field-measured conductivity will be used as an indicator parameter for distribution of the amendments early in the Pilot Test as increases in conductivity will be the first indication of the amendments reaching downgradient wells. However, based on discussion with NMED during a meeting on October 3, 2019, HFNR has revised the Work Plan to include a tracer (bromide) during the initial stages of the injection process and will monitor tracer concentrations in groundwater. HFNR also proposes using magnesium as a tracer throughout the Pilot Test. While magnesium is not inert and slowly precipitates with the final product of degradation carbonate, it remains in solution long enough especially during the beginning of EAB to act as a semi-conservative tracer and allow for estimating sulfate demand/utilization. Epsom salt is the source of sulfate and magnesium in the Pilot Test and they are in a 1:1 molar relationship (i.e., the injected solution has equal molar concentrations of sulfate and magnesium). Therefore, it is a simple calculation to evaluate sulfate utilization (i.e., sulfate demand) across each Pilot Test area as the sulfate molar concentration will decrease relative to magnesium. The sulfate demand can usually be estimated within one to three months in EAB projects (after the microbial acclimation period).

Comment 13

In Section 5.2.1 (Baseline Groundwater Quality Evaluation), page 13, paragraph 2, the Permittee states, "[b]aseline water level and water quality data will be measured in all of the wells associated with the pilot test." For the KWB-5 test area, wells KWB-5, KWB-4, and MW-99, KWB-6 and MW-112 are proposed to be monitored. For the MW-131 test area, wells MW-131, MW-129, and MW-112 are proposed to be monitored. Provide clarification regarding the following:

a. *Phase-separated hydrocarbon (PSH) has been present in wells KWB-4 and MW-112 since they were both installed; therefore, groundwater analytical data have not been collected from these wells. Data collected during the Pilot Test cannot be compared to any existing data. Samples must be collected, and the data can be used for informational purposes. Explain the basis for including these wells as a part of the test evaluation since there are no baseline data.*

b. *Well MW-99 is screened from 12 to 27 feet bgs, while the surrounding wells are screened from approximately 20 to 40 feet bgs. The screened interval of well MW-99 is not consistent with other wells and is also located more than 400 feet upgradient from the proposed test area. Explain why well MW-99 is being included in the evaluation of the Pilot Test investigation and explain if the depth of the screened interval will impact the evaluation of data from the Pilot Test.*

c. *Several wells proposed as upgradient monitoring wells for the Pilot Test are located approximately 610 to 625 feet from the test area. Propose to install upgradient wells that are closer to the test area or propose to install the injection and recovery wells closer to the monitoring wells chosen to be the upgradient wells for the Pilot Test in the revised Work Plan.*

d. *The sulfate level within the Pilot Test area is one to two orders of magnitude lower when compared to the monitoring wells in the eastern refinery boundary. The sulfate levels are not likely representative of the groundwater conditions for evaluation and the design of the full-scale system (see Comment 5). Explain why this proposed groundwater extraction location was chosen, especially since sulfate concentrations are most likely depleted in the pilot study area compared to the eastern refinery boundary.*

e. *After the full-scale system has been completed, the extracted groundwater from surrounding monitoring and extraction wells (i.e., Bolton Road) may replenish sulfate* *concentrations without amending it (see Comment 5) because concentrations from these wells range from 525 to 1,400 mg/L (April 2018 Event). Demonstrate whether or not the sulfate amendment is necessary using stoichiometric mass balance and the analytical data from all wells pertinent to the east refinery boundary where the full-scale remediation is proposed to be implemented. Provide these calculations in the revised Work Plan and provide a discussion regarding the conclusions of these calculations.*

f. *Well MW-111 is not included as a part of the Pilot Test evaluation. The screened interval of well MW-111 is consistent with other monitoring wells and may be suitable to evaluate cross-gradient migration and unanticipated preferential flow. Propose to include well MW-111 in the Pilot Test.*

Response 13

a. The objective of the baseline monitoring proposed in Section 5.2.1 of the Work Plan is to provide initial baseline groundwater elevation and quality data for the Pilot Test within 14 to 30 days prior to initiation of the Pilot Test. Results of baseline water quality testing will be used to (1) calculate the range of dosing of amendment(s) in the treatment area and (2) determine baseline conditions to be used to evaluate the effectiveness of the amendment(s) in reducing dissolved-phase concentrations in the vicinity of the reinjection zone during the Pilot Test. The proposed baseline laboratory analysis is different from the facility-wide groundwater monitoring program so none of the proposed baseline wells have historical data to which to compare for all parameters. Note KWB-4 and MW-112 were sampled in October 2013 and November 2014, respectively, in accordance with the facility-wide groundwater monitoring program.

   Wells KWB-4 and MW-112 were selected based on their relative location to the original proposed Pilot Test areas (KWB-4 is upgradient of the KWB-5 Pilot Test area; MW-112 is cross/downgradient of both the KWB-5 and MW-131 Pilot Test areas). As stated in the first paragraph on page 14 of the Work Plan, wells with more than 0.3 feet of PSH will not be sampled for laboratory and field parameters during the baseline evaluation. While laboratory and field data from wells outside the immediate Pilot Test area would be incorporated in the baseline evaluation if available, they are not critical to achieve the objective of the baseline groundwater quality monitoring. Groundwater elevations and apparent PSH thicknesses will still be measured in such wells to evaluate the potentiometric surface.

   Based on discussions with the NMED and OCD during the October 3, 2019 meeting, and a subsequent conference call with NMED on November 4, 2019, HFNR proposes moving one of the Pilot Test locations from near KWB-5 to near RW-19 as described in the revised Work Plan. Groundwater quality data from wells within each Pilot Test area (i.e., RW-19 and MW-131) are critical for the Pilot Test baseline monitoring. HFNR revised the Work Plan to state that these wells will be sampled even if there is more than 0.3 feet of PSH present.

b. HFNR proposes moving the Pilot Test location near KWB-5 to near RW-19, and as such removing MW-99 from the proposed baseline groundwater monitoring program. Nonetheless, measuring baseline groundwater quality in well(s) outside of the immediate Pilot Test area is good practice to provide data regarding potential groundwater quality changes in the general area over the relatively lengthy time of 12 to 18 months that the Pilot Test will be conducted. MW-99 is located sufficiently distal and upgradient from the Pilot Test area such that it will not be affected by it, but is sufficiently close to provide data on any potential upgradient general groundwater quality changes over the duration of the Pilot Test.

c. Groundwater quality data from the wells located outside each Pilot Test area, especially upgradient, are not critical to achieve the objective of the baseline groundwater quality monitoring. Nonetheless, measuring baseline groundwater quality in well(s) outside of the immediate Pilot Test area is good practice to provide data regarding potential groundwater quality changes in the general area over the relatively lengthy time of 12 to 18 months that the Pilot Test will be conducted. The proposed existing upgradient wells are sufficiently close to provide data on any potential upgradient general groundwater quality changes over the duration of the Pilot Test. Gauging data from these existing wells are critical in evaluating the potentiometric surface across the Pilot Test areas and the distances of these wells from the Pilot Test area will not negatively affect the interpretation of the potentiometric surface. HFNR will install one additional upgradient monitoring well closer to the Pilot Test area near MW-131 (PMW-6) after completion of the baseline evaluation as described in Section 5.2.2 of the revised Work Plan.

d. Please see Response 5b – sulfate concentrations are depressed throughout the dissolved hydrocarbon plume present across the southern portion of the refinery and East Field. The eastern refinery property boundary extends to the east of the East Field as shown on Figures 1 and 2

e. It is difficult to estimate sulfate demand based on stoichiometry as SRBs will be degrading a variety of hydrocarbon compounds and a significant portion of the degraded hydrocarbons will be incorporated into microbial growth. Sulfate amendment rates will be adjusted during the Pilot Test and full-scale system based on groundwater sulfate demand monitoring results as described in Response 5b. The objective of the Pilot Test is to demonstrate sulfate-facilitated degradation of hydrocarbons, regardless of the source of the sulfate.

f. HFNR revised the Work Plan to include MW-111 in the Pilot Test monitoring program as a downgradient monitoring well for the Pilot Test area near RW-19.

Comment 14

In Section 5.2.2 (Installation of Injection, Recovery, and Monitoring Wells), page 14, paragraph 1, the Permittee states, "[i]njection and recovery wells will be separated by a minimum distance of 200 feet to ensure that the radius of influence from recovery drawdown and injection mounding do not overlap." Section 5.0 (Pilot Test Scope) states that the Pilot Test will evaluate the effectiveness of the amendment and reinjection process. Although recirculation and capture of the injectate is not necessary for the test, further reduction of the dissolved phase hydrocarbon concentrations is expected. Explain and discuss the purpose of intentionally isolating the influence of the injection and extraction wells in the revised Work Plan.

Response 14

The primary reason for separating the injection and capture zones is to mimic operation of the full-scale system. The full-scale system would include injection at upgradient points outside of the direct zone of capture of the recovery wells. Additionally, HFNR did not want to bias the results of the test by creating any preferential pathways or circulation cells, which, as noted, will degrade dissolved-phase hydrocarbons more rapidly than will be achieved by the full-scale system. HFNR revised the Work Plan to include this discussion.

Comment 15

In Section 5.2.2 (Installation of Injection, Recovery, and Monitoring Wells), page 15, paragraph

1, the Permittee states, "[a] gamma-log study will be conducted on existing monitoring wells in the area prior to installation of the pilot test injection and recovery wells to verify the gravel seam and silty sand presence, depth, thickness, and extent in each pilot test area. Injection wells will be designed based on the gamma logging results, using lithology from the CME report and/or lithology from borings installed prior to the pilot test to evaluate the pilot test area, if deemed necessary." In the Pilot Test report, include the gamma-log study field data along with any figures and tables generated from the results. Provide a table that summarizes the data ranges generated from the site-specific evaluation that define the lithology at the site. Include a discussion about how the data supports the locations chosen for the installation and design of the injection wells. Furthermore, additional borings will be required to provide additional support to the gamma-log study to verify the gravel seam and silty sand presence. See also Comment 7.

Response 15

HFNR revised Section 6.0 of the Work Plan to include a detailed list of documentation/information to be included in the Pilot Test report, including the gamma-log study field data along with any figures and tables generated from the results, a table that summarizes the data ranges generated from the site-specific evaluation that define the lithology at the site, and a discussion about how the data supports the locations chosen for the installation and design of the injection wells.

HFNR does not agree with the statement, *"Furthermore, additional borings will be required to provide additional support to the gamma-log study to verify the gravel seam and silty sand presence."* A significant amount of geologic data for the East Field is already available, including the testing done for the CME Report and the boring logs for the existing wells. HFNR in consultation with NMED will determine the number and location of any additional soil borings after the results of gamma logging evaluation are available. As stated in Response 7, HFNR will note any deviations to the Work Plan, including any additional evaluation, in the Pilot Test report.

Comment 16

In Section 5.2.2 (Installation of Injection, Recovery, and Monitoring Wells), page 15, paragraph 1, the Permittee states, "[t]he injection wells will be constructed of stainless steel casing and screen, and will be screened across the target lithologic zone." Explain why a stainless-steel casing and screen will be used for the construction of the injection wells. In Appendix A, the Permittee's Supplemental Information Form C-108, Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements Reinjection Pilot Test Work, dated May 30, 2019 states that the maximum possible injection pressure is 150 pounds per square inch (psi).

Presumably, a stainless-steel casing and screen are chosen for the construction of injection wells to accommodate high injection pressures. A high pressure injection technique is not recommended because new fractures and flow paths may potentially develop. Once new fractures develop, the fluid may preferentially flow through the fractures and the fractures could cause short circuiting and the desired cleanup level may not be achieved. Section 5.2.3 states that care will be taken not to exceed pressure suitable for the wellbore and formation; however, a specific description of procedures to prevent formation of new flow paths is not discussed. Provide a provision to limit the injection pressure to prevent new pathways in the revised Work Plan.

Response 16

HFNR does not intend to perform reinjection at high pressure. The selection of a stainless-steel casing and screen was made based on the HFNR team's previous experience with injection wells, specifically issues related to durability and efficiency of PVC slotted casing vs stainless steel. It is the HFNR team's experience that PVC slotted screens do not function as efficiently as stainless-steel screen. The maximum possible injection pressure listed on Form C-108 is based on pressure ratings/specifications of the associated piping and connections and is provided as described – the maximum *possible* injection pressure. The actual injection pressure will be whatever is needed to reinject at a rate similar to the extraction rate, and no more. HFNR expects the injection pressure will not exceed 5 psi based on the HFNR team's previous experience. HFNR revised the Work Plan accordingly.

Comment 17

Section 5.2.2 (Installation, Recovery, and Monitoring Wells), page 16, paragraph 2, states "[a]ny PSH present in pilot test monitoring or injection wells will be measured, and if removed, stored temporarily in small totes near the recovery well so that the recovered volume can be tracked separately from the rest of the current recovery system." The Permittee did not indicate where the totes would be stored, the capacity of the totes, or the frequency for removing PSH from the site. It is also unclear if the product will be removed manually or pumped into the tote(s) from the wells. It is not feasible to continuously remove PSH without also extracting groundwater during the Pilot Test operation. Furthermore, since the location of the totes do not appear on Figure 3 (Process and Instrumentation Diagram Sulfate and Ammonia Injection) it appears that the mixture of groundwater and PSH will be recovered and possibly stored in the sulfate holding tank. If it is the Permittee's intent, the sulfate tank will presumably serve as both mixing and separation tank. NMED does not recommend this approach because the amendment mixing process (e.g., mechanical agitation/circulation) will potentially interfere with the process of PSH separation; therefore, each process must be carried out in a separate tank. The mixture must initially be retained in the separation tank with enough retention time to separate PSH by gravity; then, only the aqueous solution from the bottom of the tank can be transferred to the mixing tank. Revise Figure 3 to depict (1) where the tote(s) will be located, (2) if piping will be run from the wells to the tote(s) for PSH recovery, (3) location of individual tanks to separate water and PSH and mix the amendments, (4) a skimmer pump that removes PSH from the retention tank, if any, and (5) discuss and illustrate measures to provide adequate mixing for the amendments.

Response 17

As described in Section 5.2.2, page 18, paragraph 3, the recovery wells for the Pilot Test will be installed in the same configuration as the Phase II recovery wells. A copy of the schematic for these wells is provided in Appendix B of the revised Work Plan. These recovery wells have three separate well casings installed within the larger 14-inch diameter outer casing. One casing is used for groundwater recovery (4-inch diameter casing), one for PSH recovery (4-inch diameter casing), and one for instrumentation (1-inch diameter casing). The groundwater recovery pump intake will be set below the water table surface and operated to prevent intake of PSH. If significant amounts of PSH accumulate in either of the recovery wells during the Pilot Test, it will be skimmed from its own casing and pumped directly to a small tote (e.g. 350 gallons) located near the recovery well. An oil/water separator will be used to remove any PSH recovered with the groundwater pump prior to entry into the sulfate holding tank. PSH should not enter the sulfate holding tank, and HFNR will not attempt to mix sulfate amendment in a tank that contains a mixture of PSH and groundwater. HFNR revised the Work Plan text and figures to clarify how PSH will be managed.

Comment 18

In Section 5.2.2 (Installation of Injection, Recovery, and Monitoring Wells), page 15, paragraph 3, the Permittee states, "[t]he proposed injection and monitoring wells will also be installed as permanent wells but may be abandoned upon completion of the pilot test." The Permittee must propose to retain or abandon the wells in the Pilot Test report. The Permittee must not abandon the wells without concurrence from NMED and OCD.

Response 18

HFNR will propose to retain or abandon the wells in the Pilot Test report and will not abandon the wells without concurrence from NMED and OCD. HFNR does not believe, based on their proximity to each other and to existing refinery wells, that the proposed monitoring and injection points provide enough valuable information outside of the Pilot Test that justifies the expense of maintaining and monitoring these wells in the future.

Comment 19

In Section 5.2.3 (Initial Injection Test), pages 15 to 17, the Permittee describes the initial injection test to determine the optimal injection rate and to observe the hydrogeologic response after the injections. However, NMED requires that an initial pump test/aquifer test be conducted to characterize the wells to provide aquifer data that is not dependent on the previous pump tests that were conducted in the trenches. The pump test is also to ensure the correct pumping rates are achieved, to ensure that the well(s) will not run dry, to determine recovery rates to check the radius of influence and determine if there are any impacts to the surrounding wells. The pump test/aquifer test must run, at a minimum, of 24 hours. The Permittee must provide logs for all borings and wells installed at the site. Soil samples must be collected and analyzed for TPH as DRO/GRO/ORO, VOCs, and metals. Groundwater samples must also be tested for the same analytes and SRB at all pertinent wells. Propose the wells to be sampled for SRB in the revised Work Plan. NMED requires 20 days notification prior to beginning drilling activities at the site and also notification when the pump test/aquifer test has been completed. Once the initial testing period has been completed, the Permittee must provide a progress report that summarizes and discusses the test method(s), equipment used, field data results, the pumping rates, include SRB data, aquifer test results, and groundwater and soil sample results. Discuss the hydrogeologic response after the injections and include the lithologic logs. The progress report must also discuss any problems encountered during the testing period. The progress report must be submitted to NMED within 50 days after the initial pump test/aquifer test is completed.

Response 19

HFNR revised the Work Plan to include most of the items listed under this comment with the following modifications:

a. Based on discussions with NMED and OCD during the October 3, 2019 meeting, HFNR understands NMED prefers a pump test to take advantage of the Pilot Test system well layout that provides multiple observation wells and to further characterize hydrogeological properties of the Shallow Saturated Zone. HFNR revised the Work Plan to include a step-drawdown and constant-rate pump test at each Pilot Test location.

b. See Response 8 regarding the collection of soil samples for laboratory analysis. Soil samples collected from borings installed in the East Field will be submitted for laboratory analysis of TPH DRO, GRO, and ORO, and the Work Plan has been revised accordingly.

c. See Response 10 regarding sampling of SRBs. HFNR revised the Work Plan to include qualitative field test of SRBs.

d. HFNR requests the progress report "detailing the test method(s), equipment used, field data results, the pumping rates, SRB data, aquifer test results, and groundwater and soil sample results" be submitted within 60 days after receipt of soil analytical results or completion of the pump test (whichever occurs last) to allow time for data processing and review.

Comment 20

In Section 5.2.3 (Initial Injection Test), pages 15 to 17, the Permittee describes the initial injection test to determine the optimal injection rate and to observe the hydrogeologic response after the injections. Address the following in the revised Work Plan:

a. The Permittee did not state if the extracted groundwater will be treated to meet groundwater standards prior to injection. Revise Section 5.2.3 to clarify if the extracted groundwater will be treated prior to injection and what method will be used to treat it. Also, modify Figure 3 to include the measures, if any.

b. There were several incidents that occurred during the Shallow Saturated Zone Groundwater Pump Test that involved failure of equipment (i.e., pumps and transducers) during the test. Ensure all equipment (e.g., pumps and transducers) are checked and tested prior to starting the initial pump/aquifer test and initial injection test.

c. *Provide a table summarizing the pump specifications and transducer installation data for each well. Ensure that the injection flowrates during the test are also summarized in a table. Include the tables in the Pilot Test report.*

d. *Include all field data and notes as an appendix in the Pilot Test report.*

e. *State if the current extraction system will be operating during the installation of the transducers and explain if it will impact the Pilot Test. Also state if the East Fields are still irrigated and if this could also impact the water levels during the Pilot Test.*

Response 20

a. See response to Comment 1. No treatment of recovered water is planned nor required by state law prior to reinjection.

b. HFNR appreciates the reminder. For this test, HFNR will use equipment consistent with the current recovery system so that replacement equipment is readily available. No revisions to the Work Plan are needed to address this comment.

c. HFNR will provide the requested data in a table in the Pilot Test report and revised the Work Plan to describe what will be presented in the Pilot Test report.

d. HFNR will provide field data and notes as an appendix to the Pilot Test report and revised the Work Plan to describe what will be presented in the Pilot Test report.

e. The current extraction system will remain in operation during the installation of the transducers and the Pilot Test, with the exception at RW-19. Based on the radius of influence of the existing system as shown on the potentiometric surface maps provided in the *2018 Annual Groundwater Monitoring Report*, the existing recovery system is not expected to affect the Pilot Test. The East Fields are no longer irrigated and will not be irrigated during the Pilot Test. HFNR added this provision to the Work Plan.

Comment 21

In Section 5.2.3 (Initial Injection Test), page 16, paragraph 4, the Permittee states, "[p]ressure transducers will be placed in the injection wells, monitoring wells, and recovery wells in the pilot test area to measure the groundwater level." Comment 20 requires the Permittee to perform an initial injection test to evaluate the influence of the recovery wells. Since pressure transducers will be in place, record the change of water levels for a period of 24 hours during the injection test. Include the provision in the revised Work Plan.

Response 21

HFNR revised the Work Plan as requested.

Comment 22

In Section 5.2.3 (Initial Injection Test), pages 16-17, the Permittee states, "[t]he anticipated injection rates for the first three steps of the test are 4, 8, and 12 [gallons per minute (gpm)] based *on groundwater modeling performed in 2016 and 2018." The site formation may likely be too tight based on the lithology of the area to allow 4 gpm per well during the initial injection step. The proposed injection rate may cause injectate to overflow. Consider starting the initial injection rate at one gpm and gradually increase the injection rate if the water level continues to stabilize. Otherwise, demonstrate that the anticipated injection rates (4, 8, and 12 gpm) are appropriate starting points for the initial injection test.*

<u>Response 22</u>

HFNR revised the Work Plan to state the initial injection rate will be 1 gpm and will be increased to a maximum of 12 gpm depending upon the capacity of the injection well. Overflow will be prevented as the injection wells will be capped to allow for recirculation of water below 5 psi.

<u>Comment 23</u>

In Section 5.2.5 (Treatment Efficiency Evaluation), page 18, paragraph 1, the Permittee states, "[t]o prevent fouling of the injection system and injection well, it is critical that the redox condition of the extracted water remains anaerobic throughout the recirculation process, to the degree feasible." The recirculation system must include a function to remove the recovered PSH and to meet all injection criteria of the groundwater (see Comments 1 and 17). Section 5.2.6 states that the PSH recovered volume will be recorded; however, Figure 3 does not depict any mechanism to remove PSH (e.g., oil-water separator). Include the provisions in the revised Work Plan. Additionally, discuss specific measures that will prevent the extracted groundwater from being aerated in the recirculation process in the revised Work Plan.

<u>Response 23</u>

See Response 1 and 17. The injection criteria of the Pilot Test and full-scale system is to remove PSH (if present) and add amendments (terminal electron acceptors) to reduce hydrocarbons in situ by EAB. PSH will be removed as necessary with an OWS prior to recirculation of the extracted water. PSH will not be allowed to enter the amendment tank(s). Figure 3 of the Work Plan was revised to show how PSH will be managed.

HFNR revised the Work Plan to provide more detail about the specific measures that will minimize aeration of the recirculated water. Such measures include, ensuring all connections maintain an air-tight seal; selecting flow meters and pumps that minimize turbulence; capping the injection and recovery wells; and injecting through drop tubes that extend below the groundwater level within injection wells to prevent oxidization of injected anaerobic water. In addition, metal fittings and manifolds will be minimized so any oxygen that may be inadvertently introduced to the recirculation system does not oxidize the ferrous iron and foul the recirculation plumbing or wells. Air leaks in these recirculation systems are easy to detect (creates hissing sound associated with air aspiration) and will be repaired immediately.

Comment 24

Section 5.2.7 (Groundwater Monitoring), page 21, paragraph 1 states, "[w]here feasible, the pump intake should also be installed at least four feet below the smear zone to minimize the potential for sampling colloids associated with partially degraded hydrocarbons in smear zones." The proposed sampling method is acceptable; however, the pump intake for the recovery wells must not be installed more than two feet below the smear zone. Contaminants may be introduced to the clean soils beneath the smear zone if the pump intake is installed too far below the smear zone. Identify the lowest groundwater elevations historically recorded in nearby wells to determine specific depths where pump inlets will be placed in the recovery wells in the revised Work Plan.

Response 24

HFNR revised the Work Plan to indicate a maximum drawdown of two feet below the smear zone. The pump intake depth must remain below the water surface so that air is not entrained during extraction and to prevent pump malfunction. The Work Plan was revised to include the lowest historical groundwater elevations at wells near each proposed recovery well.

Comment 25

In Section 5.2.7 (Groundwater Monitoring) page 21, paragraph 2, the Permittee describes how the injection flow rates and amendment feed rates will be adjusted based on the daily monitoring results and sulfate concentration at the wells. NMED Comment 12 directs the Permittee to include a tracer and to monitor the tracer concentrations in the monitoring wells in order to optimize the system. Revise the Work Plan to incorporate the data collected from the tracer testing data for system adjustment as well. In addition, Table 1 (Dosing Rate Calculations) provides calculations to prepare sulfate stock solution and injectate that contains 2,000 mg/L sulfate. Table 1 also indicates that the sulfate concentration in the formation is targeted to reach from 300 mg/L to 500 mg/L. As stated in Comment 5, the sulfate amendment may not be necessary. Table 1 does not include calculations to estimate the volume of injectate necessary to achieve the target formation concentration. Revise Table 1 to include these calculations. Table 1 does not provide any dosing calculations for ammonia. Revise Table 1 to include the ammonia calculations.

Response 25

See Response 12 regarding a tracer.

The target sulfate injectate concentration (2,000 mg/L) and target groundwater concentration in the formation (500 mg/L) are initial targets selected based on the HFNR team's experience with similar projects. These target concentrations will be refined during completion of the Pilot Test based on estimated sulfate demand of the formation. Sulfate demand will change over time as described in Response 5. HFNR revised the Work Plan to clarify how the target concentrations were selected. It is not practical to estimate the volume of injectate necessary to achieve the target formation concentration as the sulfate demand or utilization rate will be determined during the Pilot Test and will change over time. Sulfate amendment rates will be adjusted during the Pilot Test based on groundwater sulfate demand monitoring results as described in Response 5b.

HFNR revised Table 1 to include the requested ammonia dosing calculations.

<u>Comment 26</u>

In Section 5.2.7 (Groundwater Monitoring), page 21, bullet item 5, the Permittee states that "[o]nce sulfate is detected at a concentration above 500 mg/L in all of the monitoring wells between the injection and recovery wells, quarterly sampling events will begin on all wells listed above." The baseline sulfate levels in some monitoring wells in the vicinity exceed 300 mg/L (e.g., wells KWB-6 and MW-111), Provide a justification for the referenced concentration of 500 mg/L in the revised Work Plan.

<u>Response 26</u>

The referenced criterion of 500 mg/L is an initial target sulfate concentration to be present throughout the targeted formation and not just in select pockets on the peripheral of the hydrocarbon plume. As described in Response 25, this target concentration was selected based on the HFNR team's experience with similar projects but will be adjusted based on estimated sulfate demand within each Pilot Test area. HFNR revised the Work Plan to provide justification of the selected target concentration and clarify how the target will change.

<u>Comment 27</u>

In Section 5.2.8 (Data Processing), page 22, paragraph 1, the Permittee states that "[d]ata will be presented in interim progress reports to be provided to NMED and OCD on a quarterly basis. A summary report including all the data and results of the test will be submitted after the completion of pilot test activities and prior to the implementation of the full-scale system upgrade." The Permittee is also required to submit the final Pilot Test data and results as a final investigation report (Pilot Test report). Furthermore, prior to implementing the full-scale system, NMED and OCD must approve the conclusions and the recommendations provided in the Pilot Test Report. The decision to move forward to the full-scale system installation will be based on the Pilot Test results.

<u>Response 27</u>

HFNR agrees with Comment 27. HFNR revised the Work Plan terminology from "summary report" to "Final Investigation Report (Pilot Test report)".

Comment 28

Section 5.3.1 (Installation of Pilot Test Injection, Recovery, and Monitoring Wells), pages 22-24, discusses the details regarding the installation of the Pilot Test wells. Although the expected screen length is described, the provision for the screen to intersect the water table is not included.

The screens for the Pilot Test recovery and monitoring wells must intersect the water table. Include the provision in the revised Work Plan. In addition, the approximate distances between the wells (e.g., distance between wells IW-1 and PMW-1) are not stated in Section 5.2.2. State the distances between the wells in the revised Work Plan.

Response 28

HFNR revised the Work Plan to include the provision that well screens intersect the water table (Section 5.3.1) and the distances between injection and monitoring wells (Section 5.2.2).

Comment 29

Section 5.3.1 (Installation of Pilot Test Injection, Recovery, and Monitoring Wells), pages 22-24, describes the specifications for the injection, recovery and monitoring wells for the Pilot Test but does not provide proposed construction diagrams for these wells. Include construction diagrams for the injection, recovery and monitoring wells in the revised Work Plan. In addition, the screened intervals of the injection wells must be set below the water table and should not be set across the water table for more uniform distribution of injectate. Include the provision in the revised Work Plan.

Response 29

HFNR revised the Work Plan to include proposed construction diagrams for injection, monitoring, and recovery wells, and the provision that injection wells are screened below the water table.

Comment 30

Section 5.3.1 (Installation of Pilot Test Injection, Recovery, and Monitoring Wells), page 23, paragraph 1, states, "[t]wo 4-inch diameter casings (one for PSH recovery and one for water recovery) and a single 2-inch diameter casing (for measurement) will be installed in each recovery well borehole." Provide a well construction diagram of the proposed recovery wells in the revised Work Plan.

<u>Response 30</u>

HFNR revised the Work Plan to include the proposed well construction diagram.

<u>Comment 31</u>

Section 5.3.1 (Installation of Pilot Test Injection, Recovery, and Monitoring Wells), page 23, paragraph 1, states, "[e]ach injection well will be screened at or slightly below the top of the target lithologic zone (i.e., gravel and silty sand interval), with an expected screen length of 10 feet, and will include a 2-foot sump below the screened interval." If the purpose of the sump is to protect the screen from organic debris in the injectate, the recirculation system must also be equipped with a filter that eliminates the debris. Include the provision in the Work Plan, as necessary.

<u>Response 31</u>

The primary reason for the sump is to allow for proper installation and operation of the drop tube to recirculate water with minimal turbulence and without the introduction of air. No filter should be needed because the recovery wells will be property developed and anaerobic water generally has low turbidity. The use of a filter will be avoided as the filtration process leads to increased turbulence and possible oxidation which could cause downstream fouling. Furthermore, opening the system to change the suggested filter elements would introduce air into the system.

<u>Comment 32</u>

In Section 5.3.1 (Installation of Pilot Test Injection, Recovery, and Monitoring Wells), page 23, paragraph 3, the Permittee states, "[i]njection wells will be permitted as temporary wells that may be abandoned at the end of the pilot test; however, the injection wells will be constructed to the same specifications as using permanent wells. Recovery wells will be permitted and constructed as permanent recovery wells using the same configuration as the Phase II recovery wells. Monitoring wells installed for the pilot test will be permitted as temporary wells and will likely be abandoned at the end of the pilot test." It is not clear to NMED why the Permittee considers these wells to be temporary wells as they could be a part of the design of the remediation system at the facility boundary when the full-scale system is in operation. Explain why these wells will not be utilized as part of the final full-scale system. Furthermore, the wells must not be abandoned without concurrence from NMED and OCD (Comment 18).

<u>Response 32</u>

As stated in the Work Plan, injection wells are considered temporary but will be constructed so that they can be left in place and used as part of the full-scale system (i.e. constructed to the same specifications) if determined to be beneficial or necessary for successful full-scale system operation. See Response 18 for discussion of temporary monitoring wells.

Comment 33

Section 5.3.1 (Installation of Pilot Test Injection, Recovery, and Monitoring Wells), page 24, paragraph 1, states, "[s] ample information and visual observations of the cuttings and core samples shall be recorded on the boring log. Soil samples will not be collected for laboratory analysis during installation." The Permittee must record and depict the smear zone on all of the logs (i.e., exploratory borings and developed wells) where groundwater is encountered during drilling activities and state the depths for each injection, recovery and monitoring well in the applicable section(s) of the Pilot Test report. Soil samples must be collected above the saturated zone, within the vadose zone where the highest PID reading is recorded, and at the bottom of each boring. Propose to analyze the soil samples for TPH as DRO/GRO/ORO, VOCs, and metals in the revised Work Plan.

Response 33

HFNR revised the Work Plan to include the provision to record and depict the smear zone on all boring logs. See Response 8 regarding collection of soil samples. Up to two soil samples from each boring will be submitted for laboratory analysis: 1) a soil sample immediately above the water table or from the bottom of the boring (if dry) and 2) a soil sample from the depth with the greatest indication of impacts from field screening (if not from the groundwater interface). The water table is expected to be encountered in all exploratory borings as the intent is to further characterize the lithology of the saturated zone. No soil samples will be collected from the saturated zone.

Comment 34

Section 5.3.1 (Installation of Pilot Test Injection, Recovery, and Monitoring Wells), page 24, paragraph 2 states that "[t]he following visual observations will be recorded on the boring log: lithology (color, type, grain size, sorting, etc.), moisture content (dry, damp, wet, moist), and any field evidence of contamination (staining, odor, and photoionization detector [PID] readings)." In addition to this information, the Permittee must also attempt to identify the smear zone on the logs based on field screening (see Comment 34).

Response 34

See Response 33.

Comment 35

In Section 5.3.4 (Groundwater Sampling), page 26, paragraph 2, the Permittee states that "[t]he purging process will be considered complete and groundwater sampling will commence when at least four of the seven water quality parameters [(pH, temperature, conductivity, TDS, ORP, DO and turbidity)] achieve stabilization within ten% for three consecutive readings." Although at least four of the seven water quality parameters are required to reach stabilization, the Permittee must *ensure that all seven water quality parameters are recorded during each consecutive reading and all seven parameters must be reported after the final reading in a table presented in the Pilot Test report.*

Response 35

HFNR revised the Work Plan to specify that all seven water quality parameters are recorded throughout and at the end of purging, and that the data is provided in the Pilot Test report.

Comment 36

In Section 5.5 (Treatment Test Effectiveness), page 28, paragraph 1, the Permittee states that "[t]he amendments will be considered effective if dissolved phase concentrations decrease during the test." The Permittee did not define a percent reduction of the dissolved phase concentrations for the amendments to be considered effective. Provide an approximation for percent decrease in concentrations that the Permittee will consider the amendments to be considered effective and state if that will be measured not only in concentration decrease but over a set time period as well. Also state how many and which constituents of concern (COCs) will be considered to determine the effectiveness of the amendment.

Response 36

HFNR revised the Work Plan to include an approximation for the expected percent decrease in dissolved hydrocarbon concentrations during the Pilot Test, with the caveat that any such approximation is based on the HFNR team's experience at other sites and is subject to significant variation. Based on the HFNR team's experience at other sites, dissolved hydrocarbons are anticipated to decrease between 50% and 90% but the degradation rate is site-specific and varies for each hydrocarbon compound. For example, benzene generally degrades faster than xylenes and ortho-xylenes degrade faster than meta-xylenes. The dissolved hydrocarbons that will be evaluated during the Pilot Test are specified in Section 5.2.7 of the Work Plan.

The trend in dissolved hydrocarbon concentrations over the Pilot Test will also be considered. The Pilot Test is intended to run for a maximum of 18 months and the trend in all measured dissolved hydrocarbon concentrations will be evaluated over the entire period of the test. While not expected, it is possible that the predicted hydrocarbon percentage reduction range described above may not be reached during the course of the Pilot Test. However, if the trend in concentration data is decreasing and indicates target concentrations in groundwater could be reached in a reasonable period of time beyond the timeframe of the Pilot Test, this data can still be used in design of upgrades to the full-scale system. In other words, failure to reach any predicted percent reduction may not result in the approach being deemed unsuccessful. The final recommendation for modifications to the system will be based on careful and thorough evaluation of all the Pilot Test data and not just comparison of predicted versus measured percent reduction. HFNR made the other changes requested.

Comment 37

Section 6.0 (Schedule), page 30, outlines a proposed schedule once NMED and OCD approve the Work Plan. Revise the schedule to include the additional work required by the comments in this Disapproval and submit an updated schedule in the revised Work Plan.

Response 37

HFNR revised the schedule based on the revisions to the Work Plan.

Comment 38

Section 7.0 (Tables) includes Table 1 (Dosing Rate Calculations). It would facilitate NMED's review to include an additional table that summarizes the current hydrogeologic properties (both measured and modeled) that were used to generate the Work Plan, determine the location of the Pilot Test and also include where the value came from (i.e., measured during [Cite Report] or modeled data from [Cite Report]). The table must be updated with the measured and/or modeled hydrogeologic properties from the completed Pilot Test. Provide the appropriate tables in the revised Work Plan.

Response 38

HFNR revised the Work Plan to include the requested table. An updated table will be provided in the Pilot Test report.

Comment 39

The maximum contaminant level (MCL,) and water quality control commission (WQCC) standard for sulfate are 250 mg/L and 600 mg/L, respectively. The tap water regional screening level (RSL) for hydrogen sulfide, a potential product of sulfate reduction, is 4.2 ug/L. Include a discussion regarding potential the risks associated with sulfate injection in the revised Work Plan.

Response 39

Sulfate does not have a primary MCL. Sulfate is a nuisance chemical and has a secondary MCL of 250 mg/L. Secondary MCLs are non-mandatory and established as guidelines to assist public water systems in managing their drinking water for aesthetic considerations.

As determined by years of groundwater monitoring, the concentrations of sulfate exceed the secondary MCL and the WQCC standard by a significant amount in areas where no hydrocarbon impacts are present and in wells located west (upgradient) of the refinery (see Figure 2).

Considering the significantly higher sulfate concentrations in areas all around the Refinery (in excess of 4,000 mg/L in some locations), the addition of sulfate to groundwater in the East Field to increase concentrations to 500 mg/L poses negligible risk compared to sulfate concentrations already present. Further, sulfate injected during the Pilot Test or the full-scale system will be used by the indigenous SRB to consume hydrocarbons, or if not used, captured by the downgradient recovery system and sent back "upstream". Once the goals of the system are achieved, the sulfate injections will stop, and aquifer conditions will return to aerobic conditions.

Sulfide (hydrogen sulfide [H_2S] and bisulfide [HS^-]) is the end product of sulfate reduction, but free hydrogen sulfide gas persistence and accumulation within groundwater systems during EAB is rare as sulfide reacts with iron or other dissolved metals to form a precipitate. Free hydrogen sulfide gas is persistent in acidic environments or in environments absent of metals to precipitate the sulfide. Groundwater in the Shallow Saturated Zone across the refinery contains dissolved metals (including iron) and is neutral as indicated by pH data collected in the field during routine semi-annual groundwater monitoring events, thus, sulfide end products will primarily be precipitated. Free hydrogen sulfide gas is not is not anticipated to be detected outside of the well casing in the breathing zone of refinery and field staff.

Field staff performing monitoring activities at the refinery wear personal hydrogen sulfide air monitors during well purging and sampling activities (and will do so during the Pilot Test) and have generally not detected any hydrogen sulfide gas in the breathing zone during groundwater monitoring within the hydrocarbon plume where sulfate reduction is ongoing. Further, the presence of black particulates in and/or slightly grey turbid purge water observed within the hydrocarbon plume during groundwater sampling activities (noted on Table 2 in Annual Groundwater Monitoring Reports) is an indication of iron sulfide precipitants associated with sulfate reduction ongoing at the site. Therefore, it is unlikely free hydrogen sulfide gas will pose a risk to refinery or field staff during sulfate injection. Any hydrogen sulfide generated may accumulate in the PSH tank. HFNR's hydrogen sulfide mitigation measures will be implemented to ensure the safety of the field personnel.

CLOSING

Should you have any questions or need any additional information prior to that meeting, please do not hesitate to contact me by phone at (575) 746-5487 or Robert Combs at (575) 746-5382.

Sincerely,

Scott M. Denton
Environmental Manager

Attachments:

Figure 1 – Benzene Isoconcentration Map (First 2018 Semiannual Event)

Figure 2 – Sulfate Isoconcentration Map (First 2018 Semiannual Event)

Figure 3 – Historically Depressed Sulfate Concentrations, Comment 5b

Attachment A – Enhanced Anaerobic Biodegradation (EAB) Case Studies

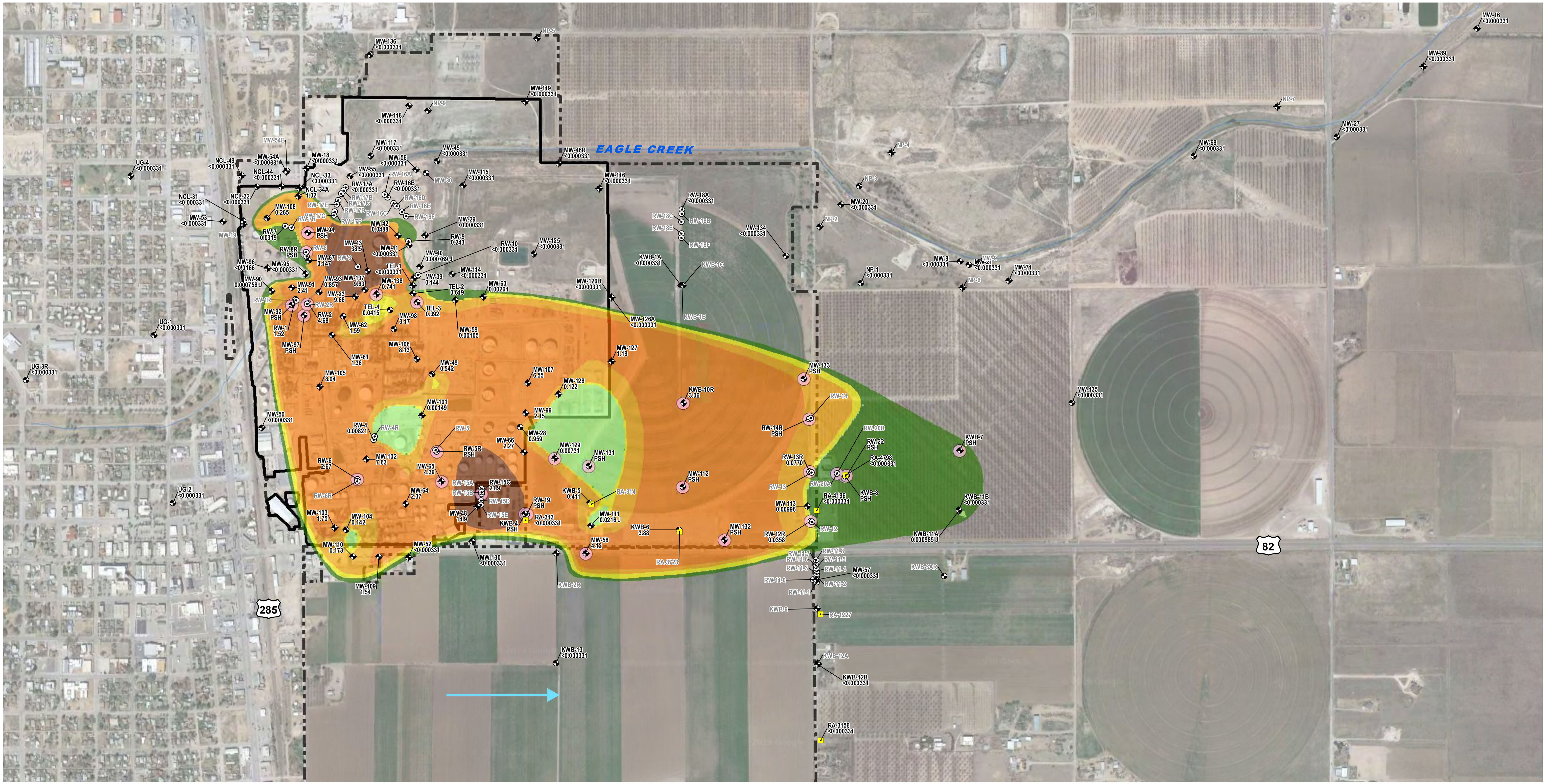
Case Study 1: St Marys Refinery, St. Marys, West Virginia

Case study 2: ELK Refinery, Clendenin, West Virginia

cc: NMED: D. Cobrain, K. Van Horn, L. Tsinnajinnie, M. Suzuki,
OCD: C. Chavez, J. Griswold
HFC: M. Holder, R. Combs, J. Leik
TRC: J. Speer, S. Brimo, C. Smith

FIGURES

Response to Comments to the July 22, 2019 Letter of Disapproval, *Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements: Reinjection Pilot Test Work Plan*



LEGEND

- MONITORING WELL
- RECOVERY WELL
- IRRIGATION WELL IN MONITORING PROGRAM
- 1.75 BENZENE CONCENTRATION
- <0.000331 BENZENE NOT DETECTED ABOVE METHOD DETECTION LIMIT
- PSH PHASE-SEPARATED HYDROCARBON PRESENT IN WELL (≥ 0.03 FEET THICK)
- KWB-9 WELL NOT SAMPLED
- REFINERY FENCELINE
- FACILITY PROPERTY BOUNDARY (FENCELINE SHOWN WHERE COINCIDENT)
- GROUNDWATER FLOW DIRECTION
- PSH PRESENCE 2016-2018

NOTES:

1. ALL CONCENTRATIONS ARE IN MILLIGRAMS PER LITER (mg/L).
2. J = CONCENTRATION QUALIFIED AS AN ESTIMATED VALUE.
3. ALL MONITORING AND RECOVERY WELLS ARE SCREENED IN THE SHALLOW SATURATED OR VALLEY FILL ZONES. IRRIGATION WELLS INCLUDED IN THE MONITORING PROGRAM ARE SCREENED IN EITHER THE VALLEY FILL ZONE OR THE DEEP ARTESIAN AQUIFER.
4. BENZENE CRITICAL GROUNDWATER SCREENING LEVEL (CGWSL) = 0.005 mg/L

AERIAL IMAGERY SOURCE: GOOGLE EARTH PRO AND THEIR DATA PARTNERS, 3/12/2016.

BENZENE CONCENTRATION FROM 2018 FIRST SEMIANNUAL EVENT (mg/L)

- 0 - 0.0001
- 0.0001 - 0.001
- 0.001 - 0.01
- 0.01 - 0.1
- 0.1 - 1.0
- 1.0 - 10
- 10 - 100

0 500 1,000 Feet

1 " = 1,000 '

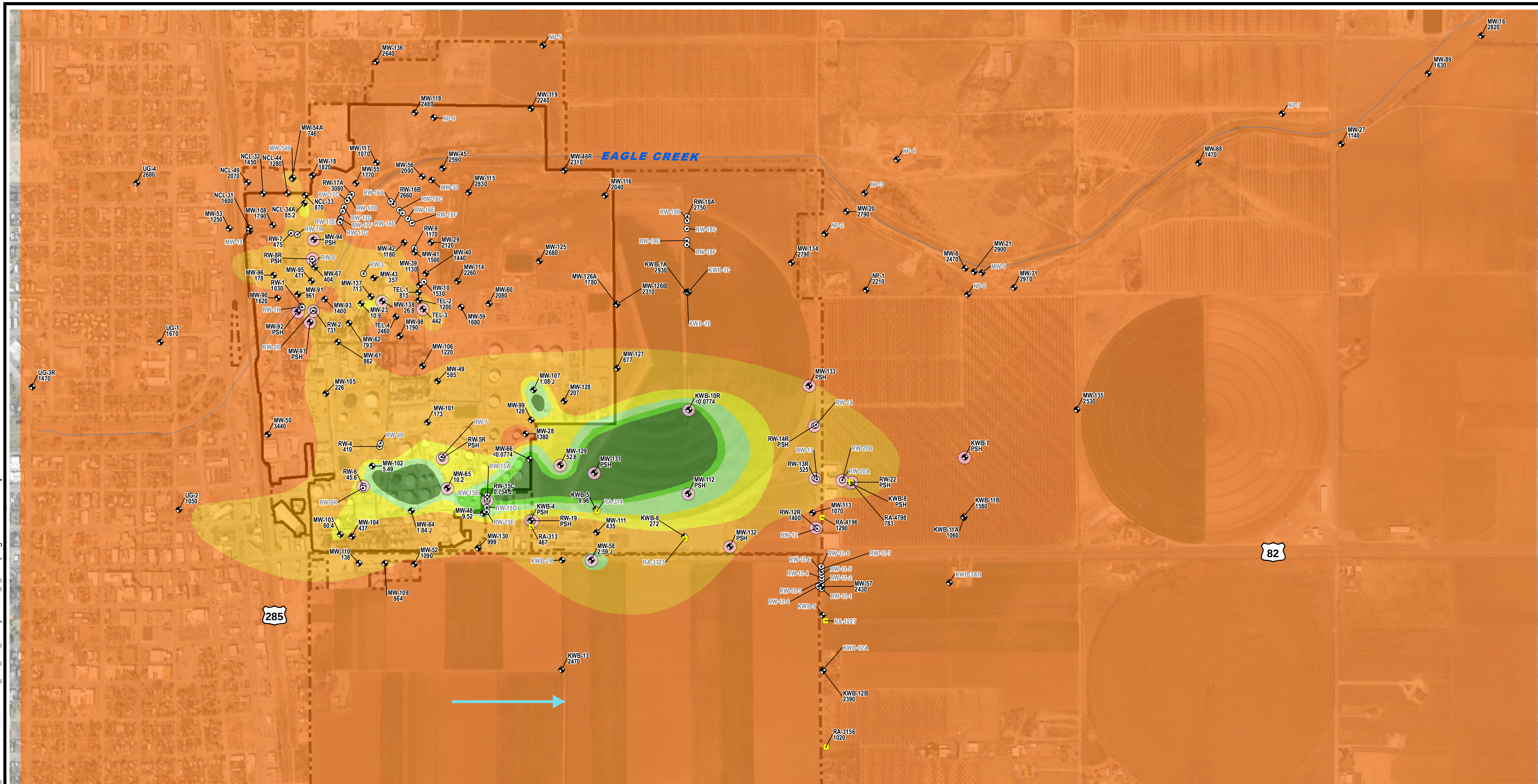
1:12,000

PROJECT: NMED JULY 22, 2019 RESPONSE TO COMMENTS LETTER HOLLYFRONTIER NAVAJO REFINERY LLC ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO	
TITLE: BENZENE ISOCONCENTRATION MAP (FIRST 2018 SEMIANNUAL EVENT)	
DRAWN BY: MHORN	PROJ. NO.: 326693
CHECKED BY: AELJURI	FIGURE 1
APPROVED BY: JSPEER	
DATE: AUGUST 2019	
TRC	505 East Huntland Drive, Suite 250 Austin, TX 78752 Phone: 512.329.6080 www.trcsolutions.com
FILE NO.:	326693_1_BenzSpring.mxd

Coordinate System: NAD 1983 2011 StatePlane New Mexico East FIPS 3001 Ft US (Foot US)
Map Rotation: 0

Plot Date: 8/13/2019, 16:43:22 PM by MHORN -- LAYOUT: ANSI B(11"x17")
Path: \\apaenvfile01\GIS\1-PROJECTS\HOLLY_ENERGY_PARTNERS\Artesia\326778_GW_Rec_Survey\326693_1_BenzSpring.mxd

TRC - GIS



LEGEND

- MONITORING WELL
- RECOVERY WELL
- IRRIGATION WELL IN MONITORING PROGRAM
- 1030 — SULFATE CONCENTRATION
- <0.0774 — SULFATE NOT DETECTED ABOVE METHOD DETECTION LIMIT
- PSH — PHASE-SEPARATED HYDROCARBON PRESENT IN WELL (≥ 0.03 FEET THICK)
- KWB-9 — WELL NOT SAMPLED
- REFINERY FENCELINE
- FACILITY PROPERTY BOUNDARY (FENCELINE SHOWN WHERE COINCIDENT)
- GROUNDWATER FLOW DIRECTION
- PSH PRESENCE 2016-2018

NOTES:

1. ALL CONCENTRATIONS ARE IN MILLIGRAMS PER LITER (mg/L).
2. J = CONCENTRATION QUALIFIED AS AN ESTIMATED VALUE.
3. ALL MONITORING AND RECOVERY WELLS ARE SCREENED IN THE SHALLOW SATURATED OR VALLEY FILL ZONES. IRRIGATION WELLS INCLUDED IN THE MONITORING PROGRAM ARE SCREENED IN EITHER THE VALLEY FILL ZONE OR THE DEEP ARTESIAN AQUIFER.
4. SULFATE CRITICAL GROUNDWATER SCREENING LEVEL (CGWSL) = 600 mg/L

SULFATE CONCENTRATION FROM 2018 FIRST SEMIANNUAL EVENT (mg/L)

- 0-0.1
- 0.1-1.0
- 1.0-10
- 10-100
- 100-1,000
- 1,000-10,000

0 500 1,000 Feet

1 " = 1,000 '

1:12,000

AERIAL IMAGERY SOURCE: GOOGLE EARTH PRO AND THEIR DATA PARTNERS, 3/12/2016.

PROJECT:	NMED JULY 22, 2019 RESPONSE TO COMMENTS LETTER HOLLYFRONTIER NAVAJO REFINERY LLC ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO
TITLE:	SULFATE ISOCONCENTRATION MAP (FIRST 2018 SEMIANNUAL EVENT)
DRAWN BY:	MHORN
PROJ. NO.:	326693
CHECKED BY:	AELJURI
APPROVED BY:	JSPEER
DATE:	AUGUST 2019
	FIGURE 2
FILE NO.:	326693_2_SulfSpring.mxd

TRC
505 East Huntland Drive, Suite 250
Austin, TX 78752
Phone: 512.329.6080
www.trcsolutions.com

Coordinate System: NAD 1983 2011 StatePlane New Mexico East FIPS 3001 Ft US (Foot US)
Map Rotation: 0

Plot Date: 8/14/2019, 09:11:59 AM by MHORN -- LAYOUT: ANSI B(11"x17")
Path: \\apaenvfile01\GIS\1-PROJECTS\HOLLY_ENERGY_PARTNERS\Artesia\326778_GW_Rec_Survey\326693_2_SulfSpring.mxd

TRC - GIS

TRC

505 E. HUNTLAND DR.
SUITE 250
AUSTIN, TX 78752
PH:512-329-6080

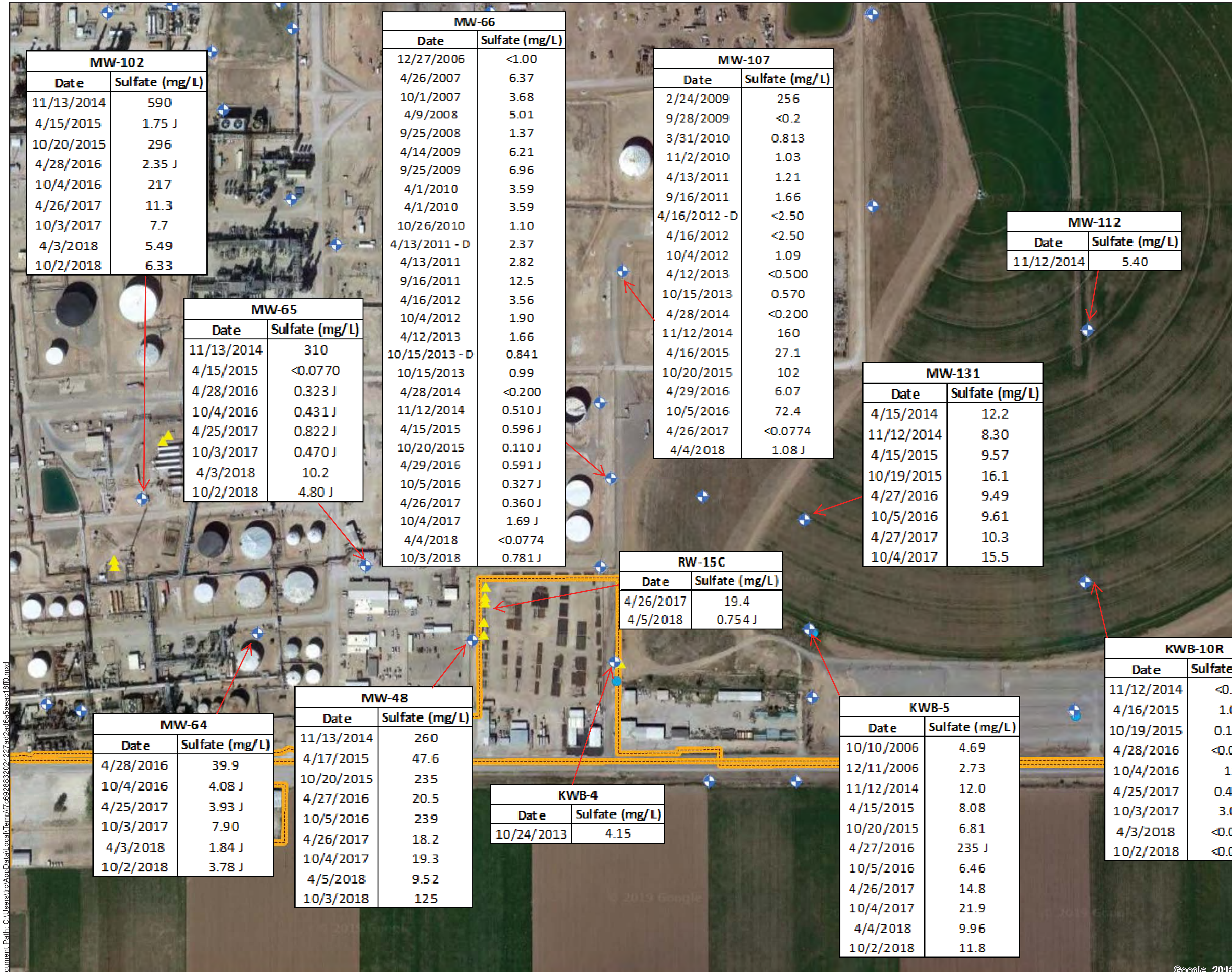
N

Due to this map being projected in the WGS84 EPSG:3857 one cannot accurately scale distances or areas from it. This map should be used for reference purposes only.

LEGEND

- Monitoring Well
- Recovery Well
- Irrigation Well
- Navajo Property
- Well ID and Historical Sulfate Concentrations

FIGURE 3 - HISTORICALLY DEPRESSED SULFATE CONCENTRATIONS, NMED JULY 22, 2019 LETTER, COMMENT 5b



MW-102

Date	Sulfate (mg/L)
11/13/2014	590
4/15/2015	1.75 J
10/20/2015	296
4/28/2016	2.35 J
10/4/2016	217
4/26/2017	11.3
10/3/2017	7.7
4/3/2018	5.49
10/2/2018	6.33

MW-65

Date	Sulfate (mg/L)
11/13/2014	310
4/15/2015	<0.0770
4/28/2016	0.323 J
10/4/2016	0.431 J
4/25/2017	0.822 J
10/3/2017	0.470 J
4/3/2018	10.2
10/2/2018	4.80 J

MW-66

Date	Sulfate (mg/L)
12/27/2006	<1.00
4/26/2007	6.37
10/1/2007	3.68
4/9/2008	5.01
9/25/2008	1.37
4/14/2009	6.21
9/25/2009	6.96
4/1/2010	3.59
4/1/2010	3.59
10/26/2010	1.10
4/13/2011 - D	2.37
4/13/2011	2.82
9/16/2011	12.5
4/16/2012	3.56
10/4/2012	1.90
4/12/2013	1.66
10/15/2013 - D	0.841
10/15/2013	0.99
4/28/2014	<0.200
11/12/2014	0.510 J
4/15/2015	0.596 J
10/20/2015	0.110 J
4/29/2016	0.591 J
10/5/2016	0.327 J
4/26/2017	0.360 J
10/4/2017	1.69 J
4/4/2018	<0.0774
10/3/2018	0.781 J

MW-107

Date	Sulfate (mg/L)
2/24/2009	256
9/28/2009	<0.2
3/31/2010	0.813
11/2/2010	1.03
4/13/2011	1.21
9/16/2011	1.66
4/16/2012 -D	<2.50
4/16/2012	<2.50
10/4/2012	1.09
4/12/2013	<0.500
10/15/2013	0.570
4/28/2014	<0.200
11/12/2014	160
4/16/2015	27.1
10/20/2015	102
4/29/2016	6.07
10/5/2016	72.4
4/26/2017	<0.0774
4/4/2018	1.08 J

MW-112

Date	Sulfate (mg/L)
11/12/2014	5.40

MW-131

Date	Sulfate (mg/L)
4/15/2014	12.2
11/12/2014	8.30
4/15/2015	9.57
10/19/2015	16.1
4/27/2016	9.49
10/5/2016	9.61
4/27/2017	10.3
10/4/2017	15.5

RW-15C

Date	Sulfate (mg/L)
4/26/2017	19.4
4/5/2018	0.754 J

MW-64

Date	Sulfate (mg/L)
4/28/2016	39.9
10/4/2016	4.08 J
4/25/2017	3.93 J
10/3/2017	7.90
4/3/2018	1.84 J
10/2/2018	3.78 J

MW-48

Date	Sulfate (mg/L)
11/13/2014	260
4/17/2015	47.6
10/20/2015	235
4/27/2016	20.5
10/5/2016	239
4/26/2017	18.2
10/4/2017	19.3
4/5/2018	9.52
10/3/2018	125

KWB-4

Date	Sulfate (mg/L)
10/24/2013	4.15

KWB-5

Date	Sulfate (mg/L)
10/10/2006	4.69
12/11/2006	2.73
11/12/2014	12.0
4/15/2015	8.08
10/20/2015	6.81
4/27/2016	235 J
10/5/2016	6.46
4/26/2017	14.8
10/4/2017	21.9
4/4/2018	9.96
10/2/2018	11.8

KWB-10R

Date	Sulfate (mg/L)
11/12/2014	<0.077
4/16/2015	1.03 J
10/19/2015	0.117 J
4/28/2016	<0.0774
10/4/2016	110
4/25/2017	0.475 J
10/3/2017	3.08 J
4/3/2018	<0.0774
10/2/2018	<0.0774

Coordinate System: WGS 1984 Web Mercator Auxiliary Sphere
Projection: Mercator Auxiliary Sphere
Datum: WGS 1984
False Easting: 0.0000
False Northing: 0.0000
Central Meridian: 0.0000
Standard Parallel 1: 0.0000
Auxiliary Sphere Type: 0.0000
Units: Meter

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ATTACHMENT A – CASE STUDY 1

ST MARYS REFINERY, ST MARYS, WEST VIRGINIA

Response to Comments to the July 22, 2019 Letter of Disapproval, *Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements: Reinjection Pilot Test Work Plan*

Enhanced Anaerobic Biodegradation (EAB)

Case Study 1:

St Marys Refinery, St. Marys West Virginia

TRC
Results you can rely on

Enhanced Anaerobic Biodegradation (EAB)

- EAB – engineered use of non-oxygen electron acceptors to accelerate the microbial metabolism of petroleum hydrocarbons
- Sulfate is the most common non-oxygen electron acceptor selected (see next slide)
- Sulfate reducing bacteria (SRBs) are ubiquitous and are readily stimulated with the addition of sulfate and nutrients
- Degradation of benzene

$$C_6H_6 + 3.75\ SO_4^{2-} + 3H_2O \rightarrow 1.875\ H_2S + 1.875\ HS^- + 6\ HCO_3^- + 0.375\ H^+$$

- SRBs can effectively degrade a broad range of hydrocarbons (HCs)
- SRBs can effectively desorb and degrade adsorbed phase HCs

Comparative Electron Acceptor Potential to Degrade Benzene

Electron Acceptor (EA)	Effective Max Concentration in Water (mg/L)	Reaction Yield: benzene mass degraded per unit mass of EA	Potential Max Benzene Degraded (mg/L)	Potential Complications
Oxygen (ambient air sources)	8 – 10	0.33	3.0 – 3.3	•Limited solubility **•Numerous non-target scavengers** •Potential for aquifer clogging through biofouling and iron precipitation
Oxygen (pure)	40 – 70	0.33	19.8 – 23.1	
Nitrate	670,000 ($NaNO_3$) 1.1x105 ($Mg(NO_3)_2$)	0.21	140,000 220,000	•Primary MCL – 10 mg/L NO_3-N (45 mg/L NO_3)
Iron (III)	0 - 1	0.024	0 – 0.024	• Not practical to inject – very low solubility at neutral aquifer pH
Sulfate	**70,000 (Na_2SO_4) 250,000 ($MgSO_4$)**	**0.20**	**9,000 25,000**	**•Secondary MCL for sulfate – 250 mg/L •Hydrogen sulfide; rarely documented as an issue in the field**

(Adapted from Cunningham et al., 2001)

Favorable EAB Conditions

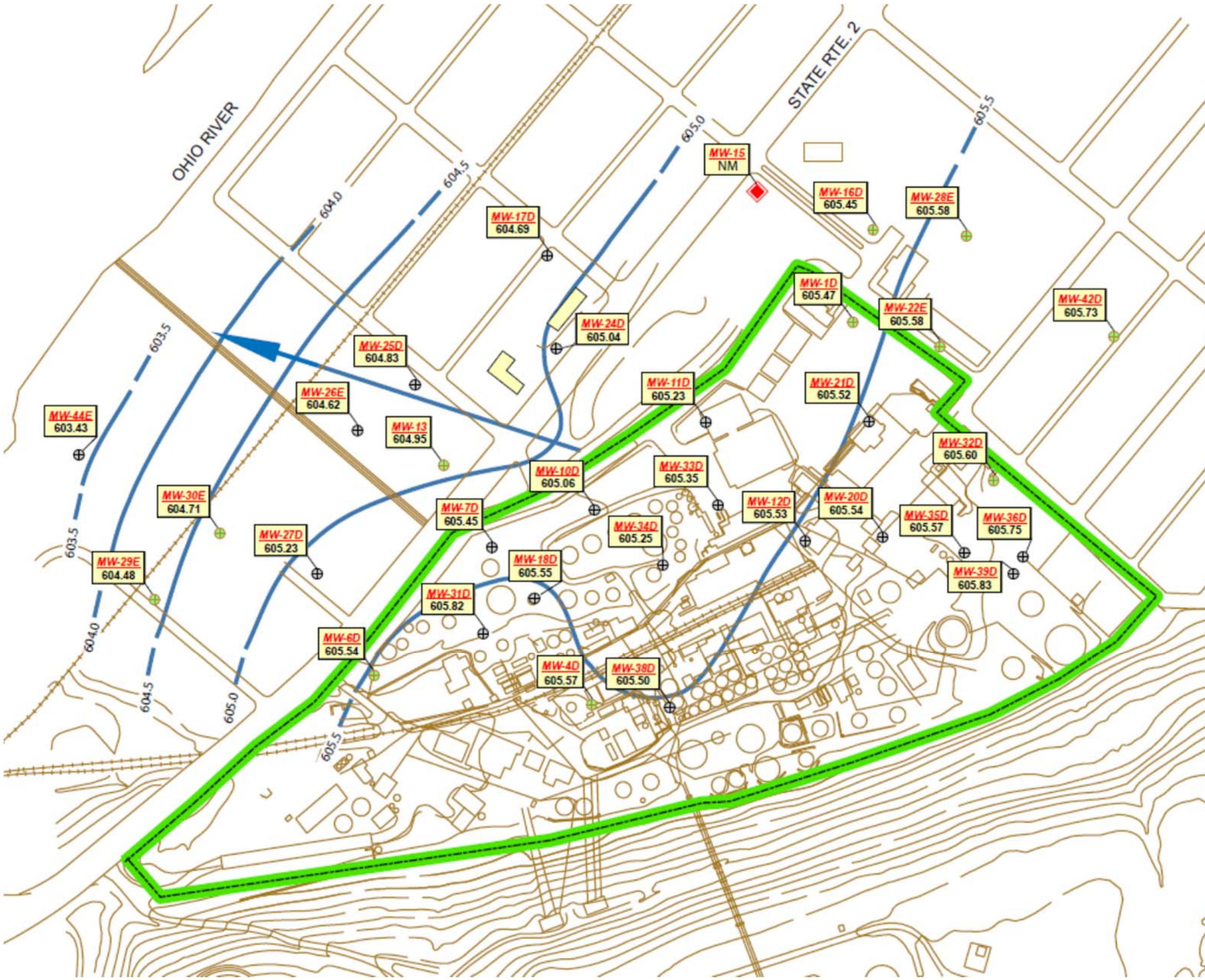
- Anaerobic aquifer – ORP between -150 and -250 mV
- Depleted sulfate mass within hydrocarbon plume – inverse concentration correlation between hydrocarbons (HCs) and sulfate
  - Usually non-detect if well screen is entirely within the hydrocarbon plume
  - If dissolved-phase HCs are vertically stratified across the well screen (low mass plumes or long wells screens can result in elevated HC concentrations shallow and low to ND concentrations towards the bottom of the well) – sulfate concentrations will be ND shallow and increase with depth
  - Sampling from vertically stratified well may result in the presence of sulfate and HCs in GW sample from the middle of the screen
- Differential degradation rates of similar HCs
  - o-xylenes are typically more degradable than m/p-xylenes under sulfate reducing conditions resulting in 1/10 ratio of o-xylene to m/p-xylenes – typical non degraded ratio is ½
  - A similar trend can be identified between 1,2,4-trimethylbenzene (1,2,4-TMB) and 1,3,5-TMB
- Differential degradation rates are very strong evidence of microbial degradation

Refinery Description

- Active refinery 1913 to 1993
- Active Tank Farm 1993 to present
- 30-acre refinery area
- 70-acre tank farms and landfills (not a groundwater source)
- Refined Pennsylvania crude into fuels and lubricants
- Remediation completed under EPA Region 3 RCRA 7003 Consent Order April 1997
- WVDEP Voluntary Cleanup Program for off site sources and plumes

Geology and Hydrology

- Alluvial deposits
  - Interbedded sand, silts and clays to 80 feet
  - Shale, siltstone, sandstone bedrock at 80 feet (not impacted)
- Wellhead Protection Considerations
  - Downgradient municipal supply wells, not impacted at time of remediation
  - Water supply protection – key consideration
- Seasonal GW fluctuation of 3 feet
- Hydraulic conductivity ranged from 1×10^{-2} to 5×10^{-4} cm/sec
- Horizontal seepage velocity of 0.1 to 10 ft/day
  - Higher velocities associated with floods and droughts
- Prior to 2007 groundwater gradient north - Ohio River/Muni Wells
- After 2007 (Muni Wells Shut Down) groundwater flow to the NE Ohio River



NOTES:

- ⊕ RCRA Monitoring Well - Sampled
- ⊕ RCRA Monitoring Well - Not Sampled
- NM Groundwater Level Not Measured
- ◆ Damaged Well/Not Sampled
- SMRC On-Site Boundary
- Groundwater Contour w/ Elevation
- Contour Intervals in 0.5 foot increments
- All Elevations in Feet Above Mean Sea Level

SCALE:

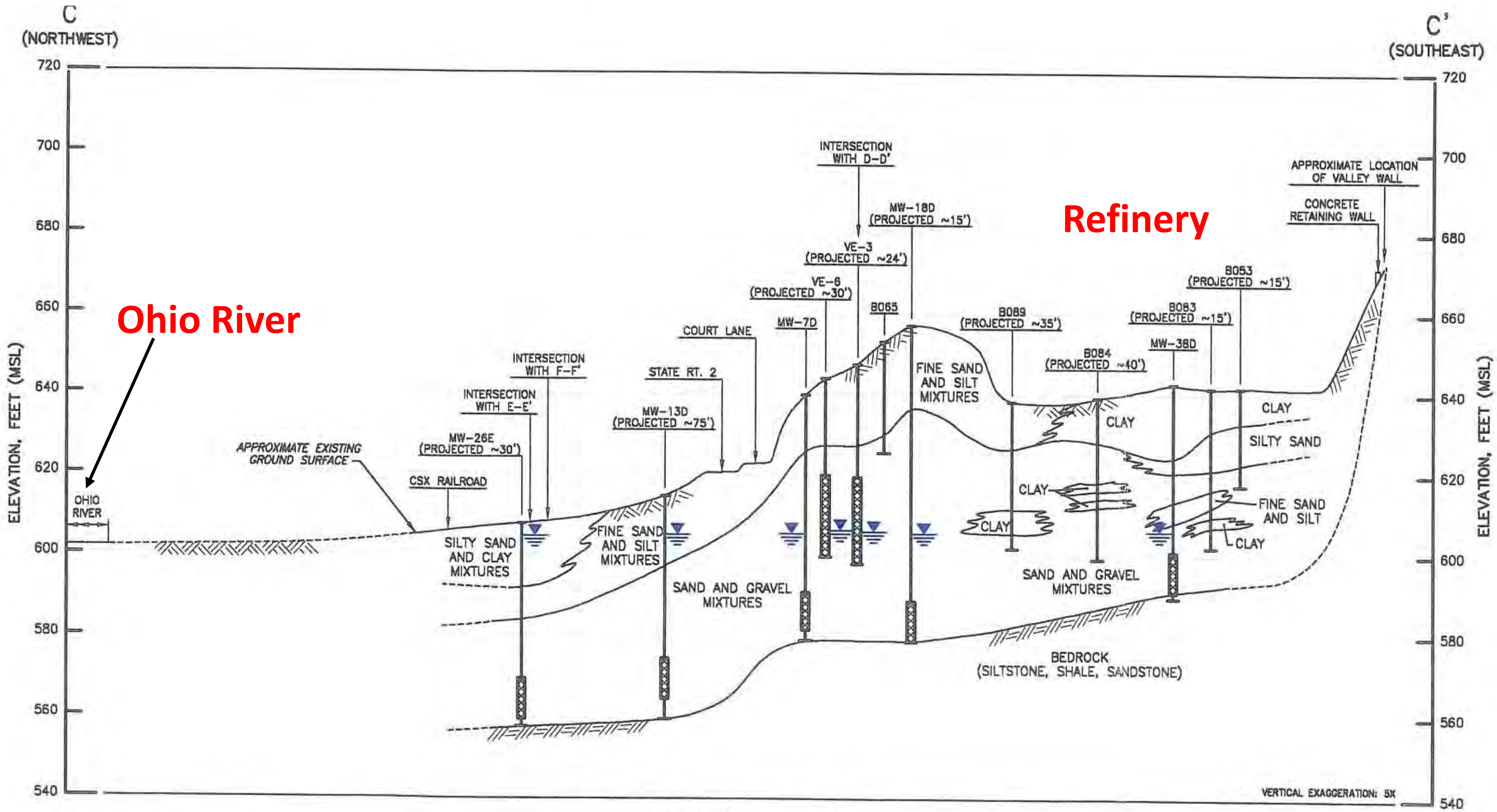
1 inch equals 200 feet

Muni Wells Shut Down

MALCOLM PIRNIE
INDEPENDENT ENVIRONMENTAL ENGINEERS, SCIENTISTS AND CONSULTANTS

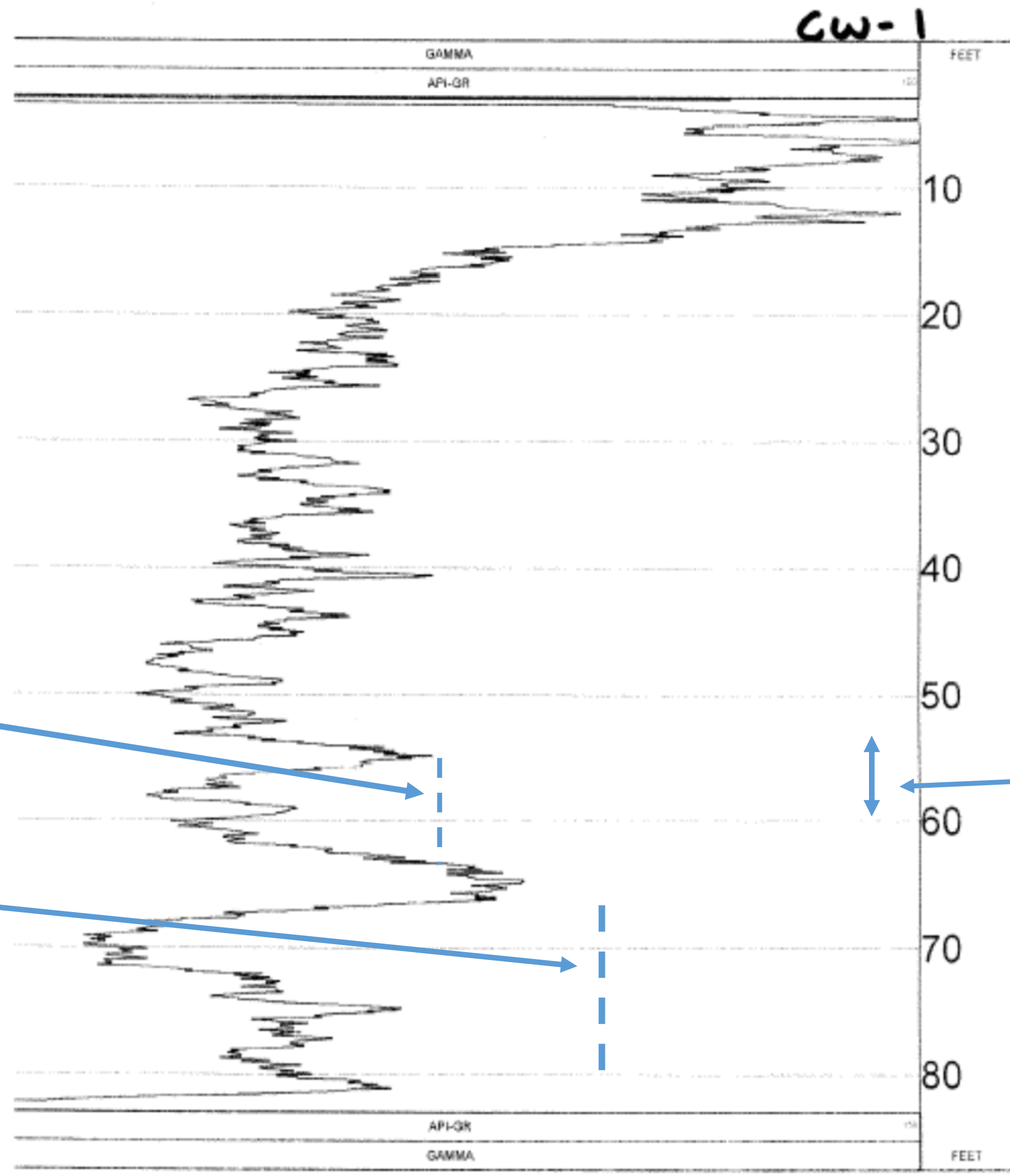
GROUNDWATER SAMPLING
SEMI-ANNUAL EVENT
ST. MARYS REFINING COMPANY
ST. MARYS, WEST VIRGINA

FIGURE 3
GROUNDWATER ELEVATION MAP
MAY 2009 SAMPLING EVENT



SECTION C–C'
(LOOKING NORTHEAST)

Gamma Log CW-1 Borehole Well Screens Designed in the Field Based on Real Time Logging Results



Discontinuous Clay Lenses

Seasonal GW Elevation Flux

Sand Interval – Benzene Plume

SVE Well Converted to EAB Smear Zone Injection Wells

Recirculation Well Screen

Groundwater Source

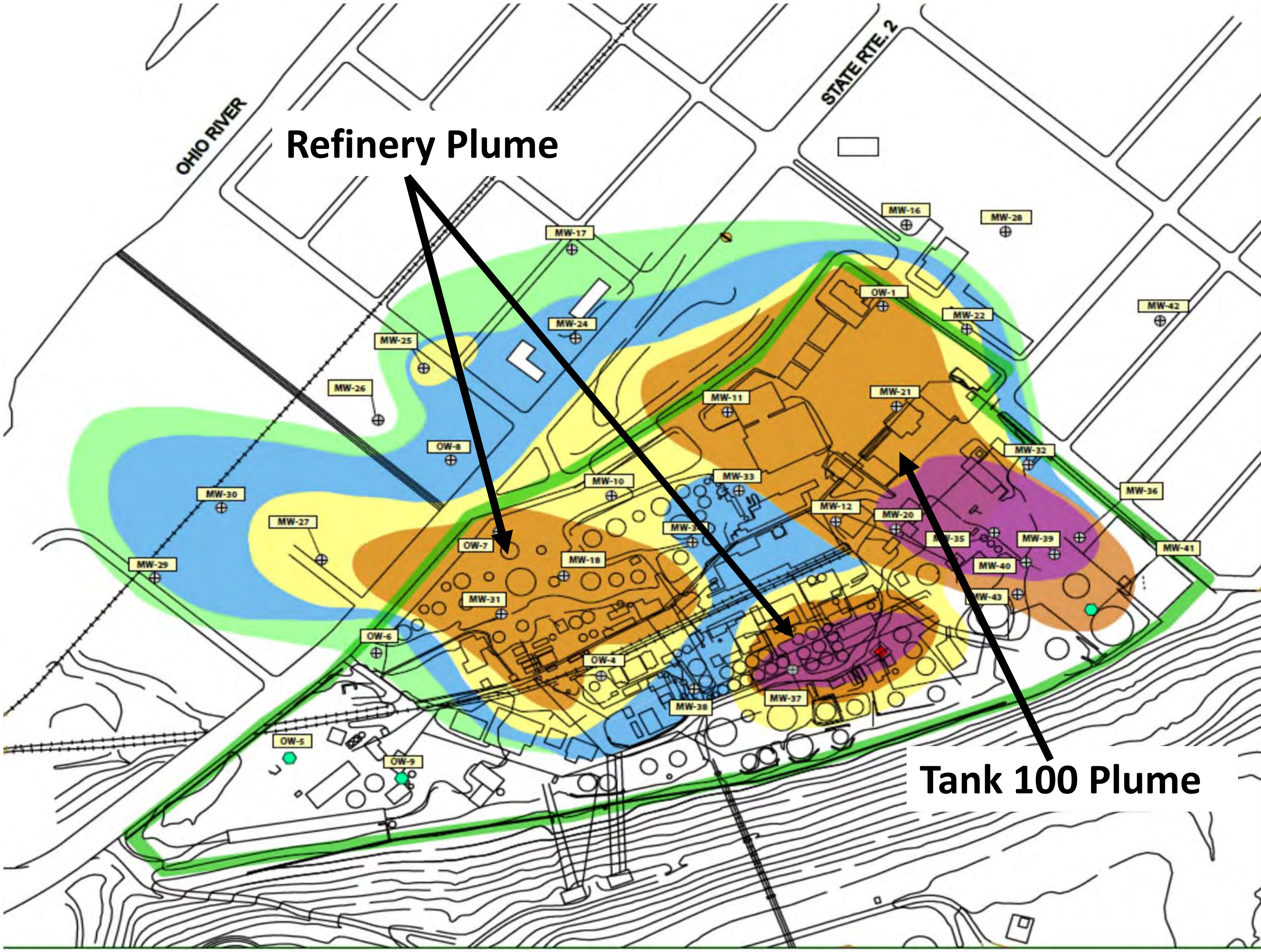
- 20- to 50-foot vadose zone laden with crude oil and refined products from historic and recent releases
- Residual mobile recoverable LNAPL and residual LNAPL (10 acres)
- Smear zone that extends 10 to 30 feet into the aquifer
    - Long term process water and noncontact cooling water extraction created localized groundwater depression below refinery
    - GW production contained plumes during active refinery operations
    - Plume started migrating to municipal wells after 1993
    - Post operation GW rebound trapped smear zone resulted in high mass anaerobic BTEX groundwater source

Groundwater Plumes – Refinery

- Buried smear zone source resulting in benzene (3,000 ug/L) and xylene (300 ug/L) plumes
- 30 acre on and off-site continuous plume
- Aquifer completely depleted of dissolved sulfate
- Background sulfate concentration 100 mg/L, identified downgradient and crossgradient
- Elevated dissolved phase and adsorbed phase TOC (degraded hydrocarbons – fatty acids) an additional substrate source (sulfate demand)
- Anaerobic aquifer ferrous iron to 100 mg/L and dissolved manganese to 10 mg/L (anaerobes in mature plumes scavenge Mn as Fe becomes less available)

Groundwater Plumes - Tank 100

- Gasoline releases late 1990s thru 2009
- Plume migrated swiftly toward muni well field (drought)
- Source BETX concentration to 100 mg/L
- Sulfate completely depleted within BETX plume
- Sulfate present side-gradient
- Anaerobic aquifer elevated ferrous iron 25 to 50 mg/L



LEGEND

- RCRA Monitoring Well
- Abandoned Monitoring Well
- Damaged Well/Not Sampled
- Perched Groundwater Well
- SMRC On-Site Boundary

Baseline Benzene Distribution

- Benzene Isoconcentration Line (5 ug/L)
- Benzene Isoconcentration Line (50 ug/L)
- Benzene Isoconcentration Line (500 ug/L)
- Benzene Isoconcentration Line (1000 ug/L)
- Benzene Isoconcentration Line (5000 ug/L)

SCALE:
1 inch equals 200 feet

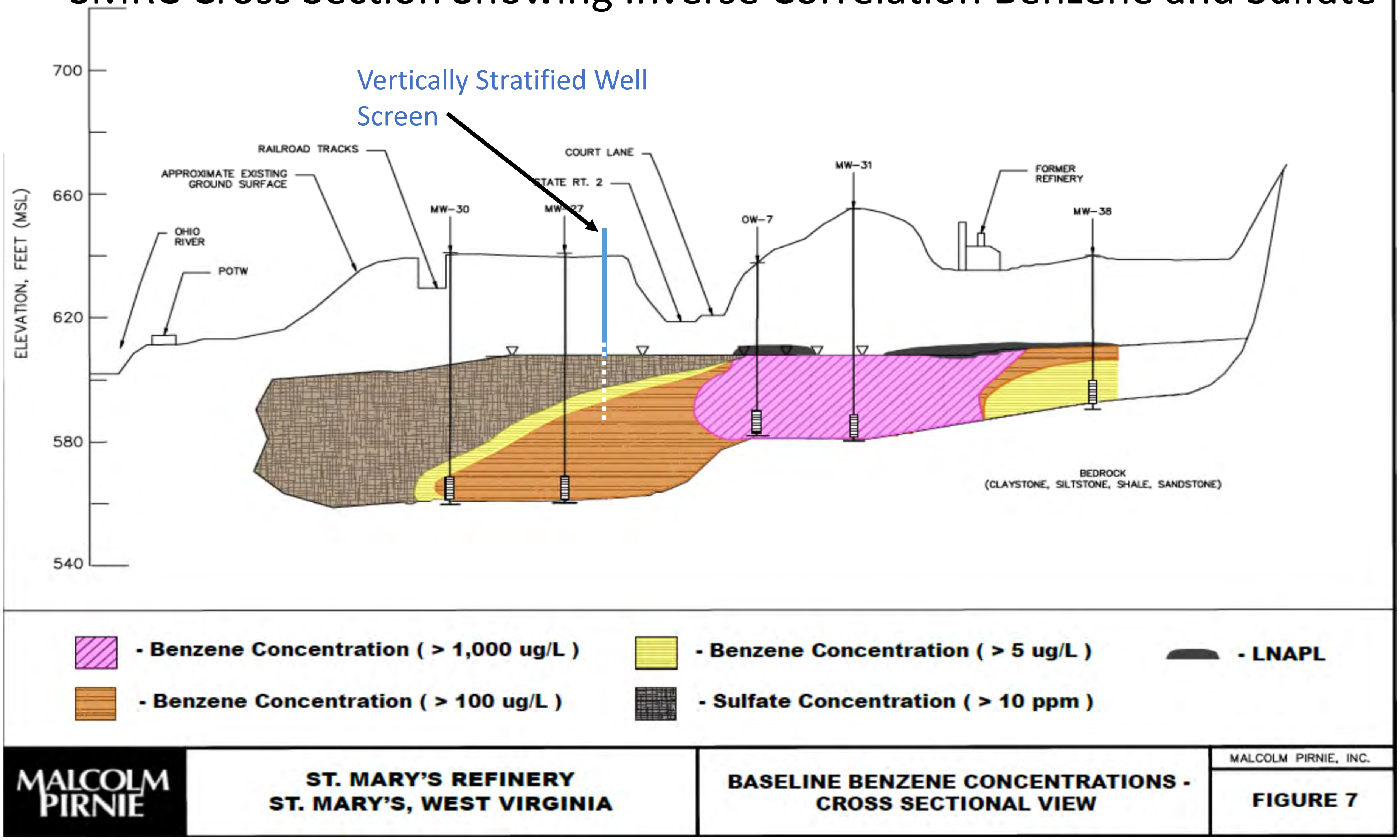
MALCOLM PIRNIE

INDEPENDENT ENVIRONMENTAL ENGINEERS, SCIENTISTS AND CONSULTANTS

ST. MARYS REFINING COMPANY
ST. MARYS, WEST VIRGINA

FIGURE 3
BASELINE BENZENE DISTRIBUTION

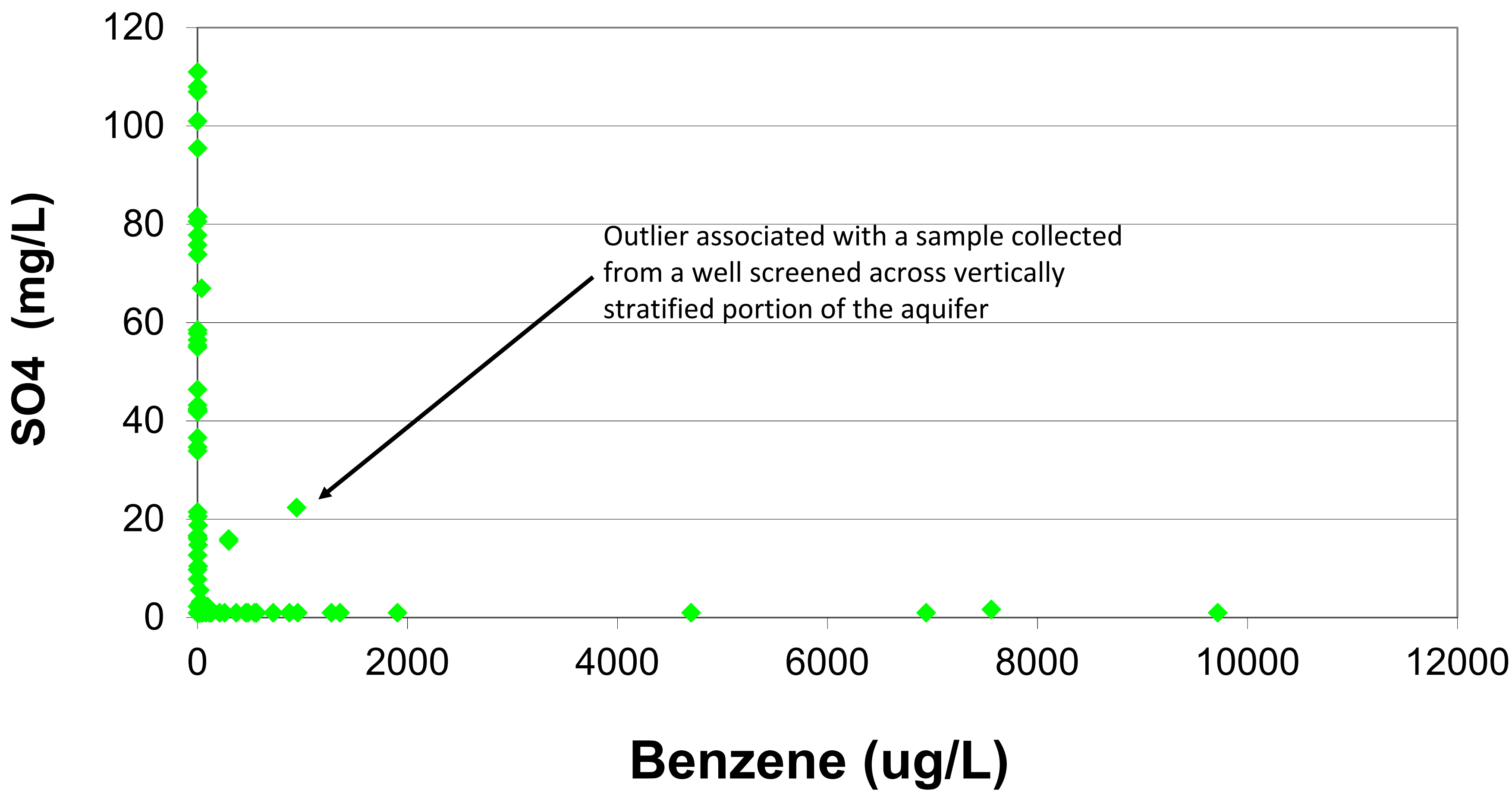
SMRC Cross Section Showing Inverse Correlation Benzene and Sulfate

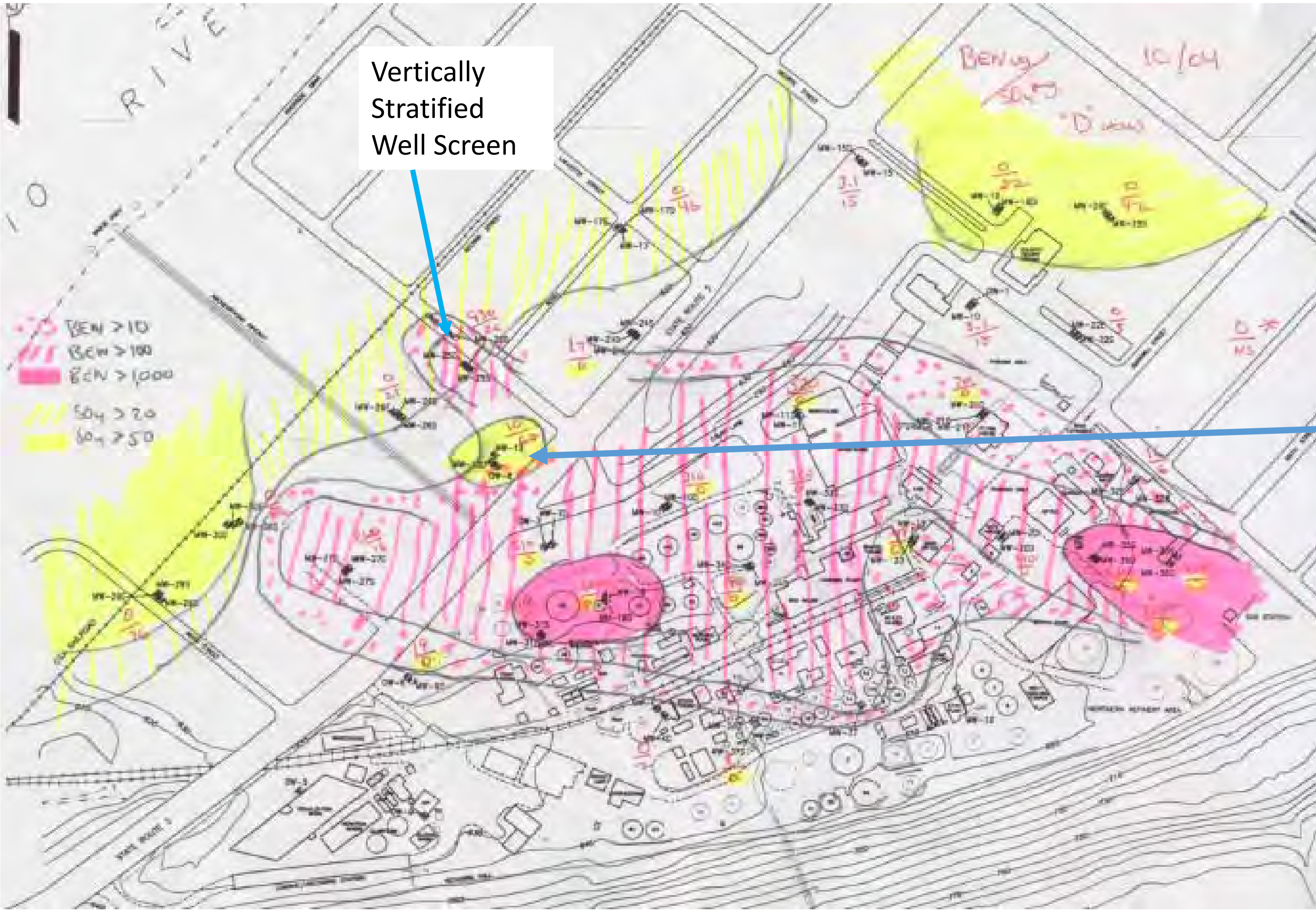


Groundwater Remedial Strategy

- Remedial Goal – Reduce source and groundwater mass to promote MNA as effective final remedy (includes reaching benzene MCLs at downgradient site boundary)
- Enhanced Anaerobic Bioremediation (EAB) – residual LNAPL below in aquifer matrix and lower smear zone
- EAB for refinery and tank farm plumes

SMRC - Benzene vs. Sulfate Groundwater Concentration





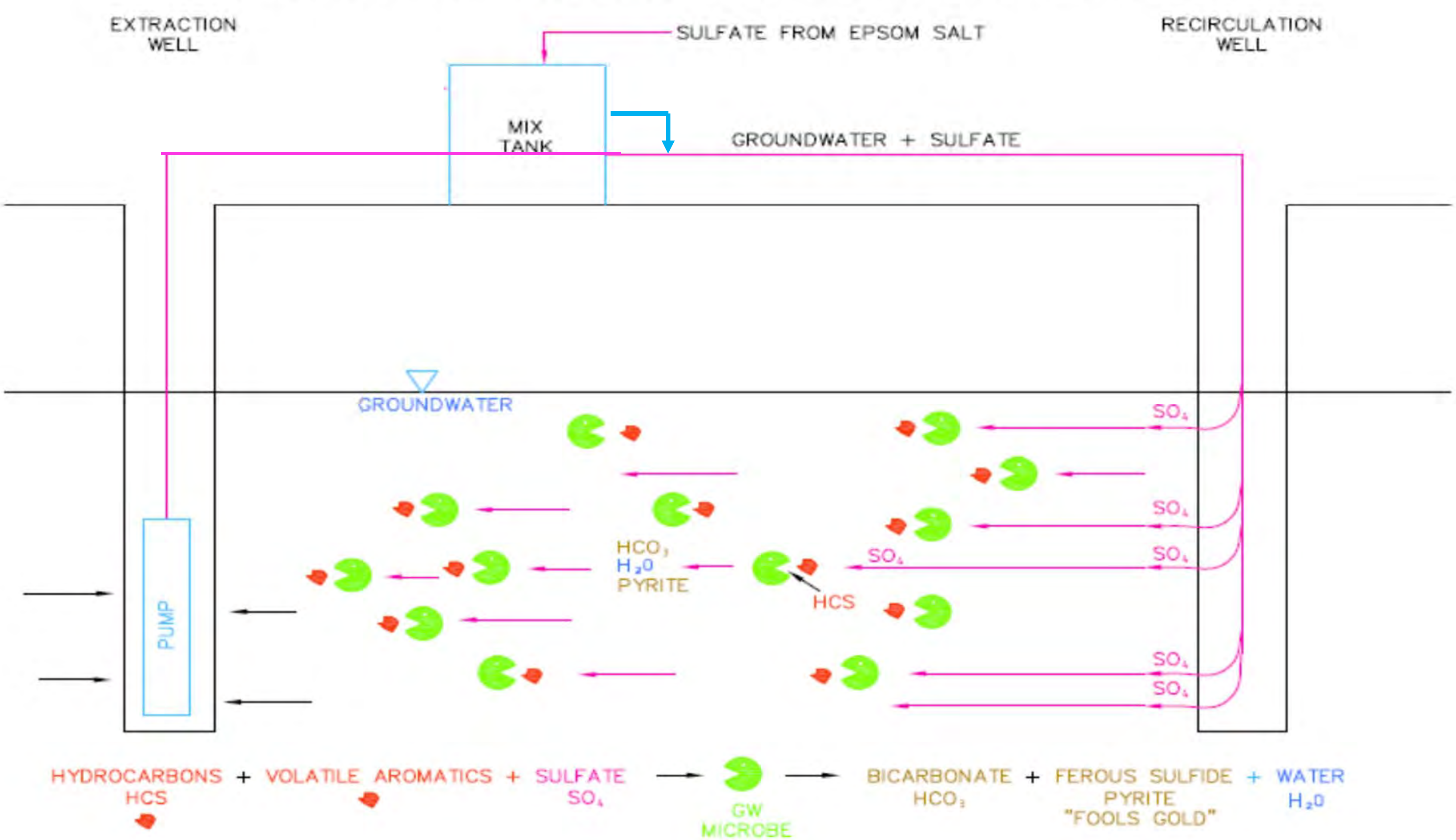
SMRC
Sand Aquifer

Fertilizer Sulfate Source Bifurcates Benzene Plume (more evidence of SRB controlling HC plume)

Typical Methods for Sulfate Distribution

- Batch Injections
- Pitch & Drift – feed dry sulfate (Epson Salt or Gypsum)
  - UST excavations
  - Flow through trenches
  - Surface distribution – shallow GW
- ISCO Residuals
  - Fenton’s when sulfuric acid is utilized as conditioner
  - Persulfate
- ***Recirculation – most effective***
  - Recirculation of sulfate amended raw/untreated GW
  - OWS effluent as sulfate carry

ENHANCED ANAEROBIC BIODEGRADATION



SMRC EAB System and Process

- On Site Recirculation permitted through EPA Region 3 (see attached letter)
- Off-Site sulfate amendments permitted under WVDEP Voluntary Cleanup program (not discussed in the case study (secondary pipeline releases)
- Pilot test completed to estimate effective distribution well configuration and design and estimate sulfate demand
  - Sulfate demand was similar to published utilization rates (25 to 50 mg/l/day)
  - Sulfate demand is difficult to estimate – SRB will degrade most TOC including partially degraded HCs and naturally occurring organics not typically analyzed for during site investigations
  - One year with expansion of system
- Full-Scale System
  - Three Sulfate supply manifolds (two for the refinery plume and one for the Tank 100 plume)
  - 25 recirculation wells could function as extraction or injection based on sulfate monitoring results
  - 25 bioventing wells converted to injection wells to address residual smear zone LNAPL
  - 2 years
- 20 million gallons of GW recirculated (most of the water was extracted from downgradient property boundary and recirculated throughout plumes
- 1.2 million lbs of Epsom salt
- 2,500 gallons of 9% ammonium water

Recirculation System – 60 gpm & 800 lbs of Epsom Salt / day

Permitted to recirculate untreated water by EPA and WV

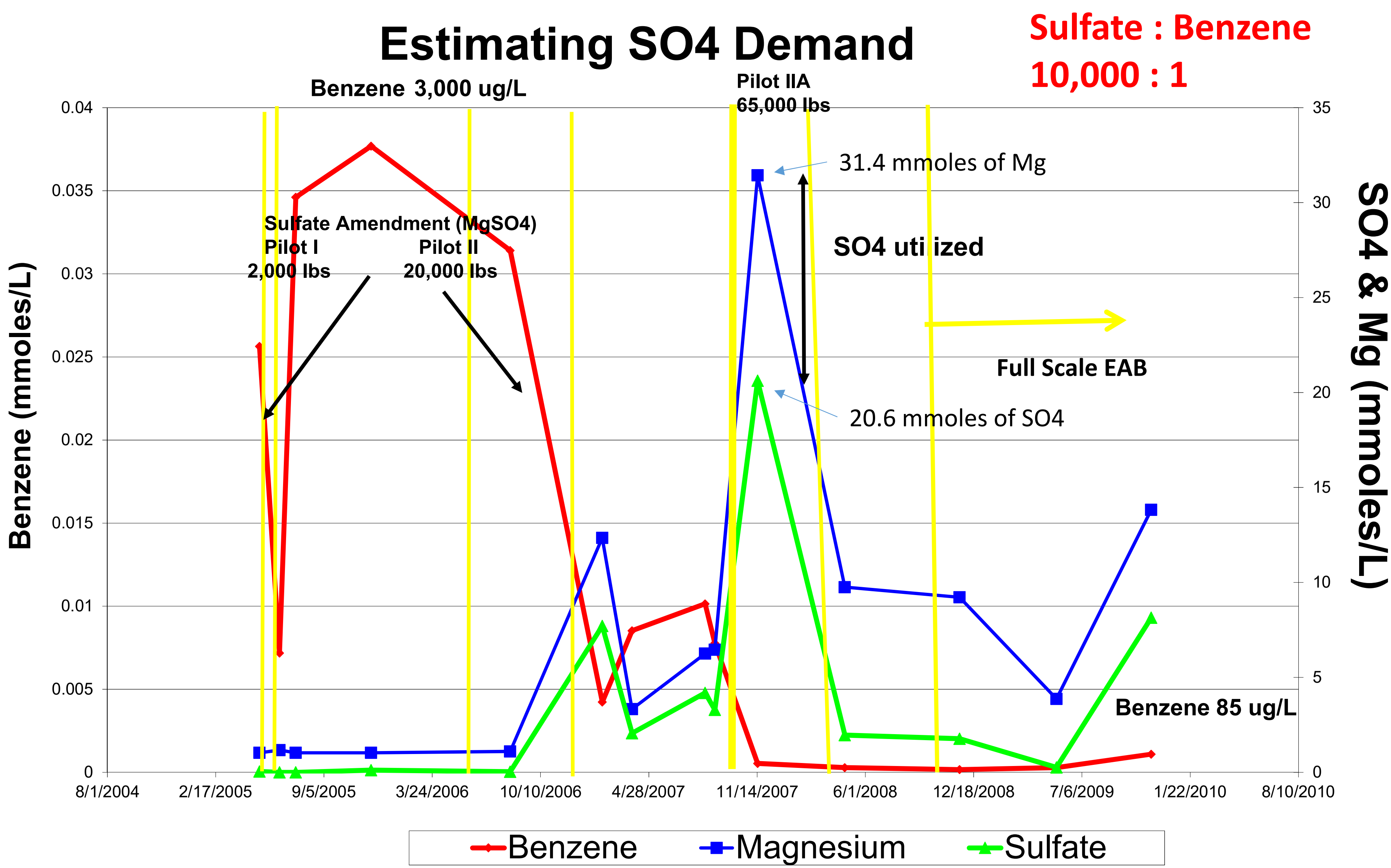
SMRC Refinery Plume: EAB Pilot, Sulfate Demand, and Full-Scale Results

- Pilot recirculation system was set up with three recirculation wells on the down-gradient portion of the plume
- Extraction wells were on the property boundary
- Injection wells were installed in one of the plume source areas
- No realistic stochiometric approach to estimating sulfate demand
    - Two major targeted, regulated compounds benzene and xylenes are an insignificant (<1%) portion of the total organic mass that is all an available substrate to SRB
    - This ratio is typical of most petroleum hydrocarbon releases although the % of targeted compound may increase to approx. 25% in newer releases
    - Soluble compounds detected in area monitoring wells are not representative of total degradable mass; 90% of this degradable mass is usually adsorbed to the aquifer matrix
- Based on our experience, we initially estimated sulfate demand by adding sufficient sulfate (Epsom Salt) to increase the aquifer concentration to 1,000 to 2,000 mg/L

SMRC Refinery Plume: EAB Pilot, Sulfate Demand, and Full-Scale Results

- Based on our experience, we initially estimated sulfate demand by adding sufficient sulfate (Epsom Salt) to increase the aquifer concentration to 1,000 to 2,000 mg/L
  - Epsom salt is $MgSO_4(H_2O)_7$ so Mg and Sulfate are added to the aquifer on a 1:1 molar ratio
  - Magnesium is a semi conservative tracer when alkalinity levels are less than 500 mg/L
  - Sulfate demand estimated by calculating the difference between the molar concentration of Mg and SO_4 (see next slide)
  - Calculated a sulfate amendment rate for each recirculation system based on sulfate demand estimate
  - The sulfate demand is regularly evaluated based on groundwater process monitoring - sampling for SO_4 and Mg and sulfate feed rates are adjusted to maintain a consistent concentration of approximately 500 mg/L
  - Sulfate demand generally decrease as the more degradable compounds are mineralized (converted to CO_2)
- During the Refinery plume remediation sulfate feed rates for one of the recirculation systems dropped from 1,000 lbs per day to 300 lbs per day

Estimating SO4 Demand



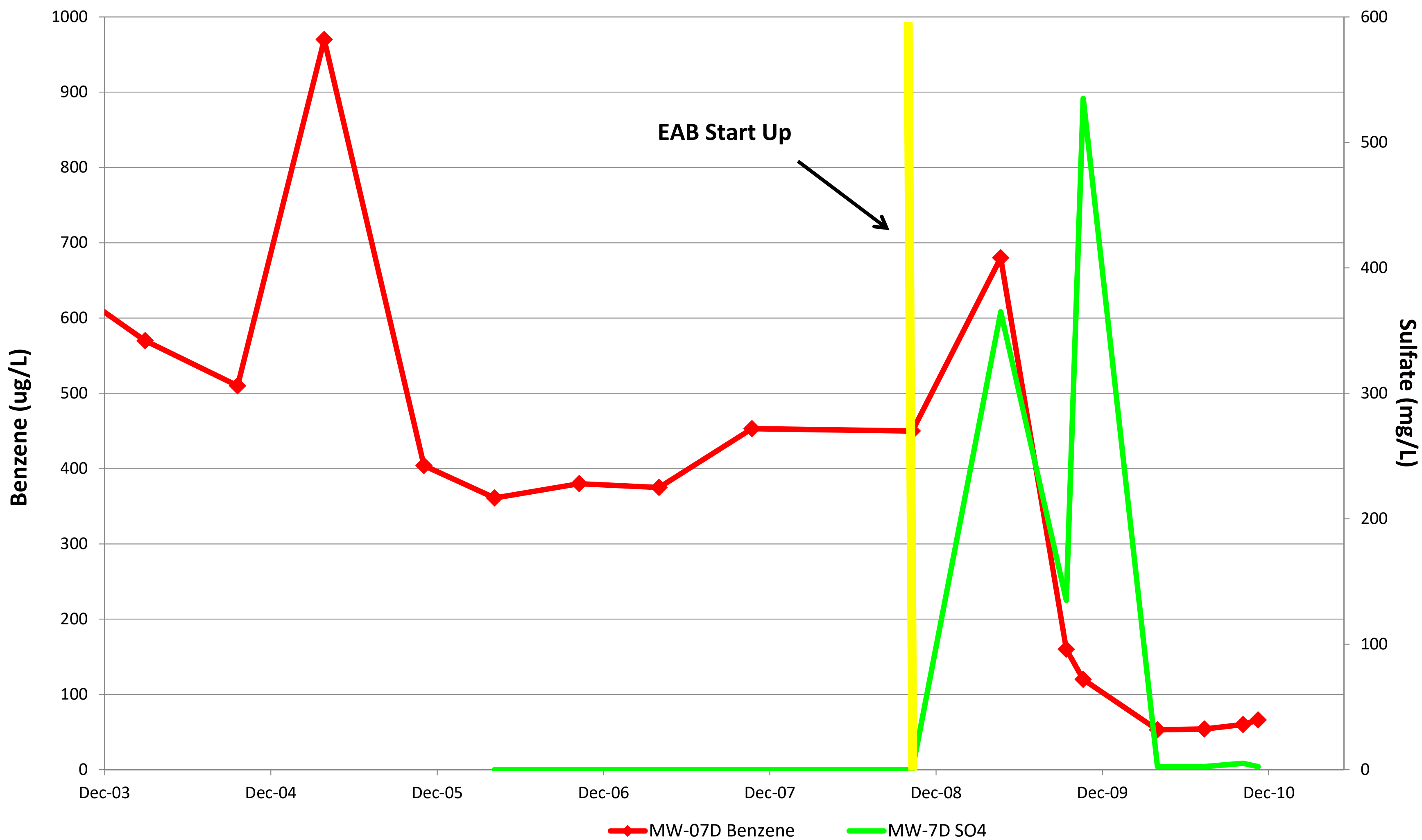
Estimating Sulfate Demand – CW-1 Pilot Test area

- As shown on the previous trend figure (Estimating Sulfate Demand), we didn’t meet the sulfate demand until Pilot Test IIA
  - The smear zone in this area is 30 feet thick and estimating the demand was tough
  - After the addition of almost 100,000 lbs of sulfate we met the demand (residual sulfate was present.
- The November2007 process groundwater sampling round produced the following sulfate demand results
  - Sulfate was present at a concentration of approximately 20.6 millimoles (mmoles)
  - Magnesium was present at a concentration of approximately 31.3 mmoles
  - If no SO4 utilization molar concentrations should be equivalent
  - When SO4 mmolar concentration is less than Mg it is a strong indication sulfate was utilized by SRB to metabolize petroleum HCs
  - Estimated utilization or sulfate demand 31.3 – 20.6 = 10.7 mmoles of sulfate utilized
  - Or 10.7 mmoles x 96 mg/mmole = 1030 mg per liter reduction in sulfate
  - Injection started on 9/28/07 sampled on 11/15/07 = 49 days
  - Sulfate utilization rate 1030 mg/L over 79 days = 21 mg/L per day
- Initial full-scale EAB SO4 addition rates were designed to meet the 21 mg/L per day utilization rate

Full-Scale Refinery Plume EAB Results

- The next trend figure shows benzene and sulfate concentrations vs time
- Following 1.5 years of sulfate recirculation in the area benzene concentrations were reduced to 26 ug/L near the MCL goal of 5 ug/L
- After an additional 6 months (October 2010) benzene concentrations dropped to below 5 ug/L (see isoconcentration figures)

Figure 9 : MW-7D - Response to EAB at OW7/MW-18



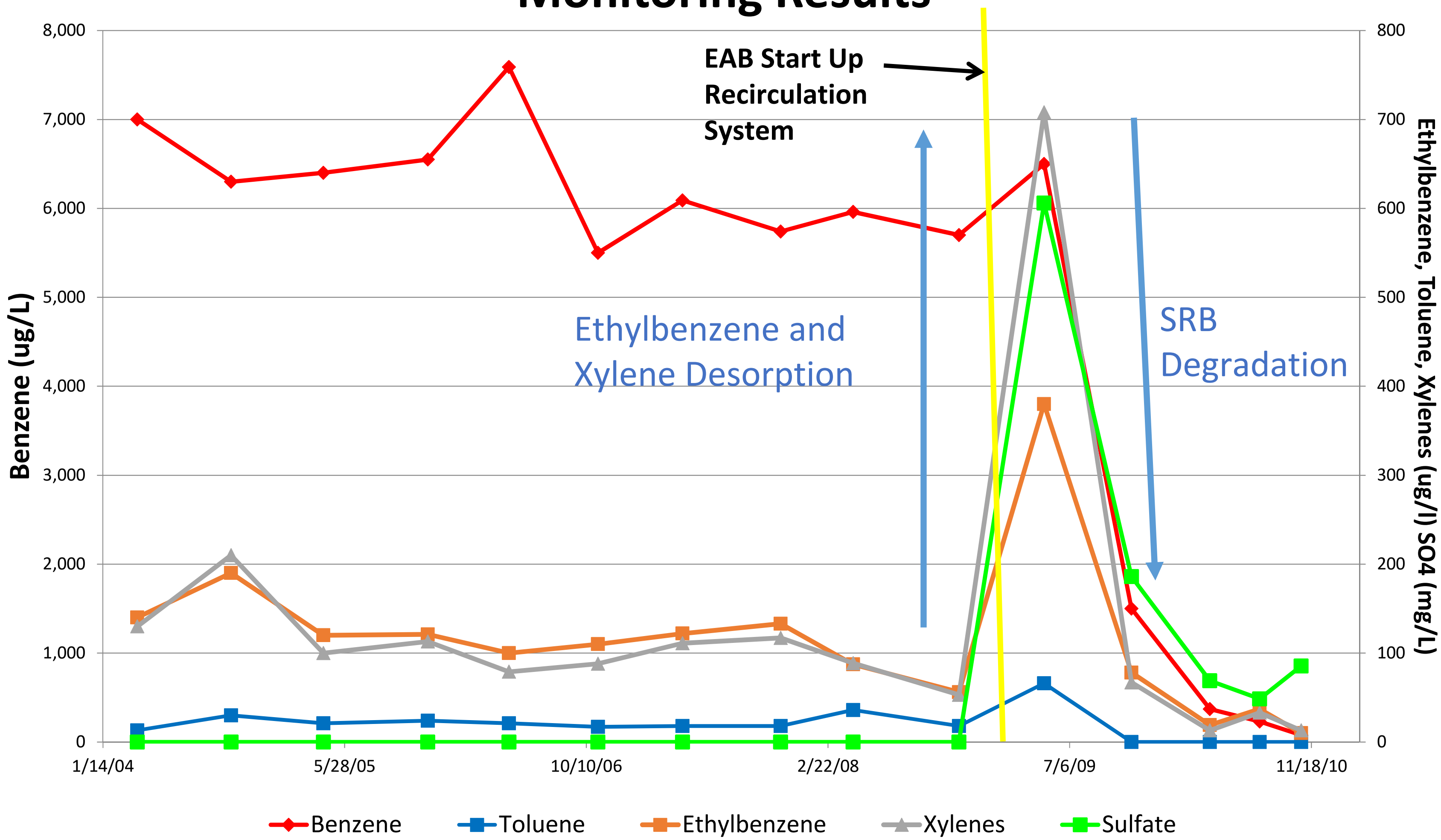
Full-Scale T-100 Plume EAB Results

- T-100 plume was a more recent releases of gasoline from over filling and tank bottom failure
- Plume was less than 10 years old
- Residual LNAPL confined to GW table resulting in typical seasonal smear zone of 3 to 4 feet and groundwater dissolved phase plume in sand aquifer approximately 20 feet thick
- Plume was pulled towards the city's muni wells
- Full Scale remediation consisted of bioventing to remediate the residual vadose zone source and EAB to degrade the dissolved phase BTEX plume
- EAB system consisted of two extraction wells and initially three recirculation wells, additional bioventing wells were converted to injection wells to address residual LNAPL pocket sources

Full-Scale T-100 Plume EAB Results

- Process monitoring results for this plume clearly demonstrate the ability of SRB to desorb and degraded adsorbed phase aromatic hydrocarbons
- Following the addition of sulfate, xylene and ethylbenzene concentrations increase dramatically and then decrease just as swiftly
- The same desorption / degradation trend is not observed for benzene (in our experience it only occasional observed while the desorption/degradation pattern is almost always observed for ethylbenzene, xylenes, and/or TMBs
- The full-scale EAB effort required approximately 250,000 lbs of sulfate substantially less than the refinery plume
  - T100 plume had typical smear zone with dissolved phase plume
  - Refinery plume had the 30-foot smear zone that generated a large sulfate demand

T100 Gasoline Plume – EAB Process/Progress Monitoring Results



Full-Scale EAB Refinery Progress Monitoring – Isoconcentration Figures

- Baseline 2005 benzene isoconcentration figure – combined shallow and sand aquifer benzene concentrations
  - T-100 benzene plume was pulled in the direction of the City's Muni Wells
  - Refinery plume almost extends to the Ohio River
- 2008 benzene isoconcentration figure shows progress following approximately one year of full-scale EAB
- 2010 benzene isoconcentration figure shows the down-gradient wells meeting the remediation goal of mcls on property boundary
  - Isolated pocket of benzene downgradient of site was cut off from the source and attenuated to below 25 ug/L during the 2012 annual sampling round completed by others
- Following the effective implementation of the remedial plan the final IRM EAB reports were approved and the EPA Statement of Basis identified MNA as the final remedy (see attached EPA Letters)

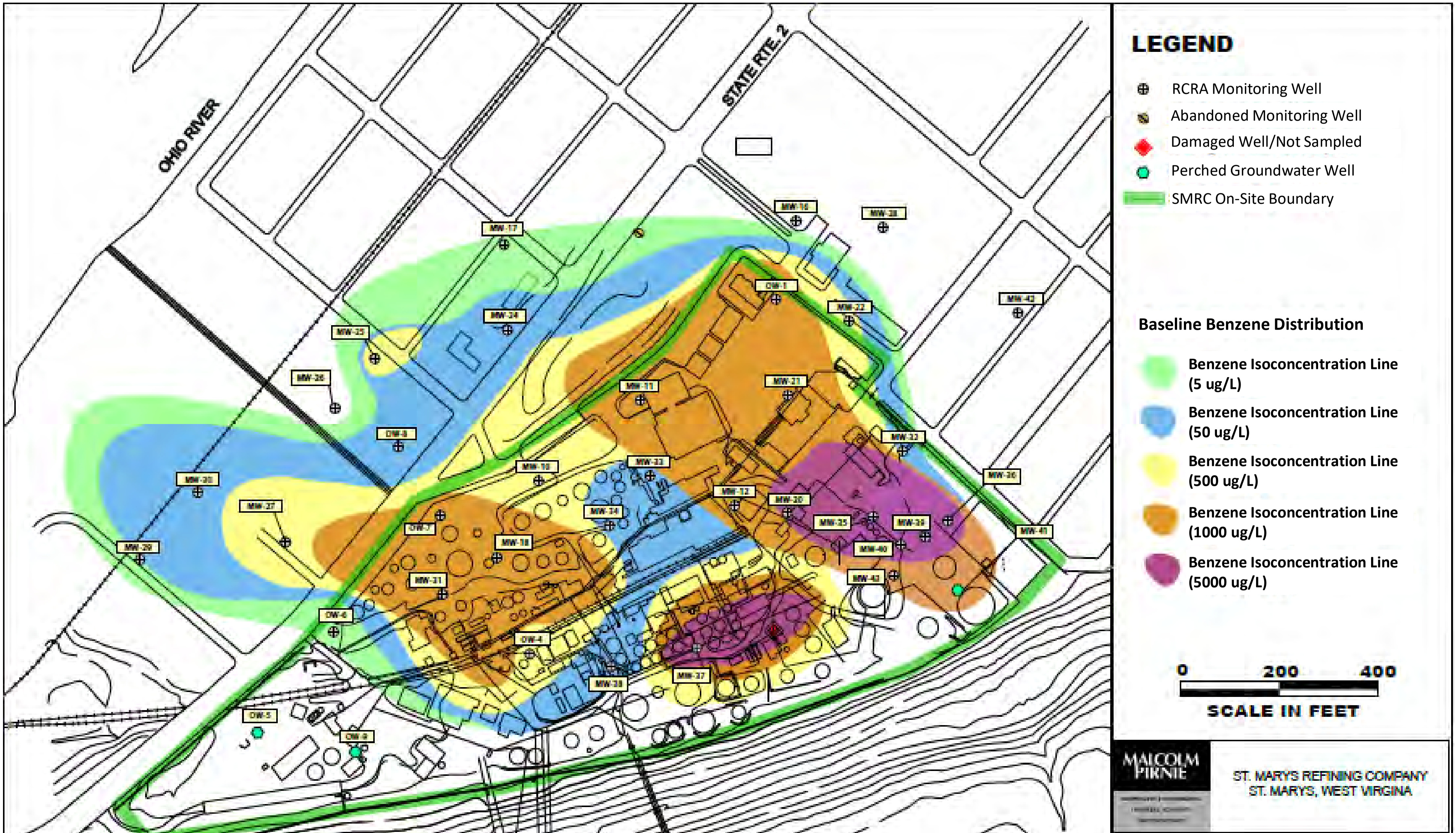
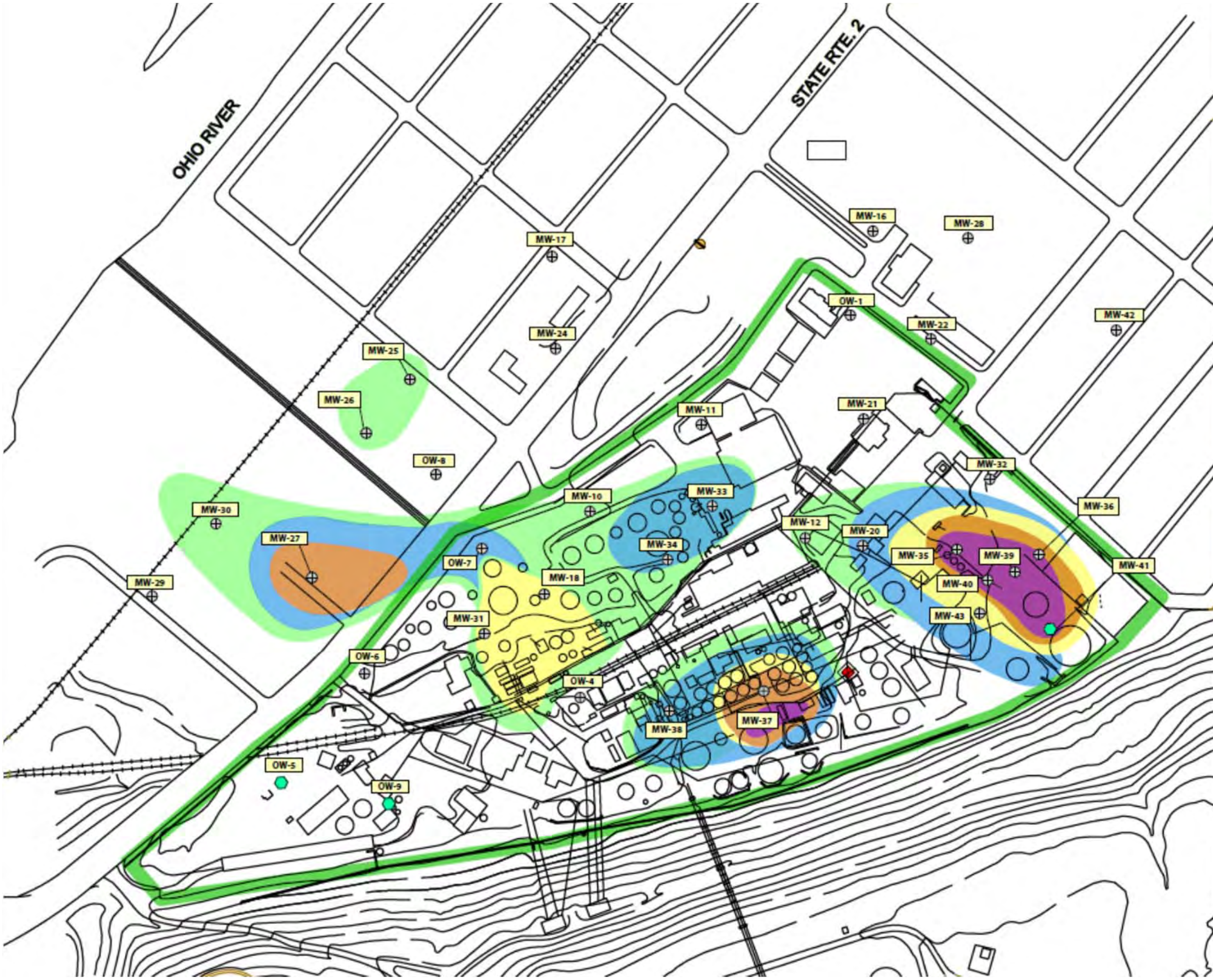


FIGURE 4
BASELINE BENZENE
DISTRIBUTION



LEGEND

- RCRA Monitoring Well
- Abandoned Monitoring Well
- Damaged Well/Not Sampled
- Perched Groundwater Well
- SMRC On-Site Boundary

November 2008 Benzene Distribution

- **Benzene Isoconcentration Line (5 ug/L)**
- **Benzene Isoconcentration Line (50 ug/L)**
- **Benzene Isoconcentration Line (500 ug/L)**
- **Benzene Isoconcentration Line (1000 ug/L)**
- **Benzene Isoconcentration Line (5000 ug/L)**

SCALE:

1 inch equals 200 feet

MALCOLM PIRNIE

ST. MARYS REFINING COMPANY
ST. MARYS, WEST VIRGINA

FIGURE 4
NOVEMBER 2008 BENZENE DISTRIBUTION

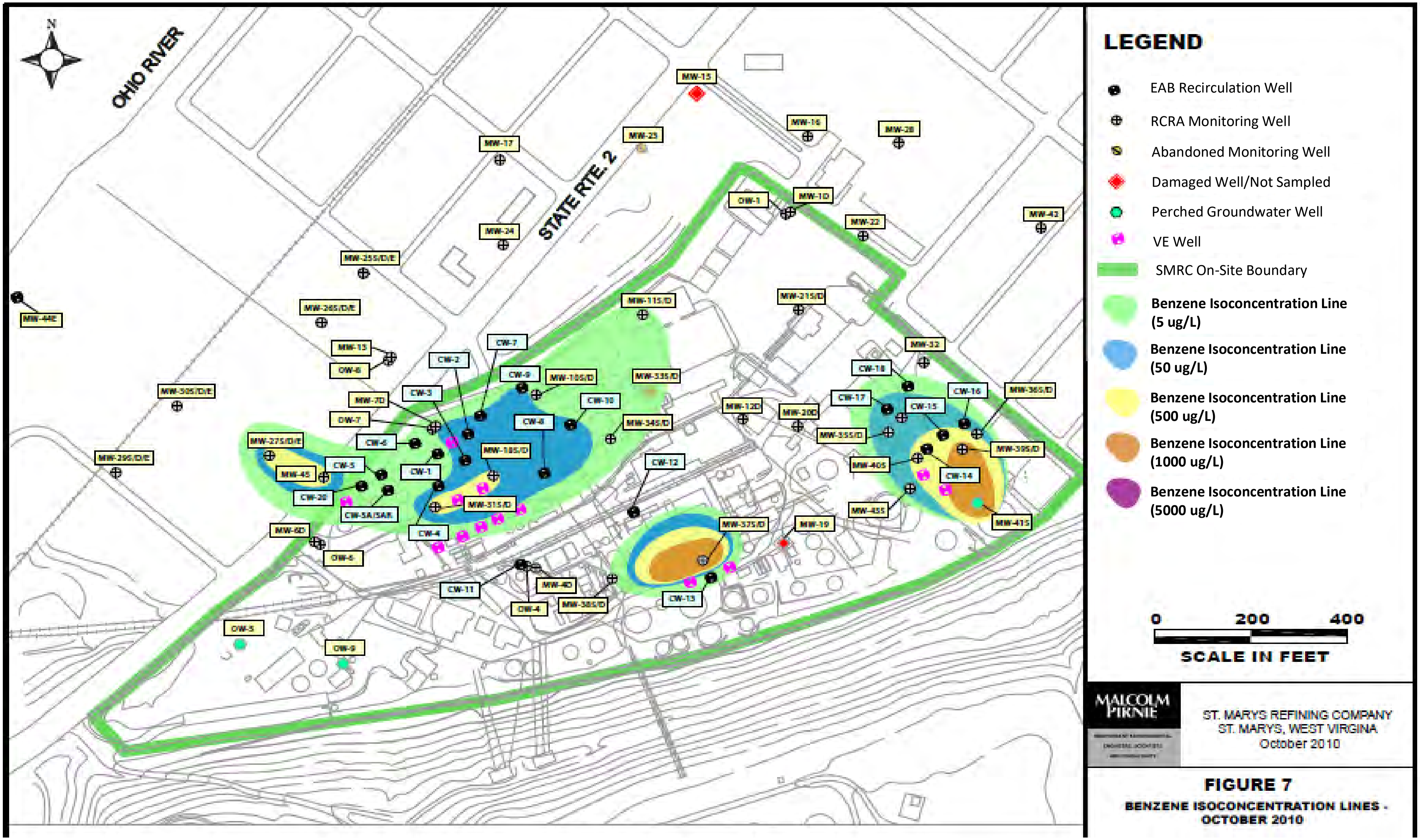


FIGURE 7

BENZENE ISOCONCENTRATION LINES - OCTOBER 2010

ATTACHMENT A – CASE STUDY 2

ELK REFINERY, CLENDENIN, WEST VIRGINIA

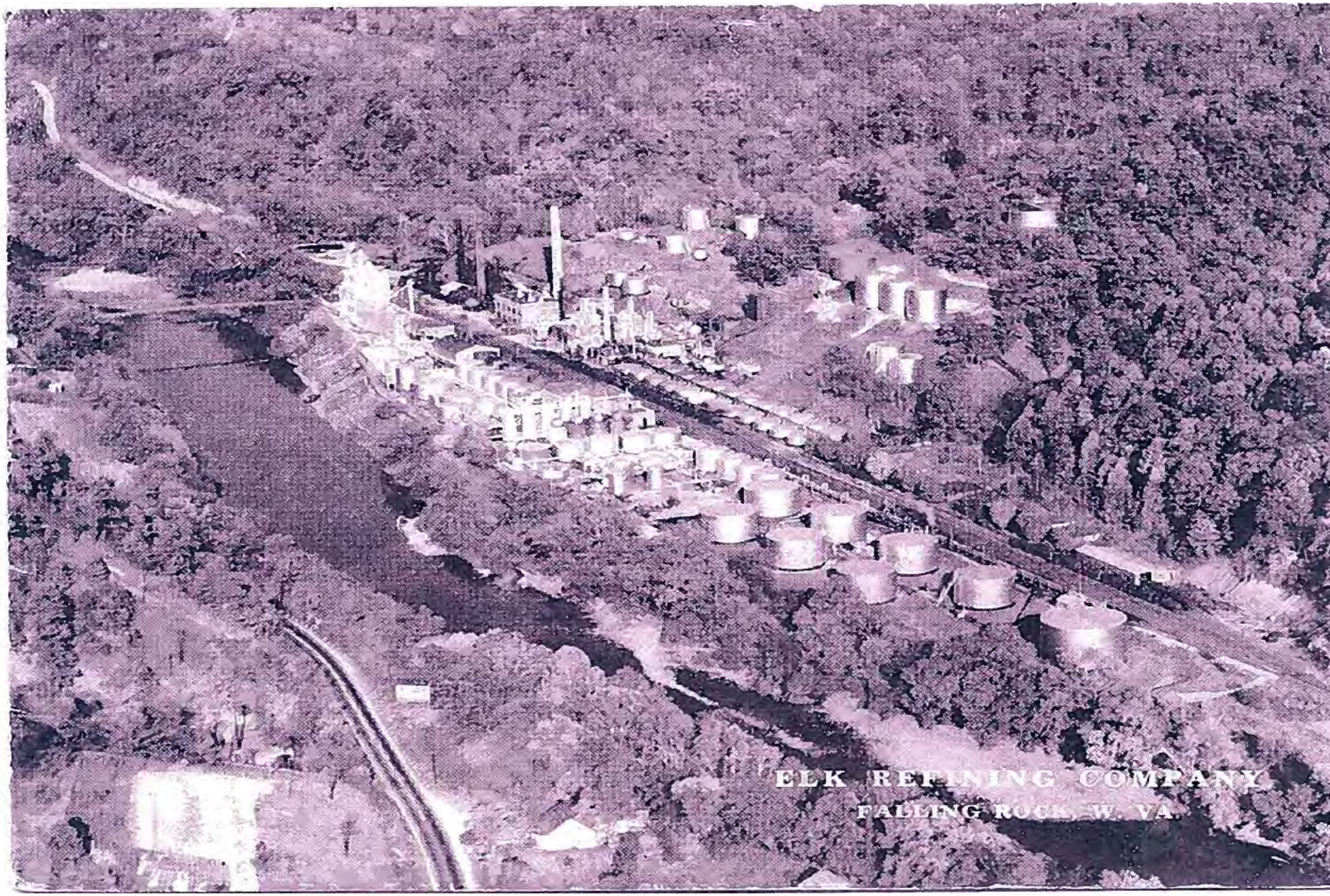
Response to Comments to the July 22, 2019 Letter of Disapproval, *Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements: Reinjection Pilot Test Work Plan*

Enhanced Anaerobic Biodegradation (EAB)

Case Study 2:

Elk Refinery, Falling Rock, West Virginia

TRC
Results you can rely on

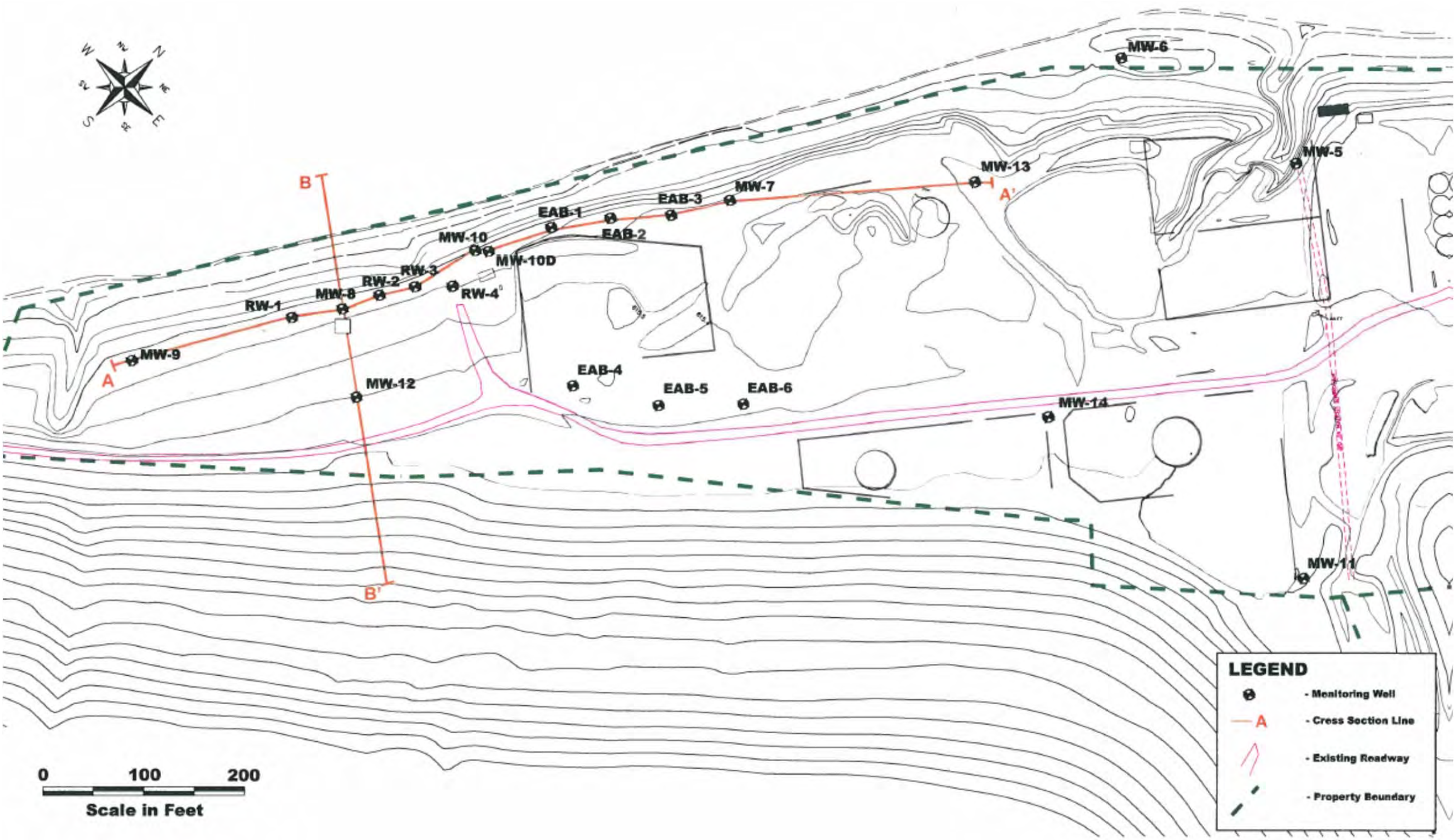

ELK REFINING COMPANY
FALLING ROCK, W. VA.

Refinery Description

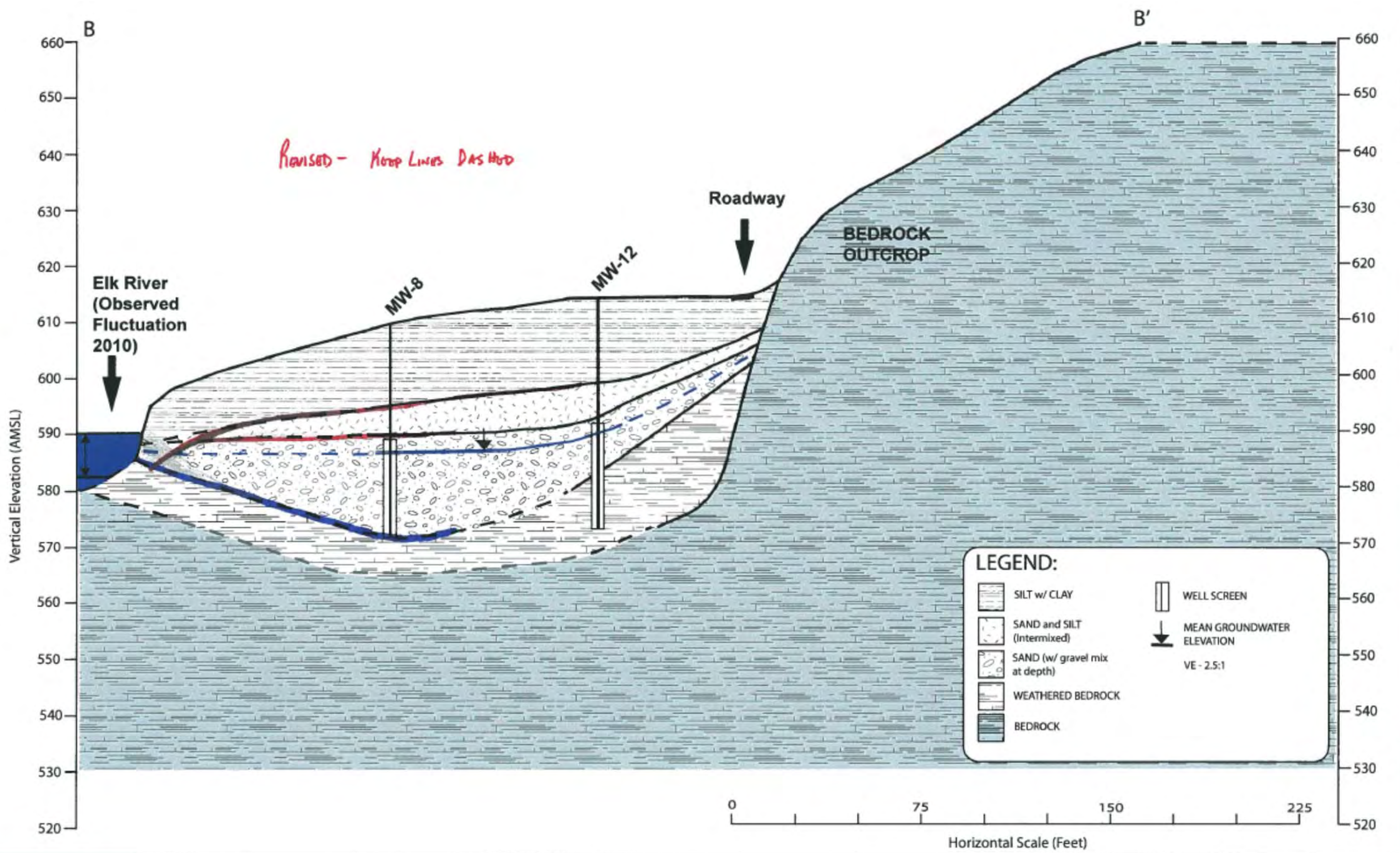
- Active refinery 1913 to 1982
- Refinery was partially demolished in the late 1980s
- 20-acre refinery area
- 30-acre tank farms and landfills (not a groundwater source)
- Refined Pennsylvania crude into fuels and lubricants
- Remediation completed under West Virginia Department of Natural Resources Voluntary Cleanup Program

Geology and Hydrology

- Alluvial deposits –
  - interbedded sand, silts and clays to 60 feet
  - Bedrock at 80 feet (not impacted)
- Seasonal GW fluctuation of 3 feet
- Hydraulic conductivity ranged from 1×10^{-2} to 5×10^{-6} cm/sec
- Horizontal seepage velocity of 0.1 to 5 ft/day
  - Higher velocities associated with floods and droughts
- Semi Confined Aquifer except during low seasonal GW levels



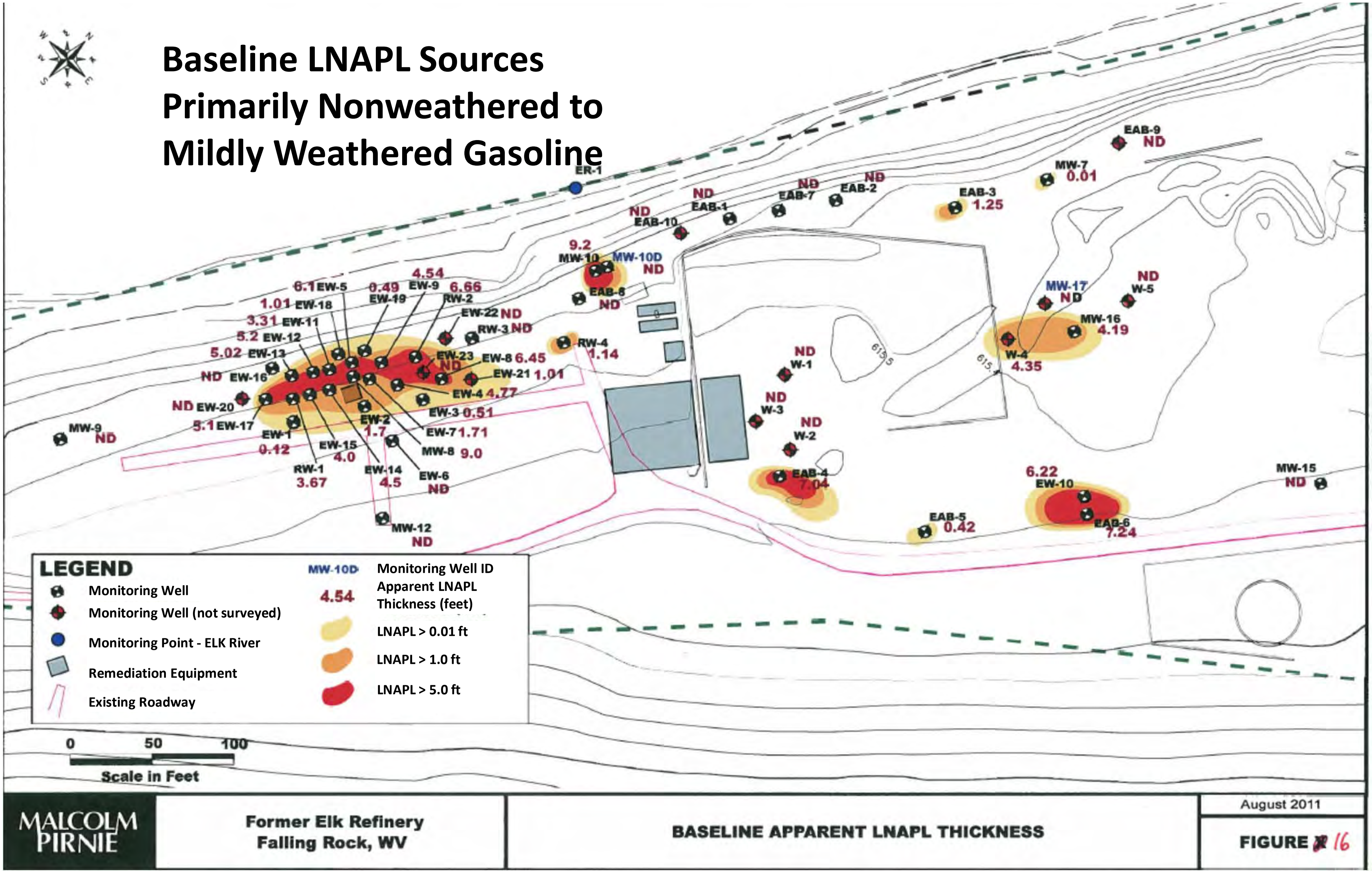
N
NE
E
SE
S
SW
W
NW
MW-6
MW-5
MW-13
A'
MW-7
EAB-3
EAB-1
EAB-2
MW-10
MW-10D
RW-3
RW-2
RW-4
MW-8
RW-1
MW-9
A
B
MW-12
B'
EAB-4
EAB-5
EAB-6
MW-14
MW-11
LEGEND
- Monitoring Well
A
- Cross Section Line
- Existing Roadway
- Property Boundary
0
100
200
Scale in Feet


B
B′
Revised - Keep Lines Dashed
Roadway
BEDROCK OUTCROP
Elk River (Observed Fluctuation 2010)
MW-8
MW-12
Vertical Elevation (AMSL)
660
650
640
630
620
610
600
590
580
570
560
550
540
530
520
LEGEND:
SILT w/ CLAY
SAND and SILT (Intermixed)
SAND (w/ gravel mix at depth)
WEATHERED BEDROCK
BEDROCK
WELL SCREEN
MEAN GROUNDWATER ELEVATION
VE - 2.5:1
0
75
150
225
Horizontal Scale (Feet)

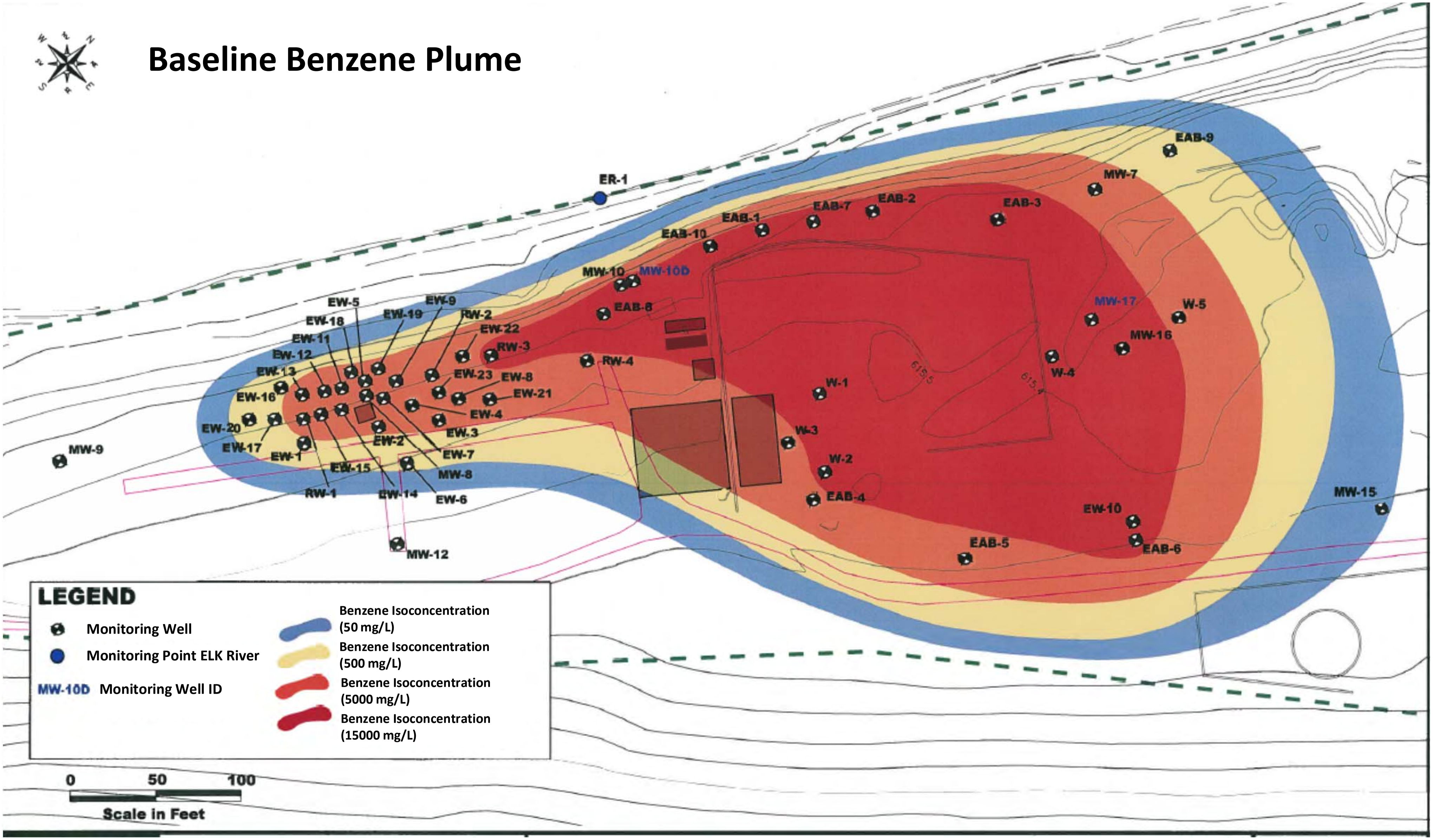
Groundwater Source and Plumes

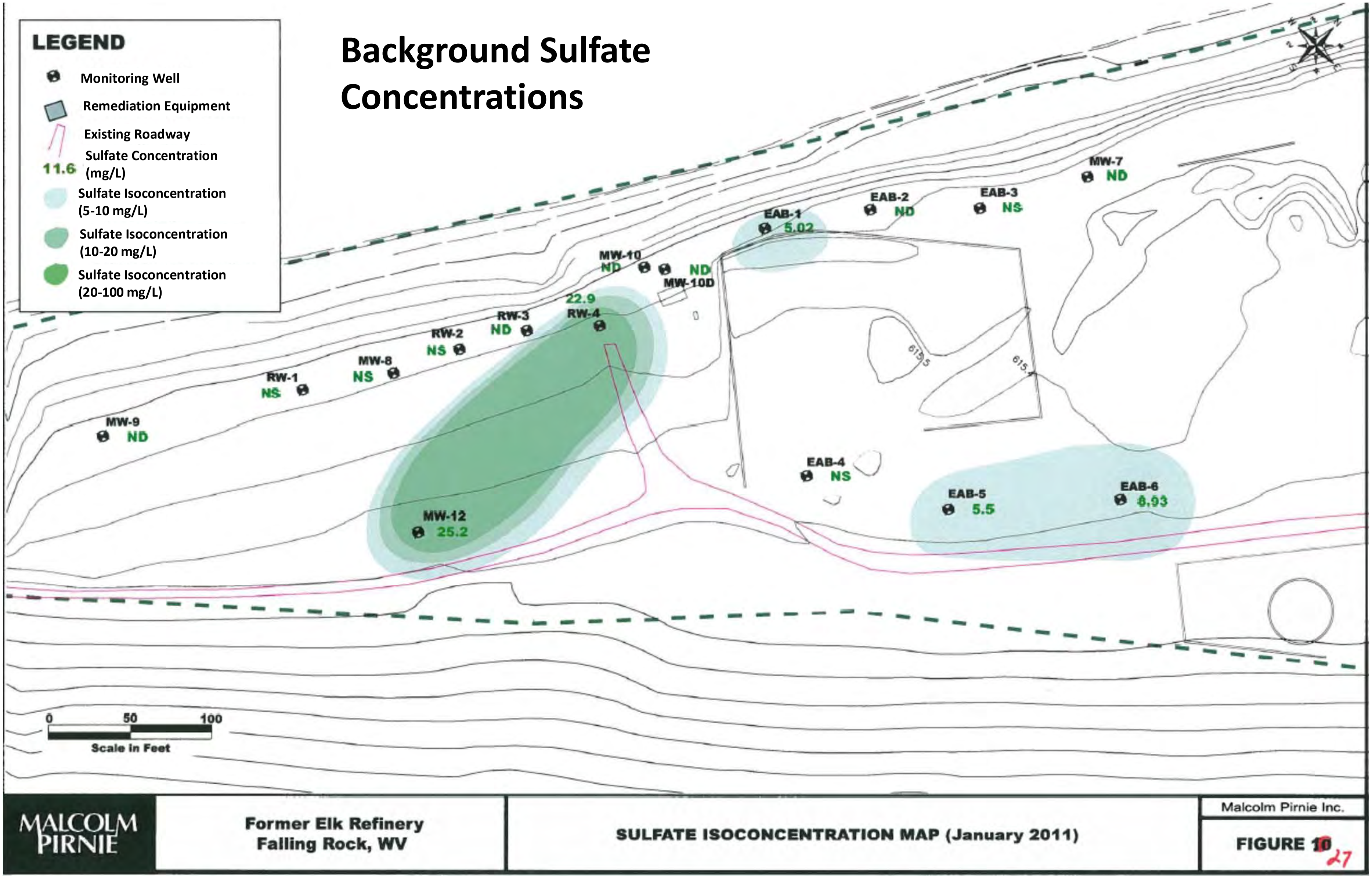
- Gasoline LNAPL Plumes
  - Relatively fresh LNAPL potential associated with release during demolition and confined aquifer
- Residual mobile recoverable LNAPL to thickness of 9 feet (confined aquifer)
- Smear zone that extends 5 feet into the aquifer
- BTEX Plume to 250 mg/L along bank of the ELK River
- Background sulfate concentrations approximately 25 mg/L
- Anaerobic aquifer ferrous iron to 100 mg/L

Baseline LNAPL Sources Primarily Nonweathered to Mildly Weathered Gasoline



Baseline Benzene Plume





LEGEND
Monitoring Well
Remediation Equipment
Existing Roadway
11.6 Sulfate Concentration (mg/L)
Sulfate Isoconcentration (5-10 mg/L)
Sulfate Isoconcentration (10-20 mg/L)
Sulfate Isoconcentration (20-100 mg/L)
Background Sulfate Concentrations
MW-9 ND
RW-1 NS
MW-8 NS
RW-2 NS
RW-3 ND
22.9 RW-4
MW-10 ND
ND MW-10D
EAB-1 5.02
EAB-2 ND
EAB-3 NS
MW-7 ND
EAB-4 NS
EAB-5 5.5
EAB-6 8.93
MW-12 25.2
615.5
615.5
0 50 100
Scale in Feet
MALCOLM PIRNIE
Former Elk Refinery
Falling Rock, WV
SULFATE ISOCONCENTRATION MAP (January 2011)
Malcolm Pirnie Inc.
FIGURE 10 27

Remedial Strategy

- Remedial Goal – Reduce source and groundwater mass to promote MNA as effective final remedy (no measurable gasoline based LNAPL)
- Total fluids extraction
- Skimmer pumps in EAB extraction wells
- EAB of dissolved phase plume and LNAPL residuals
  - Recirculated untreated GW from below LNAPL plumes
  - Recirculated OWS effluent from total fluid recovery pumps
  - Recirculated water benzene > 5 mg/L and BTEX > 50 mg/L
- EAB for refinery and tank farm plumes
- Final remedy MNA (enhanced by sulfate addition)

Elk Refinery Recirculation System – OWS Effluent

SO4 Feed Tank
15% Epson Salt
& 100 mg/l
NH4

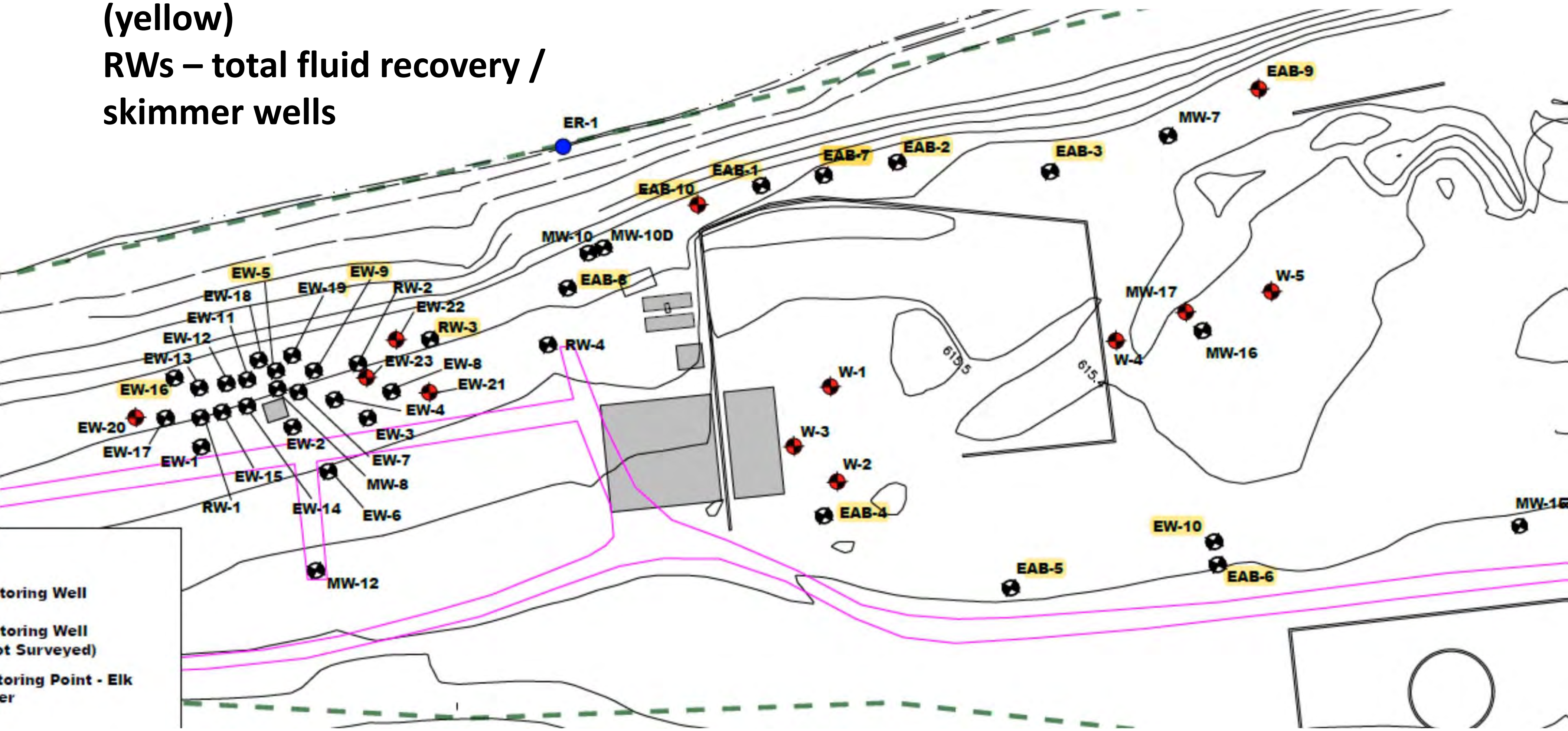
Recirculation Manifold
Lines on the right extracted water from LNAPL free wells
Line on the top OWS Effluent
Lines to the left are recirculation lines to wells

OWS Received GW LNAPL Mixtures from Skimmer pumps and total fluids pumps located in MWs with up 9 feet of LNAPL

Accelerated Remediation – No Pilot

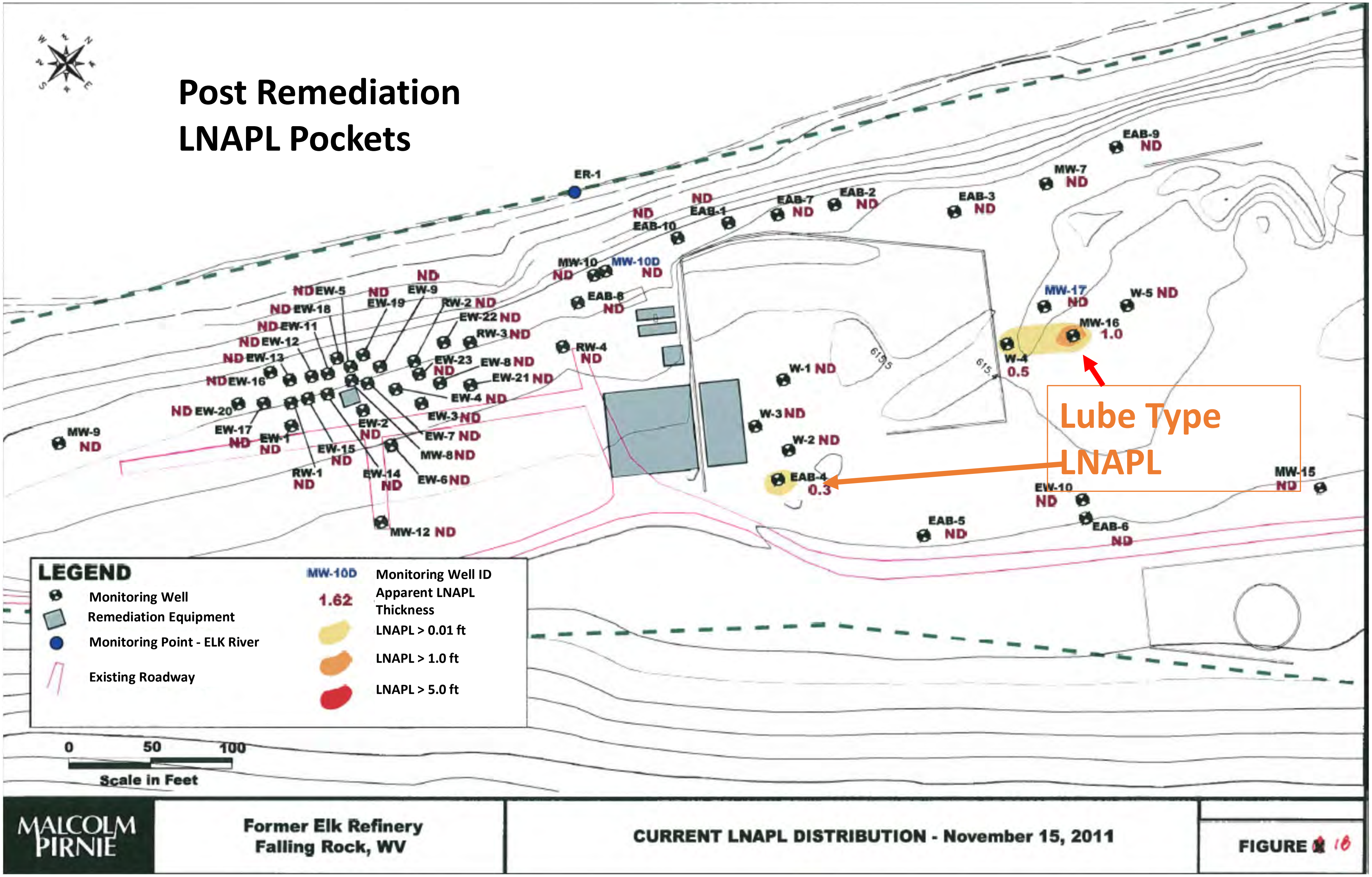
- LNAPL remediation and EAB proceeded at the same time
  - Recirculated all water associated with LNAPL recovery
  - Amendment rate was adjusted based on field conductivity readings in MWs and extracted water
- Relatively new release resulted in minimal smear zone and associated petroleum saturated soils
- Sulfate demand limited to gasoline hydrocarbons
  - approximately 10:1(sulfate to soluble BTEX)
  - Sulfate half life was much longer than typical sites
  - Nonweathered gasoline resulted in much lower demand associated with partially degraded heavier hydrocarbons

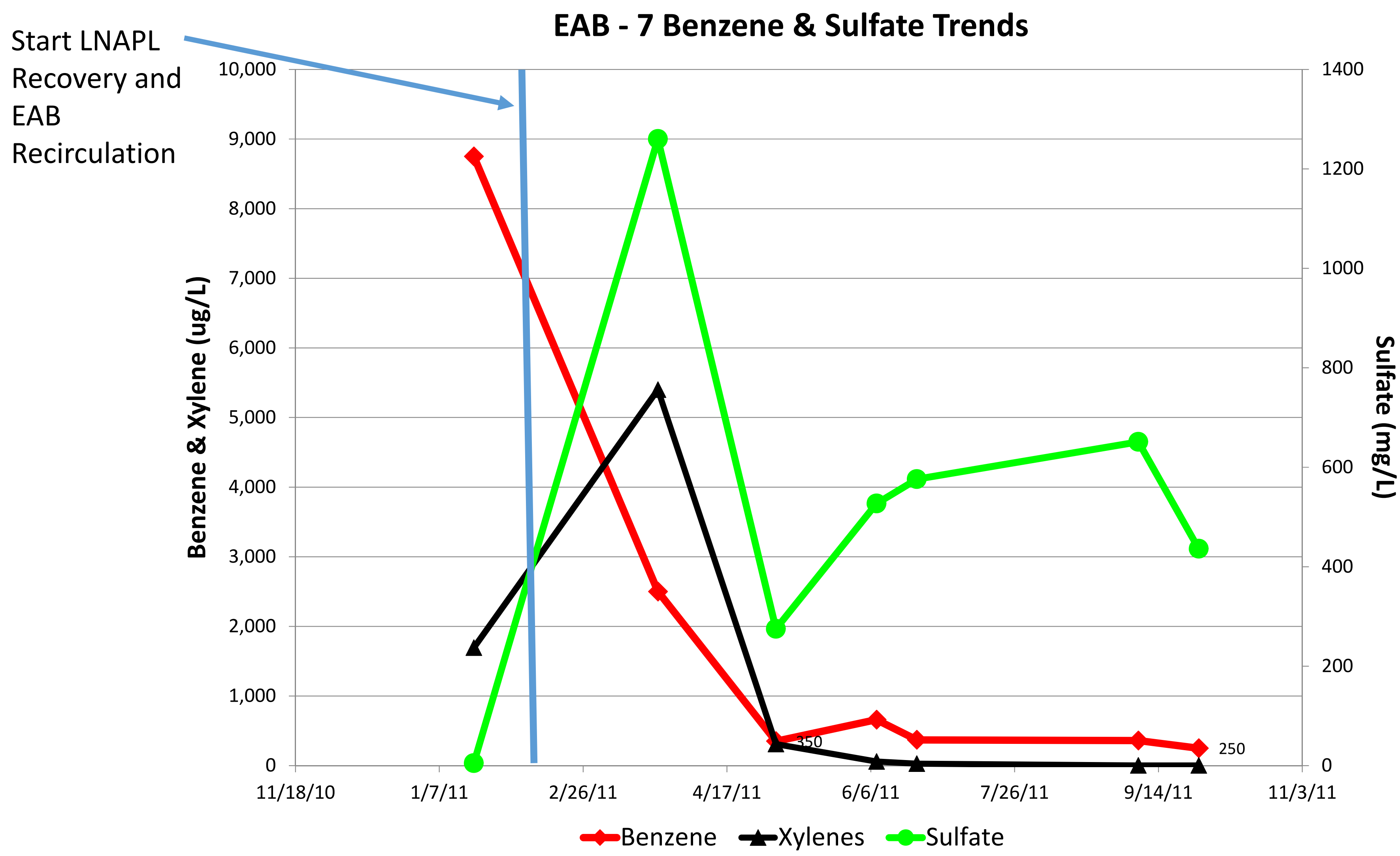
EAB Recirculation Wells (yellow)
RWs – total fluid recovery / skimmer wells



Remediation Results

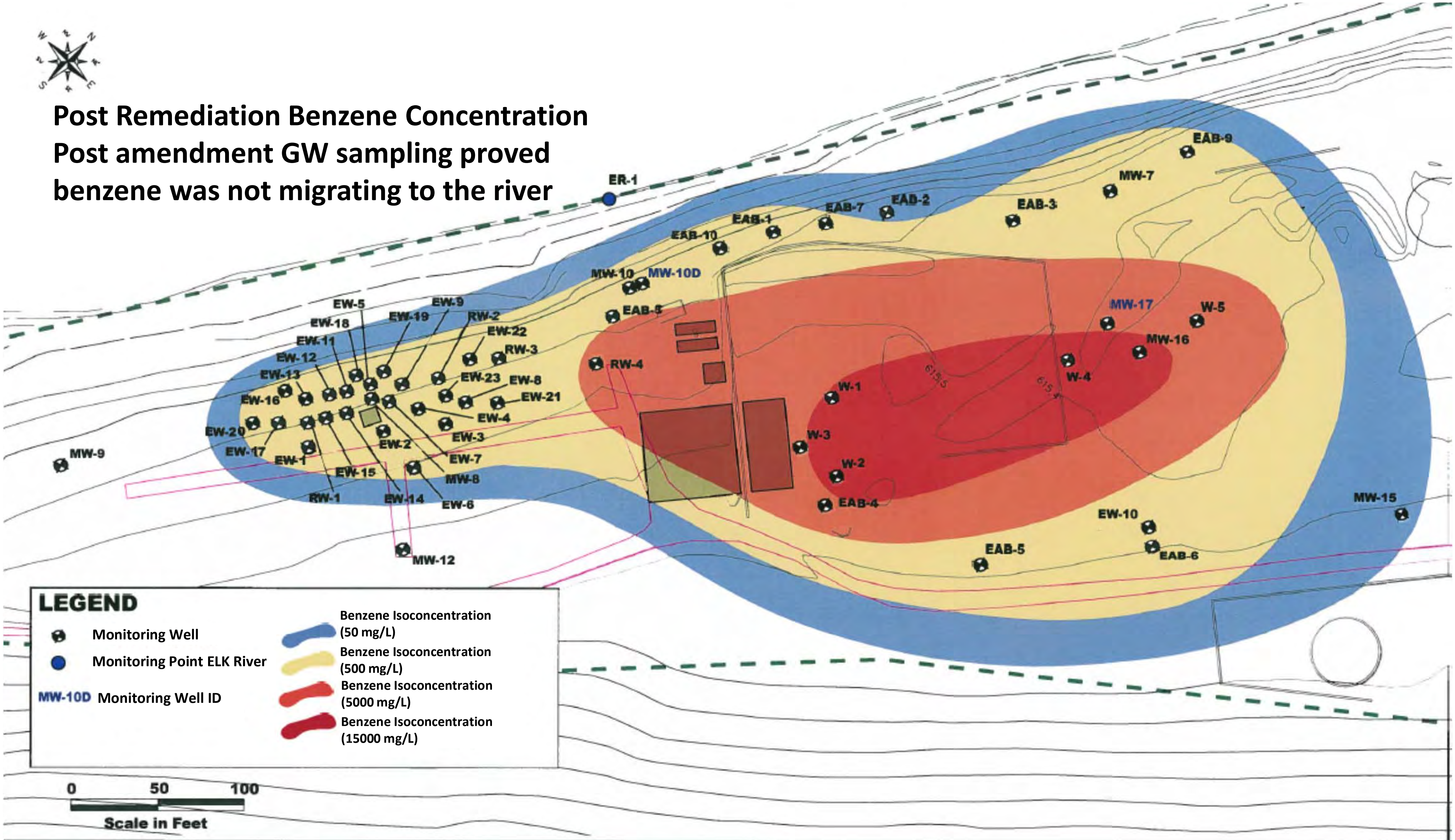
- Gasoline LNAPL plumes remediated in 1.5 years
- EAB recirculation decreased benzene concentrations to below risk based values in downgradient plume edge
- MNA sampling proved residual sulfate was sufficint to prevent migration of residual benzene
- Received NFA Letter from WVDEP Spring 2012


Post Remediation
LNAPL Pockets
Lube Type LNAPL
ER-1
MW-9 ND
EW-20 ND
EW-16 ND
EW-13 ND
EW-12 ND
EW-11 ND
EW-18 ND
EW-5 ND
EW-19 ND
EW-9 ND
RW-2 ND
EW-22 ND
RW-3 ND
EW-23 ND
EW-8 ND
EW-21 ND
EW-4 ND
EW-3 ND
EW-7 ND
MW-8 ND
EW-6 ND
EW-2 ND
EW-14 ND
EW-15 ND
RW-1 ND
EW-1 ND
EW-17 ND
MW-12 ND
RW-4 ND
MW-10 ND
MW-10D ND
EAB-8 ND
EAB-10 ND
EAB-1 ND
EAB-7 ND
EAB-2 ND
EAB-3 ND
MW-7 ND
EAB-9 ND
W-1 ND
W-3 ND
W-2 ND
EAB-4 0.3
MW-17 ND
W-5 ND
MW-16 1.0
W-4 0.5
EW-10 ND
EAB-5 ND
EAB-6 ND
MW-15 ND
615.5
615
LEGEND
Monitoring Well
Remediation Equipment
Monitoring Point - ELK River
Existing Roadway
MW-10D Monitoring Well ID
1.62 Apparent LNAPL Thickness
LNAPL > 0.01 ft
LNAPL > 1.0 ft
LNAPL > 5.0 ft
0
50
100
Scale in Feet
MALCOLM PIRNIE
Former Elk Refinery
Falling Rock, WV
CURRENT LNAPL DISTRIBUTION - November 15, 2011
FIGURE 16

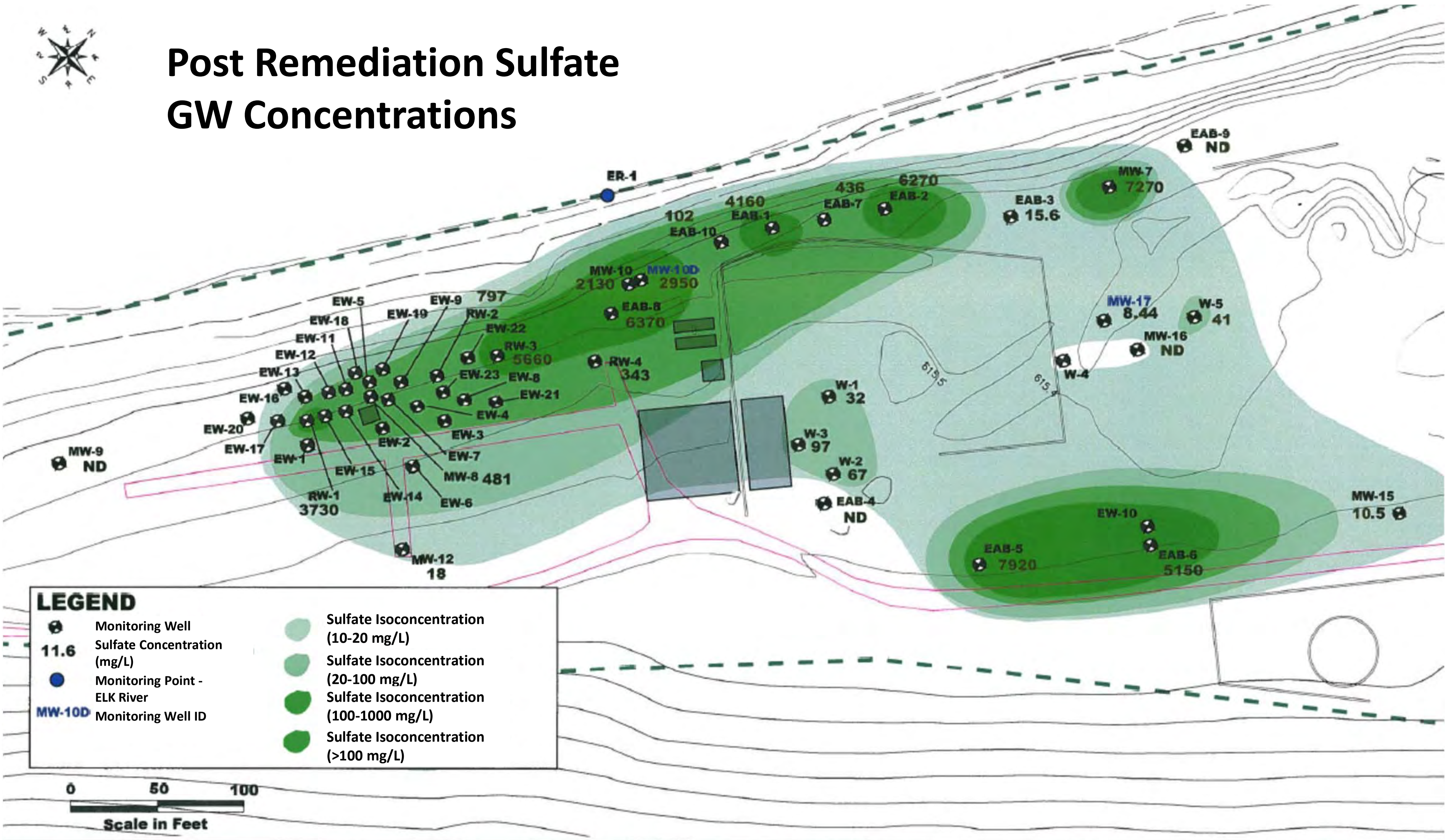


EAB - 7 Benzene & Sulfate Trends
Start LNAPL Recovery and EAB Recirculation
Benzene & Xylene (ug/L)
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Sulfate (mg/L)
1400
1200
1000
800
600
400
200
0
11/18/10
1/7/11
2/26/11
4/17/11
6/6/11
7/26/11
9/14/11
11/3/11
350
250
Benzene
Xylenes
Sulfate

Post Remediation Benzene Concentration
Post amendment GW sampling proved benzene was not migrating to the river



Post Remediation Sulfate GW Concentrations



Revised Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements: Reinjection Pilot Test Work Plan

HollyFrontier Navajo Refining LLC
Artesia Refinery
Artesia, New Mexico

December 2019

Prepared for:

HOLLYFRONTIER

HollyFrontier Navajo Refining LLC
Artesia, New Mexico

Prepared by:

TRC

TRC Environmental Corporation
Austin, Texas

LIST OF ACRONYMS

bgs	below ground surface
BTEX	benzene, ethylbenzene, toluene, and xylenes
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CME	Contaminant Migration Evaluation
COCs	constituents of concern
DO	dissolved oxygen
DRO	diesel range organics
EAB	enhanced anaerobic biodegradation
FWGMWP	Facility-Wide Groundwater Monitoring Work Plan
gpm	gallons per minute
GRO	gasoline range organics
HASP	health and safety plan
HFNR	HollyFrontier Navajo Refining LLC
HSA	hollow stem auger
IDW	investigation-derived waste
IW	injection well
mg/L	milligrams per liter
MNA	monitored natural attenuation
MTBE	methyl tert-butyl ether
mV	millivolts
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department - Hazardous Waste Bureau
NMOSE	New Mexico Office of the State Engineer
OCD	Oil Conservation Division

ORO	oil range organics
ORP	oxidation reduction potential
PCC Permit	Post-Closure Care Permit
PMW	pilot test monitoring well
PSH	phase-separated hydrocarbons
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
redox	reduction/oxidation potential
RCRA	Resource Conservation and Recovery Act
RW	recovery well
SRBs	sulfate reducing bacteria
TDS	Total dissolved solids
TEX	toluene, ethylbenzene, and xylenes
TOC	total organic carbon
TKN	total Kjeldahl nitrogen
UIC	underground injection control
WQCC	New Mexico Water Quality Control Commission
WWTP	wastewater treatment plant
%	percent

TABLE OF CONTENTS

1.0 Introduction

This work plan has been prepared on behalf of HollyFrontier Navajo Refining LLC (HFNR) for the refinery located at 501 East Main Street in Artesia, New Mexico (the Refinery). The Refinery is (1) regulated under the Resource Conservation and Recovery Act (RCRA) and subject to a Post-Closure Care Permit (PCC Permit) issued by the New Mexico Environment Department (NMED), and (2) subject to a Discharge Permit GW-028 issued by the Oil Conservation Division (OCD) of the Energy, Minerals and Natural Resources Department of the State of New Mexico. Among other requirements, the PCC Permit requires HFNR to recover phase-separated hydrocarbons (PSH) and dissolved-phase hydrocarbons from shallow groundwater (NMED, 2010). Additionally, the Discharge Permit requires HFNR to abate contaminants in the vadose zone and groundwater. HFNR actively operates an automated system to recover PSH and impacted groundwater, and is seeking to expand and enhance the recovery system.

HFNR has developed a proposed PSH/groundwater recovery and reinjection system upgrade ("upgrade"). Within this upgrade, the network of recovery wells will be expanded to enhance PSH and dissolved-phase hydrocarbon capture and hydraulic control, and enhance PSH recovery by increasing the hydraulic gradient in the direction of the proposed recovery wells (PSH will continue to be recovered and reinserted into the refining process). The goal is to control migration of dissolved-phase impacts and PSH prior to leaving HFNR's property and eventually stop PSH migration while allowing natural processes (i.e., monitored natural attenuation and biodegradation) to remediate the remaining dissolved phase hydrocarbons. With the proposed upgrade, all of the recovered groundwater will no longer be discharged to the Refinery's wastewater treatment plant (WWTP); instead, the majority of the recovered groundwater will be treated via equalization for additional phase separation, solids removal, and amendment with the addition of terminal electron acceptors and nutrients, and subsequently reinjected into the shallow saturated zone in order to enhance the anaerobic degradation rate of dissolved-phase constituents and to increase the hydraulic gradient to improve PSH recovery. A small percentage of the recovered groundwater may be treated at the Refinery's on-site WWTP. Water balance for the portion of groundwater sent to the WWTP will be maintained by injection of clean water produced from other sources (e.g., purchased city water, clean groundwater from the Refinery's deep wells, or permeate from the Refinery reverse osmosis (RO) system). Reinjection will also promote water conservation goals (reduce fresh water rights) and preserve the capacity of the Refinery's WWTP and OCD-permitted underground injection control (UIC) wells (disposal wells).

Prior to implementing the full upgrade, HFNR will complete a pilot test to optimize the treatment approach and evaluate effectiveness of treatment and injection. The purpose of this work plan is to describe the pilot tests that will be performed to evaluate the effectiveness of the amendment and reinjection process in reducing dissolved-phase concentrations in the vicinity of and downgradient of the reinjection zone. The impacts on PSH recovery will also be evaluated during the pilot test, though the pilot test may not be of sufficient length to fully understand the impacts on PSH recovery. Regardless, the system enhancement should improve overall PSH recovery as it is a proven technology. Once the pilot test is completed, HFNR will finalize the treatment process design and submit to NMED and OCD for approval prior to implementation.

This work plan describes the procedures that will be followed during implementation of the pilot tests. The format of this work plan follows the general outline specified for an investigation work plan in Appendix E.2 of the PCC Permit.

2.0 Background

2.1 Facility Background

The Refinery is an active petroleum refinery located at 501 East Main Street in the City of Artesia, Eddy County, New Mexico. The Refinery has been in operation since the 1920s and can process heavy, sour, light, and sweet crude oils into petroleum products for wholesale markets. The Refinery runs a predominant slate of Permian Basin crudes that are gathered in west Texas and southeast New Mexico and can also source a variety of crudes from Cushing, Oklahoma, including Canadian crudes. The Refinery serves markets in the southwestern United State and northern Mexico. A site location map is provided as Figure 1.

The Refinery is subject to (1) a PCC Permit issued by the NMED in October 2003 (NMED, 2003) and later modified in December 2010, and (2) the renewed Discharge Permit GW-028 issued by OCD on May 25, 2017 (OCD, 2017a) and modified on June 29, 2017 (OCD, 2017b) and December 14, 2018 (OCD, 2018). A renewal application for the PCC Permit was submitted to NMED on April 5, 2013, followed by four supplements and addenda to the application in March 2015, October 2016, and April 2017 (HFNR, 2017), and October 2019 (HFNR, 2019). NMED issued a draft PCC Permit for review in April 2017 (NMED, 2017), which has not been finalized as of December 2019.

2.2 Recovery System Background

HFNR currently operates a groundwater recovery system at the Refinery to capture both PSH and dissolved-phase hydrocarbons present within the shallow saturated zone beneath the Refinery and beneath the field east of the Refinery (East Field), which is owned by HFNR. This recovery system is operated as part of the corrective action requirements in the PCC Permit as well as conditions of the Refinery's Discharge Permit GW-028 (including prior renewals issued on October 15, 2008 [OCD, 2008], and August 22, 2012 [OCD, 2012]). HFNR began evaluating additional options and system upgrades for continued corrective action of the groundwater impacts while reducing or eliminating the need to lease shallow water rights.

The most recent meetings and correspondence between HFNR, NMED, and OCD leading to this revised work plan are as follows:

- April 26, 2018 – Conference call held with HFNR, NMED, and OCD.
- May 24, 2018 – HFNR received a Letter of Concurrence for Injection Standards from NMED.
- June 19, 2018 – HFNR received a draft Letter with Work Plan requirements from NMED.

- November 14 and November 15, 2018 – HFNR, NMED, and OCD held meeting and HFNR submitted a follow-up letter to OCD and NMED with proposed alternatives for reinjection standards.
- November 28, 2018 – HFNR, NMED, and OCD agreed upon the definition of facility during a conference call.
- December 10, 2018 – HFNR submitted a follow-up email to NMED and OCD for November 14 and 28, 2018 conference calls.
- December 18, 2018 – HFNR met with NMED and OCD regarding applicable regulations to implement the pilot study and full system using Class V Injection wells.
- February 13, 2019 – HFNR, NMED, and OCD held a meeting to discuss a summary of forthcoming draft work plan for the pilot test.
- April 12, 2019 – HFNR submitted the *Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements: Reinjection Pilot Test Work Plan*.
- July 22, 2019 – NMED received a Letter of Disapproval regarding the April 2019 *Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements: Reinjection Pilot Test Work Plan*.
- July 30, 2019 – HFNR and NMED held a conference call to discuss NMED's July 22, 2019 letter, and NMED agreed to allow the reinjection of groundwater with no ex-situ treatment, other than removal of PSH (if present) and addition of amendments (terminal electron acceptors) to promote in suit enhanced biodegradation.
- October 3, 2019 – HFNR, NMED, and OCD held a meeting to discuss NMED's July 22, 2019 letter and develop a path forward to revise, finalize, and implement the pilot test work plan.
- October 9 and October 23, 2019 – HFNR submitted the minutes of the October 3rd meeting and follow-up email regarding the reevaluation of pilot test locations and additional performance measures to NMED and OCD.
- November 4, 2019 – HFNR and OCD held a conference call to discuss alternate pilot test locations and additional pilot test performance measures proposed in HFNR's October 23, 2019 email.
- November 18,2019 – HFNR submitted a follow-up email to HFNR and OCD regarding November 4, 2019 conference call.

All parties (HFNR, NMED, and OCD) have agreed in principle to allow the upgrade to proceed in accordance with the conditions and associated requirements for the system's performance determined during the meetings/calls described above, contingent upon agency approval of the forthcoming Pilot Test Final Investigation Report (report documenting pilot test results to be submitted to NMED and OCD after completion of the pilot test) and final system upgrade design.

2.3 Previous Investigation Results

HFNR submitted a Contaminant Migration Evaluation (CME) investigation work plan in 2011, which was approved in 2012 by NMED. The initial phase of the CME investigation was completed in early 2013, additional investigation work was completed in 2014, and a CME Report was submitted to NMED in 2015 (Arcadis, 2015). The CME Report was revised in 2017 to address NMED comments received in September 2016 and included a revised conceptual site model as well as updated geophysical, soil, groundwater, and PSH investigations in areas east of the Refinery (Arcadis, 2017). The Revised CME Report also provided recommendations for additional recovery points to be installed to enhance PSH recovery based on the location of PSH and observed preferential pathways for groundwater flow. Concurrently, an updated groundwater model was produced incorporating the CME results and current conditions as well as projected upgrades to the groundwater recovery system, including the installation of additional recovery points and reinjection of recovered water. This data has been used in developing this pilot test. The results of the pilot test will then be used to optimize and finalize final design of the proposed upgraded recovery system.

In late 2016, HFNR also performed shallow saturated zone hydrogeologic testing which was used to develop a preliminary design for PSH/groundwater recovery system upgrades. Two models were produced and discussed with the agencies periodically, with the latest model results presented to NMED and OCD in March 2018 (Amec Foster Wheeler, 2018). Additional discussions with the agencies followed related to injection standards. The benefits associated with the upgrade are:

- it creates a closed-loop system that provides both hydraulic control and contaminant reduction;
- additional PSH will be removed that can no longer serve as a source of contaminants;
- the additional removal of PSH will accelerate the natural attenuation processes already occurring;
- the treatment of recovered groundwater followed by reinjection will stimulate additional degradation in-situ; and

- it will replace sulfate in groundwater in areas where the natural concentration has been depleted by the demand of sulfate reducing bacteria (SRBs).

Reinjection will also promote water conservation goals and preserve the capacity of the Refinery's WWTP and OCD-permitted UIC wells (disposal wells).

3.0 Site Conditions

This section describes the current surface and subsurface conditions at the Refinery.

3.1 Surface Conditions

The surface conditions at the Refinery are described below.

3.1.1 Topography

The Refinery is located on the east side of the City of Artesia in the broad Pecos River Valley of eastern New Mexico. The average elevation of the City of Artesia is 3,380 feet above mean sea level. The plain on which the City of Artesia is located slopes eastward at about 30 feet per mile.

3.1.2 Surface Water Drainage

Surface drainage in the region is dominated by minor ephemeral creeks and arroyos that flow eastward to the Pecos River, located approximately three miles east of the City. The major drainage feature in the immediate area of the Refinery is Eagle Creek (or Eagle Draw), which runs southwest to northeast through the northern process area of the Refinery and then eastward to the Pecos River. Eagle Creek is an ephemeral watercourse that primarily flows only following rain events. Upstream of the Refinery, Eagle Creek functions as a major stormwater conveyance for the City. Eagle Creek also drains outlying areas west of the City and is periodically scoured by intense rain events.

Natural surface drainage at the Refinery is to the north and east. Stormwater within the process areas is captured and routed to the Refinery WWTP. Stormwater from non-process areas is contained within the Refinery property inside stormwater berms and routed to stormwater retention basins. Stormwater from within the Refinery boundary is not allowed to discharge to Eagle Creek.

The elevation of Eagle Creek is 3,360 feet at its entrance to the Refinery and decreases to approximately 3,305 feet at its confluence with the Pecos River. Eagle Creek was channelized from west of the City of Artesia to the Pecos River to help control and minimize flood events. In the vicinity of the Refinery, the Eagle Creek channel was cemented to provide further protection during flood events. A check dam was also constructed west of the City of Artesia along Eagle Creek. Federal floodplain maps indicate that most of the city and the Refinery have been effectively removed from the 100-year floodplain.

3.1.3 Area Land Uses

The areas north, south, and east of the Refinery are sparsely populated and used primarily for agricultural purposes. The primary business and residential areas of the City of Artesia are located to the west, southwest, and northwest of the Refinery. Commercial/industrial businesses are present south of the Refinery along Highway 82, including an oilfield pipe company and machine shop located at the southeast corner of the Refinery. HFNR owns a majority of the land bounded by Hermosa Drive to the south, East Richey Avenue to the north, Highway 285 to the west (or Freeman Avenue on the south side of Highway 82), and Bolton Road to the east. The majority of the land located east of the Refinery between Bolton Road and Haldeman Road is cultivated as pecan orchards or used for other agricultural purposes.

The active Refinery and much of the surrounding property owned by HFNR is fenced and guarded with controlled entry points.

3.2 Subsurface Conditions

The subsurface conditions at the Refinery are described below.

3.2.1 Surficial Soils

Surficial soil at the Refinery is predominantly comprised of approximately 60 percent (%) Pima series and 40% Karro series. The Pima and Karro series both consist of deep, well drained soils that formed in alluvial settings. They are both calcareous and have slow to medium runoff.

3.2.2 Geology

The City of Artesia is located on the northwest shelf of the Permian Basin. In this region, the deposits consist of approximately 250 to 300 feet of Quaternary alluvium unconformably overlying approximately 2,000 feet of Permian clastic and carbonate rocks. These Permian deposits unconformably overlie Precambrian syenite, gneiss, and diabase crystalline rocks.

3.2.2.1 Quaternary Alluvium

The Quaternary alluvium in the Refinery area is dominantly comprised of clays, silts, sands, and gravels deposited in the Pecos River Valley. These “valley fill” deposits extend in a north-south belt approximately 20 miles wide, generally west of the Pecos River. The thickness of the valley fill varies from a thin veneer on the western margins of the Pecos River valley to a maximum of 300 feet in depressions, one of which is located beneath the Refinery. These depressions have resulted from dissolution of the underlying Permian carbonates and evaporites.

3.2.2.2 Permian Artesian Group

The Permian Artesian Group is comprised of the following five formations from shallowest to deepest: the Tansill, Yates, Seven Rivers, Queen and Grayburg Formations. The Tansill and Yates Formations outcrop at the surface east of the Pecos River and are not present in the vicinity of the Refinery. The Seven Rivers Formation is present at an approximate depth of 300 feet in the area between the Pecos River and the Refinery. However, the Seven Rivers Formation thins and pinches to the west and it is not evident, based on boring logs, that this formation is present beneath the Refinery process areas.

In the area of the Refinery, the Queen and Grayburg Formations have been mapped as a single unit consisting of approximately 700 feet of interbedded dolomite and calcareous dolomite, gypsum, fine-grained sandstone, carbonates, siltstone and mudstone. In locations where the Seven Rivers Formation is absent, the upper portion of the Queen Formation acts as a confining bed between the deep artesian aquifer and the valley fill aquifer.

3.2.2.3 San Andres Formation

The San Andres Formation lies beneath the Queen and Grayburg Formations and immediately above the Precambrian crystalline basement rocks. The San Andres Formation is greater than 700 feet thick and composed mainly of limestone and dolomite with irregular and erratic solution cavities up to several feet in diameter. The upper portion of the Formation is composed of oolitic dolomite with some anhydrite cement.

3.3 Hydrogeology

The principal aquifers in the Artesia area are within the San Andres Formation and the valley fill alluvium. Two distinct water-bearing zones within the valley fill alluvium in the vicinity of the Refinery are referred to as the “shallow saturated zone” and the “valley fill zone”. The deeper carbonate aquifer within the San Andres Formation is referred to as the “deep artesian aquifer”.

3.3.1 Shallow Saturated Zone

The shallow saturated zone occurs in fractured caliche and interbedded sand and gravel channels at 10 to 30 feet below ground surface (bgs). Groundwater in this zone is under confined conditions for some or most of the year, with static water levels measured in groundwater monitoring wells three to five feet above the shallow saturated zone.

The general direction of flow in this shallow saturated zone is to the east toward the Pecos River. Groundwater flow direction and gradient in the shallow saturated zone have remained generally consistent over time, as documented in previous annual groundwater monitoring reports.

Major sources of water in the shallow saturated zone are likely recharge from Eagle Creek and lawn watering runoff from the grass-covered urban park that occupies the Eagle Creek Channel immediately upstream of the Refinery. The water in the shallow saturated zone is highly variable in quality, volume, areal extent, and saturated thickness. Concentrations of total dissolved solids (TDS) exceeding 4,000 milligrams per liter (mg/L) and sulfate exceeding 2,000 mg/L have been recorded in most of the wells west and northwest (upgradient) of the Refinery, which significantly exceed the New Mexico Water Quality Control Commission (WQCC) standards of 1,000 mg/L for TDS and 600 mg/L for sulfate.

The shallow saturated zone contains PSH and dissolved-phase hydrocarbon constituents, as reported in the *2018 Annual Groundwater Monitoring Report* (TRC, 2019). Concentrations of dissolved-phase hydrocarbon constituents in the shallow saturated zone have generally exhibited a stable or decreasing trend over time.

3.3.2 Valley Fill Zone

The valley fill zone underlies the shallow saturated zone and occurs in Quaternary alluvial deposits of sand, silt, clay and gravel. These sediments are about 300 feet thick near the Refinery.

Irrigation and water production wells completed in the valley fill zone are typically screened across one to five water-producing intervals ranging in thickness from 20 to 170 feet, with most being approximately 20 feet thick. Production intervals are non-continuous, consist principally of sand and gravel, and are separated by less permeable lenses of silt and clay of varying thickness. Based on logs of wells located immediately to the north and east of the Refinery, the thicknesses of silt and clay deposits range from 20 to 160 feet and are interspersed with thin zones of gravels in the upper 100 feet. Wells in the valley fill zone range from 40 to 60 feet bgs and the formation yields water containing TDS ranging from 1,500 to more than 7,000 mg/L.

The valley fill zone contains dissolved-phase hydrocarbon constituents, as reported in the *2018 Annual Groundwater Monitoring Report* (TRC, 2019). Concentrations of dissolved-phase hydrocarbon constituents in the valley fill zone have generally exhibited a stable or decreasing trend over time.

The valley fill zone and the underlying San Andres aquifer are hydraulically connected in some areas.

3.3.3 Deep Artesian Aquifer

The deep artesian aquifer is closely related to the Permian San Andres Limestone and generally consists of one or more water-producing intervals of variable permeability located in the upper portion of the Formation. However, in the Artesia area, the water-producing interval rises stratigraphically and includes the lower sections of the overlying Queen and Grayburg Formations. Near the Refinery, the depth to the top of the water-producing interval is estimated to be about 440 feet bgs. The Seven Rivers Formation and the other members of the Artesia Group are generally considered to be confining beds, although some pumpage occurs locally from fractures and secondary porosity in the lower Queen and Grayburg members.

The deep artesian aquifer has been extensively developed for industrial, municipal, and agricultural use. TDS in this aquifer ranges from 500 mg/L to more than 5,000 mg/L depending on location. In the Artesia area, water from this aquifer is generally produced from depths ranging from 850 feet to 1,250 feet bgs. The aquifer recharges in the Sacramento Mountains to the west of Artesia. Extensive use of this aquifer in recent decades has lowered the potentiometric head in the aquifer in some locations from 50 to 80 feet bgs, although extensive rainfall in some years may bring the water levels in some wells close to ground surface.

Available well completion records for irrigation well RA-4798 indicate that it is screened in the deep artesian aquifer from 840 to 850 feet bgs. Analytical data from this well does not indicate the presence of hydrocarbon impacts from Refinery operations. Methyl tert-butyl ether (MTBE) has been detected in RA-4798 at levels below the WQCC standard, but these detections cannot be attributed to historical Refinery operations based on all available data as described in the report titled *Evaluation of Methyl Tert-Butyl Ether (MTBE) in Groundwater* that was submitted to NMED on September 13, 2019.

4.0 Pilot Test Setup

4.1 Test Locations

To test recovery and injection efficacy in areas that are representative of the conditions that will be addressed by the full-scale system, HFNR is planning to perform the pilot test in the East Field near existing wells RW-19 and MW-131 (proposed primary pilot test locations). The following selection criteria was used:

- Dissolved hydrocarbon (target high) and sulfate (target low) concentrations.
- Accessibility (underground and aboveground utilities, rig access, room for aboveground equipment, etc.).
- Impact to current and planned Refinery activities (pilot test equipment will be present underground and aboveground and will be accessed frequently).
- Geology and hydrogeology:
    - Pilot test injection, monitoring, and recovery wells will be oriented eastward, following groundwater flow direction.
    - Each of the pilot test location will be completed in one of the primary soil types of the shallow saturated zone (gravel and silty sand).
    - Wells within each pilot test area will be screened within the same, continuous coarse-grained lithologic zone to the degree feasible.
- Proximity to proposed well locations presented to NMED in the March 2018 “Groundwater Recovery and Reinjection System Upgrade – Groundwater Model Update”.

The area around wells RW-19 and MW-131 contains PSH and dissolved-phase constituents at concentrations of the same magnitude or higher than what is expected to be recovered by the enhanced recovery system. The two proposed pilot test locations provide the opportunity to test injection, amendment, and recovery in two of the primary soil types (gravel and silty sand) in which the full-scale system will also be installed. These locations are also readily accessible and will have limited impacts to current and planned Refinery activities. Two alternate locations have been selected for pilot testing should initial field testing (gamma logging, soil borings, etc. as described below and in Section 5.2.2) indicate one or both primary test locations are not feasible. The proposed alternate pilot test locations will only be considered as needed and in the following order: 1) immediately north of recovery trench RW-15 and 2) south of MW-105, between MW-50 and MW-101. These alternate locations are shown on the figures provided in Appendix A. HFNR will notify NMED and OCD if either of the alternate locations are selected for pilot testing in lieu of the primary proposed locations.

The exact location of the injection, monitoring, and recovery wells will be determined after completion of gamma logging of the existing wells in the area near RW-19 and MW-131 (discussed further in Section 5.2.2). Based on the geologic, geophysical, and contaminant migration investigation results from previous investigation in the East Field, preliminary pilot test locations for injection, recovery, and monitoring have been proposed with the intent of testing the effects of amendment and recovery in silty sand and gravel, both of which are prevalent in the observed preferential groundwater flow pathways in the East Field. Due to the heterogeneous nature of the shallow geology in this area, some additional exploratory borings may be installed to further characterize the lithology in the area near wells RW-19 and MW-131. The final locations of wells to be used in each of the two pilot test areas will be adjusted with the intent of having all wells within each pilot test area screened within the same, continuous coarse-grained lithologic zones, to the degree feasible based on the heterogeneous nature of the shallow geology. One pilot test area will target zones with more gravel (near RW-19) and the other pilot test area will target zones with more silty sand (near MW-131). The results of the gamma logging and any other geologic data collected during preliminary investigation will be provided with discussion in the Final Investigation Report (Pilot Test report) as described in Section 6.0.

4.2 Dissolved-Phase Conditions

Based on existing groundwater data from ongoing monitoring at the Refinery, the dissolved-phase hydrocarbon constituents are being actively degraded under anaerobic conditions and most likely by SRBs. The following observed groundwater conditions and trends are primary and secondary lines of evidence that hydrocarbon degradation by SRBs is actively occurring:

- Inverse concentration correlation between sulfate and the following dissolved-phase hydrocarbon constituents, specifically in the East Field: benzene, ethylbenzene, toluene, and xylenes (BTEX), naphthalene, gasoline range organics (GRO), and diesel range organics (DRO).
    - Sulfate concentrations upgradient (west) of the Refinery appear to range between 1,000 and 2,000 mg/L, while sulfate concentrations within the hydrocarbon plume below the East Field range from 10 to 100 mg/L and are non-detect in some wells.
    - The inverse concentration correlation indicates SRBs are utilizing sulfate to degrade hydrocarbons in both dissolved and adsorbed phases (note that the sulfate demand of dissolved-phase concentrations is too low to exceed the upgradient supply of sulfate).

- Anaerobic conditions as oxidation reduction potential (ORP) is less than -100 millivolts (mV).
- Presence of black particulates in and/or slightly grey turbid purge water during groundwater sampling activities indicates iron sulfide precipitants.
- Apparent preferential degradation of more readily degraded isomers in isomer pairs, for example:
  - o-xylene detected at concentrations less than 1/10th the concentration of m/p-xylenes in groundwater samples.
  - 1,3,5-trimethylbenzene detected at concentrations less than 1/10th the concentration of 1,2,4-trimethylbenzene in groundwater samples.

These conditions indicate that an amendment with bioavailable sulfate has the potential to increase the degradation rate of hydrocarbons. In addition to bioavailable sulfate, nitrogen in the form of ammonia may be added to the system to amend the two most likely rate-limiting nutrients. The nitrogen source will only be added if baseline monitoring indicates there is insufficient nitrogen present in the Shallow Saturated Zone (i.e., total Kjeldahl nitrogen [TKN] <10 mg/L).

5.0 Pilot Test Scope

The following sections describe the scope for the pilot test program. The pilot test will be performed to evaluate the effectiveness of the amendment and reinjection process in reducing dissolved-phase concentrations in the vicinity of the reinjection zones as well as to collect additional hydrogeologic data to confirm design parameters for the upgrade recovery and injection systems.

5.1 Health and Safety Considerations

A task-specific Health and Safety Plan (HASP) will be developed prior to commencing field activities. The HASP will provide site-specific and task-specific analysis of the physical and chemical hazards associated with anticipated field activities at the Refinery. The HASP will be reviewed and an understanding of the HASP will be acknowledged by all field team members prior to conducting any field activities at the Refinery. Safety briefings with all field team members will be held thereafter at the beginning of each work day, or as required due to changing conditions.

5.2 Planned Activities – Pilot Test

The pilot test will be conducted to accomplish three primary goals: (1) quantify hydrogeologic response to fluid recovery and injection, (2) evaluate potential for enhancement of PSH recovery, and (3) determine optimal amendment formulation(s) to maximize biodegradation results in groundwater. Through the activities described in the following sections, the pilot test will determine:

- The injection rate of the formation for proper sizing and design of the injection equipment/wells and design of the treatment train;
- The type, quantity, and relative percent of treatment amendment(s) added to the extracted water prior to reinjection to optimally enhance bioremediation;
- The response of groundwater quality to injected amendment(s);
- Sulfate and nutrient demand; and
- Changes in PSH recovery rates due to injection.

The results from the pilot test will be used to refine and finalize the full-scale recovery system upgrade design.

The pilot test will consist of activities near two existing wells, RW-19 and MW-131, located in the East Field, shown on Figures 2a and 2b. Pilot test design at each area will be similar and the tests will be executed concurrently.

5.2.1 Baseline Groundwater Quality Evaluation

Baseline trend data will be collected from existing monitoring wells in the area at least 14 days but no more than 30 days prior to initiation of the pilot test. The baseline trend data will be collected to evaluate existing groundwater quality and potentiometric surface. Results of baseline water quality testing will be used to (1) calculate the range of dosing of amendment(s) in the water treatment area and (2) determine baseline conditions to be used to evaluate the effectiveness of the amendment(s) in reducing dissolved-phase concentrations in the vicinity of the reinjection zone during the pilot test. Additionally, water level data recorded during the baseline period may be utilized to evaluate mounding and/or drawdown changes in groundwater levels observed during the pilot test. The following data will be collected and evaluated to establish baseline trends prior to the treatment efficiency test:

- Groundwater elevation;
- Presence and apparent thickness of PSH;
- Site-specific constituents of concern (COCs) concentrations: BTEX, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, MTBE, naphthalene, GRO, and DRO;
- Monitored natural attenuation (MNA) laboratory-measured parameter concentrations: sulfate, TKN, total organic carbon (TOC), alkalinity, ferrous iron, sulfide, and magnesium;
- MNA field-measured parameter concentrations: conductivity, ORP, dissolved oxygen (DO), temperature, depth to water and SRBs (qualitative measurement);
- Barometric pressure; and
- Precipitation.

Baseline water level and water quality data will be measured in existing wells nearest the pilot test. This includes RW-19 and MW-131 and respective upgradient, proximal downgradient, crossgradient, and peripheral downgradient wells as defined in Section 5.2.7 and below:

- RW-19 Pilot test area
    - Within pilot test area: RW-19 and KWB-4
    - Upgradient wells: MW-48 and RW-15C
    - Proximal downgradient well: KWB-5 and MW-111
- MW-131 Pilot test area
    - Within pilot test area: MW-131

- Upgradient well: MW-129
- Proximal downgradient well: MW-112

Groundwater levels will be measured in each well listed above using an oil-water interface probe and a pressure transducer, as described in Section 5.3. Groundwater levels will be compared to historical groundwater information obtained during semi-annual groundwater monitoring events, which are ongoing at the Refinery. Laboratory and field parameter data will only be collected from wells located outside the pilot test area that contain less than 0.30 feet of PSH in accordance with the *2018 Facility-Wide Groundwater Monitoring Work Plan* (2018 FWGMWP). Groundwater quality data from wells within each Pilot Test area (i.e., KWB-4/RW-19 and MW-131) are critical for the baseline monitoring and will be sampled even if there is more than 0.3 feet of PSH present.

Barometric pressure will be recorded to a sensitivity of 0.01 inches of mercury using a barometric pressure probe installed at a central location at the Refinery. The data will be recorded starting two weeks before the initiation of the injection test and continuing until two weeks after conclusion of the injection test. Precipitation data will be recorded for the period starting two weeks before the injection test and continuing until two weeks after conclusion of the injection test. Precipitation data will be measured using either the Refinery's local weather station or a rain gauge installed at the Refinery.

5.2.2 Installation of Injection, Recovery, and Monitoring Wells

Injection and recovery wells will be installed as part of the pilot test. One injection well and one recovery well will be installed at each pilot test area (i.e., a total of two new injection wells and two new recovery wells) near existing wells RW-19 and MW-131, as shown on Figures 2a and 2b. The exact layout of the injection, monitoring, and recovery wells may be adjusted based on the results of gamma logging and potential additional investigation in the pilot test area. One injection well and one recovery well will be used for each pilot test, with each injection well installed upgradient of the associated recovery well. Injection and recovery wells will be separated by a minimum distance of 200 feet to ensure that the radius of influence from recovery drawdown and injection mounding do not overlap. The reason for separating the injection and capture zones is to mimic operation of the full-scale system and to prevent biasing the pilot test results by creating any preferential pathways or circulation cells. To monitor the potentiometric surface and COC/MNA data as listed in Section 5.2.7, additional monitoring wells will also be installed between each injection and recovery well at an approximate spacing of 40 feet, and one monitoring well will be installed approximately 40 feet downgradient of each recovery well. For the pilot test area near MW-131, one additional monitoring well will be installed approximately 170 feet upgradient of the injection well and approximately 230 feet downgradient of the recovery well in accordance with NMED comments provided during discussions on October 3, 2019 and November

4, 2019. The proposed layout of the wells proposed for the pilot tests are shown on Figures 2a and 2b.

Gravel seams and silty sand zones are present in the shallow saturated zone in the East Field and serve as preferential pathways for groundwater and contaminant transport. The pilot test near existing well RW-19 is designed to target this gravel seam for injection and recovery, while the pilot test near existing well MW-131 is designed to target the shallow saturated zone where silty sand is more predominant (the gravel seam is limited or not present) for injection and recovery. The top of the gravel seam at RW-19 occurs from approximately 18 to 24 feet bgs. A gamma-log study will be conducted on existing monitor wells in the area prior to installation of the pilot test injection and recovery wells to verify the gravel seam and silty sand presence, depth, thickness, and extent in each pilot test area. Injection wells will be designed based on the gamma logging results, using lithology from the CME results and/or lithology from borings installed prior to the pilot test to evaluate the pilot test area, if deemed necessary. The injection wells will be constructed of stainless steel casing and screen, and will be screened below the water table and across the target lithologic zone. A proposed construction diagram for the injection wells is provided in Appendix B. Installation details for the injection and recovery wells are discussed in Section 5.3.

New recovery wells will be installed in the same configuration and method as was done for the Phase II recovery system (see well construction diagram provided in Appendix B). A 14-inch diameter boring will be drilled and three separate well casings will be installed within the boring. These casings will be used for water recovery (4-inch diameter casing with total fluid pump), PSH recovery (4-inch diameter casing with skimmer pump), and measurement (1-inch diameter casing with instrumentation). Recovery wells will include instrumentation as used in the Phase II recovery wells to allow remote monitoring and control. If PSH accumulates in the recovery wells, skimmers or total fluid pumps will be used to remove PSH from the recovery wells in the same manner as the Phase II wells. The groundwater recovery pump intake will be set below the water table surface and operated to prevent intake of PSH. If significant PSH accumulates in a pilot test recovery well, it will be skimmed from its own casing and pumped directly to a small tote located near the recovery well. Any PSH present in pilot test monitoring or injection wells will be measured, and if removed, stored temporarily in small totes near the recovery well so that the recovered volume can be tracked separately from the rest of the current recovery system.

For purposes of complying with RCRA, the injection wells are authorized by rule (permit by rule) as provided in 40 CFR §144.23(c) and 20.6.2.5004 NMAC since they are part of a RCRA

Corrective Action.[1,2]. OCD Form C-108 (Application for Authorization to Inject) is included as Appendix C for both wells for informational purposes. OCD Underground Discharge System (Class V Inventory Sheet) is included as Appendix D for both wells for informational purposes. EPA Form 7520-17 (Class V Well Pre-Closure Notification Form) is included as Appendix E for both wells for informational purposes. The proposed recovery wells will be installed as permanent recovery wells and may be used as part of the full-scale system. The proposed injection and monitoring wells will also be installed as permanent wells but may be recommended for abandonment upon completion of the pilot test. HFNR will propose to retain or abandon the wells in the Final Investigation Report and will not abandon the wells without concurrence from NMED and OCD.

5.2.3 Aquifer Testing

Pump testing and injection testing will be conducted at each pilot test area. The existing recovery system, except for RW-19, will remain in operation during installation of aquifer testing equipment and throughout the aquifer and pilot tests. Operation of the existing recovery system is not expected to affect the aquifer tests or pilot test based on the radius of influence observed during routine groundwater monitoring. The East Field is no longer irrigated and will not be irrigated during the aquifer tests or pilot test.

5.2.3.1 Pump Test

A step-drawdown and constant-rate pump test will be performed at each pilot test area near wells RW-19 and MW-131. Pump tests will be conducted from one of the pilot test monitoring wells located between the injection and recovery wells at each pilot test area so that observation wells are present to the east and west of the pumping well. The pump tests are not necessary for the design or operation of the pilot test but will be conducted to further characterize hydrogeologic properties of the Shallow Saturated Zone and confirm the injection test results.

An electric, submersible pump capable of pumping at rates of 4 to 15 gallons per minute (gpm) will be installed at the pumping well. The pump and motor will be sized to achieve the specified injection rate ranges with consideration of vertical lift and friction losses. A Grundfos Redi-Flo4 variable frequency drive pump or equivalent pump will be used; it will have a variable frequency drive motor so the flow rate can be controlled by adjusting the power input to the pump.

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[1] As provided in 40 CFR §144.23(c), injection wells used to inject contaminated ground water that has been treated and is being injected into the same formation from which it was drawn are authorized by rule for the life of the well if such subsurface emplacement of fluids is approved by EPA, or a State, pursuant to provisions for cleanup of releases under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), or pursuant to requirements and provisions under RCRA.

[2] As provided in 20.6.2.5004 NMAC, Class IV wells are prohibited, except for wells re-injecting treated ground water into the same formation from which it was drawn as part of a removal or remedial action if the injection has prior approval from the EPA or the Department under CERCLA or RCRA.

Pressure transducers will be placed in the injection wells, monitoring wells, and recovery wells in the pilot test area to measure the groundwater level. Within 60 minutes prior to commencement of the pump tests, static water levels will be recorded at each injection well, monitoring well, and recovery well included in the pilot test using an oil-water interface probe. Each pressure transducer will be installed at least 60 minutes before the test begins. Immediately prior to the test, the water level at each pressure transducer will be set to 0.00 feet to facilitate observation of water level changes. The pressure transducers will remain in the wells and record water level measurements throughout the pump tests.

The step-drawdown test will be performed to determine a sustainable pumping rate for the constant-rate test. The step-drawdown test involves pumping the well at a series of pre-defined, successively increasing, equal duration constant rates and continuously recording drawdown in the pumped well and observation wells. The data from each step will be graphed during the test with time on a logarithmic x-axis and water level of the injection well on a linear y-axis. During each step, the water level should decrease rapidly at the beginning of the test and stabilize as the test proceeds. When the water level essentially stabilizes, the pump rate will be increased to the next step. Up to a maximum of four steps may be performed. The duration of each step will be 30 to 120 minutes to provide enough time for the potential stabilization of the pumping water level. The anticipated pumping rates for the initial three steps will be 4 gpm, 8 gpm, and 12 gpm, but these rates are subject to change based on observed conditions during the test. After the pump is shut off at the completion of the step-drawdown test and prior to beginning the constant-rate test, the water level in the pumping well should recover to the static water level or at least 95% of the drawdown at the end of the test. During this recovery period, the step-drawdown data will be evaluated to determine the sustainable pumping rate of the well for the constant-rate test.

The constant-rate test will be conducted with a sustainable pumping rate determined from the step-drawdown test. The desired pumping/discharge rate will be attained rapidly and monitored frequently to ensure the rate does not vary more than a few percent. Rate decreases with increasing drawdown and may suddenly change with interception of a boundary or heterogeneity in the saturated zone. The water level in the pumping well will also be checked frequently to ensure drawdown does not reach the pump. The duration of the constant-rate test will be at least 24 hours, followed by an 8-hour recovery phase after cessation of pumping (or until water levels recover to 90% of the maximum drawdown). However, the constant-rate test may need to be terminated earlier if unanticipated drawdown occurs and a constant rate cannot be maintained for the planned test duration. The pilot test wells are designed for completion of the pilot test and are not optimal for pump testing (i.e., they are not screened across the saturated thickness of the Shallow Saturated Zone).

The pump tests will begin once all equipment has been installed and tested, and the static water levels have been measured. The injection pump, pressure transducer data loggers, and synchronized stopwatches will be activated simultaneously.

For both pump tests, the water level in the injection wells, monitoring wells, and recovery wells will be monitored using pressure transducers set at a linear data recording frequency of 30 seconds per reading at the pumping well and observation wells during the step-drawdown tests, constant-rate tests, and associated recovery phases. The water level data from the data logger will be monitored periodically to confirm the system is operating properly and to evaluate the test results. Manual gauging will be completed at regular intervals using an oil-water interface probe to confirm the pressure transducer measurements. Details regarding manual water level measurements are provided in Section 5.3.

The pumping rate will be measured using a totalizing flow meter at the pumping well that is also capable of recording flow rate. Adjustments will be made as necessary using the pump controller to achieve a constant pumping rate.

All equipment placed within each well such as the pressure transducer data loggers and oil-water interface probe will be decontaminated according to the procedure in Section 5.3.6 at the completion of the recovery phase of the constant-drawdown test. Purged groundwater generated during the pump tests will be managed as described in Section 5.3.7.

5.2.3.2 Initial Injection Test

A series of injection tests will be performed utilizing the proposed injection wells at each pilot test area near wells RW-19 and MW-131. A minimum of one test per area will be performed, and up to a maximum of four separate injection tests may be performed. Goals of the injection tests are to determine the optimal injection rate and to observe hydrogeologic response after repeated injections. The variable injection test rates and lengths will allow determination of the best way to influence the peripheral monitoring locations. The results of the initial injection test will be used to optimize pilot test injection design and ultimately the full-scale system upgrade design.

Each injection test will be performed and analyzed similar to an aquifer step-drawdown test. Extracted water from the newly-installed recovery wells will be used to perform each injection test. Water will be discharged into each injection well at the mid-point of the well screen interval or at the top of the well casing seal. The discharge line will be plumbed through a well seal rated to contain upward pressure that may be created during injection.

An electric, submersible pump capable of pumping the injection rate range of 4 to 15 gpm will be installed at the recovery well. The target injection rate will be 12 gpm based on initial full-scale system design, and the rate will be optimized during the pilot test. The pump and motor will be sized to achieve the specified injection rate ranges with consideration of vertical lift and friction losses. A Grundfos Redi-Flo4 variable frequency drive pump or equivalent pump will be used; it will have a variable frequency drive motor so the flow rate can be controlled by adjusting the power input to the pump. The recovery pumps will be connected to a Programmable Logic Controller which will also collect data from pressure transducers (as described in the next section) to control recovery and injection rates.

Pressure transducers will be placed in the injection wells, monitoring wells, and recovery wells in the pilot test area to measure the groundwater level. Within 60 minutes prior to commencement of the injection test, static water levels will be recorded at each injection well, monitoring well, and recovery well included in the pilot test using an oil-water interface probe. Each pressure transducer will be installed at least 60 minutes before the test begins. Immediately prior to the test, the water level at each pressure transducer should be set to 0.00 feet to facilitate observation of water level changes. The pressure transducers will remain in the wells and record water level measurements throughout and after the injection tests for a period of at least 24 hours.

The basic procedure for each injection test involves conducting three or more steps of injection at rates that are incrementally increased during each step. A constant injection rate will be maintained during each step. The data from each step will be graphed during the test with time on a logarithmic x-axis and water level of the injection well on a linear y-axis. During each step, the water level should increase rapidly at the beginning of the test and stabilize as the test proceeds. When the water level essentially stabilizes, the injection rate will be increased to the next step. The final step should result in a water level in the injection well that is near the top of the well casing, depending on formation characteristics near the well.

Each injection test will consist of a minimum of three successive and increasing injection rate steps. During each step, the injection rate will remain constant. The anticipated injection rates for the first three steps of the test are 1, 4, and 8 gpm based on NMED comments provided in the July 22, 2019 letter. These rates are subject to change based on observed conditions during the test (i.e., the initial injection rate will be 1 gpm and will be increased to a maximum of 12 gpm depending on the capacity of the injection well). The wellhead will be configured to allow the installation of a pressure transducer so that that pressure can be monitored throughout the duration of the test. Care will be taken not to exceed pressure suitable for the wellbore and formation. The duration of each step will typically be 60 to 180 minutes such that the entire injection test can be completed in one day. Once the water level during a step is relatively stable, the injection rate will be increased.

The injection test will begin once all of the equipment has been installed and tested, and the static water levels have been measured. The injection pump, pressure transducer data loggers, and synchronized stopwatches will be activated simultaneously.

The water level in the injection wells, monitoring wells, and recovery wells will be monitored using pressure transducers set at a linear data recording frequency of ten seconds per reading at wells near the injection well and on a logarithmic frequency at wells near the recovery well. A logarithmic recording frequency is not required as the early time data is of no particular interest during an injection test. The water level data should be monitored from the data logger as frequently as possible to confirm the system is operating properly and to evaluate the test results. Manual gauging will be completed at regular intervals using an oil-water interface probe to confirm the pressure transducer measurements. Details regarding manual water level measurements are provided in Section 5.3.

The injection rate for each successive step should be increased to the planned rate as quickly as possible, and the injection rate should be monitored and recorded as frequently as practical until the target injection rate has been achieved and stabilized. The injection rate will be measured using a totalizing flow meter at the injection wells that is also capable of recording flow rate. Adjustments should be made to achieve a constant injection rate. The injection rate can be adjusted using the pump controller. Once the injection rate has stabilized, it will be monitored and recorded every 30 minutes.

After the injection test is complete, water levels in the injection wells, monitoring wells, and recovery wells will be recorded until levels reach static conditions or recovery has occurred for the same time duration as injection. This data will be recorded using the pressure transducer data loggers.

All equipment placed within each well such as the pressure transducer data loggers and oil-water interface probe will be decontaminated according to the procedure in Section 5.3.6 at the completion of the test.

5.2.4 Treatment Efficiency Pilot Test Equipment and Process Description

During the treatment efficiency pilot tests, recovered water from the new recovery wells will be utilized as a treatment and injection water source. Water should not be oxygenated to the extent practicable during recovery and transfer to the amendment point and injection well. In order to accomplish this, the system will be installed with continuous piping and minimal plumbing in order to minimize turbulence. The line will also be buried or insulated to minimize temperature fluctuations. Mitigating temperature fluctuations minimizes potential for changes in reduction/oxidation (redox) conditions. The lines will be fitted with a pressure-controlled actuator valve to shut off flow if a loss in pressure is detected.

The aboveground storage tank containing the amendment(s) in each injection area around RW-19 and MW-131 will include a 5,000-gallon concentrated sulfate solution. Connected to this tank on the discharge side will be the following: injection manifold, flow meter (totalizer and rate), sample port, pressure gauge, sulfate injection port, inline mixer (can be eliminated if access to injection well header sample point is convenient), post injection sample port, and manifold to injection well(s). Additionally, a metering pump will be connected for addition of the amendment(s) into the system. Table 1 details sulfate and ammonia (if used) addition rates based on injection rates and targeted sulfate formation concentrations. Metering pumps are very sensitive to out of range injection pressures; pressures will be very closely monitored throughout the duration of the pilot test. The injection pressure will be whatever is needed to inject at a rate consistent with the extraction rate, but HFNR expects the injection pressure will not exceed 5 psi.

5.2.5 Treatment Efficiency Evaluation

To enhance the rate of naturally occurring anaerobic degradation in the pilot test areas, sulfate and nitrogen will be added to the extracted groundwater stream. To prevent fouling of the injection system and injection well, it is critical that the redox condition of the extracted water remains anaerobic throughout the recirculation process, to the degree feasible. The following measures will reduce aeration of the recirculated water: ensuring all connections maintain an air-tight seal; selecting flow meters, pumps, and fixtures that minimize turbulence, inducted air flow, and pressure drops; capping the injection and recovery wells; and injecting through drop tubes that extend below the groundwater level within injection wells to prevent oxidization of injected anaerobic water. Additionally, metal plumbing fittings and manifolds will be minimized so any oxygen that may be inadvertently introduced to the recirculation system does not oxidize the ferrous iron and foul the recirculation plumbing or wells. Air leaks in these recirculation systems are obvious (creates hissing sound associated with air aspiration) and will be repaired immediately.

Enhanced anaerobic biodegradation (EAB) systems are generally designed to adjust groundwater sulfate concentrations to conditions upgradient of the Refinery which are most favorable for the indigenous microbes. The sulfate groundwater concentration of 1,700 mg/L observed upgradient of the Refinery (average of four upgradient wells as measured during April 2018 monitoring event) may be difficult to meet with traditional EAB recirculation system components; therefore, the system will be designed to increase the groundwater concentration from existing low sulfate concentrations (<20 mg/L in MW-131) to approximately 1,000 mg/L or greater, as possible. These increased concentrations will be sufficient to restore and support robust microbial activity.

Table 1 provides sulfate addition rates based on a stock sulfate solution concentration of approximately 3.1% (Epsom Salt approximately 8%). The stock solution will be prepared by mixing 6,000 pounds of Epsom Salt in 4,000 gallons of water in a 5,000-gallon poly tank. The Epsom Salt will be added to a 95-gallon mixing drum fed with a water stream from the mixing tank, and the resulting slurry will be pumped to the top of the storage tank. In addition to sulfate, a small amount of additional nitrogen in the form of ammonia will be added to eliminate nitrogen as a rate-limiting constituent. Ammonia will only be added if baseline monitoring indicates there is insufficient nitrogen present in the Shallow Saturated Zone (i.e., TKN <10 mg/L). The ammonia will be added through the same mixing drum as the Epsom Salt. The ammonia source will be household unscented and surfactant free 9% ammonium water. The nitrogen concentration in the sulfate tank will be adjusted to approximately 50 mg/L for a targeted formation concentration of 10 to 25 mg/L. After in situ dilution/mixing conditions are measured, both sulfate and ammonia injection rates will be adjusted to maintain an adequate supply of nitrogen and sulfate.

Using an initial injection rate of approximately 10 gpm (subject to change based on injection tests), the sulfate dosing rate from the stock tank will be 0.63 gpm or 900 gallons per day of stock solution. It is anticipated that the stock tank will initially be recharged every four days. However, as the pilot test progress, the rate of sulfate demand, as determined by sulfate concentrations in the wells downgradient of the injection wells, is expected to decrease, resulting in an increasingly slow rate of sulfate addition.

To monitor the distribution of the amendments during the initial stage of injection, sodium-bromide will be added to the injectate to be used a tracer in the formation. The sodium-bromide will be added through the same mixing drum as the Epsom Salt. The concentration of sodium-bromide in the amendment tank will be approximately 25 mg/L for a targeted formation concentration of 5 to 10 mg/L. Magnesium and conductivity will also be used as tracers throughout the pilot test.

5.2.6 Treatment Efficiency Test Procedure

Injection flow rate and specific capacity determined in the initial injection test will be utilized to determine injection rates during the treatment efficiency portion of the pilot test. The newly-installed injection and recovery wells will be connected to the closed-loop system, along with the tank containing the amendment(s) and the chemical metering pump, described above. The groundwater extracted from the recovery well will provide source groundwater for amendment and reinjection. Any PSH present in the extracted groundwater will be removed with an oil-water separator prior to entering the amendment tank. A diagram of the pilot test closed-loop system can be found in Figure 3.

Effluent from the recovery well will be plumbed to the amendment tanks at the injection wells via a series of below grade, hard-piped lines. The estimated flow rate of effluent supplied to the injection system will be between 1 and 15 gpm, to be determined based on injection well testing and hydrogeologic information.

Fluid received from the recovery well will ultimately be injected into the injection well via an electric pump, after treatment with the amendment(s). An electric, submersible pump capable of the injection rate will be installed on the supply line from the recovery well. The pump and motor will be sized to achieve the specified injection rate with consideration to vertical lift and friction losses. A Grundfos Redi-Flo4 variable frequency drive pump or equivalent pump will be used; it will have a variable frequency drive motor so adjusting the power input to the pump can control the flow rate.

An inline totalizing and flow rate meter will be used to measure the injection rate. A flow meter will be installed at each injection well.

Any PSH that accumulates in the recovery wells will be measured on a weekly basis and, if necessary, removed from the recovery well using a skimmer pump and pumped to a small tote staged near the recovery well. The PSH thickness and recovered volume will be recorded for the duration of the pilot test to assist in evaluating any improvement to PSH recovery as a result of the test. Any PSH present in extracted groundwater will be removed with an oil-water separator prior to entering the amendment tank.

5.2.7 Groundwater Monitoring

To effectively monitor and adjust the groundwater conditions and associated sulfate feed rates, monitoring wells will be utilized to monitor conditions downgradient of the injection wells and screened typically 25 to 30 feet bgs in the mixing zone (i.e., within and below the target lithologic zone which injection and recovery wells will be screened). Upgradient and downgradient wells will be monitored throughout the treatment efficiency pilot test to determine the maximum extent of treated groundwater impact.

In addition to new monitoring wells that will be installed specifically for the test (PMW-1 through PMW-11), existing monitoring wells at the site will be included in the baseline and groundwater monitoring portion of the pilot test. Monitoring wells, as follows, will be gauged and sampled accordingly throughout the pilot test:

- RW-19 Pilot test area
  - Upgradient wells: KWB-4, RW-19, and MW-48
  - Test area wells: PMW-1, PMW-2, PWM-3, and PMW-4
  - Proximal downgradient well: PMW-5
  - Downgradient wells: KWB-5 and MW-111
- MW-131 Pilot test area
  - Upgradient wells: MW-129 and PMW-6
  - Test area wells: PMW-7, MW-131, PMW-8, and PMW-9
  - Proximal downgradient wells: PMW-10 and PMW-11
  - Downgradient well: MW-112

The groundwater monitoring portion of the pilot test consists of conducting initial and periodic gauging of groundwater and sampling for laboratory and field parameters, as described in the following subsections. The methods described below are in accordance with the 2018 FWGWMP.

The potentiometric surface will be monitored periodically throughout the pilot test to assess potentiometric response and PSH presence/absence. The depth to PSH, if present, and groundwater will be gauged at pilot test area wells according to the schedule presented in Section 6.0. Detailed gauging procedure is described in Section 5.3 below.

Groundwater from the pilot test areas and associated wells will be analyzed, as appropriate, for the follow constituents:

- Hydrocarbon laboratory-measured parameters: BTEX, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, MTBE, naphthalene, GRO, and DRO;
- MNA laboratory-measured parameters: sulfate, TKN, TOC, alkalinity, ferrous iron, sulfide, and magnesium;
- MNA field-measured parameters: conductivity, ORP, DO, temperature, depth to water, and SRBs (qualitative measurement); and
- Tracer laboratory-measured parameter: bromide.

Groundwater samples for laboratory analysis will be collected using low-flow sampling procedures, as described in Section 5.3. The sample parameters (depth of pump intake, pump rates, etc.) will remain consistent between sampling rounds, to the degree feasible. The low-flow sampling pump intake will be located within the target lithologic zone for each pilot test area (gravel seam near RW-19 and silty sand near MW-131) as defined by gamma logging prior to well installation. Where feasible, the pump intake should also be installed so a maximum drawdown of two feet below the smear zone is achieved. The pump intake must remain below the water surface so that air is not entrained during extraction and to prevent pump malfunction. The lowest historical groundwater elevations observed near each proposed recovery well indicate the bottom of the smear zone (pending recovery well installation logging observations) and are provided below:

- MW-131: 3338.88 feet above mean sea level (amsl) in April 2019 (21.72 feet bgs)
- RW-19: 3333.37 feet amsl in March 2019 (35.20 feet bgs)

During the first week of the pilot test, field parameters will be collected daily from each monitoring well located within each pilot test area, listed above. After one week, the field monitoring frequency will be reduced to weekly. Weekly field parameter monitoring will continue until the mixing and injection rates are optimized, which is likely within one month from the initiation of the pilot test. Conductivity measured in the field will be used as an indicator parameter

– increases in conductivity will be the first indication of the amendment(s) reaching the downgradient wells.

Injection flow rates and amendment feed rates will be adjusted based on the following factors:

- Daily monitoring results. Conductivity will be measured on a daily basis using automated monitoring equipment. Groundwater samples for laboratory analysis will be collected after a 100% or more increase of conductivity has been observed in the closest downgradient well, utilizing the same sampling procedures and parameters as listed above.
- Once sulfate is detected at a concentration above 500 mg/L in all of the monitoring wells between the injection and recovery wells (initial target formation concentration or sulfate demand based on HFNR's team experience at similar site), quarterly sampling events will begin on all wells listed above. Samples will be analyzed for hydrocarbon, MNA, and tracer laboratory parameters. The target formation concentration will be refined during the pilot test based on estimated sulfate demand of the formation. Sufficient data to design the full-scale system is expected to be collected after six to 12 months of pilot system operation.
- If sulfate concentrations are below 500 mg/L in the first sampling event, sulfate dosing will be adjusted upward and wells will be resampled after an additional month; quarterly sampling will begin once sulfate concentrations in all of the monitoring wells located between the injection and recovery wells reach 500 mg/L.

5.2.8 Data Processing

Data acquired in the pilot test will be recorded and utilized to implement the full-scale system upgrade design. Data will be presented in interim progress reports to be provided to NMED and OCD on a quarterly basis. A Final Investigation Report including all data and results of the pilot test will be submitted after the completion of pilot test activities and prior to the implementation of the full-scale system upgrade.

Electronic data, including actual time, test elapsed time, and water levels, obtained by the down-hole data loggers will be downloaded into Microsoft Excel spreadsheets using software developed by the data logger vendor. The manually recorded water level and discharge/injection rate data will be manually entered into a Microsoft Excel spreadsheet.

The baseline data will be evaluated to determine if the water levels were influenced by factors other than groundwater recovery. The water level data recorded at the recovery and monitoring wells will be corrected for any outside influences such as regional water level trends, barometric pressure changes, and/or recharge effects due to precipitation.

The following hydrogeologic properties of the shallow saturated zone will be determined from each pump test and injection test: specific capacity, hydraulic conductivity (vertical and horizontal), transmissivity, coefficient of storage, and specific yield. The specific capacity determined from the injection test data will be used along with previously-determined hydrogeologic properties to determine injection rates used in the treatment efficiency portion of the pilot test. The specific capacity determined from the injection test data will be used to confirm or update previous modeling and full-scale system upgrade design criteria such as injection zone of influence, groundwater flowlines, and injection rates. The analytical results from the pilot test groundwater monitoring will be used to determine the amendment(s) and dosing to be used in the full-scale closed-loop system upgrade design.

5.3 Investigation Methods

The following sections describe detailed procedures for installation of injection and recovery wells and for groundwater monitoring. Associated quality assurance, decontamination and waste management procedures are also described. All site activities will be completed in accordance with the requirements of Appendix C of the PCC Permit and the 2018 FWGWMP, as applicable.

5.3.1 Installation of Pilot Test Injection, Recovery, and Monitoring Wells

The following general specifications apply to the injection, recovery, and monitoring wells to be installed at each of the pilot test areas, as described in Section 5.2 and shown in Figures 2a and 2b. Proposed construction diagrams for the injection, recovery, and monitoring wells are provided in Appendix B. All wells at each pilot test area will be installed using hollow stem auger (HSA) drilling methods.

For the recovery wells, the HSA will be approximately 14-inch outside diameter as was used for the Phase II recovery wells. Two 4-inch diameter casings (one for PSH recovery and one for water recovery) and a single 2-inch diameter casing (for measurement) will be installed in each recovery well borehole. Recovery well casings will be constructed of schedule 80 polyvinyl chloride (PVC). Each recovery well will be screened across the water table and target lithologic zone (gravel and silty sand) in the shallow saturated zone, with an expected screen length of 10 to 15 feet. The well screens will be constructed of 4-inch diameter, schedule 80 PVC 0.020-inch slotted screen. The filter pack will consist of either 8/12- or 10/20-grade quartz sand, depending upon the predominant shallow geology in the location where the wells are installed (i.e., either gravel or silty sand). A 2-foot sump consisting of 4-inch schedule 80 PVC will be installed beneath the well screen. For the injection wells, the HSA will be approximately 8 7/8-inch inside diameter. The well casing will be constructed of 6-inch diameter stainless steel. Each injection well will be screened at or slightly below the top of the target lithologic zone (i.e., gravel and silty sand interval), with an expected screen length of 10 feet, and will include a 2-foot sump below the screened interval. Well screen will be constructed of either type 304 stainless steel louvered shutter screen with 1/16-inch horizontal slot or V-wire wrap stainless steel with a slot size of 0.060-inch, specifically designed for injection. The filter pack will consist of either 6/9- or 8/12- grade quartz sand, depending upon the predominant shallow geology in the location where the wells are installed (i.e., either gravel or silty sand). The final filter pack size and well slot size will be based on grain size analysis of the gravel and silty sand interval.

For the monitoring wells, the HSA will be approximately 7-inch inside diameter. Monitoring well casing will be constructed of 4-inch diameter schedule 80 PVC. Each monitoring well will be screened across the water table and same target lithologic zone (i.e., gravel and silty sand interval) as the respective injection well, with an expected screen length of 10 feet. Well screen will be constructed of 0.020-inch slotted schedule 80 PVC, and the filter pack will be either 8/12- or 10/20-grade quartz sand, depending upon the predominant shallow geology in the location where the wells are installed (either gravel or silty sand).

For all types of wells, the casing and screen will be attached using threaded, flush joints. The annular space will be completed with a quartz sand filter pack to 2 feet above the top of the well screen. A 20/40-grade transition sand will extend approximately 2 feet above the filter pack sand. A 2-foot thick layer of hydrated, bentonite chips will be placed in the annular space above the transition sand. The sand filter pack and bentonite chips will be placed through the augers as they are being removed from the borehole. The sand filter pack and the bentonite chips will be poured from the top of the borehole. The remainder of the annular space to 3 feet bgs will be completed with a bentonite-cement grout placed from bottom to top using a tremie pipe and grout pump. Wells will be completed several feet above grade and will be secured with a steel protective cover placed in a 3-foot square concrete pad. An expandable watertight plug will be placed at the top of each wellhead. Four steel bollards filled with cement will be placed around each aboveground wellhead.

The drilling shall be completed under the direction of a qualified engineer or geologist who shall maintain a detailed log of the materials and conditions encountered in each boring. The following visual observations will be recorded on the boring log: lithology (color, type, grain size, sorting, etc.), moisture content (dry, damp, moist, wet), smear zone, and any field evidence of contamination (staining, odor, and photoionization detector [PID] readings). Sample information and visual observations of the cuttings and core samples shall be recorded on the boring log. Up to two soil samples from each boring will be submitted for laboratory analysis: 1) a soil sample immediately above the water table or from the bottom of the boring (if dry) and 2) a soil sample from the depth with the greatest indication of impacts from field screening (if not from the groundwater interface). Soil samples collected from locations with no historical industrial activity (i.e., within the East Field at proposed primary pilot test locations near RW-19 and MW-131) will be submitted for TPH (DRO, GRO, oil range organics [ORO] range) analysis only. Soil samples collected from locations with historical industrial activity (i.e., within the Refinery at proposed alternate pilot test locations) will be submitted for laboratory analysis of TPH (DRO, GRO, and ORO range), VOCs, and metals.

All wells will be developed to create an effective filter pack around the well screen, remove fine particles from the formation near the borehole, and assist in restoring the natural water quality of the shallow saturated zone in the vicinity of the well. Wells will be developed using surging, and bailing or pumping techniques. Each newly-constructed monitoring, recovery, and injection well will be developed until the water recovered from the well is free of visible sediment, turbidity is preferably below 10 Nephelometric Turbidity Units, and the pH, temperature, turbidity, and specific conductivity have stabilized. If the well is pumped dry during development, the water level will be allowed to sufficiently recover before the next development period is initiated. The volume of water withdrawn from each well during development will be recorded. Special attention will be paid to the development of the injection and recovery wells to ensure they meet or exceed these criteria.

Injection wells will be permitted as temporary wells that may be abandoned at the end of the pilot test; however, the injection wells will be constructed to the same specifications as permanent wells. Recovery wells will be permitted and constructed as permanent recovery wells using the same configuration as the Phase II recovery wells. Monitoring wells installed for the pilot test will be permitted as temporary wells and will likely be abandoned at the end of the pilot test. HFNR will propose to retain or abandon the wells in the Final Investigation Report (Pilot Test report). Wells will be named according to the respective existing well (RW-19 or MW-131) as shown on Figures 2a and 2b and as follows:

- Recovery wells: RW-23 (near RW-19) and RW-24 (near MW-131)
- Injection wells: IW-1 (near RW-19) and IW-2 (near MW-131)
- Monitoring wells: PMW-1 through PMW-5 (near RW-19) and PMW-6 through PMW-11 (near MW-131)

5.3.2 Groundwater Monitoring

Groundwater monitoring activities will include existing monitoring wells described above in Section 5.2.7 along with newly installed injection and recovery wells. Well locations are depicted on Figures 2a and 2b. The expected duration of groundwater monitoring activities during the pilot test is approximately 12 to 18 months or until the pilot test objectives are achieved.

5.3.3 Groundwater Gauging

The depth to PSH, if present, and groundwater will be gauged at each monitoring well prior to sampling. Prior to gauging, each well cap will be removed to allow groundwater to equilibrate with atmospheric pressure. Fluid level measurements will be collected using an oil-water interface probe to an accuracy of 0.01 feet. Measurements will be made from a marked survey datum at the top of the well casing. Data will be recorded on a paper field gauging form. The oil-water interface probe will be decontaminated before use and between wells following the procedures outlined in Section 5.3.4.

The following procedure will be used to measure the depths to PSH and groundwater:

- The probe will be lowered into the well slowly until the probe alarm sounds or light illuminates, then the tape will be raised and lowered again slowly until the alarm is again audible or the light again illuminates. The depth to fluid on the tape will be recorded to within 0.01 feet. To ensure accuracy, the measurement will be repeated.
- Well identification, date, time, depth to water, depth to PSH (if applicable), and other pertinent observations will be recorded on the field gauging form.

5.3.4 Groundwater Sampling

Groundwater will be purged and sampled from monitoring, injection, and recovery wells using low-flow methods in accordance with the NMED Hazardous Waste Bureau (HWB) Position Paper "Use of Low-Flow and Other Non-Traditional Sampling Techniques for Compliance Groundwater Monitoring" (NMED, 2001). Groundwater will be purged and sampled from irrigation wells using standard procedures described below. Data collected during the purging and sampling of each well will be recorded on a paper groundwater sampling form. Samples will only be collected in wells which areas suitable for sampling as defined by the 2018 FWGMWP (i.e., wells which contain less than 0.30 feet of PSH during gauging).

Groundwater will be purged and sampled from monitoring, injection, and recovery wells using either a peristaltic pump (for sampling depths of approximately 25 feet bgs or less) or a dedicated, stainless steel submersible pump (for sampling depth greater than 25 feet bgs). An oil-water interface probe will be lowered into the monitoring well to record the depth to water.

A multi-parameter water quality meter with flow-through cell and hand-held turbidity meter will be used during the purging process to monitor for field water quality parameters (pH, temperature, conductivity, TDS, ORP, DO, and turbidity) and demonstrate stabilization. Water quality parameters will be recorded approximately every three minutes during purging. Water quality meters used to measure field parameters will be calibrated each day according to the manufacturer's specifications. The make, model, calibration fluids, and calibration results for the water quality meters will be recorded in the field logbook. The turbidity meter test cell will be triple rinsed with groundwater from the next sample aliquot prior to each reading. The water quality parameters and depth to water will be recorded on a groundwater sampling form. A description of the water quality (e.g., turbidity, sheen, odor) will be recorded during the purging process.

The purging process will be considered complete and groundwater sampling will commence when at least four of the seven water quality parameters achieve stabilization within ten% for three consecutive readings. All seven water quality parameters will be recorded during each consecutive reading.

If the well goes dry during purging, a sample will be collected as soon after the water level recovers to a level from which a sample can be collected. The samples will be collected in clean, labeled laboratory-supplied containers prepared with the appropriate amount and type of preservative.

All sampling equipment will be decontaminated before use and between wells following the procedures outlined in Section 5.3.6. Neoprene or nitrile gloves will be worn during sample collection and while handling sample containers. New disposable gloves will be used to collect each sample. The sample containers will be labeled, secured with bubble wrap, placed in a resealable plastic bag, and immediately placed on ice in a cooler and stored below 4° Celsius. The sample labels will include the Permittee name (HFNR), site name (Artesia Refinery), unique sample identification, sample collection time and date, preservatives, and the name(s) of the sampler(s). The samples will be secured with packing material and kept below 4° Celsius with wet ice in accordance with laboratory cooler shipping guidelines. The cooler will be secured with packing tape, and a signed and dated custody seal will be placed over the cooler lid and secured with tape. The samples and a completed chain-of-custody documentation will be shipped via priority overnight delivery to the analytical laboratory. The chain-of-custody forms are to be maintained as a record of sample collection, transfer, shipment, and receipt by the laboratory. At a maximum, all samples will be submitted to the laboratory within 48 hours after collection. The laboratory will be informed that samples are being submitted for analysis and it will be confirmed that the samples were received the following day. If samples are shipped on Friday for Saturday delivery, the receiving laboratory will be contacted so provisions can be made for laboratory sample receipt.

5.3.5 Quality Assurance/Quality Control

Field quality assurance/quality control (QA/QC) samples for groundwater will be collected as follows:

- Duplicates: Collected at a frequency of ten% at the same time and from the same location as the original sample.
- Equipment blanks: Collected from non-dedicated, decontaminated equipment at a frequency of five% by pouring distilled water over the equipment and collecting the sample in the appropriate laboratory containers.

- Trip blanks: One included in each cooler shipped to the laboratory that contains samples for hydrocarbon laboratory analyses. The trip blank consists of two 40-milliliter (mL) vials of reagent water provided by the laboratory that were stored in the sample cooler at all times.

Laboratory QA/QC samples will be performed according to test methodologies specified for each analytical method. The laboratory QA/QC samples may include reagent or method blanks, surrogates, matrix spike/matrix spike duplicates, blank spike/blank spike duplicates and/or laboratory duplicates, as appropriate for each method. The laboratory QA/QC samples will be run at the frequency specified by each method.

5.3.6 Decontamination

The interface probe and other non-dedicated equipment coming into contact with groundwater will be decontaminated by the following procedures:

1. PSH, if present, will be removed with an absorbent pad.
2. Any solids will be removed to the degree possible with a brush and tap or distilled water.
3. Equipment will be washed with a brush, laboratory-grade non-phosphate detergent (e.g., Liquinox, Alconox), and potable tap or distilled water. Excess soap will be allowed to drain off the equipment when finished.
4. Equipment will be double rinsed with distilled water.

5.3.7 Investigation-Derived Waste

Investigation-derived waste (IDW) (e.g., soil cuttings, purge/development water, decontamination water) generated during well installation and monitoring activities will be collected, stored, and disposed appropriately. Soil will be contained in labeled 55-gallon drums or other suitable containers and stored on-site pending disposal. Water will be disposed of in the Refinery WWTP, upstream of the oil-water separator. Miscellaneous IDW (e.g., gloves, bailers) in contact with investigative material deemed to have no or de minimis contamination will be disposed of in a general refuse container. Any IDW deemed to have greater than de minimis contamination will be stored in labeled drums and disposed appropriately on a per case basis.

5.4 Pilot Test Monitoring and Sampling Program

A semiannual monitoring and sampling program is currently ongoing at the Refinery; descriptions of the sampling program can be found in the 2018 FWGMWP. The monitoring and sampling described here is being performed in addition to the routine monitoring activities. Data obtained in the pilot test program may be compared to historical and future routine monitoring data to determine program effectiveness and divergence (if any) from area-wide trends.

Existing and newly installed monitoring wells will be monitored at a frequency appropriate for determining injection system effectiveness. The anticipated pilot test duration is approximately 12 to 18 months.

During the treatment efficiency phase of the test, indigenous microbes that are no longer limited by late terminal electron acceptors (i.e., sulfate) will preferentially degrade adsorbed phase hydrocarbons (APH) due primarily to available proximity. These microbes use extra cellular enzymes (surfactant) to desorb the adsorbed hydrocarbons. This desorption sometimes results in a short-term increase in one or more of toluene, ethylbenzene, and xylenes (TEX) while the remaining dissolved-phase hydrocarbon constituents degrade. During the test, as microbial activity catches up with this desorption, the degradation rates of all dissolved-phase hydrocarbon constituents will equilibrate. This temporary increase in TEX concentrations is referred to as hydrocarbon desorption.

Based on existing hydraulic conductivity data available for the site, the following observations are expected during the pilot test:

- Sulfate and nitrogen concentration trends will be tracked during the pilot test and correlated with hydrocarbon constituent concentrations measured during the test. This data will then be extrapolated to determine dosing requirements for the full-scale system. These trends should be evident after three to six months of pilot test system operation;
- Hydrocarbon desorption as measured by increasing TEX concentrations and subsequent attenuation as evaluated through hydrocarbon concentration trends will be used to evaluate both dosing efficacy and PSH recovery enhancement. These trends should be observable after three to six months of pilot testing; and
- Decreasing hydrocarbon COC concentration trends will be observed after one year of pilot testing.

As appropriate with the assumptions presented above, after the pilot test injection system is installed and operating, wells will be monitored on a tiered schedule, as presented in Section 6.0. Wells will be monitored and gauged more frequently at the initiation of the pilot test and decreasing over the course of the 12-to 18-month duration of the pilot test.

5.5 Treatment Test Effectiveness

The effectiveness of the proposed treatment efficiency test will be measured primarily by comparing dissolved-phase concentrations of hydrocarbon constituents (BTEX, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, MTBE, naphthalene, GRO, and DRO) before and during the test (maximum 18-month period). The amendments will be considered effective if dissolved phase concentrations decrease during the test. The key dissolved-phase parameters and changes are described in Section 4.2. The following performance measures will be used to holistically evaluate the effectiveness of each pilot test area:

- Decreasing dissolved hydrocarbon concentration trends during the test (after initial spike due to desorption of adsorbed hydrocarbons from soil matrix as described in Section 5.4). Decreasing trends will confirm the treatment is reducing dissolved hydrocarbon concentrations in situ and be used to predict the estimated timeframe to reach target concentrations with further treatment after the pilot test.
- Percent reduction of each dissolved hydrocarbon compound observed during the pilot test. Based on the HFNR team’s experience at other sites, dissolved hydrocarbons are anticipated to decrease between 50% and 90% but the degradation rate is site-specific and varies for each hydrocarbon compound. Degradation rates will be site-specific and vary for each hydrocarbon compound (benzene will generally degrade faster than xylenes, and ortho-xylenes degrade faster than meta-xylenes).
  - The percent reduction for each compound will be used with decreasing trends to predict the estimated timeframe to reach target concentrations.
  - Percent reduction will also be evaluated to determine if it varies within each pilot test area as a function of distance from the injection well.
- Number of estimated pore volume exchange cycles completed within the pilot test area compared to the predicted number of pore volume exchange cycles for the pilot test operating parameters (e.g., injection and recovery rates) and observed conditions. Based on the expected range of pilot test operating parameters, the predicted minimum and maximum number of pore volume exchanges within each pilot test area over the 18-month pilot test are estimated to be 1.5 (injection/pumping rate of 1 gpm) and 17.5 (injection/pumping rate of 12 gpm). This estimate assumes the following for each pilot test area: effective area of approximately 12,000 square feet (60 feet by 200 feet), effective saturated thickness of 20 feet, and saturated porosity of 30%.
- Changes in PSH distribution, apparent thickness, and recovery rates in and around the pilot test area. However, the pilot test may not be of sufficient length to fully understand the impacts on PSH recovery. It should be noted that changes in apparent PSH thickness in wells is not a good indicator of recoverability or actual thickness of PSH in the subsurface, so the evaluation will more heavily weigh on PSH recovery data.
- Concentration trends of MNA parameters correlated with dissolved hydrocarbon concentration trends will be used to confirm/demonstrate EAB is occurring during the pilot test.

6.0 Schedule

Following approval of the work plan by NMED and OCD, and permitting through the New Mexico Office of the State Engineer (NMOSE), the proposed schedule for the pilot test is as follows:

- Week 1: Conduct baseline sampling at existing identified monitoring wells. Conduct gamma-log study of existing wells. Install soil borings to further characterize shallow geology in test areas if needed.
- Week 2: Install and develop injection and recovery wells in the two pilot test areas along with eight new monitoring wells. Develop all wells.
- Week 3: Install equipment for injection tests.
- Week 4: Conduct step-drawdown and constant-rate pump tests concurrently at the two pilot test areas.
- Week 5: Conduct injection tests concurrently at the two pilot test areas; collect groundwater quality samples.
- Weeks 6-11: Analyze injection test data and determine appropriate injection rate and dosing requirements for treatment efficiency test.
- Weeks 11-13: Install equipment for treatment efficiency test; collect baseline hydrocarbon and MNA samples; begin initial treatment with amendment(s).
- Week 14: Collect groundwater MNA field parameters daily; gauge wells daily; adjust amendment(s) and flow rate as necessary.
- Month 4: Collect groundwater MNA field parameters weekly and gauge wells weekly; adjust amendment(s) and flow rate as necessary.
- Months 5-12/18: If sulfate concentrations are greater than 500 mg/L in samples collected from the monitoring wells between the injection and recovery wells after three months, collect hydrocarbon and MNA laboratory groundwater samples and MNA field parameters quarterly. If sulfate concentrations are below 500 mg/L in the monitoring wells between the injection and recovery wells after 3 months, sulfate dosing will be adjusted upward and monthly sampling will continue until sulfate concentrations reach 500 mg/L. Gauge wells on same schedule as sampling. Adjust amendment(s) and flow rate as necessary.
- Month 15/20: Submit Final Investigation Report to NMED/OCD summarizing pilot test results, which will include the following information at a minimum:

- Description of all activities conducted throughout the pilot test, the final pilot test system layout, and any deviations to the work plan.
- Gamma logging data, including any figures and tables generated from the gamma logging results, and a discussion of the results.
- A table summarizing data ranges that define the lithology at the site based on gamma logging results and any soil boring observations, and a discussion of how the data supports the locations chosen for installation and design of the injection wells.
- Well construction and soil boring logs.
- Pump and injection test data, analysis, and a discussion of the results, including a table summarizing the equipment specifications and installation data.
- Figures depicting the locations of the pilot test wells and equipment.
- Tables summarizing field and laboratory results (including all purge parameters), water and PSH level measurements, apparent in-well PSH thicknesses, volumes of PSH recovered, groundwater extraction and injection rates, injection dosing applications, and hydrogeologic properties measured during the pilot test.
- Plots of COC and MNA parameter concentrations over time.
- Field data and notes.
- Summary of QA/QC data review and validation.
- Estimated pore volume exchange cycles completed compared to the predicted number of pore volume exchange cycles for the pilot test operating parameters (e.g., injection and recovery rates).
- Evaluation of pilot test system effectiveness and performance measures.
- Recommendations on the path forward for the final system upgrade.

7.0 Tables

Table 1. Dosing Rate Calculations

Input Parameters

Molecular Weight of Epsom Salt (MgSO4.H2O(7)) = 246.47
Molecular Weight of Sulfate (SO4) = 96.06
Molecular Weight of Ammonia Water (NH4OH) = 35.05
Molecular Weight of Nitrogen (N) = 14.01
Grams per Pound 453.9
Liters per gallon 3.78

Sulfate Dosing Calculations

Target sulfate concentration of injected water = 2,000 mg/L
Concentration in tank: 6,000 pounds Epsom Salt in 4,000 gallons water

Gallons H2O	Liters H2O	Pounds Epsom Salt	Fraction Sulfate	Pounds SO4	Grams Sulfate	Conc. SO4 (mg/L)
4,000	33320	6,000	0.39	2338	1061427	31856

Volume Tank Solution Per Minute to Generate 2,000 mg/L at discharge (target formation concentration of 300 to 500 mg/l)

GW Pumping Rate (gpm)	Convert to L/min	Dilution Required for 2,000 mg/L	Dose in L/min	Dose in gpm	Gallons from Tank per day	Days per 4,000 gal
20	75.6	15.9	4.7	1.26	1808.2	2.2
15	56.7	15.9	3.6	0.94	1356.1	2.9
10	37.8	15.9	2.4	0.63	904.1	4.4
5	18.9	15.9	1.2	0.31	452.0	8.8

Nitrogen Dosing Calculations*

Target nitrogen concentration of injected water = approx. 50 mg/L
Concentration in tank: 150 pounds ammonia water in 4,000 gallons water

Gallons H2O	Liters H2O	Pounds Ammonia Water	Fraction Nitrogen	Pounds Nitrogen	Grams Nitrogen	Conc. Nitrogen (mg/L)
4,000	33320	150	0.40	60	27215	817

Volume Tank Solution Per Minute to Generate 50 mg/L at discharge (target formation concentration of 10 to 25 mg/l)

GW Pumping Rate (gpm)	Convert to L/min	Dilution Required for 50 mg/L	Dose in L/min	Dose in gpm	Gallons from Tank per day	Days per 4,000 gal
20	75.6	16.3	4.6	1.22	1763.1	2.3
15	56.7	16.3	3.5	0.92	1322.3	3.0
10	37.8	16.3	2.3	0.61	881.5	4.5
5	18.9	16.3	1.2	0.31	440.8	9.1

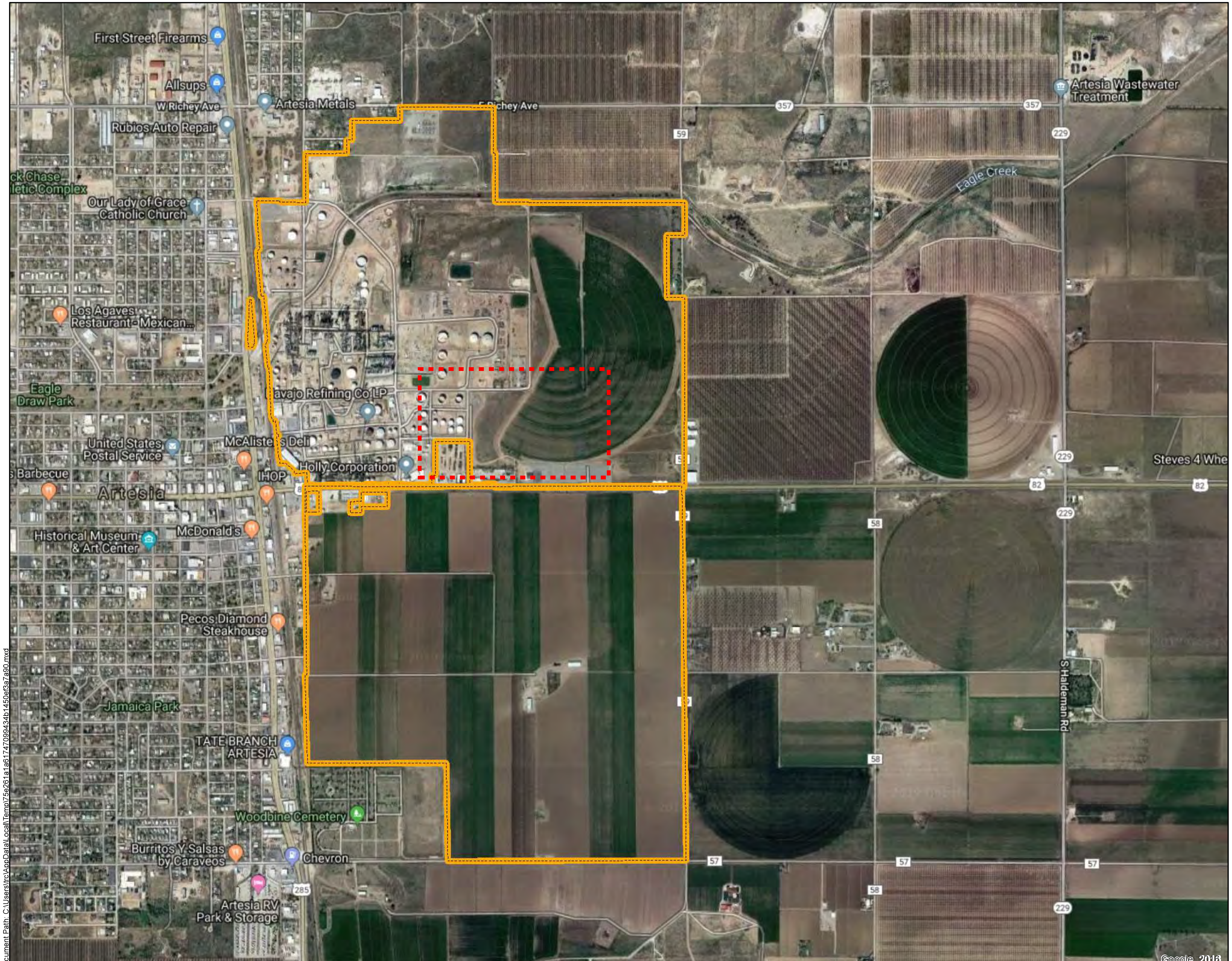
*Example calculation, nitrogen in the form of ammonia will only be added as needed to maintain a formation concentration of >10 mg/L total Kjeldahl nitrogen.

Table 2. Hydrogeologic/Geochemical Properties Used to Develop Pilot Test Work Plan

PROPERTY/DATA	SOURCE
Groundwater Flow Direction: Eastward	Annual Groundwater Monitoring Reports (potentiometric surface maps)
Expected Injection/Pumping Rate: 10 to 15 gallons per minute (gpm)	March 2018 "Groundwater Recovery and Reinjection System Upgrade – Groundwater Model Update"
Average Hydraulic Gradient: 0.003 feet per foot[(1)]	Annual Groundwater Monitoring Reports (potentiometric surface maps)
Horizontal Hydraulic Conductivity: 21 feet per day at RW-19 [(1)]	November 2016 *Draft Shallow Saturated Zone Groundwater Pump Test Report,* March 2018 "Groundwater Recovery and Reinjection System Upgrade – Groundwater Model Update," consistent with published values for silty sand
Shallow Saturated Zone Lithology: silty sand and gravel within preferential groundwater flow pathways	Boring logs from various Investigation Reports, April 2017 *Revised Contaminant Migration Evaluation Investigation Report* (boring logs, geophysical survey, and cross-sections)
Phase-Separated Hydrocarbon In-Well Thicknesses and Distribution	Annual Groundwater Monitoring Reports, April 2017 *Revised Contaminant Migration Evaluation Investigation Report*
Dissolved Hydrocarbon Concentrations and Distribution	Annual Groundwater Monitoring Reports
Monitored Natural Attenuation Parameter Concentrations and Distribution	Annual Groundwater Monitoring Reports, April 2017 *Revised Contaminant Migration Evaluation Investigation Report*

[(1)] Considered during development of Pilot Test Work Plan, but not directly used to design pilot test. Hydraulic conductivity will be determined during proposed aquifer testing.

8.0 Figures



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LEGEND
- Navajo Property
- Pilot Test Area

Figure 1 - Site Location Map

Coordinate System: WGS 1984 Web Mercator Auxiliary Sphere
Projection: Mercator Auxiliary Sphere
Datum: WGS 1984
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False Northing: 0.0000
Central Meridian: 0.0000
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LEGEND

- Monitoring Well
- Recovery Well
- Irrigation Well
- Tanks
- Proposed Injection Well
- Proposed Monitoring Well
- Proposed Recovery Well

Note: Proposed well locations subject to change based on field testing (gamma logging, soil borings, etc.) and presence of underground and aboveground utilities.

0 160 320
Approximate Scale in Feet

Figure 2a - Proposed Recovery, Injection, and Monitoring Locations near RW-19

Coordinate System: WGS 1984 Web Mercator Auxiliary Sphere
Projection: Mercator Auxiliary Sphere
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LEGEND

- Monitoring Well
- Recovery Well
- Irrigation Well
- Tanks
- Proposed Injection Well
- Proposed Monitoring Well
- Proposed Recovery Well

Note: Proposed well locations subject to change based on field testing (gamma logging, soil borings, etc.) and presence of underground and aboveground utilities.

0 160 320

Approximate Scale in Feet

Figure 2b - Proposed Recovery, Injection, and Monitoring Locations near MW-131

Coordinate System: WGS 1984 Web Mercator Auxiliary Sphere
Projection: Mercator Auxiliary Sphere
Datum: WGS 1984
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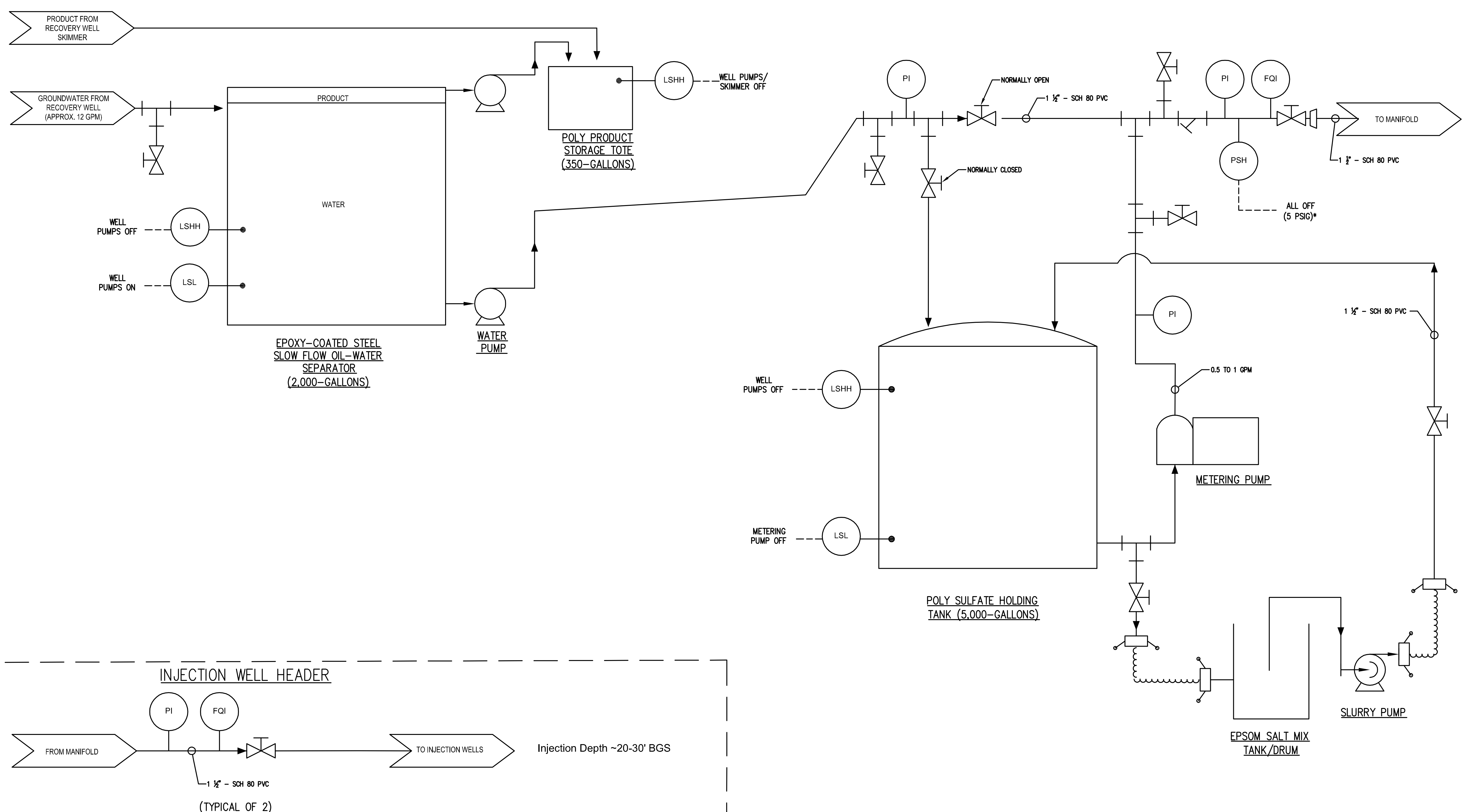

LEGEND

PI	Pressure Indicator
PSH	Pressure Switch - High*
LSHH	Level Switch - High High
LSL	Level Switch - Low
FQI	Flow Meter with Totalizer

*MAXIMUM PRESSURE WILL BE ADJUSTED AS NECESSARY

PRELIMINARY.
NOT INTENDED FOR CONSTRUCTION
OR BIDDING PURPOSES.

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PROCESS AND INSTRUMENTATION DIAGRAM
SULFATE INJECTION

FIGURE 3

S:\1-PROJECTS\HOLLY_ENERGY_PARTNERS\ARTESIA\326693_RECOVERY_SYS\P&ID SULFATE INJECTION_11X17V2.DWG

9.0 References

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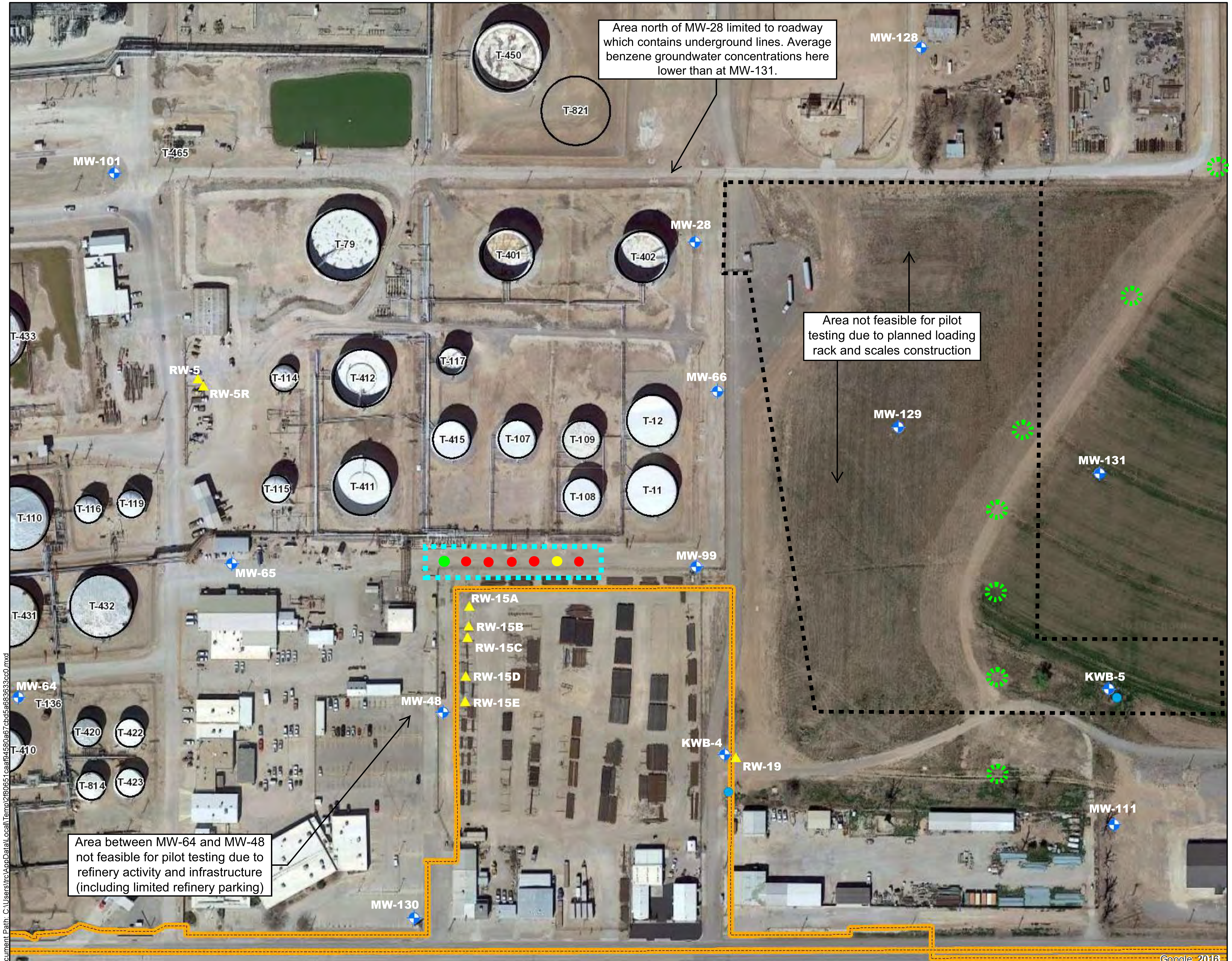
Appendix A

Alternate Pilot Test Locations



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LEGEND

- Monitoring Well
- Recovery Well
- Irrigation Well
- Tanks
- Navajo Property
- Proposed Alternate Injection Well
- Proposed Alternate Monitoring Well
- Proposed Alternate Recovery Well
- Alternate Proposed Pilot Test Area
- Approximate Extent of Loading Rack and Scales Construction Work Area (Provided by HFNR Engineering)
- Injection Well Proposed in "Groundwater Recovery and Reinjection System Upgrade, Groundwater Model Update" Presented to NMED in March 2018 (Approximate Location)

Note: Alternate Proposed Pilot Test Locations will only be considered and evaluated for pilot testing if the Primary Proposed Pilot Test Locations are determined to be not feasible based on field investigation results (geophysical, soil borings).

0 160 320

Approximate Scale in Feet

Appendix A1 - Alternate Pilot Test Location and Wells

Coordinate System: WGS 1984 Web Mercator Auxiliary Sphere
Projection: Mercator Auxiliary Sphere
Datum: WGS 1984
False Easting: 0.0000
False Northing: 0.0000
Central Meridian: 0.0000
Standard Parallel 1: 0.0000
Auxiliary Sphere Type: 0.0000
Units: Meter

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LEGEND

- Monitoring Well
- Recovery Well
- Irrigation Well
- Tanks
- Navajo Property
- Proposed Injection Well
- Proposed Monitoring Well
- Proposed Recovery Well
- Alternate Proposed Pilot Test Area
- Injection Well Proposed in "Groundwater Recovery and Reinjection System Upgrade, Groundwater Model Update" Presented to NMED in March 2018 (Approximate Location)

Note: Alternate Proposed Pilot Test Locations will only be considered and evaluated for pilot testing if the Primary Proposed Pilot Test Locations are determined to be not feasible based on field investigation results (geophysical, soil borings).

0 160 320
Approximate Scale in Feet

Appendix A2 - Proposed Primary and Alternate Pilot Test Location and Wells

Coordinate System: WGS 1984 Web Mercator Auxiliary Sphere
Projection: Mercator Auxiliary Sphere
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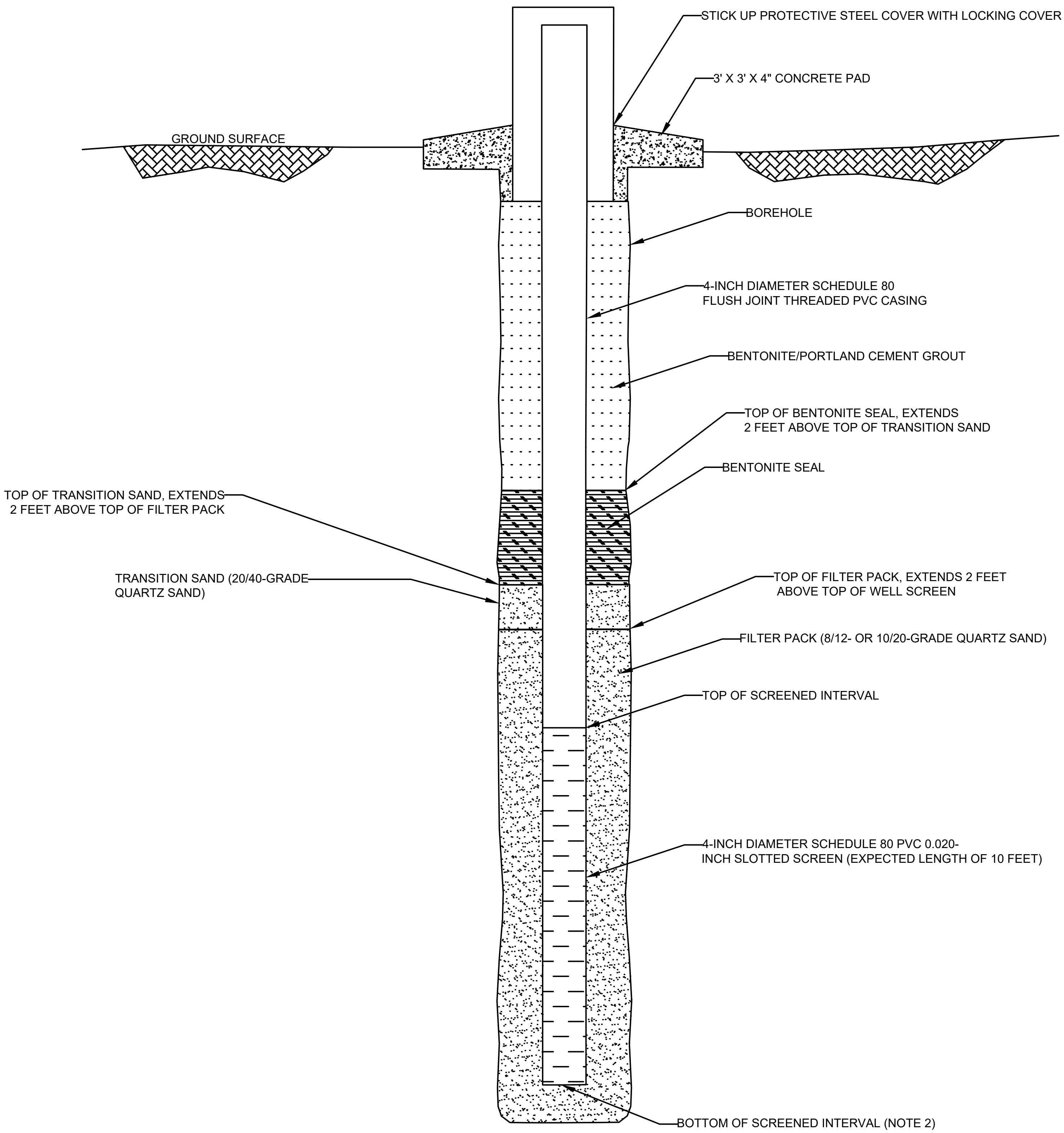
Appendix B

Proposed Well Construction Diagrams



NOTES:
1. DRAWING NOT TO SCALE.
2. SCREEN LENGTH AND TOTAL DEPTH WILL BE DETERMINED BASED ON SITE SUBSURFACE CONDITIONS ENCOUNTERED DURING DRILLING ACTIVITIES.

PROPOSED MONITORING WELL SCHEMATIC

HOLLYFRONTIER NAVAJO REFINING LLC
REVISED GROUNDWATER AND PHASE-SEARATED HYDROCARBON RECOVERY
SYSTEM ENHANCEMENTS REINJECTION PILOT TEST WORK PLAN
ARTESIA REFINERY, ARTESIA, NEW MEXICO

PROJECT NO.	326693	DWG FILE	28316–B1
DRAWN BY.	BMJ	DATE	11/26/19

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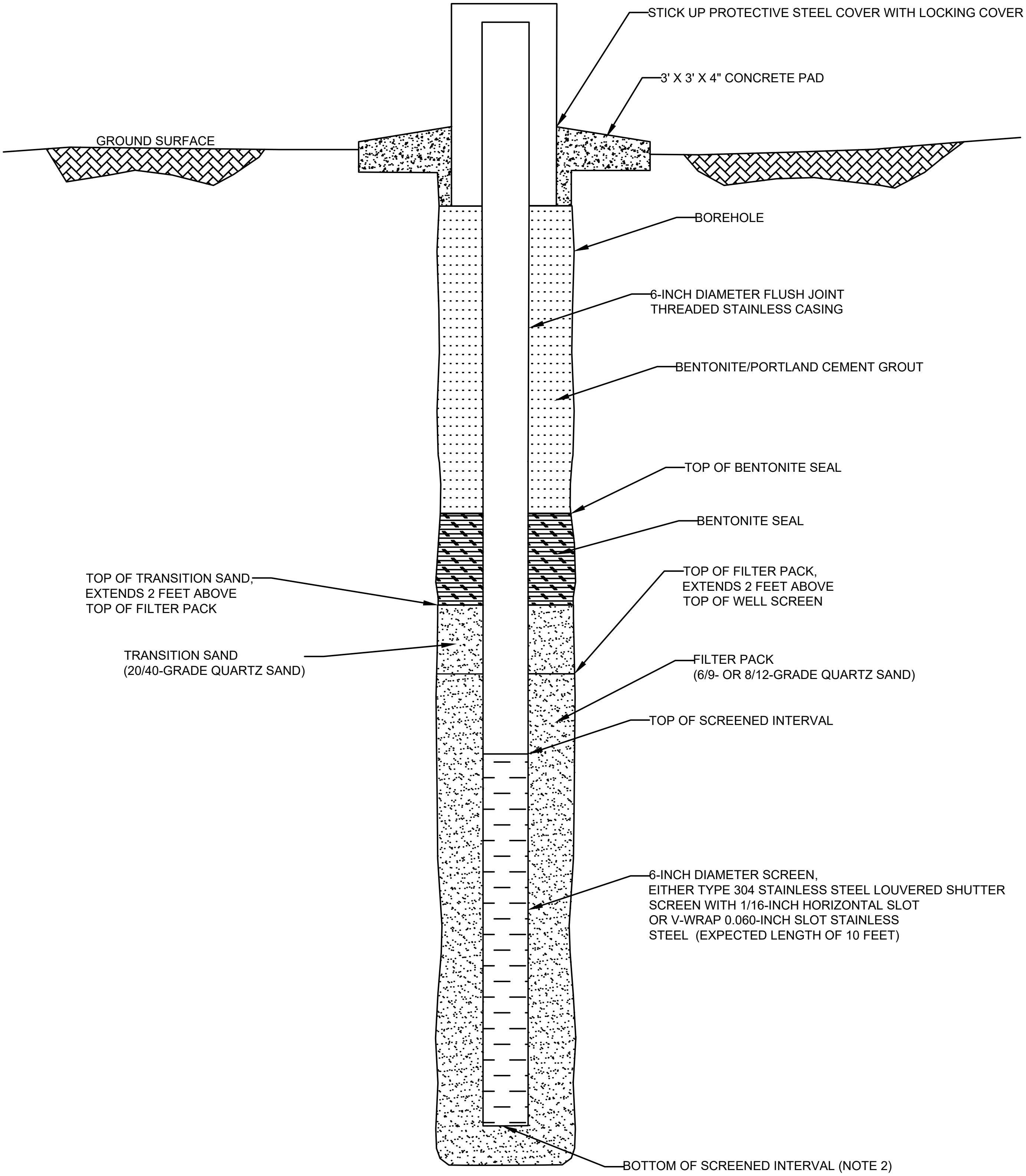
SUITE 250
AUSTIN, TEXAS 78752
(512) 329–6080

ATTACHMENT
B–1



NOTES:
1. DRAWING NOT TO SCALE.
2. SCREEN LENGTH AND TOTAL DEPTH WILL BE DETERMINED BASED ON SITE SUBSURFACE CONDITIONS ENCOUNTERED DURING DRILLING ACTIVITIES.

PROPOSED INJECTION WELL SCHEMATIC

HOLLYFRONTIER NAVAJO REFINING LLC
REVISED GROUNDWATER AND PHASE-SEARATED HYDROCARBON RECOVERY
SYSTEM ENHANCEMENTS REINJECTION PILOT TEST WORK PLAN
ARTESIA REFINERY, ARTESIA, NEW MEXICO

PROJECT NO.	326693	DWG FILE	28316–B2
DRAWN BY.	BMJ	DATE	11/26/19

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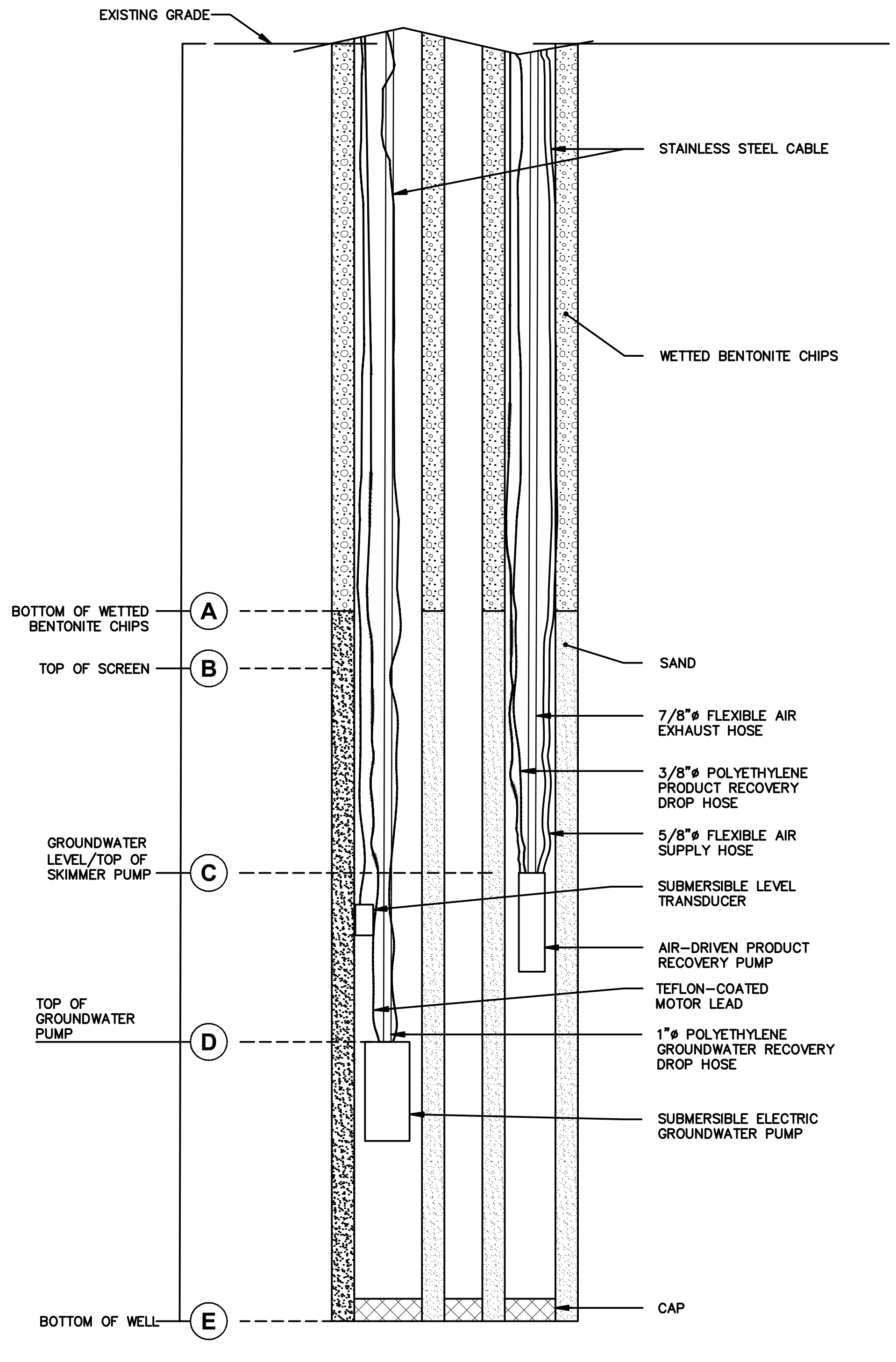
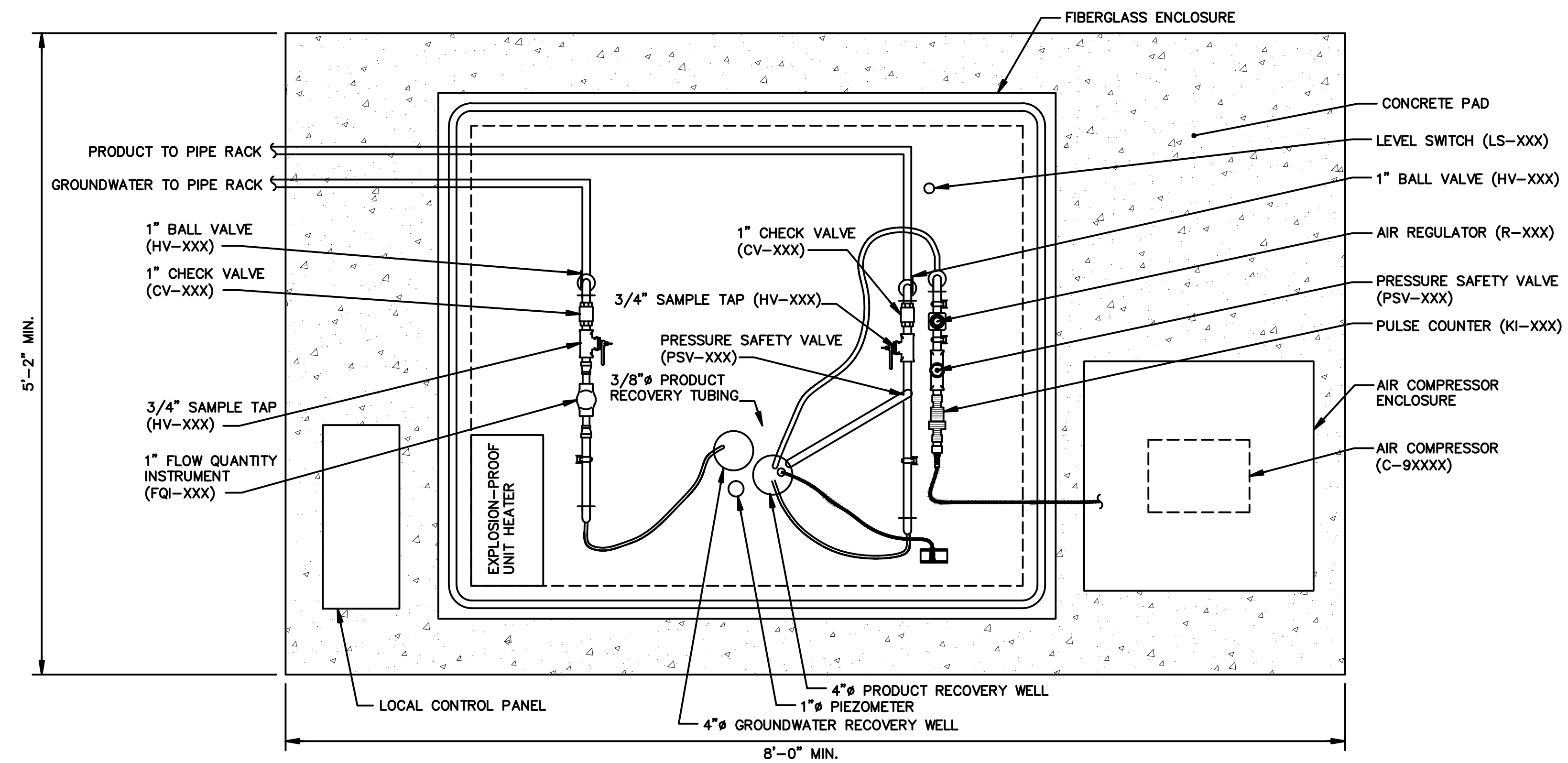
(512) 329–6080

ATTACHMENT
B–2



PROFILE
NOT TO SCALE



PLAN
NOT TO SCALE

SECTION	WELL ID	DEPTH (FT BGS)
A	RW-1	4.0
	RW-2	5.0
	RW-4	5.0
	RW-6	4.0
	RW-7	3.0
	RW-8	3.0
B	RW-1	6.0
	RW-2	7.0
	RW-4	13.0
	RW-6	6.0
	RW-7	5.0
	RW-8	5.0
C	RW-1	9.0
	RW-2	10.0
	RW-4	15.0
	RW-6	14.0
	RW-7	11.0
	RW-8	11.0
D	RW-1	14.0
	RW-2	15.0
	RW-4	20.0
	RW-6	19.0
	RW-7	14.0
	RW-8	14.0
E	RW-1	21.0
	RW-2	22.0
	RW-4	27.0
	RW-6	26.0
	RW-7	17.0
	RW-8	17.0

NOTES:

1. SPECIFICATIONS FOR PUMPS, VALVES, PIPING AND INSTRUMENTATION ARE PROVIDED ON DRAWING 34.
2. CONCRETE PAD TO BE INSTALLED IN ACCORDANCE WITH DETAIL 1 ON DRAWING 29.
3. DEPTHS SHOWN IN TABLE ARE SUBJECT TO CHANGE BASED ON CURRENT GROUNDWATER ELEVATION.
4. DETAILS FOR AIR COMPRESSOR ENCLOSURE ARE PROVIDED IN DETAIL 1 ON DRAWING 28.
5. SANITARY WELL SEALS TO BE PROVIDED FOR GROUNDWATER AND PRODUCT RECOVERY WELLS IN ACCORDANCE WITH DETAILS 2 AND 3 ON DRAWING 28.
6. ALL PIPING, VALVES, AND INSTRUMENTATION INSIDE OF FIBERGLASS ENCLOSURE SHALL BE SUPPORTED ON FREE-STANDING FIELD FABRICATED UNI-STRUT SUPPORTS.

ARCADIS
ARCADIS U.S., INC.
2929 BRIARPARK DRIVE, SUITE 300
HOUSTON, TEXAS 77042 TEL. 713.953.4800

NAVAJO REFINING CO.
ENGINEERING DEPARTMENT
P.O. DRAWER 159
ARTESIA, NEW MEXICO

NOTES

REFERENCE DRAWINGS

NO.	REVISIONS	BY	CHK.	DATE	APPR.	APPR.
7	PHASE II FINAL DESIGN	SAB		8/2013		
6	PHASE II 95% DESIGN	SAB		6/20/13		
5	REVISED EQUIP NO'S CHANGED TO UNIT 90	DGJ		4/17/13		
4	PHASE I AS-BUILT	SAB	TEM	4/2012		
3	REVISED 100% DESIGN	SAB	TEM	10/2011		
2	100% DESIGN	SAB	TEM	7/2011		
1	90% DESIGN	SAB	TEM	6/2011		

DRAWING TITLE

TYPICAL RECOVERY WELL PLAN AND PROFILE – PHASE II

DRAWN BY	CHK'D BY	SCALE	
KLS	SAB	NOT TO SCALE	
DATE	APPR BY	DRAWING NUMBER	REV.
AUGUST 2013	TEM	26	5

XREFS: 00871X00 IMAGES: PROJECTNAME: ----

CITY:SYRACUSE, NY DIV/GROUP:ENV/CAD DB:K.SARTORI LD:(OPT) PIC:P.KRUEGER PM:P.KRUEGER TM:P.KRUEGER LYR:(OPT)ON=*;OFF=*REF*
G:\ENVCAD\SYRACUSE\ACT\TX000871\0004\00002\DWG\LNAPL-PHASE II\00871G26.dwg LAYOUT: 26 SAVED: 8/23/2013 2:25 PM ACADVER: 18.1S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: PLTCONT.CTB PLOTTED: 8/23/2013 2:25 PM BY: SARTORI, KATHERINE

Appendix C

Form C-108 Application for Authorization to Inject

STATE OF NEW MEXICO
ENERGY, MINERALS AND NATURAL
RESOURCES DEPARTMENT

Oil Conservation Division
1220 South St. Francis Dr.
Santa Fe, New Mexico 87505

FORM C-108
Revised June 10, 2003

APPLICATION FOR AUTHORIZATION TO INJECT

I. PURPOSE: __________Secondary Recovery _________Pressure Maintenance _________Disposal _________Storage
Other: In Situ Groundwater Remediation Injection Wells
Application qualifies for administrative approval? ____**NA**______ Yes __________No

II. OPERATOR: ___ **HollyFrontier Navajo Refining LLC (HFNR)**___________________________________

ADDRESS: ____**501 E Main Street in Artesia, New Mexico 88210**_______________________________________

CONTACT PARTY: ____ **Scott Denton**___________________________________ PHONE: ___ **575-746-5487**___

III. WELL DATA: Complete the data required on the reverse side of this form for each well proposed for injection. Additional sheets may be attached if necessary.

IV. Is this an expansion of an existing project? ____**X**______ Yes __________ No
If yes, give the Division order number authorizing the project: _______**GW-028**____

V. Attach a map that identifies all wells and leases within two miles of any proposed injection well with a one-half mile radius circle drawn around each proposed injection well. This circle identifies the well's area of review. **Attached, Figure "C-108 Map"**

*VI. Attach a tabulation of data on all wells of public record within the area of review which penetrate the proposed injection zone. Such data shall include a description of each well's type, construction, date drilled, location, depth, record of completion, and a schematic of any plugged well illustrating all plugging detail. **Provided in previous reports and in attached Table "Tabulation of Data on Wells of Public Record within Area of Review, Application for Authorization to Inject, FORM C-108, Item VI." Details below.**

VII. Attach data on the proposed operation, including: **See attached report "Groundwater and Phase-Separated Hydrocarbon: Recovery System Enhancements: Reinjection Pilot Test Work Plan" Sections 4, 5 and 6; & Attached Supplemental Information**

1. Proposed average and maximum daily rate and volume of fluids to be injected;
2. Whether the system is open or closed;
3. Proposed average and maximum injection pressure;
4. Sources and an appropriate analysis of injection fluid and compatibility with the receiving formation if other than reinjected produced water; and,
5. If injection is for disposal purposes into a zone not productive of oil or gas at or within one mile of the proposed well, attach a chemical analysis of the disposal zone formation water (may be measured or inferred from existing literature, studies, nearby wells, etc.).

*VIII. Attach appropriate geologic data on the injection zone including appropriate lithologic detail, geologic name, thickness, and depth. Give the geologic name, and depth to bottom of all underground sources of drinking water (aquifers containing waters with total dissolved solids concentrations of 10,000 mg/l or less) overlying the proposed injection zone as well as any such sources known to be immediately underlying the injection interval.
See attached document "Groundwater and Phase-Separated Hydrocarbon: Recovery System Enhancements: Reinjection Pilot Test Work Plan" Sections 3.2 and 3.3; & Attached Supplemental Information

IX. Describe the proposed stimulation program, if any. **NA**

*X. Attach appropriate logging and test data on the well. (If well logs have been filed with the Division, they need not be resubmitted). **NA**

*XI. Attach a chemical analysis of fresh water from two or more fresh water wells (if available and producing) within one mile of any injection or disposal well showing location of wells and dates samples were taken. **Data provided for irrigation wells in the injection area in Annual Groundwater Monitoring Reports.**

XII. Applicants for disposal wells must make an affirmative statement that they have examined available geologic and engineering data and find no evidence of open faults or any other hydrologic connection between the disposal zone and any underground sources of drinking water. **NA**

XIII. Applicants must complete the "Proof of Notice" section on the reverse side of this form. **NA**

XIV. Certification: I hereby certify that the information submitted with this application is true and correct to the best of my knowledge and belief.

NAME: ____TITLE: __________________________________

SIGNATURE: ____DATE: ________________________

E-MAIL ADDRESS: ____

* If the information required under Sections VI, VIII, X, and XI above has been previously submitted, it need not be resubmitted. Please show the date and circumstances of the earlier submittal: __**See Supplemental Information, attached**____________

DISTRIBUTION: Original and one copy to Santa Fe with one copy to the appropriate District Office

III. WELL DATA

A. The following well data must be submitted for each injection well covered by this application. The data must be both in tabular and schematic form and shall include: **Attached (Supplemental Information)**

(1) Lease name; Well No.; Location by Section, Township and Range; and footage location within the section.

(2) Each casing string used with its size, setting depth, sacks of cement used, hole size, top of cement, and how such top was determined.

(3) A description of the tubing to be used including its size, lining material, and setting depth.

(4) The name, model, and setting depth of the packer used or a description of any other seal system or assembly used.

Division District Offices have supplies of Well Data Sheets which may be used or which may be used as models for this purpose. Applicants for several identical wells may submit a "typical data sheet" rather than submitting the data for each well.

B. The following must be submitted for each injection well covered by this application. All items must be addressed for the initial well. Responses for additional wells need be shown only when different. Information shown on schematics need not be repeated. **Attached (Supplemental Information)**

(1) The name of the injection formation and, if applicable, the field or pool name.

(2) The injection interval and whether it is perforated or open-hole.

(3) State if the well was drilled for injection or, if not, the original purpose of the well.

(4) Give the depths of any other perforated intervals and detail on the sacks of cement or bridge plugs used to seal off such perforations.

(5) Give the depth to and the name of the next higher and next lower oil or gas zone in the area of the well, if any.

XIV. PROOF OF NOTICE

All applicants must furnish proof that a copy of the application has been furnished, by certified or registered mail, to the owner of the surface of the land on which the well is to be located and to each leasehold operator within one-half mile of the well location.

Where an application is subject to administrative approval, a proof of publication must be submitted. Such proof shall consist of a copy of the legal advertisement which was published in the county in which the well is located. The contents of such advertisement must include:

(1) The name, address, phone number, and contact party for the applicant;

(2) The intended purpose of the injection well; with the exact location of single wells or the Section, Township, and Range location of multiple wells;

(3) The formation name and depth with expected maximum injection rates and pressures; and,

(4) A notation that interested parties must file objections or requests for hearing with the Oil Conservation Division, 1220 South St. Francis Dr., Santa Fe, New Mexico 87505, within 15 days.

NO ACTION WILL BE TAKEN ON THE APPLICATION UNTIL PROPER PROOF OF NOTICE HAS BEEN SUBMITTED.

NOTICE: Surface owners or offset operators must file any objections or requests for hearing of administrative applications within 15 days from the date this application was mailed to them.

INJECTION WELL DATA SHEET

OPERATOR: ___ **HollyFrontier Navajo Refining LLC (HFNR)** ____________________

WELL NAME & NUMBER: ___**IW-1, IW-2** __

WELL LOCATION: _**Navajo Artesia Refinery, near RW-19 (IW-1) and MW-131 (IW-2), respectively.**
Latitude/Longitude: IW-1: 32.843561, - 104.387778; IW-2: 32.844883, -104.385867

Section 4, Township 17S, Range 26E
SECTION TOWNSHIP RANGE

WELLBORE SCHEMATIC *NA*

WELL CONSTRUCTION DATA

Surface Casing

Hole Size: ____**11 in**____ Casing Size: ____**6 in**____

Cemented with: ____**TBD**____ sx. ***or*** ____________ ft^3

Top of Cement: ____**TBD**____ Method Determined: ____________

Intermediate Casing **NA**

Hole Size: ____**NA**____ Casing Size: ____________

Cemented with: ____________ sx. ***or*** ____________ ft^3

Top of Cement: ____________ Method Determined: ____________

Production Casing **NA**

Hole Size: ____**NA**____ Casing Size: ____________

Cemented with: ____________ sx. ***or*** ____________ ft^3

Top of Cement: ____________ Method Determined: ____________

Total Depth: ____________

Injection Interval

____**bottom 5-10 feet above 2-foot sump** **Perforated**____________

(Perforated or Open Hole; indicate which)

INJECTION WELL DATA SHEET

Tubing Size: ____**NA**______________________________ Lining Material: __**NA**______________

Type of Packer: ______**NA**____

Packer Setting Depth: __**NA**____________________

Other Type of Tubing/Casing Seal (if applicable): _______**NA**___________________________________

Additional Data

1. Is this a new well drilled for injection? ____**X**___Yes _______No

   If no, for what purpose was the well originally drilled? __________________________________

   ____

2. Name of the Injection Formation: ___**Shallow Saturated Zone (10-30' bgs)**___________________

3. Name of Field or Pool (if applicable): ___**NA**____

4. Has the well ever been perforated in any other zone(s)? List all such perforated intervals and give plugging detail, i.e. sacks of cement or plug(s) used. _____**No**________________

   ____

5. Give the name and depths of any oil or gas zones underlying or overlying the proposed injection zone in this area: ____

   ____________________**NA**____

   ____

   ____

Supplemental Information
Form C-108
Revised Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements Reinjection Pilot Test Work Plan HollyFrontier Navajo Refining LLC (HFNR)

VI.

Attach a tabulation of data on all wells of public record within the area of review which penetrate the proposed injection zone. Such data shall include a description of each well's type, construction, date drilled, location, depth, record of completion, and a schematic of any plugged well illustrating all plugging detail.

Provided in prior Annual Groundwater Monitoring Reports; and in attached Table "Tabulation of Data on Wells of Public Record within Area of Review, Application for Authorization to Inject, FORM C-108, Item VI."

VII.
Attach data on the proposed operation, including:
1.Proposed average and maximum daily rate and volume of fluids to be injected;
2.Whether the system is open or closed;
3.Proposed average and maximum injection pressure;
4.Sources and an appropriate analysis of injection fluid and compatibility with the receiving formation if other than reinjected produced water; and,
5.If injection is for disposal purposes into a zone not productive of oil or gas at or within one mile of the proposed well, attach a chemical analysis of the disposal zone formation water (may be measured or inferred from existing literature, studies, nearby wells, etc.).

1.Proposed average and maximum daily rate and volume of fluids to be injected;
Average: 12 gpm per injection well
Maximum: 15 gpm per injection well

2.Whether the system is open or closed;
Closed

3.Proposed average and maximum injection pressure;
To be determined during injection test - maximum possible injection pressure 150 psi based on pressure ratings/specifications of the associated piping and connections. The injection pressure is expected not to exceed 5 psi.

4.Sources and an appropriate analysis of injection fluid and compatibility with the receiving formation if other than reinjected produced water; and,
Source of injection fluid is recovered water from the Shallow Saturated Zone. The receiving formation is also the Shallow Saturated Zone approximately 200 feet upgradient of the recovery well. Recovered water will be amended with nutrients to enhance natural attenuation. All extraction and injection will be within 50 feet of the ground surface.

Supplemental Information
Form C-108
Revised Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements Reinjection Pilot Test Work Plan HollyFrontier Navajo Refining LLC (HFNR)

Table 1 calculates sulfate addition rates based on a stock sulfate solution concentration of approximately 3.1% (Epsom Salt approximately 8%). The stock solution is prepared by mixing 6,000 lbs. of Epsom Salt in 4,000 gallons of water in a 5,000 gallon poly tank. The Epsom Salt is typically added to a 95 gallon mixing drum fed with a water stream from the mixing tank and the resulting slurry is pumped to the top of the storage tank. The ammonia is then added through the same mixing drum. The ammonia source is household unscented and surfactant free 9% ammonium water. The ammonia concentration in the sulfate tank is adjusted to approximately 50 mg/L for a targeted formation concentration of 10 to 25 mg/L. After in situ dilution/mixing conditions are measured, both sulfate and ammonia injection rates will be adjusted to maintain an adequate supply of nitrogen and sulfate.

5. If injection is for disposal purposes into a zone not productive of oil or gas at or within one mile of the proposed well, attach a chemical analysis of the disposal zone formation water (may be measured or inferred from existing literature, studies, nearby wells, etc.).
NA

VIII.
Attach appropriate geologic data on the injection zone including appropriate lithologic detail, geologic name, thickness, and depth. Give the geologic name, and depth to bottom of all underground sources of drinking water (aquifers containing waters with total dissolved solids concentrations of 10,000 mg/l or less) overlying the proposed injection zone as well as any such sources known to be immediately underlying the injection interval.

See attached report "Groundwater and Phase-Separated Hydrocarbon, Recovery System Enhancements: Reinjection Pilot Test Work Plan" Sections 3.2 and 3.3. Boring logs for MW-131 and RW-19 in the injection zone are included.

III A.
The following well data must be submitted for each injection well covered by this application. The data must be both in tabular and schematic form and shall include:

(1) Lease name; Well No.; Location by Section, Township and Range; and footage location within the section.

No lease. [Section 4, Township 17S, Range 26E]
IW-1 Proposed Latitude/Longitude: 32.843561, -104.387778 (West of RW-19)
IW-2 Proposed Latitude/Longitude: 32.844883, -104.385867 (West of MW-131)

(2) Each casing string used with its size, setting depth, sacks of cement used, hole size, top of cement, and how such top was determined.
Entire wellbore
Casing size: 6-inch
Depth: TBD, will be approximately 3 feet below the base of the saturated gravel zone encountered when drilling;
Cement: sacks TBD; well will be cemented from approximately 4 feet above the top of the screened interval to 3 feet bgs
Hole size: 11 inches

Top of cement: 3 feet bgs
Top cement determined by: subsurface conditions

(3) A description of the tubing to be used including its size, lining material, and setting depth.
NA

(4) The name, model, and setting depth of the packer used or a description of any other seal system or assembly used.
NA

Supplemental Information

Form C-108

Revised Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements Reinjection Pilot Test Work Plan HollyFrontier Navajo Refining LLC (HFNR)

III B.

The following must be submitted for each injection well covered by this application. All items must be addressed for the initial well. Responses for additional wells need be shown only when different. Information shown on schematics need not be repeated.

(1) The name of the injection formation and, if applicable, the field or pool name.

Shallow Saturated Zone (10-30' bgs)

(2) The injection interval and whether it is perforated or open-hole.

TBD; expected 5-10 feet across the gravel/sand interval in the saturated zone; perforated

(3) State if the well was drilled for injection or, if not, the original purpose of the well.

Injection (In Situ Groundwater Remediation Injection Well)

(4) Give the depths of any other perforated intervals and detail on the sacks of cement or bridge plugs used to seal off such perforations.

None

(5) Give the depth to and the name of the next higher and next lower oil or gas zone in the area of the well, if any.

None

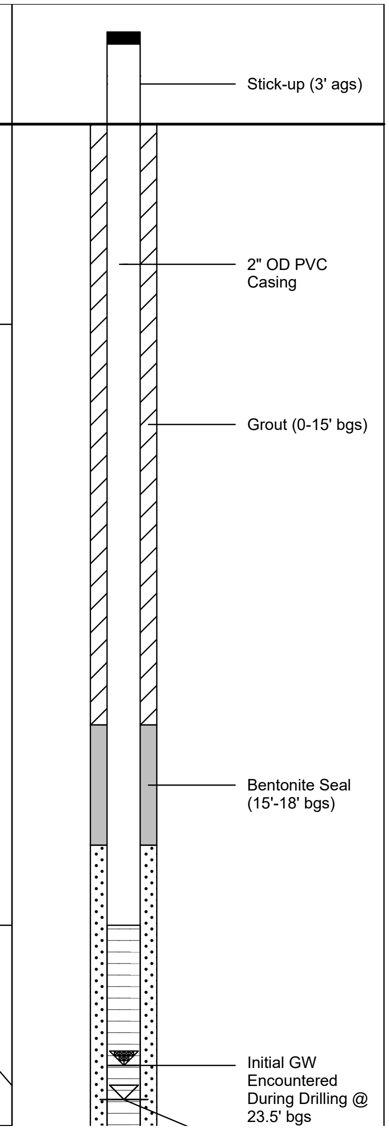
Date Start/Finish: 1/23/14
Drilling Company: National EWP
Drilling Method: Hollow Stem Auger
Sampling Method: Split Spoon
Rig Type: CME 85
Auger Size: 8 1/4"

Northing: 670346.80
Easting: 526629.79
Casing Elevation: 3357.12
Borehole Depth: 50' bgs
Surface Elevation: 3354.3
Descriptions By: Eric Bergersen

Well/Boring ID: **MW-131**
Client: Navajo
Location: Artesia, NM

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description
	3355							
0								SANDY SILT (0,20,80,0), Yellowish Red (5YR5/6), very fine grained, loose, soft, no stain/odor
		1	HA	5	0			
	3350				0			
5								SILTY CLAY (0,0,40,60), Yellowish Red (5YR5/6), dry, stiff, no plasticity, no odor/stain
		2	SS	5	0			
					0			SILTY CLAY (0,0,20,80), Reddish Brown (5YR4/4), dry, stiff, no plasticity, no odor/stain
	3345							
10					0			
								Same as above with black staining and hydrocarbon odor
		3	SS	5	0			
					2.4			SILTY CLAY (0,0,25,75), Gray (GLEY1 5/N), dry, stiff, no plasticity, stain and odor present
	3340				27.2			
15					37.1			
		4	SS	5	516			
					239			
	3335							
20					0			SANDY SILT (0,20,80,0), Dark Gray (GLEY1 4/N), very fine grained, loose, wet, strong odor and stain
		5	SS	5	0			
	3330				0			GRAVEL (95,0,5,0), Dark Gray (GLEY1 4/N), poorly sorted, 0.5"-2.5" subangular to subrounded, stain and odor present
25								

Well/Boring Construction



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Remarks: bgs = below ground surface; amsl = above mean sea level; HA = Hand Auger; ppm = parts per million; NA = not applicable/available; SS = split spoon, ags = above ground surface

Lithology described as a percentage (Gravel, Sand, Silt, Clay)

Analytical Column: X= designates soil sample; circle shaded in= positive soil shake test, open circle= negative soil shake test

Project: TX000931.0004
Data File:MW-131.dat

Created/Edited by:ESB
Date: 4/20/2014

Date Start/Finish: 1/23/14 **Drilling Company:** National EWP **Drilling Method:** Hollow Stem Auger **Sampling Method:** Split Spoon **Rig Type:** CME 85 **Auger Size:** 8 1/4"	**Northing:** 670346.80 **Easting:** 526629.79 **Casing Elevation:** 3357.12 **Borehole Depth:** 50' bgs **Surface Elevation:** 3354.3 **Descriptions By:** Eric Bergersen	**Well/Boring ID: MW-131** **Client:** Navajo **Location:** Artesia, NM

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Well/Boring Construction
25		6	SS	5	0, 0	circle shaded in; open circle		SILTY CLAY (0,0,10,90), White (5YR8/1), moist, high plasticity, medium stiffness, no stain/odor SILTY CLAY (0,0,30,70), Light Bluish Gray (GLEY2 7/10B), stiff, no plasticity, dry, light stain, no odor	GW Elevation During GW Sampling @ 24.35' bgs
30	3325	7	SS	5	0, 0, 0			SILTY CLAY (0,0,30,70), Greenish Gray (GLEY2 6/10BG), soft, high plasticity, moist, no stain/odor SILTY CLAY (0,5,35,60), Light Reddish Brown (5YR6/4), stiff, medium plasticity, dry, no stain/odor	10/20 Silica Sand Pack (18'-50' bgs) 2" OD 0.020" Slot Screen (20'-50' bgs)
35	3320	8	SS	5	0, 0			Same as above with calcareous nodules	
40	3315	9	SS	5	0, 0, 0			CLAYEY SILT (0,0,60,40), Light Gray (5YR7/1), soft, medium plasticity, moist, no stain/odor Same as above, stiff, dry, no plasticity	
45	3310	10	SS	5	0, 0			SILTY CLAY (0,0,30,70), Pale Olive (5Y6/3), stiff, low-medium plasticity, slightly moist, no stain/odor CLAY (0,0,0,100), Yellowish Red (5YR5/8), very stiff, no plasticity, dry, no stain/odor	
50	3305					X			

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Remarks: bgs = below ground surface; amsl = above mean sea level; HA = Hand Auger; ppm = parts per million; NA = not applicable/available; SS = split spoon, ags = above ground surface

Lithology described as a percentage (Gravel, Sand, Silt, Clay)

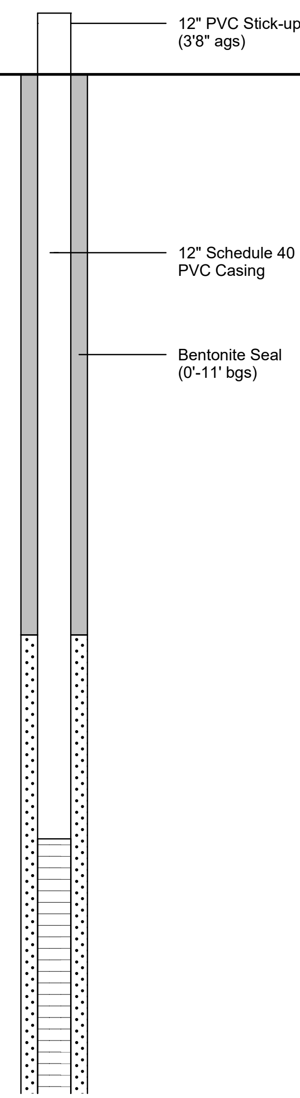
Analytical Column: X= designates soil sample; circle shaded in= positive soil shake test, open circle= negative soil shake test

Project: TX000931.0004
Data File:MW-131.dat

Created/Edited by:ESB
Date: 4/20/2014

Date Start/Finish: 8/20/2011 **Drilling Company:** SESI **Drilling Method:** Hollow Stem Auger **Sampling Method:** Split Spoon **Rig Type:** 3369.11	**Northing:** 670611.43 **Easting:** 524592.99 **Casing Elevation:** 4'2" **Borehole Depth:** 55' bgs **Surface Elevation:** 3367.09 **Descriptions By:** Joe Boldt	**Well/Boring ID: RW-19** **Client:** Navajo Refining Company **Location:** Navajo Refinery Artesia, New Mexico

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Well/Boring Construction
0	0							CLAYEY SILT	
		1							
5	-5								
		2							
10	-10								
		3							
15	-15								
		4							
								COBBLES with increased sand content and decreased clay	
20	-20								



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Remarks: bgs = below ground surface; amsl = above mean sea level; HA = Hand Auger; ppm = parts per million; NA = not applicable/available; SS = split spoon, ags = above ground surface

Northing and Easting data based on New Mexico State Plane System, Eastern Zone NAD 83. Elevation NAVD 88 referenced to NGS benchmark G-416. Temporary well casing elevations were estimated by adding a measured stick-up height to the

Date Start/Finish: 8/20/2011
Drilling Company: SESI
Drilling Method: Hollow Stem Auger

Sampling Method: Split Spoon
Rig Type: 3369.11

Northing: 670611.43
Easting: 524592.99
Casing Elevation: 4'2"

Borehole Depth: 55' bgs
Surface Elevation: 3367.09

Descriptions By: Joe Boldt

Well/Boring ID: **RW-19**

Client: Navajo Refining Company

Location: Navajo Refinery
Artesia, New Mexico

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Well/Boring Construction
20	-20	5							
								CLAYEY SAND, light gray	
25	-25	6						Cobbles	0.020" Schedule 40 0.010" Slot Screen (15'-35' bgs); 8/16 Silica Sand Pack (11'-46' bgs)
30	-30	7							
35	-35	8							
40	-40								

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Remarks: bgs = below ground surface; amsl = above mean sea level; HA = Hand Auger; ppm = parts per million; NA = not applicable/available; SS = split spoon, ags = above ground surface

Northing and Easting data based on New Mexico State Plane System, Eastern Zone NAD 83. Elevation NAVD 88 referenced to NGS benchmark G-416. Temporary well casing elevations were estimated by adding a measured stick-up height to the

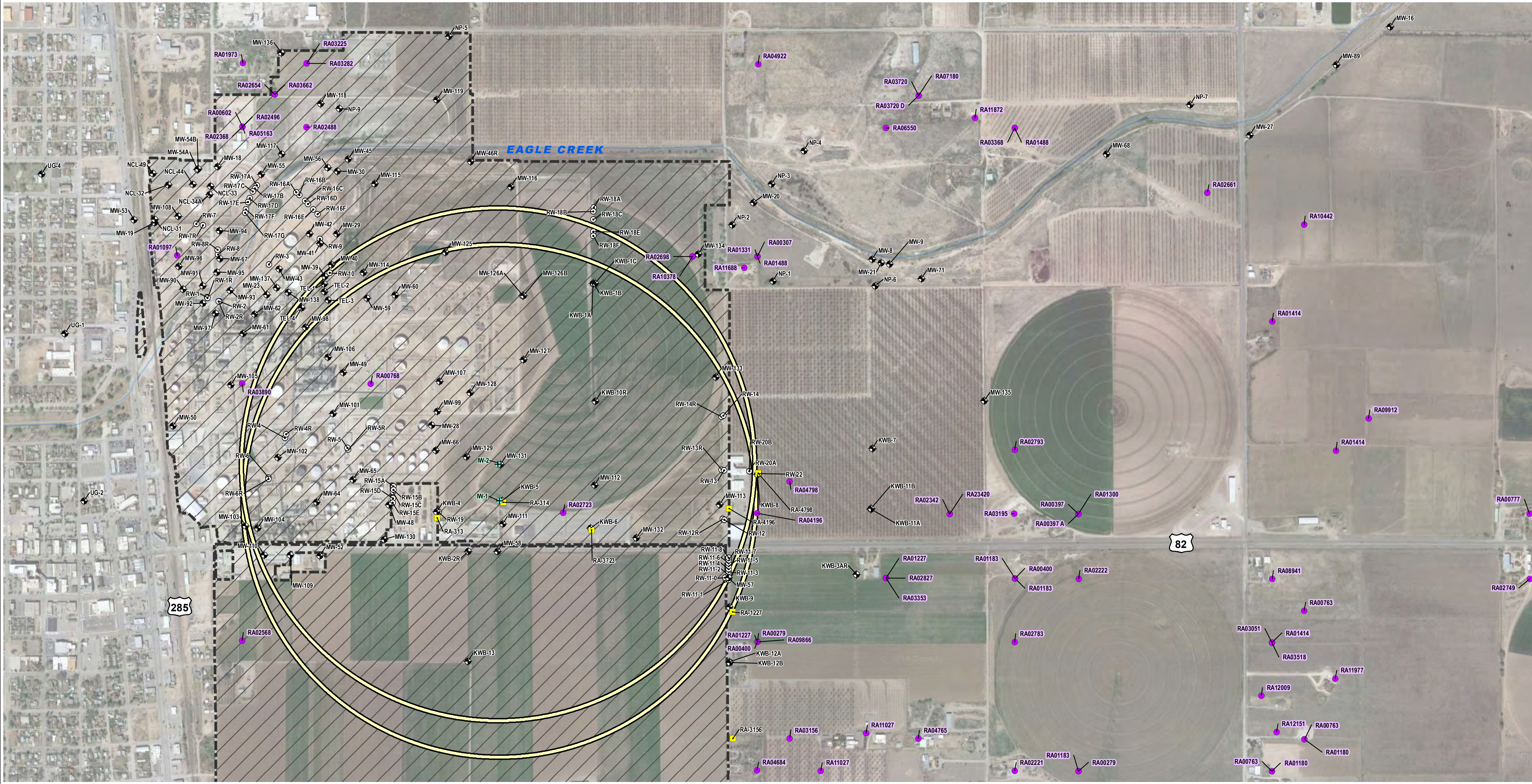
Date Start/Finish: 8/20/2011 **Drilling Company:** SESI **Drilling Method:** Hollow Stem Auger **Sampling Method:** Split Spoon **Rig Type:** 3369.11	**Northing:** 670611.43 **Easting:** 524592.99 **Casing Elevation:** 4'2" **Borehole Depth:** 55' bgs **Surface Elevation:** 3367.09 **Descriptions By:** Joe Boldt	**Well/Boring ID: RW-19** **Client:** Navajo Refining Company **Location:** Navajo Refinery Artesia, New Mexico

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Well/Boring Construction
		9							
45	-45								
50	-50								BENTONITE FILL (46'-53' bgs)
								SLOUGH	Slough (53'-55' bgs)
55	-55								

ARCADIS

Remarks: bgs = below ground surface; amsl = above mean sea level; HA = Hand Auger; ppm = parts per million; NA = not applicable/available; SS = split spoon, ags = above ground surface

Northing and Easting data based on New Mexico State Plane System, Eastern Zone NAD 83. Elevation NAVD 88 referenced to NGS benchmark G-416. Temporary well casing elevations were estimated by adding a measured stick-up height to the



LEGEND

- MONITORING WELL
- RECOVERY WELL
- IRRIGATION WELL IN MONITORING PROGRAM
- PROPOSED INJECTION WELL
- POTENTIAL WATER WELL (SEE NOTE 1)
- NAVAJO PROPERTY BOUNDARY
- 0.5 MILE RADIUS

NOTES:

1. POTENTIAL WATER WELL IDENTIFIED IN NEW MEXICO OFFICE OF THE STATE ENGINEER (NMOSE) NEW MEXICO WATER RIGHTS REPORTING SYSTEM (NMWRRS).
2. LEASE INFORMATION NOT PROVIDED BECAUSE PROPOSED INJECTION NOT IN PRODUCTION ZONE.

0 500 1,000 Feet

1 " = 1,000 '

1:12,000

BASEMAP: GOOGLE EARTHAND THEIR DATA PARTNERS, 3/12/2016

PROJECT: **GROUNDWATER AND PHASE-SEPARATED HYDROCARBON RECOVERY SYSTEM ENHANCEMENTS: REINJECTION PILOT TEST WORK PLAN HOLLYFRONTIER NAVAJO REFINERY LLC ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO**

TITLE: **AREA MAP, APPLICATION FOR AUTHORIZATION TO INJECT FORM C-108, ITEM V**

DRAWN BY:	MHORN	PROJ. NO.:	326693
CHECKED BY:	JSPEER		
APPROVED BY:		C-108 MAP	
DATE:	APRIL 2019		

TRC

505 East Huntland Drive, Suite 250
Austin, TX 78752
Phone: 512.329.6080
www.trcsolutions.com

FILE NO.: 326693_C-108.mxd

Plot Date: 4/11/2019, 12:59:33 PM by MHORN -- LAYOUT: ANSI B(11"x17")
Path: \\apaenvfile01\GIS\1-PROJECTS\HOLLY_ENERGY_PARTNERS\Artesia\326693_Recovery_Sys\326693_C-108.mxd

Coordinate System: NAD 1983 2011 StatePlane New Mexico East FIPS 3001 Ft US (Foot US)
Map Rotation: 0

TRC - GIS

Tabulation of Data on Wells of Public Record within Area of Review

Application for Authorization to Inject, FORM C-108, Item VI

Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements: Reinjection Pilot Test Work Plan

HollyFrontier Navajo Refining LLC, Artesia Refinery, Eddy County, New Mexico

Well ID	Well Type	Install Date	Well Diameter (inch)	Screen Interval(1) (ft bgs)	Surface Finish	Water Bearing Zone	X	Y
KWB-1A	Monitoring	2/11/1992	2	18 to 32	stickup	Shallow Saturated	-104.38268671500	32.85000646230
KWB-1B	Monitoring	2/15/1992	4	18 to 32	stickup	Shallow Saturated	-104.38265525800	32.85000586960
KWB-1C	Monitoring	9/29/1992	4	30.5 to 49.5	stickup	Valley Fill	-104.38261641000	32.85000401640
KWB-2R	Monitoring	--	2	--	flush mount	Shallow Saturated	-104.38686253400	32.84241334810
KWB-4	Monitoring	2/17/1992	2	20 to 39	stickup	Shallow Saturated	-104.38792192700	32.84353746700
KWB-5	Monitoring	2/11/1992	2	24.7 to 38.7	stickup	Shallow Saturated	-104.38573378800	32.84384946550
KWB-6	Monitoring	2/12/1992	2	17.5 to 36.5	stickup	Shallow Saturated	-104.38275666500	32.84308053640
KWB-9	Monitoring	2/13/1992	2	20 to 34	stickup	Shallow Saturated	-104.37810826000	32.84085165740
KWB-10R	Monitoring	10/1/2010	4	9 to 29	flush mount	Shallow Saturated	-104.38260444100	32.84667300710
KWB-13	Monitoring	--	2	--	flush mount	Shallow Saturated	-104.38687750300	32.83930672220
MW-28	Monitoring	7/8/1982	6	25 to 30	stickup	Shallow Saturated	-104.38808910200	32.84598917580
MW-39	Monitoring	6/13/1984	2	14 to 24	stickup	Shallow Saturated	-104.39166919400	32.85019604540
MW-48	Monitoring	12/14/1994	2	19 to 34	flush mount	Shallow Saturated	-104.38952434300	32.84373743570
MW-49	Monitoring	12/20/1994	2	19 to 34	flush mount	Shallow Saturated	-104.39105570200	32.84748150570
MW-52	Monitoring	1/14/1995	2	19 to 34	flush mount	Shallow Saturated	-104.39183314500	32.84229568000
MW-57	Monitoring	9/8/2003	2	10 to 30	flush mount	Shallow Saturated	-104.37813128600	32.84167011090
MW-58	Monitoring	9/5/2003	4	13 to 28	flush mount	Shallow Saturated	-104.38588441700	32.84241384470
MW-59	Monitoring	9/4/2003	2	15 to 30	stickup	Shallow Saturated	-104.39026470100	32.84957869030
MW-60	Monitoring	9/4/2003	2	15 to 30	stickup	Shallow Saturated	-104.38932368700	32.84967509680
MW-64	Monitoring	4/28/2005	4	15 to 30	flush mount	Shallow Saturated	-104.39193957000	32.84380955170
MW-65	Monitoring	4/26/2005	4	14.5 to 29.5	flush mount	Shallow Saturated	-104.39072500100	32.84445106830
MW-66	Monitoring	4/26/2005	4	14.6 to 29.6	flush mount	Shallow Saturated	-104.38796330000	32.84527235990
MW-98	Monitoring	7/3/2007	4	13 to 23	stickup	Shallow Saturated	-104.39232778200	32.84875971420
MW-99	Monitoring	7/5/2007	4	12 to 27	flush mount	Shallow Saturated	-104.38789990000	32.84638544690
MW-101	Monitoring	7/6/2007	4	8 to 23	stickup	Shallow Saturated	-104.39139427600	32.84631716520
MW-102	Monitoring	7/6/2007	4	12 to 27	stickup	Shallow Saturated	-104.39324807200	32.84507514580
MW-103	Monitoring	8/18/2008	4	7 to 22	stickup	Shallow Saturated	-104.39431870500	32.84313917690
MW-104	Monitoring	8/19/2008	4	3 to 18	stickup	Shallow Saturated	-104.39392259400	32.84307835020
MW-106	Monitoring	2/9/2009	4	0 to 11	flush mount	Shallow Saturated	-104.39156473400	32.84790824230
MW-107	Monitoring	2/24/2009	4	12 to 22	flush mount	Shallow Saturated	-104.38783298300	32.84723441900
MW-109	Monitoring	1/6/2011	2	15 to 29.5	flush mount	Shallow Saturated	-104.39282778600	32.84231997670
MW-110	Monitoring	1/5/2011	2	15 to 29.5	flush mount	Shallow Saturated	-104.39370310900	32.84231977760
MW-111	Monitoring	2/2/2013	2	25 to 40	stickup	Shallow Saturated	-104.38570153100	32.84320264290
MW-112	Monitoring	2/1/2013	2	25 to 35	stickup	Shallow Saturated	-104.38262699400	32.84429350520
MW-113	Monitoring	2/2/2013	2	20 to 35	stickup	Shallow Saturated	-104.37844189100	32.84375404280
MW-114	Monitoring	1/28/2013	2	20 to 35	stickup	Shallow Saturated	-104.39037998800	32.85031389640
MW-125	Monitoring	2/5/2014	2	15 to 25	stickup	Shallow Saturated	-104.38763152800	32.85088092510
MW-126A	Monitoring	1/29/2014	2	19 to 34	stickup	Shallow Saturated	-104.38504123400	32.84966624730
MW-126B	Monitoring	1/27/2014	2	40 to 50	stickup	Valley Fill	-104.38502113900	32.84965957700
MW-127	Monitoring	1/23/2014	2	20 to 50	stickup	Shallow Saturated	-104.38502077300	32.84784809000
MW-128	Monitoring	1/29/2014	2	15 to 35	flush mount	Shallow Saturated	-104.38680183900	32.84691797440
MW-129	Monitoring	1/22/2014	2	20 to 50	stickup	Shallow Saturated	-104.38693210300	32.84510104350
MW-130	Monitoring	2/7/2014	2	30 to 45	flush mount	Shallow Saturated	-104.38968949000	32.84275324020
MW-131	Monitoring	1/23/2014	2	20 to 50	stickup	Shallow Saturated	-104.38578564600	32.84488095180
MW-132	Monitoring	1/30/2014	2	15 to 40	stickup	Shallow Saturated	-104.38122260900	32.84279923230
MW-133	Monitoring	2/4/2014	2	15 to 35	stickup	Shallow Saturated	-104.37856491100	32.84736045400
RA-313	Irrigation	10/1/1940	10	904 to 1157	--	Artesian	-104.38789775400	32.84335683720
RA-314	Irrigation	--	--	--	--	Artesian	-104.38568775500	32.84380778820
RA-00768	Industrial	--	--	--	--	Artesian	-104.39013000000	32.84715100000
RA-3723	Irrigation	--	--	--	--	Artesian	-104.38273433100	32.84302823820
RA-4196	Irrigation	4/26/1960	8	280 to 292	--	Artesian	-104.37812725700	32.84363079660
RW-4R*	Recovery	10/21/2013	12	14.5 to 34.5	recovery vault	Shallow Saturated	-104.39300924600	32.84562930160
RW-5R*	Recovery	8/24/2011	12	13 to 33	recovery vault	Shallow Saturated	-104.39088750900	32.84529974480
RW-6R*	Recovery	10/22/2013	12	14.5 to 34.5	recovery vault	Shallow Saturated	-104.39355308100	32.84450518000
RW-10	Recovery	--	36	--	recovery vault	Shallow Saturated	-104.39151829600	32.85029690850
RW-11*	Recovery	--	36	--	recovery vault	Shallow Saturated	-104.37825293400	32.84167710390
RW-12R*	Recovery	8/21/2011	12	15 to 35	recovery vault	Shallow Saturated	-104.37832690300	32.84333821500
RW-13R*	Recovery	8/21/2011	12	15 to 35	recovery vault	Shallow Saturated	-104.37836817800	32.84473140100
RW-14R*	Recovery	8/21/2011	12	15 to 35	recovery vault	Shallow Saturated	-104.37837638900	32.84622489660
RW-15*	Recovery	--	36	--	recovery vault	Shallow Saturated	-104.38938436200	32.84409773490
RW-18*	Recovery	--	36	--	recovery vault	Shallow Saturated	-104.38267521600	32.85146909610
RW-19	Recovery	8/20/2011	12	11 to 46	recovery vault	Shallow Saturated	-104.38785500600	32.84352389010
RW-20*	Recovery	--	4	--	recovery vault	Shallow Saturated	-104.37744272800	32.84468415180
TEL-1	Monitoring	--	2	13 to 23	stickup	Shallow Saturated	-104.39170198400	32.84999491320
TEL-2	Monitoring	--	2	13 to 23	stickup	Shallow Saturated	-104.39168077100	32.84977385070
TEL-3	Monitoring	--	2	13 to 23	stickup	Shallow Saturated	-104.39155022700	32.84952697420
TEL-4	Monitoring	--	2	13 to 23	stickup	Shallow Saturated	-104.39245582300	32.84930646650

(1) Well total depth is equivalent to the bottom of the screen interval.

-- = information is not available or applicable

* = recovery well with one or more additional associated recovery well(s) completed within the same recovery trench

ft bgs = feet below ground surface

Appendix D

Underground Discharge System (Class V) Inventory Sheet

FOR SAMPLE USE ONLY – COMPARABLE FORMAT ACCEPTABLE

UNDERGROUND DISCHARGE SYSTEM (CLASS V) INVENTORY SHEET

(see instructions on back)

1. Name of facility: HollyFrontier Navajo Refining LLC (HFNR) Artesia Refinery

   Address of facility: 501 E. Main St

   City/Town: Artesia State: NM Zip Code: 88210

   County: Eddy County Location: See Figure 1

   Contact Person: Scott Denton Phone Number: 575-746-5487

2. Name of Owner or Operator: HollyFrontier Navajo Refining LLC

   Address of Owner or Operator: P.O. Box 159

   City/Town: Artesia State: NM Zip Code: 88211-0159

3. Type & number of system(s): 0 Drywell(s) 0 Septic System(s) 2 Other(describe): In Situ GW Remediation Injection Wells

   Attach a schematic of the system. Attach a map or sketch of the location of the system at the facility.

4. Source of discharge into system: Groundwater extracted from Refinery extraction wells located ~200 feet downgradient

   Navajo Artesia Refinery SIC code 2911 (Petroleum Refining); EPA ID No. NMD048918817; Discharge Permit GW-028

5. Fluids discharged: Amended groundwater

6. Treatment before discharge: Sulfate and ammonia solution (2% sulfate, 0.05% ammonia). See Table 1 for details

7. Status of underground discharge system: ☐ Existing ☐ Unused/Abandoned ☐ Under Construction ☒ Proposed

   Approved/Permitted by: NA Date constructed: NA

CERTIFICATION

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment. (Ref. 40 CFR 144.32).

Signature: ______________________ Date: __________

Name (printed): ______________________

Official Title: ______________________

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5

UNDERGROUND DISCHARGE SYSTEM (CLASS V) INVENTORY SHEET INSTRUCTIONS

Complete one sheet for each different kind of underground discharge or drainage system (Class V well) at your facility or location. For example, several storm water drainage wells of a similar construction can all go on one sheet. Another example could be a business with a single septic system (septic tank with drainfield) that accepts fluids from a paint shop sink in one area, their vehicle maintenance garage floor drains in another area and also serves the employee kitchenette and washroom: this can all go on one form.

The numbers below correspond to the numbers on the front of the sheet.

1. Supply the name and street address of the facility where the Class V well(s) is located. Please be sure to include the County name. If available, provide the Latitude/Longitude of the discharge system. If there is no street address for the discharge system(s), provide a description of the location and show the location on a map. Include the name and phone number of a person to contact if there are any questions regarding the underground discharge system(s) and/or the wastewaters discharged at the facility.

2. Provide the name and mailing address of the owner of the facility or if the facility is operated by lease, the operator of the facility.

3. Provide the number of underground discharge systems at the facility (or location) for the type of system that is described on this sheet. Please use a separate sheet for each different type of system present. If the type of system is "Other", please describe (e.g., french drain, leachfield, improved sinkhole, cesspool, etc.).

   Provide a sketch, diagram or blueprints of the construction of the system including the depth below the ground surface that the fluids are released into the soil, sediment or formation. Also provide a map or sketch of the layout of the pluming or drainage system, including all the connections, and if applicable, indicate each fluid source connection (i.e., floor drains, shop sink, process tank discharge, restrooms, etc.) and any pre-treatment, etc.

4. Describe the kind of business practice that generates the fluids being discharged into the underground system (e.g., body shop, drycleaner, carwash, print shop, restaurant, etc.), and/or if more appropriate, the source of the fluids (e.g., employee & customer restrooms, parking lot drainage, etc.). If available, include the Standard Industrial Classification (SIC) Codes for this facility.

5. List the kinds of fluids that can enter the underground system (e.g., storm water run-off, sanitary waste, solvents, biodegradable soap wash & rinse water, snowmelt from trucks, photo developing fluids, ink, paint & thinner, non-contact cooling water, etc.). Please be as specific as you can about the kinds of fluids or products that can be drained into the system. Generally, good sources for this information are the Material Safety Data Sheets (MSDS) (copies of MSDS could be attached instead of listing all the products). If available, also attach a copy of any chemical analysis for the fluids discharged.

6. Describe the kinds of treatment (if any) that the fluids go through before disposal. Examples of treatment are: grease trap, package plant, oil/water separator, catch basin, metal recovery unit, sand filter, grit cleanser, etc.

7. Select the status of the underground discharge system and include the date the system was constructed. If the status is “Existing” but it is not being used, is unusable, will not be used, or is temporarily abandoned, mark the box for “Unused/Abandoned”. If state or local government approval was given for construction of the system, or a permit was issued for the system, please provide the name of the approving authority. Provide an estimated date of construction if the actual date is unknown.

The person signing the submittal should read the certification statement before signing and dating the sheet.

If you have any questions about whether or not you may have an EPA regulated system, or about how to complete this sheet, please call (312) 886-1492. You may also try our website at www.epa.gov/r5water/uic/uic.htm for information.

Please send completed sheets to: U.S. EPA Region 5
Underground Injection Control Branch
ATTN: Lisa Perenchio (WU-16J)
77 W. Jackson Blvd.
Chicago, IL 60604

8/02

SUPPLEMENTAL INFORMATION
UNDERGROUND DISCHARGE SYSTEM (CLASS V) INVENTORY SHEET
REVISED GROUNDWATER PHASE SEPARATED HYDROCARBON (PSH) RECOVERY SYSTEM ENHANCEMENTS REINJECTION PILOT TESTING WORK PLAN
HOLLYFRONTIER NAVAJO REFINING LLC (HFNR)

The numbers below correspond to the numbers on the second page of the Underground Discharge System (Class V) Inventory Sheet.

1.

Supply the name and street address of the facility where the Class V well(s) is located. Please be sure to include the County name. If available, provide the Latitude/Longitude of the discharge system. If there is no street address for the discharge system(s), provide a description of the location and show the location on a map. Include the name and phone number of a person to contact if there are any questions regarding the underground discharge system(s) and/or the wastewaters discharged at the facility.

HollyFrontier Navajo Refining LLC

Artesia Refinery

501 E Main Street in Artesia, New Mexico 88210

Artesia, Eddy County, New Mexico

Location and Map provided in Figure 1, Figure 2a, and Figure 2b of the attached document "Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements: Reinjection Pilot Test Work Plan"

IW-1 Proposed Latitude/Longitude: 32.843561, -104.387778 (West of RW-19)

IW-2 Proposed Latitude/Longitude: 32.844883, -104.385867 (West of MW-131)

Contact: Scott Denton; 575-746-5487

2.

Provide the name and mailing address of the owner of the facility or if the facility is operated by lease, the operator of the facility.

HollyFrontier Navajo Refining LLC

Artesia Refinery

Attn: Scott Denton

501 E Main Street in Artesia, New Mexico 88210

Artesia, Eddy County, New Mexico

SUPPLEMENTAL INFORMATION
UNDERGROUND DISCHARGE SYSTEM (CLASS V) INVENTORY SHEET
REVISED GROUNDWATER PHASE SEPARATED HYDROCARBON (PSH) RECOVERY SYSTEM ENHANCEMENTS REINJECTION PILOT TESTING WORK PLAN
HOLLYFRONTIER NAVAJO REFINING LLC (HFNR)

3.

Provide the number of underground discharge systems at the facility (or location) for the type of system that is described on this sheet. Please use a separate sheet for each different type of system present. If the type of system is "Other", please describe (e.g., french drain, leachfield, improved sinkhole, cesspool, etc.).

Two groundwater recirculation systems, near existing wells RW-19 and MW-131. System design described in Section 4 and Section 5 of the attached document "Revised Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements: Reinjection Pilot Test Work Plan"

Provide a sketch, diagram or blueprints of the construction of the system including the depth below the ground surface that the fluids are released into the soil, sediment or formation. Also provide a map or sketch of the layout of the plumbing or drainage system, including all the connections, and if applicable, indicate each fluid source connection (i.e., floor drains, shop sink, process tank discharge, restrooms, etc.) and any pre-treatment, etc.

Diagram and Sketch provided in Figure 3 of the attached document "Revised Groundwater & Phase Separated Hydrocarbon Recovery System Enhancements: Reinjection Pilot Testing Work Plan".

4.

Describe the kind of business practice that generates the fluids being discharged into the underground system (e.g., body shop, drycleaner, carwash, print shop, restaurant, etc.), and/or if more appropriate, the source of the fluids (e.g., employee & customer restrooms, parking lot drainage, etc.). If available, include the Standard Industrial Classification (SIC) Codes for this facility.

The refinery (SIC Code 2911) plans to recirculate amended groundwater as part of site remediation, as described in Section 4 and Section 5 of the attached document "Revised Groundwater and Phase-Separated Hydrocarbon, Recovery System Enhancements: Reinjection Pilot Test Work Plan"

5.

List the kinds of fluids that can enter the underground system (e.g., storm water run-off, sanitary waste, solvents, biodegradable soap wash & rinse water, snowmelt from trucks, photo developing fluids, ink, paint & thinner, non-contact cooling water, etc.). Please be as specific as you can about the kinds of fluids or products that can be drained into the system. Generally, good sources for this information are the Material Safety Data Sheets (MSDS) (copies of MSDS could be attached instead of listing all the products). If available, also attach a copy of any chemical analysis for the fluids discharged.

Recirculated treated groundwater, as described in Section 4 and Section 5 of the attached document "Revised Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements: Reinjection Pilot Test Work Plan".

SDS for Magnesium Sulfate (Epsom Salts) and 9% Ammonia Solution, and most recent analytical results for MW-131 attached below (no recent analytical results available for RW-19).

SUPPLEMENTAL INFORMATION
UNDERGROUND DISCHARGE SYSTEM (CLASS V) INVENTORY SHEET
REVISED GROUNDWATER PHASE SEPARATED HYDROCARBON (PSH) RECOVERY SYSTEM ENHANCEMENTS REINJECTION PILOT TESTING WORK PLAN
HOLLYFRONTIER NAVAJO REFINING LLC (HFNR)

6.

Describe the kinds of treatment (if any) that the fluids go through before disposal. Examples of treatment are: grease trap, package plant, oil/water separator, catch basin, metal recovery unit, sand filter, grit cleanser, etc.

Injection wells will not be used for disposal. Wells are In Situ Groundwater Remediation Injection Wells. Groundwater is treated with a sulfate and ammonia solution, as described in Section 5 of the attached document "Revised Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements: Reinjection Pilot Test Work Plan"

7.

Select the status of the underground discharge system and include the date the system was constructed. If the status is "Existing" but it is not being used, is unusable, will not be used, or is temporarily abandoned, mark the box for "Unused/Abandoned". If state or local government approval was given for construction of the system, or a permit was issued for the system, please provide the name of the approving authority. Provide an estimated date of construction if the actual date is unknown.

Not yet constructed; Estimated construction date: first half 2020.

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product name:	**Epsom Salt, Magnesium Sulfate, U.S.P.**
Product description:	**Magnesium sulfate, heptahydrate**
Product Use:	**Food grade, medicinal uses**
Manufacturer:	**PQ Corporation** **P. O. Box 840, Valley Forge, PA USA** **Phone number: 610-651-4200**
Supplier:	**National Silicates** **429 Kipling Ave, Toronto, ON M8Z 5C7** **Phone number: 416-255-7771**
In case of emergency call:	**1 416-255-7771**

2. COMPOSITION/INFORMATION ON INGREDIENTS

Chemical and Common Name	*CAS Registry Number*	*Wt. %*	*OSHA PEL*	*ACGIH TLV*
Magnesium sulfate, heptahydrate; Epsom salt	**10034-99-8***	**100%**	**Not Established**	**Not Established**

***** Under the Toxic Substances Control Act (TSCA), hydrates are considered as mixtures of their anhydrous salt and water. Accordingly, the CAS Numbers 7487-88-9, 7732-18-5 are used for purposes of TSCA.

3. HAZARDS IDENTIFICATION

Emergency Overview:	**White or transparent crystalline odorless powder. Non-combustible. At very high temperatures, magnesium oxide, sulfur dioxide, and sulfur trioxide may be generated. Causes mild eye irritation.**
Eye contact:	**Causes mild irritation to the eyes.**
Skin contact:	**No known adverse effects.**
Inhalation:	**Causes nausea, vomiting, abdominal cramps, and diarrhea.**
Ingestion:	**Causes nausea, vomiting, abdominal cramps, and diarrhea.**
Chronic hazards:	**No known chronic hazards. Not listed by NTP, IARC or OSHA as a carcinogen.**
Physical hazards:	**Spilled material can be slippery.**

4. FIRST AID MEASURES

Eye:	**In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Get medical attention if irritation persists.**
Skin:	**Not applicable.**
Inhalation:	**Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.**
Ingestion:	**If large quantities of this material are swallowed, call a physician immediately. Do NOT induce vomiting unless directed to do so by a physician. Never give anything by mouth to an unconscious person.**

5. FIRE FIGHTING MEASURES

Flammable limits:	**This material is non-combustible.**
Extinguishing Media:	**This material is compatible with all extinguishing media**
Hazards to fire-fighters:	**See Section 3 for information on hazards when this material is present in the area of a fire.**

Fire-fighting equipment:	**The following protective equipment for fire fighters is recommended when this material is present in the area of a fire: chemical goggles, body-covering protective clothing, self-contained breathing apparatus.**

6. ACCIDENTAL RELEASE MEASURES

Personal protection:	**Wear chemical goggles, See section 8.**
Environmental Hazards:	**Sinks and mixes with water. No adverse effects known. Not a listed toxic chemical under SARA Title III, §313 40 CFR Part 372. Not a CERCLA Hazardous Substance under 40 CFR Part 302.**
Small spill cleanup:	**Sweep, scoop or vacuum discharged material. Flush residue with water. Observe environmental regulations.**
Large spill cleanup:	**Keep unnecessary people away; isolate hazard area and deny entry. Do not touch or walk through spilled material. Sweep, scoop or vacuum discharged material. Flush residue with water. Observe environmental regulations.**
CERCLA RQ (US):	**There is no CERCLA Reportable Quantity for this material.**

7. HANDLING AND STORAGE

Handling:	**Avoid breathing dust. Promptly clean up spills.**
Storage:	**Keep containers closed. Protect from extremes of temperature and humidity during storage. Recommended storage conditions 68-110º F and 54-87% relative humidity.**

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering controls:	**Use with adequate ventilation. Safety shower and eyewash fountain should be within direct access.**
Respiratory protection:	**Use a NIOSH-approved dust respirator where dust occurs. Observe Provincial regulations for respirator use.**
Skin protection:	**Wear gloves if abrasion or irritation occurs.**
Eye protection:	**Wear chemical goggles.**

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance:	**Crystalline odourless powder.**
Color:	**White or transparent.**
Odour:	**Odourless.**
pH:	**Approximately 6-7**
Specific gravity:	**1.76 g/cm^3, Bulk Density Approximately 1.05 g/cm^3**
Solubility in water:	**71g/100 ml at 20º C, 91g/100 ml at 40º C**

10. STABILITY AND REACTIVITY

Stability:	**This material is stable under all conditions of use and storage.**
Conditions to avoid:	**None.**
Materials to avoid:	**Metal hydrides and other water reactive materials.**
Hazardous decomposition products:	**At very high temperatures, magnesium oxide, sulfur dioxide, and sulfur trioxide may be generated.**

11. TOXICOLOGICAL INFORMATION

Acute Data: **When tested for primary irritation potential, this material caused mild eye irritation. RTECS reports Oral TDLo= 428 mg/kg in man 351 mg/kg in women**

12. ECOLOGICAL INFORMATION

Eco toxicity: **Data not available.**
Environmental Fate: **This material is not persistent in aquatic systems and does not contribute to BOD. It does not bioconcentrate up the food chain.**
Physical/Chemical: **Sinks and mixes with water.**

13. DISPOSAL CONSIDERATIONS

Disposal Method: **Dispose in accordance with federal, provincial and local regulations.**

14. TRANSPORT INFORMATION

TDG UN Status: **This material is not regulated hazardous material for transportation.**

15. REGULATORY INFORMATION

WHMIS (Canada): **Not a WHMIS controlled product**
DSL (Canada): **All components of this formulation are listed on the CEPA-DSL**
CERCLA (US): **No CERCLA Reportable Quantity has been established for this material.**
SARA TITLE III (US): **Not an Extremely Hazardous Substance under §302. Not a Toxic Chemical under §313. Hazard Categories under §§311/312: Acute**
TSCA (US): **All ingredients of this material are listed on the TSCA inventory.**
FDA: **Magnesium sulfate is authorized by FDA GRAS substance pursuant to 21 CFR 184.1443.**

16. OTHER INFORMATION

Prepared by: **EHS Dept**
Supersedes revision of: **March 10, 2009**

THE INFORMATION ON THIS SAFETY DATA SHEET IS BELIEVED TO BE ACCURATE AND IT IS THE BEST INFORMATION AVAILABLE TO NATIONAL SILICATES THIS DOCUMENT IS INTENDED ONLY AS A GUIDE TO THE APPROPRIATE PRECAUTIONS FOR HANDLING A CHEMICAL BY A PERSON TRAINED IN CHEMICAL HANDLING. NATIONAL SILICATES MAKES NO WARRANTY OF MERCHANTABILITY OR ANY OTHER WARRANTY, EXPRESS OR IMPLIED WITH RESPECT TO SUCH INFORMATION OR THE PRODUCT TO WHICH IT RELATES, AND WE ASSUME NO LIABILITY RESULTING FROM THE USE OR HANDLING OF THE PRODUCT TO WHICH THIS SAFETY DATA SHEET RELATES. USERS AND HANDLERS OF THIS PRODUCT SHOULD MAKE THEIR OWN INVESTIGATIONS TO DETERMINE THE SUITABILITY OF THE INFORMATION PROVIDED HEREIN FOR THEIR OWN PURPOSES.

SAFETY DATA SHEET

Aqua Ammonia (5-19.9%)

Airgas
an Air Liquide company

Section 1. Identification

GHS product identifier : Aqua Ammonia (5-19.9%)

Other means of identification : Aqua Ammonia, Ammonium Hydroxide

Product use : Synthetic/Analytical chemistry.

Synonym : Aqua Ammonia, Ammonium Hydroxide

SDS # : 001196

Supplier's details : Airgas USA, LLC and its affiliates
259 North Radnor-Chester Road
Suite 100
Radnor, PA 19087-5283
1-610-687-5253

24-hour telephone : 1-866-734-3438

Section 2. Hazards identification

OSHA/HCS status : This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200).

Classification of the substance or mixture : SKIN CORROSION/IRRITATION - Category 1B
SPECIFIC TARGET ORGAN TOXICITY (SINGLE EXPOSURE) (Respiratory tract irritation) - Category 3
AQUATIC HAZARD (ACUTE) - Category 1

GHS label elements

Hazard pictograms :

Signal word : Danger

Hazard statements : May displace oxygen and cause rapid suffocation.
Causes severe skin burns and eye damage.
May cause respiratory irritation.
Very toxic to aquatic life.

Precautionary statements

General : Read label before use. Keep out of reach of children. If medical advice is needed, have product container or label at hand.

Prevention : Wear protective gloves. Wear eye or face protection. Wear protective clothing. Use only outdoors or in a well-ventilated area. Avoid release to the environment. Avoid breathing vapor. Wash hands thoroughly after handling.

Response : Collect spillage. IF INHALED: Remove person to fresh air and keep comfortable for breathing. Immediately call a POISON CENTER or physician. IF SWALLOWED: Immediately call a POISON CENTER or physician. Rinse mouth. Do NOT induce vomiting. IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water or shower. Wash contaminated clothing before reuse. Immediately call a POISON CENTER or physician. IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Immediately call a POISON CENTER or physician.

Storage : Store locked up.

Disposal : Dispose of contents and container in accordance with all local, regional, national and international regulations.

Hazards not otherwise classified : None known.

Section 3. Composition/information on ingredients

Substance/mixture : Mixture

Other means of identification : Aqua Ammonia, Ammonium Hydroxide

CAS number/other identifiers

CAS number : Not applicable.

Product code : 001196

Ingredient name	%	CAS number
Aqua Ammonia	100	1336-21-6
WATER	80.1 - 95	7732-18-5
ammonia, anhydrous	5 - 19.9	7664-41-7

Any concentration shown as a range is to protect confidentiality or is due to batch variation.

There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.

Occupational exposure limits, if available, are listed in Section 8.

Section 4. First aid measures

Description of necessary first aid measures

Eye contact : Get medical attention immediately. Call a poison center or physician. Immediately flush eyes with plenty of water, occasionally lifting the upper and lower eyelids. Check for and remove any contact lenses. Continue to rinse for at least 10 minutes. Chemical burns must be treated promptly by a physician.

Inhalation : Get medical attention immediately. Call a poison center or physician. Remove victim to fresh air and keep at rest in a position comfortable for breathing. If it is suspected that fumes are still present, the rescuer should wear an appropriate mask or self-contained breathing apparatus. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband. In case of inhalation of decomposition products in a fire, symptoms may be delayed. The exposed person may need to be kept under medical surveillance for 48 hours.

Skin contact : Get medical attention immediately. Call a poison center or physician. Flush contaminated skin with plenty of water. Remove contaminated clothing and shoes. Wash contaminated clothing thoroughly with water before removing it, or wear gloves. Continue to rinse for at least 10 minutes. Chemical burns must be treated promptly by a physician. Wash clothing before reuse. Clean shoes thoroughly before reuse.

Ingestion : Get medical attention immediately. Call a poison center or physician. Wash out mouth with water. Remove dentures if any. Remove victim to fresh air and keep at rest in a position comfortable for breathing. If material has been swallowed and the exposed person is conscious, give small quantities of water to drink. Stop if the exposed person feels sick as vomiting may be dangerous. Do not induce vomiting unless directed to do so by medical personnel. If vomiting occurs, the head should be kept low so that vomit does not enter the lungs. Chemical burns must be treated promptly by a physician. Never give anything by mouth to an unconscious person. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Most important symptoms/effects, acute and delayed

Potential acute health effects

Eye contact : No known significant effects or critical hazards.

Inhalation : May cause respiratory irritation.

Skin contact : Causes severe burns.

Frostbite : Try to warm up the frozen tissues and seek medical attention.

Section 4. First aid measures

Ingestion	: No known significant effects or critical hazards.

Over-exposure signs/symptoms

Eye contact	: Adverse symptoms may include the following:, pain, watering, redness
Inhalation	: Adverse symptoms may include the following:, respiratory tract irritation, coughing
Skin contact	: Adverse symptoms may include the following:, pain or irritation, redness, blistering may occur
Ingestion	: Adverse symptoms may include the following:, stomach pains

Indication of immediate medical attention and special treatment needed, if necessary

Notes to physician	: In case of inhalation of decomposition products in a fire, symptoms may be delayed. The exposed person may need to be kept under medical surveillance for 48 hours.
Specific treatments	: No specific treatment.
Protection of first-aiders	: No action shall be taken involving any personal risk or without suitable training. If it is suspected that fumes are still present, the rescuer should wear an appropriate mask or self-contained breathing apparatus. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Wash contaminated clothing thoroughly with water before removing it, or wear gloves.

See toxicological information (Section 11)

Section 5. Fire-fighting measures

Extinguishing media

Suitable extinguishing media	: Use an extinguishing agent suitable for the surrounding fire.
Unsuitable extinguishing media	: None known.
Specific hazards arising from the chemical	: In a fire or if heated, a pressure increase will occur and the container may burst. This material is very toxic to aquatic life. Fire water contaminated with this material must be contained and prevented from being discharged to any waterway, sewer or drain.
Hazardous thermal decomposition products	: Decomposition products may include the following materials: nitrogen oxides
Special protective actions for fire-fighters	: Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training.
Special protective equipment for fire-fighters	: Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

Personal precautions, protective equipment and emergency procedures

For non-emergency personnel	: No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Do not touch or walk through spilled material. Do not breathe vapor or mist. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment.
For emergency responders	: If specialised clothing is required to deal with the spillage, take note of any information in Section 8 on suitable and unsuitable materials. See also the information in "For non-emergency personnel".
Environmental precautions	: Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air). Water polluting material. May be harmful to the environment if released in large quantities. Collect spillage.

Section 6. Accidental release measures

Methods and materials for containment and cleaning up

Small spill : Stop leak if without risk. Move containers from spill area. Dilute with water and mop up if water-soluble. Alternatively, or if water-insoluble, absorb with an inert dry material and place in an appropriate waste disposal container. Dispose of via a licensed waste disposal contractor.

Large spill : Stop leak if without risk. Move containers from spill area. Approach release from upwind. Prevent entry into sewers, water courses, basements or confined areas. Wash spillages into an effluent treatment plant or proceed as follows. Contain and collect spillage with non-combustible, absorbent material e.g. sand, earth, vermiculite or diatomaceous earth and place in container for disposal according to local regulations (see Section 13). Dispose of via a licensed waste disposal contractor. Contaminated absorbent material may pose the same hazard as the spilled product. Note: see Section 1 for emergency contact information and Section 13 for waste disposal.

Section 7. Handling and storage

Precautions for safe handling

Protective measures : Put on appropriate personal protective equipment (see Section 8). Do not get in eyes or on skin or clothing. Do not breathe vapor or mist. Do not ingest. Avoid release to the environment. Use only with adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Keep in the original container or an approved alternative made from a compatible material, kept tightly closed when not in use. Empty containers retain product residue and can be hazardous. Do not reuse container.

Advice on general occupational hygiene : Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Remove contaminated clothing and protective equipment before entering eating areas. See also Section 8 for additional information on hygiene measures.

Conditions for safe storage, including any incompatibilities : Store in accordance with local regulations. Store in original container protected from direct sunlight in a dry, cool and well-ventilated area, away from incompatible materials (see Section 10) and food and drink. Store locked up. Keep container tightly closed and sealed until ready for use. Containers that have been opened must be carefully resealed and kept upright to prevent leakage. Do not store in unlabeled containers. Use appropriate containment to avoid environmental contamination.

Section 8. Exposure controls/personal protection

Control parameters

Occupational exposure limits

Ingredient name	Exposure limits
Aqua Ammonia	None.
WATER	None.
ammonia, anhydrous	**ACGIH TLV (United States, 3/2016).** STEL: 24 mg/m³ 15 minutes. STEL: 35 ppm 15 minutes. TWA: 17 mg/m³ 8 hours. TWA: 25 ppm 8 hours. **NIOSH REL (United States, 10/2013).** STEL: 27 mg/m³ 15 minutes. STEL: 35 ppm 15 minutes. TWA: 18 mg/m³ 10 hours. TWA: 25 ppm 10 hours. **OSHA PEL (United States, 2/2013).** TWA: 35 mg/m³ 8 hours. TWA: 50 ppm 8 hours. **OSHA PEL 1989 (United States, 3/1989).** STEL: 27 mg/m³ 15 minutes. STEL: 35 ppm 15 minutes.

Section 8. Exposure controls/personal protection

Appropriate engineering controls : Use only with adequate ventilation. If user operations generate dust, fumes, gas, vapor or mist, use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits.

Environmental exposure controls : Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

Individual protection measures

Hygiene measures : Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing. Ensure that eyewash stations and safety showers are close to the workstation location.

Eye/face protection : Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists, gases or dusts. If contact is possible, the following protection should be worn, unless the assessment indicates a higher degree of protection: chemical splash goggles and/or face shield. If inhalation hazards exist, a full-face respirator may be required instead.

Skin protection

Hand protection : Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary. Considering the parameters specified by the glove manufacturer, check during use that the gloves are still retaining their protective properties. It should be noted that the time to breakthrough for any glove material may be different for different glove manufacturers. In the case of mixtures, consisting of several substances, the protection time of the gloves cannot be accurately estimated.

Body protection : Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Other skin protection : Appropriate footwear and any additional skin protection measures should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Respiratory protection : Use a properly fitted, air-purifying or air-fed respirator complying with an approved standard if a risk assessment indicates this is necessary. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator.

Section 9. Physical and chemical properties

Appearance

Physical state : Liquid.

Color : Colorless.

Boiling/condensation point : Lowest known value: 38°C (100.4°F) (ammonia). Weighted average: 68.21°C (154.8°F)

Melting/freezing point : 22ºF (5% solution) to -34ºF (19.9% solution)

Critical temperature : Not available.

Odor : Pungent.

Odor threshold : Not available.

pH : Approx. 11.6 for 1 N Sol'n. in water

Flash point : Not available.

Burning time : Not applicable.

Burning rate : Not applicable.

Evaporation rate : Not available.

Flammability (solid, gas) : Not available.

Section 9. Physical and chemical properties

Lower and upper explosive (flammable) limits : Not available.

Vapor pressure : Not available.

Vapor density : Highest known value: 0.6 to 1.2 (Air = 1) (ammonia).

Gas Density (lb/ft ^{3}) : Weighted average: 0.33

Relative density : Not available.

Solubility : Not available.

Solubility in water : Complete

Partition coefficient: n-octanol/water : Not available.

Auto-ignition temperature : Not available.

Decomposition temperature : Not available.

SADT : Not available.

Viscosity : Not available.

Section 10. Stability and reactivity

Reactivity : No specific test data related to reactivity available for this product or its ingredients.

Chemical stability : The product is stable.

Possibility of hazardous reactions : Under normal conditions of storage and use, hazardous reactions will not occur.

Conditions to avoid : No specific data.

Incompatible materials : No specific data.

Hazardous decomposition products : Under normal conditions of storage and use, hazardous decomposition products should not be produced.

Hazardous polymerization : Under normal conditions of storage and use, hazardous polymerization will not occur.

Section 11. Toxicological information

Information on toxicological effects

Acute toxicity

Product/ingredient name	Result	Species	Dose	Exposure
Aqua Ammonia	LD50 Oral	Rat	350 mg/kg	-
ammonia, anhydrous	LC50 Inhalation Gas.	Rat	7338 ppm	1 hours

Irritation/Corrosion

Product/ingredient name	Result	Species	Score	Exposure	Observation
Aqua Ammonia	Eyes - Severe irritant	Rabbit	-	250 Micrograms	-
	Eyes - Severe irritant	Rabbit	-	0.5 minutes 1 milligrams	-

Sensitization

Not available.

Mutagenicity

Not available.

Section 11. Toxicological information

Carcinogenicity

Not available.

Reproductive toxicity

Not available.

Teratogenicity

Not available.

Specific target organ toxicity (single exposure)

Name	Category	Route of exposure	Target organs
Aqua Ammonia	Category 3	Not applicable.	Respiratory tract irritation

Specific target organ toxicity (repeated exposure)

Not available.

Aspiration hazard

Not available.

Information on the likely routes of exposure : Not available.

Potential acute health effects

Eye contact : No known significant effects or critical hazards.

Inhalation : May cause respiratory irritation.

Skin contact : Causes severe burns.

Ingestion : No known significant effects or critical hazards.

Symptoms related to the physical, chemical and toxicological characteristics

Eye contact : Adverse symptoms may include the following:, pain, watering, redness

Inhalation : Adverse symptoms may include the following:, respiratory tract irritation, coughing

Skin contact : Adverse symptoms may include the following:, pain or irritation, redness, blistering may occur

Ingestion : Adverse symptoms may include the following:, stomach pains

Delayed and immediate effects and also chronic effects from short and long term exposure

Short term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Long term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Potential chronic health effects

Not available.

General : No known significant effects or critical hazards.

Carcinogenicity : No known significant effects or critical hazards.

Mutagenicity : No known significant effects or critical hazards.

Teratogenicity : No known significant effects or critical hazards.

Developmental effects : No known significant effects or critical hazards.

Fertility effects : No known significant effects or critical hazards.

Section 11. Toxicological information

Numerical measures of toxicity

Acute toxicity estimates

Not available.

Section 12. Ecological information

Toxicity

Product/ingredient name	Result	Species	Exposure
Aqua Ammonia ammonia, anhydrous	Acute LC50 37 ppm Fresh water Acute EC50 29.2 mg/l Marine water Acute LC50 2080 µg/l Fresh water Acute LC50 0.53 ppm Fresh water Acute LC50 300 µg/l Fresh water Chronic NOEC 0.204 mg/l Marine water	Fish - Gambusia affinis - Adult Algae - Ulva fasciata - Zoea Crustaceans - Gammarus pulex Daphnia - Daphnia magna Fish - Hypophthalmichthys nobilis Fish - Dicentrarchus labrax	96 hours 96 hours 48 hours 48 hours 96 hours 62 days

Persistence and degradability

Not available.

Bioaccumulative potential

Product/ingredient name	$LogP_{ow}$	BCF	Potential
WATER	-1.38	-	low

Mobility in soil

Soil/water partition coefficient (K_{OC}) : Not available.

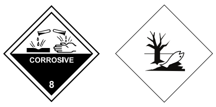
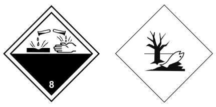
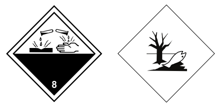
Other adverse effects : No known significant effects or critical hazards.

Section 13. Disposal considerations

Disposal methods : The generation of waste should be avoided or minimized wherever possible. Disposal of this product, solutions and any by-products should at all times comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Waste should not be disposed of untreated to the sewer unless fully compliant with the requirements of all authorities with jurisdiction. Waste packaging should be recycled. Incineration or landfill should only be considered when recycling is not feasible. This material and its container must be disposed of in a safe way. Care should be taken when handling emptied containers that have not been cleaned or rinsed out. Empty containers or liners may retain some product residues. Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers.

Section 14. Transport information

Section 14. Transport information

	DOT	TDG	Mexico	IMDG	IATA
UN number	UN2672	UN2672	UN2672	UN2672	UN2672
UN proper shipping name	Ammonium Hydroxide or Ammonia solutions	AMMONIA SOLUTION	AMMONIA SOLUTION	AMMONIA SOLUTION	Ammonia solution
Transport hazard class(es)	8 	8 	8 	8 	8 
Packing group	III	III	III	III	III
Environment	No.	No.	No.	Yes.	No.
Additional information	This product is not regulated as a marine pollutant when transported on inland waterways in sizes of ≤5 L or ≤5 kg or by road, rail, or inland air in non-bulk sizes, provided the packagings meet the general provisions of §§ 173.24 and 173.24a. **Reportable quantity** 1000 lbs / 454 kg Package sizes shipped in quantities less than the product reportable quantity are not subject to the RQ (reportable quantity) transportation requirements.	Product classified as per the following sections of the Transportation of Dangerous Goods Regulations: 2.40-2.42 (Class 8), 2.7 (Marine pollutant mark). The marine pollutant mark is not required when transported by road or rail.	-	The marine pollutant mark is not required when transported in sizes of ≤5 L or ≤5 kg.	The environmentally hazardous substance mark may appear if required by other transportation regulations.

"Refer to CFR 49 (or authority having jurisdiction) to determine the information required for shipment of the product."

Special precautions for user : **Transport within user's premises:** always transport in closed containers that are upright and secure. Ensure that persons transporting the product know what to do in the event of an accident or spillage.

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code : Not available.

Section 15. Regulatory information

U.S. Federal regulations : **TSCA 8(a) CDR Exempt/Partial exemption**: Not determined

United States inventory (TSCA 8b): All components are listed or exempted.

Clean Water Act (CWA) 311: ammonia; ammonia, anhydrous

Clean Air Act (CAA) 112 regulated toxic substances: ammonia, anhydrous

Clean Air Act Section 112 (b) Hazardous Air Pollutants (HAPs) : Not listed

Clean Air Act Section 602 Class I Substances : Not listed

Clean Air Act Section 602 Class II Substances : Not listed

Section 15. Regulatory information

DEA List I Chemicals (Precursor Chemicals) : Not listed

DEA List II Chemicals (Essential Chemicals) : Not listed

SARA 302/304

Composition/information on ingredients

Name	%	EHS	SARA 302 TPQ		SARA 304 RQ	
			(lbs)	(gallons)	(lbs)	(gallons)
ammonia, anhydrous	5 - 19.9	Yes.	500	-	100	-

SARA 304 RQ : 502.5 lbs / 228.1 kg

SARA 311/312

Classification : Immediate (acute) health hazard

Composition/information on ingredients

Name	%	Fire hazard	Sudden release of pressure	Reactive	Immediate (acute) health hazard	Delayed (chronic) health hazard
Aqua Ammonia ammonia, anhydrous	100 5 - 19.9	No. Yes.	No. Yes.	No. No.	Yes. Yes.	No. No.

SARA 313

	Product name	CAS number	%
Form R - Reporting requirements	ammonia ammonia, anhydrous	1336-21-6 7664-41-7	100 5 - 19.9
Supplier notification	ammonia ammonia, anhydrous	1336-21-6 7664-41-7	100 5 - 19.9

SARA 313 notifications must not be detached from the SDS and any copying and redistribution of the SDS shall include copying and redistribution of the notice attached to copies of the SDS subsequently redistributed.

State regulations

Massachusetts : The following components are listed: AMMONIUM HYDROXIDE; AMMONIUM WATER; AMMONIA; AMMONIA, ANHYDROUS

New York : The following components are listed: Ammonium hydroxide; Ammonia

New Jersey : The following components are listed: AMMONIUM HYDROXIDE; AMMONIA

Pennsylvania : The following components are listed: AMMONIUM HYDROXIDE; AMMONIA

International regulations

International lists

National inventory

Australia : All components are listed or exempted.

Canada : All components are listed or exempted.

China : All components are listed or exempted.

Europe : All components are listed or exempted.

Japan : All components are listed or exempted.

Malaysia : All components are listed or exempted.

New Zealand : All components are listed or exempted.

Philippines : All components are listed or exempted.

Republic of Korea : All components are listed or exempted.

Taiwan : All components are listed or exempted.

Canada

Section 15. Regulatory information

WHMIS (Canada) : Class D-1A: Material causing immediate and serious toxic effects (Very toxic).
Class E: Corrosive material

CEPA Toxic substances: The following components are listed: Ammonia dissolved in water
Canadian ARET: None of the components are listed.
Canadian NPRI: The following components are listed: Ammonia (total); Ammonia (total)
Alberta Designated Substances: None of the components are listed.
Ontario Designated Substances: None of the components are listed.
Quebec Designated Substances: None of the components are listed.

Section 16. Other information

Canada Label requirements : Class D-1A: Material causing immediate and serious toxic effects (Very toxic).
Class E: Corrosive material

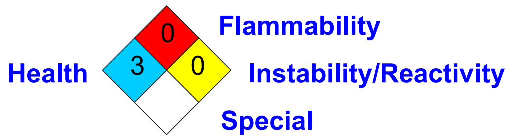
Hazardous Material Information System (U.S.A.)

Health	3
Flammability	0
Physical hazards	0

Caution: HMIS® ratings are based on a 0-4 rating scale, with 0 representing minimal hazards or risks, and 4 representing significant hazards or risks Although HMIS® ratings are not required on SDSs under 29 CFR 1910. 1200, the preparer may choose to provide them. HMIS® ratings are to be used with a fully implemented HMIS® program. HMIS® is a registered mark of the National Paint & Coatings Association (NPCA). HMIS® materials may be purchased exclusively from J. J. Keller (800) 327-6868.

The customer is responsible for determining the PPE code for this material.

National Fire Protection Association (U.S.A.)



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Copyright ©2001, National Fire Protection Association, Quincy, MA 02269. This warning system is intended to be interpreted and applied only by properly trained individuals to identify fire, health and reactivity hazards of chemicals. The user is referred to certain limited number of chemicals with recommended classifications in NFPA 49 and NFPA 325, which would be used as a guideline only. Whether the chemicals are classified by NFPA or not, anyone using the 704 systems to classify chemicals does so at their own risk.

Procedure used to derive the classification

Classification	Justification
Skin Corr. 1B, H314	Expert judgment
STOT SE 3, H335	Calculation method
Aquatic Acute 1, H400	Calculation method

History

Date of printing : 12/20/2016
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Date of previous issue : 12/20/2016
Version : 0.07

Section 16. Other information

Key to abbreviations : ATE = Acute Toxicity Estimate
BCF = Bioconcentration Factor
GHS = Globally Harmonized System of Classification and Labelling of Chemicals
IATA = International Air Transport Association
IBC = Intermediate Bulk Container
IMDG = International Maritime Dangerous Goods
LogPow = logarithm of the octanol/water partition coefficient
MARPOL 73/78 = International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978. ("Marpol" = marine pollution)
UN = United Nations

References : Not available.

Indicates information that has changed from previously issued version.

Notice to reader

To the best of our knowledge, the information contained herein is accurate. However, neither the above-named supplier, nor any of its subsidiaries, assumes any liability whatsoever for the accuracy or completeness of the information contained herein.
Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

Gravimetric Analysis by Method 2540 C-2011

Analyte	Result mg/l	Qualifier	MDL mg/l	RDL mg/l	Dilution	Analysis date / time	Batch
Dissolved Solids	1230		2.82	10.0	1	05/03/2017 14:39	WG975911

Wet Chemistry by Method 353.2

Analyte	Result mg/l	Qualifier	MDL mg/l	RDL mg/l	Dilution	Analysis date / time	Batch
Nitrate-Nitrite	U		0.197	1.00	10	05/04/2017 11:36	WG976256

Sample Narrative:

353.2 L905668-62 WG976256: Dilution due to matrix

Wet Chemistry by Method 9056A

Analyte	Result mg/l	Qualifier	MDL mg/l	RDL mg/l	Dilution	Analysis date / time	Batch
Chloride	285		1.04	20.0	20	05/03/2017 20:28	WG975914
Fluoride	0.773		0.00990	0.100	1	05/03/2017 21:50	WG975914
Sulfate	10.3		0.0774	5.00	1	05/03/2017 21:50	WG975914

Metals (ICPMS) by Method 6020

Analyte	Result mg/l	Qualifier	MDL mg/l	RDL mg/l	Dilution	Analysis date / time	Batch
Arsenic	0.0214		0.000250	0.00200	1	05/04/2017 12:42	WG975078
Arsenic,Dissolved	0.0183		0.000250	0.00200	1	05/02/2017 23:29	WG975069
Barium	2.75		0.000360	0.00500	1	05/04/2017 12:42	WG975078
Barium,Dissolved	2.48		0.000360	0.00500	1	05/02/2017 23:29	WG975069
Calcium	151		0.0460	1.00	1	05/04/2017 12:42	WG975078
Chromium	U		0.000540	0.00200	1	05/04/2017 12:42	WG975078
Chromium,Dissolved	U		0.000540	0.00200	1	05/02/2017 23:29	WG975069
Iron	1.29		0.0150	0.100	1	05/04/2017 12:42	WG975078
Iron,Dissolved	U		0.0150	0.100	1	05/02/2017 23:29	WG975069
Lead	U		0.000240	0.00200	1	05/04/2017 12:42	WG975078
Lead,Dissolved	U		0.000240	0.00200	1	05/02/2017 23:29	WG975069
Manganese	0.294		0.000250	0.00500	1	05/04/2017 12:42	WG975078
Manganese,Dissolved	0.309		0.000250	0.00500	1	05/02/2017 23:29	WG975069
Potassium	0.275	J	0.0370	1.00	1	05/04/2017 12:42	WG975078
Selenium	U		0.000380	0.00200	1	05/04/2017 12:42	WG975078
Selenium,Dissolved	0.000632	B J	0.000380	0.00200	1	05/02/2017 23:29	WG975069
Sodium	153		0.110	1.00	1	05/04/2017 12:42	WG975078

Volatile Organic Compounds (GC) by Method 8015D/GRO

Analyte	Result mg/l	Qualifier	MDL mg/l	RDL mg/l	Dilution	Analysis date / time	Batch
TPH (GC/FID) Low Fraction	6.81		0.0314	0.100	1	05/01/2017 04:31	WG975304
(S) a,a,a-Trifluorotoluene(FID)	*82.6*			*77.0-122*		*05/01/2017 04:31*	WG975304

Volatile Organic Compounds (GC/MS) by Method 8260B

Analyte	Result mg/l	Qualifier	MDL mg/l	RDL mg/l	Dilution	Analysis date / time	Batch
Acetone	U		0.0100	0.0500	1	05/02/2017 17:59	WG975483
Benzene	3.09		0.00662	0.0200	20	05/03/2017 23:07	WG975483
Bromodichloromethane	U		0.000380	0.00100	1	05/02/2017 17:59	WG975483
Bromoform	U		0.000469	0.00100	1	05/02/2017 17:59	WG975483
Bromomethane	U		0.000866	0.00500	1	05/02/2017 17:59	WG975483
n-Butylbenzene	0.00255		0.000361	0.00100	1	05/02/2017 17:59	WG975483

Volatile Organic Compounds (GC/MS) by Method 8260B

Analyte	Result mg/l	Qualifier	MDL mg/l	RDL mg/l	Dilution	Analysis date / time	Batch
sec-Butylbenzene	0.00331		0.000365	0.00100	1	05/02/2017 17:59	WG975483
Carbon disulfide	U		0.000275	0.00100	1	05/02/2017 17:59	WG975483
Carbon tetrachloride	U		0.000379	0.00100	1	05/02/2017 17:59	WG975483
Chlorobenzene	U		0.000348	0.00100	1	05/02/2017 17:59	WG975483
Chlorodibromomethane	U		0.000327	0.00100	1	05/02/2017 17:59	WG975483
Chloroethane	U		0.000453	0.00500	1	05/02/2017 17:59	WG975483
Chloroform	U		0.000324	0.00500	1	05/02/2017 17:59	WG975483
Chloromethane	U		0.000276	0.00250	1	05/02/2017 17:59	WG975483
1,2-Dibromoethane	U		0.000381	0.00100	1	05/02/2017 17:59	WG975483
1,1-Dichloroethane	U		0.000259	0.00100	1	05/02/2017 17:59	WG975483
1,2-Dichloroethane	U		0.000361	0.00100	1	05/02/2017 17:59	WG975483
1,1-Dichloroethene	U		0.000398	0.00100	1	05/02/2017 17:59	WG975483
cis-1,2-Dichloroethene	U		0.000260	0.00100	1	05/02/2017 17:59	WG975483
trans-1,2-Dichloroethene	U		0.000396	0.00100	1	05/02/2017 17:59	WG975483
1,2-Dichloropropane	U		0.000306	0.00100	1	05/02/2017 17:59	WG975483
cis-1,3-Dichloropropene	U		0.000418	0.00100	1	05/02/2017 17:59	WG975483
trans-1,3-Dichloropropene	U		0.000419	0.00100	1	05/02/2017 17:59	WG975483
Ethylbenzene	0.0532		0.000384	0.00100	1	05/02/2017 17:59	WG975483
Isopropylbenzene	0.0206		0.000326	0.00100	1	05/02/2017 17:59	WG975483
p-Isopropyltoluene	0.000554	J	0.000350	0.00100	1	05/02/2017 17:59	WG975483
2-Butanone (MEK)	U		0.00393	0.0100	1	05/02/2017 17:59	WG975483
2-Hexanone	U		0.00382	0.0100	1	05/02/2017 17:59	WG975483
Methylene Chloride	U		0.00100	0.00500	1	05/02/2017 17:59	WG975483
4-Methyl-2-pentanone (MIBK)	U		0.00214	0.0100	1	05/02/2017 17:59	WG975483
Methyl tert-butyl ether	3.99		0.0367	0.100	100	05/08/2017 01:06	WG975483
Naphthalene	0.0295		0.00100	0.00500	1	05/02/2017 17:59	WG975483
n-Propylbenzene	0.0338		0.000349	0.00100	1	05/02/2017 17:59	WG975483
Styrene	U		0.000307	0.00100	1	05/02/2017 17:59	WG975483
1,1,1,2-Tetrachloroethane	U		0.000385	0.00100	1	05/02/2017 17:59	WG975483
1,1,2,2-Tetrachloroethane	U		0.000130	0.00100	1	05/02/2017 17:59	WG975483
Tetrachloroethene	U		0.000372	0.00100	1	05/02/2017 17:59	WG975483
Toluene	0.153		0.000412	0.00100	1	05/02/2017 17:59	WG975483
1,1,1-Trichloroethane	U		0.000319	0.00100	1	05/02/2017 17:59	WG975483
1,1,2-Trichloroethane	U		0.000383	0.00100	1	05/02/2017 17:59	WG975483
Trichloroethene	U		0.000398	0.00100	1	05/02/2017 17:59	WG975483
1,2,4-Trimethylbenzene	0.0137		0.000373	0.00100	1	05/02/2017 17:59	WG975483
1,3,5-Trimethylbenzene	0.00348		0.000387	0.00100	1	05/02/2017 17:59	WG975483
Vinyl chloride	U		0.000259	0.00100	1	05/02/2017 17:59	WG975483
o-Xylene	0.0406		0.000341	0.00100	1	05/02/2017 17:59	WG975483
m&p-Xylene	0.0735		0.000719	0.00200	1	05/02/2017 17:59	WG975483
Xylenes, Total	0.114		0.00106	0.00300	1	05/02/2017 17:59	WG975483
(S) Toluene-d8	*101*			*80.0-120*		*05/03/2017 23:07*	WG975483
(S) Toluene-d8	*103*			*80.0-120*		*05/02/2017 17:59*	WG975483
(S) Toluene-d8	*106*			*80.0-120*		*05/08/2017 01:06*	WG975483
(S) Dibromofluoromethane	*75.6*	J2		*76.0-123*		*05/02/2017 17:59*	WG975483
(S) Dibromofluoromethane	*104*			*76.0-123*		*05/08/2017 01:06*	WG975483
(S) Dibromofluoromethane	*113*			*76.0-123*		*05/03/2017 23:07*	WG975483
(S) 4-Bromofluorobenzene	*92.7*			*80.0-120*		*05/03/2017 23:07*	WG975483
(S) 4-Bromofluorobenzene	*102*			*80.0-120*		*05/08/2017 01:06*	WG975483
(S) 4-Bromofluorobenzene	*102*			*80.0-120*		*05/02/2017 17:59*	WG975483

Semi-Volatile Organic Compounds (GC) by Method 3511/8015

Analyte	Result mg/l	Qualifier	MDL mg/l	RDL mg/l	Dilution	Analysis date / time	Batch
TPH (GC/FID) High Fraction	1.77		0.0247	0.100	1	05/02/2017 21:30	WG975552
(S) o-Terphenyl	*78.5*			*31.0-160*		*05/02/2017 21:30*	WG975552

1 Cp
2 Tc
3 Ss
4 Cn
5 Sr
6 Qc
7 Gl
8 Al
9 Sc

Appendix E

Class V Well Pre-Closure Notification Form

United States Environmental Protection Agency

UIC Federal Reporting System

Class V Well Pre-Closure Notification Form

1. **Name of facility:** HollyFrontier Navajo Refining LLC

   Address of facility: 501 E Main

   City/Town: Artesia **State:** New Mexico **Zip Code:** 88210

   County: Eddy **Location:** -104.3857337880 N **Lat./Long.:** 32.84384946550 W

2. **Name of Owner/Operator:** HollyFrontier Navajo Refining LLC

   Address of Owner/Operator: 501 E Main

   City/Town: Artesia **State:** New Mexico **Zip Code:** 88210

   Legal contact: Scott Denton **Phone number:** 575-746-5487

3. **Type of well(s):** In Situ Groundwater Remediation Injection Well **Number of well(s):** 2

4. **Well construction (check all that apply):**

   ☐ **Drywell** ☐ **Septic tank** ☐ **Cesspool**

   ☐ **Improved sinkhole** ☐ **Drainfield/leachfield** ☒ **Other**

5. **Type of discharge:** Recirculation of recovered groundwater amended with nutrients

6. **Average flow (gallons/day):** 24 (12 each well) 7. **Year of well construction:** 2020 (Proposed)

8. **Type of well closure (check all that apply):**

   ☐ **Sample fluids/sediments** ☐ **Clean out well**

   ☒ **Appropiate disposal of remaining fluids/sediments** ☐ **Install permanent plug**

   ☒ **Remove well & any contaminated soil** ☐ **Conversion to other well type**

   ☐ **Other (describe):**

9. **Proposed date of well closure:** December 31, 2021

10. **Name of preparer:** Julie Speer **Date:**

Certification

I certify under the penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment. (Ref. 40 CFR 144.32).

Name and Official Title (*Please type or print*)	Signature	Date Signed

INSTRUCTIONS FOR EPA FORM 7520-17

This form contains the minimum information that you must provide your UIC Program Director if you intend to close your Class V well. This form will be used exclusively where the EPA administers the UIC Program: AK, AS, AZ, CA, CO, DC, DE, HI, IA, IN, KY, MI, MN, MT, NY, PA, SD, TN, VA, VI, and on all Tribal Lands. If you are located in a different State or jurisdiction, ask the agency that administers the UIC Program in your State for the appropriate form.

If you are closing two or more Class V wells that are of similar construction at your facility (two dry wells, for example) you may use one form. If you are closing Class V wells of different construction (a septic system and a dry well, for example) use one form per construction type.

The numbers below correspond to the numbers on the form.

1. Supply the name and street address of the facility where the Class V well(s) is located. Include the City/Town, State (U.S. Postal Service abbreviation) and Zip Code. If there is no street address for the Class V well, provide the route number or locate the well(s) on a map and attach it to this form. Under "Location," provide the Latitude/Longitude of the well, if available.

2. Provide the name and mailing address of the owner of the facility, or if the facility is operated by lease, the operator of the facility. Include the name and phone number of the legal contact for any questions regarding the information provided on this form.

3. Indicate the type of Class V well that you intend to close (for example, motor vehicle waste disposal well or cesspool). Provide the number of wells of this well type at your location that will be closed.

4. Mark an "X" in the appropriate box to indicate the type of well construction. Mark all that apply to your situation. For example, for a septic tank that drains into a drywell, mark both the "septic tank" and "drywell" boxes. Please provide a generalized sketch or schematic of the well construction if available.

5. List or describe the types of fluids that enter the Class V well. If available, attach a copy of the chemical analysis results and/or the Material Safety Data Sheets for the fluids that enter the well.

6. Estimate the average daily flow into the well in gallons per day.

7. Provide the year that the Class V well was constructed. If unknown, provide the length of time that your business has been at this location and used this well.

8. Mark an "X" in the appropriate box(s) to indicate briefly how the well closure is expected to proceed. Mark all that apply to your situation. For example, all boxes except the "Remove well & any contaminated soil" and "Other" would be marked if: the connection of an automotive service bay drain leading to a septic tank and drainfield will be closed, but the septic system will continue to be used for washroom waste disposal only, and the fluids and sludge throughout the system will be removed for proper disposal, the system cleaned, a cement plug placed in the service bay drain and the pipe leading to the washroom connection, and the septic tank/drainfield remains open for septic use only. In this example, the motor vehicle waste disposal well is being converted to another well type (a large capacity septic system).

9. Self explanatory.

10. Self explanatory.

PLEASE READ . . .

The purpose of this form is to serve as the means for the Class V well owner or operator's notice to the UIC Director of his/her intent to close the well in accordance with Title 40 of the Code of Federal Regulations (40 CFR) Section 144.12(a). According to 40 CFR §144.86, you must notify the UIC Program Director at least 30 days prior to well closure of your intent to close and abandon your well. Upon receipt of this form, if the Director determines that more specific information is required to be submitted to ensure that the well closure will be conducted in a manner that will protect underground sources of drinking water (as defined in 40 CFR §144.3), the Director can require the owner/operator to prepare, submit and comply with a closure plan acceptable to, and approved by the Director.

Please be advised that this form is intended to satisfy Federal UIC requirements regarding pre-closure notification only. Other State, Tribal or Local requirements may also apply.

Paper Work Reduction Act Notice

The public reporting and record keeping burden for this collection of information is estimated to average 1.5 hours per respondent. Burden means the total time, effort, or financial resources expended by persons to generate, maintain, retain, or disclose or provide information to or for a Federal agency. This includes the time needed to review instructions, develop, acquire, install, and utilize technology and systems for the purposes of collecting, validating, and verifying information, processing and maintaining information, and disclosing and providing information, adjust the existing ways to comply with any previously applicable instructions and requirements; train personnel to be able to respond to a collection of information; search data sources; complete and review the collection of information; and transmit or otherwise disclose the information. An agency may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid OMB control number.

Send comments on the Agency's need for this information, the accuracy of the provided burden estimates, and any suggested methods for minimizing respondent burden, including thorough the use of automated collection techniques to the Director, Regulatory information Division, U.S. Environmental Protection Agency (2137), 401 M. Street, S.W., Washington, D.C. 20460. Include the OMB control number in any correspondence. Do not send the completed form to this address.

Chavez, Carl J, EMNRD

From: Tsinnajinnie, Leona, NMENV
Sent: Monday, November 18, 2019 5:09 PM
To: Jason.Leik@HollyFrontier.com
Cc: Cobrain, Dave, NMENV; VanHorn, Kristen, NMENV; Suzuki, Michiya, NMENV; Griswold, Jim, EMNRD; Chavez, Carl J, EMNRD; Holder, Mike; Scott M. Denton (scott.denton@hollyfrontier.com); Combs, Robert (Robert.Combs@hollyfrontier.com); JSpeer@trccompanies.com; SBrimo@trccompanies.com
Subject: RE: HollyFrontier Navajo Refining LLC - Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements - Revised Pilot Test Locations EPA ID No.NMD048918817 HWB-NRC-19-002

NMED does not have any additional questions or comments regarding the proposed pilot test locations. However, we do not provide pre-approval for documents that we have not reviewed. Please include the proposed locations and the rationale for choosing them in the work plan and we will review it once we receive the formal submittal.

Thank you,
Leona

From: Leik, Jason <Jason.Leik@HollyFrontier.com>
Sent: Monday, November 18, 2019 12:26 PM
To: Cobrain, Dave, NMENV <dave.cobrain@state.nm.us>; Tsinnajinnie, Leona, NMENV <Leona.Tsinnajinnie@state.nm.us>; Suzuki, Michiya, NMENV <Michiya.Suzuki@state.nm.us>; VanHorn, Kristen, NMENV <Kristen.VanHorn@state.nm.us>; Griswold, Jim, EMNRD <Jim.Griswold@state.nm.us>; Chavez, Carl J, EMNRD <CarlJ.Chavez@state.nm.us>
Cc: Holder, Mike <Michael.Holder@hollyfrontier.com>; Speer, Julie <JSpeer@trccompanies.com>; Brimo, Stella <SBrimo@trccompanies.com>; Denton, Scott <Scott.Denton@HollyFrontier.com>; Combs, Robert <Robert.Combs@HollyFrontier.com>
Subject: [EXT] HollyFrontier Navajo Refining LLC - Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements - Revised Pilot Test Locations EPA ID No.NMD048918817 HWB-NRC-19-002

Team,

Thank you for attending the November 4, 2019 conference call to review the proposed pilot test locations and performance measures outlined in HollyFrontier’s October 23, 2019 email. Based on our call, it is HollyFrontier’s understanding that NMED:

- Prefers pilot test injection wells to be installed at locations that will be used as part of the final system upgrade and understands that the final system design will be modified based on the pilot test results.
- Prefers test locations closer to the east refinery fence line, specifically east of MW-99, RW-19 and/or KWB-4.
- Is concerned KWB-5 and MW-131 may be too far east to be used as pilot test locations. If the area in the vicinity of MW-131 is selected as a pilot test location, NMED would like an additional monitoring well installed downgradient between MW-131 and MW-112.
- Understands the two locations recommended by the NMED during the October 3, 2019 meeting (between wells MW-64 and MW-48; and immediately north of well MW-2) are not feasible for pilot testing due to accessibility/refinery operating constraints.
- Agrees with the proposed performance measures outlined in the October 23, 2019 email and understands it is not practical to pre-set specific targets as a measure of success in advance of the pilot test. The effectiveness of

the pilot test will be discussed in the final pilot test report and include an evaluation of qualitative and quantitative metrics.

In a subsequent email on November 6, 2019, NMED requested HollyFrontier also consider the area near MW-127 as a pilot test location.

HollyFrontier has reevaluated all potential pilot test locations at the refinery and has selected two primary and two alternate pilot test locations. The alternate test locations will only be investigated in the event field testing (gamma logging, soil borings, etc.) at the primary test locations indicate one or both locations are not feasible for pilot testing. A summary of the evaluation of the pilot test locations is provided below.

Please let us know if you agree with the pilot test locations and approach or would like to have another call to discuss any additional questions or comments before we finalize the pilot test workplan due December 13, 2019. We are available for a call on November 21st or November 22nd. Please let us know your availability for a call on these dates. Our hope is to have agreement on the workplan before we submit on December13th in order to minimize/avoid additional comments prior to approval of the plan. This will allow us to get to the field in early 2020.

Thank you,

Jason

==

Pilot Test Locations

As described in HollyFrontier's October 23, 2019 email, areas with the highest dissolved hydrocarbon concentrations were identified and evaluated as potential pilot test locations per NMED comments during the October 3, 2019 meeting. Following the November 4, 2019 call, HollyFrontier reevaluated all potential refinery locations for pilot testing according to the following criteria:

- Dissolved hydrocarbon (target high) and sulfate (target low) concentrations.
- Accessibility (underground and aboveground utilities, rig access, room for aboveground equipment, etc.).
- Impact to current and planned refinery activities (pilot test equipment will be present underground and aboveground and will be accessed frequently).
- Geology and hydrogeology:
    - Pilot test injection, monitoring, and recovery wells will be oriented eastward, following groundwater flow direction.
    - Each of the pilot test location will be completed in one of the primary soil types of the shallow saturated zone (gravel and silty sand).
    - Wells within each pilot test area will be screened within the same, continuous coarse-grained lithologic zone to the degree feasible.
- Proximity to proposed well locations presented to NMED in the March 2018 "Groundwater Recovery and Reinjection System Upgrade – Groundwater Model Update".

The two locations recommended by the NMED during the November 4, 2019 call (east of MW-99 and MW-127) are not feasible for pilot testing based on the above criteria. The area east of MW-99 will not be accessible due to the planned loading rack and scales construction (see attached Figure 1).

The area east of MW-127 is not optimal for pilot testing based on historical analytical concentrations. The average TPH and benzene concentrations at MW-127 since 2015 are less than at MW-131, and the average sulfate concentrations are significantly higher at MW-127 than at MW-131, as shown in the table below. The concentrations referenced for MW-127 in NMED's November 6, 2019 email were incorrect (the referenced concentrations are for MW-107).

Well	Date	TPH DRO (mg/L)	TPH GRO (mg/L)	Benzene (mg/L)	Sulfate (mg/L)
MW-127	Apr-15	1.68	--	4.41	511
	Oct-15	0.585	--	1.51	642
	Apr-16	1.43	6.40	2.01	552
	Oct-16	1.22	3.81	0.644	713
	Apr-17	1.38	4.45	1.04	799
	Oct-17	1.41	1.68	0.462	776
	Apr-18	1.06	5.15	1.18	677
	Oct-18	1.30	3.13	1.15	670
	Apr-19	1.11	5.94	1.65	612
MW-127 Average:		**1.24**	**4.37**	**1.56**	**661**
MW-131	Apr-15	2.8	7.68	1.91	9.57
	Oct-15	4.00	6.76	2.19	16.1
	Apr-16	2.12	9.16	2.42	9.49
	Oct-16	1.86	6.31	1.58	9.61
	Apr-17	1.77	6.81	3.09	10.3
	Oct-17	1.58	4.95	1.39	15.5
MW-131 Average:		**2.36**	**6.95**	**2.10**	**11.8**

Primary Proposed Pilot Test Locations

After considering all potential refinery locations based on the selection criteria and recommendations from NMED, HollyFrontier determined the two most feasible pilot test locations are as follows:

1. MW-131 (see attached Figure 1)
   - The average benzene concentration since 2015 at this well (2.10 mg/L) is higher than at wells MW-28 (1.88 mg/L), MW-127 (1.56 mg/L), and MW-128 (0.231 mg/L) which surround other pilot testing areas recommended by NMED. PSH is present in MW-131 (0.13 feet in April 2019).
   - This area appears to have more silty sand based on borings logs from wells in the vicinity of MW-131.
   - An additional monitoring well would be installed downgradient between MW-131 and MW-112 (east of MW-131, not shown on Figure 1).
   - Pros:
     - Near one of the proposed injection wells in the "Groundwater Recovery and Reinjection System Upgrade – Groundwater Model Update" presented to NMED in March 2018. However, the final system design and model will ultimately be updated based on the pilot testing results.
     - PSH and elevated concentrations of benzene are present in this area.
     - No infrastructure, access , or refinery operation interference issues in this area.
   - Cons:
     - This area is not as far upgradient/west near the east refinery fence line as NMED proposed.
2. East of KWB-4/RW-19 (see attached Figure 1)
   - PSH is present in this area. Apparent in-well PSH thicknesses measured in April 2019 were 1.64 feet in KWB-4 and 0.04 feet in RW-19. Due to the presence of PSH, these wells have not been sampled during recent monitoring events.

- The boring logs for KWB-4 and RW-19 indicate the lithology in the area appears to be primarily clayey/silty sand. The boring log for RW-19 indicates the presence of a 5-foot thick gravel interval, but the boring log for KWB-4 does not indicate any gravel is present.
- Pros:
  - Near the east refinery fence line.
  - PSH is present in this area.
  - Limited infrastructure or access issues. Area will not interfere with refinery operations.
- Cons:
  - Lithology is very heterogeneous in this area with interbedded clay, silt, and sand lenses observed at KWB-4. PSH pumping from RW-19 and KWB-4 indicate there is limited hydraulic connectivity within a short distance (approximately 20 feet) due to the heterogeneity.
  - There is limited historical dissolved-phase analytical data available for this area due to the historic presence of PSH.

Alternate Proposed Pilot Test Locations

HollyFrontier proposes the following locations as alternate pilot test locations that will only be considered should initial field testing (gamma logging, soil borings, etc.) at the primary proposed pilot test locations indicate one or both primary pilot test locations are not feasible. These proposed alternate locations will only be considered as-needed and in the order listed below.

1. <u>Immediately north of recovery trench RW-15</u> (see attached Figure 1)
   - Elevated dissolved hydrocarbon concentrations were historically detected immediately south of this area at RW-15C and MW-48. The average benzene concentration since 2015 was 7.09 mg/L at MW-48 and 20.5 mg/L at RW-15C. Since 2015, measurable PSH has intermittently been present in RW-15C at thicknesses of 0.12 feet or less.
   - This area appears to have more gravel based on boring logs of wells in the vicinity of RW-15.
   - Pros:
     - Near the east refinery fence line.
     - Elevated dissolved-phase hydrocarbon concentrations and potentially PSH are in this area.
   - Cons:
     - Limited space available for system (along refinery road). Underground and aboveground utilities/infrastructure may limit well spacing and pilot test equipment.
     - Potential interference with refinery operations.
2. <u>South of MW-105, between MW-50 and MW-101</u> (south/west refinery – see attached Figure 2)
   - Elevated dissolved hydrocarbon concentrations were historically detected at nearby well MW-105. The average benzene concentrations since 2015 in MW-105 was 8.76 mg/L. PSH is not historically present in this area.
   - This area appears to have more gravel present based on boring logs of wells located across the southwestern portion of the refinery.
   - Pros:
     - Near one of the proposed injection wells in the "Groundwater Recovery and Reinjection System Upgrade – Groundwater Model Update" presented to NMED in March 2018. However, the final system design and model will ultimately be updated based on the pilot testing results.
     - Elevated dissolved-phase hydrocarbon concentrations and an apparent continuous and substantial gravel interval is in this area.
   - Cons:
     - Limited space available. Underground and aboveground utilities/infrastructure will limit well spacing and pilot test equipment.

- Will interfere with refinery operations.

Jason Leik, P.E.
Corporate Environmental Specialist - Remediation
HollyFrontier Corporation
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Chavez, Carl J, EMNRD

From: Holder, Mike <Michael.Holder@hollyfrontier.com>
Sent: Wednesday, October 9, 2019 5:09 PM
To: Cobrain, Dave, NMENV; Tsinnajinnie, Leona, NMENV; Suzuki, Michiya, NMENV; VanHorn, Kristen, NMENV; Griswold, Jim, EMNRD; Chavez, Carl J, EMNRD
Cc: Holder, Mike; Leik, Jason; Julie Speer (JSpeer@trcsolutions.com); Stella Brimo (SBrimo@trccompanies.com); Denton, Scott; Combs, Robert
Subject: [EXT] Notes from Oct 3, 2019 Meeting on Pilot Test Work Plan

Importance: High

Team,

Thank you for meeting with us on October 3, 2019 to discuss NMED's July 22, 2019 comments on the April 12, 2019 Artesia Refinery Groundwater Reinjection Pilot Test Work Plan.

HollyFrontier understands NMED's primary concerns are that the proposed pilot test locations do not include areas with the highest dissolved hydrocarbon concentrations and how the effectiveness of the pilot system will be evaluated. We also understand NMED and OCD agree that no ex-situ treatment of groundwater will be required prior to reinjection, with the exception of the removal of phase-separated hydrocarbons and the addition of electron acceptors to promote in-situ enhanced anaerobic biodegradation.

<u>Next Steps</u>

As discussed, HollyFrontier will:

1. Re-evaluate pilot test locations considering areas with the highest dissolved hydrocarbon concentrations (if accessible) in addition to geology, hydrogeology, other dissolved concentrations, and locations that would yield the best data. A prioritized selection criteria list will be prepared.

2. Establish additional performance measures for the pilot system.

3. Schedule a meeting with NMED, OCD, and HollyFrontier in the near future to agree on the proposed pilot test locations and performance measures before submitting the revised work plan (due by December 13, 2019).

4. Include the following items in the revised workplan, in addition to the items already agreed upon in HollyFrontier's Draft August 19, 2019 Response To Comments Letter:
   a. Final agreed upon pilot test locations and the prioritized selection criteria.
   b. Agreed upon performance measures.
   c. Pump test at each pilot location.
   d. Revised upgradient and cross-gradient wells based on the pilot test locations selected. At least one upgradient well located within 200 feet of each injection well will be proposed.
   e. Estimate and track the number of pore volume exchange cycles within the pilot test area.
   f. Collect soil samples from each boring drilled for the pilot test. Up to two soil samples from each boring will be submitted for laboratory analysis: 1) a soil sample immediately above the water table or from the bottom of the boring (if dry) and 2) a soil sample from the depth with the greatest potential for impacts from field screening (if not from the groundwater interface). Soil samples collected from locations with historical industrial activity will be submitted for TPH (DRO/GRO range) analysis, VOCs, and metals. Soil

samples collected from locations with no historical industrial activity will be submitted for TPH (DRO/GRO range) analysis only.

g. Conduct a tracer test in each pilot test area and consider using bromide as a tracer.
h. Provide more detailed explanation on how aeration of re-injected groundwater will be minimized.
i. Include field testing for sulfate reducing bacteria at pilot test locations for qualitative purposes only.

5. Submit a response to NMED's July 22, 2019 comments and a revised work plan by December 13, 2019.

HollyFrontier appreciates your time and we look forward to future discussions to finalize and implement the Artesia Refinery's Groundwater Reinjection Pilot Test Work Plan. If I've missed anything please don't hesitate to respond so we make sure we capture everything in the next round. As always, if you have any additional thoughts, please contact us. We may also be reaching out to you as we work through the items above.

Thanks,
Mike

Mike Holder
Corporate Environmental Specialist – Water & Waste
The HollyFrontier Companies
2828 North Harwood, Suite 1300
Dallas, TX 75201
(575) 308-1115 (cell)

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An official website of the United States government.

Close

We've made some changes to EPA.gov. If the information you are looking for is not here, you may be able to find it on the EPA Web Archive or the January 19, 2017 Web Snapshot.

EPA United States Environmental Protection Agency

Hazardous Waste Cleanup: Saint Mary's Refining Company, Incorporated (Formerly: Quaker State) in Saint Marys, West Virginia

On this page:

In April 1997, EPA and Saint Mary's Refining Company (SMRC) entered into a Resource Conservation and Recovery Act (RCRA) 7003 Administrative Consent Order requiring SMRC to investigate and clean-up Site related contamination. Pennzoil – Quaker State Company (PQS), a previous owner of the Facility, conducted the on- and off-Site environmental investigations and clean-ups at the SMRC Facility. Fifteen Solid Waste Management Units (SWMUs) and five Areas of Concern (AOC) were identified at the Facility. SWMUs are areas of known or suspected contaminant releases.

Site Facts

EPA ID: WVD004337135
Location: 201 Barkwill Street
Saint Marys, WV 26170
Property Area: 70 Acres
Other Names: Formerly: Quaker State,
Pennzoil – Quaker State Company
Cleanup Status: Complete With Controls
Human Exposures under Control:

Yes, Controlled
Groundwater under Control:
Yes, Controlled
Final Update: 9/22/2017

Cleanup Status

Environmental investigations documented hydrocarbon contaminants in on-site soil and groundwater on- and off-site. Primary contaminants are benzene, ethylbenzene, toluene and xylene (BTEX), methyl-tertiary butyl ether (MTBE), naphthalene, total petroleum hydrocarbons and arsenic. Groundwater (GW) on and around the site is not used as a drinking water source.

Intensive Facility-wide soil and GW clean-up began in August 2006, with installation of clean-up technologies. In the former refinery area, PQS installed over 100 wells into the shallow groundwater aquifer for Soil Vapor Extraction and Bioventing (SVEB) treatment. Bioventing changed subsurface anaerobic conditions to aerobic to support naturally occurring microbes in breaking down hydrocarbons. Vapor extraction removed volatile hydrocarbons from the subsurface and an oxidizer reduced volatiles to carbon dioxide and water. In the deeper aquifer, PQS injected sulfate to support anaerobic bacteria in the breaking down hydrocarbons in the dissolved plume.

Two years later (September 2008), the SVEB treatment had removed about 98% of the contaminant source mass from subsurface soil in the former refinery area. GW contaminants were also significantly reduced. In the deeper aquifer, the bacteria population grew large enough to continue contaminant reduction without further sulfate injection. Natural processes will continue to reduce remaining hydrocarbons in GW, eventually attaining drinking water levels throughout the Facility.

On the bluff or cliff area of the former Refinery, contaminated soil from SWMUs 12 and 13 and AOC 3 was excavated and treated in the former Refining area (in the valley) using bioventing. The bluff excavations were backfilled with clean soil. The treated soil meets EPA’s acceptable risk level for industrial workers and soil remaining on the bluff meets West Virginia’s residential use levels.

The neighborhood well survey found that no private wells around the Facility were being used.

In November 2006, SMRC moved the vent pipe for the truck loading area, located off of Barkwill Street, to the center of the facility, and thereby reduced hydrocarbon vapor emissions and odors from the residential Barkwill Street area.

In 2007, EPA required sampling of stream sediments, Ohio River sediments and on-site polychlorinated biphenyl (PCB) analysis. The final results from these investigations showed minimal Facility impact to these areas.

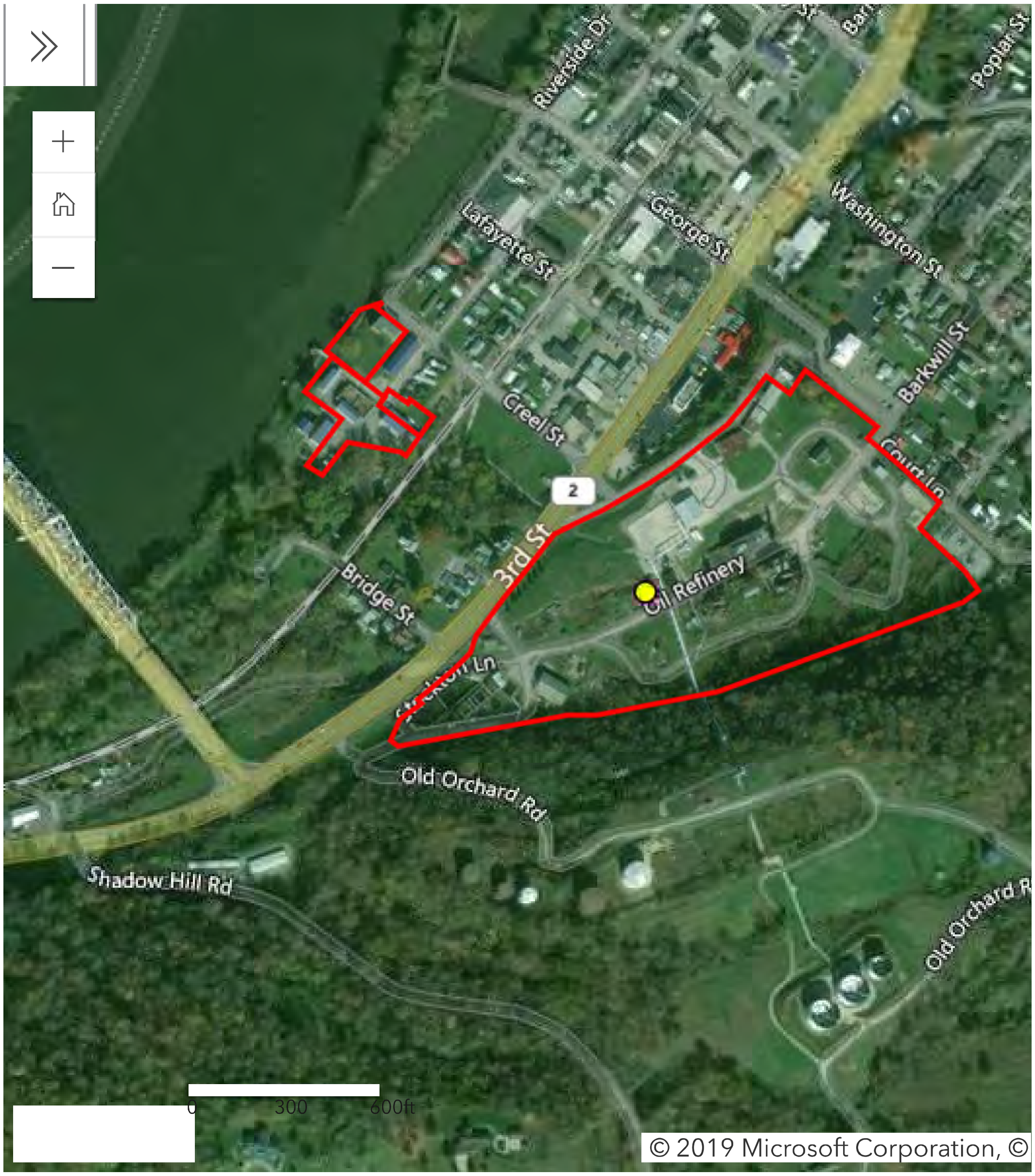
As discussed in the Environmental Indicator Forms located on EPA’s website (see Government Contacts), human health exposures are under control, and GW contamination is delineated and naturally attenuating. In 2011-2012, three downgradient locations along the Ohio River were found to have Refinery related contaminants. These sites were entered into West Virginia's Voluntary Remediation Program (VRP) for cleanup. Soil and groundwater cleanup along the SMRC pipe line near the City's Wastewater Treatment Plant is completed.

In September 2011, EPA issued a Statement of Basis which provided the basis for EPA's proposed remedy decision for the Facility. During the 30-day public comment period, only SMRC submitted comments. The Final (remedy) Decision and Response to Comments (FDRTC) was signed by EPA on January 30, 2012. The Statement of Basis and FDRTC is available on this EPA's website.

The final remedy includes on- and off-site GW monitoring, with wells (off-site wells are located between Route 2 and the Ohio River) sampled twice a year to measure hydrocarbon levels (benzene, toluene, ethyl benzene, xylenes, methyl tertiary butyl ether (MTBE), naphthalene) and arsenic, to document the natural attenuation of remaining hydrocarbons. Environmental covenants restrict land use in the former refinery area to non-residential uses and prohibits using groundwater as a source of drinking water for on- and off-site locations.

Site Description

Interactive Map of Saint Mary's Refining Company, Incorporated, Saint Marys, West Virginia



View larger map

Additional Site Information

- Contacts for this Clean Up
- Documents, Reports and Photographs
- More Information from the Envirofacts database

The SMRC Facility began petroleum refining in the early 1900's. The Facility produced lubricating oils, waxes, gasoline, jet fuel, and other petroleum products over the decades. The Facility had different owner/operators over the years and refining ceased in the early 1990's. The current use of the Facility is for bulk storage and transport of finished petroleum products (gasoline and diesel) and uses a portion of the 70-acre site. The Facility is divided into two areas: the main plant area with truck loading racks, and the bluff or cliff area (which is about 70 feet higher than the main area), where the petroleum is stored in large above ground storage tanks. The Facility is surrounded by commercial, industrial and residential properties. The Ohio River is north of the Facility. The Facility is fenced, with 24-hour security. Public meetings were held every October from 2006 to 2009. More information about the site is located at the Pleasants County Library, West Virginia and at the U.S. EPA office in Philadelphia, Pennsylvania.

Contaminants at this Facility

The primary contaminants are benzene, ethylbenzene, toluene and xylene (BTEX), methyl-tertiary butyl ether (MTBE-an oxygenate), naphthalene, total petroleum hydrocarbons and arsenic. Ground water on and around the site is not used as a drinking water source.

Institutional and Engineering Controls at this Facility

Institutional /Engineering Control Summary

Restrictions or Controls that Address:	Yes	No
Groundwater Use	X	
Residential Use	X	
Excavation	X	
Vapor Intrusion		X
Capped Area(s)		X
Other Engineering Controls	X	
Other Restrictions		X

Institutional control are enforced through an environmental covenant with West Virginia Department of Environmental Protection (WVDEP), recorded on October 22, 2008. This covenant prohibits the following activities on the property: Groundwater extraction except for monitoring purposes; Residential land use. Excavation, drilling or penetration must be by certified contractors who have an approved Soil Management Plan (SMP) to WVDEP/EPA for the area. Engineering Controls for established for Groundwater monitoring.

Land Reuse Information at this Facility

A small portion of the larger 70-acre property is currently used as a petroleum bulk storage and transporting operation. The remainder of the main plant is currently not used.

Site Responsibility at this Facility

RCRA Corrective Action activities are being conducted under the direction of the EPA Region 3 with assistance from WVDEP.

LAST UPDATED ON AUGUST 16, 2019

Michelle Lujan Grisham
Governor

Howie C. Morales
Lt. Governor

NEW MEXICO
ENVIRONMENT DEPARTMENT

Hazardous Waste Bureau

2905 Rodeo Park Drive East, Building 1
Santa Fe, New Mexico 87505-6313
Phone (505) 476-6000 Fax (505) 476-6030
www.env.nm.gov

James C. Kenney
Cabinet Secretary

Jennifer J. Pruett
Deputy Secretary

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

October 2, 2019

Mr. Scott M. Denton
Environmental Manager
HollyFrontier Navajo Refining LLC
P.O. Box 159
Artesia, New Mexico 88211-0159

RE: APPROVAL
EXTENSION REQUEST FOR SUBMITTAL OF THE REVISED GROUNDWATER AND PHASE-SEPARATED HYDROCARBON RECOVERY SYSTEM ENHANCEMENTS: REINJECTION PILOT TEST WORK PLAN
HOLLYFRONTIER NAVAJO REFINING LLC, ARTESIA REFINERY
EPA ID NO. NMD048918817
HWB-NRC-19-002

Dear Mr. Denton:

The New Mexico Environment Department (NMED) has received the HollyFrontier Navajo Refining LLC, Artesia Refinery (the Permittee) *Extension Request for Submittal of the Revised Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements: Reinjection Pilot Test Work Plan* dated September 9, 2019. The stated reason for the request is to allow additional time to incorporate decisions from the meeting scheduled on October 3, 2019 for the *Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements: Reinjection Pilot Test Work Plan* (Work Plan). The October 3, 2019 meeting is to discuss the Permittee's draft responses to the Work Plan. The Permittee is requesting a 90-day extension date of December 13, 2019 for submission of the revised Work Plan. NMED hereby approves the extension request for the revised Work Plan to be submitted no later than **December 13, 2019.**

If you have any questions regarding this letter, please contact Leona Tsinnajinnie of my staff at (505) 476-6057.

Sincerely,

John E. Kieling
Chief
Hazardous Waste Bureau

cc: D. Cobrain, NMED HWB
K. Van Horn, NMED HWB
L. Tsinnajinnie, NMED HWB
M. Suzuki, NMED HWB
C. Chavez, NMEMNRD OCD
R. Combs, HFNR LLC

File: Reading File and NRC 2019, HWB-NRC-19-002

Chavez, Carl J, EMNRD

From: Denton, Scott <Scott.Denton@HollyFrontier.com>
Sent: Friday, September 20, 2019 2:25 PM
To: Cobrain, Dave, NMENV; Chavez, Carl J, EMNRD; Tsinnajinnie, Leona, NMENV; Suzuki, Michiya, NMENV; Griswold, Jim, EMNRD; Wade, Gabriel, EMNRD
Cc: Holder, Mike; Leik, Jason; Combs, Robert; Speer, Julie; Brimo, Stella
Subject: [EXT] Draft Agenda - Navajo Reinjection Pilot Test Work Plan
Attachments: Draft Agenda - Agency Meeting 10-03-19.docx

Happy Friday everyone!

Attached is our Draft Agenda for the meeting on October 3rd. We thought putting this together early will provide some time to review and be prepared for what we hope to accomplish during our meeting.

We are looking forward to seeing you all soon and hope to have a productive meeting so that we can move this project forward.

Have a great weekend.

SMD

Scott M. Denton
Environmental Manager

HollyFrontier Navajo Refining LLC
P.O. Box 159
Artesia, NM 88211-0159
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Draft Agenda for 10/3/2019 Meeting on Groundwater Reinjection Pilot Test at Artesia Refinery – NMED, OCD, and HollyFrontier

- Introductions and Objectives
    - Attendees:
        - NMED: Dave Cobrain, Leona Tsinnajinnie, Michiya Suzuki
        - OCD: Carl Chavez and Jim Griswold
        - HollyFrontier: Scott Denton, Jason Leik, Mike Holder
        - TRC (Consultant): Julie Speer and Stella Brimo
    - Objective is to come to final agreement on NMED/OCD comments regarding the Pilot Test Work Plan in order to finalize and implement
- Draft Response to NMED 7/22/2019 Letter
    - Initial Agency thoughts and questions
    - Primary Comments (Biggest Issues)
        - Injection Criteria – removal of PSH and addition of amendments (terminal electron acceptors)
            - 7/30/2019 call with NMED & HFNR; follow-up emails on 7/31/19
            - Comments 1, 5b, 20, 23
        - Pilot Test Locations/Refinery Boundary
            - Test Locations (and site conditions) – Comments 5a, 5b, 6, 13d
            - Refinery Boundary – Comments 5a, 13d, 13e
        - Amendments
            - Current Conditions – Comments 5b, 10, 13d
            - Dosing – Comments 5a-b, 13e, 25, 26
            - Potential Concerns – Comments 11, 39
        - Evaluating Effectiveness – Comment 36
    - Secondary Comments
        - Pilot Test Layout
            - Well locations – Comments 13a-c, 13c, 14
            - Well construction – Comments 17, 28-31
            - Temporary vs Permanent wells – Comments 18, 32
            - Pump installation – Comment
        - Pilot Test Monitoring Analytes – Response 12, 19
        - PSH Removal – Comments 17, 23
        - Aquifer Testing
            - Injection/Pump Test – Comments 19, 22
            - Tracers – Comments 12, 25
        - Soil Sampling – Comments 8, 19, 33
- Path Forward
    - Submittal of Revised Work Plan – within 45 days of this meeting (by November 15, 2019)
        - Agency approval
        - Implement Work Plan – Commence field work within 60 days approval of the Work Plan, schedule pending NMOSE permits and subcontractor availability

HOLLYFRONTIER®

September 9, 2019

Mr. John E. Kieling, Chief
Hazardous Waste Bureau
New Mexico Environment Department
2905 Rodeo Park Drive East, Building 1
Santa Fe, New Mexico 87505

Re: Extension Request for Submittal of the Revised *Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements: Reinjection Pilot Test Work Plan*
HollyFrontier Navajo Refining LLC, Artesia Refinery
EPA ID No. NMD048918817
HWB-NRC-19-002

Dear Mr. Kieling:

HollyFrontier Navajo Refining LLC (HFNR) is submitting this letter to request a 90-day extension for submittal of a revised *Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements: Reinjection Pilot Test Work Plan* (Work Plan). HFNR submitted the original Work Plan on April 12, 2019. In a letter dated July 22, 2019, the New Mexico Environment Department (NMED) provided comments to the Work Plan and requested submittal of a revised Work Plan by September 13, 2019. HFNR provided draft responses to each of the NMED's comments in a letter dated August 19, 2019 and scheduled a meeting with the NMED and the New Mexico Oil Conservation Division (OCD) for October 3, 2019 to discuss HFNR's draft responses and develop an agreed path forward for the revised Work Plan. A 90-day extension will allow HFNR time to incorporate decisions from the October 3, 2019 meeting into the revised Work Plan. HFNR will submit the revised Work Plan on or before December 13, 2019.

If you have any questions or comments regarding this report, please feel free to contact me at 575-746-5487 or Robert Combs at 575-746-5382.

Sincerely,

Scott M. Denton
Environmental Manager
HollyFrontier Navajo Refining LLC

cc: NMED: D. Cobrain, L. Tsinnajinnie, K. Van Horn, M. Suzuki
OCD: C. Chavez, J. Griswold
HF: R. Combs, J. Leik, M. Holder
TRC: J. Speer, C. Smith

August 19, 2019 **DRAFT**

Mr. John E. Kieling, Chief
Hazardous Waste Bureau
New Mexico Environment Department
2905 Rodeo Park Drive East, Building 1
Santa Fe, New Mexico 87505

Re: Response to Comments to the July 22, 2019 Letter of Disapproval, *Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements: Reinjection Pilot Test Work Plan*
HollyFrontier Navajo Refining LLC, Artesia Refinery
EPA ID No. NMD048918817
HWB-NRC-19-002

Dear Mr. Kieling:

This letter provides responses to the New Mexico Environment Department (NMED) letter dated July 22, 2019, regarding the April 2019 *Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements: Reinjection Pilot Test Work Plan* (Work Plan). HollyFrontier Navajo Refining LLC's (HFNR's) responses to each of NMED comments included in the July 22, 2019 letter are provided below. For convenience, NMED's comments are shown in *italics*.

RESPONSE TO NMED COMMENTS

Comment 1

The groundwater at the East Field is contaminated above the injection criteria established by NMED and Energy Minerals and Natural Resource Department Oil Conservation Division (OCD). It will be difficult to verify the effectiveness of the proposed in-situ treatment with only the proposed method, even if the constituents of concern (COCs) concentrations are reduced in-situ, it will be difficult to distinguish whether the reduction is caused by biodegradation or dilution. NMED is concerned that it may not be possible to achieve the injection criteria with the proposed in-situ bioremediation alone. The use of the proposed in-situ treatment with an aboveground treatment system (e.g., air stripper with granulated activated carbon (GAC)) would achieve the required standards and generate measurable and quantifiable data to demonstrate this. The Permittee must consider additional measures to ensure the treated groundwater will meet the injection criteria.

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Response 1

Based on discussions between NMED and HFNR on July 30, 2019, HFNR understands that NMED is accepting of reinjection of extracted groundwater without ex-situ treatment other than removal of phase-separated hydrocarbons (PSH), if present, and addition of amendments (terminal electron acceptors) to promote in situ enhanced anaerobic bioremediation (EAB). HFNR also understands that NMED is supportive of moving forward with the proposed Pilot Test upon resolution of NMED's comments on the Work Plan. HFNR is appreciative of the dialogue with NMED to facilitate understanding and to move forward toward the common goal of addressing hydrocarbon impacts in groundwater in the subject area. The following response provides background to our Pilot Study approach and to specific NMED's concerns expressed in Comment 1.

The stated intent of the Recovery System upgrades is to control migration of dissolved-phase impacts and PSH prior to leaving HFNR's property and to eventually stop PSH migration while allowing natural processes (i.e., natural attenuation and biodegradation) to remediate the remaining dissolved-phase hydrocarbons. The system selected and presented in the Work Plan for testing was based on the HFNR team's experience at similar facilities with similar types of constituents and similar hydrogeologic conditions.

HFNR met with NMED and OCD representatives on multiple occasions in 2018 (as summarized in Section 2.2 of the Work Plan) and provided written documentation of regulations pertaining to reinjection on November 15, 2018. Per those discussions and correspondence, treatment to regulatory levels is not required per RCRA section 3020(b), which New Mexico adopted in 20.6.2.5004A(3)(b) NMAC. NMED and OCD representatives agreed with HFNR's findings that treatment to regulatory levels is not required prior to injection as follows:

- It will be implemented as an Interim Measure as part of the refinery's RCRA corrective action program intended to help clean up contamination.
- The contaminated groundwater will be treated (removal of PSH and addition of terminal electron acceptors) to substantially reduce hazardous constituents prior to such reinjection, though the reduction will occur in situ as allowed by EPA and state law.
- It will protect human health and the environment through hydraulic control and reduction in contaminant levels, in conjunction with the lack of exposure pathways given that the area is within refinery property and the water-bearing zone is not a source of drinking water.

Enclosed with this letter are two case studies (Attachment A) for other refineries in West Virginia where reinjection of sulfate-amended water was used to reduce dissolved-phase hydrocarbon concentrations in situ to below regulatory levels. An overview of EAB and sulfate reduction is

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provided at the beginning of Case Study 1 in Attachment A. As shown on the table provided on page 3 of Case Study 1, sulfate is an effective electron acceptor for anaerobic degradation of elevated dissolved hydrocarbon concentrations (e.g., benzene) with limited potential complications compared to other electron acceptors. The use of sulfate amendments to increase the rate of anaerobic degradation of hydrocarbons in situ is well understood and proven to be successful as demonstrated by the case studies provided.

Regarding the statement, "It will be difficult to verify the effectiveness of the proposed in-situ treatment with only the proposed method, even if the constituents of concern (COCs) concentrations are reduced in-situ, it will be difficult to distinguish whether the reduction is caused by biodegradation or dilution," HFNR provides the following further explanation: groundwater that is extracted will be contained within a closed-loop system with no ex situ treatment other than removal of PSH (if present) and addition of the amendments (terminal electron acceptors). Thus, the water that is reinjected will have a similar concentration of dissolved hydrocarbons as the groundwater extracted from the formation. Any reduction in dissolved hydrocarbon concentrations can only be attributable to additional in situ degradation due to increased SRB activity as confirmed by the sampling program proposed in the Work Plan.

Also with respect to the statement, "The use of the proposed in-situ treatment with an aboveground treatment system (e.g., air stripper with granulated activated carbon (GAC)) would achieve the required standards and generate measurable and quantifiable data to demonstrate this," HFNR offers the following: the intent of the pilot study is to maintain anaerobic conditions in the aquifer, and to maintain that condition in the above-ground section of the closed-loop system. If the recirculated water is treated ex-situ as suggested, it will not be compatible with the anaerobic degradation approach and, in addition, the aerated water would swiftly foul injection wells and the formation without further chemical amendment. The recirculation system proposed in the Work Plan was designed to minimize any change to the redox condition of the recirculated water.

Comment 2

In Section 3.3.1 (Shallow Saturated Zone), page 8, paragraph 3, the Permittee states, "[c]oncentrations of total dissolved solids (TDS) exceeding 2,000 milligrams per liter (mg/L) and sulfate exceeding 500 mg/L have been recorded northwest (upgradient) of the Refinery." The TDS and sulfate concentrations in the groundwater samples collected from most of the wells installed in the shallow saturated zone significantly exceed the referenced concentrations in the area. For example, the TDS and sulfate concentrations in the groundwater sample collected from upgradient well UG-4 are recorded as 4,030 mg/L and 2,680 mg/L, respectively, during the April 2018 sampling event according to the 2018 Annual Groundwater Monitoring Report. Although the statement is correct, the referenced concentrations are somewhat misleading because it suggests that most of the concentrations are in close approximation to the referenced concentrations. In

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the revised Work Plan, clarify that a majority of the wells referenced in the northwest (upgradient) in the Refinery significantly exceed the range of concentrations provided.

Response 2

HFNR will revise the text to note that the concentrations significantly exceed the critical groundwater screening level (CGWSL) and the ranges provided in the text for TDS and sulfate in the Shallow Saturated Zone.

Comment 3

In Section 3.3.2 (Valley Fill Zone), page 9, paragraph 1, the Permittee states, "[w]ells in the valley fill zone range from 40 to 60 feet bgs and the formation yields water containing TDS ranging from 500 to 1,500 mg/L." The TDS concentrations in groundwater samples collected from well MW-18B installed in the valley fill zone were recorded as being above 4,000 mg/L since 2013, exceeding the referenced range according to the 2018 Annual Groundwater Monitoring Report, submitted in February 2019. Revise the Work Plan to clarify that some wells significantly exceed the range of concentrations provided.

Response 3

HFNR will revise the range provided in the text to match the available data for TDS in the Valley Fill Zone. Note monitoring well MW-18B is located along the eastern boundary of the Evaporation Pond and is not representative of conditions beneath the refinery.

Comment 4

In Section 3.3.3 (Deep Artesian Aquifer), page 9, paragraph 3, the Permittee states, "[a]vailable well completion records for irrigation well RA-4798 indicate that it is screened in the deep artesian aquifer from 840 to 850 feet bgs. Historic analytical data from this well does not indicate the presence of hydrocarbon impacts from Refinery operations." The statement is not accurate. MTBE has been detected from well RA-4798 since 2016 according to the 2018 Annual Groundwater Monitoring Report. Revise the Work Plan for accuracy.

Response 4

HFNR is currently working on an MTBE evaluation report that will include a summary of historical use and storage of MTBE at the Refinery. The report will also provide a more detailed summary of MTBE detections in wells near the Refinery including supporting data. Based on that data, HFNR does not believe that the MTBE detected in RA-4798 can be conclusively attributed to historic refinery operations. No other dissolved volatile organic compounds (VOCs) have been detected in groundwater samples collected from RA-4798. Because MTBE is more recalcitrant and mobile than other VOCs, there are numerous potential sources of MTBE upgradient of RA-4798 in addition to the Refinery that may be the source of the detected concentrations.

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HFNR will revise Section 3.3.3, page 9, paragraph 3 to state, "Historic analytical data from this well does not indicate the presence of hydrocarbon impacts from Refinery operations. MTBE has been detected in RA-4798 at levels below the WQCC standard, but these detections cannot be attributed to historical Refinery operations based on all available data."

Comment 5

Section 4.1 (Test Location), page 10, paragraph 1 states that "[t]o test recovery and injection efficiency in areas that are representative of the conditions that will be addressed by the full scale system, HFNR is planning to perform that pilot test in the East field near existing wells KWB-5 and MW-131. The area around these wells [KWB-5 and MW-131] contains PSH and dissolved-phase constituents at concentrations of the same magnitude or higher than what is expected to be recovered by the enhanced recovery system." In the revised Work Plan, address the following:

a. *NMED is concerned that the proposed Pilot Test wells KWB-5 and MW-131 may not be representative of conditions where the full-scale system is proposed (i.e., at the Eastern Boundary and East Field) to be installed. COC analytical groundwater data in the proposed Pilot Test wells are lower than the groundwater analytical results in the groundwater monitoring wells at the eastern refinery boundary. The difference is significant enough that the results from the Pilot Test may skew the design of the full scale system and may not translate to wells with significantly higher contaminant concentrations. In the revised Work Plan discuss the conditions in the proposed Pilot Test area compared to the eastern refinery boundary area and discuss how the Pilot Test results are expected to scale up.*

b. *The sulfate level in well MW-131 was recorded as 15.5 mg/L during the October 2017 sampling event, which is exceptionally low compared to the rest of the wells in the vicinity: therefore, it is not representative of site conditions. The low groundwater sulfate level in the Pilot Test location is misleading and may overstate success and a possibly false demonstration of the injection criteria being met by the proposed amendment in a full-scale system. If sulfate reducing bacteria (SRB) are present in the aquifer and favorable conditions are met, the sulfate groundwater concentrations in the East Field generally exceed the theoretical demands required to reduce all organic constituent concentrations below the screening levels. Since the injection fluid for the full-scale system will be a mixture of groundwater extracted from the trenches at Bolton Road, the sulfate level in the injection fluid of the full-scale system will likely exceed the required sulfate demand. Sulfate is abundant at the site; therefore, amending the system with sulfate does not appear to be necessary to attain the injection criteria. Provide more discussion for the basis of the proposed sulfate biostimulation and how it will help to attain the injection criteria in the revised Work Plan.*

Response 5

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a. Regarding the statement, "COC analytical groundwater data in the proposed Pilot Test wells are lower than the groundwater analytical results in the groundwater monitoring wells at the eastern refinery boundary," HFNR notes the following: benzene concentrations in the East Field are greater than those in wells located further downgradient along the refinery boundary (i.e., along Bolton Road), as shown on the attached benzene isoconcentration map[1] (Figure 1). The refinery property boundary extends to the east of the main refinery plant and fence line as shown on Figures 1 and 2. The Pilot Test areas are representative of the overall conditions across the dissolved hydrocarbon plume.

   The Pilot Test results are expected to scale up throughout the dissolved hydrocarbon plume as the microbial consortium will be similar throughout plume. Therefore, the initial sulfate demand will be similar throughout the plume so the approach and design will be similar throughout the plume. The Pilot Study is intended to demonstrate reduction in hydrocarbon concentrations while maintaining sulfate concentrations at 500 mg/L (initial target sulfate demand based on the HFNR team's experience at similar sites). Scale up of the full-scale system will be based on a similar target concentration and the actual amount of sulfate amendment in the full-scale system will be adjusted based on actual conditions observed. The remedial timeframe may vary as it will be proportional to the mass of hydrocarbons in the targeted zone.

b. Regarding the perspective that sulfate concentrations in MW-131 are "exceptionally low compared to other wells in the vicinity," HFNR provides the following further information: sulfate concentrations are depressed within the dissolved hydrocarbon plume across the southern refinery, as shown on Figure 2. Historical sulfate concentrations in wells MW-48, MW-64, MW-65, MW-66, MW-102, MW-107, KWB-5, KWB-10R, and RW-15C are generally consistent with or less than the noted sulfate concentrations in MW-131 as shown on Figures 2 and 3. Further, sulfate has either not been detected or detected at low estimated J-flag concentrations in some of these wells during recent groundwater monitoring events.

   Sulfate concentrations are significantly lower in wells with dissolved hydrocarbon impacts across the East Field compared to other site wells with no dissolved hydrocarbon impacts as shown on Figures 1 and 2. While not a direct measurement, the inverse

[1] Benzene is representative of the dissolved hydrocarbons in the Shallow Saturated Zone because it is the most prevalent dissolved hydrocarbon in shallow groundwater beneath and downgradient of the refinery property. Other dissolved hydrocarbons present in the Shallow Saturated Zone have a similar distribution to dissolved benzene but smaller lateral extent. Total petroleum hydrocarbons (TPH) dissolved range organics (DRO) and gasoline range organics (GRO) are present in shallow groundwater upgradient, crossgradient, and downgradient of the Facility. Naphthalene was used as an indicator compound for TPH DRO and GRO and demonstrated a smaller lateral extent than benzene.

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correlation of sulfate and dissolved benzene concentrations shown on these figures is a primary line of evidence that SRB are actively degrading the hydrocarbon plume in the East Field, and that more robust degradation is limited by the depressed sulfate concentrations within these areas. The addition of sulfate will stimulate additional SRB activity, which will increase the hydrocarbon attenuation and desorption rates. In typical unconsolidated aquifers the majority of the hydrocarbon mass is adsorbed to the soil. The provided case studies show the initial response to sulfate addition is an increase in dissolved hydrocarbon concentrations that is associated with SRBs actively desorbing hydrocarbons (substrate) from the formation matrix as these microbes live on the outside of soil particles near adsorbed hydrocarbons. The desorbed hydrocarbons are then degraded in the dissolved-phase. This process demonstrates how the proposed biostimulation is more efficient in reducing hydrocarbon concentrations by increasing the bioavailability of electron acceptors to the adsorbed hydrocarbons in an aquifer than traditional "pump and treat" and in situ chemical oxidation (ISCO) processes that only rely on solubility of the individual hydrocarbon compounds to address the adsorbed hydrocarbons.

The Pilot Test is intended to be a controlled study that will demonstrate the applicability and effectiveness of EAB of hydrocarbons in the Shallow Saturated Zone (i.e., proof of concept). The design and layout of the full-scale system will be reviewed and modified as necessary based on the results of the Pilot Test. The Pilot Test results will also be used to estimate sulfate nutrient demand and remedial timeframes of the full-scale system. The use of a mixture of groundwater from the East Field and Bolton Road in the full-scale system would involve adjusting the amendment dosing throughout operation to ensure sulfate is present throughout the targeted formation (initial goal is to maintain approximately 500 mg/L in targeted formation but will be adjusted based on estimated sulfate demand). The sulfate demand is expected to decrease over time as the relative concentrations of the more degradable hydrocarbon compounds (e.g., BTEX) decrease with respect to the total remaining hydrocarbons.

As stated in Response 1, the injection criteria for the proposed injection system is to remove PSH (if present) and add amendments (terminal electron acceptors) to reduce hydrocarbons in situ by EAB.

Comment 6

In Section 4.1 (Test Locations), page 10, paragraph 1, the Permittee states, "[t]he two proposed pilot test locations provide the opportunity to test injection, amendment, and recovery in two of the primary soil types (gravel and silty sand) in which the full-scale system will also be installed." The Permittee must explain why KWB-5 is considered to be a "target zone with more gravel" when the KWB-5 well log does not include gravel in the soil type description. If

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available, provide additional soil boring logs that are pertinent to the discussion and demonstrate that the two different soil types are present in the Pilot Test area in the revised Work Plan.

Response 6

The paragraph immediately following the cited paragraph (Section 4.1, page 10, paragraph 2) states, “Based on the geologic, geophysical, and contaminant migration investigation results documented in the revised CME Report [April 2017 *Revised Contaminant Evaluation Report*], preliminary pilot test locations for injection, recovery, and monitoring have been proposed with the intent of testing the effects of amendment and recovery in silty sand and gravel, both of which are prevalent in the observed preferential groundwater flow pathways in the East Field.” The selection of the area “near” KWB-5 was selected because data from the CME shows that area to have gravel seams based on geophysical testing, as shown on Figure 27 of the revised CME Report. As described in this section of the Work Plan, an initial evaluation is to be performed (discussed further in Comment 7) to confirm (1) the presence of gravel through gamma logging and potentially exploratory borings and (2) confirm or adjust the location/design of the pilot test wells based on the results.

Comment 7

In Section 4.1 (Test Locations), page 10, paragraph 2, the Permittee states, "[t]he exact location of the injection, monitoring, and recovery wells will be determined after completion of gamma logging of the existing well in the area around KWB-5 and MW-131 ." The Permittee must include the gamma logging data, the potential figures generated from the data results and include a discussion of the data and the results in the Pilot Test report.

Response 7

HFNR will include the gamma logging data, figures generated from the data results, and a discussion of the data and the results in the Pilot Test report. HFNR will revise the Work Plan to indicate that the requested items will be included in the Pilot Test report. If the evaluation directs the placement to be different from the chosen areas, these will be noted as deviations in the Pilot Test report.

Comment 8

In Section 4.1 (Test Locations), page 10, paragraph 2, the Permittee states, "[d]ue to the heterogeneous nature of the shallow geology in this area, some additional exploratory borings may be installed to further characterize the lithology in the area near well KWB-5 and MW-131. The final locations of wells to be used in each of the two pilot test areas will be adjusted with the intent of having all wells within each pilot test area screened within the same, continuous coarse-grained lithology zone, to the degree feasible on the heterogeneous nature of the shallow geology.

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One pilot test area will target zones with more gravel (KWB-5) and the other pilot test area will target zones with more silty sand (near MW-131)." The Permittee must provide all boring logs for the additional exploratory borings, including borings that were not converted to wells. The additional borings are subject to soil sampling and must also include analysis for VOCs, total petroleum hydrocarbons (TPH as diesel-range organics (DRO), gasoline-range organics (GRO), and oil-range organics (ORO)) and metals analyses, at a minimum. The data must be included in the Pilot Test report. While the Permittee's intent is to conduct the test in two lithologic zones, it appears the gravel zone may not be present in well KWB-5 (see Comment 5a). The Permittee will not be able to extrapolate the data to the full-scale system, if the test is conducted as proposed.

Response 8

See response to Comment 6 (not 5a) regarding gravel in the vicinity of KWB-5. HFNR will provide boring logs for all exploratory borings including borings that are not converted to wells.

The East Field where the pilot test is planned has never been used for any industrial purposes. Constituents present in the groundwater in the areas around KWB-5 and MW-131 migrated from the refinery laterally via the Shallow Saturated Zone as described in previous investigation reports including the revised CME Report. Any unexpected hydrocarbon impacts as well as the smear zone can and will be noted using standard field screening techniques (i.e. visual, olfactory, and/or PID screening). HFNR respectfully does not believe collecting soil samples from borings intended to define shallow hydrogeology and optimize placement of wells for aquifer testing is warranted or will provide any additional meaningful data.

Comment 9

In Section 4.2 (Dissolved-Phase Conditions), page 10, bullet item 2, the Permittee states that "[b]ackground sulfate concentrations west of the Refinery appear to range between 1,000 and 2,000 mg/L, while sulfate concentrations within the hydrocarbon plume below the East Field range from 10 to 100 mg/L, and are non-detect in some wells." Wells UG-I, UG-2, and UG-3R were not intended to be utilized for background and were originally installed to monitor contamination migrating on to the Refinery property. It has been discussed several times that background at the site is not achievable and that only a baseline can be established with the current conditions of the site. The baseline conditions must be established specific to the East Field relevant to the areas of the Pilot Test and full-scale remediation system. Revise all sections that refer to "background" and replace with the term "baseline".

Response 9

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HFNR will change the word “background” to “upgradient” for similar instances throughout the Work Plan. The intent in the referenced sentence was to describe the distribution and magnitude of sulfate concentrations within and outside of the dissolved hydrocarbon plume to demonstrate the inverse correlation of sulfate and dissolved hydrocarbon concentrations which is a primary line of evidence that biodegradation of hydrocarbons is occurring via sulfate reduction. The term “baseline” in the Pilot Test will be relevant to the baseline groundwater quality evaluation described in Section 5.2.1 of the Work Plan.

Comment 10

Section 4.2 (Dissolved-Phase Conditions), page 11, bullet item 1, states, "[t]he inverse concentration correlation indicates SRBs are utilizing sulfate to degrade hydrocarbons in both dissolved and adsorbed phases (note that the sulfate demand of dissolved-phase concentrations is too low to exceed the background supply of sulfate)." The Permittee has not demonstrated that there is a correlation between the SRB and the degradation of hydrocarbons in both the dissolved and adsorbed phase and there is no data to support this statement. Therefore, groundwater samples must be collected from wells within the East Field to determine the concentrations of sulfide and sulfate and the population of the SRB. Since the Work Plan is developed based on the assumption that SRB play a vital role in hydrocarbon degradation, the presence of SRB and the occurrence of sulfate reduction must be demonstrated prior to Pilot Test start up. Include SRB sampling and evaluation in the revised Work Plan. Sampling of the SRB population must be conducted throughout the duration of the Pilot Test.

Response 10

Section 4.2 of the Work Plan provides a list of primary and secondary lines of evidence that indicate SRBs are actively utilizing sulfate to degrade hydrocarbons in the Shallow Saturated Zone (i.e, sulfate reduction is occurring). These lines of evidence are consistent with sulfate reduction as detailed in the December 2013 EPA Office of Solid Waste and Emergency Response document *Introduction to In Situ Bioremediation of Groundwater* (542-R-13-018). Qualitative and quantitative data associated with lines of evidence have been provided to NMED in numerous reports, including the revised CME Report that was submitted in March 2017 and Annual Groundwater Monitoring Reports that were submitted in February of each calendar year. Figures 1 and 2 were developed for this letter to visually demonstrate the inverse relationship of benzene and sulfate concentrations as an example of a primary line of evidence that sulfate reduction is occurring.

Sampling for SRBs is neither practical nor effective in demonstrating that sulfate reduction is occurring as (1) the process of sampling, shipping, and laboratory analysis reduces anaerobic populations in samples due to exposure to oxygen, light, and temperature changes, and (2) the vast majority of the microbial population are attached to the formation matrix (soil particles) and

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not suspended or free "swimming" in the groundwater[2]. The ratio of attached to suspended microbial populations in an aquifer can range between 59:1 and 1657:1[3].

Sulfide is an end product of sulfate reduction, but it precipitates with ferrous iron and is effectively immobilized or is transient[4,5]. However, HFNR will revise the Work Plan to include the analysis of sulfide during baseline sampling and at a selected frequency throughout the pilot test. Note the presence of black particulates in and/or slightly grey turbid purge water observed within the hydrocarbon plume during groundwater sampling activities (noted on Table 2 in Annual Groundwater Monitoring Reports) is an indication of iron sulfide precipitants. The sulfide results can be used as one of the multiple lines of evidence to evaluate the Pilot Test results, but will not be the primary or the sole criterion for evaluation of sulfate reduction.

<u>Comment 11</u>

Section 4.2 (Dissolved-Phase Conditions), page 11, paragraph 1, states, "[i]n addition to bioavailable sulfate, nitrogen in the form of ammonia will be added to the system to amend the two most likely rate-limiting nutrients." The screening level for nitrate concentration in groundwater is 10 mg/L. Verify that the ammonia amendment will not cause nitrate exceedances and provide a more detailed basis for amending with ammonia in the revised Work Plan.

<u>Response 11</u>

The addition of a nitrogen source was proposed to boost the indigenous microbial population growth based on the HFNR team's experience at other similar facilities with similar COCs and similar geology. However, the nitrogen source will only be added if it is determined that there is insufficient nitrogen present in the Shallow Saturated Zone (i.e., total Kjeldahl nitrogen <10 mg/L). The application rate of the nitrogen source (ammonia) generally decreases over time as the indigenous microbial population stabilizes. Under anaerobic conditions, ammonia cannot oxidize to nitrate due to the lack of oxygen. There is minor potential for nitrification within wells that are screened across variable redox conditions, but the resulting nitrate concentrations would be significantly below 10 mg/L and would be swiftly reduced by the anaerobic formation. In addition, there is limited potential for downgradient migration of minor quantities of nitrogen or nitrate past the Pilot Test recovery wells.

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2 Griebler, C. and T. Lueders. Microbial Biodiversity in Groundwater Ecosystems. *Freshwater Biology* 54 (2009): 649-677.
3 Griebler C., Mindl B., Slezak D. & Geiger-Kaiser M. Distribution Patterns of Attached and Suspended Bacteria in Pristine and Contaminated Shallow Aquifers Studied with an In Situ Sediment Exposure Microcosm. *Aquatic Microbial Ecology* 28, (2002): 117–129
4 Office of Solid Waste and Emergency Response, United States Environmental Protection Agency. December 2013. *Introduction to In Situ Bioremediation of Groundwater*. 542-R-13-018.
5 R. Kolhatkar and M. Schnobrich. Land Application of Sulfate Salts for Enhanced Natural Attenuation of Benzene in Groundwater: A Case Study. *Monitoring & Remediation* 37, no. 2, Spring 2017: 43–57.

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Comment 12

Section 5.2.1 (Baseline Groundwater Quality Evaluation), page 13, bullet item 4, states,

"[m]onitored natural attenuation (MNA) laboratory-measured parameter concentrations: sulfate, total Kjeldahl nitrogen (TKN), total organic carbon (TOC), alkalinity, ferrous iron, and magnesium." Discuss the basis for monitoring TKN in the response letter. Since the dissolved phase hydrocarbon is to be primarily degraded by SRB, measurement of SRB and sulfide concentrations must also be included (see Comment 10). In addition, since the proposed MNA parameters are unlikely to provide accurate information regarding the distribution of amendments in the vicinity of the injection wells, a tracer must be included during the initial stage of the injection process and the tracer level must be monitored. Revise the Work Plan accordingly.

Response 12

TKN is a measure of all forms of nitrogen present in the analyzed media (in this case, groundwater). The analysis of TKN in the pilot test monitoring program was included to ensure that data necessary to evaluate all potential limiting constituents is collected.

As described in Response 10, sampling for SRBs is not practical or effective. HFNR will revise the Work Plan to include sampling for sulfide during baseline sampling and at a selected frequency throughout the pilot test.

HFNR believes that the distribution of amendments in the vicinity of the injection wells can be reliably determined from the proposed testing procedure. The well layout, monitoring frequency, and monitoring parameters have been selected to ensure changes in water table elevation, PSH thickness, and constituent concentration can be observed and compared between locations and over time. HFNR proposes using magnesium as a tracer throughout the pilot test. While magnesium is not inert and slowly precipitates with the final product of degradation carbonate, it remains in solution long enough especially during the beginning of EAB to act as a semi-conservative tracer and allow for estimating sulfate demand/utilization. Epsom salt is the source of sulfate and magnesium in the Pilot Test and they are in a 1:1 molar relationship (i.e., the injected solution has equal molar concentrations of sulfate and magnesium). Therefore, it is a simple calculation to evaluate sulfate utilization (i.e., sulfate demand) across each Pilot Test area as the sulfate molar concentration will decrease relative to magnesium. The sulfate demand can usually be estimated within one to three months in EAB projects (after the microbial acclimation period).

Comment 13

In Section 5.2.1 (Baseline Groundwater Quality Evaluation), page 13, paragraph 2, the Permittee states, "[b]aseline water level and water quality data will be measured in all of the wells

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associated with the pilot test." For the KWB-5 test area, wells KWB-5, KWB-4, and MW-99, KWB-6 and MW-112 are proposed to be monitored. For the MW-131 test area, wells MW-131, MW-129, and MW-112 are proposed to be monitored. Provide clarification regarding the following:

a. *Phase-separated hydrocarbon (PSH) has been present in wells KWB-4 and MW-112 since they were both installed; therefore, groundwater analytical data have not been collected from these wells. Data collected during the Pilot Test cannot be compared to any existing data. Samples must be collected, and the data can be used for informational purposes. Explain the basis for including these wells as a part of the test evaluation since there are no baseline data.*

b. *Well MW-99 is screened from 12 to 27 feet bgs, while the surrounding wells are screened from approximately 20 to 40 feet bgs. The screened interval of well MW-99 is not consistent with other wells and is also located more than 400 feet upgradient from the proposed test area. Explain why well MW-99 is being included in the evaluation of the Pilot Test investigation and explain if the depth of the screened interval will impact the evaluation of data from the Pilot Test.*

c. *Several wells proposed as upgradient monitoring wells for the Pilot Test are located approximately 610 to 625 feet from the test area. Propose to install upgradient wells that are closer to the test area or propose to install the injection and recovery wells closer to the monitoring wells chosen to be the upgradient wells for the Pilot Test in the revised Work Plan.*

d. *The sulfate level within the Pilot Test area is one to two orders of magnitude lower when compared to the monitoring wells in the eastern refinery boundary. The sulfate levels are not likely representative of the groundwater conditions for evaluation and the design of the full-scale system (see Comment 5). Explain why this proposed groundwater extraction location was chosen, especially since sulfate concentrations are most likely depleted in the pilot study area compared to the eastern refinery boundary.*

e. *After the full-scale system has been completed, the extracted groundwater from surrounding monitoring and extraction wells (i.e., Bolton Road) may replenish sulfate concentrations without amending it (see Comment 5) because concentrations from these wells range from 525 to 1,400 mg/L (April 2018 Event). Demonstrate whether or not the sulfate amendment is necessary using stoichiometric mass balance and the analytical data from all wells pertinent to the east refinery boundary where the full-scale remediation is proposed to be implemented. Provide these calculations in the revised Work Plan and provide a discussion regarding the conclusions of these calculations.*

f. *Well MW-111 is not included as a part of the Pilot Test evaluation. The screened interval of well MW-111 is consistent with other monitoring wells and may be suitable to evaluate cross-gradient migration and unanticipated preferential flow. Propose to include well MW-111 in the Pilot Test.*

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Response 13

a. The objective of the baseline monitoring proposed in Section 5.2.1 of the Work Plan is to provide initial baseline groundwater elevation and quality data for the Pilot Test within 14 to 30 days prior to initiation of the Pilot Test. Results of baseline water quality testing will be used to (1) calculate the range of dosing of amendment(s) in the treatment area and (2) determine baseline conditions to be used to evaluate the effectiveness of the amendment(s) in reducing dissolved-phase concentrations in the vicinity of the reinjection zone during the Pilot Test. The proposed baseline laboratory analysis is different from the facility-wide groundwater monitoring program so none of the proposed baseline wells have historical data to which to compare for all parameters. Note KWB-4 and MW-112 were sampled in October 2013 and November 2014, respectively, in accordance with the facility-wide groundwater monitoring program.

   Wells KWB-4 and MW-112 were selected based on their relative location to the Pilot Test areas (KWB-4 is upgradient of the KWB-5 Pilot Test area; MW-112 is cross/downgradient of both the KWB-5 and MW-131 Pilot Test areas). As stated in the first paragraph on page 14 of the Work Plan, wells with more than 0.3 feet of PSH will not be sampled for laboratory and field parameters during the baseline evaluation. While laboratory and field data from these wells would be incorporated in the baseline evaluation if available, they are outside the immediate Pilot Test area and are not critical to achieve the objective of the baseline groundwater quality monitoring. Groundwater elevations and apparent PSH thicknesses will still be measured in these wells to evaluate the potentiometric surface.

   Groundwater quality data from wells within each Pilot Test area (i.e., KWB-5 and MW-131) are critical for the Pilot Test baseline monitoring. HFNR will revise the Work Plan to state that these wells will be sampled even if there is more than 0.3 feet of PSH present.

b. As described in Response 13a, groundwater quality data from the wells located outside each Pilot Test area, especially upgradient, are not critical to achieve the objective of the baseline groundwater quality monitoring. Nonetheless, measuring baseline groundwater quality in well(s) outside of the immediate Pilot Test area is good practice to provide data regarding potential groundwater quality changes in the general area over the relatively lengthy time of 12 to 18 months that the Pilot Test will be conducted. MW-99 is located sufficiently distal and upgradient from the Pilot Test area such that it will not be affected by it, but is sufficiently close to provide data on any potential upgradient general groundwater quality changes over the duration of the Pilot Test. Gauging data from MW-99 is critical in evaluating the potentiometric surface across the Pilot Test areas and the screened interval will not affect that evaluation.

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c. As described in Response 13b, groundwater quality data from the wells located outside each Pilot Test area, especially upgradient, are not critical to achieve the objective of the baseline groundwater quality monitoring, and their location is adequate to their purpose. Gauging data from these wells are critical in evaluating the potentiometric surface across the Pilot Test areas and the distances of these wells from the Pilot Test area will not negatively affect the interpretation of the potentiometric surface. HFNR believes that upgradient monitoring wells closer to the Pilot Test areas are not required because the proposed upgradient monitoring wells are located adequately proximal to the Pilot Study given the intended use of data obtained from these wells.

d. Please see Response 5b – sulfate concentrations are depressed throughout the dissolved hydrocarbon plume present across the southern portion of the refinery and East Field. The eastern refinery property boundary extends to the east of the East Field as shown on Figures 1 and 2

e. It is difficult to estimate sulfate demand based on stoichiometry as SRBs will be degrading a variety of hydrocarbon compounds and a significant portion of the degraded hydrocarbons will be incorporated into microbial growth. Sulfate amendment rates will be adjusted during the Pilot Test and full-scale system based on groundwater sulfate demand monitoring results as described in Response 5b. The objective of the Pilot Test is to demonstrate sulfate-facilitated degradation of hydrocarbons, regardless of the source of the sulfate.

f. HFNR will revise the Work Plan to include MW-111 in the Pilot Test monitoring program.

<u>Comment 14</u>

In Section 5.2.2 (Installation of Injection, Recovery, and Monitoring Wells), page 14, paragraph 1, the Permittee states, "[i]njection and recovery wells will be separated by a minimum distance of 200 feet to ensure that the radius of influence from recovery drawdown and injection mounding do not overlap." Section 5.0 (Pilot Test Scope) states that the Pilot Test will evaluate the effectiveness of the amendment and reinjection process. Although recirculation and capture of the injectate is not necessary for the test, further reduction of the dissolved phase hydrocarbon concentrations is expected. Explain and discuss the purpose of intentionally isolating the influence of the injection and extraction wells in the revised Work Plan.

<u>Response 14</u>

The primary reason for separating the injection and capture zones is to mimic operation of the full-scale system. The full-scale system would include injection at upgradient points outside of the direct zone of capture of the recovery wells. Additionally, HFNR did not want to bias the results of the test by creating any preferential pathways or circulation cells, which, as noted, will degrade

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dissolved-phase hydrocarbons more rapidly than will be achieved by the full-scale system. HFNR will revise the Work Plan to include this discussion.

Comment 15

In Section 5.2.2 (Installation of Injection, Recovery, and Monitoring Wells), page 15, paragraph 1, the Permittee states, "[a] gamma-log study will be conducted on existing monitoring wells in the area prior to installation of the pilot test injection and recovery wells to verify the gravel seam and silty sand presence, depth, thickness, and extent in each pilot test area. Injection wells will be designed based on the gamma logging results, using lithology from the CME report and/or lithology from borings installed prior to the pilot test to evaluate the pilot test area, if deemed necessary." In the Pilot Test report, include the gamma-log study field data along with any figures and tables generated from the results. Provide a table that summarizes the data ranges generated from the site-specific evaluation that define the lithology at the site. Include a discussion about how the data supports the locations chosen for the installation and design of the injection wells. Furthermore, additional borings will be required to provide additional support to the gamma-log study to verify the gravel seam and silty sand presence. See also Comment 7.

Response 15

HFNR will revise the Work Plan to include a detailed list of documentation/information to be included in the Pilot Test report, including the gamma-log study field data along with any figures and tables generated from the results, a table that summarizes the data ranges generated from the site-specific evaluation that define the lithology at the site, and a discussion about how the data supports the locations chosen for the installation and design of the injection wells.

Respectfully, HFNR does not concur with the statement, *"Furthermore, additional borings will be required to provide additional support to the gamma-log study to verify the gravel seam and silty sand presence."* A significant amount of geologic data for the East Field is already available, including the testing done for the CME Report and the boring logs for the existing wells. HFNR in consultation with NMED will determine the number and location of any additional soil borings after the results of gamma logging evaluation are available. As stated in the Response 7, HFNR will note any deviations to the Work Plan, including any additional evaluation, in the Pilot Test report.

Comment 16

In Section 5.2.2 (Installation of Injection, Recovery, and Monitoring Wells), page 15, paragraph 1, the Permittee states, "[t]he injection wells will be constructed of stainless steel casing and screen, and will be screened across the target lithologic zone." Explain why a stainless-steel casing and screen will be used for the construction of the injection wells. In Appendix A, the Permittee's Supplemental Information Form C-108, Groundwater and Phase-Separated

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Hydrocarbon Recovery System Enhancements Reinjection Pilot Test Work, dated May 30, 2019 states that the maximum possible injection pressure is 150 pounds per square inch (psi).

Presumably, a stainless-steel casing and screen are chosen for the construction of injection wells to accommodate high injection pressures. A high pressure injection technique is not recommended because new fractures and flow paths may potentially develop. Once new fractures develop, the fluid may preferentially flow through the fractures and the fractures could cause short circuiting and the desired cleanup level may not be achieved. Section 5.2.3 states that care will be taken not to exceed pressure suitable for the wellbore and formation; however, a specific description of procedures to prevent formation of new flow paths is not discussed. Provide a provision to limit the injection pressure to prevent new pathways in the revised Work Plan.

Response 16

It is not HFNR's intention to perform reinjection at high pressure. The selection of stainless-steel casing and screen was made based on the HFNR team's previous experience with injection wells, specifically issues related to durability and efficiency of PVC slotted casing vs stainless steel. It is the HFNR team's experience that PVC slotted screens do not function as efficiently as stainless-steel screen. The maximum possible injection pressure listed on Form C-108 is based on pressure ratings/specifications of the associated piping and connections and is provided as described – the maximum *possible* injection pressure. The actual injection pressure will be whatever is needed to reinject at a rate similar to the extraction rate, and no more. HFNR expects the injection pressure not to exceed 5 psi based on the HFNR team's previous experience. HFNR will revise the Work Plan accordingly.

Comment 17

Section 5.2.2 (Installation, Recovery, and Monitoring Wells), page 16, paragraph 2, states "[a]ny PSH present in pilot test monitoring or injection wells will be measured, and if removed, stored temporarily in small totes near the recovery well so that the recovered volume can be tracked separately from the rest of the current recovery system." The Permittee did not indicate where the totes would be stored, the capacity of the totes, or the frequency for removing PSH from the site. It is also unclear if the product will be removed manually or pumped into the tote(s) from the wells. It is not feasible to continuously remove PSH without also extracting groundwater during the Pilot Test operation. Furthermore, since the location of the totes do not appear on Figure 3 (Process and Instrumentation Diagram Sulfate and Ammonia Injection) it appears that the mixture of groundwater and PSH will be recovered and possibly stored in the sulfate holding tank. If it is the Permittee's intent, the sulfate tank will presumably serve as both mixing and separation tank. NMED does not recommend this approach because the amendment mixing process (e.g., mechanical agitation/circulation) will potentially interfere with the process of PSH separation; therefore, each process must be carried out in a separate tank. The mixture must initially be

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retained in the separation tank with enough retention time to separate PSH by gravity; then, only the aqueous solution from the bottom of the tank can be transferred to the mixing tank. Revise Figure 3 to depict (1) where the tote(s) will be located, (2) if piping will be run from the wells to the tote(s) for PSH recovery, (3) location of individual tanks to separate water and PSH and mix the amendments, (4) a skimmer pump that removes PSH from the retention tank, if any, and (5) discuss and illustrate measures to provide adequate mixing for the amendments.

Response 17

As described in Section 5.2.2, page 15, paragraph 2, the recovery wells for the Pilot Test will be installed in the same configuration as the Phase II recovery wells. A copy of the schematic for these wells is provided with this response letter as Attachment B. These recovery wells have three separate well casings installed within the larger 14" diameter outer casing. One casing is used for groundwater recovery (4" diameter casing), one for PSH recovery (4" diameter casing), and one for instrumentation (2" diameter casing). The groundwater recovery pump intake will be set below the water table surface and operated to prevent intake of PSH. If significant amounts of PSH accumulate in either of the recovery wells during the Pilot Test, it will be skimmed from its own casing and pumped directly to a small tote located near the recovery well. An oil/water separator will be used to remove any PSH recovered with the groundwater pump prior to entry into the sulfate holding tank. PSH should not enter the sulfate holding tank, and HFNR will not attempt to mix sulfate amendment in a tank that contains a mixture of PSH and groundwater. HFNR will revise the Work Plan text and figures to clarify how PSH will be managed.

Comment 18

In Section 5.2.2 (Installation of Injection, Recovery, and Monitoring Wells), page 15, paragraph 3, the Permittee states, "[t]he proposed injection and monitoring wells will also be installed as permanent wells but may be abandoned upon completion of the pilot test." The Permittee must propose to retain or abandon the wells in the Pilot Test report. The Permittee must not abandon the wells without concurrence from NMED and OCD.

Response 18

HFNR will propose to retain or abandon the wells in the Pilot Test report and will not abandon the wells without concurrence from NMED and OCD. HFNR does not believe, based on their proximity to each other and to existing refinery wells, that the proposed monitoring and injection points provide enough valuable information outside of the Pilot Test that justifies the expense of maintaining and monitoring these wells in the future.

Comment 19

In Section 5.2.3 (Initial Injection Test), pages 15 to 17, the Permittee describes the initial injection test to determine the optimal injection rate and to observe the hydrogeologic response

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after the injections. However, NMED requires that an initial pump test/aquifer test be conducted to characterize the wells to provide aquifer data that is not dependent on the previous pump tests that were conducted in the trenches. The pump test is also to ensure the correct pumping rates are achieved, to ensure that the well(s) will not run dry, to determine recovery rates to check the radius of influence and determine if there are any impacts to the surrounding wells. The pump test/aquifer test must run, at a minimum, of 24 hours. The Permittee must provide logs for all borings and wells installed at the site. Soil samples must be collected and analyzed for TPH as DRO/GRO/ORO, VOCs, and metals. Groundwater samples must also be tested for the same analytes and SRB at all pertinent wells. Propose the wells to be sampled for SRB in the revised Work Plan. NMED requires 20 days notification prior to beginning drilling activities at the site and also notification when the pump test/aquifer test has been completed. Once the initial testing period has been completed, the Permittee must provide a progress report that summarizes and discusses the test method(s), equipment used, field data results, the pumping rates, include SRB data, aquifer test results, and groundwater and soil sample results. Discuss the hydrogeologic response after the injections and include the lithologic logs. The progress report must also discuss any problems encountered during the testing period. The progress report must be submitted to NMED within 50 days after the initial pump test/aquifer test is completed.

<u>Response 19</u>

HFNR will revise the Work Plan to include most of the items listed under this comment. HFNR respectfully takes exception to the following items:

a. NMED states that a pump test "*…be conducted to characterize the wells to provide aquifer data that is not dependent on the previous pump tests that were conducted in the trenches.*" HFNR believes the aquifer test, as proposed in the Work Plan, is sufficient to collect all of the data needed to define Pilot Test operation. HFNR referred to previous hydrogeologic testing as that data was used to develop the preliminary design for the full-scale system. The only data that was taken from the previous testing was the design injection rate, and this rate was used to ensure that the Pilot Test is consistent with the full-scale system. HFNR is unclear in what other way the proposed pump test is "dependent on the previous pump tests." During the test, the drawdown will be monitored to ensure that the well is not pumped dry and the rate will be set so that recharge will not be overcome.

b. See Response 8 regarding the collection of soil samples for laboratory analysis. The East Field has never been used for industrial purposes, and the collection of soil samples for the parameters listed provides no useful information for the Pilot Test. Any unexpected hydrocarbon impacts as well as the smear zone can and will be noted using standard field screening techniques (i.e. visual, olfactory, and/or PID screening).

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c. See Response 10 regarding the collection of SRBs. Sampling for SRBs is not practical or effective in demonstrating that sulfate reduction is occurring.

Comment 20

In Section 5.2.3 (Initial Injection Test), pages 15 to 17, the Permittee describes the initial injection test to determine the optimal injection rate and to observe the hydrogeologic response after the injections. Address the following in the revised Work Plan:

a. The Permittee did not state if the extracted groundwater will be treated to meet groundwater standards prior to injection. Revise Section 5.2.3 to clarify if the extracted groundwater will be treated prior to injection and what method will be used to treat it. Also, modify Figure 3 to include the measures, if any.

b. There were several incidents that occurred during the Shallow Saturated Zone Groundwater Pump Test that involved failure of equipment (i.e., pumps and transducers) during the test. Ensure all equipment (e.g., pumps and transducers) are checked and tested prior to starting the initial pump/aquifer test and initial injection test.

c. *Provide a table summarizing the pump specifications and transducer installation data for each well. Ensure that the injection flowrates during the test are also summarized in a table. Include the tables in the Pilot Test report.*

d. *Include all field data and notes as an appendix in the Pilot Test report.*

e. *State if the current extraction system will be operating during the installation of the transducers and explain if it will impact the Pilot Test. Also state if the East Fields are still irrigated and if this could also impact the water levels during the Pilot Test.*

Response 20

a. See response to Comment 1. No treatment of recovered water is planned nor required by state law prior to reinjection.

b. HFNR appreciates the reminder. For this test, HFNR will use equipment consistent with the current recovery system so that replacement equipment is readily available. No revisions to the Work Plan are needed to address this comment.

c. HFNR will provide the requested data in a table in the Pilot Test report and will revise the Work Plan to describe what will be presented in the Pilot Test report.

d. HFNR will provide field data and notes as an appendix to the Pilot Test report and will revise the Work Plan to describe what will be presented in the Pilot Test report.

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e. The current extraction system will remain in operation during the Pilot Test. Based on the radius of influence of the existing system as shown on the potentiometric surface maps provided in the *2018 Annual Groundwater Monitoring Report*, the existing recovery system is not expected to affect the Pilot Test. The East Fields are no longer irrigated and will not be irrigated during the Pilot Test. HFNR will add this provision to the Work Plan.

Comment 21

In Section 5.2.3 (Initial Injection Test), page 16, paragraph 4, the Permittee states, "[p]ressure transducers will be placed in the injection wells, monitoring wells, and recovery wells in the pilot test area to measure the groundwater level." Comment 20 requires the Permittee to perform an initial injection test to evaluate the influence of the recovery wells. Since pressure transducers will be in place, record the change of water levels for a period of 24 hours during the injection test. Include the provision in the revised Work Plan.

Response 21

HFNR will revise the Work Plan as requested.

Comment 22

In Section 5.2.3 (Initial Injection Test), pages 16-17, the Permittee states, "[t]he anticipated injection rates for the first three steps of the test are 4, 8, and 12 [gallons per minute (gpm)] based on groundwater modeling performed in 2016 and 2018." The site formation may likely be too tight based on the lithology of the area to allow 4 gpm per well during the initial injection step. The proposed injection rate may cause injectate to overflow. Consider starting the initial injection rate at one gpm and gradually increase the injection rate if the water level continues to stabilize. Otherwise, demonstrate that the anticipated injection rates (4, 8, and 12 gpm) are appropriate starting points for the initial injection test.

Response 22

HFNR will revise the Work Plan to state the initial injection rate will be 1 gpm and will be increased to a maximum of 12 gpm depending upon the capacity of the injection well. Overflow will be prevented as the injection wells will be capped to allow for recirculation of water below 5 psi.

Comment 23

In Section 5.2.5 (Treatment Efficiency Evaluation), page 18, paragraph 1, the Permittee states, "[t]o prevent fouling of the injection system and injection well, it is critical that the redox condition of the extracted water remains anaerobic throughout the recirculation process, to the degree feasible." The recirculation system must include a function to remove the recovered PSH and to meet all injection criteria of the groundwater (see Comments 1 and 17). Section 5.2.6 states that

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the PSH recovered volume will be recorded; however, Figure 3 does not depict any mechanism to remove PSH (e.g., oil-water separator). Include the provisions in the revised Work Plan. Additionally, discuss specific measures that will prevent the extracted groundwater from being aerated in the recirculation process in the revised Work Plan.

Response 23

See Response 1 and 17. The injection criteria of the Pilot Test and full-scale system is to remove PSH (if present) and add amendments (terminal electron acceptors) to reduce hydrocarbons in situ by EAB. PSH will be removed as necessary with an OWS prior to recirculation of the extracted water. PSH will not be allowed to enter the amendment tank(s). Figure 3 of the Work Plan will be revised to show how PSH will be managed.

HFNR will revise the Work Plan to provide more detail about the specific measures that will minimize aeration of the recirculated water. Such measures include, ensuring all connections maintain an air-tight seal; selecting flow meters and pumps that minimize turbulence; capping the injection and recovery wells; and injecting through drop tubes that extend below the groundwater level within injection wells to prevent oxidization of injected anaerobic water. In addition, metal fittings and manifolds will be minimized so that any oxygen that may be inadvertently introduced to the recirculation system does not oxidize the ferrous iron and foul the recirculation plumbing or wells. Air leaks in these recirculation systems are easy to detect (creates hissing sound associated with air aspiration) and will be repaired immediately.

Comment 24

Section 5.2.7 (Groundwater Monitoring), page 21, paragraph 1 states, "[w]here feasible, the pump intake should also be installed at least four feet below the smear zone to minimize the potential for sampling colloids associated with partially degraded hydrocarbons in smear zones." The proposed sampling method is acceptable; however, the pump intake for the recovery wells must not be installed more than two feet below the smear zone. Contaminants may be introduced to the clean soils beneath the smear zone if the pump intake is installed too far below the smear zone. Identify the lowest groundwater elevations historically recorded in nearby wells to determine specific depths where pump inlets will be placed in the recovery wells in the revised Work Plan.

Response 24

HFNR will revise the Work Plan to indicate a maximum drawdown of two feet below the smear zone. The pump intake depth must remain below the water surface so that air is not entrained during extraction and to prevent pump malfunction. The Work Plan will be revised to include the lowest historical groundwater elevations at wells near each proposed recovery well.

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Comment 25

In Section 5.2.7 (Groundwater Monitoring) page 21, paragraph 2, the Permittee describes how the injection flow rates and amendment feed rates will be adjusted based on the daily monitoring results and sulfate concentration at the wells. NMED Comment 12 directs the Permittee to include a tracer and to monitor the tracer concentrations in the monitoring wells in order to optimize the system. Revise the Work Plan to incorporate the data collected from the tracer testing data for system adjustment as well. In addition, Table 1 (Dosing Rate Calculations) provides calculations to prepare sulfate stock solution and injectate that contains 2,000 mg/L sulfate. Table 1 also indicates that the sulfate concentration in the formation is targeted to reach from 300 mg/L to 500 mg/L. As stated in Comment 5, the sulfate amendment may not be necessary. Table 1 does not include calculations to estimate the volume of injectate necessary to achieve the target formation concentration. Revise Table 1 to include these calculations. Table 1 does not provide any dosing calculations for ammonia. Revise Table 1 to include the ammonia calculations.

Response 25

See Response 12. HFNR will use magnesium as a tracer and will revise the Work Plan to clarify how magnesium monitoring data will be used.

The target sulfate injectate concentration (2,000 mg/L) and target groundwater concentration in the formation (500 mg/L) are initial targets selected based on the HFNR team's experience with similar projects. These target concentrations will be refined during completion of the Pilot Test based on estimated sulfate demand of the formation. Sulfate demand will change over time as described in Response 5. HFNR will revise the Work Plan to clarify how the target concentrations were selected and Table 1 to include the calculations made to determine the volume of injectate necessary to achieve the target formation concentration.

HFNR will revise Table 1 to include the requested ammonia dosing calculations.

Comment 26

In Section 5.2.7 (Groundwater Monitoring), page 21, bullet item 5, the Permittee states that "[o]nce sulfate is detected at a concentration above 500 mg/L in all of the monitoring wells between the injection and recovery wells, quarterly sampling events will begin on all wells listed above." The baseline sulfate levels in some monitoring wells in the vicinity exceed 300 mg/L (e.g., wells KWB-6 and MW-111), Provide a justification for the referenced concentration of 500 mg/L in the revised Work Plan.

Response 26

The referenced criterion of 500 mg/L is an initial target sulfate concentration to be present throughout the targeted formation and not just in select pockets on the peripheral of the

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hydrocarbon plume. As described in Response 25, this target concentration was selected based on the HFNR team's experience with similar projects but will be adjusted based on estimated sulfate demand within each Pilot Test area. HFNR will revise the Work Plan to provide justification of the selected target concentration and clarify how the target will change.

Comment 27

In Section 5.2.8 (Data Processing), page 22, paragraph 1, the Permittee states that "[d]ata will be presented in interim progress reports to be provided to NMED and OCD on a quarterly basis. A summary report including all the data and results of the test will be submitted after the completion of pilot test activities and prior to the implementation of the full-scale system upgrade." The Permittee is also required to submit the final Pilot Test data and results as a final investigation report (Pilot Test report). Furthermore, prior to implementing the full-scale system, NMED and OCD must approve the conclusions and the recommendations provided in the Pilot Test Report. The decision to move forward to the full-scale system installation will be based on the Pilot Test results.

Response 27

HFNR agrees with Comment 27. HFNR will revise the Work Plan termination and change "summary report" to "Final Investigation Report (Pilot Test report)".

Comment 28

Section 5.3.1 (Installation of Pilot Test Injection, Recovery, and Monitoring Wells), pages 22-24, discusses the details regarding the installation of the Pilot Test wells. Although the expected screen length is described, the provision for the screen to intersect the water table is not included.

The screens for the Pilot Test recovery and monitoring wells must intersect the water table. Include the provision in the revised Work Plan. In addition, the approximate distances between the wells (e.g., distance between wells IW-1 and PMW-1) are not stated in Section 5.2.2. State the distances between the wells in the revised Work Plan.

Response 28

HFNR will revise the Work Plan to include the provision that well screens intersect the water table and the distances between injection and monitoring wells.

Comment 29

Section 5.3.1 (Installation of Pilot Test Injection, Recovery, and Monitoring Wells), pages 22-24, describes the specifications for the injection, recovery and monitoring wells for the Pilot Test but does not provide proposed construction diagrams for these wells. Include construction diagrams for the injection, recovery and monitoring wells in the revised Work Plan. In addition, the screened intervals of the injection wells must be set below the water table and should not be set across the

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water table for more uniform distribution of injectate. Include the provision in the revised Work Plan.

Response 29

HFNR will revise the Work Plan to include proposed construction diagrams for injection, monitoring, and recovery wells, and the provision that injection wells are screened below the water table.

Comment 30

Section 5.3.1 (Installation of Pilot Test Injection, Recovery, and Monitoring Wells), page 23, paragraph 1, states, "[t]wo 4-inch diameter casings (one for PSH recovery and one for water recovery) and a single 2-inch diameter casing (for measurement) will be installed in each recovery well borehole." Provide a well construction diagram of the proposed recovery wells in the revised Work Plan.

Response 30

HFNR will revise the Work Plan to include the proposed well construction diagram, and a copy is provided with this response letter as Attachment B.

Comment 31

Section 5.3.1 (Installation of Pilot Test Injection, Recovery, and Monitoring Wells), page 23, paragraph 1, states, "[e]ach injection well will be screened at or slightly below the top of the target lithologic zone (i.e., gravel and silty sand interval), with an expected screen length of 10 feet, and will include a 2-foot sump below the screened interval." If the purpose of the sump is to protect the screen from organic debris in the injectate, the recirculation system must also be equipped with a filter that eliminates the debris. Include the provision in the Work Plan, as necessary.

Response 31

The primary reason for the sump is to allow for proper installation and operation of the drop tube to recirculate water with minimal turbulence and without the introduction of air. No filter should be needed because the recovery wells will be property developed and anaerobic water generally has low turbidity. The use of a filter will be avoided as the filtration process leads to increased turbulence and possible oxidation which could cause downstream fouling. Furthermore, opening the system to change the suggested filter elements would introduce air into the system.

Comment 32

In Section 5.3.1 (Installation of Pilot Test Injection, Recovery, and Monitoring Wells), page 23, paragraph 3, the Permittee states, "[i]njection wells will be permitted as temporary wells that may

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be abandoned at the end of the pilot test; however, the injection wells will be constructed to the same specifications as using permanent wells. Recovery wells will be permitted and constructed as permanent recovery wells using the same configuration as the Phase II recovery wells. Monitoring wells installed for the pilot test will be permitted as temporary wells and will likely be abandoned at the end of the pilot test." It is not clear to NMED why the Permittee considers these wells to be temporary wells as they could be a part of the design of the remediation system at the facility boundary when the full-scale system is in operation. Explain why these wells will not be utilized as part of the final full-scale system. Furthermore, the wells must not be abandoned without concurrence from NMED and OCD (Comment 18).

Response 32

As stated in the Work Plan, injection wells are considered temporary but will be constructed so that they can be left in place and used as part of the full-scale system (i.e. constructed to the same specifications) if determined to be beneficial or necessary for successful full-scale system operation. See Response 18 for discussion of temporary monitoring wells.

Comment 33

Section 5.3.1 (Installation of Pilot Test Injection, Recovery, and Monitoring Wells), page 24, paragraph 1, states, "[s] ample information and visual observations of the cuttings and core samples shall be recorded on the boring log. Soil samples will not be collected for laboratory analysis during installation." The Permittee must record and depict the smear zone on all of the logs (i.e., exploratory borings and developed wells) where groundwater is encountered during drilling activities and state the depths for each injection, recovery and monitoring well in the applicable section(s) of the Pilot Test report. Soil samples must be collected above the saturated zone, within the vadose zone where the highest PID reading is recorded, and at the bottom of each boring. Propose to analyze the soil samples for TPH as DRO/GRO/ORO, VOCs, and metals in the revised Work Plan.

Response 33

HFNR will revise the Work Plan to include the provision to record and depict the smear zone on all of the boring logs. See Response 8 regarding collection of soil samples.

Comment 34

Section 5.3.1 (Installation of Pilot Test Injection, Recovery, and Monitoring Wells), page 24, paragraph 2 states that "[t]he following visual observations will be recorded on the boring log: lithology (color, type, grain size, sorting, etc.), moisture content (dry, damp, wet, moist), and any field evidence of contamination (staining, odor, and photoionization detector [PID] readings)." In addition to this information, the Permittee must also attempt to identify the smear zone on the logs based on field screening (see Comment 34).

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Response 34

See Response 33.

Comment 35

In Section 5.3.4 (Groundwater Sampling), page 26, paragraph 2, the Permittee states that "[t]he purging process will be considered complete and groundwater sampling will commence when at least four of the seven water quality parameters [(pH, temperature, conductivity, TDS, ORP, DO and turbidity)] achieve stabilization within ten% for three consecutive readings." Although at least four of the seven water quality parameters are required to reach stabilization, the Permittee must ensure that all seven water quality parameters are recorded during each consecutive reading and all seven parameters must be reported after the final reading in a table presented in the Pilot Test report.

Response 35

HFNR will revise the Work Plan to specify that all seven water quality parameters are recorded throughout and at the end of purging, and that the data is provided in the Pilot Test report.

Comment 36

In Section 5.5 (Treatment Test Effectiveness), page 28, paragraph 1, the Permittee states that "[t]he amendments will be considered effective if dissolved phase concentrations decrease during the test." The Permittee did not define a percent reduction of the dissolved phase concentrations for the amendments to be considered effective. Provide an approximation for percent decrease in concentrations that the Permittee will consider the amendments to be considered effective and state if that will be measured not only in concentration decrease but over a set time period as well. Also state how many and which constituents of concern (COCs) will be considered to determine the effectiveness of the amendment.

Response 36

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HFNR will revise the Work Plan to include an approximation for the expected percent decrease in dissolved hydrocarbon concentrations during the Pilot Test, with the caveat that any such approximation is based on the HFNR team's experience at other sites and is subject to significant variation. Based on the HFNR team's experience at other sites, dissolved hydrocarbons are anticipated to decrease between 50% and 90% but the degradation rate is site-specific and varies for each hydrocarbon compound. For example, benzene generally degrades faster than xylenes and ortho-xylenes degrade faster than meta-xylenes. The dissolved hydrocarbons that will be evaluated during the Pilot Test are specified in Section 5.2.7 of the Work Plan.

The trend in dissolved hydrocarbon concentrations over the Pilot Test will also be considered. The Pilot Test is intended to run for a maximum of 18 months and the trend in all measured dissolved hydrocarbon concentrations will be evaluated over the entire period of the test. While not expected, it is possible that the predicted hydrocarbon percentage reduction range described above may not be reached during the course of the Pilot Test. However, if the trend in concentration data is decreasing and indicates target concentrations in groundwater could be reached in a reasonable period of time beyond the timeframe of the Pilot Test, this data can still be used in design of upgrades to the full-scale system. In other words, failure to reach any predicted percent reduction may not result in the approach being deemed unsuccessful. The final recommendation for modifications to the system will be based on careful and thorough evaluation of all the pilot test data and not just comparison of predicted versus measured percent reduction. HFNR will make the other changes requested.

Comment 37

Section 6.0 (Schedule), page 30, outlines a proposed schedule once NMED and OCD approve the Work Plan. Revise the schedule to include the additional work required by the comments in this Disapproval and submit an updated schedule in the revised Work Plan.

Response 37

HFNR will revise the schedule based on the revisions to the Work Plan.

Comment 38

Section 7.0 (Tables) includes Table 1 (Dosing Rate Calculations). It would facilitate NMED's review to include an additional table that summarizes the current hydrogeologic properties (both measured and modeled) that were used to generate the Work Plan, determine the location of the Pilot Test and also include where the value came from (i.e., measured during [Cite Report] or modeled data from [Cite Report]). The table must be updated with the measured and/or modeled hydrogeologic properties from the completed Pilot Test. Provide the appropriate tables in the revised Work Plan.

Response 38

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HFNR revise the Work Plan to include the requested table.

Comment 39

The maximum contaminant level (MCL,) and water quality control commission (WQCC) standard for sulfate are 250 mg/L and 600 mg/L, respectively. The tap water regional screening level (RSL) for hydrogen sulfide, a potential product of sulfate reduction, is 4.2 ug/L. Include a discussion regarding potential the risks associated with sulfate injection in the revised Work Plan.

Response 39

Sulfate does not have a primary MCL. Sulfate is a nuisance chemical and has a secondary MCL of 250 mg/L. Secondary MCLs are non-mandatory and established as guidelines to assist public water systems in managing their drinking water for aesthetic considerations.

As determined by years of groundwater monitoring, the concentrations of sulfate exceed the secondary MCL and the WQCC standard by a significant amount in areas where no hydrocarbon impacts are present and in wells located west (upgradient) of the refinery (see Figure 2).

In light of the significantly higher sulfate concentrations in areas all around the Refinery (in excess of 4,000 mg/L in some locations), the addition of sulfate to groundwater in the East Field to increase concentrations to 500 mg/L poses negligible risk as compared to sulfate concentrations already present. Further, sulfate injected during the Pilot Test or the full-scale system will be used by the indigenous SRB to consume hydrocarbons, or if not used, captured by the downgradient recovery system and sent back "upstream". Once the goals of the system are achieved, the sulfate injections will stop, and aquifer conditions will return to aerobic conditions.

Sulfide is the typical end product of sulfate reduction as described in Response 10. Hydrogen sulfide is only a potential product of sulfate reduction in acidic environments or in environments absent of metals to precipitate the sulfide. Groundwater in the Shallow Saturated Zone across the refinery is neutral as indicated by pH data collected in the field during routine semi-annual groundwater monitoring events. Field staff wear personal hydrogen sulfide air monitors during monitoring activities (and will do so during the Pilot Test) and have not detected any hydrogen sulfide gas during groundwater monitoring within the hydrocarbon plume where sulfate reduction is ongoing. Further, the presence of black particulates in and/or slightly grey turbid purge water observed within the hydrocarbon plume during groundwater sampling activities (noted on Table 2 in Annual Groundwater Monitoring Reports) is an indication of iron sulfide precipitants associated with sulfate reduction ongoing at the site. Therefore, it is unlikely hydrogen sulfide will be generated during sulfate injection. Any hydrogen sulfide generated may accumulate in the PSH tank. HFNR's hydrogen sulfide mitigation measures will be implemented to ensure the safety of the field personnel.

CLOSING

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HFNR looks forward to discussing the Pilot Test and these responses with NMED in an upcoming meeting. The goal of the meeting is to come to final agreement on all items so we can revise and finalize the Work Plan and commence the Pilot Test. Should you have any questions or need any additional information prior to that meeting, please do not hesitate to contact me by phone at (575) 746-5487 or Robert Combs at (575) 746-5382.

Sincerely,

Scott M. Denton
Environmental Manager

Attachments:

Figure 1 – Benzene Isoconcentration Map (First 2018 Semiannual Event)

Figure 2 – Sulfate Isoconcentration Map (First 2018 Semiannual Event)

Figure 3 – Historically Depressed Sulfate Concentrations, Comment 5b

Attachment A – Enhanced Anaerobic Biodegradation (EAB) Case Studies

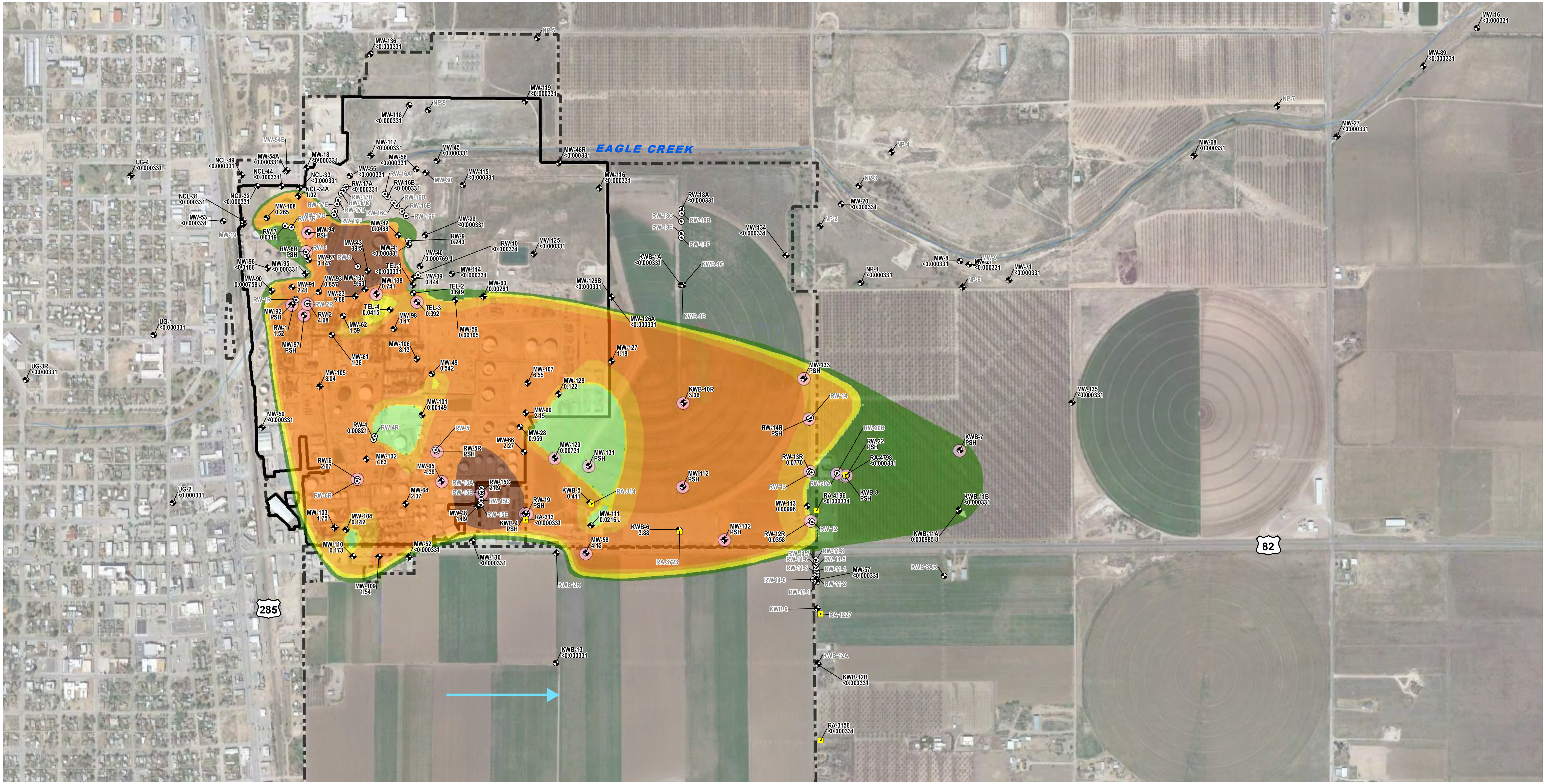
Case Study 1: St Marys Refinery, St. Marys West Virginia

Case study 2: ELK Refinery, Clendenin, West Virginia

Attachment B – Typical Recovery Well Plan and Profile – Phase II

cc: NMED: D. Cobrain, K. Van Horn, L. Tsinnajinnie, M. Suzuki,
OCD: C. Chavez, J. Griswold
HFC: M. Holder, R. Combs, J. Leik
TRC: J. Speer, C. Smith,

FIGURES



LEGEND

- MONITORING WELL
- RECOVERY WELL
- IRRIGATION WELL IN MONITORING PROGRAM
- **1.75** BENZENE CONCENTRATION
- **<0.000331** BENZENE NOT DETECTED ABOVE METHOD DETECTION LIMIT
- **PSH** PHASE-SEPARATED HYDROCARBON PRESENT IN WELL (≥ 0.03 FEET THICK)
- **KWB-9** WELL NOT SAMPLED
- REFINERY FENCELINE
- FACILITY PROPERTY BOUNDARY (FENCELINE SHOWN WHERE COINCIDENT)
- GROUNDWATER FLOW DIRECTION
- PSH PRESENCE 2016-2018

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NOTES:

1. ALL CONCENTRATIONS ARE IN MILLIGRAMS PER LITER (mg/L).
2. J = CONCENTRATION QUALIFIED AS AN ESTIMATED VALUE.
3. ALL MONITORING AND RECOVERY WELLS ARE SCREENED IN THE SHALLOW SATURATED OR VALLEY FILL ZONES. IRRIGATION WELLS INCLUDED IN THE MONITORING PROGRAM ARE SCREENED IN EITHER THE VALLEY FILL ZONE OR THE DEEP ARTESIAN AQUIFER.
4. BENZENE CRITICAL GROUNDWATER SCREENING LEVEL (CGWSL) = 0.005 mg/L

AERIAL IMAGERY SOURCE: GOOGLE EARTH PRO AND THEIR DATA PARTNERS, 3/12/2016.

BENZENE CONCENTRATION FROM 2018 FIRST SEMIANNUAL EVENT (mg/L)

- 0 - 0.0001
- 0.0001 - 0.001
- 0.001 - 0.01
- 0.01 - 0.1
- 0.1 - 1.0
- 1.0 - 10
- 10 - 100

0 500 1,000 Feet
1 " = 1,000 '
1:12,000

PROJECT:	NMED JULY 22, 2019 RESPONSE TO COMMENTS LETTER HOLLYFRONTIER NAVAJO REFINERY LLC ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO
TITLE:	BENZENE ISOCONCENTRATION MAP (FIRST 2018 SEMIANNUAL EVENT)
DRAWN BY:	MHORN
PROJ. NO.:	326693
CHECKED BY:	AELJURI
APPROVED BY:	JSPEER
DATE:	AUGUST 2019
	FIGURE 1
FILE NO.:	326693_1_BenzSpring.mxd

TRC
505 East Huntland Drive, Suite 250
Austin, TX 78752
Phone: 512.329.6080
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Plot Date: 8/13/2019, 16:43:22 PM by MHORN -- LAYOUT: ANSI B(11"x17")
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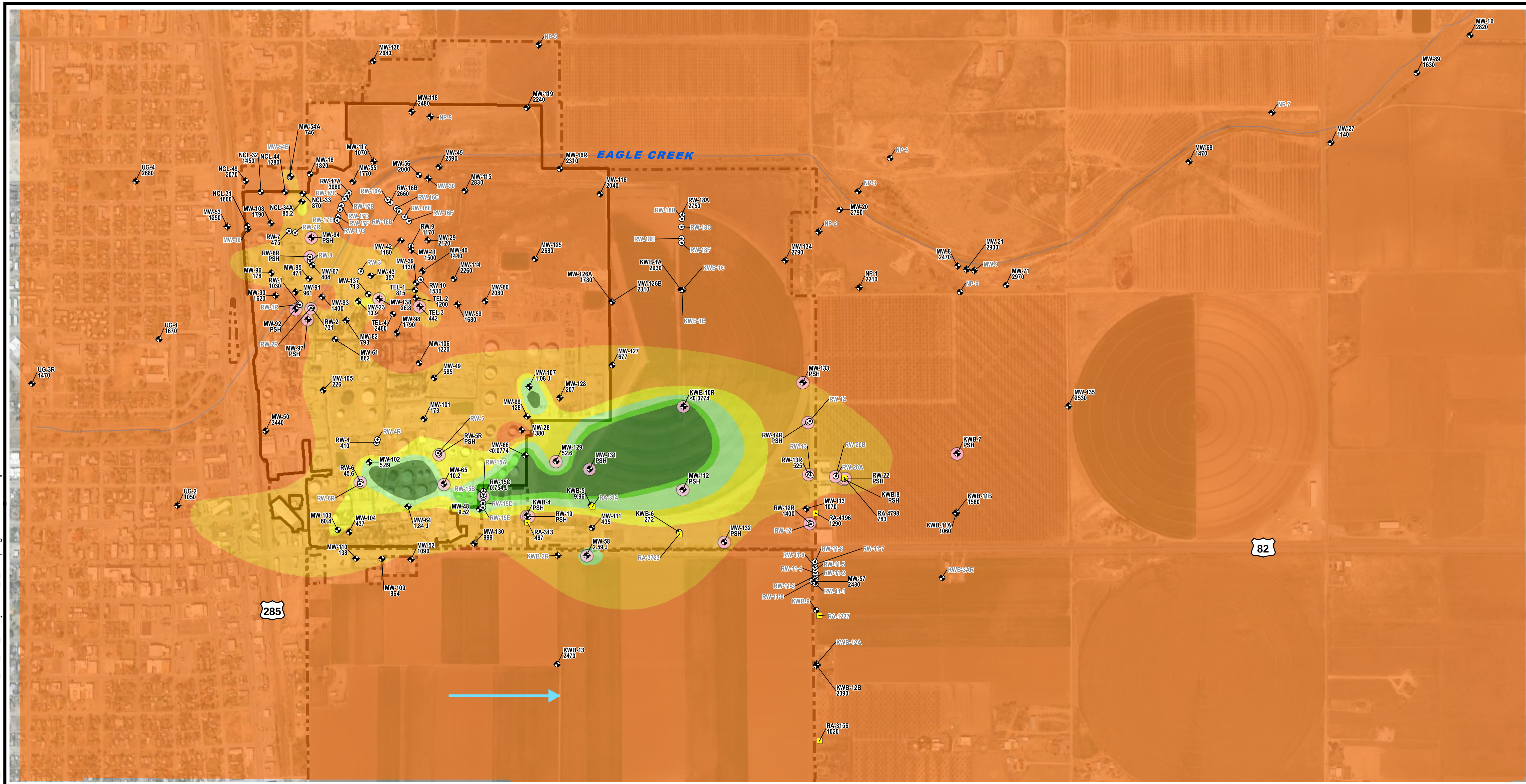
Coordinate System: NAD 1983 2011 StatePlane New Mexico East FIPS 3001 Ft US (Foot US)
Map Rotation: 0

TRC - GIS



LEGEND

- MONITORING WELL
- RECOVERY WELL
- IRRIGATION WELL IN MONITORING PROGRAM
- 1030 SULFATE CONCENTRATION
- <0.0774 SULFATE NOT DETECTED ABOVE METHOD DETECTION LIMIT
- PSH PHASE-SEPARATED HYDROCARBON PRESENT IN WELL (≥ 0.03 FEET THICK)
- KWB-9 WELL NOT SAMPLED
- REFINERY FENCELINE
- FACILITY PROPERTY BOUNDARY (FENCELINE SHOWN WHERE COINCIDENT)
- GROUNDWATER FLOW DIRECTION
- PSH PRESENCE 2016-2018

DRAFT

NOTES:

1. ALL CONCENTRATIONS ARE IN MILLIGRAMS PER LITER (mg/L).
2. J = CONCENTRATION QUALIFIED AS AN ESTIMATED VALUE.
3. ALL MONITORING AND RECOVERY WELLS ARE SCREENED IN THE SHALLOW SATURATED OR VALLEY FILL ZONES. IRRIGATION WELLS INCLUDED IN THE MONITORING PROGRAM ARE SCREENED IN EITHER THE VALLEY FILL ZONE OR THE DEEP ARTESIAN AQUIFER.
4. SULFATE CRITICAL GROUNDWATER SCREENING LEVEL (CGWSL) = 600 mg/L

AERIAL IMAGERY SOURCE: GOOGLE EARTH PRO AND THEIR DATA PARTNERS, 3/12/2016.

SULFATE CONCENTRATION FROM 2018 FIRST SEMIANNUAL EVENT (mg/L)

- 0-0.1
- 0.1-1.0
- 1.0-10
- 10-100
- 100-1,000
- 1,000-10,000

0 500 1,000 Feet

1 " = 1,000 '

1:12,000

PROJECT:
NMED JULY 22, 2019 RESPONSE TO COMMENTS LETTER
HOLLYFRONTIER NAVAJO REFINERY LLC
ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO

TITLE:
SULFATE ISOCONCENTRATION MAP
(FIRST 2018 SEMIANNUAL EVENT)

DRAWN BY:	MHORN	PROJ. NO.:	326693
CHECKED BY:	AELJURI		
APPROVED BY:	JSPEER	**FIGURE 2**	
DATE:	AUGUST 2019		

TRC

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FILE NO.: 326693_2_SulfSpring.mxd

Coordinate System: NAD 1983 2011 StatePlane New Mexico East FIPS 3001 Ft US (Foot US)
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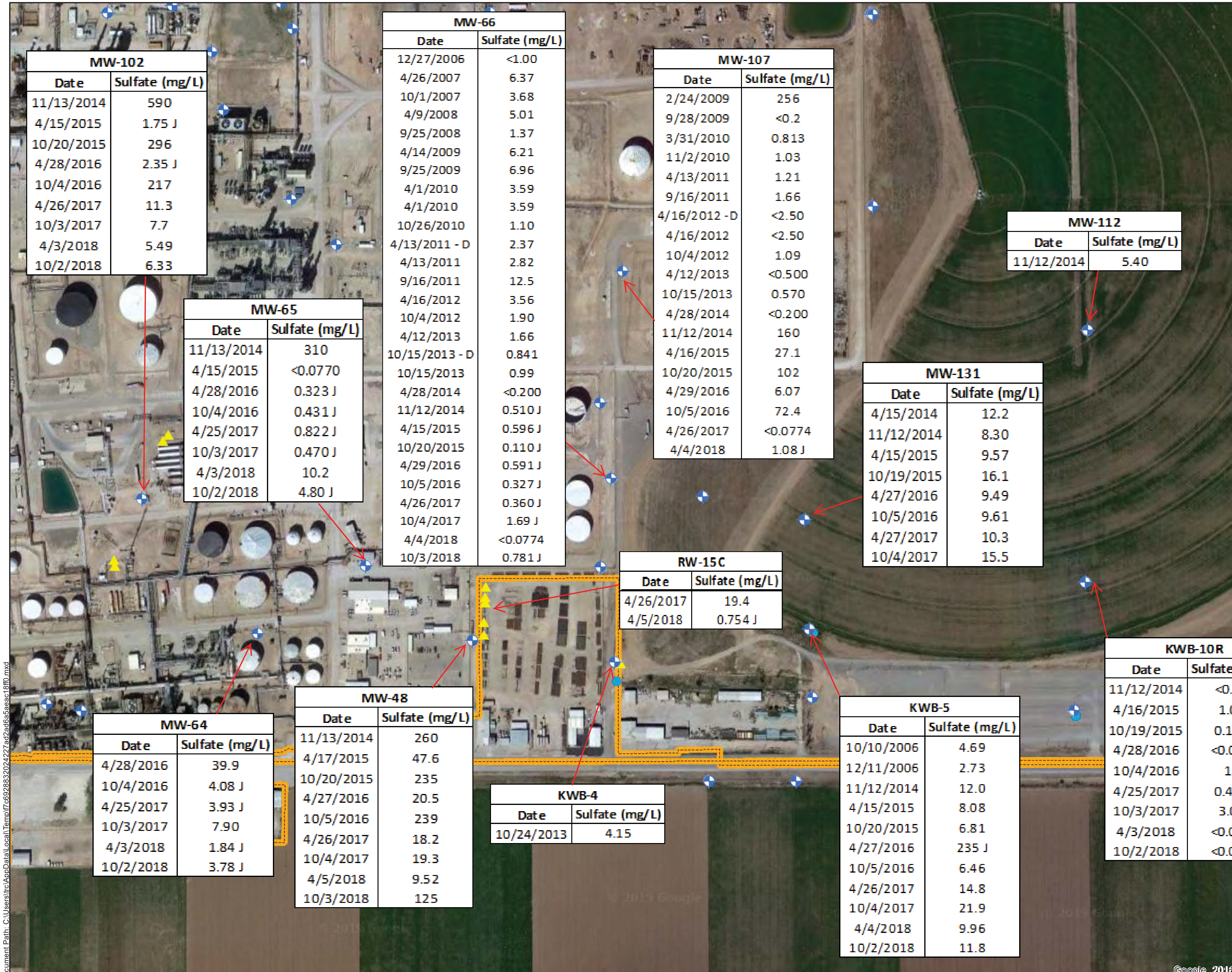
TRC - GIS



MW-102	
Date	Sulfate (mg/L)
11/13/2014	590
4/15/2015	1.75 J
10/20/2015	296
4/28/2016	2.35 J
10/4/2016	217
4/26/2017	11.3
10/3/2017	7.7
4/3/2018	5.49
10/2/2018	6.33

MW-65	
Date	Sulfate (mg/L)
11/13/2014	310
4/15/2015	<0.0770
4/28/2016	0.323 J
10/4/2016	0.431 J
4/25/2017	0.822 J
10/3/2017	0.470 J
4/3/2018	10.2
10/2/2018	4.80 J

MW-66	
Date	Sulfate (mg/L)
12/27/2006	<1.00
4/26/2007	6.37
10/1/2007	3.68
4/9/2008	5.01
9/25/2008	1.37
4/14/2009	6.21
9/25/2009	6.96
4/1/2010	3.59
4/1/2010	3.59
10/26/2010	1.10
4/13/2011 - D	2.37
4/13/2011	2.82
9/16/2011	12.5
4/16/2012	3.56
10/4/2012	1.90
4/12/2013	1.66
10/15/2013 - D	0.841
10/15/2013	0.99
4/28/2014	<0.200
11/12/2014	0.510 J
4/15/2015	0.596 J
10/20/2015	0.110 J
4/29/2016	0.591 J
10/5/2016	0.327 J
4/26/2017	0.360 J
10/4/2017	1.69 J
4/4/2018	<0.0774
10/3/2018	0.781 J

MW-107	
Date	Sulfate (mg/L)
2/24/2009	256
9/28/2009	<0.2
3/31/2010	0.813
11/2/2010	1.03
4/13/2011	1.21
9/16/2011	1.66
4/16/2012 -D	<2.50
4/16/2012	<2.50
10/4/2012	1.09
4/12/2013	<0.500
10/15/2013	0.570
4/28/2014	<0.200
11/12/2014	160
4/16/2015	27.1
10/20/2015	102
4/29/2016	6.07
10/5/2016	72.4
4/26/2017	<0.0774
4/4/2018	1.08 J

MW-112	
Date	Sulfate (mg/L)
11/12/2014	5.40

MW-131	
Date	Sulfate (mg/L)
4/15/2014	12.2
11/12/2014	8.30
4/15/2015	9.57
10/19/2015	16.1
4/27/2016	9.49
10/5/2016	9.61
4/27/2017	10.3
10/4/2017	15.5

RW-15C	
Date	Sulfate (mg/L)
4/26/2017	19.4
4/5/2018	0.754 J

MW-64	
Date	Sulfate (mg/L)
4/28/2016	39.9
10/4/2016	4.08 J
4/25/2017	3.93 J
10/3/2017	7.90
4/3/2018	1.84 J
10/2/2018	3.78 J

MW-48	
Date	Sulfate (mg/L)
11/13/2014	260
4/17/2015	47.6
10/20/2015	235
4/27/2016	20.5
10/5/2016	239
4/26/2017	18.2
10/4/2017	19.3
4/5/2018	9.52
10/3/2018	125

KWB-4	
Date	Sulfate (mg/L)
10/24/2013	4.15

KWB-5	
Date	Sulfate (mg/L)
10/10/2006	4.69
12/11/2006	2.73
11/12/2014	12.0
4/15/2015	8.08
10/20/2015	6.81
4/27/2016	235 J
10/5/2016	6.46
4/26/2017	14.8
10/4/2017	21.9
4/4/2018	9.96
10/2/2018	11.8

KWB-10R	
Date	Sulfate (mg/L)
11/12/2014	<0.077
4/16/2015	1.03 J
10/19/2015	0.117 J
4/28/2016	<0.0774
10/4/2016	110
4/25/2017	0.475 J
10/3/2017	3.08 J
4/3/2018	<0.0774
10/2/2018	<0.0774

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N

Due to this map being projected in the WGS84 EPSG:3857 one cannot accurately scale distances or areas from it. This map should be used for reference purposes only.

LEGEND

- Monitoring Well
- Recovery Well
- Irrigation Well
- Navajo Property
- Well ID and Historical Sulfate Concentrations

FIGURE 3 - HISTORICALLY DEPRESSED SULFATE CONCENTRATIONS, NMED JULY 22, 2019 LETTER, COMMENT 5b

DRAFT

Coordinate System: WGS 1984 Web Mercator Auxiliary Sphere
Projection: Mercator Auxiliary Sphere
Datum: WGS 1984
False Easting: 0.0000
False Northing: 0.0000
Central Meridian: 0.0000
Standard Parallel 1: 0.0000
Auxiliary Sphere Type: 0.0000
Units: Meter

Document Path: C:\Users\trc\AppData\Local\Temp\7c6928832024227ad2ad6a5aeac18ff0.mxd

ATTACHMENT A – CASE STUDY 1

ST MARYS REFINERY, ST MARYS, WEST VIRGINIA

Enhanced Anaerobic Biodegradation (EAB)

Case Study 1:

St Marys Refinery, St. Marys West Virginia

TRC
Results you can rely on

Enhanced Anaerobic Biodegradation (EAB)

- EAB – engineered use of non-oxygen electron acceptors to accelerate the microbial metabolism of petroleum hydrocarbons
- Sulfate is the most common non-oxygen electron acceptor selected (see next slide)
- Sulfate reducing bacteria (SRBs) are ubiquitous and are readily stimulated with the addition of sulfate and nutrients
- Degradation of benzene

$$C_6H_6 + 3.75\ SO_4^{2-} + 3H_2O \rightarrow 1.875\ H_2S + 1.875\ HS^{-} + 6\ HCO_3^{-} + 0.375\ H^{+}$$

- SRBs can effectively degrade a broad range of hydrocarbons (HCs)
- SRBs can effectively desorb and degrade adsorbed phase HCs

Comparative Electron Acceptor Potential to Degrade Benzene

Electron Acceptor (EA)	Effective Max Concentration in Water (mg/L)	Reaction Yield: benzene mass degraded per unit mass of EA	Potential Max Benzene Degraded (mg/L)	Potential Complications
Oxygen (ambient air sources)	8 – 10	0.33	3.0 – 3.3	•Limited solubility •**Numerous non-target scavengers** •Potential for aquifer clogging through biofouling and iron precipitation
Oxygen (pure)	40 – 70	0.33	19.8 – 23.1	
Nitrate	670,000 ($NaNO_3$) 1.1x105 ($Mg(NO_3)_2$)	0.21	140,000 220,000	•Primary MCL – 10 mg/L NO_3-N (45 mg/L NO_3)
Iron (III)	0 - 1	0.024	0 – 0.024	• Not practical to inject – very low solubility at neutral aquifer pH
Sulfate	**70,000 (Na_2SO_4)** **250,000 ($MgSO_4$)**	**0.20**	**9,000** **25,000**	**•Secondary MCL for sulfate – 250 mg/L** **•Hydrogen sulfide; rarely documented as an issue in the field**

(Adapted from Cunningham et al., 2001)

Favorable EAB Conditions

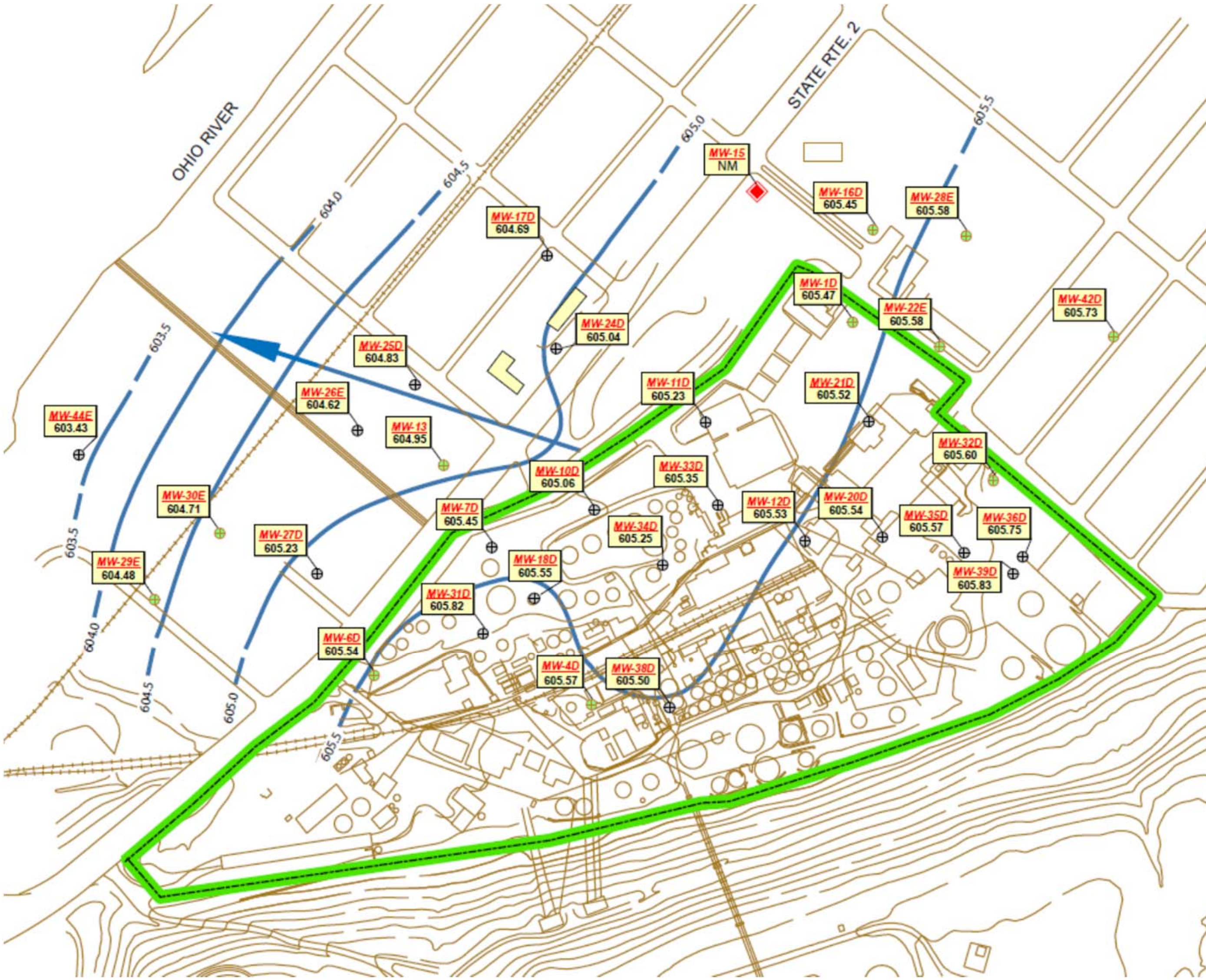
- Anaerobic aquifer – ORP between -150 and -250 mV
- Depleted sulfate mass within hydrocarbon plume – inverse concentration correlation between hydrocarbons (HCs) and sulfate
  - Usually non-detect if well screen is entirely within the hydrocarbon plume
  - If dissolved-phase HCs are vertically stratified across the well screen (low mass plumes or long wells screens can result in elevated HC concentrations shallow and low to ND concentrations towards the bottom of the well) – sulfate concentrations will be ND shallow and increase with depth
  - Sampling from vertically stratified well may result in the presence of sulfate and HCs in GW sample from the middle of the screen
- Differential degradation rates of similar HCs
  - o-xylenes are typically more degradable than m/p-xylenes under sulfate reducing conditions resulting in 1/10 ratio of o-xylene to m/p-xylenes – typical non degraded ratio is ½
  - A similar trend can be identified between 1,2,4-trimethylbenzene (1,2,4-TMB) and 1,3,5-TMB
- Differential degradation rates are very strong evidence of microbial degradation

Refinery Description

- Active refinery 1913 to 1993
- Active Tank Farm 1993 to present
- 30-acre refinery area
- 70-acre tank farms and landfills (not a groundwater source)
- Refined Pennsylvania crude into fuels and lubricants
- Remediation completed under EPA Region 3 RCRA 7003 Consent Order April 1997
- WVDEP Voluntary Cleanup Program for off site sources and plumes

Geology and Hydrology

- Alluvial deposits
  - Interbedded sand, silts and clays to 80 feet
  - Shale, siltstone, sandstone bedrock at 80 feet (not impacted)
- Wellhead Protection Considerations
  - Downgradient municipal supply wells, not impacted at time of remediation
  - Water supply protection – key consideration
- Seasonal GW fluctuation of 3 feet
- Hydraulic conductivity ranged from 1×10^{-2} to 5×10^{-4} cm/sec
- Horizontal seepage velocity of 0.1 to 10 ft/day
  - Higher velocities associated with floods and droughts
- Prior to 2007 groundwater gradient north - Ohio River/Muni Wells
- After 2007 (Muni Wells Shut Down) groundwater flow to the NE Ohio River



NOTES:

- ⊕ RCRA Monitoring Well - Sampled
- ⊕ RCRA Monitoring Well - Not Sampled
- NM Groundwater Level Not Measured
- ◆ Damaged Well/Not Sampled
- SMRC On-Site Boundary
- Groundwater Contour w/ Elevation

Contour Intervals in 0.5 foot increments

All Elevations in Feet Above Mean Sea Level

SCALE:

1 inch equals 200 feet

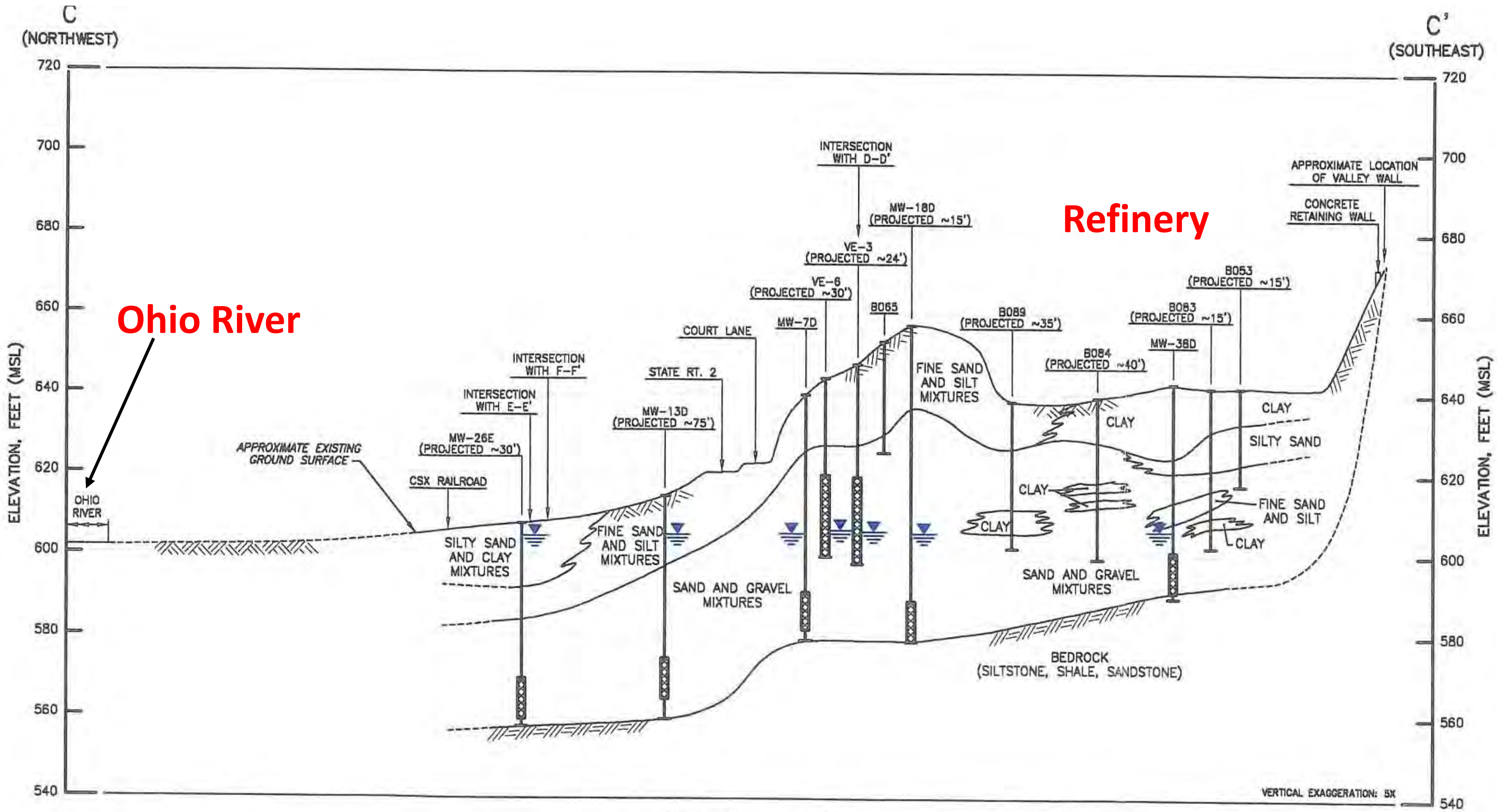
Muni Wells Shut Down

MALCOLM PIRNIE

INDEPENDENT ENVIRONMENTAL ENGINEERS, SCIENTISTS AND CONSULTANTS

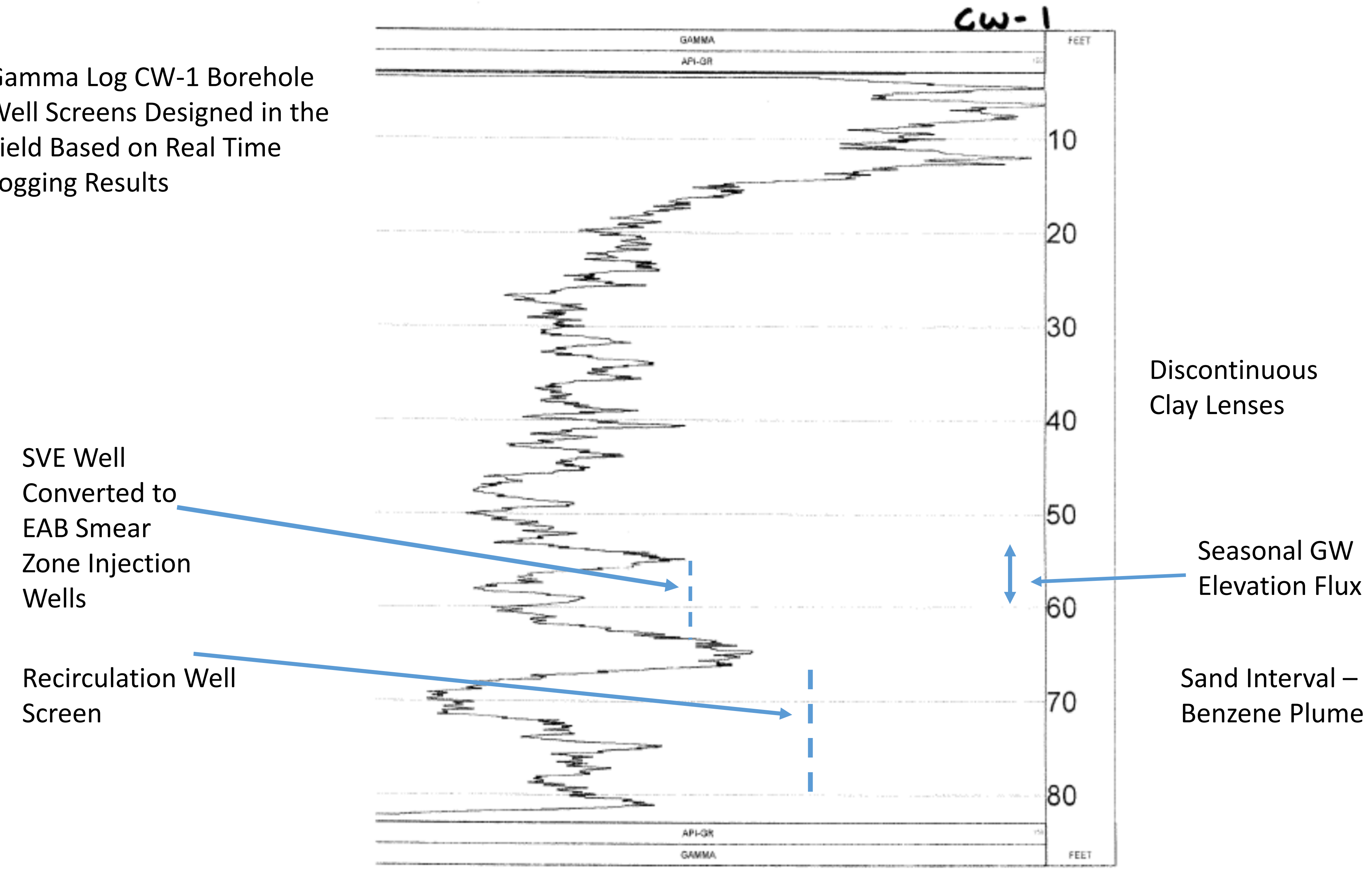
GROUNDWATER SAMPLING
SEMI-ANNUAL EVENT
ST. MARYS REFINING COMPANY
ST. MARYS, WEST VIRGINA

FIGURE 3
GROUNDWATER ELEVATION MAP
MAY 2009 SAMPLING EVENT



SECTION C–C'
(LOOKING NORTHEAST)

Gamma Log CW-1 Borehole Well Screens Designed in the Field Based on Real Time Logging Results



Groundwater Source

- 20- to 50-foot vadose zone laden with crude oil and refined products from historic and recent releases
- Residual mobile recoverable LNAPL and residual LNAPL (10 acres)
- Smear zone that extends 10 to 30 feet into the aquifer
  - Long term process water and noncontact cooling water extraction created localized groundwater depression below refinery
  - GW production contained plumes during active refinery operations
  - Plume started migrating to municipal wells after 1993
  - Post operation GW rebound trapped smear zone resulted in high mass anaerobic BTEX groundwater source

Groundwater Plumes – Refinery

- Buried smear zone source resulting in benzene (3,000 ug/L) and xylene (300 ug/L) plumes
- 30 acre on and off-site continuous plume
- Aquifer completely depleted of dissolved sulfate
- Background sulfate concentration 100 mg/L, identified downgradient and crossgradient
- Elevated dissolved phase and adsorbed phase TOC (degraded hydrocarbons – fatty acids) an additional substrate source (sulfate demand)
- Anaerobic aquifer ferrous iron to 100 mg/L and dissolved manganese to 10 mg/L (anaerobes in mature plumes scavenge Mn as Fe becomes less available)

Groundwater Plumes - Tank 100

- Gasoline releases late 1990s thru 2009
- Plume migrated swiftly toward muni well field (drought)
- Source BETX concentration to 100 mg/L
- Sulfate completely depleted within BETX plume
- Sulfate present side-gradient
- Anaerobic aquifer elevated ferrous iron 25 to 50 mg/L

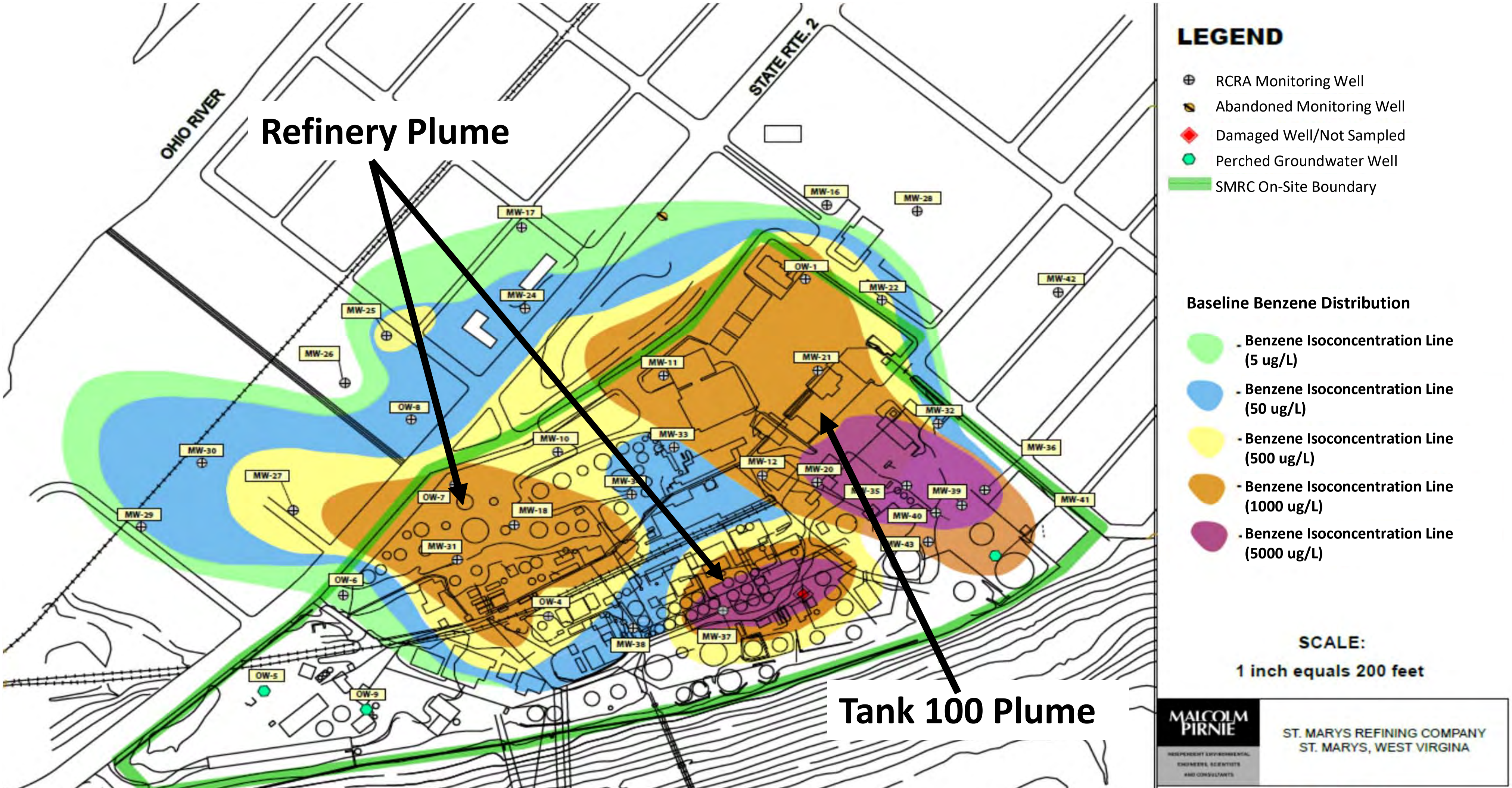
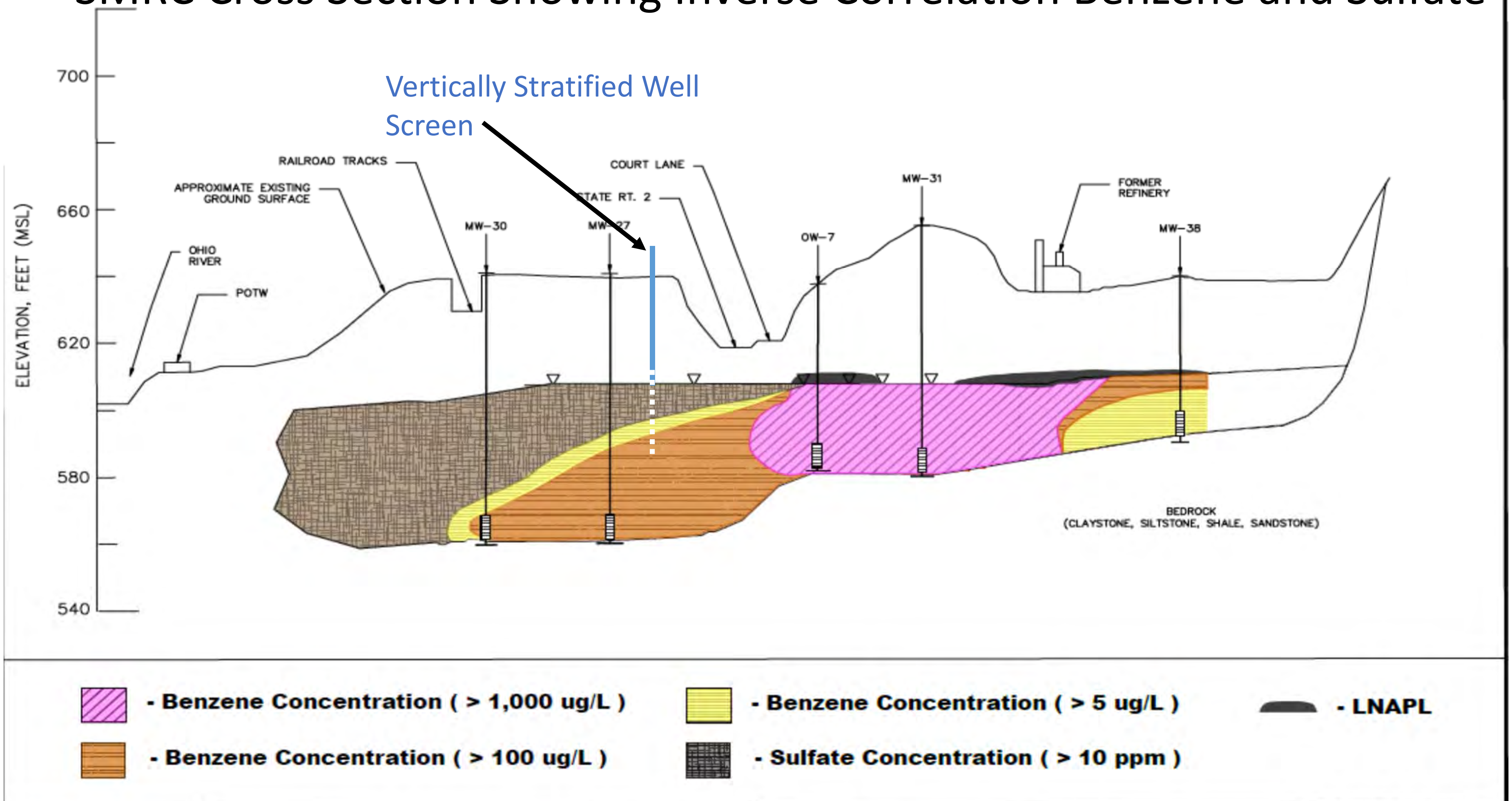


FIGURE 3
BASELINE BENZENE DISTRIBUTION

SMRC Cross Section Showing Inverse Correlation Benzene and Sulfate



MALCOLM PIRNIE

ST. MARY'S REFINERY
ST. MARY'S, WEST VIRGINIA

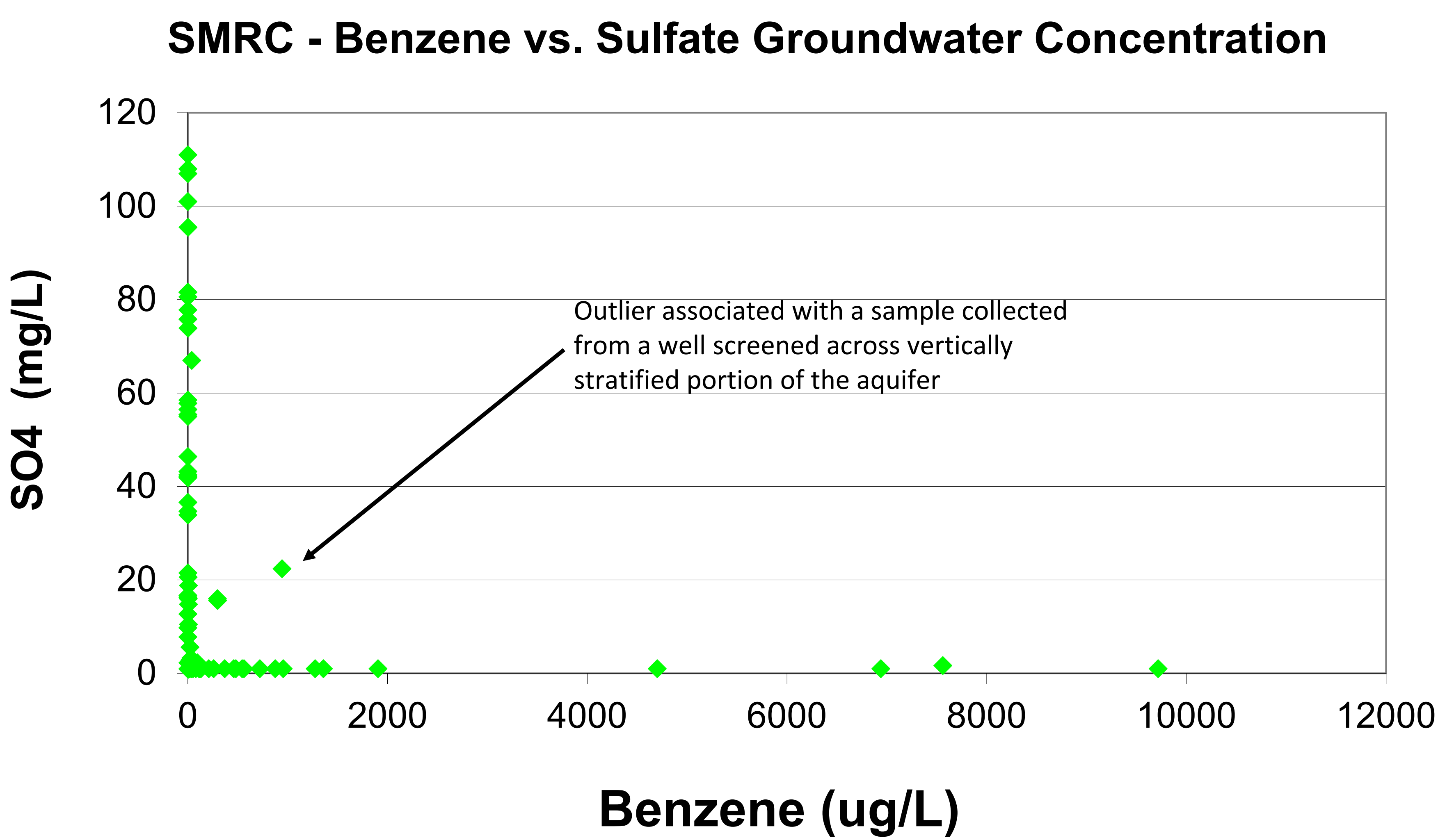
BASELINE BENZENE CONCENTRATIONS - CROSS SECTIONAL VIEW

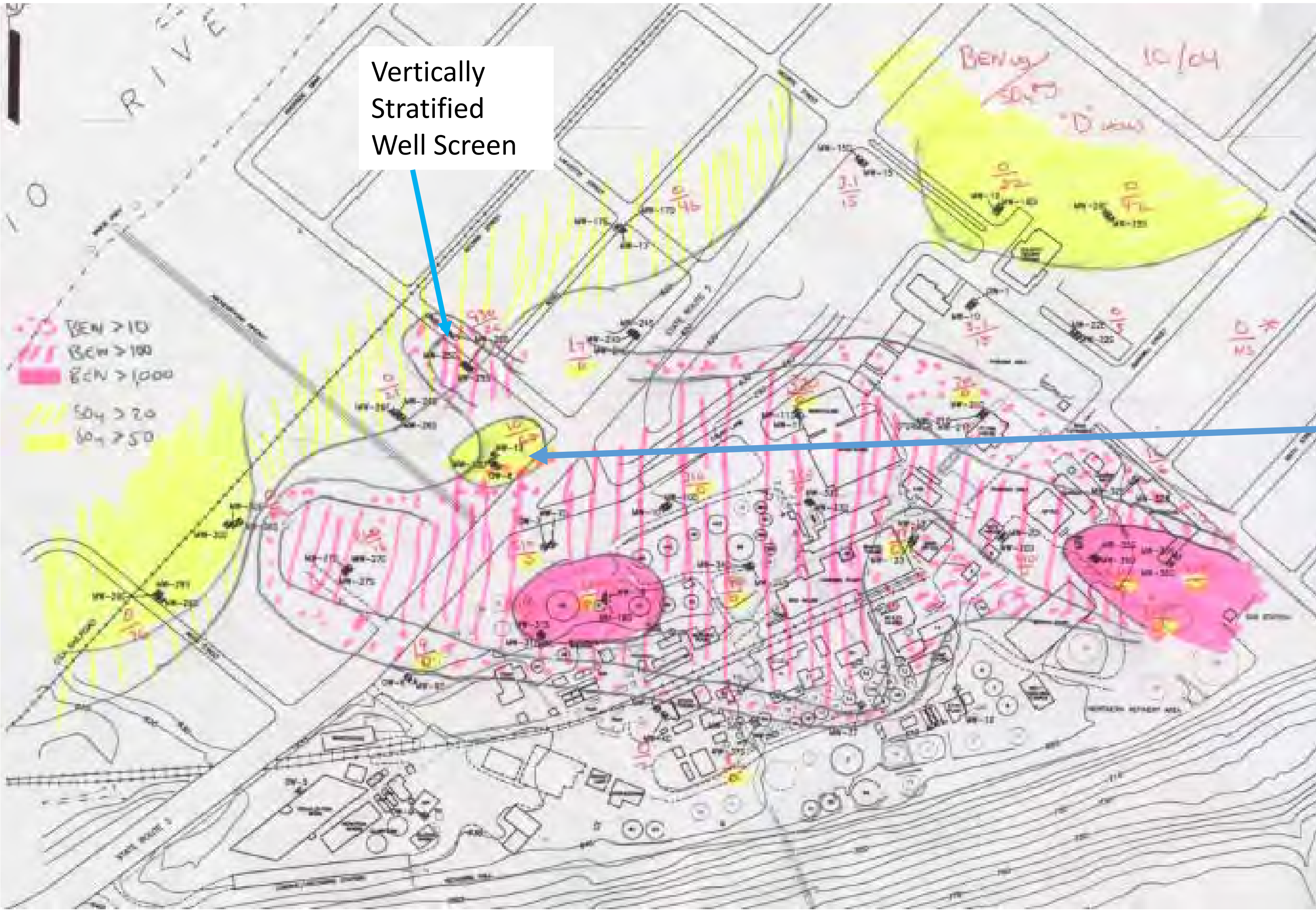
MALCOLM PIRNIE, INC.

FIGURE 7

Groundwater Remedial Strategy

- Remedial Goal – Reduce source and groundwater mass to promote MNA as effective final remedy (includes reaching benzene MCLs at downgradient site boundary)
- Enhanced Anaerobic Bioremediation (EAB) – residual LNAPL below in aquifer matrix and lower smear zone
- EAB for refinery and tank farm plumes


SMRC - Benzene vs. Sulfate Groundwater Concentration
SO4 (mg/L)
120
100
80
60
40
20
0
Outlier associated with a sample collected from a well screened across vertically stratified portion of the aquifer
0
2000
4000
6000
8000
10000
12000
Benzene (ug/L)



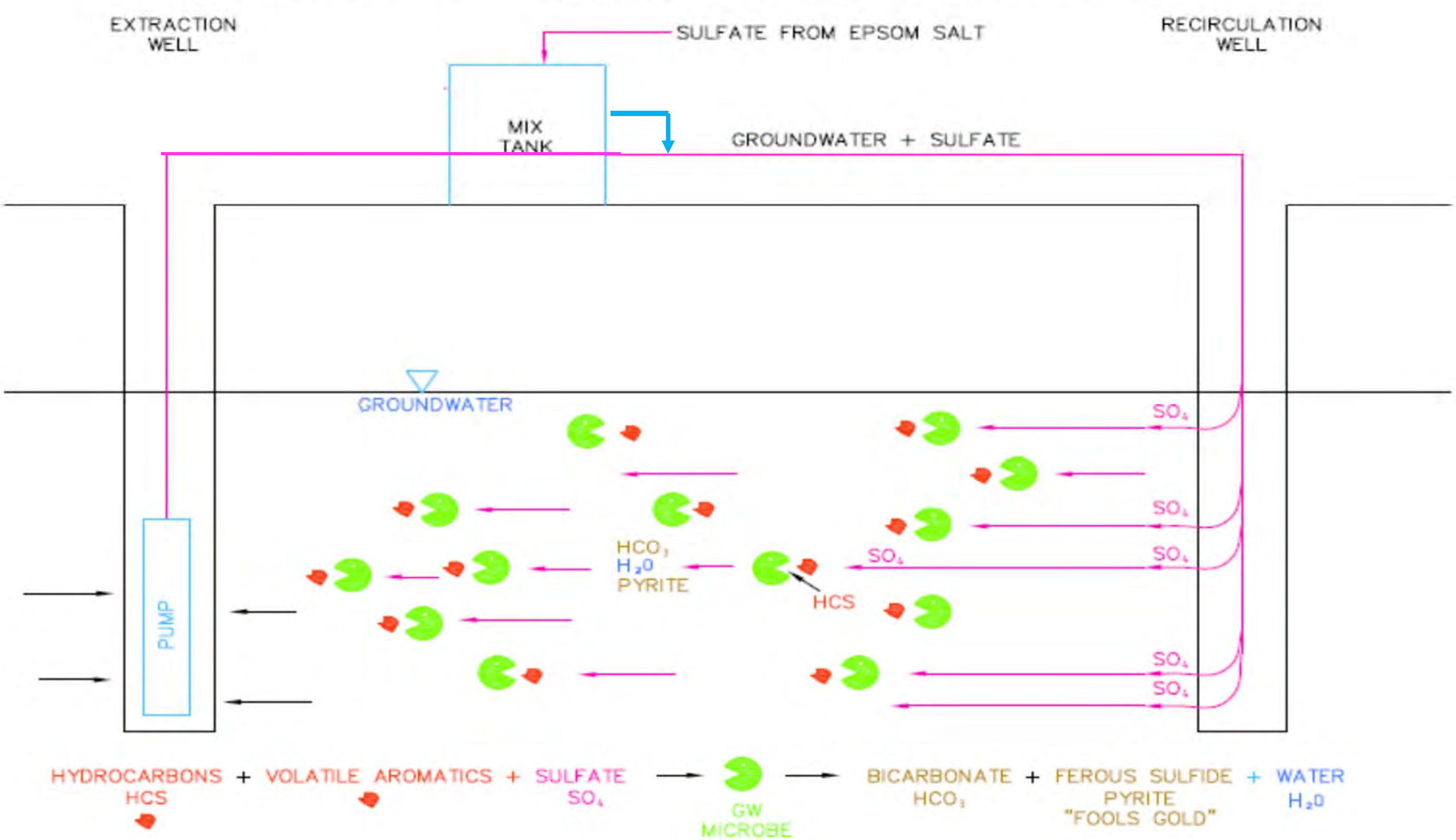
SMRC
Sand Aquifer

Fertilizer Sulfate Source Bifurcates Benzene Plume (more evidence of SRB controlling HC plume)

Typical Methods for Sulfate Distribution

- Batch Injections
- Pitch & Drift – feed dry sulfate (Epson Salt or Gypsum)
  - UST excavations
  - Flow through trenches
  - Surface distribution – shallow GW
- ISCO Residuals
  - Fenton's when sulfuric acid is utilized as conditioner
  - Persulfate
- ***Recirculation – most effective***
  - Recirculation of sulfate amended raw/untreated GW
  - OWS effluent as sulfate carry

ENHANCED ANAEROBIC BIODEGRADATION



SMRC EAB System and Process

- On Site Recirculation permitted through EPA Region 3 (see attached letter)
- Off-Site sulfate amendments permitted under WVDEP Voluntary Cleanup program (not discussed in the case study (secondary pipeline releases)
- Pilot test completed to estimate effective distribution well configuration and design and estimate sulfate demand
  - Sulfate demand was similar to published utilization rates (25 to 50 mg/l/day)
  - Sulfate demand is difficult to estimate – SRB will degrade most TOC including partially degraded HCs and naturally occurring organics not typically analyzed for during site investigations
  - One year with expansion of system
- Full-Scale System
  - Three Sulfate supply manifolds (two for the refinery plume and one for the Tank 100 plume)
  - 25 recirculation wells could function as extraction or injection based on sulfate monitoring results
  - 25 bioventing wells converted to injection wells to address residual smear zone LNAPL
  - 2 years
- 20 million gallons of GW recirculated (most of the water was extracted from downgradient property boundary and recirculated throughout plumes
- 1.2 million lbs of Epsom salt
- 2,500 gallons of 9% ammonium water

Recirculation System – 60 gpm & 800 lbs of Epsom Salt / day

Permitted to recirculate untreated water by EPA and WV

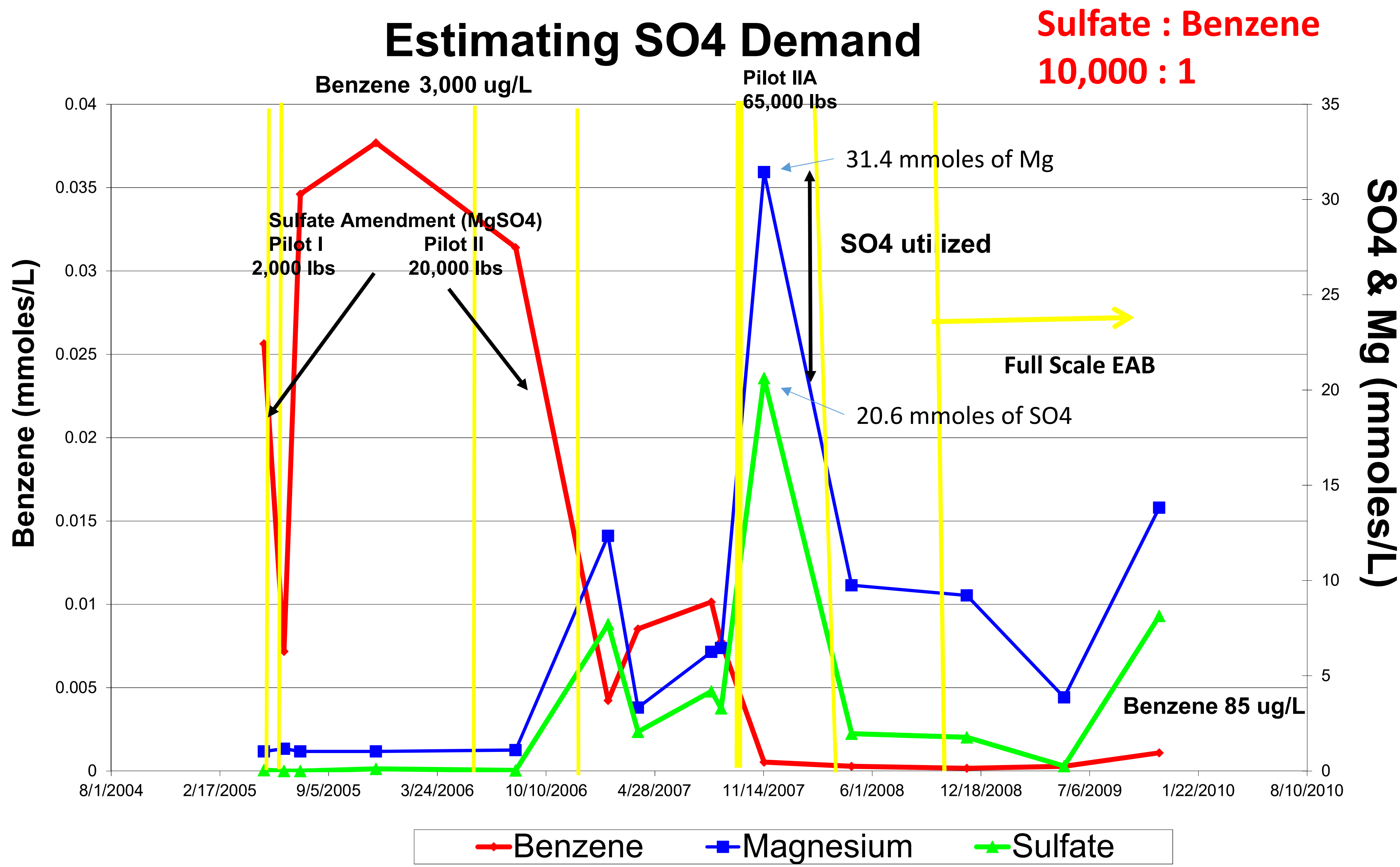
SMRC Refinery Plume: EAB Pilot, Sulfate Demand, and Full-Scale Results

- Pilot recirculation system was set up with three recirculation wells on the down-gradient portion of the plume
- Extraction wells were on the property boundary
- Injection wells were installed in one of the plume source areas
- No realistic stochiometric approach to estimating sulfate demand
  - Two major targeted, regulated compounds benzene and xylenes are an insignificant (<1%) portion of the total organic mass that is all an available substrate to SRB
  - This ratio is typical of most petroleum hydrocarbon releases although the % of targeted compound may increase to approx. 25% in newer releases
  - Soluble compounds detected in area monitoring wells are not representative of total degradable mass; 90% of this degradable mass is usually adsorbed to the aquifer matrix
- Based on our experience, we initially estimated sulfate demand by adding sufficient sulfate (Epsom Salt) to increase the aquifer concentration to 1,000 to 2,000 mg/L

SMRC Refinery Plume: EAB Pilot, Sulfate Demand, and Full-Scale Results

- Based on our experience, we initially estimated sulfate demand by adding sufficient sulfate (Epsom Salt) to increase the aquifer concentration to 1,000 to 2,000 mg/L
  - Epsom salt is $MgSO_4 (H_2O)_7$ so Mg and Sulfate are added to the aquifer on a 1:1 molar ratio
  - Magnesium is a semi conservative tracer when alkalinity levels are less than 500 mg/L
  - Sulfate demand estimated by calculating the difference between the molar concentration of Mg and SO_4 (see next slide)
  - Calculated a sulfate amendment rate for each recirculation system based on sulfate demand estimate
  - The sulfate demand is regularly evaluated based on groundwater process monitoring - sampling for SO_4 and Mg and sulfate feed rates are adjusted to maintain a consistent concentration of approximately 500 mg/L
  - Sulfate demand generally decrease as the more degradable compounds are mineralized (converted to CO_2)
- During the Refinery plume remediation sulfate feed rates for one of the recirculation systems dropped from 1,000 lbs per day to 300 lbs per day

Estimating SO4 Demand



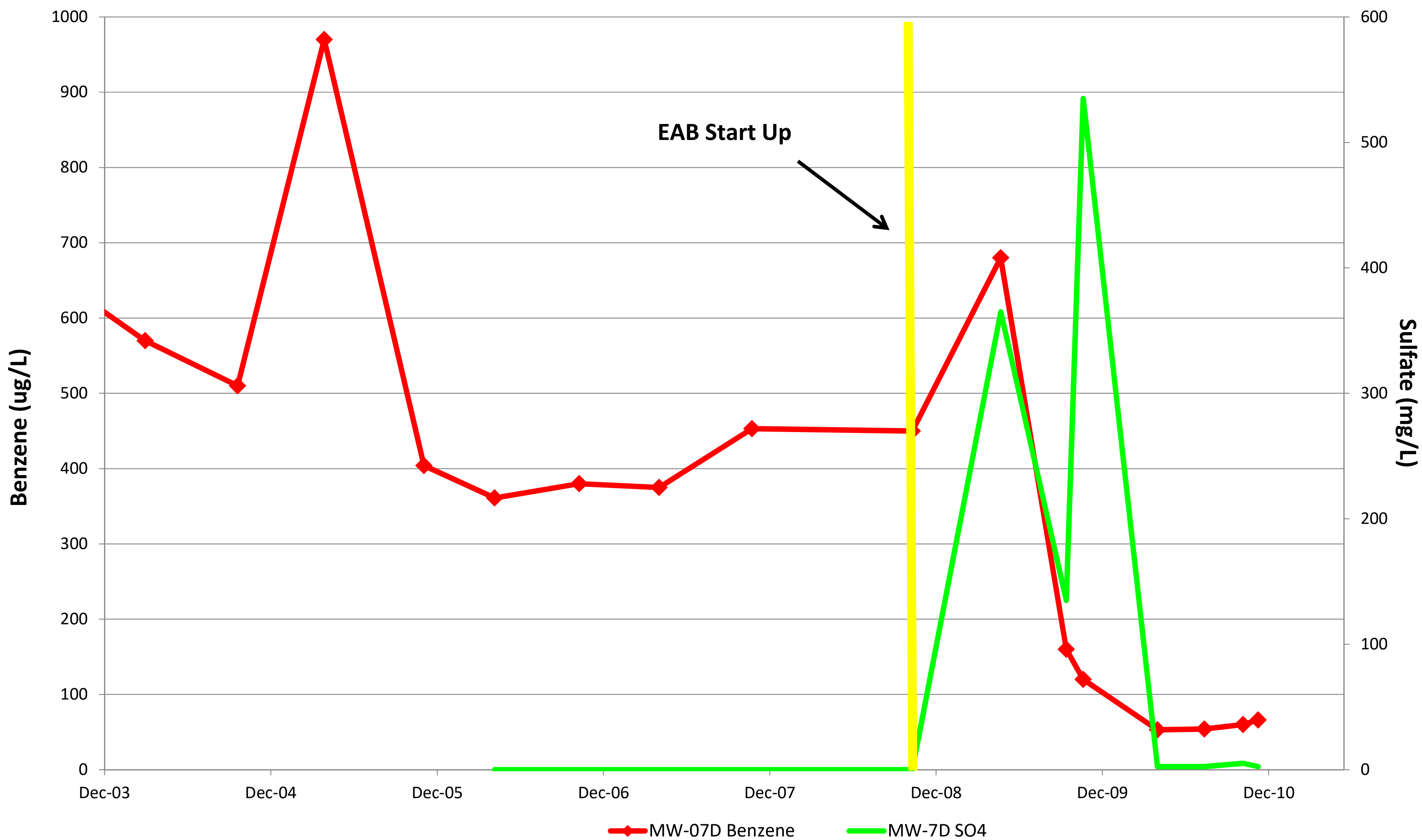
Estimating Sulfate Demand – CW-1 Pilot Test area

- As shown on the previous trend figure (Estimating Sulfate Demand), we didn't meet the sulfate demand until Pilot Test IIA
  - The smear zone in this area is 30 feet thick and estimating the demand was tough
  - After the addition of almost 100,000 lbs of sulfate we met the demand (residual sulfate was present.
- The November2007 process groundwater sampling round produced the following sulfate demand results
  - Sulfate was present at a concentration of approximately 20.6 millimoles (mmoles)
  - Magnesium was present at a concentration of approximately 31.3 mmoles
  - If no SO4 utilization molar concentrations should be equivalent
  - When SO4 mmolar concentration is less than Mg it is a strong indication sulfate was utilized by SRB to metabolize petroleum HCs
  - Estimated utilization or sulfate demand 31.3 – 20.6 = 10.7 mmoles of sulfate utilized
  - Or 10.7 mmoles x 96 mg/mmole = 1030 mg per liter reduction in sulfate
  - Injection started on 9/28/07 sampled on 11/15/07 = 49 days
  - Sulfate utilization rate 1030 mg/L over 79 days = 21 mg/L per day
- Initial full-scale EAB SO4 addition rates were designed to meet the 21 mg/L per day utilization rate

Full-Scale Refinery Plume EAB Results

- The next trend figure shows benzene and sulfate concentrations vs time
- Following 1.5 years of sulfate recirculation in the area benzene concentrations were reduced to 26 ug/L near the MCL goal of 5 ug/L
- After an additional 6 months (October 2010) benzene concentrations dropped to below 5 ug/L (see isoconcentration figures)

Figure 9 : MW-7D - Response to EAB at OW7/MW-18



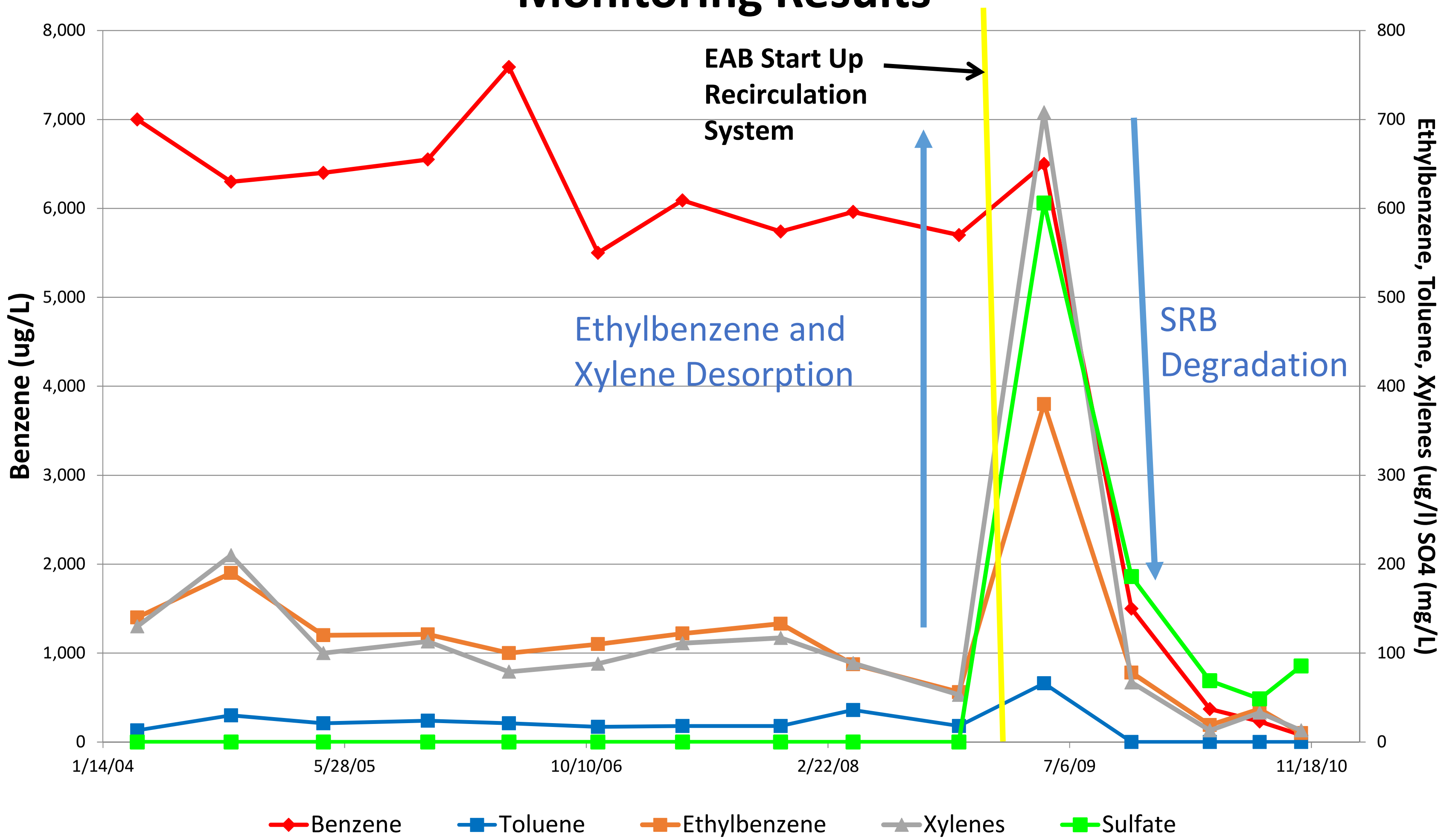
Full-Scale T-100 Plume EAB Results

- T-100 plume was a more recent releases of gasoline from over filling and tank bottom failure
- Plume was less than 10 years old
- Residual LNAPL confined to GW table resulting in typical seasonal smear zone of 3 to 4 feet and groundwater dissolved phase plume in sand aquifer approximately 20 feet thick
- Plume was pulled towards the city’s muni wells
- Full Scale remediation consisted of bioventing to remediate the residual vadose zone source and EAB to degrade the dissolved phase BTEX plume
- EAB system consisted of two extraction wells and initially three recirculation wells, additional bioventing wells were converted to injection wells to address residual LNAPL pocket sources

Full-Scale T-100 Plume EAB Results

- Process monitoring results for this plume clearly demonstrate the ability of SRB to desorb and degraded adsorbed phase aromatic hydrocarbons
- Following the addition of sulfate, xylene and ethylbenzene concentrations increase dramatically and then decrease just as swiftly
- The same desorption / degradation trend is not observed for benzene (in our experience it only occasional observed while the desorption/degradation pattern is almost always observed for ethylbenzene, xylenes, and/or TMBs
- The full-scale EAB effort required approximately 250,000 lbs of sulfate substantially less than the refinery plume
  - T100 plume had typical smear zone with dissolved phase plume
  - Refinery plume had the 30-foot smear zone that generated a large sulfate demand

T100 Gasoline Plume – EAB Process/Progress Monitoring Results



Full-Scale EAB Refinery Progress Monitoring – Isoconcentration Figures

- Baseline 2005 benzene isoconcentration figure – combined shallow and sand aquifer benzene concentrations
  - T-100 benzene plume was pulled in the direction of the City's Muni Wells
  - Refinery plume almost extends to the Ohio River
- 2008 benzene isoconcentration figure shows progress following approximately one year of full-scale EAB
- 2010 benzene isoconcentration figure shows the down-gradient wells meeting the remediation goal of mcls on property boundary
  - Isolated pocket of benzene downgradient of site was cut off from the source and attenuated to below 25 ug/L during the 2012 annual sampling round completed by others
- Following the effective implementation of the remedial plan the final IRM EAB reports were approved and the EPA Statement of Basis identified MNA as the final remedy (see attached EPA Letters)

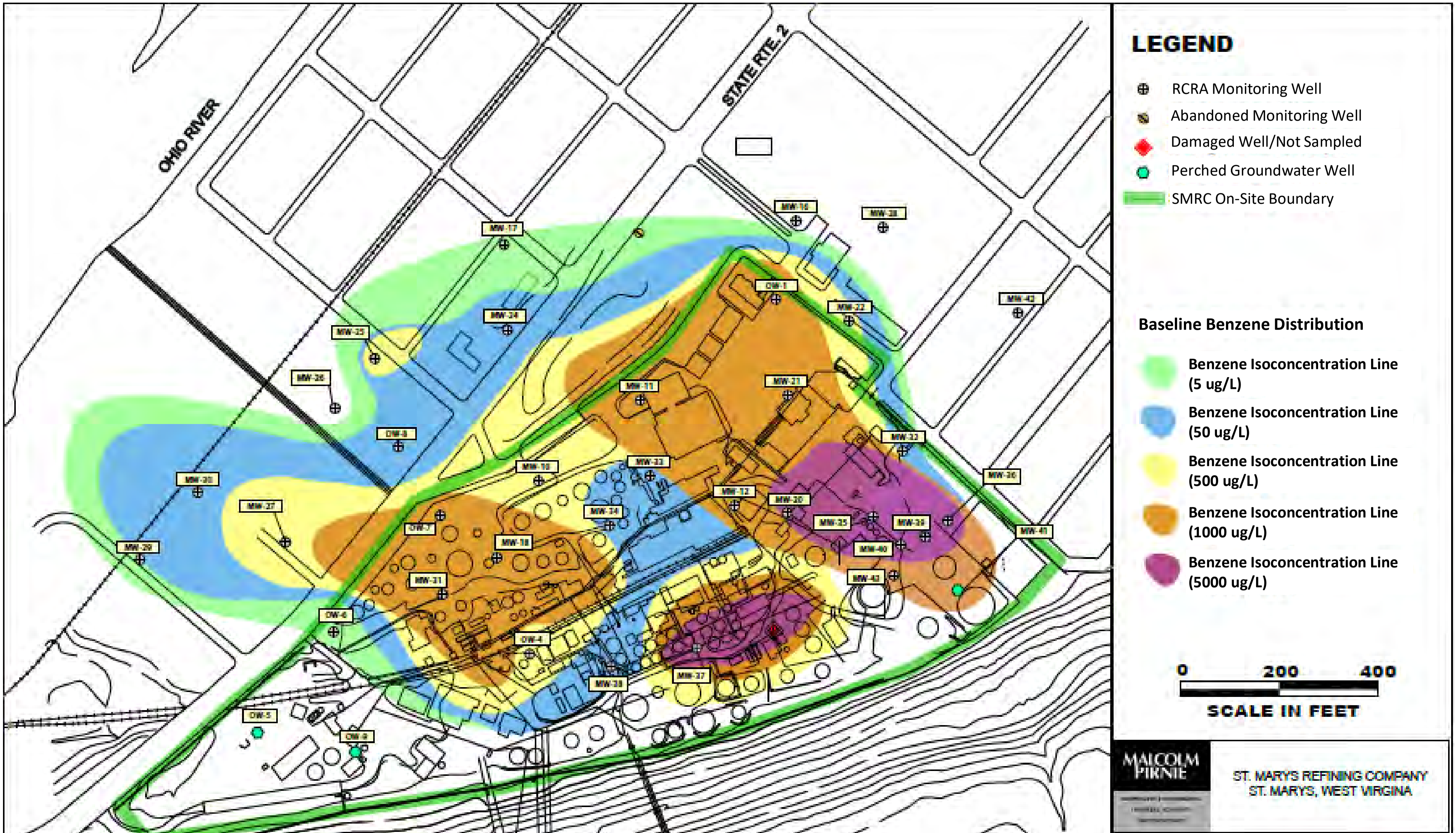
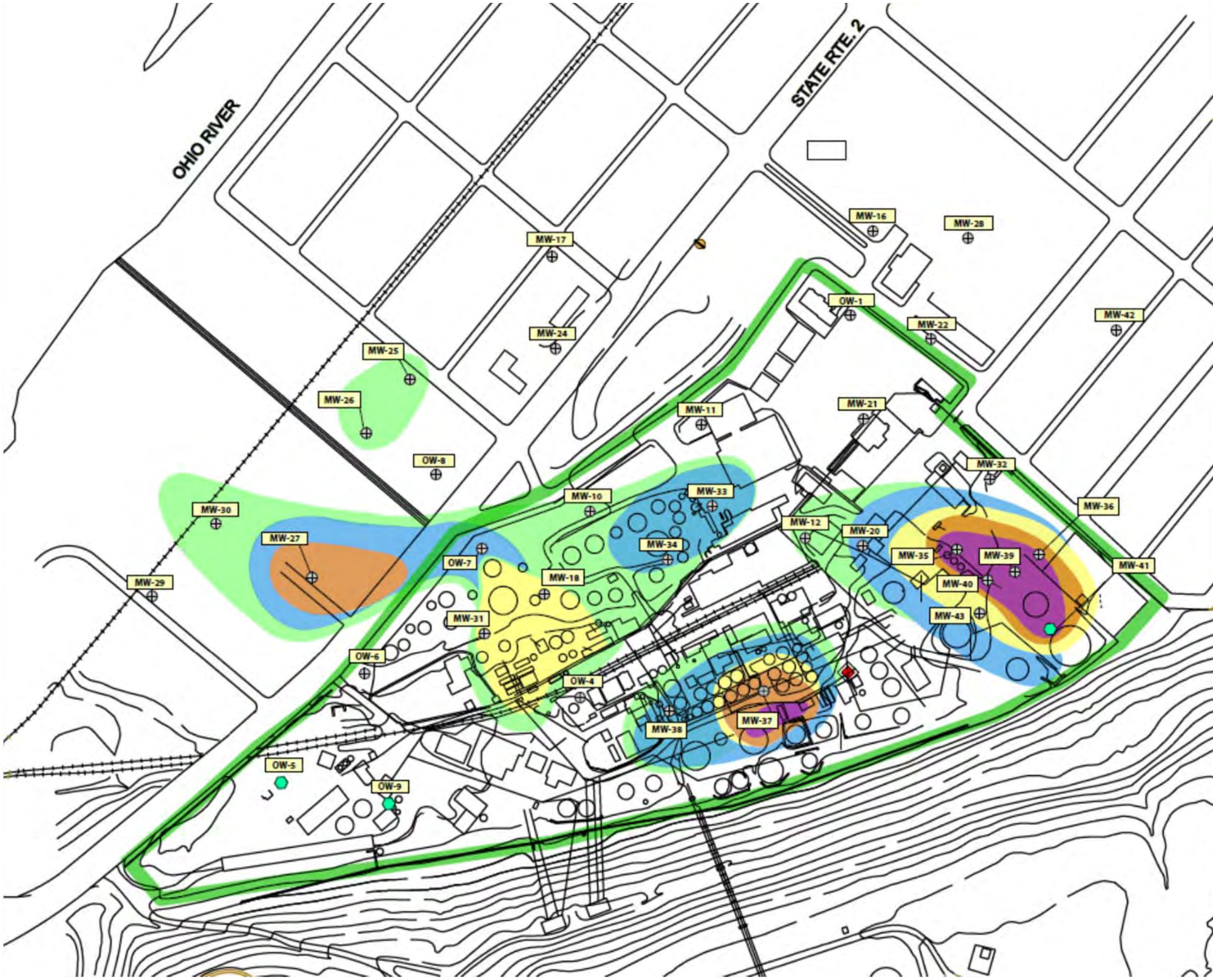


FIGURE 4
BASELINE BENZENE



LEGEND

- RCRA Monitoring Well
- Abandoned Monitoring Well
- Damaged Well/Not Sampled
- Perched Groundwater Well
- SMRC On-Site Boundary

November 2008 Benzene Distribution

- **Benzene Isoconcentration Line (5 ug/L)**
- **Benzene Isoconcentration Line (50 ug/L)**
- **Benzene Isoconcentration Line (500 ug/L)**
- **Benzene Isoconcentration Line (1000 ug/L)**
- **Benzene Isoconcentration Line (5000 ug/L)**

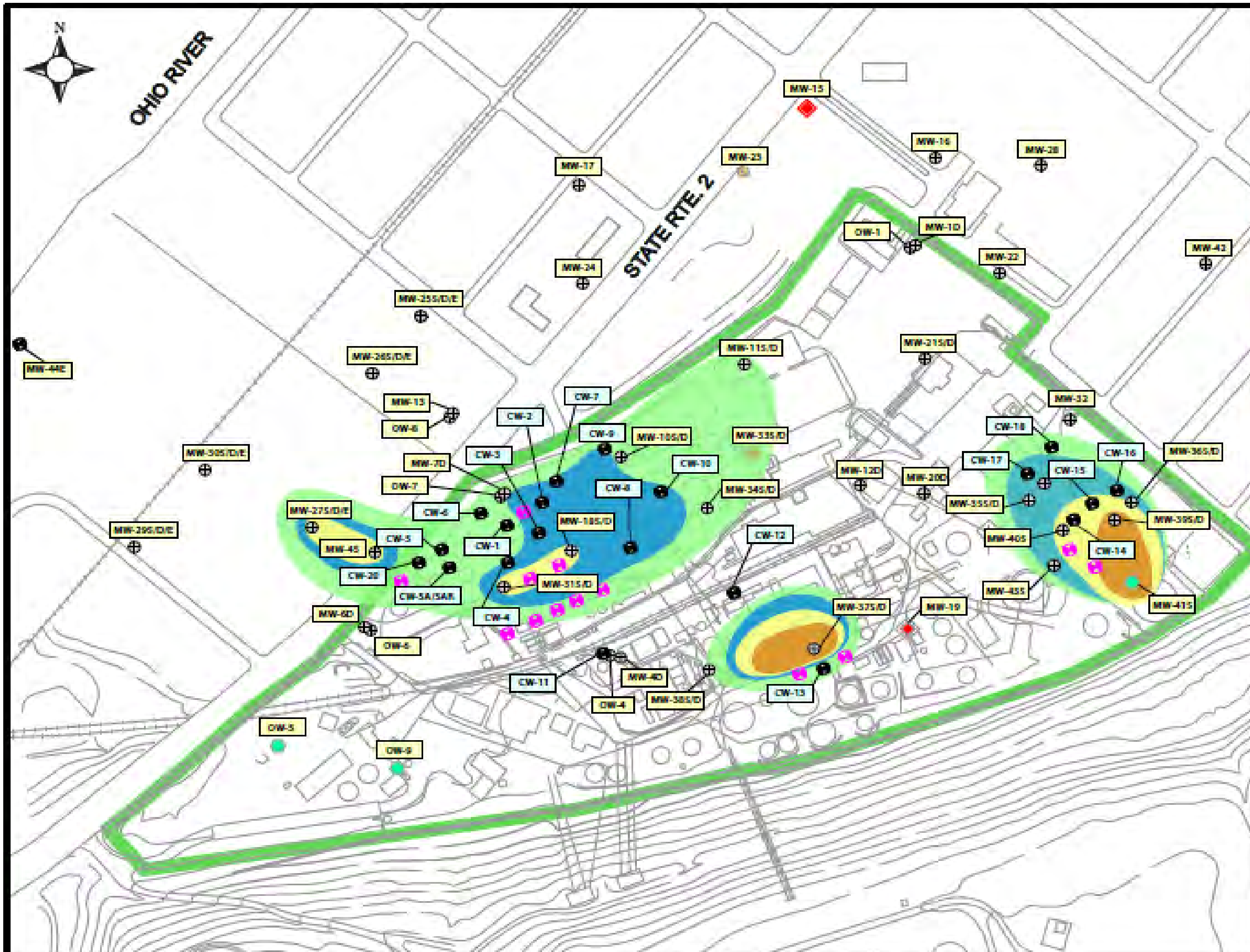
SCALE:

1 inch equals 200 feet

MALCOLM PIRNIE

ST. MARYS REFINING COMPANY
ST. MARYS, WEST VIRGINA

FIGURE 4
NOVEMBER 2008 BENZENE DISTRIBUTION



LEGEND

- EAB Recirculation Well
- RCRA Monitoring Well
- Abandoned Monitoring Well
- Damaged Well/Not Sampled
- Perched Groundwater Well
- VE Well
- SMRC On-Site Boundary
- **Benzene Isoconcentration Line (5 ug/L)**
- **Benzene Isoconcentration Line (50 ug/L)**
- **Benzene Isoconcentration Line (500 ug/L)**
- **Benzene Isoconcentration Line (1000 ug/L)**
- **Benzene Isoconcentration Line (5000 ug/L)**

0 200 400

SCALE IN FEET

MALCOLM PIRNIE

ST. MARYS REFINING COMPANY
ST. MARYS, WEST VIRGINA
October 2010

FIGURE 7

BENZENE ISOCONCENTRATION LINES - OCTOBER 2010

ATTACHMENT A – CASE STUDY 2

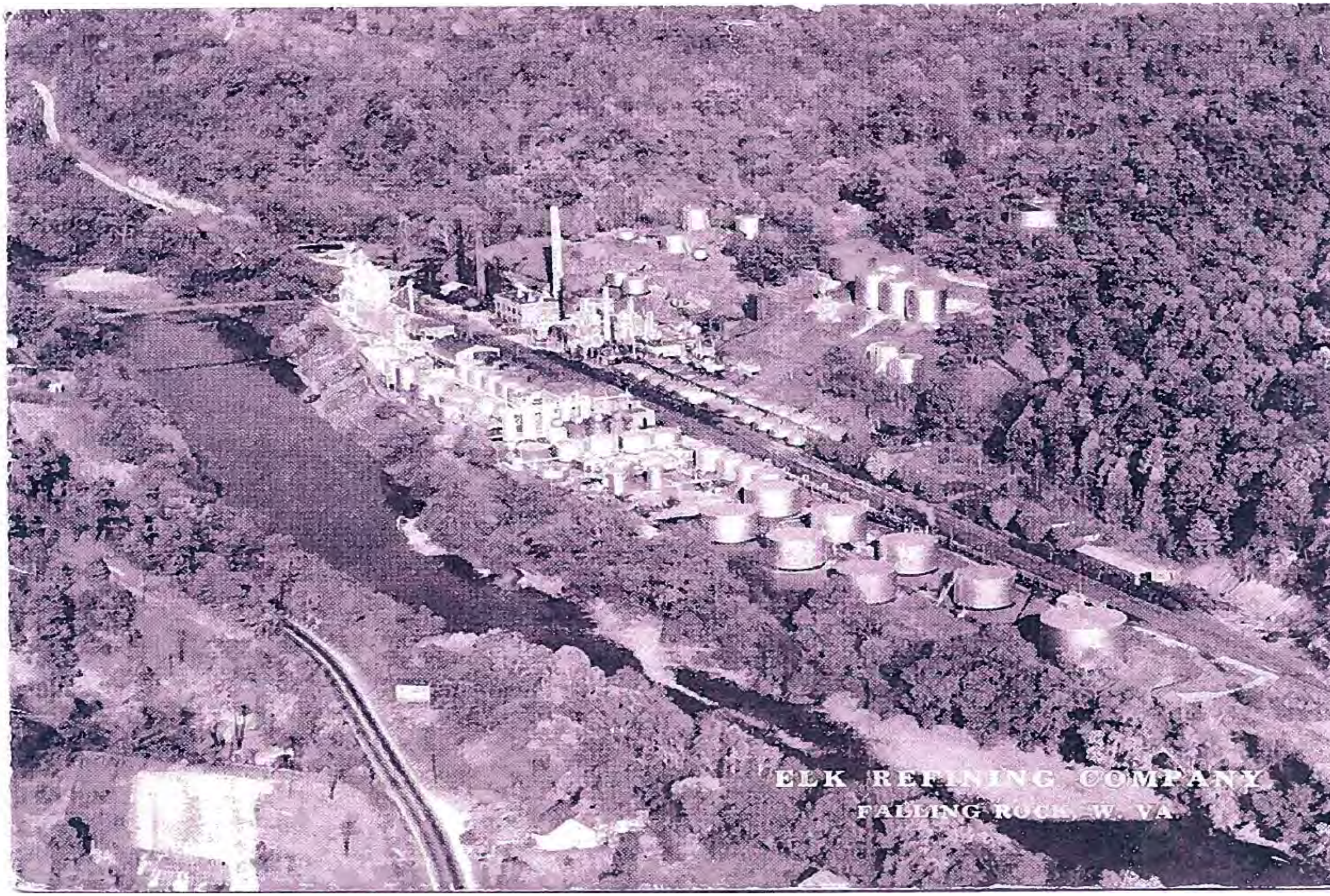
ELK REFINERY, CLENDENIN, WEST VIRGINIA

Enhanced Anaerobic Biodegradation (EAB)

Case Study 2:

Elk Refinery, Falling Rock, West Virginia

TRC
Results you can rely on

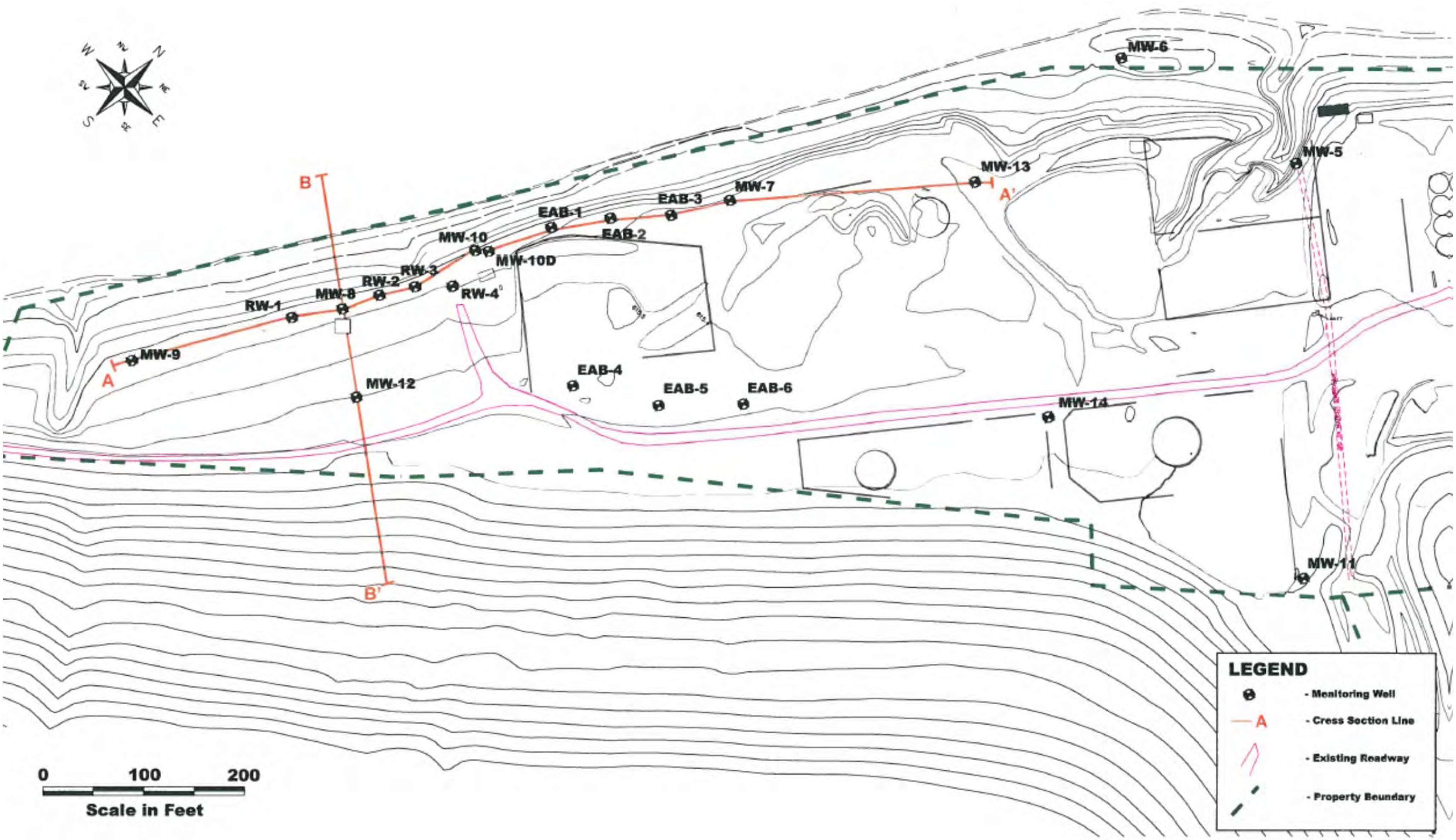

ELK REFINING COMPANY
FALLING ROCK, W. VA.

Refinery Description

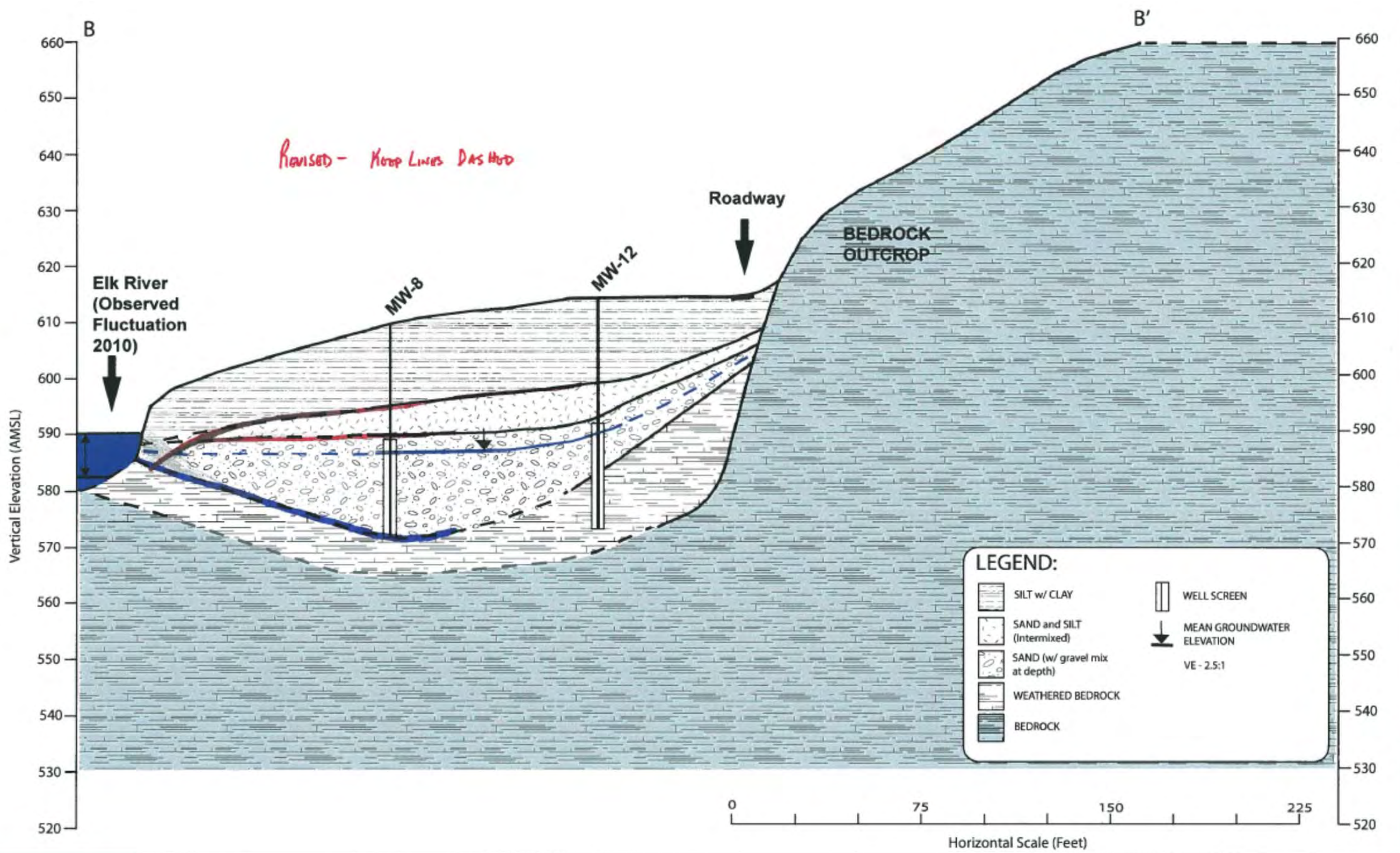
- Active refinery 1913 to 1982
- Refinery was partially demolished in the late 1980s
- 20-acre refinery area
- 30-acre tank farms and landfills (not a groundwater source)
- Refined Pennsylvania crude into fuels and lubricants
- Remediation completed under West Virginia Department of Natural Resources Voluntary Cleanup Program

Geology and Hydrology

- Alluvial deposits –
  - interbedded sand, silts and clays to 60 feet
  - Bedrock at 80 feet (not impacted)
- Seasonal GW fluctuation of 3 feet
- Hydraulic conductivity ranged from 1×10^{-2} to 5×10^{-6} cm/sec
- Horizontal seepage velocity of 0.1 to 5 ft/day
  - Higher velocities associated with floods and droughts
- Semi Confined Aquifer except during low seasonal GW levels



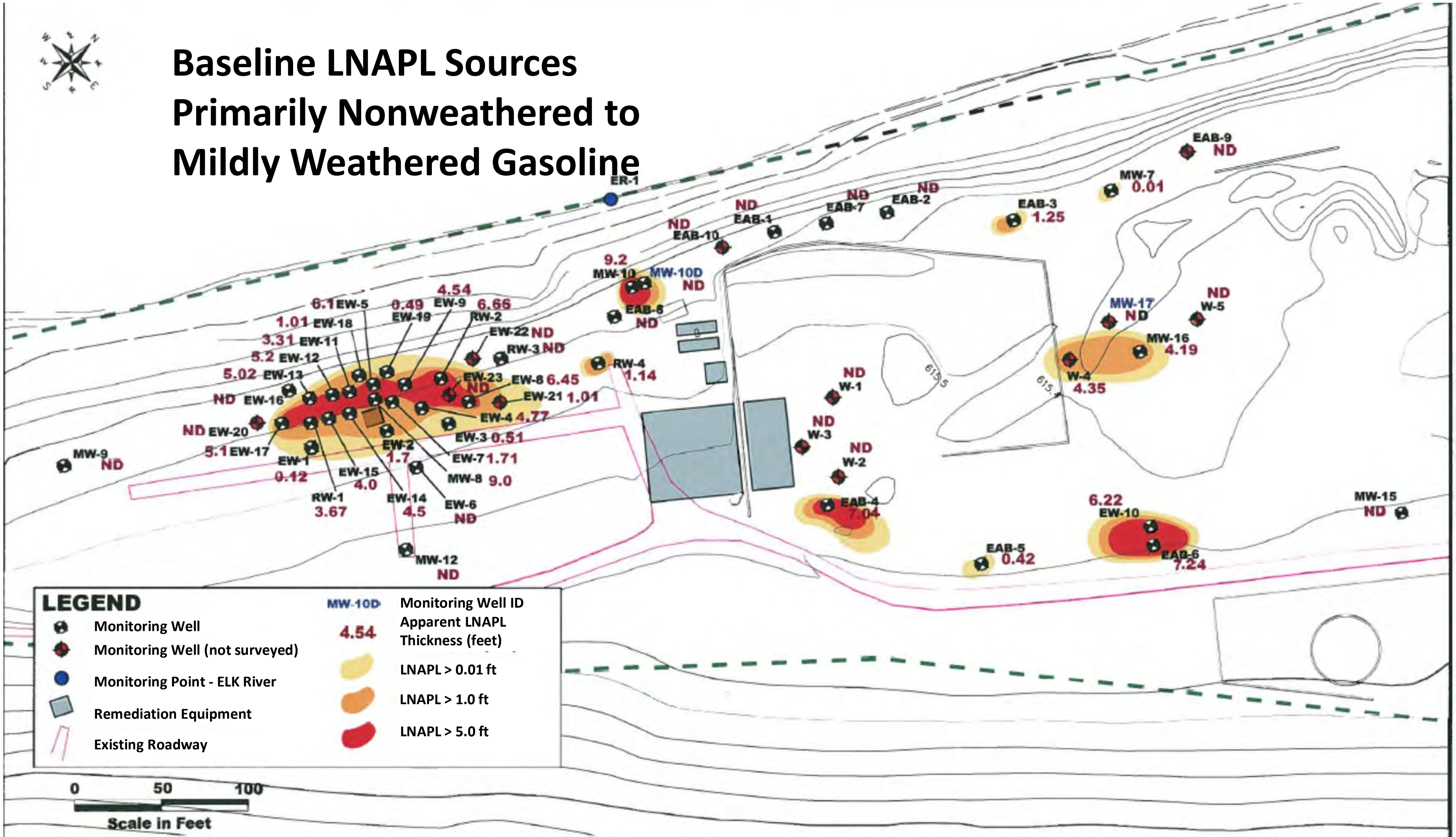
N
E
S
W
MW-6
MW-5
MW-13
A'
MW-7
EAB-3
EAB-1
EAB-2
MW-10
MW-10D
RW-3
RW-2
RW-1
MW-8
RW-4
MW-9
A
B
B'
MW-12
EAB-4
EAB-5
EAB-6
MW-14
MW-11
LEGEND
- Monitoring Well
- Cross Section Line
- Existing Roadway
- Property Boundary
0
100
200
Scale in Feet


B
B′
Revised - Keep Lines Dashed
Roadway
BEDROCK OUTCROP
Elk River (Observed Fluctuation 2010)
MW-8
MW-12
Vertical Elevation (AMSL)
660
650
640
630
620
610
600
590
580
570
560
550
540
530
520
LEGEND:
SILT w/ CLAY
SAND and SILT (Intermixed)
SAND (w/ gravel mix at depth)
WEATHERED BEDROCK
BEDROCK
WELL SCREEN
MEAN GROUNDWATER ELEVATION
VE - 2.5:1
0
75
150
225
Horizontal Scale (Feet)

Groundwater Source and Plumes

- Gasoline LNAPL Plumes
  - Relatively fresh LNAPL potential associated with release during demolition and confined aquifer
- Residual mobile recoverable LNAPL to thickness of 9 feet (confined aquifer)
- Smear zone that extends 5 feet into the aquifer
- BTEX Plume to 250 mg/L along bank of the ELK River
- Background sulfate concentrations approximately 25 mg/L
- Anaerobic aquifer ferrous iron to 100 mg/L

Baseline LNAPL Sources Primarily Nonweathered to Mildly Weathered Gasoline



MALCOLM PIRNIE

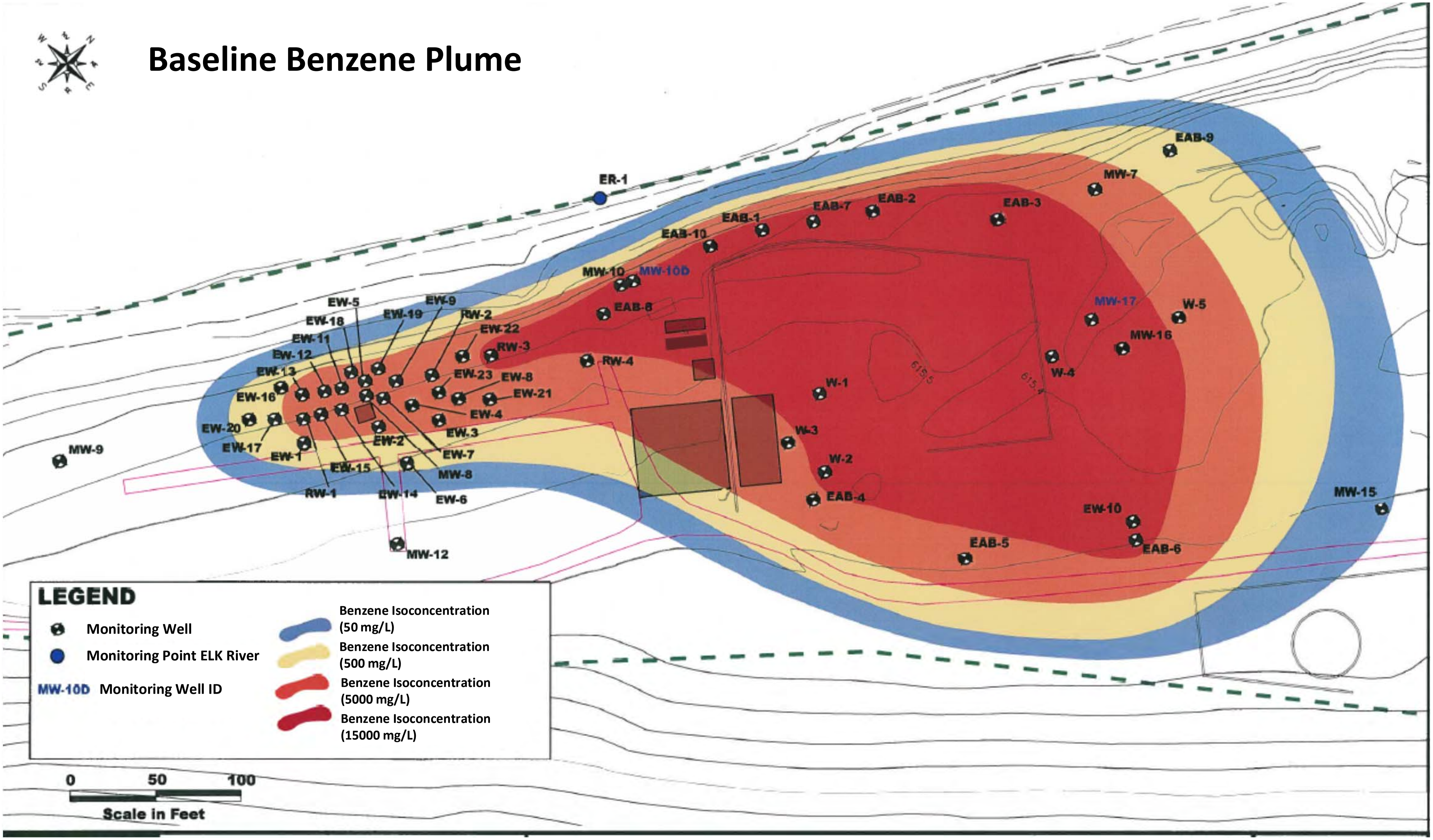
Former Elk Refinery
Falling Rock, WV

BASELINE APPARENT LNAPL THICKNESS

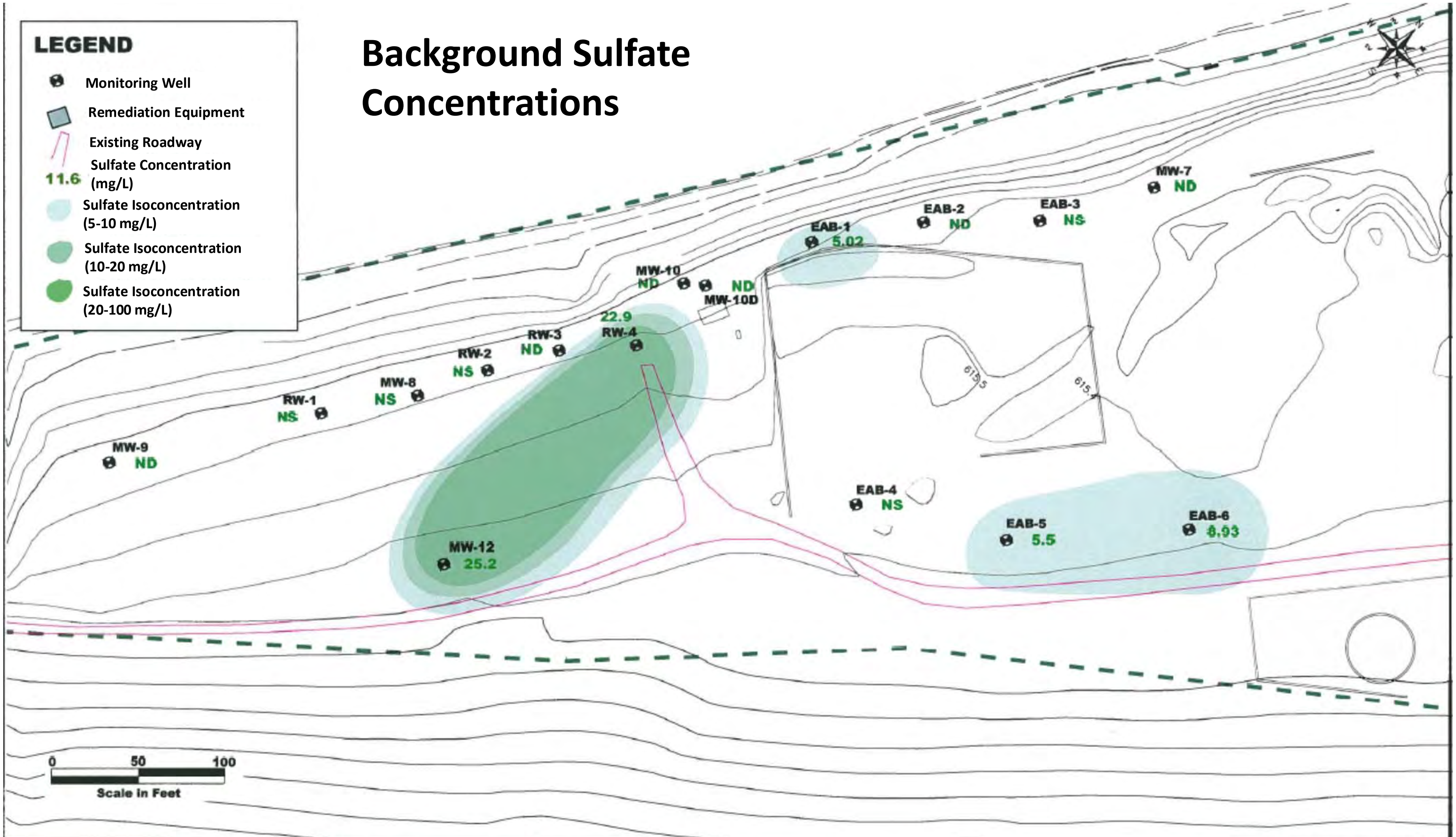
August 2011

FIGURE ~~X~~ 16

Baseline Benzene Plume



Background Sulfate Concentrations



MALCOLM PIRNIE

Former Elk Refinery
Falling Rock, WV

SULFATE ISOCONCENTRATION MAP (January 2011)

Malcolm Pirnie Inc.

FIGURE 10 27

Remedial Strategy

- Remedial Goal – Reduce source and groundwater mass to promote MNA as effective final remedy (no measurable gasoline based LNAPL)
- Total fluids extraction
- Skimmer pumps in EAB extraction wells
- EAB of dissolved phase plume and LNAPL residuals
  - Recirculated untreated GW from below LNAPL plumes
  - Recirculated OWS effluent from total fluid recovery pumps
  - Recirculated water benzene > 5 mg/L and BTEX > 50 mg/L
- EAB for refinery and tank farm plumes
- Final remedy MNA (enhanced by sulfate addition)

Elk Refinery Recirculation System – OWS Effluent

SO4 Feed Tank
15% Epson Salt
& 100 mg/l
NH4

Recirculation Manifold
Lines on the right extracted water from LNAPL free wells
Line on the top OWS Effluent
Lines to the left are recirculation lines to wells

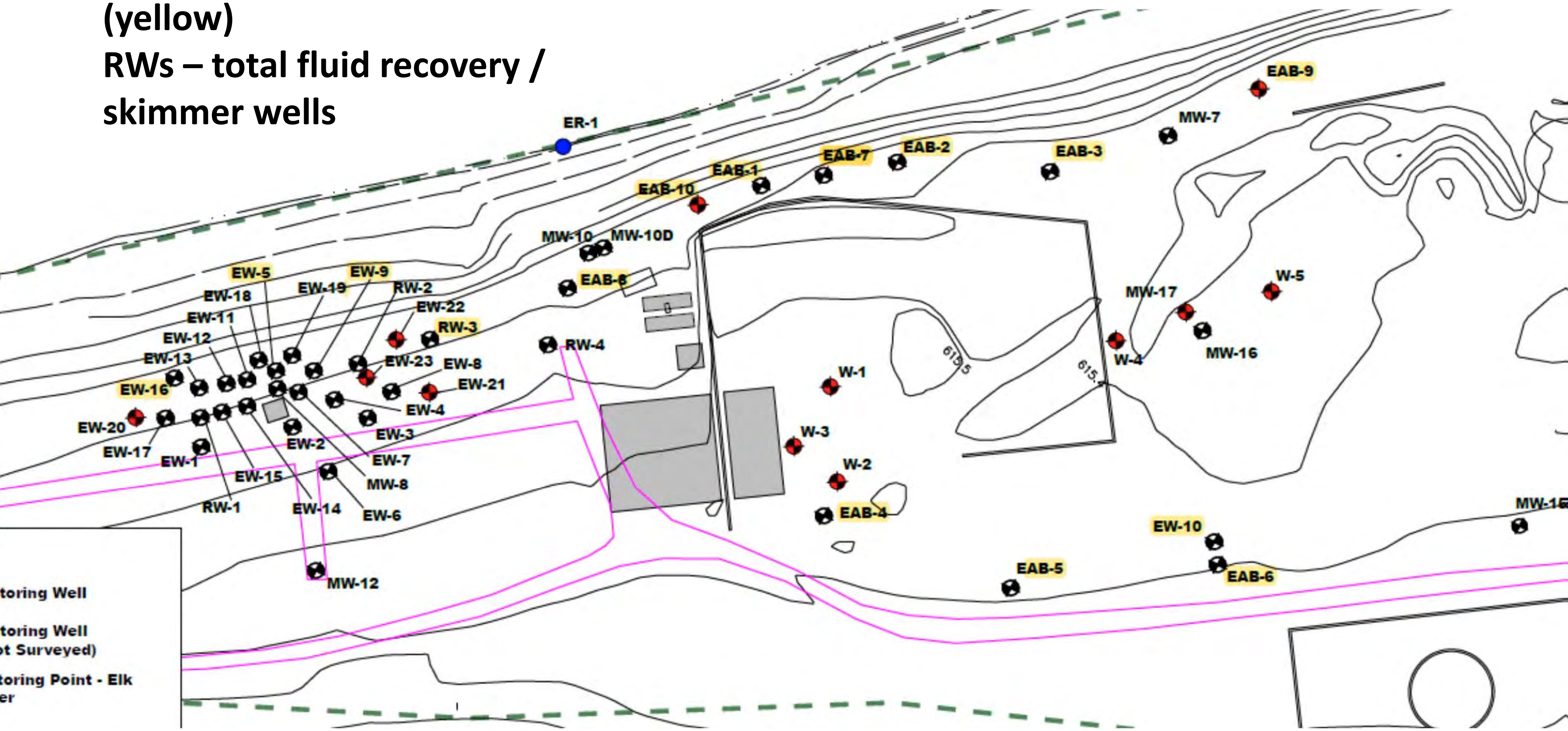
OWS Received GW LNAPL Mixtures from Skimmer pumps and total fluids pumps located in MWs with up 9 feet of LNAPL

Accelerated Remediation – No Pilot

- LNAPL remediation and EAB proceeded at the same time
  - Recirculated all water associated with LNAPL recovery
  - Amendment rate was adjusted based on field conductivity readings in MWs and extracted water
- Relatively new release resulted in minimal smear zone and associated petroleum saturated soils
- Sulfate demand limited to gasoline hydrocarbons
  - approximately 10:1(sulfate to soluble BTEX)
  - Sulfate half life was much longer than typical sites
  - Nonweathered gasoline resulted in much lower demand associated with partially degraded heavier hydrocarbons

EAB Recirculation Wells (yellow)

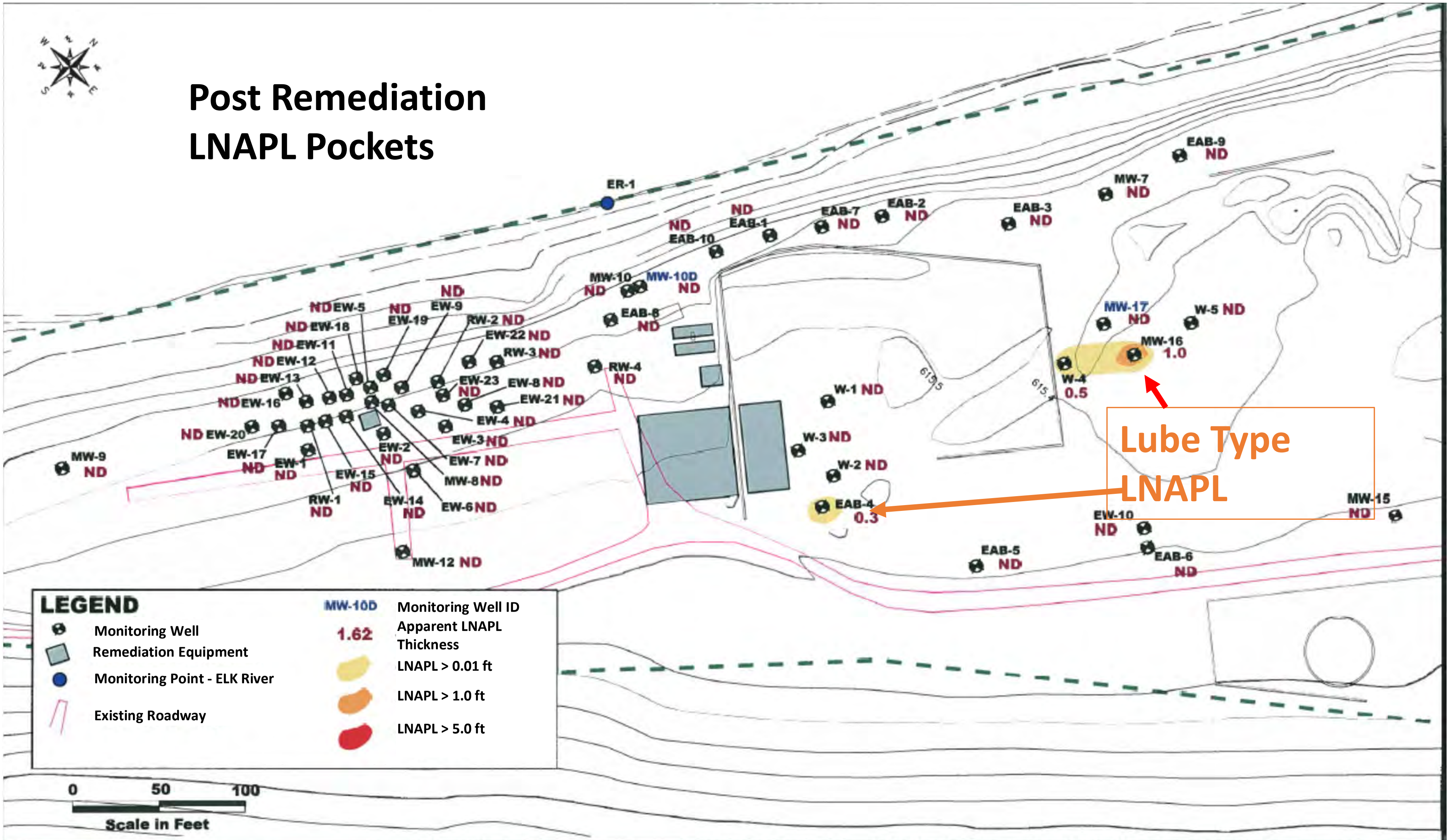
RWs – total fluid recovery / skimmer wells



Remediation Results

- Gasoline LNAPL plumes remediated in 1.5 years
- EAB recirculation decreased benzene concentrations to below risk based values in downgradient plume edge
- MNA sampling proved residual sulfate was sufficint to prevent migration of residual benzene
- Received NFA Letter from WVDEP Spring 2012

Post Remediation LNAPL Pockets

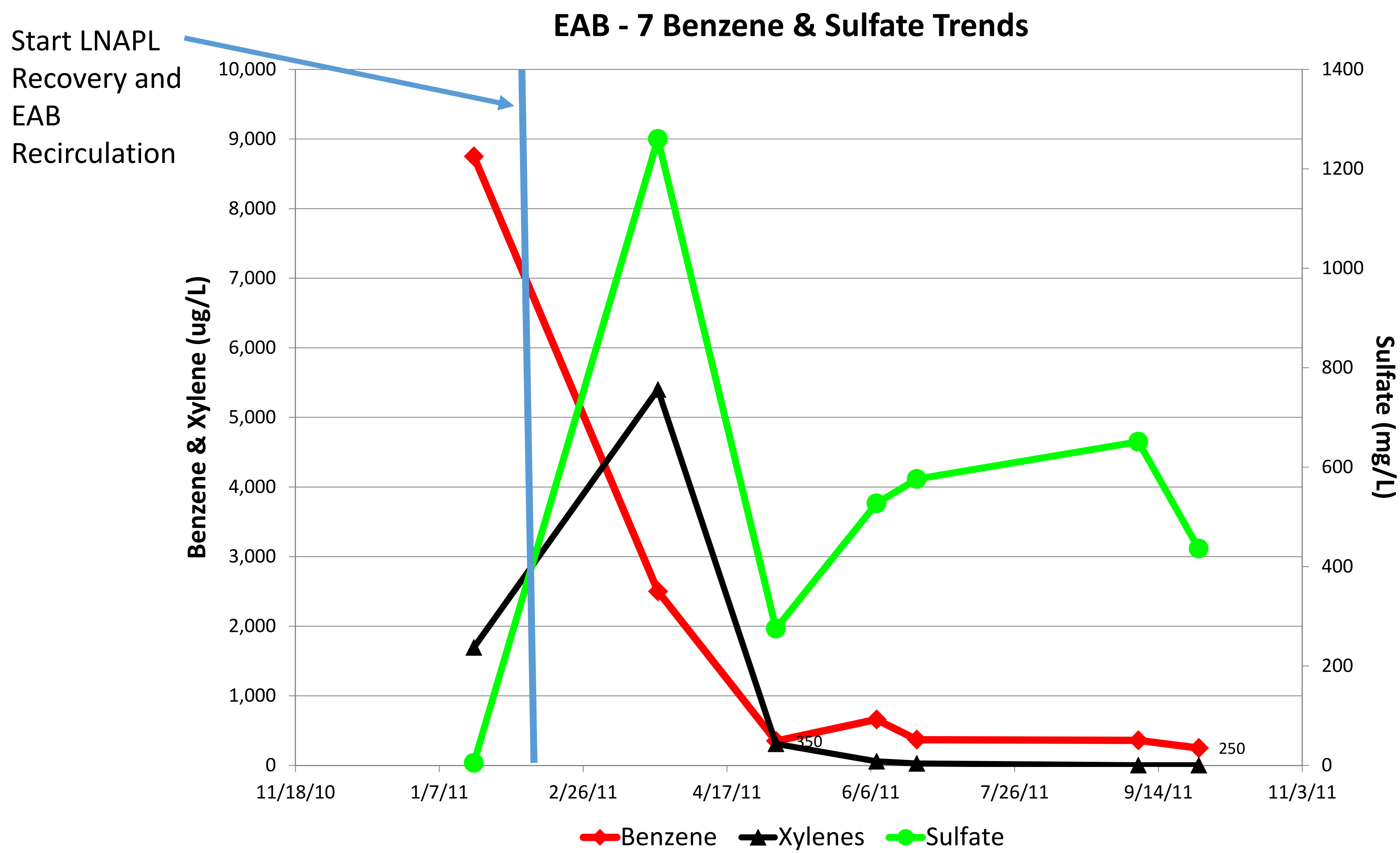


MALCOLM PIRNIE

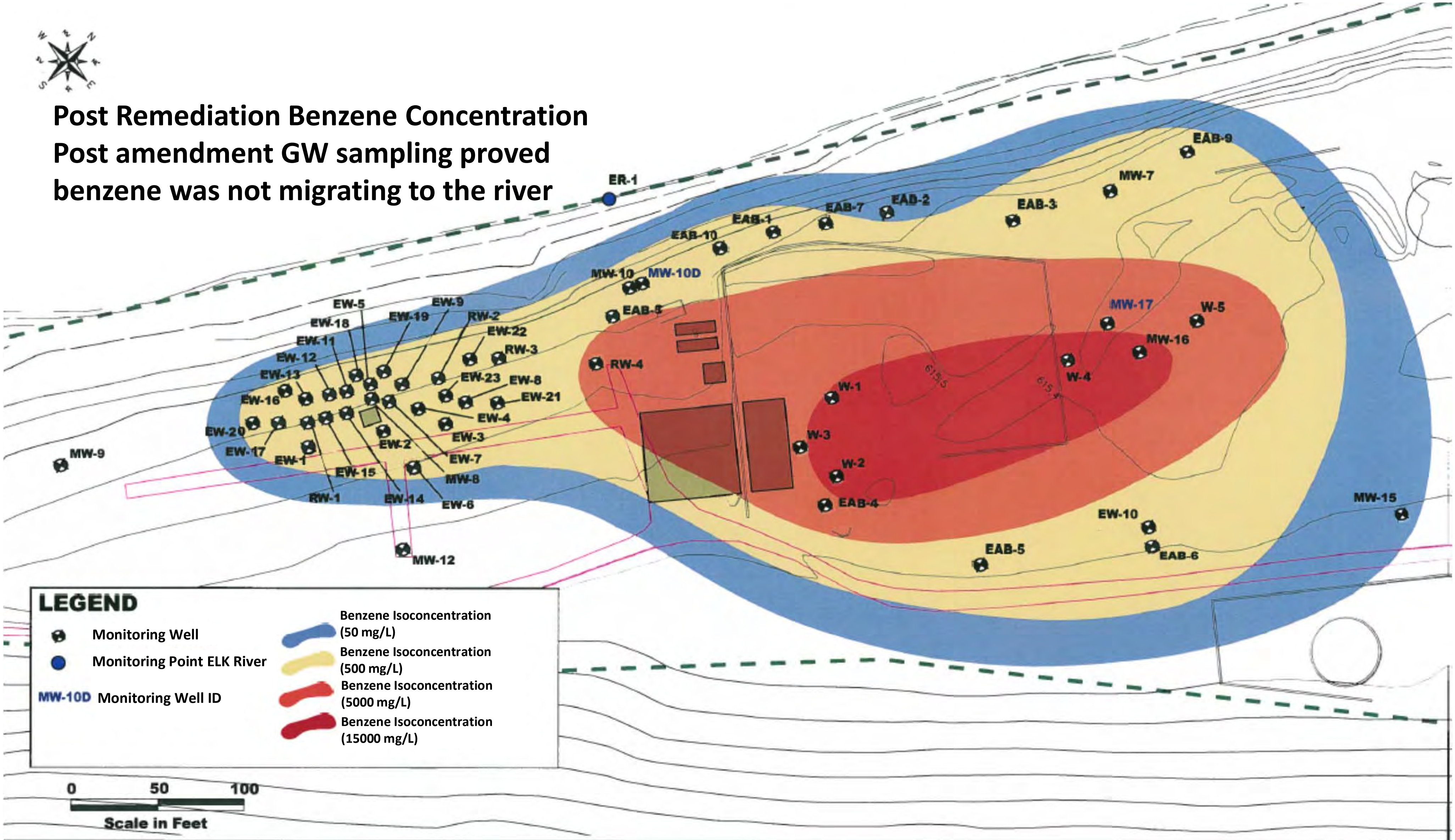
Former Elk Refinery
Falling Rock, WV

CURRENT LNAPL DISTRIBUTION - November 15, 2011

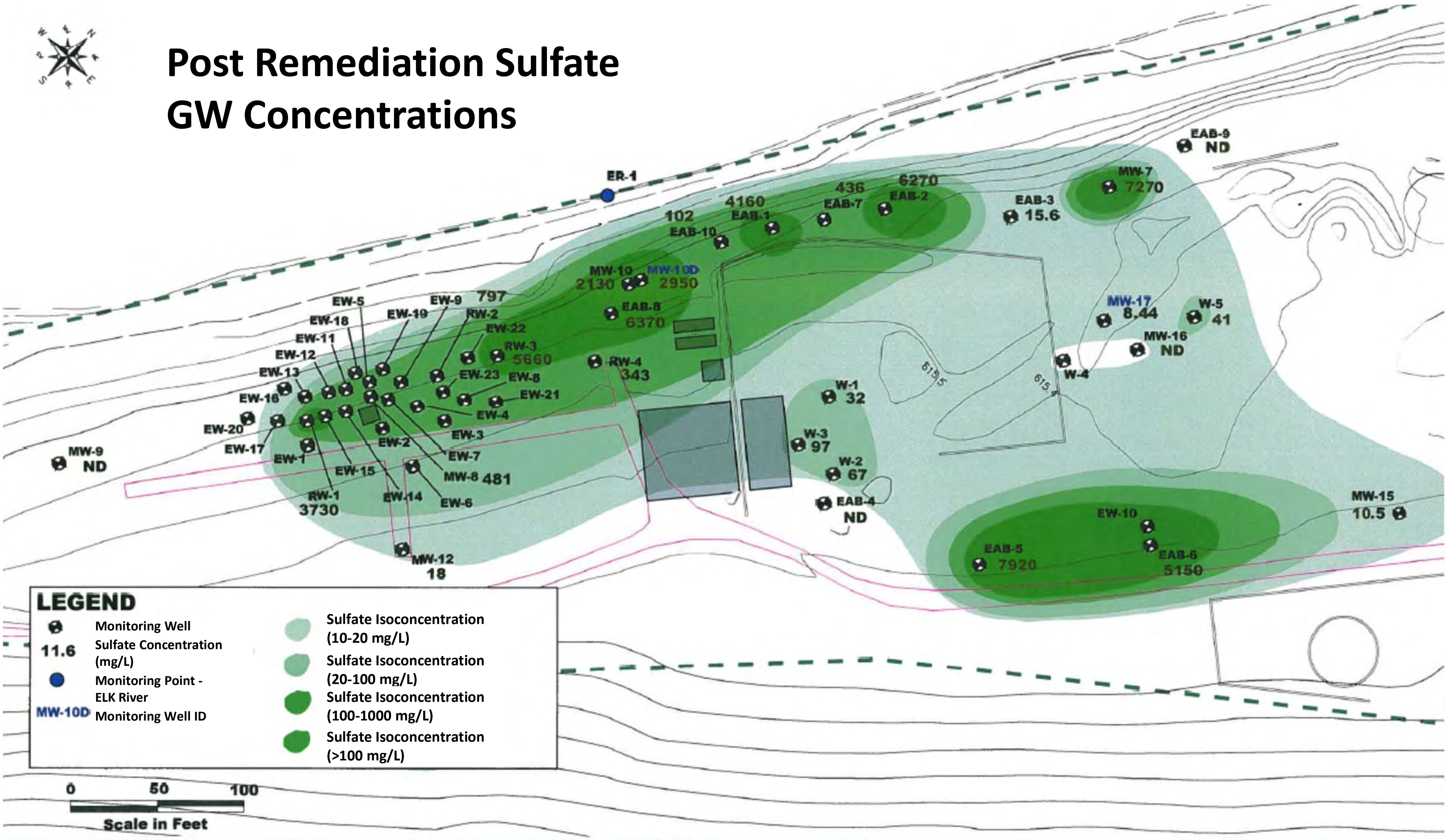
FIGURE 16


EAB - 7 Benzene & Sulfate Trends
Start LNAPL Recovery and EAB Recirculation
Benzene & Xylene (ug/L)
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Sulfate (mg/L)
1400
1200
1000
800
600
400
200
0
11/18/10
1/7/11
2/26/11
4/17/11
6/6/11
7/26/11
9/14/11
11/3/11
350
250
Benzene
Xylenes
Sulfate

Post Remediation Benzene Concentration
Post amendment GW sampling proved benzene was not migrating to the river

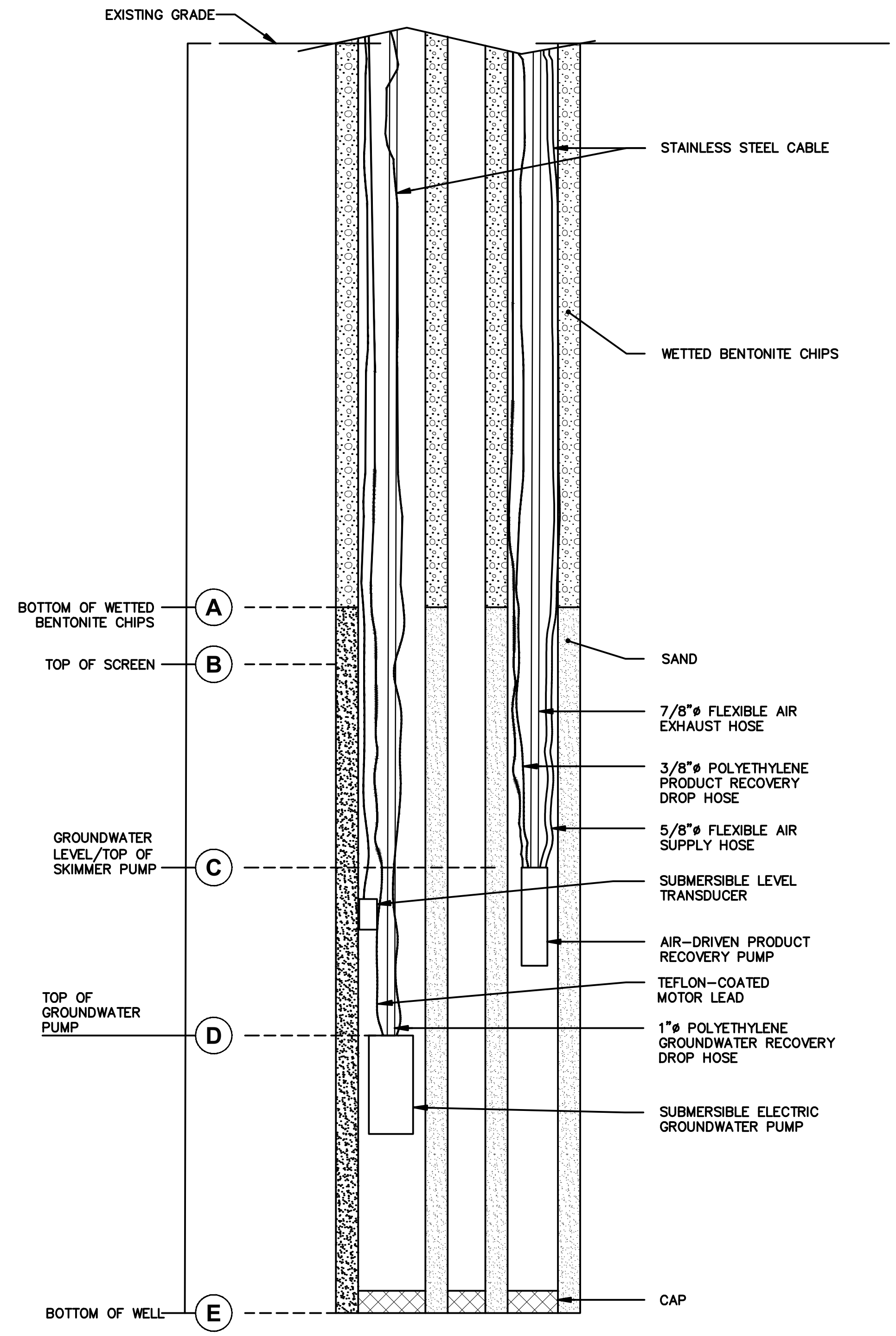


Post Remediation Sulfate GW Concentrations

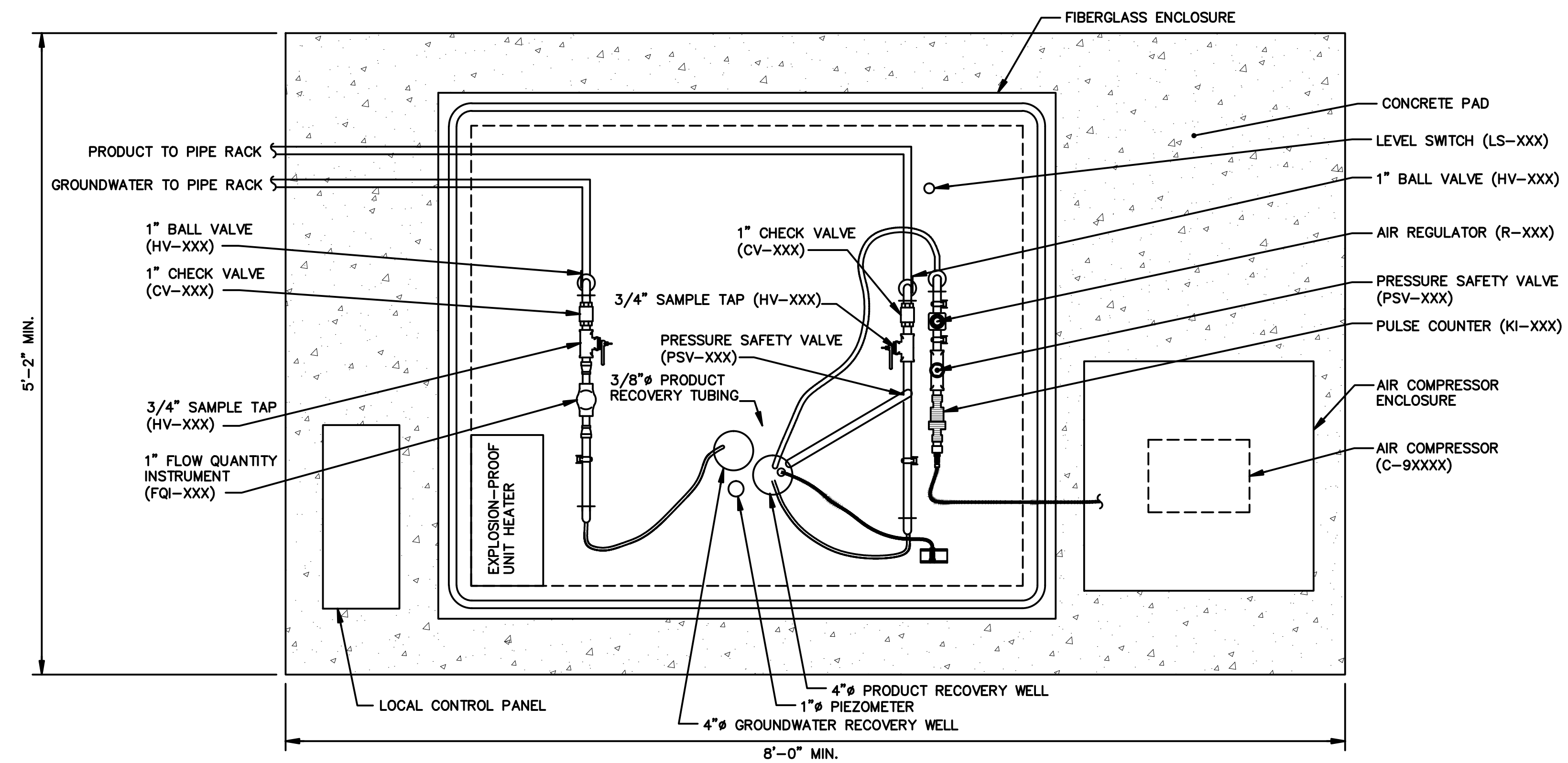


ATTACHMENT B

TYPICAL RECOVERY WELL PLAN AND PROFILE – PHASE II



PROFILE
NOT TO SCALE



PLAN
NOT TO SCALE

SECTION	WELL ID	DEPTH (FT BGS)
A	RW-1	4.0
	RW-2	5.0
	RW-4	5.0
	RW-6	4.0
	RW-7	3.0
	RW-8	3.0
B	RW-1	6.0
	RW-2	7.0
	RW-4	13.0
	RW-6	6.0
	RW-7	5.0
	RW-8	5.0
C	RW-1	9.0
	RW-2	10.0
	RW-4	15.0
	RW-6	14.0
	RW-7	11.0
	RW-8	11.0
D	RW-1	14.0
	RW-2	15.0
	RW-4	20.0
	RW-6	19.0
	RW-7	14.0
	RW-8	14.0
E	RW-1	21.0
	RW-2	22.0
	RW-4	27.0
	RW-6	26.0
	RW-7	17.0
	RW-8	17.0

NOTES:

1. SPECIFICATIONS FOR PUMPS, VALVES, PIPING AND INSTRUMENTATION ARE PROVIDED ON DRAWING 34.
2. CONCRETE PAD TO BE INSTALLED IN ACCORDANCE WITH DETAIL 1 ON DRAWING 29.
3. DEPTHS SHOWN IN TABLE ARE SUBJECT TO CHANGE BASED ON CURRENT GROUNDWATER ELEVATION.
4. DETAILS FOR AIR COMPRESSOR ENCLOSURE ARE PROVIDED IN DETAIL 1 ON DRAWING 28.
5. SANITARY WELL SEALS TO BE PROVIDED FOR GROUNDWATER AND PRODUCT RECOVERY WELLS IN ACCORDANCE WITH DETAILS 2 AND 3 ON DRAWING 28.
6. ALL PIPING, VALVES, AND INSTRUMENTATION INSIDE OF FIBERGLASS ENCLOSURE SHALL BE SUPPORTED ON FREE-STANDING FIELD FABRICATED UNI-STRUT SUPPORTS.

XREFS: 00871X00 IMAGES: PROJECTNAME: ----

NOTES

REFERENCE DRAWINGS

NO.	REVISIONS	BY	CHK.	DATE	APPR.	APPR.

NO.	REVISIONS	BY	CHK.	DATE	APPR.	APPR.
7	PHASE II FINAL DESIGN	SAB		8/2013		
6	PHASE II 95% DESIGN	SAB		6/20/13		
5	REVISED EQUIP NO'S CHANGED TO UNIT 90	DGJ		4/17/13		
4	PHASE I AS-BUILT	SAB	TEM	4/2012		
3	REVISED 100% DESIGN	SAB	TEM	10/2011		
2	100% DESIGN	SAB	TEM	7/2011		
1	90% DESIGN	SAB	TEM	6/2011		

DRAWING TITLE

TYPICAL RECOVERY WELL PLAN AND PROFILE – PHASE II

ARCADIS
ARCADIS U.S., INC.
2929 BRIARPARK DRIVE, SUITE 300
HOUSTON, TEXAS 77042 TEL. 713.953.4800

NAVAJO REFINING CO.
ENGINEERING DEPARTMENT
P.O. DRAWER 159
ARTESIA, NEW MEXICO

DRAWN BY	CHK'D BY	SCALE	
KLS	SAB	NOT TO SCALE	
DATE	APPR BY	DRAWING NUMBER	REV.
AUGUST 2013	TEM	26	5

CITY:SYRACUSE, NY DIV/GROUP:ENV/CAD DB:K.SARTORI LD:(OPT) PIC:P.KRUEGER PM:P.KRUEGER TM:P.KRUEGER LYR:(OPT)ON=*;OFF=*REF*
G:\ENVCAD\SYRACUSE\ACT\TX000871\0004\00002\DWG\LNAPL-PHASE II\00871G26.dwg LAYOUT: 26 SAVED: 8/23/2013 2:25 PM ACADVER: 18.1S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: PLTCONT.CTB PLOTTED: 8/23/2013 2:25 PM BY: SARTORI, KATHERINE

Chavez, Carl J, EMNRD

From: Cobrain, Dave, NMENV
Sent: Wednesday, July 31, 2019 3:33 PM
To: Holder, Mike; Griswold, Jim, EMNRD; Chavez, Carl J, EMNRD
Cc: Denton, Scott
Subject: RE: Pilot Test Follow Up

Mike,

That's essentially it. As a reminder, NMED views the ultimate goal of the system to be to achieve cleanup levels in off-site groundwater so that needs to be a consideration as you respond to the comments.

Thanks.

Dave

Dave Cobrain
New Mexico Environment Department
Hazardous Waste Bureau
2905 Rodeo Park Drive East Bldg 1
Santa Fe, NM 87505-6313
Main Office Phone 505-476-6000
Direct Line 505-476-6055
Fax 505-476-6030

-----Original Message-----
From: Holder, Mike <Michael.Holder@hollyfrontier.com>
Sent: Wednesday, July 31, 2019 2:54 PM
To: Cobrain, Dave, NMENV <dave.cobrain@state.nm.us>; Griswold, Jim, EMNRD <Jim.Griswold@state.nm.us>; Chavez, Carl J, EMNRD <CarlJ.Chavez@state.nm.us>
Cc: Denton, Scott <Scott.Denton@HollyFrontier.com>
Subject: [EXT] Pilot Test Follow Up

Dave - just to summarize our call yesterday (thanks for taking time to discuss!) - comment #1 is a suggestion for alternatives to consider if the in-situ approach doesn't work & NMED intends we proceed with the pilot test as proposed once we've worked they the other comments. In addition, the injection criteria remain removal of free-phase & addition of amendments. The path forward is for HFNR to develop a preliminary response package and submit to NMED & OCD for review & then meet shortly thereafter for a working mtg to hammer our final decisions so the plan can be finalized & we can move forward. Hopefully this will avoid a letter campaign & get things rolling faster. If needed, we will request an extension to the current response due date. We are working out a schedule and will let you know soon. If you, or OCD, have any additional input in the interim, please let us know so we can address in our submittal. Thanks again & we'll be in contact soon.

Regards,
Mike

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Michelle Lujan Grisham
Governor

Howie C. Morales
Lt. Governor

NEW MEXICO
ENVIRONMENT DEPARTMENT

Hazardous Waste Bureau
2905 Rodeo Park Drive East, Building 1
Santa Fe, New Mexico 87505-6313
Phone (505) 476-6000 Fax (505) 476-6030
www.env.nm.gov

James C. Kenney
Cabinet Secretary

Jennifer J. Pruett
Deputy Secretary

CERTIFIED MAIL – RETURN RECEIPT REQUESTED

July 22, 2019

Scott M. Denton
Environmental Manager
HollyFrontier Navajo Refining LLC
P.O. Box 159
Artesia, New Mexico 88211-0159

RE: DISAPPROVAL
GROUNDWATER AND PHASE-SEPARATED HYDROCARBON RECOVERY SYSTEM ENHANCEMENTS: REINJECTION PILOT TEST WORK PLAN
HOLLYFRONTIER NAVAJO REFINING LLC – ARTESIA REFINERY
EPA ID NO. NMD048918817
HWB-NRC-19-002

Dear Mr. Denton:

The New Mexico Environment Department (NMED) has completed its review of HollyFrontier Navajo Refining LLC, Artesia Refinery's (the Permittee) *Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements: Reinjection Pilot Test Work Plan* (Work Plan), dated April 2019. NMED hereby provides this Disapproval with the following comments.

Comment 1

The groundwater at the East Field is contaminated above the injection criteria established by NMED and Energy Minerals and Natural Resource Department Oil Conservation Division (OCD). It will be difficult to verify the effectiveness of the proposed in-situ treatment with only the proposed method, even if the constituents of concern (COCs) concentrations are reduced in-situ, it will be difficult to distinguish whether the reduction is caused by biodegradation or dilution. NMED is concerned that it may not be possible to achieve the injection criteria with the proposed in-situ bioremediation alone. The use of the proposed in-situ treatment with an aboveground treatment system (e.g., air stripper with granulated activated carbon (GAC)) would achieve the required standards and generate measurable and quantifiable data to demonstrate this. The Permittee must consider additional measures to ensure the treated groundwater will meet the injection criteria.

Comment 2

In Section 3.3.1 (Shallow Saturated Zone), page 8, paragraph 3, the Permittee states, "[c]oncentrations of total dissolved solids (TDS) exceeding 2,000 milligrams per liter (mg/L) and sulfate exceeding 500 mg/L have been recorded northwest (upgradient) of the Refinery." The TDS and sulfate concentrations in the groundwater samples collected from most of the wells installed in the shallow saturated zone significantly exceed the referenced concentrations in the area. For example, the TDS and sulfate concentrations in the groundwater sample collected from upgradient well UG-4 are recorded as 4,030 mg/L and 2,680 mg/L, respectively, during the April 2018 sampling event according to the *2018 Annual Groundwater Monitoring Report*. Although the statement is correct, the referenced concentrations are somewhat misleading because it suggests that most of the concentrations are in close approximation to the referenced concentrations. In the revised Work Plan, clarify that a majority of the wells referenced in the northwest (upgradient) in the Refinery significantly exceed the range of concentrations provided.

Comment 3

In Section 3.3.2 (Valley Fill Zone), page 9, paragraph 1, the Permittee states, "[w]ells in the valley fill zone range from 40 to 60 feet bgs and the formation yields water containing TDS ranging from 500 to 1,500 mg/L." The TDS concentrations in groundwater samples collected from well MW-18B installed in the valley fill zone were recorded as being above 4,000 mg/L since 2013, exceeding the referenced range according to the *2018 Annual Groundwater Monitoring Report*, submitted in February 2019. Revise the Work Plan to clarify that some wells significantly exceed the range of concentrations provided.

Comment 4

In Section 3.3.3 (Deep Artesian Aquifer), page 9, paragraph 3, the Permittee states, "[a]vailable well completion records for irrigation well RA-4798 indicate that it is screened in the deep artesian aquifer from 840 to 850 feet bgs. Historic analytical data from this well does not indicate the presence of hydrocarbon impacts from Refinery operations." The statement is not accurate. MTBE has been detected from well RA-4798 since 2016 according to the *2018 Annual Groundwater Monitoring Report*. Revise the Work Plan for accuracy.

Comment 5

Section 4.1 (Test Location), page 10, paragraph 1 states that "[t]o test recovery and injection efficiency in areas that are representative of the conditions that will be addressed by the full-scale system, HFNR is planning to perform that pilot test in the East field near existing wells KWB-5 and MW-131. The area around these wells [KWB-5 and MW-131] contains PSH and dissolved-phase constituents at concentrations of the same magnitude or higher than what is expected to be recovered by the enhanced recovery system." In the revised Work Plan, address the following:

a. NMED is concerned that the proposed Pilot Test wells KWB-5 and MW-131 may not be representative of conditions where the full-scale system is proposed (i.e., at the Eastern Boundary and East Field) to be installed. COC analytical groundwater data in the proposed Pilot Test wells are lower than the groundwater analytical results in the groundwater monitoring wells at the eastern refinery boundary. The difference is significant enough that the results from the Pilot Test may skew the design of the full-scale system and may not translate to wells with significantly higher contaminant concentrations. In the revised Work Plan discuss the conditions in the proposed Pilot Test area compared to the eastern refinery boundary area and discuss how the Pilot Test results are expected to scale up.

b. The sulfate level in well MW-131 was recorded as 15.5 mg/L during the October 2017 sampling event, which is exceptionally low compared to the rest of the wells in the vicinity: therefore, it is not representative of site conditions. The low groundwater sulfate level in the Pilot Test location is misleading and may overstate success and a possibly false demonstration of the injection criteria being met by the proposed amendment in a full-scale system. If sulfate reducing bacteria (SRB) are present in the aquifer and favorable conditions are met, the sulfate groundwater concentrations in the East Field generally exceed the theoretical demands required to reduce all organic constituent concentrations below the screening levels. Since the injection fluid for the full-scale system will be a mixture of groundwater extracted from the trenches at Bolton Road, the sulfate level in the injection fluid of the full-scale system will likely exceed the required sulfate demand. Sulfate is abundant at the site; therefore, amending the system with sulfate does not appear to be necessary to attain the injection criteria. Provide more discussion for the basis of the proposed sulfate biostimulation and how it will help to attain the injection criteria in the revised Work Plan.

Comment 6

In Section 4.1 (Test Locations), page 10, paragraph 1, the Permittee states, "[t]he two proposed pilot test locations provide the opportunity to test injection, amendment, and recovery in two of the primary soil types (gravel and silty sand) in which the full-scale system will also be installed." The Permittee must explain why KWB-5 is considered to be a "target zone with more gravel" when the KWB-5 well log does not include gravel in the soil type description. If available, provide additional soil boring logs that are pertinent to the discussion and demonstrate that the two different soil types are present in the Pilot Test area in the revised Work Plan.

Comment 7

In Section 4.1 (Test Locations), page 10, paragraph 2, the Permittee states, "[t]he exact location of the injection, monitoring, and recovery wells will be determined after completion of gamma logging of the existing well in the area around KWB-5 and MW-131." The Permittee must include the gamma logging data, the potential figures generated from the data results and include a discussion of the data and the results in the Pilot Test report.

Comment 8

In Section 4.1 (Test Locations), page 10, paragraph 2, the Permittee states, "[d]ue to the heterogeneous nature of the shallow geology in this area, some additional exploratory borings may be installed to further characterize the lithology in the area near well KWB-5 and MW-131. The final locations of wells to be used in each of the two pilot test areas will be adjusted with the intent of having all wells within each pilot test area screened within the same, continuous coarse-grained lithology zone, to the degree feasible on the heterogeneous nature of the shallow geology. One pilot test area will target zones with more gravel (KWB-5) and the other pilot test area will target zones with more silty sand (near MW-131)." The Permittee must provide all boring logs for the additional exploratory borings, including borings that were not converted to wells. The additional borings are subject to soil sampling and must also include analysis for VOCs, total petroleum hydrocarbons (TPH as diesel-range organics (DRO), gasoline-range organics (GRO), and oil-range organics (ORO)) and metals analyses, at a minimum. The data must be included in the Pilot Test report. While the Permittee's intent is to conduct the test in two lithologic zones, it appears the gravel zone may not be present in well KWB-5 (see Comment 5a). The Permittee will not be able to extrapolate the data to the full-scale system, if the test is conducted as proposed.

Comment 9

In Section 4.2 (Dissolved-Phase Conditions), page 10, bullet item 2, the Permittee states that "[b]ackground sulfate concentrations west of the Refinery appear to range between 1,000 and 2,000 mg/L, while sulfate concentrations within the hydrocarbon plume below the East Field range from 10 to 100 mg/L, and are non-detect in some wells." Wells UG-1, UG-2, and UG-3R were not intended to be utilized for background and were originally installed to monitor contamination migrating on to the Refinery property. It has been discussed several times that background at the site is not achievable and that only a baseline can be established with the current conditions of the site. The baseline conditions must be established specific to the East Field relevant to the areas of the Pilot Test and full-scale remediation system. Revise all sections that refer to "background" and replace with the term "baseline".

Comment 10

Section 4.2 (Dissolved-Phase Conditions), page 11, bullet item 1, states, "[t]he inverse concentration correlation indicates SRBs are utilizing sulfate to degrade hydrocarbons in both dissolved and adsorbed phases (note that the sulfate demand of dissolved-phase concentrations is too low to exceed the background supply of sulfate)." The Permittee has not demonstrated that there is a correlation between the SRB and the degradation of hydrocarbons in both the dissolved and adsorbed phase and there is no data to support this statement. Therefore, groundwater samples must be collected from wells within the East Field to determine the concentrations of sulfide and sulfate and the population of the SRB. Since the Work Plan is developed based on the assumption that SRB play a vital role in hydrocarbon degradation, the presence of SRB and the occurrence of sulfate reduction must be demonstrated prior to Pilot Test start up. Include

SRB sampling and evaluation in the revised Work Plan. Sampling of the SRB population must be conducted throughout the duration of the Pilot Test.

Comment 11

Section 4.2 (Dissolved-Phase Conditions), page 11, paragraph 1, states, "[i]n addition to bioavailable sulfate, nitrogen in the form of ammonia will be added to the system to amend the two most likely rate-limiting nutrients." The screening level for nitrate concentration in groundwater is 10 mg/L. Verify that the ammonia amendment will not cause nitrate exceedances and provide a more detailed basis for amending with ammonia in the revised Work Plan.

Comment 12

Section 5.2.1 (Baseline Groundwater Quality Evaluation), page 13, bullet item 4, states, "[m]onitored natural attenuation (MNA) laboratory-measured parameter concentrations: sulfate, total Kjeldahl nitrogen (TKN), total organic carbon (TOC), alkalinity, ferrous iron, and magnesium." Discuss the basis for monitoring TKN in the response letter. Since the dissolved phase hydrocarbon is to be primarily degraded by SRB, measurement of SRB and sulfide concentrations must also be included (see Comment 10). In addition, since the proposed MNA parameters are unlikely to provide accurate information regarding the distribution of amendments in the vicinity of the injection wells, a tracer must be included during the initial stage of the injection process and the tracer level must be monitored. Revise the Work Plan accordingly.

Comment 13

In Section 5.2.1 (Baseline Groundwater Quality Evaluation), page 13, paragraph 2, the Permittee states, "[b]aseline water level and water quality data will be measured in all of the wells associated with the pilot test." For the KWB-5 test area, wells KWB-5, KWB-4, and MW-99, KWB-6 and MW-112 are proposed to be monitored. For the MW-131 test area, wells MW-131, MW-129, and MW-112 are proposed to be monitored. Provide clarification regarding the following:

a. Phase-separated hydrocarbon (PSH) has been present in wells KWB-4 and MW-112 since they were both installed; therefore, groundwater analytical data have not been collected from these wells. Data collected during the Pilot Test cannot be compared to any existing data. Samples must be collected, and the data can be used for informational purposes. Explain the basis for including these wells as a part of the test evaluation since there are no baseline data.

b. Well MW-99 is screened from 12 to 27 feet bgs, while the surrounding wells are screened from approximately 20 to 40 feet bgs. The screened interval of well MW-99 is not consistent with other wells and is also located more than 400 feet upgradient from the proposed test area. Explain why well MW-99 is being included in the evaluation of the Pilot Test investigation and explain if the depth of the screened interval will impact the evaluation of data from the Pilot Test.

c. Several wells proposed as upgradient monitoring wells for the Pilot Test are located approximately 610 to 625 feet from the test area. Propose to install upgradient wells that are closer to the test area or propose to install the injection and recovery wells closer to the monitoring wells chosen to be the upgradient wells for the Pilot Test in the revised Work Plan.

d. The sulfate level within the Pilot Test area is one to two orders of magnitude lower when compared to the monitoring wells in the eastern refinery boundary. The sulfate levels are not likely representative of the groundwater conditions for evaluation and the design of the full-scale system (see Comment 5). Explain why this proposed groundwater extraction location was chosen, especially since sulfate concentrations are most likely depleted in the pilot study area compared to the eastern refinery boundary.

e. After the full-scale system has been completed, the extracted groundwater from surrounding monitoring and extraction wells (i.e., Bolton Road) may replenish sulfate concentrations without amending it (see Comment 5) because concentrations from these wells range from 525 to 1,400 mg/L (April 2018 Event). Demonstrate whether or not the sulfate amendment is necessary using stoichiometric mass balance and the analytical data from all wells pertinent to the east refinery boundary where the full-scale remediation is proposed to be implemented. Provide these calculations in the revised Work Plan and provide a discussion regarding the conclusions of these calculations.

f. Well MW-111 is not included as a part of the Pilot Test evaluation. The screened interval of well MW-111 is consistent with other monitoring wells and may be suitable to evaluate cross-gradient migration and unanticipated preferential flow. Propose to include well MW-111 in the Pilot Test.

Comment 14

In Section 5.2.2 (Installation of Injection, Recovery, and Monitoring Wells), page 14, paragraph 1, the Permittee states, "[i]njection and recovery wells will be separated by a minimum distance of 200 feet to ensure that the radius of influence from recovery drawdown and injection mounding do not overlap." Section 5.0 (Pilot Test Scope) states that the Pilot Test will evaluate the effectiveness of the amendment and reinjection process. Although recirculation and capture of the injectate is not necessary for the test, further reduction of the dissolved phase hydrocarbon concentrations is expected. Explain and discuss the purpose of intentionally isolating the influence of the injection and extraction wells in the revised Work Plan.

Comment 15

In Section 5.2.2 (Installation of Injection, Recovery, and Monitoring Wells), page 15, paragraph 1, the Permittee states, "[a] gamma-log study will be conducted on existing monitoring wells in the area prior to installation of the pilot test injection and recovery wells to verify the gravel seam and silty sand presence, depth, thickness, and extent in each pilot test area. Injection wells will be designed based on the gamma logging results, using lithology from the CME report and/or lithology from borings installed prior to the pilot test to evaluate the pilot test area, if deemed necessary." In the Pilot Test report, include the gamma-log study field data along with any figures and tables generated from the results. Provide a table that summarizes the data ranges generated from the site-specific evaluation that define the lithology at the site. Include a discussion about how the data supports the locations chosen for the installation and design of the injection wells. Furthermore, additional borings will be required to provide additional support to the gamma-log study to verify the gravel seam and silty sand presence. See also Comment 7.

Comment 16

In Section 5.2.2 (Installation of Injection, Recovery, and Monitoring Wells), page 15, paragraph 1, the Permittee states, "[t]he injection wells will be constructed of stainless steel casing and screen, and will be screened across the target lithologic zone." Explain why a stainless-steel casing and screen will be used for the construction of the injection wells. In Appendix A, the Permittee's *Supplemental Information Form C-108, Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements Reinjection Pilot Test Work,* dated May 30, 2019 states that the maximum possible injection pressure is 150 pounds per square inch (psi). Presumably, a stainless-steel casing and screen are chosen for the construction of injection wells to accommodate high injection pressures. A high pressure injection technique is not recommended because new fractures and flow paths may potentially develop. Once new fractures develop, the fluid may preferentially flow through the fractures and the fractures could cause short circuiting and the desired cleanup level may not be achieved. Section 5.2.3 states that care will be taken not to exceed pressure suitable for the wellbore and formation; however, a specific description of procedures to prevent formation of new flow paths is not discussed. Provide a provision to limit the injection pressure to prevent new pathways in the revised Work Plan.

Comment 17

Section 5.2.2 (Installation, Recovery, and Monitoring Wells), page 16, paragraph 2, states "[a]ny PSH present in pilot test monitoring or injection wells will be measured, and if removed, stored temporarily in small totes near the recovery well so that the recovered volume can be tracked separately from the rest of the current recovery system." The Permittee did not indicate where the totes would be stored, the capacity of the totes, or the frequency for removing PSH from the site. It is also unclear if the product will be removed manually or pumped into the tote(s) from the wells. It is not feasible to continuously remove PSH without also extracting groundwater during the Pilot Test operation. Furthermore, since the location of the totes do not appear on Figure 3 (Process and Instrumentation Diagram Sulfate and Ammonia Injection) it appears that the mixture of groundwater and PSH will be recovered and possibly stored in the sulfate holding tank. If it is the Permittee's intent, the sulfate tank will presumably serve as both mixing and separation tank. NMED does not recommend this approach because the amendment mixing process (e.g., mechanical agitation/circulation) will potentially interfere with the process of PSH separation; therefore, each process must be carried out in a separate tank. The mixture must initially be retained in the separation tank with enough retention time to separate PSH by gravity; then, only the aqueous solution from the bottom of the tank can be transferred to the mixing tank. Revise Figure 3 to depict (1) where the tote(s) will be located, (2) if piping will be run from the wells to the tote(s) for PSH recovery, (3) location of individual tanks to separate water and PSH and mix the amendments, (4) a skimmer pump that removes PSH from the retention tank, if any, and (5) discuss and illustrate measures to provide adequate mixing for the amendments.

Comment 18

In Section 5.2.2 (Installation of Injection, Recovery, and Monitoring Wells), page 15, paragraph 3, the Permittee states, "[t]he proposed injection and monitoring wells will also be installed as permanent wells but may be abandoned upon completion of the pilot test." The Permittee must propose to retain or abandon the wells in the Pilot Test report. The Permittee must not abandon the wells without concurrence from NMED and OCD.

Comment 19

In Section 5.2.3 (Initial Injection Test), pages 15 to 17, the Permittee describes the initial injection test to determine the optimal injection rate and to observe the hydrogeologic response after the injections. However, NMED requires that an initial pump test/aquifer test be conducted to characterize the wells to provide aquifer data that is not dependent on the previous pump tests that were conducted in the trenches. The pump test is also to ensure the correct pumping rates are achieved, to ensure that the well(s) will not run dry, to determine recovery rates to check the radius of influence and determine if there are any impacts to the surrounding wells. The pump test/aquifer test must run, at a minimum, of 24 hours. The Permittee must provide logs for all borings and wells installed at the site. Soil samples must be collected and analyzed for TPH as DRO/GRO/ORO, VOCs, and metals. Groundwater samples must also be tested for the same analytes and SRB at all pertinent wells. Propose the wells to be sampled for SRB in the revised Work Plan. NMED requires 20 days notification prior to beginning drilling activities at the site and also notification when the pump test/aquifer test has been completed. Once the initial testing period has been completed, the Permittee must provide a progress report that summarizes and discusses the test method(s), equipment used, field data results, the pumping rates, include SRB data, aquifer test results, and groundwater and soil sample results. Discuss the hydrogeologic response after the injections and include the lithologic logs. The progress report must also discuss any problems encountered during the testing period. The progress report must be submitted to NMED within 50 days after the initial pump test/aquifer test is completed.

Comment 20

In Section 5.2.3 (Initial Injection Test), pages 15 to 17, the Permittee describes the initial injection test to determine the optimal injection rate and to observe the hydrogeologic response after the injections. Address the following in the revised Work Plan:

a. The Permittee did not state if the extracted groundwater will be treated to meet groundwater standards prior to injection. Revise Section 5.2.3 to clarify if the extracted groundwater will be treated prior to injection and what method will be used to treat it. Also, modify Figure 3 to include the measures, if any.

b. There were several incidents that occurred during the *Shallow Saturated Zone Groundwater Pump Test* that involved failure of equipment (i.e., pumps and transducers) during the test. Ensure all equipment (e.g., pumps and transducers) are checked and tested prior to starting the initial pump/aquifer test and initial injection test.

c. Provide a table summarizing the pump specifications and transducer installation data for each well. Ensure that the injection flowrates during the test are also summarized in a table. Include the tables in the Pilot Test report.

d. Include all field data and notes as an appendix in the Pilot Test report.

e. State if the current extraction system will be operating during the installation of the transducers and explain if it will impact the Pilot Test. Also state if the East Fields are still irrigated and if this could also impact the water levels during the Pilot Test.

Comment 21

In Section 5.2.3 (Initial Injection Test), page 16, paragraph 4, the Permittee states, "[p]ressure transducers will be placed in the injection wells, monitoring wells, and recovery wells in the pilot test area to measure the groundwater level." Comment 20 requires the Permittee to perform an initial injection test to evaluate the influence of the recovery wells. Since pressure transducers will be in place, record the change of water levels for a period of 24 hours during the injection test. Include the provision in the revised Work Plan.

Comment 22

In Section 5.2.3 (Initial Injection Test), pages 16-17, the Permittee states, "[t]he anticipated injection rates for the first three steps of the test are 4, 8, and 12 [gallons per minute (gpm)] based on groundwater modeling performed in 2016 and 2018." The site formation may likely be too tight based on the lithology of the area to allow 4 gpm per well during the initial injection step. The proposed injection rate may cause injectate to overflow. Consider starting the initial injection rate at one gpm and gradually increase the injection rate if the water level continues to stabilize. Otherwise, demonstrate that the anticipated injection rates (4, 8, and 12 gpm) are appropriate starting points for the initial injection test.

Comment 23

In Section 5.2.5 (Treatment Efficiency Evaluation), page 18, paragraph 1, the Permittee states, "[t]o prevent fouling of the injection system and injection well, it is critical that the redox condition of the extracted water remains anaerobic throughout the recirculation process, to the degree feasible." The recirculation system must include a function to remove the recovered PSH and to meet all injection criteria of the groundwater (see Comments 1 and 17). Section 5.2.6 states that the PSH recovered volume will be recorded; however, Figure 3 does not depict any mechanism to remove PSH (e.g., oil-water separator). Include the provisions in the revised Work Plan. Additionally, discuss specific measures that will prevent the extracted groundwater from being aerated in the recirculation process in the revised Work Plan.

Comment 24

Section 5.2.7 (Groundwater Monitoring), page 21, paragraph 1 states, "[w]here feasible, the pump intake should also be installed at least four feet below the smear zone to minimize the potential for sampling colloids associated with partially degraded hydrocarbons in smear zones." The proposed sampling method is acceptable; however, the pump intake for the recovery wells must not be installed more than two feet below the smear zone. Contaminants may be introduced to the clean soils beneath the smear zone if the pump intake is installed too far below the smear zone. Identify the lowest groundwater elevations historically recorded in nearby wells to determine specific depths where pump inlets will be placed in the recovery wells in the revised Work Plan.

Comment 25

In Section 5.2.7 (Groundwater Monitoring) page 21, paragraph 2, the Permittee describes how the injection flow rates and amendment feed rates will be adjusted based on the daily monitoring results and sulfate concentration at the wells. NMED Comment 12 directs the Permittee to include a tracer and to monitor the tracer concentrations in the monitoring wells in order to optimize the system. Revise the Work Plan to incorporate the data collected from the tracer testing data for system adjustment as well. In addition, Table 1 (Dosing Rate Calculations) provides calculations to prepare sulfate stock solution and injectate that contains 2,000 mg/L sulfate. Table 1 also indicates that the sulfate concentration in the formation is targeted to reach from 300 mg/L to 500 mg/L. As stated in Comment 5, the sulfate amendment may not be necessary. Table 1 does not include calculations to estimate the volume of injectate necessary to achieve the target formation concentration. Revise Table 1 to include these calculations. Table 1 does not provide any dosing calculations for ammonia. Revise Table 1 to include the ammonia calculations.

Comment 26

In Section 5.2.7 (Groundwater Monitoring), page 21, bullet item 5, the Permittee states that "[o]nce sulfate is detected at a concentration above 500 mg/L in all of the monitoring wells between the injection and recovery wells, quarterly sampling events will begin on all wells listed above." The baseline sulfate levels in some monitoring wells in the vicinity exceed 300 mg/L (e.g., wells KWB-6 and MW-111). Provide a justification for the referenced concentration of 500 mg/L in the revised Work Plan.

Comment 27

In Section 5.2.8 (Data Processing), page 22, paragraph 1, the Permittee states that "[d]ata will be presented in interim progress reports to be provided to NMED and OCD on a quarterly basis. A summary report including all the data and results of the test will be submitted after the completion of pilot test activities and prior to the implementation of the full-scale system upgrade." The Permittee is also required to submit the final Pilot Test data and results as a final investigation report (Pilot Test report). Furthermore, prior to implementing the full-scale system, NMED and OCD must approve the conclusions and the recommendations provided in the Pilot Test Report. The decision to move forward to the full-scale system installation will be based on the Pilot Test results.

Comment 28

Section 5.3.1 (Installation of Pilot Test Injection, Recovery, and Monitoring Wells), pages 22-24, discusses the details regarding the installation of the Pilot Test wells. Although the expected screen length is described, the provision for the screen to intersect the water table is not included. The screens for the Pilot Test recovery and monitoring wells must intersect the water table. Include the provision in the revised Work Plan. In addition, the approximate distances between the wells (e.g., distance between wells IW-1 and PMW-1) are not stated in Section 5.2.2. State the distances between the wells in the revised Work Plan.

Comment 29

Section 5.3.1 (Installation of Pilot Test Injection, Recovery, and Monitoring Wells), pages 22-24, describes the specifications for the injection, recovery and monitoring wells for the Pilot Test but does not provide proposed construction diagrams for these wells. Include construction diagrams for the injection, recovery and monitoring wells in the revised Work Plan. In addition, the screened intervals of the injection wells must be set below the water table and should not be set across the water table for more uniform distribution of injectate. Include the provision in the revised Work Plan.

Comment 30

Section 5.3.1 (Installation of Pilot Test Injection, Recovery, and Monitoring Wells), page 23, paragraph 1, states, "[t]wo 4-inch diameter casings (one for PSH recovery and one for water recovery) and a single 2-inch diameter casing (for measurement) will be installed in each recovery well borehole." Provide a well construction diagram of the proposed recovery wells in the revised Work Plan.

Comment 31

Section 5.3.1 (Installation of Pilot Test Injection, Recovery, and Monitoring Wells), page 23, paragraph 1, states, "[e]ach injection well will be screened at or slightly below the top of the target lithologic zone (i.e., gravel and silty sand interval), with an expected screen length of 10 feet, and will include a 2-foot sump below the screened interval." If the purpose of the sump is to protect the screen from organic debris in the injectate, the recirculation system must also be equipped with a filter that eliminates the debris. Include the provision in the Work Plan, as necessary.

Comment 32
In Section 5.3.1 (Installation of Pilot Test Injection, Recovery, and Monitoring Wells), page 23, paragraph 3, the Permittee states, "[i]njection wells will be permitted as temporary wells that may be abandoned at the end of the pilot test; however, the injection wells will be constructed to the same specifications as using permanent wells. Recovery wells will be permitted and constructed as permanent recovery wells using the same configuration as the Phase II recovery wells. Monitoring wells installed for the pilot test will be permitted as temporary wells and will likely be abandoned at the end of the pilot test." It is not clear to NMED why the Permittee considers these wells to be temporary wells as they could be a part of the design of the remediation system at the facility boundary when the full-scale system is in operation. Explain why these wells will not be utilized as part of the final full-scale system. Furthermore, the wells must not be abandoned without concurrence from NMED and OCD (Comment 18).

Comment 33
Section 5.3.1 (Installation of Pilot Test Injection, Recovery, and Monitoring Wells), page 24, paragraph 1, states, "[s]ample information and visual observations of the cuttings and core samples shall be recorded on the boring log. Soil samples will not be collected for laboratory analysis during installation." The Permittee must record and depict the smear zone on all of the logs (i.e., exploratory borings and developed wells) where groundwater is encountered during drilling activities and state the depths for each injection, recovery and monitoring well in the applicable section(s) of the Pilot Test report. Soil samples must be collected above the saturated zone, within the vadose zone where the highest PID reading is recorded, and at the bottom of each boring. Propose to analyze the soil samples for TPH as DRO/GRO/ORO, VOCs, and metals in the revised Work Plan.

Comment 34
Section 5.3.1 (Installation of Pilot Test Injection, Recovery, and Monitoring Wells), page 24, paragraph 2 states that "[t]he following visual observations will be recorded on the boring log: lithology (color, type, grain size, sorting, etc.), moisture content (dry, damp, wet, moist), and any field evidence of contamination (staining, odor, and photoionization detector [PID] readings)." In addition to this information, the Permittee must also attempt to identify the smear zone on the logs based on field screening (see Comment 34).

Comment 35
In Section 5.3.4 (Groundwater Sampling), page 26, paragraph 2, the Permittee states that "[t]he purging process will be considered complete and groundwater sampling will commence when at least four of the seven water quality parameters [(pH, temperature, conductivity, TDS, ORP, DO and turbidity)] achieve stabilization within ten% for three consecutive readings." Although at least four of the seven water quality parameters are required to reach stabilization, the Permittee must ensure that all seven water quality parameters are recorded during each consecutive reading

and all seven parameters must be reported after the final reading in a table presented in the Pilot Test report.

Comment 36

In Section 5.5 (Treatment Test Effectiveness), page 28, paragraph 1, the Permittee states that "[t]he amendments will be considered effective if dissolved phase concentrations decrease during the test." The Permittee did not define a percent reduction of the dissolved phase concentrations for the amendments to be considered effective. Provide an approximation for percent decrease in concentrations that the Permittee will consider the amendments to be considered effective and state if that will be measured not only in concentration decrease but over a set time period as well. Also state how many and which constituents of concern (COCs) will be considered to determine the effectiveness of the amendment.

Comment 37

Section 6.0 (Schedule), page 30, outlines a proposed schedule once NMED and OCD approve the Work Plan. Revise the schedule to include the additional work required by the comments in this Disapproval and submit an updated schedule in the revised Work Plan.

Comment 38

Section 7.0 (Tables) includes Table 1 (Dosing Rate Calculations). It would facilitate NMED's review to include an additional table that summarizes the current hydrogeologic properties (both measured and modeled) that were used to generate the Work Plan, determine the location of the Pilot Test and also include where the value came from (i.e., measured during [Cite Report] or modeled data from [Cite Report]). The table must be updated with the measured and/or modeled hydrogeologic properties from the completed Pilot Test. Provide the appropriate tables in the revised Work Plan.

Comment 39

The maximum contaminant level (MCL) and water quality control commission (WQCC) standard for sulfate are 250 mg/L and 600 mg/L, respectively. The tap water regional screening level (RSL) for hydrogen sulfide, a potential product of sulfate reduction, is 4.2 ug/L. Include a discussion regarding potential the risks associated with sulfate injection in the revised Work Plan.

The Permittee must submit a revised Work Plan that addresses all comments contained in this Disapproval. Two hard copies and an electronic version of the revised Work Plan must be submitted to NMED. The Permittee must also include a red-line strikeout version in electronic format showing where all revisions to the Work Plan have been made. The revised Work Plan must be accompanied with a response letter that details where all revisions have been made, cross-referencing NMED's numbered comments. The revised Work Plan must be submitted to NMED no later than **September 13, 2019**.

If you have any questions regarding this Disapproval, please contact Leona Tsinnajinnie or Michiya Suzuki of my staff at (505) 476-6057 or (505) 476-6059.

Sincerely,

John E. Kieling
Chief
Hazardous Waste Bureau

cc: D. Cobrain, NMED HWB
K. Van Horn, NMED HWB
L. Tsinnajinnie, NMED HWB
M. Suzuki, NMED HWB
C. Chavez, EMNRD OCD
R. Combs, HollyFrontier Navajo Refining LLC, Artesia Refinery
A. Sahba, HollyFrontier Navajo Refining LLC, Artesia Refinery
L. King, EPA Region 6 (6LCRRC)

File: Reading File and NRC 2019, HWB-NRC-19-002

Chavez, Carl J, EMNRD

From: Combs, Robert <Robert.Combs@HollyFrontier.com>
Sent: Tuesday, May 21, 2019 2:54 PM
To: Cobrain, Dave, NMENV; Griswold, Jim, EMNRD; Chavez, Carl J, EMNRD
Cc: Denton, Scott; Holder, Mike; Sahba, Arsin M.
Subject: [EXT] Monitor Well Installation - Groundwater Receptor Survey and Vapor Intrusion Evaluation Technical Memorandum
Attachments: Proposed Wells Maps 5-14-19 benzene.pdf

Dave, Jim, and Carl:

As discussed with NMED and OCD on May 16th, 2019, HollyFrontier Navajo Refining LLC (HFNR) proposes the following scope and schedule for follow-on work from the recently submitted *Groundwater Receptor Survey and Vapor Intrusion Evaluation Technical Memorandum* dated April 12, 2019. HFNR is working on access as described in the memo; a draft schedule is presented here. HFNR will notify NMED/OCD via email if access or other issue causes delays to the proposed schedule.

Phase 1: Monitoring Well Installations (June/July 2019 pending access)

- Two monitoring wells will be installed south of monitoring well MW-135 to identify whether the downgradient residential property (Parcel ID 4-154-098-397-381) and potential domestic water wells RA-02793 and RA-03195 are affected by the dissolved-phase hydrocarbon and phase separated hydrocarbon (PSH) plumes. Both of these wells will be installed on property owned by Chase Farms.
- Two monitoring wells will be installed near the residential property with Parcel ID 4-153-098-515-219, to identify whether the potential domestic water well RA-10378 is affected by the dissolved-phase hydrocarbon plume and to further delineate the extent of MTBE in exceedance of critical groundwater screening levels (CGWSL) at monitoring well NP-1:
    - Install one monitoring well to the north of monitoring well MW-133, near the southwestern corner of Parcel ID 4-153-098-515-219, to better delineate the crossgradient extent of the benzene and MTBE plumes. (HFNR Property)
    - Install one monitoring well to the west of monitoring well NP-1, across Bolton Road from the eastern portion of Parcel ID 4-153-098-515-219, to better delineate the upgradient extent of the isolated MTBE plume near monitoring well NP-1. (Property owned by Chase Farms)
- One monitoring well will be installed north of monitoring well KWB-3AR to identify whether crossgradient residential property (Parcel ID 4-154-099-146-071) and potential domestic water wells RA-02827 and RA-03353 are affected by the dissolved-phase hydrocarbon plume. This residence is not inhabited and was not recommended for additional well installation in the Technical Memorandum. However, due to difficulty accessing the well on-site at the residence, an additional well is now recommended, if installation is possible. The well will either be installed in NM DOT ROW or Chase Farms property depending on access and NM DOT roadworks. Note: Pipeline ROWs exist both north and south of Hwy 82 – it may not be possible to install a well where needed. HFNR will keep NMED/OCD appraised.

Prior to monitoring well installations, permits will be obtained from the New Mexico Office of the State Engineer (NM OSE) and New Mexico One Call will be conducted to verify the location of any underground lines near the proposed monitoring well locations.

The five (5) monitoring wells will be installed by a NM licensed driller at or as close to the locations specified in the April 12 Memorandum, using air rotary drilling methods. All wells will be installed to an approximate depth of 35 feet below ground surface (bgs) and constructed with two-inch diameter casing and 20 feet of screen, with approximately ten feet of screen extending into the shallow aquifer. Two proposed monitoring wells south of monitoring well MW-135 will be installed with flush mount surface completions, and two monitoring wells near the residential property with Parcel ID 4-153-098-515-219 will be installed with above ground steel riser surface completions. The fifth well (N of KWB-3AR) will also be a flush mount completion. All monitoring wells will be developed (by purging groundwater from the wells) following installation to remove sediments from the screened interval.

Soil from well installations and water from well development will be placed in drums that will be moved to the refinery container storage area. Samples will be collected from each drum for waste characterization and proper disposal.

Groundwater samples will be collected from the new monitoring wells after well development (June/July assuming access obtained), using low-flow sampling methods. The wells will either be sampled with dedicated tubing and peristaltic pump or dedicated submersible pump (depending on depth). A second round to be scheduled pending receipt of the initial data. Samples will be submitted to a NM approved laboratory for analysis of volatile organic compounds (VOCs).

A letter report will be prepared after well installation and the initial sampling event is conducted and will include well construction reports, coordinates, details of installation/sampling, and the analytical data from the initial round of sampling (submittal by end of August 2019). The data from the second round of sampling will be provided in a letter report within 30 days of receipt of final laboratory data.

If you have any questions or would to discuss, please let us know.

Thanks,
Robert

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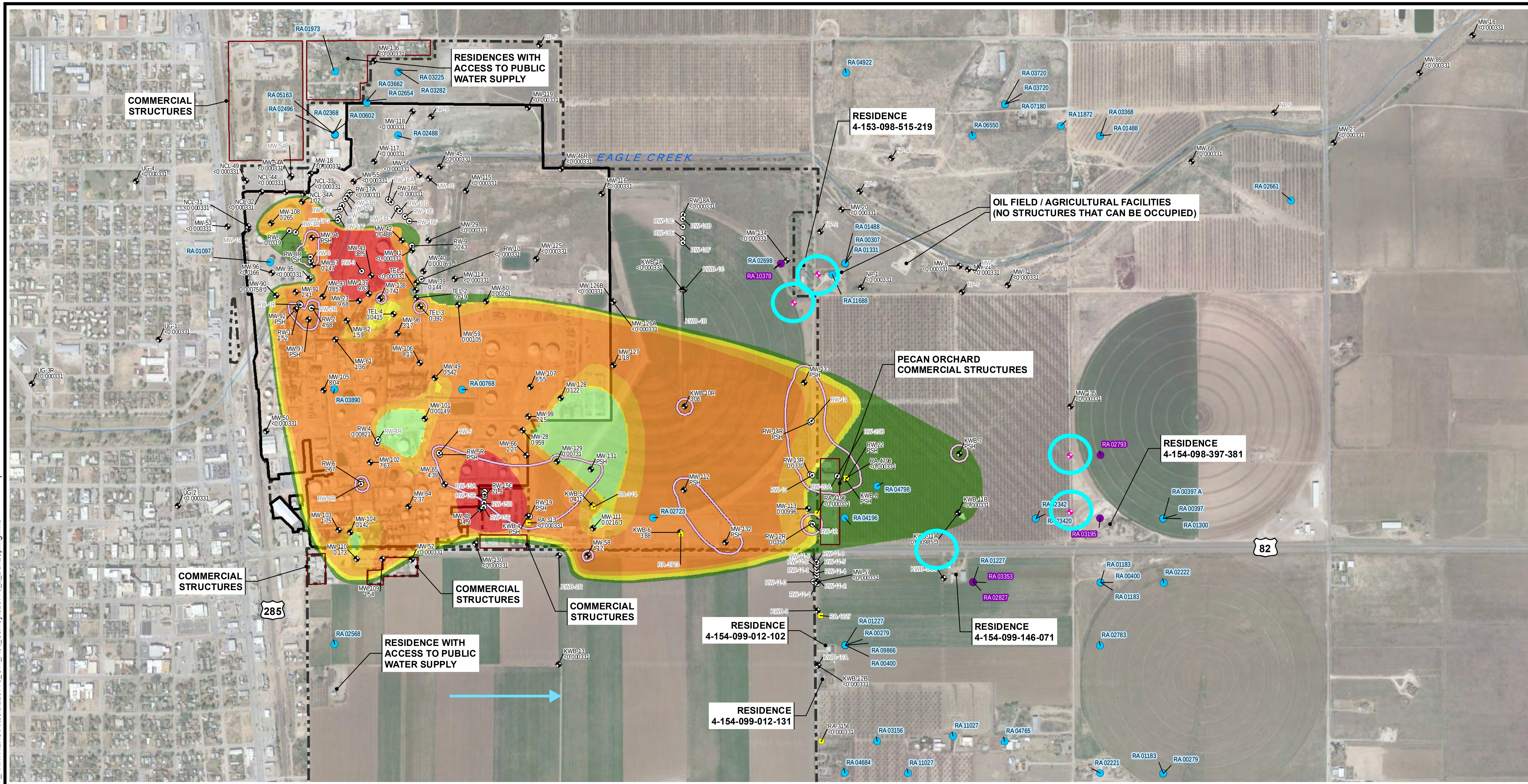

LEGEND

- MONITORING WELL
- RECOVERY WELL
- IRRIGATION WELL IN MONITORING PROGRAM
- PROPOSED MONITORING WELL
- 1.75 BENZENE CONCENTRATION
- <0.000331 BENZENE NOT DETECTED ABOVE METHOD DETECTION LIMIT
- PSH PHASE-SEPARATED HYDROCARBON PRESENT IN WELL (≥ 0.03 FEET THICK)
- KWB-9 WELL NOT SAMPLED
- POTENTIAL SHALLOW WATER WELL
- POTENTIAL DOMESTIC WATER WELL, FURTHER ASSESSMENT RECOMMENDED
- REFINERY FENCELINE
- FACILITY PROPERTY BOUNDARY (FENCELINE SHOWN WHERE COINCIDENT)
- GROUNDWATER FLOW DIRECTION
- PSH PRESENCE 2016-2018

NOTES:

1. ALL CONCENTRATIONS ARE IN MILLIGRAMS PER LITER (mg/L).
2. POTENTIAL SHALLOW WELLS IDENTIFIED IN RECORDS SEARCH BY ATKINS ENGINEERING ASSOCIATES INC. LOCATION SHOWN CONSISTENT WITH RECORDS.
3. J = CONCENTRATION QUALIFIED AS AN ESTIMATED VALUE.
4. ALL MONITORING AND RECOVERY WELLS ARE SCREENED IN THE SHALLOW SATURATED OR VALLEY FILL ZONES. IRRIGATION WELLS INCLUDED IN THE MONITORING PROGRAM ARE SCREENED IN EITHER THE VALLEY FILL ZONE OR THE DEEP ARTESIAN AQUIFER.
5. BENZENE CRITICAL GROUNDWATER SCREENING LEVEL (CGWSL) = 0.005 mg/L

AERIAL IMAGERY SOURCE: GOOGLE EARTH PRO AND THEIR DATA PARTNERS, 3/12/2016.

BENZENE CONCENTRATION FROM 2018 FIRST SEMIANNUAL EVENT (mg/L)

- 0 - 0.0001
- 0.0001 - 0.001
- 0.001 - 0.01
- 0.01 - 0.1
- 0.1 - 1.0
- 1.0 - 10
- 10 - 100

0 500 1,000 Feet

1 " = 1,000 '

1:12,000

PROJECT:
**RECEPTOR SURVEY AND VAPOR INSTRUSION EVALUATION
HOLLYFRONTIER NAVAJO REFINERY LLC
ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO**

TITLE:
POTENTIAL GROUNDWATER RECEPTORS AND BENZENE ISOCONCENTRATION MAP (FIRST 2018 SEMIANNUAL EVENT)

DRAWN BY:	MHORN	PROJ. NO.:	326778
CHECKED BY:	AELJURI		
APPROVED BY:	JSPEER	**FIGURE 2**	
DATE:	APRIL 2019		

TRC

505 East Huntland Drive, Suite 250
Austin, TX 78752
Phone: 512.329.6080
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FILE NO.: 326778_2_BenzSpring.mxd

Coordinate System: NAD 1983 2011 StatePlane New Mexico East FIPS 3001 Ft US (Foot US)
Map Rotation: 0

Plot Date: 4/10/2019, 14:26:15 PM by MHORN -- LAYOUT: ANSI B(11"x17")
Path: \\apaenvfile01\GIS\1-PROJECTS\HOLLY_ENERGY_PARTNERS\Artesia\326778_GW_Rec_Survey\326778_2_BenzSpring.mxd

TRC - GIS

HOLLYFRONTIER.

April 12, 2019

Mr. John Kieling
Chief, Hazardous Waste Bureau
New Mexico Environment Department
2905 Rodeo Park Drive East, Building 1
Santa Fe, New Mexico 87505

Mr. Carl Chavez
New Mexico Energy, Minerals and Natural Resources Department
Oil Conservation Division
1220 South St. Francis Drive
Santa Fe, New Mexico 87505

RE: Submittal of the *Desktop Groundwater Receptor Survey and Vapor Intrusion Evaluation of Off-Site Receptors* Memorandum
HollyFrontier Navajo Refining LLC, Artesia Refinery
RCRA Permit No. NMD048918817
Discharge Permit GW-028

Dear Mr. Kieling and Mr. Chavez:

Enclosed is the memorandum documenting the desktop groundwater receptor survey and vapor intrusion evaluation of off-site receptors located in the vicinity of the HollyFrontier Navajo Refining LLC (Navajo) refinery and Navajo-owned property in Artesia, New Mexico. This memorandum was prepared and is being submitted according to the meetings and conference calls attended by Navajo, the New Mexico Environment Department (NMED), and the New Mexico Energy, Minerals and Natural Resources Department Oil Conservation Division (OCD) on November 14-15, 2018, November 28, 2018, February 13, 2019, and March 28, 2019. The memorandum is being submitted in both hard copy and electronic format.

If you have any questions or comments regarding this request, please feel free to contact me at 575-746-5487 or Robert Combs at 575-746-5382.

Sincerely,

Scott M. Denton
Environmental Manager
HollyFrontier Navajo Refining LLC

cc: HFC: R. Combs, A. Sahba, M. Holder
TRC: C. Smith, J. Speer, L. Trozzolo

TRC

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Memorandum

To:	Scott Denton, Robert Combs HollyFrontier Navajo Refining LLC
From:	Julie Speer, Laura Trozzolo, and Catriona Smith TRC Companies (TRC)
Subject:	Artesia Refinery, Desktop Groundwater Receptor Survey and Vapor Intrusion Evaluation of Off-Site Receptors
Date:	April 12, 2019
CC:	HollyFrontier Corporation: Arsin Sahba, Mike Holder TRC: Jason Leik, Scott Reed, Audrey Eljuri
Project No.:	326778.0000.0000

This memorandum summarizes the results of the desktop groundwater receptor survey and vapor intrusion (VI) evaluation for off-site receptors potentially impacted by the dissolved-phase hydrocarbon and phase-separated hydrocarbon (PSH) plumes present downgradient of the HollyFrontier Navajo Refining LLC (Navajo) Refinery (the Refinery) and Navajo-owned property in Artesia, New Mexico (the Navajo Property). The Refinery and the Navajo Property are collectively referred to as "the Facility" in this memorandum. The desktop groundwater receptor survey and VI evaluation of off-site receptors were conducted to achieve the following objectives:

- Identify potential off-site receptors downgradient of the Facility that may be impacted by the dissolved-phase hydrocarbon and/or PSH plumes;
- Determine whether such identified potential off-site receptors could be affected by dissolved-phase hydrocarbon and/or PSH plumes (i.e., affected by direct exposure to impacted groundwater and/or PSH, or vapors from the impacted groundwater and/or PSH);
- Evaluate the on-going NMED- and OCD-approved Facility groundwater monitoring network and program to assess its effectiveness in determining the potential of the dissolved-phase hydrocarbon and PSH plumes to affect potential off-site, downgradient receptors; and
- Identify data gaps and limitations of the desktop groundwater receptor survey and VI evaluation and recommend a path forward to address any identified data gaps and limitations.

SUMMARY

The receptor survey identified a handful of potential off-site downgradient receptors. However, none of these receptors were determined to be impacted, affected, or at risk for direct exposure to dissolved-phase hydrocarbons or PSH in shallow groundwater. Target volatile organic compounds (VOCs) were evaluated, including benzene, toluene, ethylbenzene, xylenes (BTEX), naphthalene,

and methyl tert-butyl ether (MTBE), and none of the off-site receptors were identified to be impacted, affected or at risk for direct exposure to groundwater with VOC concentrations in exceedance of critical groundwater screening levels (CGWSLs) based on the: (1) observed historical extent and distribution of the plumes relative to locations of identified off-site receptors, (2) historical analytical results at irrigation wells (RA-04196 and RA-04798) located within the plumes, and (3) active monitoring and mitigation activities conducted to prevent exposure at the Pecan Orchard pit. However, additional groundwater assessment is recommended to delineate the extent of dissolved-phase hydrocarbon and PSH plumes in the vicinity of potential domestic water wells RA-02793, RA-02827, RA-03195, RA-03353, and RA-10378.

Overall, the approved groundwater monitoring network and program are effective with respect to assessing the potential for the dissolved-phase hydrocarbon and PSH plumes to impact the identified potential off-site receptors. The network/program are comprehensive, thus no significant changes to the groundwater monitoring network and program are necessary other than those to support the additional groundwater assessment recommended above.

The VI evaluation indicates that virtually all of the identified potential receptors are not at risk from vapor intrusion. Only one off-site monitoring well and one recovery well (KWB-8 and RW-22) indicate a potential VI concern for off-site workers at the Pecan Orchard plant. This area will be examined in more detail using VI modeling at KWB-8 with potential soil gas sampling if results warrant further evaluation. The remaining receptors, including the residential properties, were confirmed to not be at risk for VI based on the lines of evidence approach.

The available data are largely inclusive and only three data gaps or data limitations were identified: (1) confirm the presence and location of key potential domestic wells RA-02793, RA-02827, RA-03195, RA-03353, and RA-10378 to the degree feasible through visual field survey due to inaccurate well location data in available records; (2) confirm building-specific construction details and worker occupancy information for the Pecan Orchard plant buildings to further evaluate potential for VI exposure; and (3) identify geotechnical parameters such as soil bulk density, total porosity, and water-filled porosity for soils in vicinity of the Pecan Orchard plant, KWB-8, and RW-22 to further evaluate potential for VI exposure.

GROUNDWATER RECEPTOR SURVEY

The groundwater receptor desktop survey included a review of Navajo documents, aerial imagery, public property records, and water well records to identify potential off-site receptors that could be affected by the dissolved-phase hydrocarbon and PSH plumes. Target VOCs - BTEX, naphthalene (in lieu of Diesel Range Organics [DRO]), and MTBE - were used to represent the extent of the dissolved-phase plume(s). These constituents were then used to evaluate the off-site extent of the dissolved-phase hydrocarbon plume and to assess whether potential downgradient off-site receptors could be affected. In conjunction with the dissolved-phase plume evaluation, the locations of off-site wells with PSH were identified relative to potential groundwater receptors.

Facility Location and Surrounding Land Use

The Facility is located immediately east of Highway 285 (North 1st Street) and north of Highway 82 (East Main Street) in Artesia, New Mexico. Navajo owns property that extends to the north, east, and south of the main plant. The Facility and surrounding properties are shown on **Figure 1**. Property to the west (upgradient) of the Facility is used for commercial/industrial or residential purposes. Property to the north (crossgradient) of the Facility is used for commercial/industrial, residential, or agricultural purposes. Property to the east (downgradient) of the Facility is primarily used for agricultural purposes, but there are also some residences present as shown on **Figure 1**. Property to the south (crossgradient) of the Facility is primarily used for commercial/industrial and agricultural purposes. The historical[1] extent of target VOCs present in shallow groundwater at concentrations in exceedance of their respective CGWSLs is also shown on **Figure 1**.

Groundwater Conditions – Hydrogeology

The principal aquifers in the Artesia area are within the valley fill alluvium (Quaternary alluvium) and the San Andres Formation. Two distinct water-bearing zones within the valley fill alluvium in the vicinity of the Facility are referred to as the "shallow saturated zone" and the "valley fill zone". The deeper carbonate aquifer within the San Andres Formation is referred to as the "deep artesian aquifer". The hydrogeology of each of these aquifers is summarized below.

- Shallow Saturated Zone: Occurs in interbedded sand and gravel channels at 10 to 30 feet below ground surface (bgs). Overlying clays, silts, and caliche undulate at and near the Facility and create intermittent confined and unconfined groundwater conditions in the shallow saturated zone. Static water levels in groundwater monitoring wells completed within this zone are three to five feet above the top of the shallow saturated zone, indicating groundwater in this zone is under confined conditions for some or most of the year. Groundwater in this zone generally flows to the east and is highly variable in quality and volume. The shallow saturated zone is not generally used for domestic or agricultural purposes.

- Valley Fill Zone: Underlies the shallow saturated zone and occurs in alluvial deposits of sand, silt, clay, and gravel that are approximately 300 feet thick near the Facility. Irrigation and water production wells completed in this zone are typically screened across one to five water-producing intervals ranging in thickness from 20 to 170 feet, with most being approximately 20 feet thick. Production intervals are non-continuous, consist principally of sand and gravel, and are separated by less permeable lenses of silt and clay of varying thickness. In the

[1] The historical extent of target VOCs in exceedance of CGWSLs shown on Figure 1 is based on more than one CGWSL exceedance in a monitoring or recovery well over time. The time frame of historical data evaluated for each off-site well is shown on the concentration time-series plots provided in Attachment A. The time frame of historical data evaluated for on-site wells is shown on the concentration time-series plots provided in Appendix C of the *2018 Annual Groundwater Monitoring Report* dated February 2019. The time frame for all wells includes analytical data from at least 2010 (with many wells from at least 2006) or the well installation date (if installed after 2010) through October 2018. Monitoring wells MW-125 through MW-137 were installed in 2014.

immediate vicinity of the Facility, irrigation wells completed in this zone are typically screened between 240 to 320 feet bgs (e.g., irrigation wells RA-3723 and RA-04196). Groundwater in this zone generally flows to the east and is under confined conditions, with static water levels in monitoring wells completed in this zone being similar to or higher than that observed in shallow saturated zone wells. The valley fill zone has been developed for domestic and agricultural use.

- Deep Artesian Aquifer: Primarily occurs in the upper portion of San Andres Formation (limestone and dolomite with irregular and erratic solution cavities). The San Andres Formation underlies the Queen and Grayburg Formations, which primarily act as a confining bed between this aquifer and the valley fill zone. However, near the City of Artesia, the deep artesian aquifer includes the lower section of the Queen and Grayburg Formations (in localized fractures and secondary porosity). Near the Facility, the depth to the top of the water-producing interval is approximately 440 feet bgs. The deep artesian aquifer has been extensively developed for industrial, municipal, and agricultural use, but not domestic use.

The Facility's current facility-wide groundwater monitoring program includes 190 monitoring and recovery wells screened within the shallow saturated zone; 19 monitoring wells screened within the valley fill zone; 3 irrigation wells screened within the valley fill zone (wells RA-01227, RA-03156, and RA-04196); and 2 irrigation wells screened within the deep artesian aquifer (RA-0313 and RA-04798). Monitoring wells and recovery wells are gauged and sampled on a regular basis (primarily semiannually or annually, but a few select wells biennially). Of the 190 monitoring and recovery wells, 142 are located within the area of interest shown on **Figure 1** (the others in the monitoring program are located along Three Mile Ditch or are at the former Evaporation Ponds). Irrigation wells owned by Navajo (RA-313 – sampled regularly since 2008) and others (i.e., RA-03156, RA-04196, and RA-04798, which have been sampled regularly since 2006, and RA-01227, which was sampled in 2010 and 2011, but not since due to lack of access) are sampled on either a semiannual or annual basis. Groundwater monitoring results indicate that PSH is present in the shallow saturated zone and dissolved-phase hydrocarbons are present at concentrations exceeding their respective CGWSLs in the shallow saturated zone and the valley fill zone. Dissolved-phase hydrocarbons have not been detected above the CGWSLs in the two irrigation wells (RA-0313 and RA-04798) screened within the deep artesian aquifer that have been sampled for VOCs since 2006.

Groundwater Conditions – Hydrocarbon Plumes

Concentrations of dissolved-phase hydrocarbons, specifically the target VOCs in the shallow saturated zone and valley fill zone, have generally exhibited a stable or decreasing trend over time, as documented in Annual Groundwater Monitoring Reports. Benzene and MTBE are the target

VOCs that are most prevalent in shallow groundwater downgradient of the Facility[2]. The distribution of benzene and MTBE concentrations in shallow groundwater (shallow saturated and valley fill zones) during the semiannual monitoring event conducted in April 2018 (i.e., the most comprehensive recent monitoring event) are shown on **Figures 2** and **3**, respectively. The April 2018 distribution and extent of benzene and MTBE detections in shallow groundwater are generally consistent with the historical target VOC CGWSLs exceedance area shown on **Figure 1**.

The current maximum extent (2016 through 2018) of PSH in the shallow saturated zone is shown on **Figures 1** through **3**. Despite sometimes being under confined conditions, apparent PSH thicknesses in wells screened in the shallow saturated zone are generally inversely affected by fluctuations in groundwater elevations. Confined conditions result in the apparent in-well PSH elevation being higher than the actual PSH elevation in formation.

As shown on **Figure 2**, the current extent of PSH and benzene detections in shallow groundwater are primarily contained within the Facility and a downgradient commercial pecan orchard (the Pecan Orchard). As shown on **Figure 3**, the current extent of MTBE detections in shallow groundwater is primarily contained within the Facility, the Pecan Orchard, and a portion of property to the northeast of the Facility that is primarily used for oilfield or pipeline surface facilities. Concentration time-series plots for wells located at off-site properties are provided as **Attachment A** (these are also included in Appendix C of the *2018 Annual Groundwater Monitoring Report* dated February 2019). Detailed analysis of concentration trends in these wells are provided in Section 5 of the *2018 Annual Groundwater Monitoring Report* dated February 2019 and show that dissolved-phase hydrocarbon concentrations have generally exhibited a stable or decreasing trend over time.

Potential Off-Site Downgradient Receptors

Public records and aerial imagery were used to identify potential receptors that are present within/above or immediately downgradient of the dissolved-phase hydrocarbon and PSH plumes. The results of the records review are discussed below.

Water Wells

In December 2015, Atkins Engineering Associates, Inc. (AEA) conducted a record search on behalf of Navajo to identify water wells in the Facility area that are potentially: (1) screened within the valley fill alluvium, and (2) used for non-monitoring purposes. Note, the New Mexico Office of the State Engineer (NMOSE) records referencing the "shallow" zone are referring to the valley fill alluvium since water wells are not likely to be completed within the shallow saturated zone

[2] Total Petroleum Hydrocarbons (TPH) Diesel Range Organics (DRO) is prevalent in shallow groundwater upgradient, crossgradient, and downgradient of the Facility. Naphthalene was used as an indicator compound for TPH DRO and demonstrated a smaller lateral extent than benzene or MTBE, and so the extent of benzene and MTBE were used for this receptor survey as more conservative (largest extent) indicators.

due to naturally poor quality and low productivity. Wells screened within the deep artesian aquifer were not included because the valley fill alluvium and deep artesian aquifer are not considered to be hydraulically connected. AEA searched the following database and paper records available from the NMOSE: New Mexico Water Rights Reporting System (NMWRRS) database, well logs, and Hydrographic Surveys. AEA summarized the results of their records search in the February 2016 *Draft Report of Navajo Refining Company Possible Shallow Receptor Records Study, Artesia, NM.* At the request of TRC and Navajo, AEA conducted an updated search in February 2019 to identify any new wells or records and to determine if the status of any of the previously identified wells had changed since 2015. AEA summarized the updated search results in the February 17, 2019 *Limited Update to Draft Report of Navajo Refining Company Possible Shallow Receptor Records Study, Artesia, NM.* The February 2016 and February 2019 AEA documents are provided as **Attachment B**.

Table 1 summarizes the results of the AEA records search of potential shallow water wells located within 0.25 miles of the current extent of benzene and MTBE detections in shallow groundwater. **Table 1** specifies the approximate distance of each potential water well from the benzene and MTBE shallow groundwater plumes and provides further analysis of each water well record. The records search identified potential shallow water wells that are located off-site and within or in the downgradient proximity of the current extent of benzene and MTBE detections in shallow groundwater. These wells are shown on **Figures 2** and **3**, respectively. The available location data for the majority of these wells is approximate. The NMWRRS database records that include location data based on the Public Land Survey System (PLSS) provide coordinate data for the center of the smallest quarter delineated in North American Datum (NAD) 83 Universe Transverse Mercator (UTM) Zone 13, which ranges from a 0.625-acre tract (5 quarters) to 10-acre tract (3 quarters). A majority of the NMWRRS database records are based on the PLSS and provide location data at the center of a 10-acre tract. The discrepancy between the NMWRRS record locations and actual locations (based on Navajo sampling event data and records) can been seen on **Figures 2** and **3** for the irrigation wells that are currently included in the Navajo facility-wide groundwater monitoring program: RA-01227, RA-03156, RA-04196, and RA-04798.

The only identified water wells that are located within the benzene and MTBE shallow groundwater plumes downgradient of the Facility are irrigation wells RA-04196 and RA-04798, which are sampled on a semiannual basis as part of the facility-wide groundwater monitoring program. Historical analytical results indicate that benzene and MTBE are not present in these irrigation wells at concentrations that exceed their respective CGWSLs.

As highlighted on **Table 1** and shown on **Table 2**, NMWRRS records included five domestic water wells (RA-02793, RA-02827, RA-03353, RA-03195, and RA-10378) that: (1) potentially could intersect the benzene and/or MTBE plumes downgradient of the Facility where these plumes are currently not delineated and (2) are located near residential structures with at least one apparent domestic well observed by Navajo during a visual drive-by survey. As shown on **Table 1**, and discussed further below, domestic wells RA-02342 and RA-23420 were confirmed to not be present within the Pecan Orchard and probably no longer exist (likely just one well with multiple records/IDs; records indicate well was reported as "failed" in 1960 and to be moved – see supplemental records provided in **Attachment C**). Well RA-11688, located approximately 800 feet north (crossgradient) of the benzene plume, is listed as installed for non-consumptive use. Wells RA-02342, RA-23420, and RA-11688 are also located outside the historical target VOC CGWSLs exceedance area.

Residences

Aerial imagery and Eddy County Tax Assessor records were used to identify potential residences located within 0.25 miles (1,320 feet) downgradient or crossgradient of the current lateral extent of benzene and MTBE detections in shallow groundwater. Five residential properties were identified, as summarized in **Table 2,** and their locations are shown on **Figures 2, 3,** and **4**. Eddy County property records for each of these residential properties are provided in **Attachment D**. Four of these five residential properties appear to be associated with at least one potential domestic shallow water well identified in the AEA records search. Apparent associated shallow domestic water wells for each property are noted in **Table 2**.

Navajo's extensive monitoring network and program provide comprehensive data for virtually all of the study area. None of the identified residential properties are located above the current extent of benzene, MTBE, or PSH detections in shallow groundwater. However, the extent of the benzene, MTBE, and PSH detections is not fully delineated near the following three residential properties:

- Parcel ID 4-153-098-515-219 includes a residence and one potential domestic shallow water well (RA-10378). Navajo confirmed by visual survey that one domestic water well is present, and the well is likely RA-10378; however, the precise location of RA-10378 should be confirmed. This property is located immediately downgradient of a monitoring well (MW-134) with no detections of benzene or MTBE since April 2014 and immediately upgradient of a monitoring well (NP-1) that has historically exceeded the MTBE CGWSL. Based on the direction of groundwater flow and the extensive conceptual site model for the Facility (i.e., preferential groundwater flow pathways within gravel channels to the south of this area, as described in the April 2017 *Revised Contaminant Migration Evaluation Investigation Report* [Revised CME Report]), it appears the presence of the MTBE plume in the vicinity of NP-1 is isolated relative to the main groundwater plume. The extent of the MTBE plume in shallow groundwater to the south and east of this property and the extent of the benzene plume in shallow groundwater to the south of this property is not fully delineated.
- Parcel ID 4-154-098-397-381 includes a residence and potential domestic shallow water well (RA-03195) that is located downgradient of monitoring wells KWB-11A and KWB-11B; and a potential domestic shallow water well (RA-02793) that is located downgradient of monitoring well KWB-7 (contains PSH). The extent of the benzene, MTBE, and PSH plumes in shallow groundwater to the west of this property is not fully delineated. During a visual

drive-by survey, Navajo observed one apparent domestic well (likely RA-03195) located near the residential structure on this parcel, but the well did not appear to be operable. As shown on **Table 1** and in supplemental well records provided in **Attachment C**, the well record for RA-03195 is associated with the repair of irrigation well RA-00397 (completed in the deep artesian aquifer) and therefore this well may not exist.

- Parcel ID 4-154-099-146-071 includes a residence and potentially two domestic shallow water wells (RA-02827 and RA-03353). However, as described in **Table 1**, well RA-02827 may not have been installed (permit approved in 1951 and cancelled in 1954; see supplemental well records provided in **Attachment C**) and well RA-03353 was removed from the facility-wide groundwater monitoring program around 2010 because it was not operable due to lack of electricity. The residence has appeared to be vacant since at least 2010. The crossgradient to downgradient extent of the benzene and MTBE plumes is not currently delineated to the north and northwest of this property. Monitoring well KWB-3AR is located on this property, but it has not been sampled since 2011 due to lack of access. However, target VOCs were not historically detected in exceedance of CGWSLs in KWB-3AR.

Pecan Orchard

The Pecan Orchard is located immediately downgradient to the east of the Facility and is present above the benzene and MTBE shallow groundwater plumes and the PSH plume. The Pecan Orchard operates a subsurface "pecan pit" where harvested pecans are temporarily deposited and then moved into the pecan plant by means of a conveyor belt system. This pit is located within an open-air structure along the western property boundary of the Pecan Orchard immediately downgradient of a Navajo recovery trench. Prior to liner installation, the pit was subject to fluctuating groundwater levels that could cause infiltration of shallow groundwater and PSH. The depth of the pit is approximately 16 feet bgs and is lined on the exterior. Navajo applied a spray-on liner to the interior. Both measures mitigate the potential infiltration of shallow groundwater and PSH. The pit is only used and entered temporarily by Pecan Orchard employees for maintenance on an as-needed basis for short durations, primarily during the months of October through December of each year.

Navajo also actively conducts the following additional activities to prevent shallow groundwater and PSH from infiltrating the pit:

- Operates groundwater pumps within the French drain of the pit as necessary;
- Operates recovery systems located immediately upgradient and downgradient of the pit to recover PSH and groundwater, and to lower groundwater elevations around the pit; and
- Gauges recovery wells located immediately around the pit on a weekly basis to monitor groundwater and PSH elevations relative to the pit.

Two irrigation wells (RA-04196 and RA-04798) within the Pecan Orchard operational area are sampled on a semiannual basis as part of the facility-wide groundwater monitoring program. RA-04196 is screened within the valley fill zone (from 280 to 292 feet bgs) and RA-04798 is screened in the deep artesian aquifer (from 840 to 850 feet bgs), as documented in Navajo's monitoring plans and reports. RA-04798 was misidentified as a shallow domestic water well within the NMOSE records search, but it is actually an irrigation well. No target VOCs have been detected in exceedance of CGWSLs in either of these irrigation wells based on sampling since 2006. In addition, the deep artesian aquifer is not considered to be hydraulically connected to the valley fill alluvium. Two additional water wells (RA-23420 and RA-02342) were identified in AEA's record search to be present at the southeastern portion of the Pecan Orchard, as shown on **Figures 2** and **3**, but these wells are not present within the Pecan Orchard as determined by a visual survey of the area. As noted on **Table 1**, additional records indicate only well RA-02342 ever existed (multiple IDs likely resulted from typographical error) and the well was planned to be moved in 1960 as it had "failed".

As shown on the concentration plots provided in **Attachment A**, benzene and MTBE concentrations in monitoring wells KWB-7, KWB-11A, and KWB-11B (located at the Pecan Orchard along the downgradient extent of the benzene and MTBE plumes) are stable to decreasing over time, with the exception of occasional fluctuations. Apparent PSH thicknesses in monitoring and recovery wells located within the Pecan Orchard have generally decreased over time but are inversely affected by fluctuations in groundwater elevations.

Facility Groundwater Monitoring Network and Program Effectiveness

As discussed above, Navajo's facility-wide groundwater monitoring program includes gauging and sampling monitoring wells and recovery wells on a semiannual, annual, or biennial basis; and sampling irrigation wells on semiannual or annual basis. The locations of the groundwater monitoring network wells in the vicinity of the Facility are shown on **Figures 1** through **3**. A total of 126 wells are sampled in the vicinity of the Facility on a semiannual or annual basis, including wells located upgradient, crossgradient, and downgradient of the Facility (while the remaining 16 wells are gauged on a semiannual or annual basis, gauged on a biennial basis, or sampled on a biennial basis). Overall, the monitoring program is largely effective in monitoring the lateral extent of dissolved-phase hydrocarbons and PSH in shallow groundwater within and beyond the Facility, but could benefit from the addition of a few wells at select monitoring locations as discussed below:

- Due to a lack of landowner access for Parcel ID 4-154-099-146-071, monitoring wells KWB-3AR and KWB-9 and irrigation well RA-01227 have not been sampled since 2011. Sampling KWB-3AR and KWB-9 would provide better delineation of the extent of benzene and MTBE detections in shallow groundwater to the south and southeast of the plume. Navajo will attempt to obtain an access agreement for this property. If unsuccessful, then Navajo will evaluate the feasibility and effectiveness of installing one monitoring well along Highway 82 north of this property (though access for such a well may also not be feasible).

- The crossgradient extent of benzene detections and the benzene CGWSL exceedance area is not defined on the Facility to the south of monitoring wells MW-52, MW-58, MW-109, MW-110, MW-130, MW-132, and KWB-6. The crossgradient extent of PSH is not defined on the Facility to the south of monitoring wells MW-58 and MW-132. Navajo now owns a majority of the land and water rights to the south of these wells. Additional monitoring wells are not required in this area to monitor or control the PSH and benzene plumes as groundwater is consistently flowing to the east, and PSH and benzene have not historically been detected in monitoring wells KWB-13 (located to the south of KWB-2R) and MW-57 (located along Bolton Road southeast of MW-132), indicating the crossgradient extent of the PSH and benzene plumes does not extend south of the Facility.

- The crossgradient extent of MTBE detections and the MTBE CGWSL exceedance area is not defined on the Facility to the south of monitoring wells MW-58, MW-130, MW-132 and KWB-6. These wells are located along the southern Facility fence line, but Navajo now owns a majority of the land to the south of these wells. Additional monitoring wells are not required in this area to monitor or control the MTBE plume as groundwater is consistently flowing to the east and MTBE has not historically been detected in monitoring well KWB-13 (located to the south of KWB-2R) and MW-57 (located along Bolton Road southeast of MW-132) indicating the crossgradient extent of the MTBE plume does not extend south of the Facility.

- The downgradient extent of detected benzene and MTBE concentrations is not defined to the east of monitoring wells KWB-7, KWB-11A and KWB-11B; and the downgradient extent of PSH is not defined to the east of monitoring well KWB-7. However, the downgradient extent of benzene and MTBE CGWSL exceedance areas is defined in this area (see Figures 14, 15, 18, and 19 of the *2018 Annual Groundwater Monitoring Report* dated February 2019). Monitoring well MW-135 delineates the downgradient extent of the detected benzene and MTBE concentrations to the east/northeast of this area, but two additional monitoring wells located south of MW-135, as proposed in the Revised CME Report, are recommended to better delineate the plumes. The proposed monitoring wells would provide data to determine whether the potential shallow domestic water wells (RA-02793 and RA-03195) within the downgradient residential property (Parcel ID 4-154-098-397-381) are not at risk of exposure to the shallow groundwater plumes. The location of the two proposed monitoring wells are shown on **Figures 2** and **3**.

- The upgradient extent of MTBE in exceedance of the CGWSL at monitoring well NP-1 should be further evaluated to confirm the residential property (Parcel ID 4-153-098-515-219) and potential shallow water well RA-10378 located upgradient of NP-1 are not at risk of exposure to the isolated MTBE plume. MTBE has consistently exceeded the CGWSL in well NP-1, but has consistently not been detected in upgradient monitoring wells MW-134, RW-18A, and KWB-1A. Based on the direction of groundwater flow and the extensive conceptual site model for the Facility (preferential groundwater flow pathways within gravel channels to the south of this area, as identified in the Revised CME Report), it appears MTBE in the vicinity of NP-1 is isolated from the larger MTBE plume present to the south. Additional monitoring wells installed to the west of monitoring well NP-1, near the southwestern and eastern corners of the upgradient residential property (Parcel ID 4-153-098-515-219), are recommended to better delineate the isolated MTBE plume. The proposed monitoring wells would provide data to determine whether the upgradient residential property and potential shallow water well RA-10378 are not at risk of exposure to the shallow groundwater plumes. The location of the two proposed monitoring wells are shown on **Figures 2** and **3.**

Potential for Direct Exposure to Groundwater and PSH Plumes

No off-site receptors were identified to be at risk for direct exposure (i.e., ingestion and dermal contact through domestic uses) of shallow groundwater containing PSH or target VOCs at concentrations in exceedance of CGWSLs based on the: (1) observed historical extent and distribution of the plumes relative to locations of identified off-site receptors, (2) historical analytical results for VOCs are below the CGWSLs at irrigation wells (RA-04196 and RA-04798) located within the plumes, and (3) active monitoring and mitigation activities and engineering controls installed to prevent exposure at the Pecan Orchard pit. Additional explanation is provided below.

- No domestic shallow water wells were identified to be present within the historical target VOC CGWSLs exceedance area. However, additional assessment is recommended to delineate the dissolved-phase benzene and MTBE shallow groundwater plumes, as well as the PSH plumes, with the objective of determining whether the following potential domestic water wells intersect the plumes: Parcel ID 4-153-098-515-219 (RA-10378), Parcel ID 4-154-098-397-381 (RA-02793 and RA-03195), and Parcel ID 4-154-099-146-071 (RA-02827 and RA-03353).
- The two groundwater irrigation wells (RA-04196 and RA-04798) located within the Pecan Orchard and the dissolved-phase hydrocarbon and PSH plumes are sampled on a semiannual basis, and historical analytical results (since 2006) indicate no target VOCs are present at concentrations in exceedance of CGWSLs. The historical monitoring results for these irrigation wells indicate that other potential water wells located downgradient of the Facility are not likely to be affected by PSH and target VOCs present in shallow groundwater at concentrations in exceedance of CGWSLs if they are screened at a depth of 275 feet bgs or lower (screened interval of RA-04196 that does not exceed CGWSLs). Well RA-03353 is screened from 232 to 295 feet bgs, well RA-10378 is screened from 115 to 190 feet bgs, and the screened intervals of potential domestic water wells RA-02827, RA-02793, and RA-03195 are unknown. However, due to the upward pressure gradient (upwelling caused by artesian conditions) observed in wells screened within the valley fill zone, it is unlikely that target VOCs would migrate to the screened depths of these domestic wells at concentrations in exceedance of the CGWSLs.

- Navajo actively conducts monitoring and mitigation activities and has installed engineering controls to prevent shallow groundwater and PSH from infiltrating the Pecan Orchard pit, as described above, to protect Pecan Orchard employees from potential exposure to impacted groundwater and PSH.

VAPOR INTRUSION EVALUATION

A screening-level VI evaluation was conducted for identified potential off-site receptors within and downgradient of the dissolved-phase hydrocarbon and PSH plumes. The evaluation was conducted according to the New Mexico Environment Department (NMED) 2017 Risk Assessment Guidance for Site Investigations and Remediation (NMED, 2017), as well as the United States Environmental Protection Agency (USEPA) VI guidance documents (USEPA, 2015a; 2015b). The objectives were as follows:

- Evaluate the potential for vapors from the dissolved-phase hydrocarbon plume (i.e., volatilization of dissolved-phase constituents of concern [COCs]) to affect potential off-site receptors identified in the previous sections based on the following steps:
  - Compare concentrations of VOCs in off-site groundwater wells to appropriate vapor intrusion screening levels (VISLs) based on NMED's and USEPA's VI guidance;
  - Review the depth to groundwater in off-site areas where COCs exceed their VISLs (i.e., USEPA's vertical separation distance for petroleum hydrocarbons); and
  - Identify off-site buildings/structures located within 100 feet of a groundwater sample exceeding VISLs, per NMED guidance.
- Identify the presence of PSH in off-site groundwater wells and use the distance from nearest building and USEPA's vertical separation distance guidance for petroleum hydrocarbons to identify whether VI is a concern.
- Identify data gaps and limitations of the VI evaluation, including additional VI modeling or soil gas collection to better characterize VI potential.

The approach, results, and recommendations of this off-site VI evaluation are discussed in detail below.

Dataset Used in the Vapor Intrusion Evaluation

The Facility's facility-wide groundwater monitoring program includes gauging and sampling monitoring wells and recovery wells on a semiannual, annual, or biennial basis; and sampling irrigation wells on a semiannual or annual basis. The samples utilized in this VI evaluation are presented in **Table 3** and include groundwater data collected from 2016 through 2018.

The area of VI interest includes off-site monitoring/recovery wells located predominantly east of the Facility (i.e., downgradient). Residential and agricultural buildings are located in these off-site areas, as well as several industrial properties located south of the Facility. To be conservative, the downgradient (off-site) VI evaluation assumes a residential scenario. The off-site groundwater data used in the VI evaluation is summarized in **Table 4**.

Nature and Extent of Dissolved-Phase Hydrocarbon Plume

As shown on **Figure 1**, the historical combined extent of target VOCs present in shallow groundwater at concentrations in exceedance of their respective CGWSLs (potential VI risk driver) extends in an easterly (downgradient) direction beyond the Facility boundary. Therefore, receptors located within these off-site areas and extending 100 feet from the off-site plume extent may have potential VI concerns according to USEPA's 2015 VI Guidance Documents (USEPA, 2015a and 2015b).

Selection of Constituents of Concern

Groundwater VISLs protective of residents were obtained from Table A-3 of NMED's *Risk Assessment Guidance for Site Investigations and Remediation: Volume 1 Soil Screening Guidance for Human Health Risk Assessments* (NMED, 2017) and are presented in **Table 5**. In accordance with NMED 2017 guidance, groundwater VISLs are based on a cancer target risk level (TRL) of 1E-05 and non-cancer hazard quotient (HQ) of 1. Note, VISLs are only available for chemicals that are considered volatile (i.e., Henry's Law Constant greater than 1E-05 atm/m^3-mol and vapor pressure greater than 1 millimeter of mercury) and have inhalation toxicity data available.

The NMED VISLs were last updated in 2017, and per industry standards and USEPA guidance, the latest toxicity criteria available were reviewed using the USEPA's Regional Screening Level (RSL) Table (USEPA, 2018), which is available online at: https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables. The toxicity values for six analytes (1,2,4-trimethylbenzene [1,2,4-TMB]; 1,3,5-trimethylbenzene [1,3,5-TMB]; 2-hexanone; chloromethane; n-propylbenzene; and trans-1,2-dichloroethylene [trans-1,2-DCE]) have changed since 2017. Therefore, VISLs were calculated for these six analytes using USEPA's VISL calculator (USEPA, 2019), which is available online at: https://www.epa.gov/vaporintrusion/vapor-intrusion-screening-level-calculator. Note, inhalation toxicity values are no longer available for trans-1,2-DCE; therefore, according to the USEPA guidance, a VISL could not be calculated. Final residential groundwater VISLs used in the data screening process are summarized in **Table 5**.

An analyte's maximum detected concentrations (MDCs) identified in off-site groundwater datasets were compared to its VISLs and retained as a COC if the analyte's MDC exceeded a VISL. Analytes detected at concentrations below their VISLs (or analytes that were not detected in groundwater) were eliminated from further consideration in the VI evaluation. **Figure 4** identifies two off-site monitoring wells with VISL exceedances (KWB-7 and KWB-8), which are both located on the Pecan Orchard property.

As shown in **Table 6**, the MDC of six analytes detected in off-site groundwater exceeded their residential VISLs. These six off-site COCs are identified as: 1,2,4-TMB; benzene; ethylbenzene;

m,p-xylene; naphthalene; and total xylenes. Note, all off-site COCs are petroleum hydrocarbons, which is important in evaluating separation distance, as discussed in the following section as part of a Lines of Evidence approach. Individual well locations with residential VISL exceedances are provided in **Table 7** and, as mentioned above, are limited to two well locations (KWB-7 and KWB-8), which are both located on the Pecan Orchard property.

The six off-site COCs identified above were retained for further VI evaluation in the approach outlined below.

Lines of Evidence Approach

The VI exposure pathway was evaluated based on a hierarchy of lines of evidence (or criteria), which includes:

1. VISL exceedances (discussed above);
2. Adequate separation distance between the groundwater source and building foundation (or ground surface where no buildings are present) to allow for aerobic biodegradation to occur. Note that the buildings identified and evaluated did not appear to have subsurface structures (basements) other than the Pecan Orchard pit identified previously, which has an open-air construction and would not be considered a VI source because it is an open pit and vapors would not be drawn by advective force from the pit through cracks in a building's foundation;
3. Identification of buildings within 100 feet of VISL exceedances;
4. Concentration trends in wells with VISL exceedances; and
5. Presence of PSH in wells.

The sequential lines of evidence/criteria are each discussed below, followed by a discussion of recommended next steps.

Separation Distance Criteria

Table 8 presents a refined VI evaluation of off-site groundwater monitoring/recovery wells with residential VISL exceedances. Among these wells, the depth to groundwater was identified to determine whether adequate separation distance exists between the groundwater source and building foundation (or ground surface where no buildings are present) to allow for aerobic biodegradation to occur. According to USEPA's 2015 Office of Underground Storage Tanks (OUST) VI guidance, 6 feet is an adequate separation distance for dissolved-phase petroleum hydrocarbons (USEPA, 2015b), which allows for elimination of the VI concern. As shown in **Table 8**, the only off-site buildings of concern are at the Pecan Orchard plant, which appear to have a slab-on-grade construction (no basement present), with a subsurface pecan processing pit. Therefore, monitoring wells KWB-7 and KWB-8, with groundwater greater than 6 feet bgs and petroleum hydrocarbon COCs (i.e., vertical separation distance between groundwater and building slab foundation is greater than 6 feet), were eliminated as a VI concern, as shown in **Table 8**.

Building Distance Criteria

The second screening criterion identifies whether the distance between the off-site groundwater well of interest with PSH and the nearest building is less than 100 feet. According to USEPA's 2015 OUST and Office of Solid Waste and Emergency Response (OSWER) VI guidance documents, 100 feet is an adequate radius distance from a building, in which the building would not have enough advective force to pull vapors from the subsurface through cracks in the building's foundation (USEPA, 2015a and 2015b). **Table 8** identifies only one groundwater monitoring well (KWB-8) located less than 100 feet from buildings (Pecan Orchard plant). Monitoring well KWB-7 was eliminated from further VI evaluation as no buildings are located within 100 feet from the well. **Figure 5** presents this 100-foot radius around off-site groundwater monitoring wells KWB-7 and KWB-8 with VISL exceedances.

Groundwater Data Trends

Monitoring well KWB-8 is recommended for further evaluation as shown above; therefore, groundwater concentration data trends were evaluated, and are provided in **Attachment A**. In general, groundwater concentration data over time indicates a range of concentrations, including non-detect results, as may be expected due to the fluctuating groundwater elevations and presence of PSH in these wells. Although groundwater trends are predominantly stable to decreasing, eliminating KWB-8 from further evaluation based on groundwater data trends is not recommended at this time due the presence of PSH, which requires further investigation.

Presence of PSH

A final line of evidence evaluates whether PSH present in seven off-site groundwater monitoring/recovery wells (KWB-4, KWB-7, KWB-8, RW-15C, RW-20A, RW-20B and RW-22) may present a VI concern to nearby building occupants (within 100 feet laterally), which is summarized in **Table 9**. According to USEPA's 2015 OUST VI guidance, 15 feet is an adequate vertical separation distance from PSH to a building foundation for free-phase petroleum hydrocarbons (USEPA, 2015b). Of the off-site buildings located near PSH (Pecan Orchard plant buildings and commercial/industrial buildings located in the vicinity of RW-15C and KWB-4), all appear to have slab foundations. Therefore, monitoring/recovery wells KWB-4, RW-15C, RW-20A, and RW-20B with PSH present at depths greater than 15 feet bgs (i.e., vertical separation distance between PSH and building slab foundation is greater than 15 feet) were eliminated from further VI evaluation, as shown in **Table 9**. As stated above, monitoring well KWB-7 was eliminated from further VI evaluation as the Pecan Orchard plant buildings are greater than 100 feet from the well.

Lines of Evidence Conclusions

Based on the lines of evidence approach, virtually all potential receptors can be eliminated from the risk of vapor intrusion. As detailed in **Tables 8 and 9** for off-site groundwater and PSH, respectively, only two monitoring/recovery wells (KWB-8 and RW-22) indicate a potential VI concern for off-site workers. Specifically, KWB-8 may be a concern to the Pecan Orchard plant worker because, although depth to groundwater is greater than 6 feet, PSH is present at less than 15 feet vertical separation distance and the plant building is located nearby. Likewise, RW-22, a recovery well, is located near the Pecan Orchard plant, and PSH is present at a depth of less than 15 feet vertical separation distance. Further evaluation of KWB-8 and RW-22 in relation to the Pecan Orchard plant buildings is recommended. The remaining receptors were confirmed to not be at risk for vapor intrusion based on the lines of evidence approach.

DATA GAPS AND LIMITATIONS

The data gaps and limitations identified/encountered during the desktop off-site groundwater receptor survey and off-site VI evaluation are described below.

Off-Site Groundwater Receptor Survey

- Inaccurate well location data in NMOSE records necessitate, to the degree feasible, confirmation of the presence and location of key potential domestic wells RA-02793, RA-02827, RA-03195, RA-03353, and RA-10378 through visual field survey.

Off-Site Vapor Intrusion Evaluation

- Confirmation of building-specific construction details and worker occupancy information for the Pecan Orchard plant buildings to further evaluate potential for VI exposure.
- Identify geotechnical parameters such as soil bulk density, total porosity, and water-filled porosity for soils in vicinity of the Pecan Orchard plant, KWB-8, and RW-22 to further evaluate potential for VI exposure.

RECOMMENDATIONS

- Install two monitoring wells south of monitoring well MW-135, as shown on **Figures 2** and **3**, to identify whether the downgradient residential property (Parcel ID 4-154-098-397-381) and potential domestic water wells RA-02793 and RA-03195 are affected by the dissolved-phase hydrocarbon and PSH plumes.
    - Install one monitoring well west of domestic well RA-02793 and east of monitoring well KWB-7 to better define the downgradient extent of the benzene, MTBE and PSH plumes.
    - Install one monitoring well west of domestic well RA-03195 and east of monitoring wells KWB-11A and KWB-11B to better define the downgradient extent of the benzene and MTBE plumes.

- Install two monitoring wells near the residential property with Parcel ID 4-153-098-515-219 as shown on **Figures 2** and **3**, to identify whether the potential domestic water well RA-10378 is affected by the dissolved-phase hydrocarbon plume and to further delineate the extent of MTBE in exceedance of CGWSL at monitoring well NP-1:
  - Install one monitoring well to the north of monitoring well MW-133, near the southwestern corner of Parcel ID 4-153-098-515-219, to better delineate the crossgradient extent of the benzene and MTBE plumes.
  - Install one monitoring well to the west of monitoring well NP-1, across Bolton Road from the eastern portion of Parcel ID 4-153-098-515-219, to better delineate the upgradient extent of the isolated MTBE plume near monitoring well NP-1.
- Navajo will attempt to obtain an access agreement for Parcel ID 4-154-099-146-071. If not successful, Navajo will evaluate the feasibility and effectiveness of installing one monitoring well along Highway 82 north of Parcel ID 4-154-099-146-071 (though access for a well may not be feasible).
- Conduct VI modeling using existing groundwater data from monitoring well KWB-8, which will also evaluate the area of recovery well RW-22, to determine any potential indoor air risk to the Pecan Orchard plant buildings.
- If the predicted indoor air risk based on VI modeling is unacceptable, then collect multi-depth soil gas data from a nested soil gas probe(s) near the Pecan Orchard plant building(s). Soil gas data will be used to characterize bioattenuation and conduct further VI modeling for the Pecan Orchard plant buildings.
- Continue mitigation activities at the Pecan Orchard pit to continue to ensure impacted groundwater and PSH do not infiltrate the pit.

ATTACHMENTS

REFERENCES

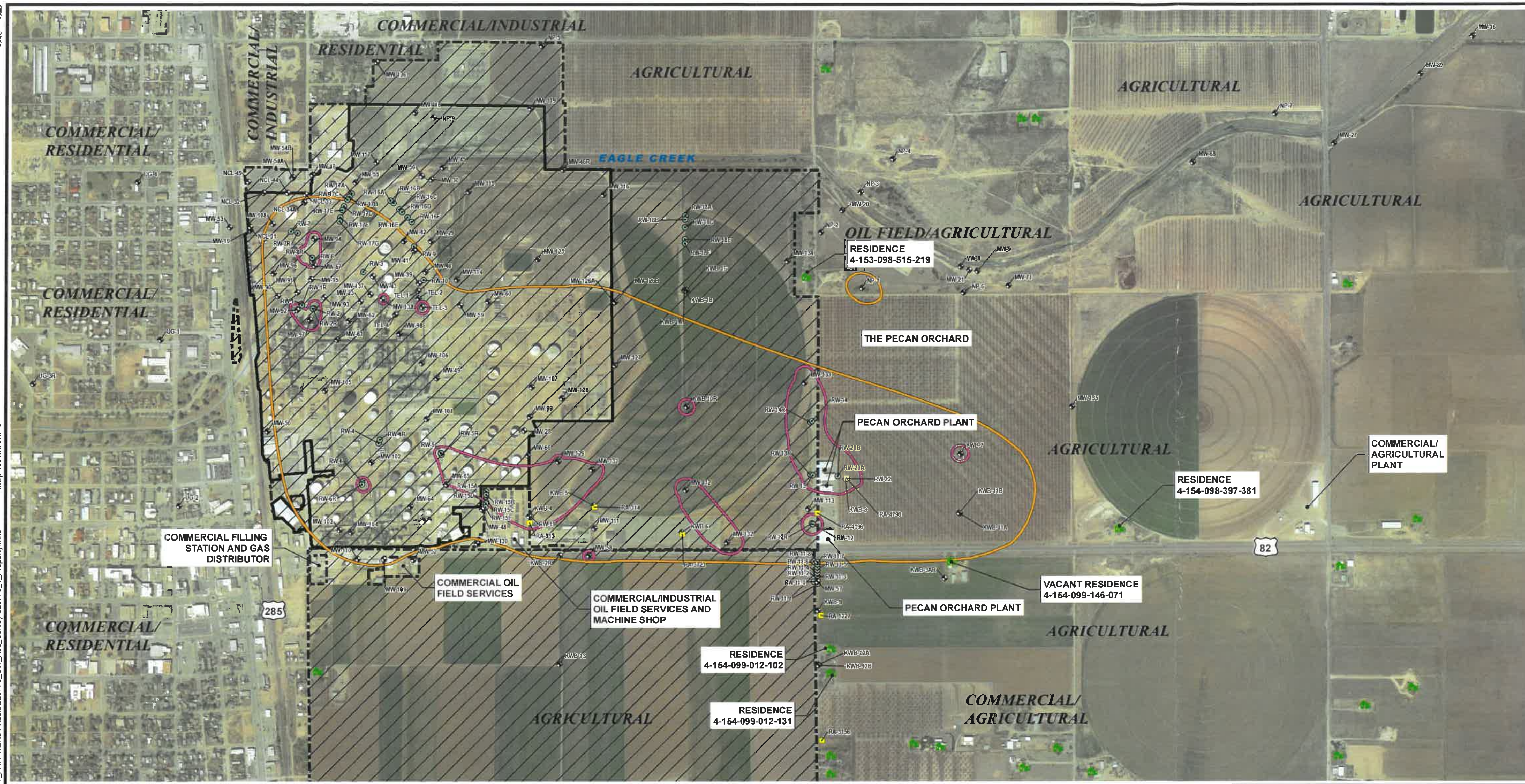
NMED. 2017. *Risk Assessment Guidance for Site Investigations and Remediation. Volume 1. Soil Screening Guidance for Human Health Risk Assessments.* Table A-3: NMED Vapor Intrusion Screening Levels (VISLs). March.

USEPA. 2015a. *OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air.* Office of Solid Waste and Emergency Response, OSWER Publication 9200.2-154. June.

USEPA. 2015b. *Technical Guide for Addressing Petroleum Vapor Intrusion at Leaking Underground Storage Tank Sites*. Office of Underground Storage Tanks, Washington, D.C. EPA 510-R-15-001. June.

USEPA. 2018. *Regional Screening Level (RSL) Table.* November 2018 update: https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables.

USEPA. 2019. *Vapor Intrusion Screening Level (VISL) Calculator.* Available online at: https://www.epa.gov/vaporintrusion/vapor-intrusion-screening-level-calculator



LEGEND

- MONITORING WELL
- RECOVERY WELL
- IRRIGATION WELL IN MONITORING PROGRAM
- RESIDENCE
- REFINERY FENCELINE
- FACILITY PROPERTY BOUNDARY (FENCELINE SHOWN WHERE COINCIDENT)
- PSH PRESENCE 2016-2018
- HISTORICAL EXTENT OF TARGET VOCs IN EXCEEDANCE OF CGWSLs (SEE NOTE 2)

NOTES:

1. TARGET VOCs = BENZENE, TOLUENE, ETHYLBENZENE, XYLENES, MTBE, AND NAPHTHALENE.
2. HISTORICAL EXTENT SHOWN BASED ON MORE THAN ONE CGWSL EXCEEDANCE IN WELL OVER TIME. ANALYTICAL DATA AVAILABLE FOR MOST WELLS SINCE AT LEAST 2010 (FOR MANY WELLS SINCE 2006) OR THE WELL INSTALLATION DATE (WELLS MW-125 THROUGH MW-137 INSTALLED IN 2014). THE FOLLOWING PERIMETER WELLS HAD ONE ISOLATED HISTORICAL CGWSL EXCEEDANCE AND THUS WERE NOT INCLUDED IN THE EXCEEDANCE AREA: MW-21 (BENZENE, OCT. 2006), MW-29 (BENZENE, OCT. 2006), MW-54A (XYLENES, APRIL 2011), MW-57 (BENZENE, NOV. 2014), NCL-33 (BENZENE, SEPT. 2006), AND NP-6 (BENZENE, OCT. 2006).
3. VOCs = VOLATILE ORGANIC COMPOUNDS
4. CGWSL = CRITICAL GROUNDWATER SCREENING LEVEL, SEE ANNUAL GROUNDWATER MONITORING REPORTS FOR SELECTION CRITERIA.
5. MTBE = METHYL TERT-BUTYL ETHER

PROJECT
RECEPTOR SURVEY AND VAPOR INSTRUSION EVALUATION
HOLLYFRONTIER NAVAJO REFINERY LLC
ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO

TITLE
HISTORICAL TARGET VOC CGWSL EXCEEDANCE AREA AND SUROUNDING PROPERTY MAP

DRAWN BY	MHORN	PROJ. NO.:	326778
CHECKED BY	JSPEER	**FIGURE 1**	
APPROVED BY	CSMITH		
DATE	APRIL 2019		

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FILE NO. 326778_1_Property.mxd

Coordinate System: NAD 1983 2011 StatePlane New Mexico East FIPS 3001 Ft US (Foot US)
Map Rotation: 0

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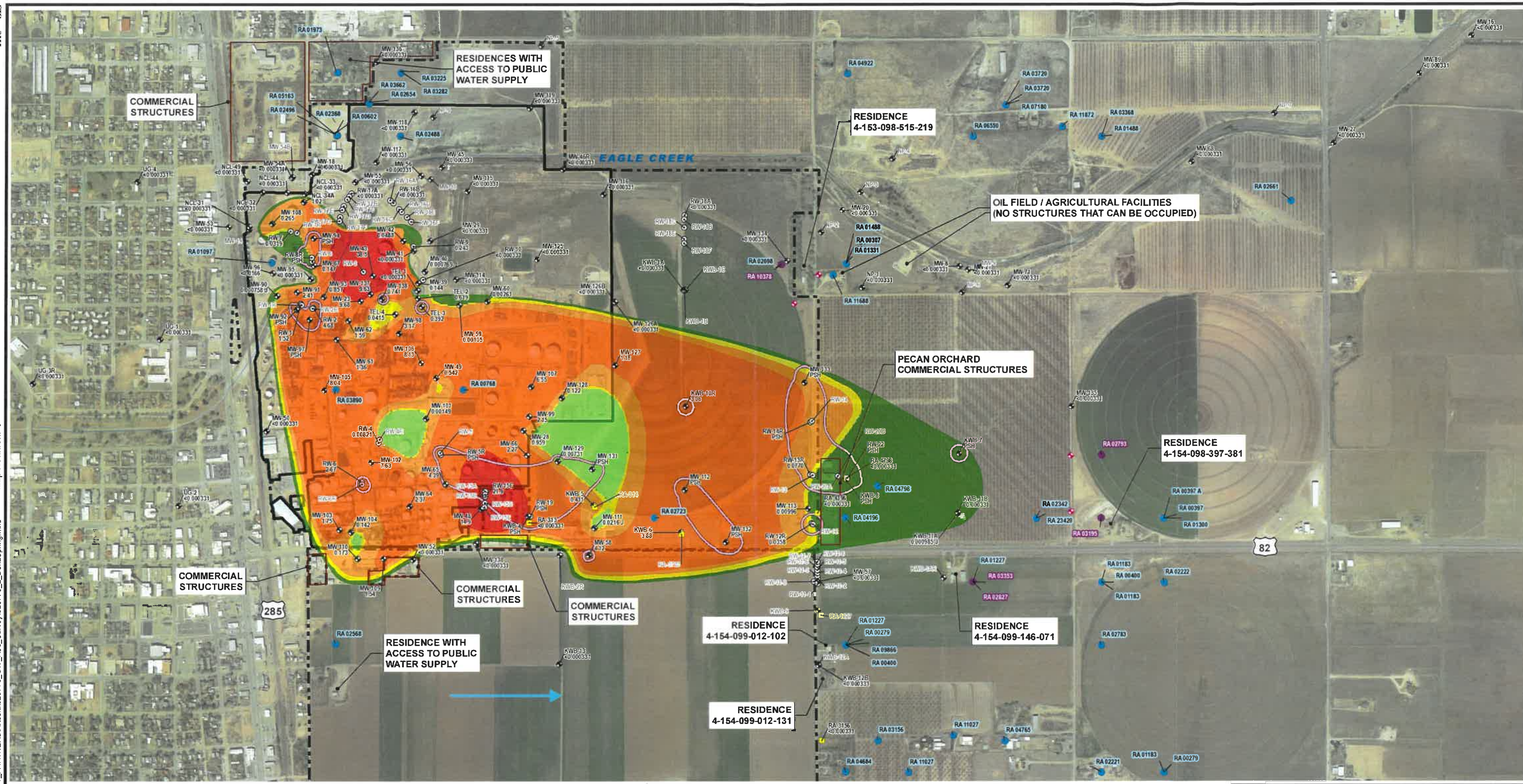
TRC - GIS



LEGEND

- MONITORING WELL
- RECOVERY WELL
- IRRIGATION WELL IN MONITORING PROGRAM
- PROPOSED MONITORING WELL
- 1.75 BENZENE CONCENTRATION
- <0.000331 BENZENE NOT DETECTED ABOVE METHOD DETECTION LIMIT
- PSH PHASE-SEPARATED HYDROCARBON PRESENT IN WELL (≥ 0.03 FEET THICK)
- KWB-9 WELL NOT SAMPLED
- POTENTIAL SHALLOW WATER WELL
- POTENTIAL DOMESTIC WATER WELL, FURTHER ASSESSMENT RECOMMENDED
- REFINERY FENCELINE
- FACILITY PROPERTY BOUNDARY (FENCELINE SHOWN WHERE COINCIDENT)
- GROUNDWATER FLOW DIRECTION
- PSH PRESENCE 2016-2018

NOTES:

1. ALL CONCENTRATIONS ARE IN MILLIGRAMS PER LITER (mg/L).
2. POTENTIAL SHALLOW WELLS IDENTIFIED IN RECORDS SEARCH BY ATKINS ENGINEERING ASSOCIATES INC. LOCATION SHOWN CONSISTENT WITH RECORDS.
3. J = CONCENTRATION QUALIFIED AS AN ESTIMATED VALUE.
4. ALL MONITORING AND RECOVERY WELLS ARE SCREENED IN THE SHALLOW SATURATED OR VALLEY FILL ZONES. IRRIGATION WELLS INCLUDED IN THE MONITORING PROGRAM ARE SCREENED IN EITHER THE VALLEY FILL ZONE OR THE DEEP ARTESIAN AQUIFER.
5. BENZENE CRITICAL GROUNDWATER SCREENING LEVEL (CGWSL) = 0.005 mg/L

AERIAL IMAGERY SOURCE: GOOGLE EARTH PRO AND THEIR DATA PARTNERS, 3/12/2016.

BENZENE CONCENTRATION FROM 2018 FIRST SEMIANNUAL EVENT (mg/L)

- 0 - 0.0001
- 0.0001 - 0.001
- 0.001 - 0.01
- 0.01 - 0.1
- 0.1 - 1.0
- 1.0 - 10
- 10 - 100

N

0 500 1,000 Feet

1 " = 1,000 '
1:12,000

PROJECT
RECEPTOR SURVEY AND VAPOR INSTRUSION EVALUATION
HOLLYFRONTIER NAVAJO REFINERY LLC
ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO

TITLE
POTENTIAL GROUNDWATER RECEPTORS
AND BENZENE ISOCONCENTRATION MAP
(FIRST 2018 SEMIANNUAL EVENT)

DRAWN BY	MHORN	PROJ. NO.:	326778
CHECKED BY	AELJURI	FIGURE 2	
APPROVED BY	JSPEER		
DATE	APRIL 2019		

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FILE NO: 326778_2_BenzSpring.mxd

Coordinate System: NAD 1983 2011 StatePlane New Mexico East FIPS 3001 Ft US (Foot US)
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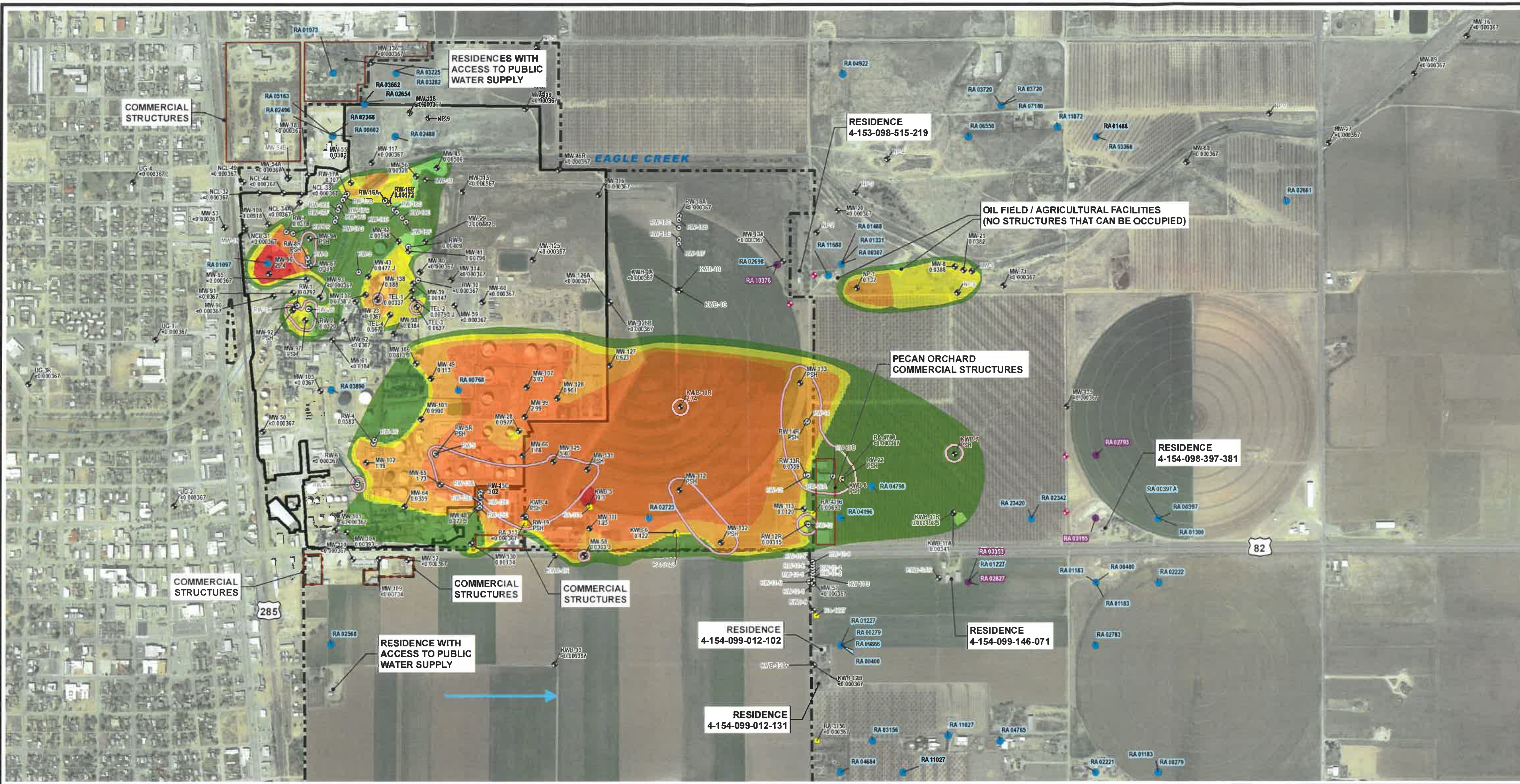

LEGEND

- MONITORING WELL
- RECOVERY WELL
- IRRIGATION WELL IN MONITORING PROGRAM
- PROPOSED MONITORING WELL
- 1.19 MTBE CONCENTRATION
- <0.000367 MTBE NOT DETECTED ABOVE METHOD DETECTION LIMIT
- PSH PHASE-SEPARATED HYDROCARBON PRESENT IN WELL (≥ 0.03 FEET THICK)
- KWB-9 WELL NOT SAMPLED
- POTENTIAL SHALLOW WATER WELL
- POTENTIAL DOMESTIC WATER WELL, FURTHER ASSESSMENT RECOMMENDED
- REFINERY FENCELINE
- FACILITY PROPERTY BOUNDARY (FENCELINE SHOWN WHERE COINCIDENT)
- GROUNDWATER FLOW DIRECTION
- PSH PRESENCE 2016-2018

NOTES:

1. ALL CONCENTRATIONS ARE IN MILLIGRAMS PER LITER (mg/L).
2. POTENTIAL SHALLOW WELLS IDENTIFIED IN RECORDS SEARCH BY ATKINS ENGINEERING ASSOCIATES INC. LOCATION SHOWN CONSISTENT WITH RECORDS.
3. J = CONCENTRATION QUALIFIED AS AN ESTIMATED VALUE.
4. MTBE = METHYL TERT-BUTYL ETHER
5. ALL MONITORING AND RECOVERY WELLS ARE SCREENED IN THE SHALLOW SATURATED OR VALLEY FILL ZONES. IRRIGATION WELLS INCLUDED IN THE MONITORING PROGRAM ARE SCREENED IN EITHER THE VALLEY FILL ZONE OR THE DEEP ARTESIAN AQUIFER.
6. MTBE CRITICAL GROUNDWATER SCREENING LEVEL (CGWSL) = 0.1 mg/L

AERIAL IMAGERY SOURCE: GOOGLE EARTH PRO AND THEIR DATA PARTNERS, 3/12/2016.

MTBE CONCENTRATION FROM 2018 FIRST SEMIANNUAL EVENT (mg/L)

- 0 - 0.0001
- 0.0001 - 0.001
- 0.001 - 0.01
- 0.01 - 0.1
- 0.1 - 1.0
- 1.0 - 10
- 10 - 100

0 500 1,000 Feet
1" = 1,000'
1:12,000

PROJECT:
RECEPTOR SURVEY AND VAPOR INSTRUSION EVALUATION
HOLLYFRONTIER NAVAJO REFINERY LLC
ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO

TITLE:
POTENTIAL GROUNDWATER RECEPTORS AND MTBE ISOCONCENTRATION MAP (FIRST 2018 SEMIANNUAL EVENT)

DRAWN BY	MHORN	PROJ. NO.:	326778
CHECKED BY	AELJURI		
APPROVED BY	JSPEER		
DATE	APRIL 2019		

FIGURE 3

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FILE NO: 326778_3_MTBESpring.mxd

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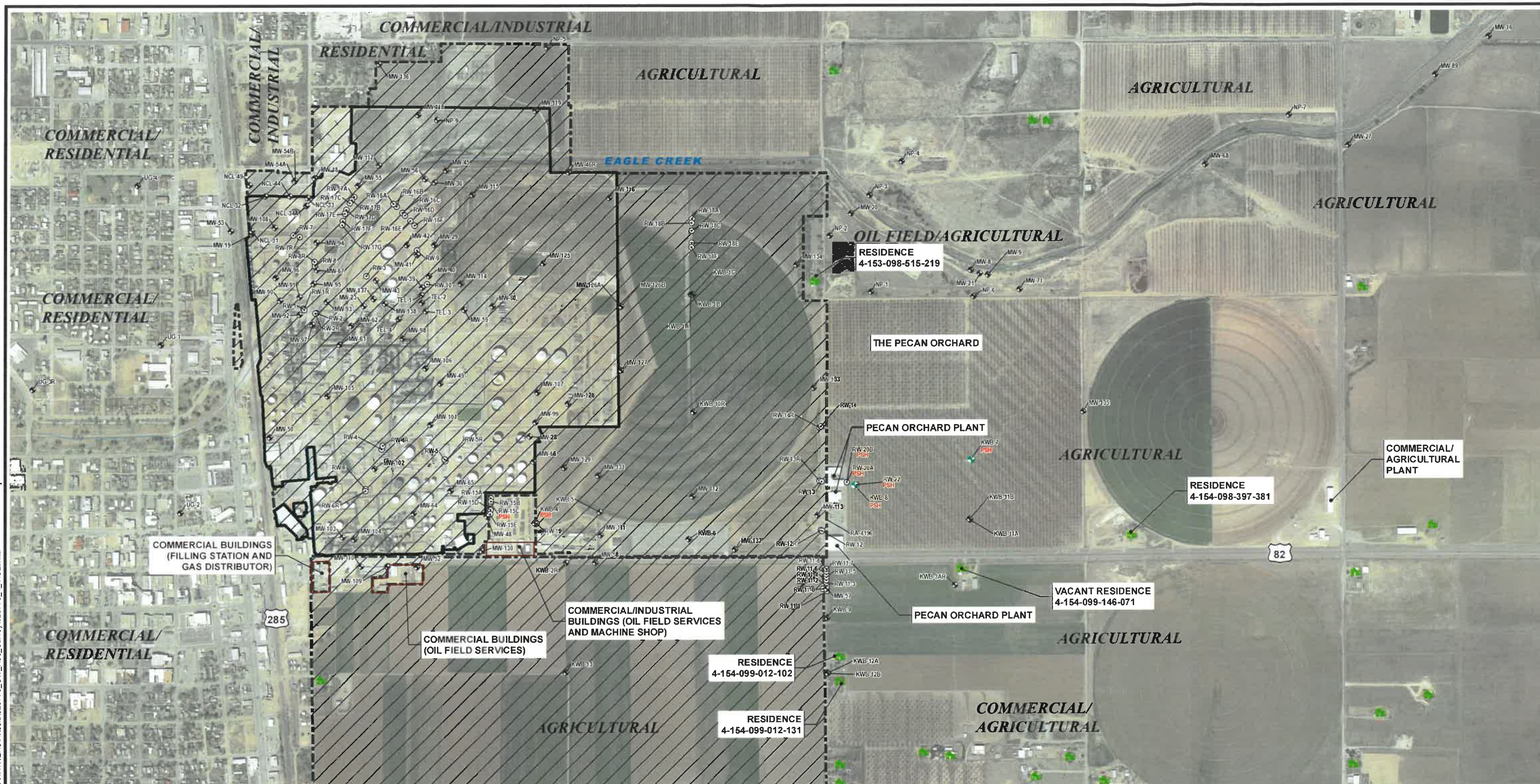
Map Rotation: 0

TRC - GIS



LEGEND

- OFF-SITE MONITORING WELL, EXCEEDED RESIDENTIAL GW VISL
- MONITORING WELL
- RECOVERY WELL
- RESIDENCE
- REFINERY FENCELINE
- FACILITY PROPERTY BOUNDARY (FENCELINE SHOWN WHERE COINCIDENT)
- PSH PHASE-SEPARATED HYDROCARBON OCCURRED IN OFF-SITE WELL BETWEEN 2016-2018 (≥ 0.01 FEET THICK)

NOTES:

1. GW VISL = GROUNDWATER VAPOR INTRUSION SCREENING LEVEL.
2. WELLS SHOWN AS EXCEEDING A RESIDENTIAL GW VISL EXCEEDED A GW VISL FOR AT LEAST ONE ANALYTE BETWEEN 2016 AND 2018.

0 500 1,000 Feet

1" = 1,000'

1:12,000

AERIAL IMAGERY SOURCE: GOOGLE EARTH PRO AND THEIR DATA PARTNERS, 3/12/2016.

PROJECT	
RECEPTOR SURVEY AND VAPOR INSTRUSION EVALUATION HOLLYFRONTIER NAVAJO REFINERY LLC ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO	
TITLE: GROUNDWATER VAPOR INTRUSION SCREENING LEVEL EXCEEDANCES (2016-2018)	
DRAWN BY: MHORN	PROJ. NO.: 326778
CHECKED BY: JSPEER	FIGURE 4
APPROVED BY: CSMITH	
DATE: APRIL 2019	
TRC	505 East Huntland Drive, Suite 250 Austin, TX 78752 Phone: 512.329.6080 www.trcsolutions.com
FILE NO.: 326778_4_VISL.mxd	

Plot Date: 4/10/2019, 14:32:46 PM by MHORN -- LAYOUT: ANSI B(11"x17")
Path: \\apaenvfile01\GIS\1-PROJECTS\HOLLY_ENERGY_PARTNERS\Artesia\326778_GW_Rec_Survey\326778_4_VISL.mxd

Coordinate System: NAD 1983 2011 StatePlane New Mexico East FIPS 3001 Ft US (Foot US)
Map Rotation: 0

TRC - GIS

LEGEND

- OFF-SITE MONITORING WELL, EXCEEDED RESIDENTIAL GW VISL
- MONITORING WELL
- RECOVERY WELL
- REFINERY FENCELINE
- FACILITY PROPERTY BOUNDARY (FENCELINE SHOWN WHERE COINCIDENT)
- PSH PRESENCE (2016-2018)
- 100 FEET BUFFER ZONE

PSH PHASE-SEPARATED HYDROCARBON OCCURRED IN OFF-SITE WELL BETWEEN 2016-2018 (≥ 0.01 FEET THICK)
B- BENZENE
E- ETHYLBENZENE
N- NAPHTHALENE
X- XYLENES
TMB- 1,2,4-TRIMETHYLBENZENE
MP- M&P-XYLENES

NOTES:

1. GW VISL = GROUNDWATER VAPOR INTRUSION SCREENING LEVEL.
2. WELLS SHOWN AS EXCEEDING A RESIDENTIAL GW VISL EXCEEDED A GW VISL FOR AT LEAST ONE ANALYTE BETWEEN 2016 AND 2018.

N

0 150 300 Feet
1 " = 300 '
1:3,600

AERIAL IMAGERY SOURCE: GOOGLE EARTH PRO AND THEIR DATA PARTNERS, 3/12/2016.

PROJECT:
RECEPTOR SURVEY AND VAPOR INSTRUSION EVALUATION
HOLLYFRONTIER NAVAJO REFINERY LLC
ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO

TITLE:
GROUNDWATER VAPOR INTRUSION SCREENING LEVEL EXCEEDANCES AND PSH REQUIRING FURTHER EVALUATION

DRAWN BY:	MHORN	PROJ. NO.:	326778
CHECKED BY:	LTOROZZO		
APPROVED BY:	CSMITH	FIGURE 5	
DATE:	APRIL 2019		

TRC

505 East Huntland Drive, Suite 250
Austin, TX 78752
Phone: 512.329.6080
www.trcsolutions.com

FILE NO.: 326778_5_VISL.mxd

TRC - GIS

Coordinate System: NAD 1983 2011 StatePlane New Mexico East FIPS 3001 Ft US (Foot US)
Map Rotation: 0

Plot Date: 4/10/2019, 14:32:23 PM by MHORN -- LAYOUT: ANSI B(11"x17")
Path: \\apaenvfile01\GIS\1-PROJECTS\HOLLY_ENERGY_PARTNERS\Artesia\326778_GW_Rec_Survey\326778_5_VISL.mxd

HOLLYFRONTIER

April 12, 2019

Mr. John Kieling
Chief, Hazardous Waste Bureau
New Mexico Environment Department
2905 Rodeo Park Drive East, Building 1
Santa Fe, New Mexico 87505

Mr. Carl Chavez
New Mexico Energy, Minerals and Natural Resources Department
Oil Conservation Division
1220 South St. Francis Drive
Santa Fe, New Mexico 87505

RE: Submittal of the *Desktop Groundwater Receptor Survey and Vapor Intrusion Evaluation of Off-Site Receptors* Memorandum
HollyFrontier Navajo Refining LLC, Artesia Refinery
RCRA Permit No. NMD048918817
Discharge Permit GW-028

Dear Mr. Kieling and Mr. Chavez:

Enclosed is the memorandum documenting the desktop groundwater receptor survey and vapor intrusion evaluation of off-site receptors located in the vicinity of the HollyFrontier Navajo Refining LLC (Navajo) refinery and Navajo-owned property in Artesia, New Mexico. This memorandum was prepared and is being submitted according to the meetings and conference calls attended by Navajo, the New Mexico Environment Department (NMED), and the New Mexico Energy, Minerals and Natural Resources Department Oil Conservation Division (OCD) on November 14-15, 2018, November 28, 2018, February 13, 2019, and March 28, 2019. The memorandum is being submitted in both hard copy and electronic format.

If you have any questions or comments regarding this request, please feel free to contact me at 575-746-5487 or Robert Combs at 575-746-5382.

Sincerely,

Scott M. Denton
Environmental Manager
HollyFrontier Navajo Refining LLC

cc: HFC: R. Combs, A. Sahba, M. Holder
TRC: C. Smith, J. Speer, L. Trozzolo

Chavez, Carl J, EMNRD

From:	Combs, Robert <Robert.Combs@HollyFrontier.com>
Sent:	Friday, May 31, 2019 3:24 PM
To:	Chavez, Carl J, EMNRD
Cc:	Tsinnajinnie, Leona, NMENV; Denton, Scott; Holder, Mike; Sahba, Arsin M.; Leik, Jason
Subject:	[EXT] RE: Recovery system reinjection pilot test work plan
Attachments:	B2_Class V Inventory Sheet Suppl Info_amended.pdf; A2_C-108 amended.pdf; A2_C-108 suppl info_amended.pdf

Carl,

Please find attached replacement pages for Appendix A (Form C-108 Application for Authorization to Inject) and Appendix B (Underground Discharge System [Class V] Inventory Sheet) of the *Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements: Reinjection Pilot Test Work Plan*. These appendices were amended to include the coordinates of each proposed injection well in accordance with OCD's request in the 5/16/2019 meeting. The coordinates are specified on the following pages of each attached pdf:

A1_C-108: page 5 of pdf (Injection Well Data Sheet)
A2_C-108 suppl doc: page 3 of pdf under item IIIA.(1)
B2_Class V Inventory Suppl: page 1 of pdf under item #1

Please let us know if you have any revisions or comments and we will address them accordingly.

Thanks,
Robert

Robert Combs
Environmental Specialist
The HollyFrontier Companies
P.O. Box 159
Artesia, NM 88211-0159
office: 575-746-5382
cell: 575-308-2718
fax: 575-746-5451
Robert.Combs@hollyfrontier.com

CONFIDENTIALITY NOTICE: This e-mail, and any attachments, may contain information that is privileged and confidential.If you received this message in error, please advise the sender immediately by reply e-mail and do not retain any paper or electronic copies of this message or any attachments.Unless expressly stated, nothing contained in this message should be construed as a digital or electronic signature or a commitment to a binding agreement.

STATE OF NEW MEXICO
ENERGY, MINERALS AND NATURAL
RESOURCES DEPARTMENT

Oil Conservation Division
1220 South St. Francis Dr.
Santa Fe, New Mexico 87505

FORM C-108
Revised June 10, 2003

APPLICATION FOR AUTHORIZATION TO INJECT

I. PURPOSE: ________Secondary Recovery ________Pressure Maintenance ________Disposal ________Storage
Other: In Situ Groundwater Remediation Injection Wells
Application qualifies for administrative approval? ____**NA**_____ Yes ________ No

II. OPERATOR: ___ **HollyFrontier Navajo Refining LLC (HFNR)**________________________

ADDRESS: ____**501 E Main Street in Artesia, New Mexico 88210**________________________

CONTACT PARTY: ____ **Scott Denton**________________________ PHONE: ___ **575-746-5487**___

III. WELL DATA: Complete the data required on the reverse side of this form for each well proposed for injection. Additional sheets may be attached if necessary.

IV. Is this an expansion of an existing project? ____**X**_____ Yes ________ No
If yes, give the Division order number authorizing the project: ______**GW-028**________________________

V. Attach a map that identifies all wells and leases within two miles of any proposed injection well with a one-half mile radius circle drawn around each proposed injection well. This circle identifies the well's area of review. **Attached, Figure "C-108 Map"**

*VI. Attach a tabulation of data on all wells of public record within the area of review which penetrate the proposed injection zone. Such data shall include a description of each well's type, construction, date drilled, location, depth, record of completion, and a schematic of any plugged well illustrating all plugging detail. **Provided in previous reports and in attached Table "Tabulation of Data on Wells of Public Record within Area of Review, Application for Authorization to Inject, FORM C-108, Item VI." Details below.**

VII. Attach data on the proposed operation, including: **See attached report "Groundwater and Phase-Separated Hydrocarbon: Recovery System Enhancements: Reinjection Pilot Test Work Plan" Sections 4, 5 and 6; & Attached Supplemental Information**

1. Proposed average and maximum daily rate and volume of fluids to be injected;
2. Whether the system is open or closed;
3. Proposed average and maximum injection pressure;
4. Sources and an appropriate analysis of injection fluid and compatibility with the receiving formation if other than reinjected produced water; and,
5. If injection is for disposal purposes into a zone not productive of oil or gas at or within one mile of the proposed well, attach a chemical analysis of the disposal zone formation water (may be measured or inferred from existing literature, studies, nearby wells, etc.).

*VIII. Attach appropriate geologic data on the injection zone including appropriate lithologic detail, geologic name, thickness, and depth. Give the geologic name, and depth to bottom of all underground sources of drinking water (aquifers containing waters with total dissolved solids concentrations of 10,000 mg/l or less) overlying the proposed injection zone as well as any such sources known to be immediately underlying the injection interval.
See attached document "Groundwater and Phase-Separated Hydrocarbon: Recovery System Enhancements: Reinjection Pilot Test Work Plan" Sections 3.2 and 3.3; & Attached Supplemental Information

IX. Describe the proposed stimulation program, if any. **NA**

*X. Attach appropriate logging and test data on the well. (If well logs have been filed with the Division, they need not be resubmitted). **NA**

*XI. Attach a chemical analysis of fresh water from two or more fresh water wells (if available and producing) within one mile of any injection or disposal well showing location of wells and dates samples were taken. **Data provided for irrigation wells in the injection area in Annual Groundwater Monitoring Reports.**

XII. Applicants for disposal wells must make an affirmative statement that they have examined available geologic and engineering data and find no evidence of open faults or any other hydrologic connection between the disposal zone and any underground sources of drinking water. **NA**

XIII. Applicants must complete the "Proof of Notice" section on the reverse side of this form. **NA**

XIV. Certification: I hereby certify that the information submitted with this application is true and correct to the best of my knowledge and belief.

NAME: Scott Denton TITLE: Env. Mgr.

SIGNATURE: ______________________ DATE: 05/30/19

E-MAIL ADDRESS: ______________________

* If the information required under Sections VI, VIII, X, and XI above has been previously submitted, it need not be resubmitted. Please show the date and circumstances of the earlier submittal: __**See Supplemental Information, attached**__________

DISTRIBUTION: Original and one copy to Santa Fe with one copy to the appropriate District Office

III. WELL DATA

A. The following well data must be submitted for each injection well covered by this application. The data must be both in tabular and schematic form and shall include: **Attached (Supplemental Information)**

(1) Lease name; Well No.; Location by Section, Township and Range; and footage location within the section.

(2) Each casing string used with its size, setting depth, sacks of cement used, hole size, top of cement, and how such top was determined.

(3) A description of the tubing to be used including its size, lining material, and setting depth.

(4) The name, model, and setting depth of the packer used or a description of any other seal system or assembly used.

Division District Offices have supplies of Well Data Sheets which may be used or which may be used as models for this purpose. Applicants for several identical wells may submit a "typical data sheet" rather than submitting the data for each well.

B. The following must be submitted for each injection well covered by this application. All items must be addressed for the initial well. Responses for additional wells need be shown only when different. Information shown on schematics need not be repeated. **Attached (Supplemental Information)**

(1) The name of the injection formation and, if applicable, the field or pool name.

(2) The injection interval and whether it is perforated or open-hole.

(3) State if the well was drilled for injection or, if not, the original purpose of the well.

(4) Give the depths of any other perforated intervals and detail on the sacks of cement or bridge plugs used to seal off such perforations.

(5) Give the depth to and the name of the next higher and next lower oil or gas zone in the area of the well, if any.

XIV. PROOF OF NOTICE

All applicants must furnish proof that a copy of the application has been furnished, by certified or registered mail, to the owner of the surface of the land on which the well is to be located and to each leasehold operator within one-half mile of the well location.

Where an application is subject to administrative approval, a proof of publication must be submitted. Such proof shall consist of a copy of the legal advertisement which was published in the county in which the well is located. The contents of such advertisement must include:

(1) The name, address, phone number, and contact party for the applicant;

(2) The intended purpose of the injection well; with the exact location of single wells or the Section, Township, and Range location of multiple wells;

(3) The formation name and depth with expected maximum injection rates and pressures; and,

(4) A notation that interested parties must file objections or requests for hearing with the Oil Conservation Division, 1220 South St. Francis Dr., Santa Fe, New Mexico 87505, within 15 days.

NO ACTION WILL BE TAKEN ON THE APPLICATION UNTIL PROPER PROOF OF NOTICE HAS BEEN SUBMITTED.

NOTICE: Surface owners or offset operators must file any objections or requests for hearing of administrative applications within 15 days from the date this application was mailed to them.

Side 1

INJECTION WELL DATA SHEET

OPERATOR: ___ **HollyFrontier Navajo Refining LLC (HFNR)** ____________

WELL NAME & NUMBER: ___**IW-1, IW-2** __

WELL LOCATION: _**Navajo Artesia Refinery, near KWB-5 (IW-1) and MW-131 (IW-2), respectively.**
Latitude/Longitude: IW-1: 32.843850, -104.385814; IW-2: 32.844883, -104.385867 **Section 4, Township 17S, Range 26E**
SECTION TOWNSHIP RANGE

WELLBORE SCHEMATIC *NA*

WELL CONSTRUCTION DATA

Surface Casing

Hole Size: ________**11 in**________ Casing Size: ______**6 in**______

Cemented with: ______**TBD**______ sx. ***or*** ________________ ft^3

Top of Cement: _____**TBD**__________ Method Determined: __________

Intermediate Casing **NA**

Hole Size: ________**NA**__________ Casing Size: ______________

Cemented with: ________________ sx. ***or*** ________________ ft^3

Top of Cement: ________________ Method Determined: __________

Production Casing **NA**

Hole Size: _________**NA**_________ Casing Size: ______________

Cemented with: ________________ sx. ***or*** ________________ ft^3

Top of Cement: ________________ Method Determined: __________

Total Depth: ________________

Injection Interval

____**bottom 5-10 feet above 2-foot sump** **Perforated**________________

(Perforated or Open Hole; indicate which)

INJECTION WELL DATA SHEET

Tubing Size: **NA** Lining Material: **NA**

Type of Packer: **NA**

Packer Setting Depth: **NA**

Other Type of Tubing/Casing Seal (if applicable): **NA**

Additional Data

1. Is this a new well drilled for injection? **X** Yes ____ No

   If no, for what purpose was the well originally drilled? ____

2. Name of the Injection Formation: **Shallow Saturated Zone (10-30' bgs)**
3. Name of Field or Pool (if applicable): **NA**
4. Has the well ever been perforated in any other zone(s)? List all such perforated intervals and give plugging detail, i.e. sacks of cement or plug(s) used. **No**
5. Give the name and depths of any oil or gas zones underlying or overlying the proposed injection zone in this area:

   NA

Supplemental Information
Form C-108
Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements Reinjection Pilot Test Work Plan HollyFrontier Navajo Refining LLC (HFNR)

VI.

Attach a tabulation of data on all wells of public record within the area of review which penetrate the proposed injection zone. Such data shall include a description of each well's type, construction, date drilled, location, depth, record of completion, and a schematic of any plugged well illustrating all plugging detail.

Provided in prior Annual Groundwater Monitoring Reports; and in attached Table "Tabulation of Data on Wells of Public Record within Area of Review, Application for Authorization to Inject, FORM C-108, Item VI."

VII.
Attach data on the proposed operation, including:
1.Proposed average and maximum daily rate and volume of fluids to be injected;
2.Whether the system is open or closed;
3.Proposed average and maximum injection pressure;
4.Sources and an appropriate analysis of injection fluid and compatibility with the receiving formation if other than reinjected produced water; and,
5.If injection is for disposal purposes into a zone not productive of oil or gas at or within one mile of the proposed well, attach a chemical analysis of the disposal zone formation water (may be measured or inferred from existing literature, studies, nearby wells, etc.).

1.Proposed average and maximum daily rate and volume of fluids to be injected;
Average: 12 gpm per injection well
Maximum: 15 gpm per injection well

2.Whether the system is open or closed;
Closed

3.Proposed average and maximum injection pressure;
To be determined during injection test - maximum possible injection pressure 150 psi

4.Sources and an appropriate analysis of injection fluid and compatibility with the receiving formation if other than reinjected produced water; and,
Source of injection fluid is recovered water from the Shallow Saturated Zone. The receiving formation is also the Shallow Saturated Zone approximately 200 feet upgradient of the recovery well. Recovered water will be amended with nutrients to enhance natural attenuation. All extraction and injection will be within 50 feet of the ground surface.

Supplemental Information
Form C-108
Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements Reinjection Pilot Test Work Plan HollyFrontier Navajo Refining LLC (HFNR)

Table 1 calculates sulfate addition rates based on a stock sulfate solution concentration of approximately 3.1% (Epsom Salt approximately 8%). The stock solution is prepared by mixing 6,000 lbs. of Epsom Salt in 4,000 gallons of water in a 5,000 gallon poly tank. The Epsom Salt is typically added to a 95 gallon mixing drum fed with a water stream from the mixing tank and the resulting slurry is pumped to the top of the storage tank. The ammonia is then added through the same mixing drum. The ammonia source is household unscented and surfactant free 9% ammonium water. The ammonia concentration in the sulfate tank is adjusted to approximately 50 mg/L for a targeted formation concentration of 10 to 25 mg/L. After in situ dilution/mixing conditions are measured, both sulfate and ammonia injection rates will be adjusted to maintain an adequate supply of nitrogen and sulfate.

5. If injection is for disposal purposes into a zone not productive of oil or gas at or within one mile of the proposed well, attach a chemical analysis of the disposal zone formation water (may be measured or inferred from existing literature, studies, nearby wells, etc.).
NA

VIII.
Attach appropriate geologic data on the injection zone including appropriate lithologic detail, geologic name, thickness, and depth. Give the geologic name, and depth to bottom of all underground sources of drinking water (aquifers containing waters with total dissolved solids concentrations of 10,000 mg/l or less) overlying the proposed injection zone as well as any such sources known to be immediately underlying the injection interval.

See attached report "Groundwater and Phase-Separated Hydrocarbon, Recovery System Enhancements: Reinjection Pilot Test Work Plan" Sections 3.2 and 3.3. Boring logs for MW-131 and KWB-5 in the injection zone are included.

III A.
The following well data must be submitted for each injection well covered by this application. The data must be both in tabular and schematic form and shall include:

(1) Lease name; Well No.; Location by Section, Township and Range; and footage location within the section.

No lease. [Section 4, Township 17S, Range 26E]
IW-1 Proposed Latitude/Longitude: 32.843850, -104.385814 (West of KWB-5)
IW-2 Proposed Latitude/Longitude: 32.844883, -104.385867 (West of MW-131)

(2) Each casing string used with its size, setting depth, sacks of cement used, hole size, top of cement, and how such top was determined.
Entire wellbore
Casing size: 6-inch
Depth: TBD, will be approximately 3 feet below the base of the saturated gravel zone encountered when drilling;
Cement: sacks TBD; well will be cemented from approximately 4 feet above the top of the screened interval to 3 feet bgs
Hole size: 11 inches

Supplemental Information
Form C-108
Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements Reinjection Pilot Test Work Plan HollyFrontier Navajo Refining LLC (HFNR)

Top of cement: 3 feet bgs
Top cement determined by: subsurface conditions

(3) A description of the tubing to be used including its size, lining material, and setting depth.
NA

(4) The name, model, and setting depth of the packer used or a description of any other seal system or assembly used.
NA

Supplemental Information
Form C-108
Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements Reinjection Pilot Test Work Plan HollyFrontier Navajo Refining LLC (HFNR)

III B.
The following must be submitted for each injection well covered by this application. All items must be addressed for the initial well. Responses for additional wells need be shown only when different. Information shown on schematics need not be repeated.

(1) The name of the injection formation and, if applicable, the field or pool name.
Shallow Saturated Zone (10-30' bgs)

(2) The injection interval and whether it is perforated or open-hole.
TBD; expected 5-10 feet across the gravel/sand interval in the saturated zone; perforated

(3) State if the well was drilled for injection or, if not, the original purpose of the well.
Injection (In Situ Groundwater Remediation Injection Well)

(4) Give the depths of any other perforated intervals and detail on the sacks of cement or bridge plugs used to seal off such perforations.
None

(5) Give the depth to and the name of the next higher and next lower oil or gas zone in the area of the well, if any.
None

SUPPLEMENTAL INFORMATION
UNDERGROUND DISCHARGE SYSTEM (CLASS V) INVENTORY SHEET
GROUNDWATER PHASE SEPARATED HYDROCARBON (PSH) RECOVERY SYSTEM ENHANCEMENTS
REINJECTION PILOT TESTING WORK PLAN
HOLLYFRONTIER NAVAJO REFINING LLC (HFNR)

The numbers below correspond to the numbers on the second page of the Underground Discharge System (Class V) Inventory Sheet.

1.

Supply the name and street address of the facility where the Class V well(s) is located. Please be sure to include the County name. If available, provide the Latitude/Longitude of the discharge system. If there is no street address for the discharge system(s), provide a description of the location and show the location on a map. Include the name and phone number of a person to contact if there are any questions regarding the underground discharge system(s) and/or the wastewaters discharged at the facility.

HollyFrontier Navajo Refining LLC

Artesia Refinery

501 E Main Street in Artesia, New Mexico 88210

Artesia, Eddy County, New Mexico

Location and Map provided in Figure 1, Figure 2a, and Figure 2b of the attached document "Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements: Reinjection Pilot Test Work Plan"

IW-1 Proposed Latitude/Longitude: 32.843850, -104.385814 (West of KWB-5)

IW-2 Proposed Latitude/Longitude: 32.844883, -104.385867 (West of MW-131)

Contact: Scott Denton; 575-746-5487

2.

Provide the name and mailing address of the owner of the facility or if the facility is operated by lease, the operator of the facility.

HollyFrontier Navajo Refining LLC

Artesia Refinery

Attn: Scott Denton

501 E Main Street in Artesia, New Mexico 88210

Artesia, Eddy County, New Mexico

SUPPLEMENTAL INFORMATION
UNDERGROUND DISCHARGE SYSTEM (CLASS V) INVENTORY SHEET
GROUNDWATER PHASE SEPARATED HYDROCARBON (PSH) RECOVERY SYSTEM ENHANCEMENTS
REINJECTION PILOT TESTING WORK PLAN
HOLLYFRONTIER NAVAJO REFINING LLC (HFNR)

3.

Provide the number of underground discharge systems at the facility (or location) for the type of system that is described on this sheet. Please use a separate sheet for each different type of system present. If the type of system is "Other", please describe (e.g., french drain, leachfield, improved sinkhole, cesspool, etc.).

Two groundwater recirculation systems, near existing wells KWB-5 and MW-131. System design described in Section 4 and Section 5 of the attached document "Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements: Reinjection Pilot Test Work Plan"

Provide a sketch, diagram or blueprints of the construction of the system including the depth below the ground surface that the fluids are released into the soil, sediment or formation. Also provide a map or sketch of the layout of the plumbing or drainage system, including all the connections, and if applicable, indicate each fluid source connection (i.e., floor drains, shop sink, process tank discharge, restrooms, etc.) and any pre-treatment, etc.

Diagram and Sketch provided in Figure 3 of the attached document "Groundwater & Phase Separated Hydrocarbon Recovery System Enhancements: Reinjection Pilot Testing Work Plan".

4.

Describe the kind of business practice that generates the fluids being discharged into the underground system (e.g., body shop, drycleaner, carwash, print shop, restaurant, etc.), and/or if more appropriate, the source of the fluids (e.g., employee & customer restrooms, parking lot drainage, etc.). If available, include the Standard Industrial Classification (SIC) Codes for this facility.

The refinery (SIC Code 2911) plans to recirculate amended groundwater as part of site remediation, as described in Section 4 and Section 5 of the attached document "Groundwater and Phase-Separated Hydrocarbon, Recovery System Enhancements: Reinjection Pilot Test Work Plan"

5.

List the kinds of fluids that can enter the underground system (e.g., storm water run-off, sanitary waste, solvents, biodegradable soap wash & rinse water, snowmelt from trucks, photo developing fluids, ink, paint & thinner, non-contact cooling water, etc.). Please be as specific as you can about the kinds of fluids or products that can be drained into the system. Generally, good sources for this information are the Material Safety Data Sheets (MSDS) (copies of MSDS could be attached instead of listing all the products). If available, also attach a copy of any chemical analysis for the fluids discharged.

Recirculated treated groundwater, as described in Section 4 and Section 5 of the attached document "Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements: Reinjection Pilot Test Work Plan".

SDS for Magnesium Sulfate (Epsom Salts) and 9% Ammonia Solution, and most recent analytical results for MW-131 and KBW-5 attached below.

SUPPLEMENTAL INFORMATION
UNDERGROUND DISCHARGE SYSTEM (CLASS V) INVENTORY SHEET
GROUNDWATER PHASE SEPARATED HYDROCARBON (PSH) RECOVERY SYSTEM ENHANCEMENTS
REINJECTION PILOT TESTING WORK PLAN
HOLLYFRONTIER NAVAJO REFINING LLC (HFNR)

6.

Describe the kinds of treatment (if any) that the fluids go through before disposal. Examples of treatment are: grease trap, package plant, oil/water separator, catch basin, metal recovery unit, sand filter, grit cleanser, etc.

Injection wells will not be used for disposal. Wells are In Situ Groundwater Remediation Injection Wells. Groundwater is treated with a sulfate and ammonia solution, as described in Section 5 of the attached document "Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements: Reinjection Pilot Test Work Plan"

7.

Select the status of the underground discharge system and include the date the system was constructed. If the status is "Existing" but it is not being used, is unusable, will not be used, or is temporarily abandoned, mark the box for "Unused/Abandoned". If state or local government approval was given for construction of the system, or a permit was issued for the system, please provide the name of the approving authority. Provide an estimated date of construction if the actual date is unknown.

Not yet constructed; Estimated construction date: second half 2019.

HOLLYFRONTIER.

April 12, 2019

Mr. John Kieling
Chief, Hazardous Waste Bureau
New Mexico Environment Department
2905 Rodeo Park Drive East, Building 1
Santa Fe, New Mexico 87505

Mr. Carl Chavez
New Mexico Energy, Minerals and Natural Resources Department
Oil Conservation Division
1220 South St. Francis Drive
Santa Fe, New Mexico 87505

RE: Submittal of the *Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements: Reinjection Pilot Test Work Plan*
HollyFrontier Navajo Refining LLC, Artesia Refinery
RCRA Permit No. NMD048918817
Discharge Permit GW-028

Dear Mr. Kieling and Mr. Chavez:

Enclosed is the *Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements: Reinjection Pilot Test Work Plan* for the Artesia Refinery. This work plan describes the proposed pilot testing that will be performed to evaluate the effectiveness of the amendment and reinjection process associated with the proposed phase-separated hydrocarbon (PSH) and groundwater recovery system enhancements at the Artesia Refinery. This work plan was prepared and is being submitted according to the meetings and conference calls attended by Navajo, the New Mexico Environment Department (NMED), and the New Mexico Energy, Minerals and Natural Resources Department Oil Conservation Division (OCD) between April 2018 and March 2019. The work plan is being submitted in both agencies in hard copy and electronic format.

If you have any questions or comments regarding this request, please feel free to contact me at 575-746-5487 or Robert Combs at 575-746-5382.

Sincerely,

Scott M. Denton
Environmental Manager
HollyFrontier Navajo Refining LLC

cc: HFC: R. Combs, A. Sahba, M. Holder
TRC: C. Smith, J. Speer, J. Leik

Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements:

Reinjection Pilot Test Work Plan

HollyFrontier Navajo Refining LLC
Artesia Refinery
Artesia, New Mexico

April 2019

Prepared for:

HOLLYFRONTIER

HollyFrontier Navajo Refining LLC
Artesia, New Mexico

Prepared by:

TRC

TRC Environmental Corporation
Austin, Texas

LIST OF ACRONYMS

APH	adsorbed phase hydrocarbon
bgs	below ground surface
BTEX	benzene, ethylbenzene, toluene, and xylenes
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CME	Contaminant Migration Evaluation
COCs	constituents of concern
DO	dissolved oxygen
DRO	diesel range organics
EAB	enhanced anaerobic biodegradation
FWGMWP	Facility-Wide Groundwater Monitoring Work Plan
gpm	gallons per minute
GRO	gasoline range organics
HASP	health and safety plan
HFNR	HollyFrontier Navajo Refining LLC
HSA	hollow stem auger
IDW	investigation-derived waste
IW	injection well
mg/L	milligrams per liter
MNA	monitored natural attenuation
MTBE	methyl tert-butyl ether
mV	millivolts
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department - Hazardous Waste Bureau
NMOSE	New Mexico Office of the State Engineer

OCD	Oil Conservation Division
ORP	oxidation reduction potential
PCC Permit	Post-Closure Care Permit
PMW	pilot test monitoring well
PSH	phase-separated hydrocarbons
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
redox	reduction/oxidation potential
RCRA	Resource Conservation and Recovery Act
RW	recovery well
SRBs	sulfate reducing bacteria
TDS	Total dissolved solids
TEX	toluene, ethylbenzene, and xylenes
TOC	total organic carbon
TKN	total Kjeldahl nitrogen
UIC	underground injection control
WWTP	wastewater treatment plant
%	percent

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1.0 Introduction

This work plan has been prepared on behalf of HollyFrontier Navajo Refining LLC (HFNR) for the refinery located at 501 East Main Street in Artesia, New Mexico (the Refinery). The Refinery is (1) regulated under the Resource Conservation and Recovery Act (RCRA) and subject to a Post-Closure Care Permit (PCC Permit) issued by the New Mexico Environment Department (NMED), and (2) subject to a Discharge Permit GW-028 issued by the Oil Conservation Division (OCD) of the Energy, Minerals and Natural Resources Department of the State of New Mexico. Among other requirements, the PCC Permit requires HFNR to recover phase-separated hydrocarbons (PSH) and dissolved-phase hydrocarbons from shallow groundwater (NMED, 2010). Additionally, the Discharge Permit requires HFNR to abate contaminants in the vadose zone and groundwater. HFNR actively operates an automated system to recover PSH and impacted groundwater, and is seeking to expand and enhance the recovery system.

HFNR has developed a proposed PSH/groundwater recovery and reinjection system upgrade ("upgrade"). Within this upgrade, the network of recovery wells will be expanded to enhance PSH and dissolved-phase hydrocarbon capture and hydraulic control, and enhance PSH recovery by increasing the hydraulic gradient in the direction of the proposed recovery wells (PSH will continue to be recovered and reinserted into the refining process). The goal is to control migration of dissolved-phase impacts and PSH prior to leaving HFNR's property and eventually stop PSH migration while allowing natural processes (i.e., monitored natural attenuation and biodegradation) to remediate the remaining dissolved phase hydrocarbons. With the proposed upgrade, all of the recovered groundwater will no longer be discharged to the Refinery's wastewater treatment plant (WWTP); instead, the majority of the recovered groundwater will be treated via equalization for additional phase separation, solids removal, and amendment with the addition of terminal electron acceptors and nutrients, and subsequently reinjected into the shallow saturated zone in order to enhance the anaerobic degradation rate of dissolved-phase constituents and to increase the hydraulic gradient to improve PSH recovery. A small percentage of the recovered groundwater may be treated at the Refinery's on-site WWTP. Water balance for the portion of groundwater sent to the WWTP will be maintained by injection of clean water produced from other sources (e.g., purchased city water, clean groundwater from the Refinery's deep wells, or permeate from the Refinery reverse osmosis (RO) system). Reinjection will also promote water conservation goals (reduce fresh water rights) and preserve the capacity of the Refinery's WWTP and OCD-permitted underground injection control (UIC) wells (disposal wells).

Prior to implementing the full upgrade, HFNR will complete a pilot test to optimize the treatment approach and evaluate effectiveness of treatment and injection. The purpose of this work plan is to describe the pilot tests that will be performed to evaluate the effectiveness of the amendment and reinjection process in reducing dissolved-phase concentrations in the vicinity of and downgradient of the reinjection zone. The impacts on PSH recovery will also be evaluated during the pilot test, though the pilot test may not be of sufficient length to fully understand the impacts on PSH recovery. Regardless, the system enhancement should improve overall PSH recovery as it is a proven technology. Once the pilot test is completed, HFNR will finalize the treatment process design and submit to NMED and OCD for approval prior to implementation.

This work plan describes the procedures that will be followed during implementation of the pilot tests. The format of this work plan follows the general outline specified for an investigation work plan in Appendix E.2 of the PCC Permit.

2.0 Background

2.1 Facility Background

The Refinery is an active petroleum refinery located at 501 East Main Street in the City of Artesia, Eddy County, New Mexico. The Refinery has been in operation since the 1920s and currently processes crude oil and other feedstocks into asphalt, fuel oil, gasoline, diesel, jet fuel, and liquefied petroleum gas. A site location map is provided as Figure 1.

The Refinery is subject to (1) a PCC Permit issued by the NMED in October 2003 (NMED, 2003) and later modified in December 2010, and (2) the renewed Discharge Permit GW-028 issued by OCD on May 25, 2017 (OCD, 2017a) and modified on June 29, 2017 (OCD, 2017b). A renewal application for the PCC Permit was submitted to NMED on April 5, 2013, followed by three supplements and addenda to the application in March 2015, October 2016, and April 2017 (HFNR, 2017). NMED issued a draft PCC Permit for review in April 2017 (NMED, 2017), which has not been finalized as of April 2019.

2.2 Recovery System Background

HFNR currently operates a groundwater recovery system at the Refinery to capture both PSH and dissolved-phase hydrocarbons present within the shallow saturated zone beneath the Refinery and beneath the field east of the Refinery (East Field), which is owned by HFNR. This recovery system is operated as part of the corrective action requirements in the PCC Permit as well as conditions of the Refinery's Discharge Permit GW-028 (including prior renewals issued on October 15, 2008 [OCD, 2008], and August 22, 2012 [OCD, 2012]). HFNR began evaluating additional options and system upgrades for continued corrective action of the groundwater impacts while reducing or eliminating the need to lease shallow water rights.

The most recent meetings and correspondence between HFNR, NMED, and OCD leading to this work plan are as follows:

- April 26, 2018 – Conference call held with HFNR, NMED, and OCD.
- May 24, 2018 – HFNR received Letter of Concurrence for Injection Standards from NMED.
- June 19, 2018 – HFNR received draft Letter with Work Plan requirements from NMED.
- November 14 and November 15, 2018 – HFNR, NMED, and OCD held meeting and HFNR submitted follow-up letter to OCD and NMED with proposed alternatives for reinjection standards.
- November 28, 2018 – HFNR, NMED, and OCD agreed upon definition of facility during a conference call.

- December 10, 2018 – HFNR submitted follow-up email to NMED and OCD for November 14 and 28 conference calls.
- December 18, 2018 – HFNR met with NMED and OCD regarding applicable regulations to implement the pilot study and full system using Class V Injection wells.
- February 13, 2019 – HFNR, NMED, and OCD held meeting to discuss a summary of forthcoming draft work plan for the pilot test.

All parties (HFNR, NMED, and OCD) have agreed in principle to allow the upgrade to proceed in accordance with the conditions and associated requirements for the system's performance determined during the meetings/calls described above, contingent upon agency approval of the forthcoming Pilot Test Report (report documenting pilot test results to be submitted to NMED and OCD after completion of the pilot test) and final system upgrade design.

2.3 Previous Investigation Results

HFNR submitted a Contaminant Migration Evaluation (CME) investigation work plan in 2011, which was approved in 2012 by NMED. The initial phase of the CME investigation was completed in early 2013, additional investigation work was completed in 2014, and a CME Report was submitted to NMED in 2015 (Arcadis, 2015). The CME Report was revised in 2017 to address NMED comments received in September 2016 and included a revised conceptual site model as well as updated geophysical, soil, groundwater, and PSH investigations in areas east of the Refinery (Arcadis, 2017). The Revised CME Report also provided recommendations for additional recovery points to be installed to enhance PSH recovery based on the location of PSH and observed preferential pathways for groundwater flow. Concurrently, an updated groundwater model was produced incorporating the CME results and current conditions as well as projected upgrades to the groundwater recovery system, including the installation of additional recovery points and reinjection of recovered water. This data has been used in developing this pilot test. The results of the pilot test will then be used to optimize and finalize final design of the proposed upgraded recovery system.

In late 2016, HFNR also performed shallow saturated zone hydrogeologic testing which was used to develop a preliminary design for PSH/groundwater recovery system upgrades. Two models were produced and discussed with the agencies periodically, with the latest model results presented to NMED and OCD in March 2018. Additional discussions with the agencies followed related to injection standards. The benefits associated with the upgrade are:

- it creates a closed-loop system that provides both hydraulic control and contaminant reduction;
- additional PSH will be removed that can no longer serve as a source of contaminants;

- the additional removal of PSH will accelerate the natural attenuation processes already occurring;
- the treatment of recovered groundwater followed by reinjection will stimulate additional degradation in-situ; and
- it will replace sulfate in groundwater in areas where the natural concentration has been depleted by the demand of sulfate reducing bacteria (SRBs).

Reinjection will also promote water conservation goals and preserve the capacity of the Refinery's WWTP and OCD-permitted UIC wells (disposal wells).

3.0 Site Conditions

This section describes the current surface and subsurface conditions at the Refinery.

3.1 Surface Conditions

3.1.1 Topography

The Refinery is located on the east side of the City of Artesia in the broad Pecos River Valley of eastern New Mexico. The average elevation of the City of Artesia is 3,380 feet above mean sea level. The plain on which the City of Artesia is located slopes eastward at about 20 feet per mile or 0.378 percent (%).

3.1.2 Surface Water Drainage

Surface drainage in the region is dominated by minor ephemeral creeks and arroyos that flow eastward to the Pecos River, located approximately three miles east of the City. The major drainage feature in the immediate area of the Refinery is Eagle Creek (or Eagle Draw), which runs southwest to northeast through the northern process area of the Refinery and then eastward to the Pecos River. Eagle Creek is an ephemeral watercourse that primarily flows only following rain events. Upstream of the Refinery, Eagle Creek functions as a major stormwater conveyance for the City. Eagle Creek also drains outlying areas west of the City and is periodically scoured by intense rain events.

Natural surface drainage at the Refinery is to the north and east. Stormwater within the process areas is captured and routed to the Refinery WWTP. Stormwater from non-process areas is contained within the Refinery property inside stormwater berms and routed to stormwater retention basins. Stormwater from within the Refinery boundary is not allowed to discharge to Eagle Creek.

The elevation of Eagle Creek is 3,360 feet at its entrance to the Refinery and decreases to approximately 3,305 feet at its confluence with the Pecos River. Eagle Creek was channelized from west of the City of Artesia to the Pecos River to help control and minimize flood events. In the vicinity of the Refinery, the Eagle Creek channel was cemented to provide further protection during flood events. A check dam was also constructed west of the City of Artesia along Eagle Creek. Federal floodplain maps indicate that most of the city and the Refinery have been effectively removed from the 100-year floodplain.

3.1.3 Area Land Uses

The areas north, south, and east of the Refinery are sparsely populated and used primarily for agricultural purposes. The primary business and residential areas of the City of Artesia are located to the west, southwest, and northwest of the Refinery. Commercial businesses are present south of the Refinery along Highway 82, including an oilfield pipe company and machine shop located at the southeast corner of the Refinery. HFNR owns a majority of the land bounded by

Highway 82 to the south, East Richey Avenue to the north, Highway 285 to the west, and Bolton Road to the east. The majority of the land located east of the Refinery between Bolton Road and Haldeman Road is cultivated as pecan orchards or used for other agricultural purposes.

The active Refinery and much of the surrounding property owned by HFNR is fenced and guarded with controlled entry points.

3.2 Subsurface Conditions

3.2.1 Surficial Soils

Surficial soil at the Refinery is predominantly comprised of approximately 60% Pima series and 40% Karro series. The Pima and Karro series both consist of deep, well drained soils that formed in alluvial settings. They are both calcareous and have slow to medium runoff.

3.2.2 Geology

The City of Artesia is located on the northwest shelf of the Permian Basin. In this region, the deposits consist of approximately 250 to 300 feet of Quaternary alluvium unconformably overlying approximately 2,000 feet of Permian clastic and carbonate rocks. These Permian deposits unconformably overlie Precambrian syenite, gneiss, and diabase crystalline rocks.

3.2.2.1 Quaternary Alluvium

The Quaternary alluvium in the Refinery area is dominantly comprised of clays, silts, sands, and gravels deposited in the Pecos River Valley. These “valley fill” deposits extend in a north-south belt approximately 20 miles wide, generally west of the Pecos River. The thickness of the valley fill varies from a thin veneer on the western margins of the Pecos River valley to a maximum of 300 feet in depressions, one of which is located beneath the Refinery. These depressions have resulted from dissolution of the underlying Permian carbonates and evaporites.

3.2.2.2 Permian Artesian Group

The Permian Artesian Group is comprised of the following five formations from shallowest to deepest: the Tansill, Yates, Seven Rivers, Queen and Grayburg Formations. The Tansill and Yates Formations outcrop at the surface east of the Pecos River and are not present in the vicinity of the Refinery. The Seven Rivers Formation is present at an approximate depth of 300 feet in the area between the Pecos River and the Refinery. However, the Seven Rivers Formation thins and pinches to the west and it is not evident, based on boring logs, that this formation is present beneath the Refinery process areas.

In the area of the Refinery, the Queen and Grayburg Formations have been mapped as a single unit consisting of approximately 700 feet of interbedded dolomite and calcareous dolomite, gypsum, fine-grained sandstone, carbonates, siltstone and mudstone. In locations where the Seven Rivers Formation is absent, the upper portion of the Queen Formation acts as a confining bed between the deep artesian aquifer and the valley fill aquifer.

3.2.2.3 San Andres Formation

The San Andres Formation lies beneath the Queen and Grayburg Formations and immediately above the Precambrian crystalline basement rocks. The San Andres Formation is greater than 700 feet thick and composed mainly of limestone and dolomite with irregular and erratic solution cavities up to several feet in diameter. The upper portion of the Formation is composed of oolitic dolomite with some anhydrite cement.

3.3 Hydrogeology

The principal aquifers in the Artesia area are within the San Andres Formation and the valley fill alluvium. Two distinct water-bearing zones within the valley fill alluvium in the vicinity of the Refinery are referred to as the “shallow saturated zone” and the “valley fill zone”. The deeper carbonate aquifer within the San Andres Formation is referred to as the “deep artesian aquifer”.

3.3.1 Shallow Saturated Zone

The shallow saturated zone occurs in interbedded sand and gravel channels at 10 to 30 feet below ground surface (bgs). The overlying clays, silts, and caliche undulate at the Refinery, which creates intermittent confined and unconfined groundwater conditions in the shallow saturated zone. Groundwater in this zone is under confined conditions for some or most of the year, with static water levels measured in groundwater monitoring wells three to five feet above the shallow saturated zone.

The general direction of flow in this shallow saturated zone is to the east toward the Pecos River. Groundwater flow direction and gradient in the shallow saturated zone have remained generally consistent over time, as documented in previous annual groundwater monitoring reports.

Major sources of water in the shallow saturated zone are likely recharge from Eagle Creek and lawn watering runoff from the grass-covered urban park that occupies the Eagle Creek Channel immediately upstream of the Refinery. The water in the shallow saturated zone is highly variable in quality, volume, areal extent, and saturated thickness. Concentrations of total dissolved solids (TDS) exceeding 2,000 milligrams per liter (mg/L) and sulfate exceeding 500 mg/L have been recorded northwest (upgradient) of the Refinery.

The shallow saturated zone contains PSH and dissolved-phase hydrocarbon constituents, as reported in the *2018 Annual Groundwater Monitoring Report* (TRC, 2019). Concentrations of dissolved-phase hydrocarbon constituents in the shallow saturated zone have generally exhibited a stable or decreasing trend over time.

3.3.2 Valley Fill Zone

The valley fill zone underlies the shallow saturated zone and occurs in Quaternary alluvial deposits of sand, silt, clay and gravel. These sediments are about 300 feet thick near the Refinery.

Irrigation and water production wells completed in the valley fill zone are typically screened across one to five water-producing intervals ranging in thickness from 20 to 170 feet, with most being approximately 20 feet thick. Production intervals are non-continuous, consist principally of sand and gravel, and are separated by less permeable lenses of silt and clay of varying thickness. Based on logs of wells located immediately to the north and east of the Refinery, the thicknesses of silt and clay deposits range from 20 to 160 feet and are interspersed with thin zones of gravels in the upper 100 feet. Wells in the valley fill zone range from 40 to 60 feet bgs and the formation yields water containing TDS ranging from 500 to 1,500 mg/L.

The valley fill zone contains dissolved-phase hydrocarbon constituents, as reported in the *2018 Annual Groundwater Monitoring Report* (TRC, 2019). Concentrations of dissolved-phase hydrocarbon constituents in the valley fill zone have generally exhibited a stable or decreasing trend over time.

The valley fill zone and the underlying San Andres aquifer are hydraulically connected in some areas.

3.3.3 Deep Artesian Aquifer

The deep artesian aquifer is closely related to the Permian San Andres Limestone and generally consists of one or more water-producing intervals of variable permeability located in the upper portion of the Formation. However, in the Artesia area, the water-producing interval rises stratigraphically and includes the lower sections of the overlying Queen and Grayburg Formations. Near the Refinery, the depth to the top of the water-producing interval is estimated to be about 440 feet bgs. The Seven Rivers Formation and the other members of the Artesia Group are generally considered to be confining beds, although some pumpage occurs locally from fractures and secondary porosity in the lower Queen and Grayburg members.

The deep artesian aquifer has been extensively developed for industrial, municipal, and agricultural use. TDS in this aquifer ranges from 500 mg/L to more than 5,000 mg/L depending on location. In the Artesia area, water from this aquifer is generally produced from depths ranging from 850 feet to 1,250 feet bgs. The aquifer recharges in the Sacramento Mountains to the west of Artesia. Extensive use of this aquifer in recent decades has lowered the potentiometric head in the aquifer in some locations from 50 to 80 feet bgs, although extensive rainfall in some years may bring the water levels in some wells close to ground surface.

Available well completion records for irrigation well RA-4798 indicate that it is screened in the deep artesian aquifer from 840 to 850 feet bgs. Historic analytical data from this well does not indicate the presence of hydrocarbon impacts from Refinery operations.

4.0 Pilot Test Setup

4.1 Test Locations

To test recovery and injection efficacy in areas that are representative of the conditions that will be addressed by the full-scale system, HFNR is planning to perform the pilot test in the East Field near existing monitoring wells KWB-5 and MW-131. The area around these wells contains PSH and dissolved-phase constituents at concentrations of the same magnitude or higher than what is expected to be recovered by the enhanced recovery system. The two proposed pilot test locations provide the opportunity to test injection, amendment, and recovery in two of the primary soil types (gravel and silty sand) in which the full-scale system will also be installed.

The exact location of the injection, monitoring, and recovery wells will be determined after completion of gamma logging of the existing wells in the area around KWB-5 and MW-131 (discussed further in Section 5.2.2). Based on the geologic, geophysical, and contaminant migration investigation results documented in the Revised CME Report, preliminary pilot test locations for injection, recovery, and monitoring have been proposed with the intent of testing the effects of amendment and recovery in silty sand and gravel, both of which are prevalent in the observed preferential groundwater flow pathways in the East Field. Due to the heterogeneous nature of the shallow geology in this area, some additional exploratory borings may be installed to further characterize the lithology in the area near wells KWB-5 and MW-131. The final locations of wells to be used in each of the two pilot test areas will be adjusted with the intent of having all wells within each pilot test area screened within the same, continuous coarse-grained lithologic zones, to the degree feasible based on the heterogeneous nature of the shallow geology. One pilot test area will target zones with more gravel (near KWB-5) and the other pilot test area will target zones with more silty sand (near MW-131).

4.2 Dissolved-Phase Conditions

Based on existing groundwater data from ongoing monitoring at the Refinery, the dissolved-phase hydrocarbon constituents are being actively degraded under anaerobic conditions and most likely by SRBs. The following observed groundwater conditions and trends are indicative of active hydrocarbon degradation by SRBs:

- Inverse concentration correlation between sulfate and the following dissolved-phase hydrocarbon constituents, specifically in the East Field: benzene, ethylbenzene, toluene, and xylenes (BTEX), naphthalene, gasoline range organics (GRO), and diesel range organics (DRO).
    - Background sulfate concentrations west of the Refinery appear to range between 1,000 and 2,000 mg/L, while sulfate concentrations within the hydrocarbon plume below the East Field range from 10 to 100 mg/L, and are non-detect in some wells.

- The inverse concentration correlation indicates SRBs are utilizing sulfate to degrade hydrocarbons in both dissolved and adsorbed phases (note that the sulfate demand of dissolved-phase concentrations is too low to exceed the background supply of sulfate).

- Anaerobic conditions as oxidation reduction potential (ORP) is less than -100 millivolts (mV).
- Presence of black particulates in and/or slightly grey turbid purge water during groundwater sampling activities indicates iron sulfide precipitants.
- Apparent preferential degradation of more readily degraded isomers in isomer pairs, for example:
    - o-xylene detected at concentrations less than 1/10th the concentration of m/p-xylenes in groundwater samples.
    - 1,3,5-trimethylbenzene detected at concentrations less than 1/10th the concentration of 1,2,4-trimethylbenzene in groundwater samples.

These conditions indicate that an amendment with bioavailable sulfate has the potential to increase the degradation rate of hydrocarbons. In addition to bioavailable sulfate, nitrogen in the form of ammonia will be added to the system to amend the two most likely rate-limiting nutrients.

5.0 Pilot Test Scope

The following sections describe the scope for the pilot test program. The pilot test will be performed to evaluate the effectiveness of the amendment and reinjection process in reducing dissolved-phase concentrations in the vicinity of the reinjection zones as well as to collect additional hydrogeologic data to confirm design parameters for the upgrade recovery and injection systems.

5.1 Health and Safety Considerations

A task-specific Health and Safety Plan (HASP) will be developed prior to commencing field activities. The HASP will provide site-specific and task-specific analysis of the physical and chemical hazards associated with anticipated field activities at the Refinery. The HASP will be reviewed and an understanding of the HASP will be acknowledged by all field team members prior to conducting any field activities at the Refinery. Safety briefings with all field team members will be held thereafter at the beginning of each work day, or as required due to changing conditions.

5.2 Planned Activities – Pilot Test

The pilot test will be conducted to accomplish three primary goals: (1) quantify hydrogeologic response to fluid recovery and injection, (2) evaluate potential for enhancement of PSH recovery, and (3) determine optimal amendment formulation(s) to maximize biodegradation results in groundwater. Through the activities described in the following sections, the pilot test will determine:

- The injection rate of the formation for proper sizing and design of the injection equipment/wells and design of the treatment train;
- The type, quantity, and relative percent of treatment amendment(s) added to the extracted water prior to reinjection to optimally enhance bioremediation;
- The response of groundwater quality to injected amendment(s);
- Sulfate and nutrient demand; and
- Changes in PSH recovery rates due to injection.

The results from the pilot test will be used to confirm and finalize the full-scale recovery system upgrade design.

The pilot test will consist of activities centered around two existing monitoring wells, KWB-5 and MW-131, located in the East Field, shown on Figures 2a and 2b. Pilot test design at each area will be similar and the tests will be executed concurrently.

5.2.1 Baseline Groundwater Quality Evaluation

Baseline trend data will be collected from existing monitoring wells in the area at least 14 days but no more than 30 days prior to initiation of the pilot test. The baseline trend data will be collected to evaluate existing groundwater quality and potentiometric surface. Results of baseline water quality testing will be used to (1) calculate the range of dosing of amendment(s) in the water treatment area and (2) determine baseline conditions to be used to evaluate the effectiveness of the amendment(s) in reducing dissolved-phase concentrations in the vicinity of the reinjection zone during the pilot test. Additionally, water level data recorded during the baseline period may be utilized to evaluate mounding and/or drawdown changes in groundwater levels observed during the pilot test. The following data will be collected and evaluated to establish baseline trends prior to the treatment efficiency test:

- Groundwater elevation;
- Presence and apparent thickness of PSH;
- Site-specific constituents of concern (COCs) concentrations: BTEX, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, methyl tert-butyl ether (MTBE), naphthalene, GRO, and DRO;
- Monitored natural attenuation (MNA) laboratory-measured parameter concentrations: sulfate, total Kjeldahl nitrogen (TKN), total organic carbon (TOC), alkalinity, ferrous iron, and magnesium;
- MNA field-measured parameter concentrations: conductivity, ORP, dissolved oxygen (DO), temperature, and depth to water;
- Barometric pressure; and
- Precipitation.

Baseline water level and water quality data will be measured in all of the wells associated with the pilot test. This includes KWB-5 and MW-131 and respective upgradient, proximal downgradient, crossgradient, and peripheral downgradient wells as defined in Section 5.2.7 and below:

- KWB-5 Pilot test area
  - Within pilot test area: KWB-5
  - Upgradient wells: KWB-4 and MW-99
  - Proximal downgradient well: KWB-6 and MW-112
- MW-131 Pilot test area

- Within pilot test area: MW-131
- Upgradient well: MW-129
- Proximal downgradient well: MW-112

Groundwater levels will be measured in each well listed above using an oil-water interface probe and a pressure transducer, as described in Section 5.3 below. Groundwater levels will be compared to historical groundwater information obtained during semi-annual groundwater monitoring events, which are ongoing at the Refinery. Laboratory and field parameter data will only be collected in wells that contain less than 0.30 feet of PSH in accordance with the *2018 Facility-Wide Groundwater Monitoring Work Plan* (2018 FWGMWP).

Barometric pressure will be recorded to a sensitivity of 0.01 inches of mercury using a barometric pressure probe installed at a central location at the Refinery. The data will be recorded starting two weeks before the initiation of the injection test and continuing until two weeks after conclusion of the injection test. Precipitation data will be recorded for the period starting two weeks before the injection test and continuing until two weeks after conclusion of the injection test. Precipitation data will be measured using either the Refinery's local weather station or a rain gauge installed at the Refinery.

5.2.2 Installation of Injection, Recovery, and Monitoring Wells

Injection and recovery wells will be installed as part of the pilot test. One injection well and one recovery well will be installed at each pilot test area (i.e., a total of two new injection wells and two new recovery wells) near existing wells KWB-5 and MW-131, as shown on Figures 2a and 2b. Each injection well will be installed upgradient of existing wells KWB-5 and MW-131, while each recovery well will be installed downgradient of existing wells KWB-5 and MW-131. The exact layout of the injection, monitoring, and recovery wells may be adjusted based on the results of gamma logging and potential additional investigation in the pilot test area. One injection well will be used for each pilot test. Injection and recovery wells will be separated by a minimum distance of 200 feet to ensure that the radius of influence from recovery drawdown and injection mounding do not overlap. Additional monitoring wells will also be added between the injection and recovery wells and downgradient of the recovery well to monitor potentiometric surface and COC/MNA data as listed in Section 5.2.7. The proposed layout of the wells proposed for the pilot tests are shown on Figures 2a and 2b.

Gravel seams and silty sand zones are present in the shallow saturated zone in the East Field and serves as a preferential pathway for groundwater and contaminant transport. The pilot test near existing well KWB-5 is designed to target this gravel seam for injection and recovery, while the pilot test near existing well MW-131 is designed to target the shallow saturated zone where silty sand is more predominant (the gravel seam is limited or not present) for injection and recovery. The top of the gravel seam at KWB-5 occurs at approximately 22 to 26 feet bgs and is approximately one to five feet thick. A gamma-log study will be conducted on existing monitor wells in the area prior to installation of the pilot test injection and recovery wells to verify the gravel seam and silty sand presence, depth, thickness, and extent in each pilot test area. Injection wells will be designed based on the gamma logging results, using lithology from the CME report and/or lithology from borings installed prior to the pilot test to evaluate the pilot test area, if deemed necessary. The injection wells will be constructed of stainless steel casing and screen, and will be screened across the target lithologic zone. Installation details for the injection and recovery wells are discussed in Section 5.3.

New recovery wells will be installed in the same configuration and method as was done for the Phase II recovery system. A 14-inch diameter boring will be drilled and three separate well casings will be installed within the boring. These casings will be used for water recovery, product recovery, and measurement. Recovery wells will include instrumentation as used in the Phase II recovery wells to allow remote monitoring and control. If PSH accumulates in the recovery wells, skimmers or total fluid pumps will be used to remove PSH from the recovery wells in the same manner as the Phase II wells. Any PSH present in pilot test monitoring or injection wells will be measured, and if removed, stored temporarily in small totes near the recovery well so that the recovered volume can be tracked separately from the rest of the current recovery system.

For purposes of complying with RCRA, the injection wells are authorized by rule (permit by rule) as provided in 40 CFR §144.23(c) and 20.6.2.5004 NMAC since they are part of a RCRA Corrective Action.[1,2]. OCD Form C-108 (Application for Authorization to Inject) is included as Appendix A for both wells for informational purposes. OCD Underground Discharge System (Class V Inventory Sheet) is included as Appendix B for both wells for informational purposes. EPA Form 7520-17 (Class V Well Pre-Closure Notification Form) is included as Appendix C for both wells for informational purposes. The proposed recovery wells will be installed as permanent recovery wells and may be used as part of the full-scale system. The proposed injection and monitoring wells will also be installed as permanent wells but may be abandoned upon completion of the pilot test.

5.2.3 Initial Injection Test

A series of injection tests will be performed utilizing the proposed injection wells at each pilot test area around wells KWB-5 and MW-131. A minimum of one test per area will be performed, and up to a maximum of four separate injection tests may be performed. Goals of the

[1] As provided in 40 CFR §144.23(c), injection wells used to inject contaminated ground water that has been treated and is being injected into the same formation from which it was drawn are authorized by rule for the life of the well if such subsurface emplacement of fluids is approved by EPA, or a State, pursuant to provisions for cleanup of releases under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), or pursuant to requirements and provisions under RCRA.

[2] As provided in 20.6.2.5004 NMAC, Class IV wells are prohibited, except for wells re-injecting treated ground water into the same formation from which it was drawn as part of a removal or remedial action if the injection has prior approval from the EPA or the Department under CERCLA or RCRA.

injection tests are to determine the optimal injection rate and to observe hydrogeologic response after repeated injections. The variable injection test rates and lengths will allow determination of the best way to influence the peripheral monitoring locations. The results of the initial injection test will be used to optimize pilot test injection design and ultimately the full-scale system upgrade design.

Each injection test will be performed and analyzed similar to an aquifer step-drawdown test. Extracted water from the newly-installed recovery wells will be used to perform each injection test. Water will be discharged into each injection well at the mid-point of the well screen interval or at the top of the well casing seal. The discharge line will be plumbed through a well seal rated to contain upward pressure that may be created during injection.

An electric, submersible pump capable of pumping the injection rate range of 4 to 15 gallons per minute (gpm) will be installed at the recovery well. The target injection rate will be 12 gpm based on initial full-scale system design, and the rate will be optimized during the pilot test. The pump and motor will be sized to achieve the specified injection rate ranges with consideration of vertical lift and friction losses. A Grundfos Redi-Flo4 variable frequency drive pump or equivalent pump will be used; it will have a variable frequency drive motor so the flow rate can be controlled by adjusting the power input to the pump. The recovery pumps will be connected to a Programmable Logic Controller which will also collect data from pressure transducers (as described in the next section) to control recovery and injection rates.

Pressure transducers will be placed in the injection wells, monitoring wells, and recovery wells in the pilot test area to measure the groundwater level. Within 60 minutes prior to commencement of the injection test, static water levels will be recorded at each injection well, monitoring well, and recovery well included in the pilot test using an oil-water interface probe. Each pressure transducer will be installed at least 60 minutes before the test begins. Immediately prior to the test, the water level at each pressure transducer should be set to 0.00 feet to facilitate observation of water level changes.

The basic procedure for each injection test involves conducting three or more steps of injection at rates that are incrementally increased during each step. A constant injection rate will be maintained during each step. The data from each step will be graphed during the test with time on a logarithmic x-axis and water level of the injection well on a linear y-axis. During each step, the water level should increase rapidly at the beginning of the test and stabilize as the test proceeds. When the water level essentially stabilizes, the injection rate will be increased to the next step. The final step should result in a water level in the injection well that is near the top of the well casing, depending on formation characteristics near the well.

Each injection test will consist of a minimum of three successive and increasing injection rate steps. During each step, the injection rate will remain constant. The anticipated injection rates for the first three steps of the test are 4, 8, and 12 gpm based on groundwater modeling performed in 2016 and 2018. These rates are subject to change based on observed conditions during the test. The wellhead will be configured to allow the installation of a pressure transducer so that that pressure can be monitored throughout the duration of the test. Care will be taken not to exceed pressure suitable for the wellbore and formation. The duration of each step will typically be 60 to 180 minutes such that the entire injection test can be completed in one day. Once the water level during a step is relatively stable, the injection rate will be increased.

The injection test will begin once all of the equipment has been installed and tested, and the static water levels have been measured. The injection pump, pressure transducer data loggers, and synchronized stopwatches will be activated simultaneously.

The water level in the injection wells, monitoring wells, and recovery wells will be monitored using pressure transducers set at a linear data recording frequency of ten seconds per reading at wells near the injection well and on a logarithmic frequency at wells near the recovery well. Details regarding water level measurements are provided in Section 5.3. A logarithmic recording frequency is not required as the early time data is of no particular interest during an injection test. The water level data should be monitored from the data logger as frequently as possible to confirm the system is operating properly and to evaluate the test results.

The injection rate will be monitored according to the methods and procedures presented in Section 5.3. The injection rate for each successive step should be increased to the planned rate as quickly as possible, and the injection rate should be monitored and recorded as frequently as practical until the target injection rate has been achieved and stabilized. The injection rate will be measured using a totalizing flow meter at the injection wells that is also capable of recording flow rate. Adjustments should be made to achieve a constant injection rate. The injection rate can be adjusted using the pump controller. Once the injection rate has stabilized, it will be monitored and recorded every 30 minutes.

After the injection test is complete, water levels in the injection wells, monitoring wells, and recovery wells will be recorded until levels reach static conditions or recovery has occurred for the same time duration as injection. This data will be recorded using the pressure transducer data loggers.

All equipment placed within each well such as the pressure transducer data loggers and oil-water interface probe will be decontaminated according to the procedure in Section 5.3.6 at the completion of the test.

5.2.4 Treatment Efficiency Pilot Test Equipment and Process Description

During the treatment efficiency pilot tests, recovered water from the new recovery wells will be utilized as a treatment and injection water source. Water should not be oxygenated to the extent practicable during recovery and transfer to the amendment point and injection well. In order to accomplish this, the system will be installed with continuous piping and minimal plumbing in order to minimize turbulence. The line will also be buried or insulated to minimize temperature fluctuations. Mitigating temperature fluctuations minimizes potential for changes in reduction/oxidation (redox) conditions. The lines will be fitted with a pressure-controlled actuator valve to shut off flow if a loss in pressure is detected.

The aboveground storage tank containing the amendment(s) in each injection area around KWB-5 and MW-131 will include a 5,000-gallon concentrated sulfate solution. Connected to this tank on the discharge side will be the following: injection manifold, flow meter (totalizer and rate), sample port, pressure gauge, sulfate injection port, inline mixer (can be eliminated if access to injection well header sample point is convenient), post injection sample port, and manifold to injection well(s). Additionally, a metering pump will be connected for addition of the amendment(s) into the system. Table 1 details sulfate addition rates based on injection rates and targeted sulfate formation concentrations. Metering pumps are very sensitive to out of range injection pressures; pressures will be very closely monitored throughout the duration of the pilot test.

5.2.5 Treatment Efficiency Evaluation

To enhance the rate of naturally occurring anaerobic degradation in the pilot test areas, sulfate and nitrogen will be added to the extracted groundwater stream. To prevent fouling of the injection system and injection well, it is critical that the redox condition of the extracted water remains anaerobic throughout the recirculation process, to the degree feasible. Plumbing fixtures will be reduced throughout the system to reduce the potential inducted air flow, turbulence, and pressure drops in the anaerobic groundwater stream.

Enhanced anaerobic biodegradation (EAB) systems are generally designed to adjust groundwater sulfate concentrations to near background conditions which are most favorable for the indigenous microbes. The site background sulfate groundwater concentration of 1,700 mg/L (average of four upgradient wells as measured during April 2018 monitoring event) may be difficult to meet with traditional EAB recirculation system components; therefore, the system will be designed to increase the groundwater concentration from existing low sulfate concentrations (<20 mg/L in MW-131 and KWB-5 as measured in April 2018) to approximately 1,000 mg/L or greater, as possible. These increased concentrations will be sufficient to restore and support robust microbial activity.

Table 1 provides sulfate addition rates based on a stock sulfate solution concentration of approximately 3.1% (Epsom Salt approximately 8%). The stock solution will be prepared by mixing 6,000 pounds of Epsom Salt in 4,000 gallons of water in a 5,000-gallon poly tank. The Epsom Salt will be added to a 95-gallon mixing drum fed with a water stream from the mixing tank, and the resulting slurry will be pumped to the top of the storage tank. In addition to sulfate, a small amount of additional nitrogen in the form of ammonia will be added to eliminate nitrogen as a rate-limiting constituent. The ammonia will be added through the same mixing drum as the

Epsom Salt. The ammonia source will be household unscented and surfactant free 9% ammonium water. The ammonia concentration in the sulfate tank will be adjusted to approximately 50 mg/L for a targeted formation concentration of 10 to 25 mg/L. After in situ dilution/mixing conditions are measured, both sulfate and ammonia injection rates will be adjusted to maintain an adequate supply of nitrogen and sulfate.

Using an initial injection rate of approximately 10 gpm, the sulfate dosing rate from the stock tank will be 0.63 gpm or 900 gallons per day of stock solution. It is anticipated that the stock tank will initially be recharged every four days. However, as the pilot test progress, the rate of sulfate demand, as determined by sulfate concentrations in the wells downgradient of the injection wells, is expected to decrease, resulting in an increasingly slow rate of sulfate addition.

5.2.6 Treatment Efficiency Test Procedure

Injection flow rate and specific capacity determined in the initial injection test will be utilized to determine injection rates during the treatment efficiency portion of the pilot test. The newly-installed injection and recovery wells will be connected to the closed-loop system, along with the tank containing the amendment(s) and the chemical metering pump, described above. The groundwater extracted from the recovery well will provide source groundwater for amendment and reinjection. A diagram of the pilot test closed-loop system can be found in Figure 3.

Effluent from the recovery well will be plumbed to the amendment tanks at the injection wells via a series of below grade, hard-piped lines. The estimated flow rate of effluent supplied to the injection system will be between 1 and 15 gpm, to be determined based on injection well testing and hydrogeologic information.

Fluid received from the recovery well will ultimately be injected into the injection well via an electric pump, after treatment with the amendment(s). An electric, submersible pump capable of the injection rate will be installed on the supply line from the recovery well. The pump and motor will be sized to achieve the specified injection rate with consideration to vertical lift and friction losses. A Grundfos Redi-Flo4 variable frequency drive pump or equivalent pump will be used; it will have a variable frequency drive motor so adjusting the power input to the pump can control the flow rate.

An inline totalizing and flow rate meter will be used to measure the injection rate. A flow meter will be installed at each injection well.

Any PSH that accumulates in the recovery wells will be measured on a weekly basis and, if necessary, pumped from the recovery well to a small tank or tote staged near the recovery well. The PSH thickness and recovered volume will be recorded for the duration of the pilot test to assist in evaluating any improvement to PSH recovery as a result of the test.

5.2.7 Groundwater Monitoring

To effectively monitor and adjust the groundwater conditions and associated sulfate feed rates, monitoring wells will be utilized to monitor conditions downgradient of the injection wells and screened typically 25 to 30 feet bgs in the mixing zone (i.e., within and below the target lithologic zone which injection and recovery wells will be screened). Upgradient and downgradient wells will be monitored throughout the treatment efficiency pilot test to determine the maximum extent of treated groundwater impact.

In addition to new monitoring wells that will be installed specifically for the test (PMW-1 through PMW-8), existing monitoring wells at the site will be included in the baseline and groundwater monitoring portion of the pilot test. Monitoring wells, as follows, will be gauged and sampled accordingly throughout the pilot test:

- KWB-5 Pilot test area
  - Upgradient wells: KWB-4 and MW-99
  - Test area wells: PMW-1, PMW-2, KWB-5, PWM-3
  - Proximal downgradient well: PMW-4
  - Downgradient wells: KWB-6 and MW-112
- MW-131 Pilot test area
  - Upgradient well: MW-129
  - Test area wells: PMW-5, PMW-6, MW-131, PMW-7
  - Proximal downgradient well: PMW-8
  - Downgradient well: MW-112

The groundwater monitoring portion of the pilot test consists of conducting initial and periodic gauging of groundwater and sampling for MNA laboratory and field parameters, as described in the following subsections. The methods described below are in accordance with the 2018 FWGWMP.

The potentiometric surface will be monitored periodically throughout the pilot test to assess potentiometric response and PSH presence/absence. The depth to PSH, if present, and groundwater will be gauged at pilot test area wells according to the schedule presented in Section 6.0. Detailed gauging procedure is described in Section 5.3 below.

Groundwater from the pilot test areas and associated wells will be analyzed, as appropriate, for the follow constituents:

- Hydrocarbon laboratory-measured parameters: BTEX, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, MTBE, naphthalene, GRO, and DRO;
- MNA laboratory-measured parameters: sulfate, TKN, TOC, alkalinity, ferrous iron, magnesium; and
- MNA field-measured parameters: conductivity, ORP, DO, temperature, and depth to water.

Groundwater samples for laboratory analysis will be collected using low-flow sampling procedures, as described in Section 5.3. The sample parameters (depth of pump intake, pump rates, etc.) will remain consistent between sampling rounds, to the degree feasible. The low-flow sampling pump intake will be located within the target lithologic zone for each pilot test area (gravel seam near KWB-5 and silty sand near MW-131) as defined by gamma logging prior to well installation. Where feasible, the pump intake should also be installed at least four feet below the smear zone to minimize the potential for sampling colloids associated with partially degraded hydrocarbons in smear zones.

During the first week of the pilot test, field parameters will be collected daily from each monitoring well located within each pilot test area, listed above. After one week, the field monitoring frequency will be reduced to weekly. Weekly field parameter monitoring will continue until the mixing and injection rates are optimized, which is likely within one month from the initiation of the pilot test. Conductivity measured in the field will be used as an indicator parameter – increases in conductivity will be the first indication of the amendment(s) reaching the downgradient wells.

Injection flow rates and amendment feed rates will be adjusted based on the following factors:

- Daily monitoring results. Conductivity will be measured on a daily basis using automated monitoring equipment. Groundwater samples for laboratory analysis will be collected after a 100% or more increase of conductivity has been observed in the closest downgradient well, utilizing the same sampling procedures and parameters as listed above.
- Once sulfate is detected at a concentration above 500 mg/L in all of the monitoring wells between the injection and recovery wells, quarterly sampling events will begin on all wells listed above. Samples will be analyzed for hydrocarbon and MNA laboratory parameters. Sufficient data to design the full-scale system will be collected after six to 12 months of pilot system operation.
- If sulfate concentrations are below 500 mg/L in the first sampling event, sulfate dosing will be adjusted upward and wells will be resampled after an additional month;

quarterly sampling will begin once sulfate concentrations in all of the monitoring wells located between the injection and recovery wells reach 500 mg/L.

5.2.8 Data Processing

Data acquired in the pilot test will be recorded and utilized to implement the full-scale system upgrade design. Data will be presented in interim progress reports to be provided to NMED and OCD on a quarterly basis. A summary report including all data and results of the test will be submitted after the completion of pilot test activities and prior to the implementation of the full-scale system upgrade.

Electronic data, including actual time, test elapsed time, and water levels, obtained by the down-hole data loggers will be downloaded into Microsoft Excel spreadsheets using software developed by the data logger vendor. The manually recorded water level and discharge/injection rate data will be manually entered into a Microsoft Excel spreadsheet.

The baseline data will be evaluated to determine if the water levels were influenced by factors other than groundwater recovery. The water level data recorded at the recovery and monitoring wells will be corrected for any outside influences such as regional water level trends, barometric pressure changes, and/or recharge effects due to precipitation.

The following hydrogeologic properties of the shallow saturated zone will be determined from each injection test: specific capacity, hydraulic conductivity (vertical and horizontal), transmissivity, coefficient of storage, and specific yield. The specific capacity determined from the injection test data will be used along with previously-determined hydrogeologic properties to determine injection rates used in the treatment efficiency portion of the pilot test. The specific capacity determined from the injection test data will be used to confirm or update previous modeling and full-scale system upgrade design criteria such as injection zone of influence, groundwater flowlines, and injection rates. The analytical results from the pilot test groundwater monitoring will be used to determine the amendment(s) and dosing to be used in the full-scale closed-loop system upgrade design.

5.3 Investigation Methods

The following sections describe detailed procedures for installation of injection and recovery wells and for groundwater monitoring. Associated quality assurance, decontamination and waste management procedures are also described. All site activities will be completed in accordance with the requirements of Appendix C of the PCC Permit and the 2018 FWGWMP, as applicable.

5.3.1 Installation of Pilot Test Injection, Recovery, and Monitoring Wells

The following general specifications apply to the injection, recovery, and monitoring wells to be installed at each of the pilot test areas, as described in Section 5.2 and shown in Figures 2a and 2b. All wells at each pilot test area will be installed using hollow stem auger (HSA) drilling methods.

For the recovery wells, the HSA will be approximately 14-inch outside diameter as was used for the Phase II recovery wells. Two 4-inch diameter casings (one for PSH recovery and one for water recovery) and a single 2-inch diameter casing (for measurement) will be installed in each recovery well borehole. All of the recovery well casings will be constructed of schedule 80 polyvinyl chloride (PVC). Each recovery well will be screened across the target lithologic zone (gravel and silty sand) in the shallow saturated zone, with an expected screen length of 10 to 15 feet. The well screens will be constructed of 4-inch diameter, schedule 80 PVC 0.020-inch slotted screen. The filter pack will consist of either 8/12- or 10/20-grade quartz sand, depending upon the predominant shallow geology in the location where the wells are installed (i.e., either gravel or silty sand). A 2-foot sump consisting of 4-inch schedule 80 PVC will be installed beneath the well screen. For the injection wells, the HSA will be approximately 8 7/8-inch inside diameter. The well casing will be constructed of 6-inch diameter stainless steel. Each injection well will be screened at or slightly below the top of the target lithologic zone (i.e., gravel and silty sand interval), with an expected screen length of 10 feet, and will include a 2-foot sump below the screened interval. Well screen will be constructed of either type 304 stainless steel louvered shutter screen with 1/16-inch horizontal slot or V-wire wrap stainless steel with a slot size of 0.060-inch, specifically designed for injection. The filter pack will consist of either 6/9- or 8/12- grade quartz sand, depending upon the predominant shallow geology in the location where the wells are installed (i.e., either gravel or silty sand). The final filter pack size and well slot size will be based on grain size analysis of the gravel and silty sand interval.

For the monitoring wells, the HSA will be approximately 7-inch inside diameter. Monitoring well casing will be constructed of 4-inch diameter schedule 80 PVC. Each monitoring well will be screened across the same target lithologic zone (i.e., gravel and silty sand interval) as the respective injection well, with an expected screen length of 10 feet. Well screen will be constructed of 0.020-inch slotted schedule 80 PVC, and the filter pack will be either 8/12- or 10/20-grade quartz sand, depending upon the predominant shallow geology in the location where the wells are installed (either gravel or silty sand).

For all types of wells, the casing and screen will be attached using threaded, flush joints. The annular space will be completed with a quartz sand filter pack to 2 feet above the top of the well screen. A 20/40-grade transition sand will extend approximately 2 feet above the filter pack sand. A 2-foot thick layer of hydrated, bentonite chips will be placed in the annular space above the transition sand. The sand filter pack and bentonite chips will be placed through the augers as they are being removed from the borehole. The sand filter pack and the bentonite chips will be poured from the top of the borehole. The remainder of the annular space to 3 feet bgs will be completed with a bentonite-cement grout placed from bottom to top using a tremie pipe and grout pump. Wells will be completed several feet above grade and will be secured with a steel protective cover placed in a 3-foot square concrete pad. An expandable watertight plug will be placed at the top of each wellhead. Four steel bollards filled with cement will be placed around each aboveground wellhead.

The drilling shall be completed under the direction of a qualified engineer or geologist who shall maintain a detailed log of the materials and conditions encountered in each boring. The following visual observations will be recorded on the boring log: lithology (color, type, grain size, sorting, etc.), moisture content (dry, damp, moist, wet), and any field evidence of contamination (staining, odor, and photoionization detector [PID] readings). Sample information and visual observations of the cuttings and core samples shall be recorded on the boring log. Soil samples will not be collected for laboratory analysis during installation.

All wells will be developed to create an effective filter pack around the well screen, remove fine particles from the formation near the borehole, and assist in restoring the natural water quality of the shallow saturated zone in the vicinity of the well. Wells will be developed using surging, and bailing or pumping techniques. Each newly-constructed monitoring, recovery, and injection well will be developed until the water recovered from the well is free of visible sediment, turbidity is preferably below 10 Nephelometric Turbidity Units, and the pH, temperature, turbidity, and specific conductivity have stabilized. If the well is pumped dry during development, the water level will be allowed to sufficiently recover before the next development period is initiated. The volume of water withdrawn from each well during development will be recorded. Special attention will be paid to the development of the injection and recovery wells to ensure they meet or exceed these criteria.

Injection wells will be permitted as temporary wells that may be abandoned at the end of the pilot test; however, the injection wells will be constructed to the same specifications as permanent wells. Recovery wells will be permitted and constructed as permanent recovery wells using the same configuration as the Phase II recovery wells. Monitoring wells installed for the pilot test will be permitted as temporary wells and will likely be abandoned at the end of the pilot test. Wells will be named according to the respective existing monitoring well (KWB-5 or MW-131) as follows:

- Recovery wells: RW-23 and RW-24
- Injection wells: IW-1 and IW-2
- Monitoring wells: PMW-1 through PMW-8

5.3.2 Groundwater Monitoring

Groundwater monitoring activities will include existing monitoring wells described above in Section 5.2.7 along with newly installed injection and recovery wells. Well locations are depicted on Figures 2a and 2b. The expected duration of groundwater monitoring activities during the pilot test is approximately 12 to 18 months or until the pilot test objectives are achieved.

5.3.3 Groundwater Gauging

The depth to PSH, if present, and groundwater will be gauged at each monitoring well prior to sampling. Prior to gauging, each well cap will be removed to allow groundwater to equilibrate with atmospheric pressure. Fluid level measurements will be collected using an oil-water interface probe to an accuracy of 0.01 feet. Measurements will be made from a marked survey datum at the top of the well casing. Data will be recorded on a paper field gauging form. The oil-water interface probe will be decontaminated before use and between wells following the procedures outlined in Section 5.3.4.

The following procedure will be used to measure the depths to PSH and groundwater:

- The probe will be lowered into the well slowly until the probe alarm sounds or light illuminates, then the tape will be raised and lowered again slowly until the alarm is again audible or the light again illuminates. The depth to fluid on the tape will be recorded to within 0.01 feet. To ensure accuracy, the measurement will be repeated.
- Well identification, date, time, depth to water, depth to PSH (if applicable), and other pertinent observations will be recorded on the field gauging form.

5.3.4 Groundwater Sampling

Groundwater will be purged and sampled from monitoring, injection, and recovery wells using low-flow methods in accordance with the NMED Hazardous Waste Bureau (HWB) Position Paper "Use of Low-Flow and Other Non-Traditional Sampling Techniques for Compliance Groundwater Monitoring" (NMED, 2001). Groundwater will be purged and sampled from irrigation wells using standard procedures described below. Data collected during the purging and sampling of each well will be recorded on a paper groundwater sampling form. Samples will only be collected in wells which areas suitable for sampling as defined by the 2018 FWGMWP (i.e., wells which contain less than 0.30 feet of PSH during gauging).

Groundwater will be purged and sampled from monitoring, injection, and recovery wells using either a peristaltic pump (for sampling depths of approximately 25 feet bgs or less) or a dedicated, stainless steel submersible pump (for sampling depth greater than 25 feet bgs). An oil-water interface probe will be lowered into the monitoring well to record the depth to water.

A multi-parameter water quality meter with flow-through cell and hand-held turbidity meter will be used during the purging process to monitor for field water quality parameters (pH, temperature, conductivity, TDS, ORP, DO, and turbidity) and demonstrate stabilization. Water quality parameters will be recorded approximately every three minutes during purging. Water quality meters used to measure field parameters will be calibrated each day according to the manufacturer's specifications. The make, model, calibration fluids, and calibration results for the water quality meters will be recorded in the field logbook. The turbidity meter test cell will be triple rinsed with groundwater from the next sample aliquot prior to each reading. The water quality parameters and depth to water will be recorded on a groundwater sampling form. A description of the water quality (e.g., turbidity, sheen, odor) will be recorded during the purging process.

The purging process will be considered complete and groundwater sampling will commence when at least four of the seven water quality parameters achieve stabilization within ten% for three consecutive readings.

If the well goes dry during purging, a sample will be collected as soon after the water level recovers to a level from which a sample can be collected. The samples will be collected in clean, labeled laboratory-supplied containers prepared with the appropriate amount and type of preservative.

All sampling equipment will be decontaminated before use and between wells following the procedures outlined in Section 5.3.6. Neoprene or nitrile gloves will be worn during sample collection and while handling sample containers. New disposable gloves will be used to collect each sample. The sample containers will be labeled, secured with bubble wrap, placed in a resealable plastic bag, and immediately placed on ice in a cooler and stored below 4° C. The sample labels will include the Permittee name (HFNR), site name (Artesia Refinery), unique sample identification, sample collection time and date, preservatives, and the name(s) of the sampler(s). The samples will be secured with packing material and kept below 4° Celsius with wet ice in accordance with laboratory cooler shipping guidelines. The cooler will be secured with packing tape, and a signed and dated custody seal will be placed over the cooler lid and secured with tape. The samples and a completed chain-of-custody documentation will be shipped via priority overnight delivery to the analytical laboratory. The chain-of-custody forms are to be maintained as a record of sample collection, transfer, shipment, and receipt by the laboratory. At a maximum, all samples will be submitted to the laboratory within 48 hours after collection. The laboratory will be informed that samples are being submitted for analysis and it will be confirmed that the samples were received the following day. If samples are shipped on Friday for Saturday delivery, the receiving laboratory will be contacted so provisions can be made for laboratory sample receipt.

5.3.5 Quality Assurance/Quality Control

Field quality assurance/quality control (QA/QC) samples for groundwater will be collected as follows:

- Duplicates: Collected at a frequency of ten% at the same time and from the same location as the original sample.
- Equipment blanks: Collected from non-dedicated, decontaminated equipment at a frequency of five% by pouring distilled water over the equipment and collecting the sample in the appropriate laboratory containers.

- Trip blanks: One included in each cooler shipped to the laboratory that contains samples for hydrocarbon laboratory analyses. The trip blank consists of two 40-milliliter (mL) vials of reagent water provided by the laboratory that were stored in the sample cooler at all times.

Laboratory QA/QC samples will be performed according to test methodologies specified for each analytical method. The laboratory QA/QC samples may include reagent or method blanks, surrogates, matrix spike/matrix spike duplicates, blank spike/blank spike duplicates and/or laboratory duplicates, as appropriate for each method. The laboratory QA/QC samples will be run at the frequency specified by each method.

5.3.6 Decontamination

The interface probe and other non-dedicated equipment coming into contact with groundwater will be decontaminated by the following procedures:

1. PSH, if present, will be removed with an absorbent pad.
2. Any solids will be removed to the degree possible with a brush and tap or distilled water.
3. Equipment will be washed with a brush, laboratory-grade non-phosphate detergent (e.g., Liquinox, Alconox), and potable tap or distilled water. Excess soap will be allowed to drain off the equipment when finished.
4. Equipment will be double rinsed with distilled water.

5.3.7 Investigation-Derived Waste

Investigation-derived waste (IDW) (e.g., soil cuttings, purge/development water, decontamination water) generated during well installation and monitoring activities will be collected, stored, and disposed appropriately. Soil will be contained in labeled 55-gallon drums or other suitable containers and stored on-site pending disposal. Water will be disposed of in the Refinery WWTP, upstream of the oil-water separator. Miscellaneous IDW (e.g., gloves, bailers) in contact with investigative material deemed to have no or de minimis contamination will be disposed of in a general refuse container. Any IDW deemed to have greater than de minimis contamination will be stored in labeled drums and disposed appropriately on a per case basis.

5.4 Pilot Test Monitoring and Sampling Program

A semiannual monitoring and sampling program is currently ongoing at the Refinery; descriptions of the sampling program can be found in the 2018 FWGMWP. The monitoring and sampling described here is being performed in addition to the routine monitoring activities. Data obtained in the pilot test program may be compared to historical and future routine monitoring data to determine program effectiveness and divergence (if any) from area-wide trends.

Existing and newly installed monitoring wells will be monitored at a frequency appropriate for determining injection system effectiveness. The anticipated pilot test duration is approximately 12 to 18 months.

During the treatment efficiency phase of the test, indigenous microbes that are no longer limited by late terminal electron acceptors (i.e., sulfate) will preferentially degrade adsorbed phase hydrocarbons (APH) due primarily to available proximity. These microbes use extra cellular enzymes (surfactant) to desorb the adsorbed hydrocarbons. This desorption sometimes results in a short-term increase in one or more of toluene, ethylbenzene, and xylenes (TEX) while the remaining dissolved-phase hydrocarbon constituents degrade. During the test, as microbial activity catches up with this desorption, the degradation rates of all dissolved-phase hydrocarbon constituents will equilibrate. This temporary increase in TEX concentrations is referred to as hydrocarbon desorption.

Based on existing hydraulic conductivity data available for the site, the following observations are expected during the pilot test:

- Sulfate and nitrogen concentration trends will be tracked during the pilot test and correlated with hydrocarbon constituent concentrations measured during the test. This data will then be extrapolated to determine dosing requirements for the full-scale system. These trends should be evident after three to six months of pilot test system operation;
- Hydrocarbon desorption as measured by increasing TEX concentrations and subsequent attenuation as evaluated through hydrocarbon concentration trends will be used to evaluate both dosing efficacy and PSH recovery enhancement. These trends should be observable after three to six months of pilot testing; and
- Decreasing hydrocarbon COC concentration trends will be observed after one year of pilot testing.

As appropriate with the assumptions presented above, after the pilot test injection system is installed and operating, wells will be monitored on a tiered schedule, as presented in Section 6.0. Wells will be monitored and gauged more frequently at the initiation of the pilot test and decreasing over the course of the 12-to 18-month duration of the pilot test.

5.5 Treatment Test Effectiveness

The effectiveness of the proposed treatment efficiency test will be measured primarily by comparing dissolved-phase constituent concentrations before and during the test. The amendments will be considered effective if dissolved phase concentrations decrease during the test. The key dissolved phase parameters and changes are described in Section 4.2. Changes in PSH recovery and presence in wells will also be evaluated by comparing PSH distribution, apparent thickness, and recovery rates in wells located in and around the pilot test area. It should be noted that changes in apparent PSH thickness in wells is not a good indicator of recoverability or actual thickness of PSH in the subsurface, so the evaluation will more heavily weigh on PSH recovery data.

6.0 Schedule

Following approval of the work plan by NMED and OCD, and permitting through NMOSE, the proposed schedule for the injection test and treatment efficiency test is as follows:

- Week 1: Conduct baseline sampling at existing identified monitoring wells. Conduct gamma-log study of existing wells. Install soil borings to further characterize shallow geology in test areas if needed.
- Week 2: Install and develop injection and recovery wells in the two pilot test areas along with eight new monitoring wells. Develop all wells.
- Week 3: Install equipment for injection tests.
- Week 4: Conduct injection tests concurrently at the two pilot test areas; collect groundwater quality samples.
- Weeks 5-10: Analyze injection test data and determine appropriate injection rate and dosing requirements for treatment efficiency test.
- Weeks 10-12: Install equipment for treatment efficiency test; collect baseline hydrocarbon and MNA samples; begin initial treatment with amendment(s).
- Week 13: Collect groundwater MNA field parameters daily; gauge wells daily; adjust amendment(s) and flow rate as necessary.
- Month 4: Collect groundwater MNA field parameters weekly and gauge wells weekly; adjust amendment(s) and flow rate as necessary.
- Months 5-12/18: If sulfate concentrations are greater than 500 mg/L in samples collected from the monitoring wells between the injection and recovery wells after three months, collect hydrocarbon and MNA laboratory groundwater samples and MNA field parameters quarterly. If sulfate concentrations are below 500 mg/L in the monitoring wells between the injection and recovery wells after 3 months, sulfate dosing will be adjusted upward and monthly sampling will continue until sulfate concentrations reach 500 mg/L. Gauge wells on same schedule as sampling. Adjust amendment(s) and flow rate as necessary.
- Month 15/20: Submit summary report to NMED/OCD summarizing pilot test results.

7.0 Tables

Table 1
Dosing Rate Calculations

Input Parameters

Molecular Weight of MgSO4.H2O(7) = 246.47
Molecular Weight of SO4 = 96.06
Grams per Pound 453.9
Liters per gallon 3.78

Target Concentration in injected water 2,000 mg/l
Target GW concentration is between 500 to 1000 mg/l

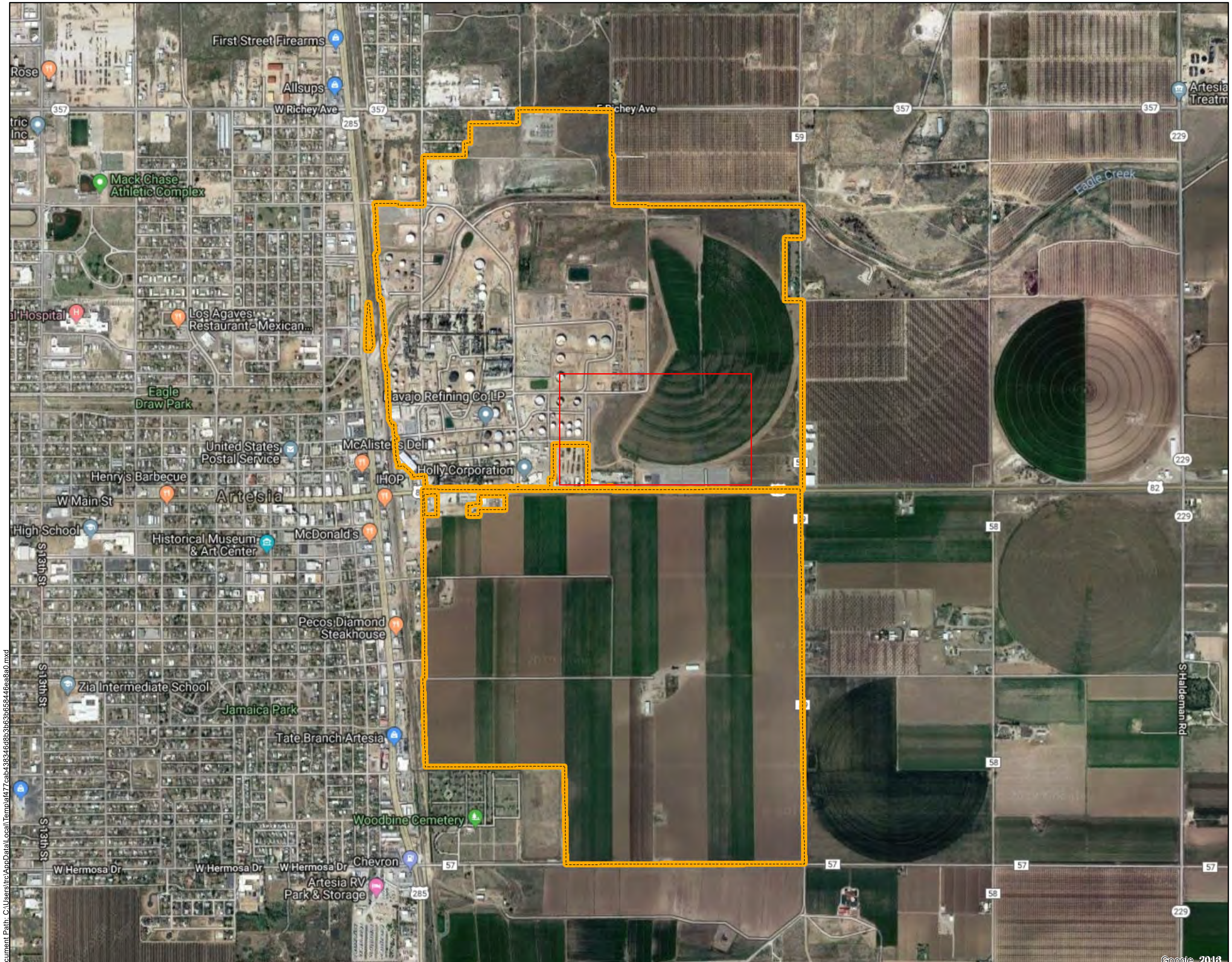
Concentration in tank - 6,100 pound sulfate in 4,000 gallons water

Gallons H2O	Liters	Pounds Epsom	Fraction Sulfate	Pounds SO4	Grams Sulfate	Conc SO4 (mg/L)
4,000	33320	6,000	0.39	2338	1061427	31856

Volume Tank Solution Per Minute to Generate 2,000 mg/l at discharge
(formation concentration of 300 to 500 mg/l)

GW Pumping Rate (gpm)	Convert to L/min	Dilution Required for 2,000 mg/l	Dose in L/min	Dose in Gallons per minute	Gallons from Tank per day	days per 4,000 gal
20	75.6	15.9	4.7	1.26	1808.2	2.2
15	56.7	15.9	3.6	0.94	1356.1	2.9
10	37.8	15.9	2.4	0.63	904.1	4.4
5	18.9	15.9	1.2	0.31	452.0	8.8

8.0 Figures



TRC
505 E. HUNTLAND DR.
SUITE 250
AUSTIN, TX 78752
PH:512-329-6080

N

Due to this map being projected in the WGS84 EPSG:3857 one cannot accurately scale distances or areas from it. This map should be used for reference purposes only.

LEGEND

Navajo Property

Pilot Test Area

Figure 1 - Site Location Map

Coordinate System: WGS 1984 Web Mercator Auxiliary Sphere
Projection: Mercator Auxiliary Sphere
Datum: WGS 1984
False Easting: 0.0000
False Northing: 0.0000
Central Meridian: 0.0000
Standard Parallel 1: 0.0000
Auxiliary Sphere Type: 0.0000
Units: Meter

Document Path: C:\Users\trc\AppData\Local\Temp\af477cab4383346d8b3b63b65844 6ea8a0.mxd

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N

Due to this map being projected in the WGS84 EPSG:3857 one cannot accurately scale distances or areas from it. This map should be used for reference purposes only.

LEGEND

- Monitoring Well
- Recovery Well
- Soil Boring
- Irrigation Well
- Tanks
- Proposed Monitoring Well
- Proposed Injection Well
- Proposed Recovery Well

Note: Proposed well locations subject to change.

0 100 200
Approximate Scale in Feet

Figure 2a - Proposed Recovery, Injection and Monitoring Locations around KWB-5

Coordinate System: WGS 1984 Web Mercator Auxiliary Sphere
Projection: Mercator Auxiliary Sphere
Datum: WGS 1984
False Easting: 0.0000
False Northing: 0.0000
Central Meridian: 0.0000
Standard Parallel 1: 0.0000
Auxiliary Sphere Type: 0.0000
Units: Meter

Document Path: C:\Users\trc\AppData\Local\Temp\04bff7d4f2fc4eb38da12afdda55d6d10.mxd

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SUITE 250
AUSTIN, TX 78752
PH:512-329-6080

N

Due to this map being projected in the WGS84 EPSG:3857 one cannot accurately scale distances or areas from it. This map should be used for reference purposes only.

LEGEND

- Monitoring Well
- Recovery Well
- Soil Boring
- Irrigation Well
- Tanks
- Proposed Monitoring Well
- Proposed Injection Well
- Proposed Recovery Well

Note: Proposed well locations subject to change.

0 100 200

Approximate Scale in Feet

Figure 2b - Proposed Recovery, Injection, and Monitoring Locations around MW-131

Coordinate System: WGS 1984 Web Mercator Auxiliary Sphere
Projection: Mercator Auxiliary Sphere
Datum: WGS 1984
False Easting: 0.0000
False Northing: 0.0000
Central Meridian: 0.0000
Standard Parallel 1: 0.0000
Auxiliary Sphere Type: 0.0000
Units: Meter

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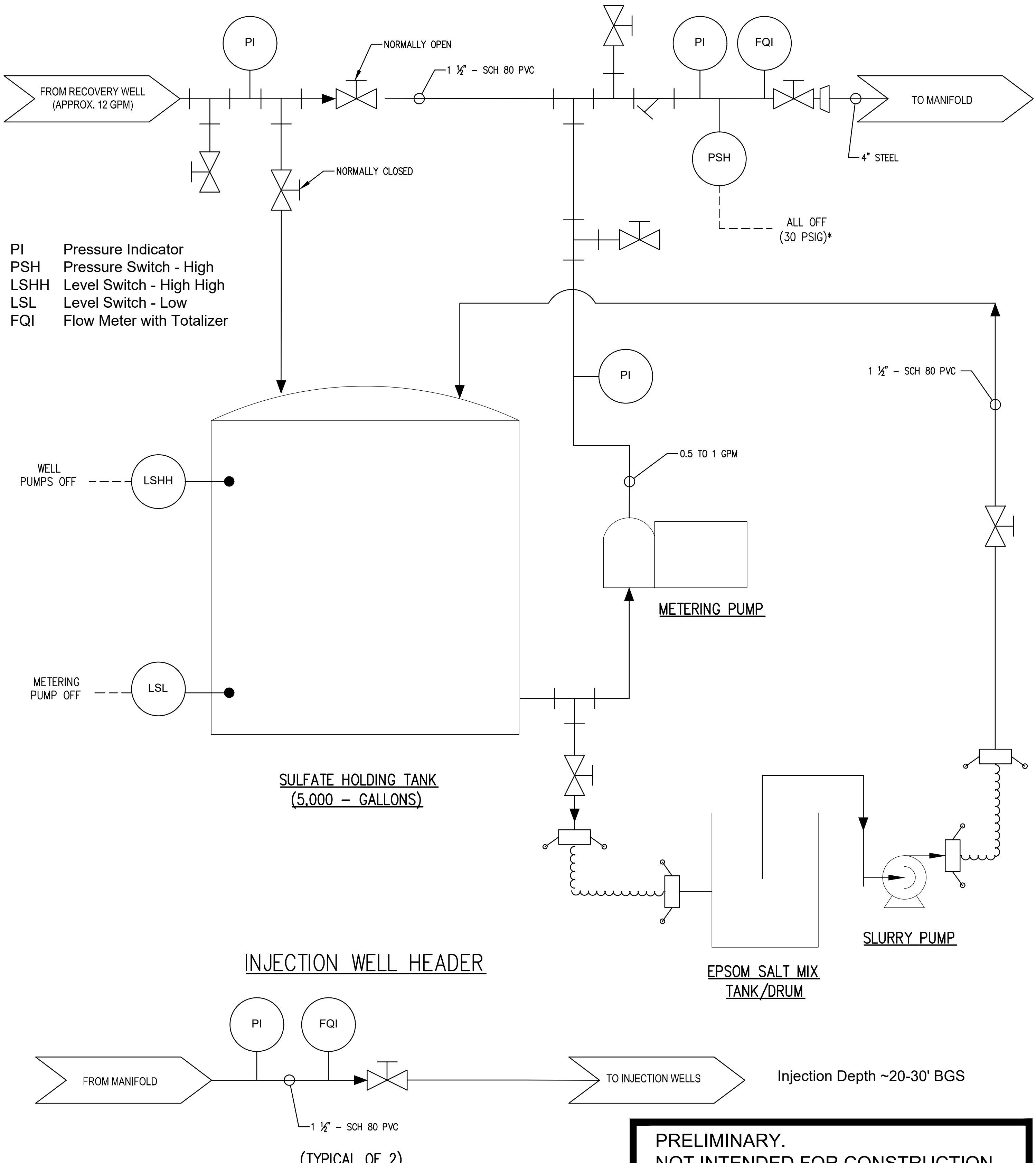

PI	Pressure Indicator
PSH	Pressure Switch - High
LSHH	Level Switch - High High
LSL	Level Switch - Low
FQI	Flow Meter with Totalizer

Injection Depth ~20-30' BGS

PRELIMINARY.
NOT INTENDED FOR CONSTRUCTION
OR BIDDING PURPOSES.

TRC

700 HIGHLANDER BLVD., SUITE 210, ARLINGTON, TEXAS 76015
FIRM CERTIFICATE OF AUTHORIZATION #E-1420
(817) 522 - 1000

FIGURE 3: PROCESS AND INSTRUMENTATION DIAGRAM
SULFATE AND AMMONIA INJECTION

DRAWN BY: B. HECKER
CHECKED BY: M. EBERLE

C:\USERS\VESELKA EMPLOYEES\DESKTOP\PROJECTS\MIS\PROJECTS FOR JASON\SULFATE INJECTION P&ID\P&ID SULFATE INJECTION.DWG - 4/11/19

9.0 References

Arcadis, 2015. Contaminant Migration Evaluation Investigation Report, RCRA Permit NMD048918817. February 2015.

Arcadis, 2017. Revised Contaminant Migration Evaluation Report RCRA Permit NMD048918817. April 2017.

HFNR, 2017. Addendum - RCRA Part B Renewal Application, Evaporation Pond (EP) 1 Designation and Tetraethyl Lead (TEL) Unit Modification, HollyFrontier Navajo Refining LLC – Artesia Refinery, EPA ID# NMD048918817. April 21, 2017.

NMED 2001. Use of Low-Flow and Other Non-traditional Sampling Techniques for RCRA Compliant Groundwater Monitoring. October 30, 2001.

NMED, 2003. Navajo Refining Company Artesia Refinery Post-Closure Care Permit. September 2003.

NMED, 2010. Navajo Refining Company Artesia Refinery Post-Closure Care Permit. December 2010.

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OCD, 2008. Discharge Permit (GW-028), Navajo Refining Company - Artesia Refinery. August 20, 2008.

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OCD, 2017a. HollyFrontier Navajo Refining LLC Artesia Refinery, Renewal of Discharge Permit GW-028. May 25, 2017.

OCD, 2017b. HollyFrontier Navajo Refining LLC, Artesia Refinery (GW-028) Discharge Permit Modification. June 29, 2017.

TRC, 2019. 2018 Annual Groundwater Monitoring Report, NMD048918817 and DP GW-028. February 2019.

Appendix A

Form C-108 Application for Authorization to Inject

STATE OF NEW MEXICO
ENERGY, MINERALS AND NATURAL RESOURCES DEPARTMENT

Oil Conservation Division
1220 South St. Francis Dr.
Santa Fe, New Mexico 87505

FORM C-108
Revised June 10, 2003

APPLICATION FOR AUTHORIZATION TO INJECT

I. PURPOSE: ________Secondary Recovery ________Pressure Maintenance ________Disposal ________Storage
Other: In Situ Groundwater Remediation Injection Wells
Application qualifies for administrative approval? ____**NA**______ Yes __________No

II. OPERATOR: ___ **HollyFrontier Navajo Refining LLC (HFNR)**________________________________

ADDRESS: ____**501 E Main Street in Artesia, New Mexico 88210**________________________________

CONTACT PARTY: ____ **Scott Denton**________________________________ PHONE: ___ **575-746-5487**___

III. WELL DATA: Complete the data required on the reverse side of this form for each well proposed for injection. Additional sheets may be attached if necessary.

IV. Is this an expansion of an existing project? ____**X**______ Yes __________ No
If yes, give the Division order number authorizing the project: _______**GW-028**________________________________

V. Attach a map that identifies all wells and leases within two miles of any proposed injection well with a one-half mile radius circle drawn around each proposed injection well. This circle identifies the well's area of review. **Attached, Figure "C-108 Map"**

*VI. Attach a tabulation of data on all wells of public record within the area of review which penetrate the proposed injection zone. Such data shall include a description of each well's type, construction, date drilled, location, depth, record of completion, and a schematic of any plugged well illustrating all plugging detail. **Provided in previous reports and in attached Table "Tabulation of Data on Wells of Public Record within Area of Review, Application for Authorization to Inject, FORM C-108, Item VI." Details below.**

VII. Attach data on the proposed operation, including: **See attached report "Groundwater and Phase-Separated Hydrocarbon: Recovery System Enhancements: Reinjection Pilot Test Work Plan" Sections 4, 5 and 6; & Attached Supplemental Information**

1. Proposed average and maximum daily rate and volume of fluids to be injected;
2. Whether the system is open or closed;
3. Proposed average and maximum injection pressure;
4. Sources and an appropriate analysis of injection fluid and compatibility with the receiving formation if other than reinjected produced water; and,
5. If injection is for disposal purposes into a zone not productive of oil or gas at or within one mile of the proposed well, attach a chemical analysis of the disposal zone formation water (may be measured or inferred from existing literature, studies, nearby wells, etc.).

*VIII. Attach appropriate geologic data on the injection zone including appropriate lithologic detail, geologic name, thickness, and depth. Give the geologic name, and depth to bottom of all underground sources of drinking water (aquifers containing waters with total dissolved solids concentrations of 10,000 mg/l or less) overlying the proposed injection zone as well as any such sources known to be immediately underlying the injection interval.
See attached document "Groundwater and Phase-Separated Hydrocarbon: Recovery System Enhancements: Reinjection Pilot Test Work Plan" Sections 3.2 and 3.3; & Attached Supplemental Information

IX. Describe the proposed stimulation program, if any. **NA**

*X. Attach appropriate logging and test data on the well. (If well logs have been filed with the Division, they need not be resubmitted). **NA**

*XI. Attach a chemical analysis of fresh water from two or more fresh water wells (if available and producing) within one mile of any injection or disposal well showing location of wells and dates samples were taken. **Data provided for irrigation wells in the injection area in Annual Groundwater Monitoring Reports.**

XII. Applicants for disposal wells must make an affirmative statement that they have examined available geologic and engineering data and find no evidence of open faults or any other hydrologic connection between the disposal zone and any underground sources of drinking water. **NA**

XIII. Applicants must complete the "Proof of Notice" section on the reverse side of this form. **NA**

XIV. Certification: I hereby certify that the information submitted with this application is true and correct to the best of my knowledge and belief.

NAME: Scott M Denton TITLE: Env. Manager

SIGNATURE: ______________________________ DATE: 04/12/19 ______________

E-MAIL ADDRESS: SCOTT.DENTON@HOLLYFRONTIER.COM

* If the information required under Sections VI, VIII, X, and XI above has been previously submitted, it need not be resubmitted. Please show the date and circumstances of the earlier submittal: __**See Supplemental Information, attached**____________

DISTRIBUTION: Original and one copy to Santa Fe with one copy to the appropriate District Office

III. WELL DATA

A. The following well data must be submitted for each injection well covered by this application. The data must be both in tabular and schematic form and shall include: **Attached (Supplemental Information)**

(1) Lease name; Well No.; Location by Section, Township and Range; and footage location within the section.

(2) Each casing string used with its size, setting depth, sacks of cement used, hole size, top of cement, and how such top was determined.

(3) A description of the tubing to be used including its size, lining material, and setting depth.

(4) The name, model, and setting depth of the packer used or a description of any other seal system or assembly used.

Division District Offices have supplies of Well Data Sheets which may be used or which may be used as models for this purpose. Applicants for several identical wells may submit a "typical data sheet" rather than submitting the data for each well.

B. The following must be submitted for each injection well covered by this application. All items must be addressed for the initial well. Responses for additional wells need be shown only when different. Information shown on schematics need not be repeated. **Attached (Supplemental Information)**

(1) The name of the injection formation and, if applicable, the field or pool name.

(2) The injection interval and whether it is perforated or open-hole.

(3) State if the well was drilled for injection or, if not, the original purpose of the well.

(4) Give the depths of any other perforated intervals and detail on the sacks of cement or bridge plugs used to seal off such perforations.

(5) Give the depth to and the name of the next higher and next lower oil or gas zone in the area of the well, if any.

XIV. PROOF OF NOTICE

All applicants must furnish proof that a copy of the application has been furnished, by certified or registered mail, to the owner of the surface of the land on which the well is to be located and to each leasehold operator within one-half mile of the well location.

Where an application is subject to administrative approval, a proof of publication must be submitted. Such proof shall consist of a copy of the legal advertisement which was published in the county in which the well is located. The contents of such advertisement must include:

(1) The name, address, phone number, and contact party for the applicant;

(2) The intended purpose of the injection well; with the exact location of single wells or the Section, Township, and Range location of multiple wells;

(3) The formation name and depth with expected maximum injection rates and pressures; and,

(4) A notation that interested parties must file objections or requests for hearing with the Oil Conservation Division, 1220 South St. Francis Dr., Santa Fe, New Mexico 87505, within 15 days.

NO ACTION WILL BE TAKEN ON THE APPLICATION UNTIL PROPER PROOF OF NOTICE HAS BEEN SUBMITTED.

NOTICE: Surface owners or offset operators must file any objections or requests for hearing of administrative applications within 15 days from the date this application was mailed to them.

Side 1

INJECTION WELL DATA SHEET

OPERATOR: ___ **HollyFrontier Navajo Refining LLC (HFNR)** ____

WELL NAME & NUMBER: ___**IW-1, IW-2 __**

WELL LOCATION: _**Navajo Artesia Refinery, near KWB-5 and MW-131, respectively. (Section 4, Township 17S, Range 26E)**_____

FOOTAGE LOCATION | UNIT LETTER | SECTION | TOWNSHIP | RANGE

WELLBORE SCHEMATIC ***NA***

WELL CONSTRUCTION DATA

Surface Casing

Hole Size: _________**11 in**__________ Casing Size:_______**6 in**________

Cemented with: _______**TBD**_______ sx. ***or*** __________________________ ft^3

Top of Cement: ______**TBD**___________ Method Determined: _____________

Intermediate Casing **NA**

Hole Size: _________**NA**_____________ Casing Size:____________________

Cemented with: _________________ sx. ***or*** __________________________ ft^3

Top of Cement: ____________________ Method Determined: _____________

Production Casing **NA**

Hole Size: __________**NA**___________ Casing Size:____________________

Cemented with: _________________ sx. ***or*** __________________________ ft^3

Top of Cement: ____________________ Method Determined: _____________

Total Depth: ______________________

Injection Interval

____**bottom 5-10 feet above 2-foot sump** **Perforated**__________________

(Perforated or Open Hole; indicate which)

INJECTION WELL DATA SHEET

Tubing Size: ____**NA**________________________________Lining Material: __**NA**______________

Type of Packer: ______**NA**____

Packer Setting Depth: __**NA**____________________

Other Type of Tubing/Casing Seal (if applicable): _______**NA**___________________________________

Additional Data

1. Is this a new well drilled for injection? ____**X**___Yes _______No

   If no, for what purpose was the well originally drilled? ___________________________________

   ____

2. Name of the Injection Formation: ___**Shallow Saturated Zone (10-30' bgs)**___________________

3. Name of Field or Pool (if applicable): ___**NA**____

4. Has the well ever been perforated in any other zone(s)? List all such perforated intervals and give plugging detail, i.e. sacks of cement or plug(s) used. _____**No**________________

   ____

5. Give the name and depths of any oil or gas zones underlying or overlying the proposed injection zone in this area: ____

   ____________________**NA**____

   ____

   ____

Supplemental Information
Form C-108
Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements Reinjection Pilot Test Work Plan HollyFrontier Navajo Refining LLC (HFNR)

VI.

Attach a tabulation of data on all wells of public record within the area of review which penetrate the proposed injection zone. Such data shall include a description of each well's type, construction, date drilled, location, depth, record of completion, and a schematic of any plugged well illustrating all plugging detail.

Provided in prior Annual Groundwater Monitoring Reports; and in attached Table "Tabulation of Data on Wells of Public Record within Area of Review, Application for Authorization to Inject, FORM C-108, Item VI."

VII.
Attach data on the proposed operation, including:
1.Proposed average and maximum daily rate and volume of fluids to be injected;
2.Whether the system is open or closed;
3.Proposed average and maximum injection pressure;
4.Sources and an appropriate analysis of injection fluid and compatibility with the receiving formation if other than reinjected produced water; and,
5.If injection is for disposal purposes into a zone not productive of oil or gas at or within one mile of the proposed well, attach a chemical analysis of the disposal zone formation water (may be measured or inferred from existing literature, studies, nearby wells, etc.).

1.Proposed average and maximum daily rate and volume of fluids to be injected;
Average: 12 gpm per injection well
Maximum: 15 gpm per injection well

2.Whether the system is open or closed;
Closed

3.Proposed average and maximum injection pressure;
To be determined during injection test - maximum possible injection pressure 150 psi

4.Sources and an appropriate analysis of injection fluid and compatibility with the receiving formation if other than reinjected produced water; and,
Source of injection fluid is recovered water from the Shallow Saturated Zone. The receiving formation is also the Shallow Saturated Zone approximately 200 feet upgradient of the recovery well. Recovered water will be amended with nutrients to enhance natural attenuation. All extraction and injection will be within 50 feet of the ground surface.

Supplemental Information
Form C-108
Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements Reinjection Pilot Test Work Plan HollyFrontier Navajo Refining LLC (HFNR)

Table 1 calculates sulfate addition rates based on a stock sulfate solution concentration of approximately 3.1% (Epsom Salt approximately 8%). The stock solution is prepared by mixing 6,000 lbs. of Epsom Salt in 4,000 gallons of water in a 5,000 gallon poly tank. The Epsom Salt is typically added to a 95 gallon mixing drum fed with a water stream from the mixing tank and the resulting slurry is pumped to the top of the storage tank. The ammonia is then added through the same mixing drum. The ammonia source is household unscented and surfactant free 9% ammonium water. The ammonia concentration in the sulfate tank is adjusted to approximately 50 mg/L for a targeted formation concentration of 10 to 25 mg/L. After in situ dilution/mixing conditions are measured, both sulfate and ammonia injection rates will be adjusted to maintain an adequate supply of nitrogen and sulfate.

5. If injection is for disposal purposes into a zone not productive of oil or gas at or within one mile of the proposed well, attach a chemical analysis of the disposal zone formation water (may be measured or inferred from existing literature, studies, nearby wells, etc.).
NA

VIII.
Attach appropriate geologic data on the injection zone including appropriate lithologic detail, geologic name, thickness, and depth. Give the geologic name, and depth to bottom of all underground sources of drinking water (aquifers containing waters with total dissolved solids concentrations of 10,000 mg/l or less) overlying the proposed injection zone as well as any such sources known to be immediately underlying the injection interval.

See attached report "Groundwater and Phase-Separated Hydrocarbon, Recovery System Enhancements: Reinjection Pilot Test Work Plan" Sections 3.2 and 3.3. Boring logs for MW-131 and KWB-5 in the injection zone are included.

III A.
The following well data must be submitted for each injection well covered by this application. The data must be both in tabular and schematic form and shall include:

(1) Lease name; Well No.; Location by Section, Township and Range; and footage location within the section.

No lease. [Section 4, Township 17S, Range 26E]

(2) Each casing string used with its size, setting depth, sacks of cement used, hole size, top of cement, and how such top was determined.
Entire wellbore
Casing size: 6-inch
Depth: TBD, will be approximately 3 feet below the base of the saturated gravel zone encountered when drilling;
Cement: sacks TBD; well will be cemented from approximately 4 feet above the top of the screened interval to 3 feet bgs
Hole size: 11 inches
Top of cement: 3 feet bgs
Top cement determined by: subsurface conditions

Supplemental Information
Form C-108
Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements Reinjection Pilot Test Work Plan HollyFrontier Navajo Refining LLC (HFNR)

(3) A description of the tubing to be used including its size, lining material, and setting depth.
NA

(4) The name, model, and setting depth of the packer used or a description of any other seal system or assembly used.
NA

Supplemental Information

Form C-108

Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements Reinjection Pilot Test Work Plan HollyFrontier Navajo Refining LLC (HFNR)

III B.

The following must be submitted for each injection well covered by this application. All items must be addressed for the initial well. Responses for additional wells need be shown only when different. Information shown on schematics need not be repeated.

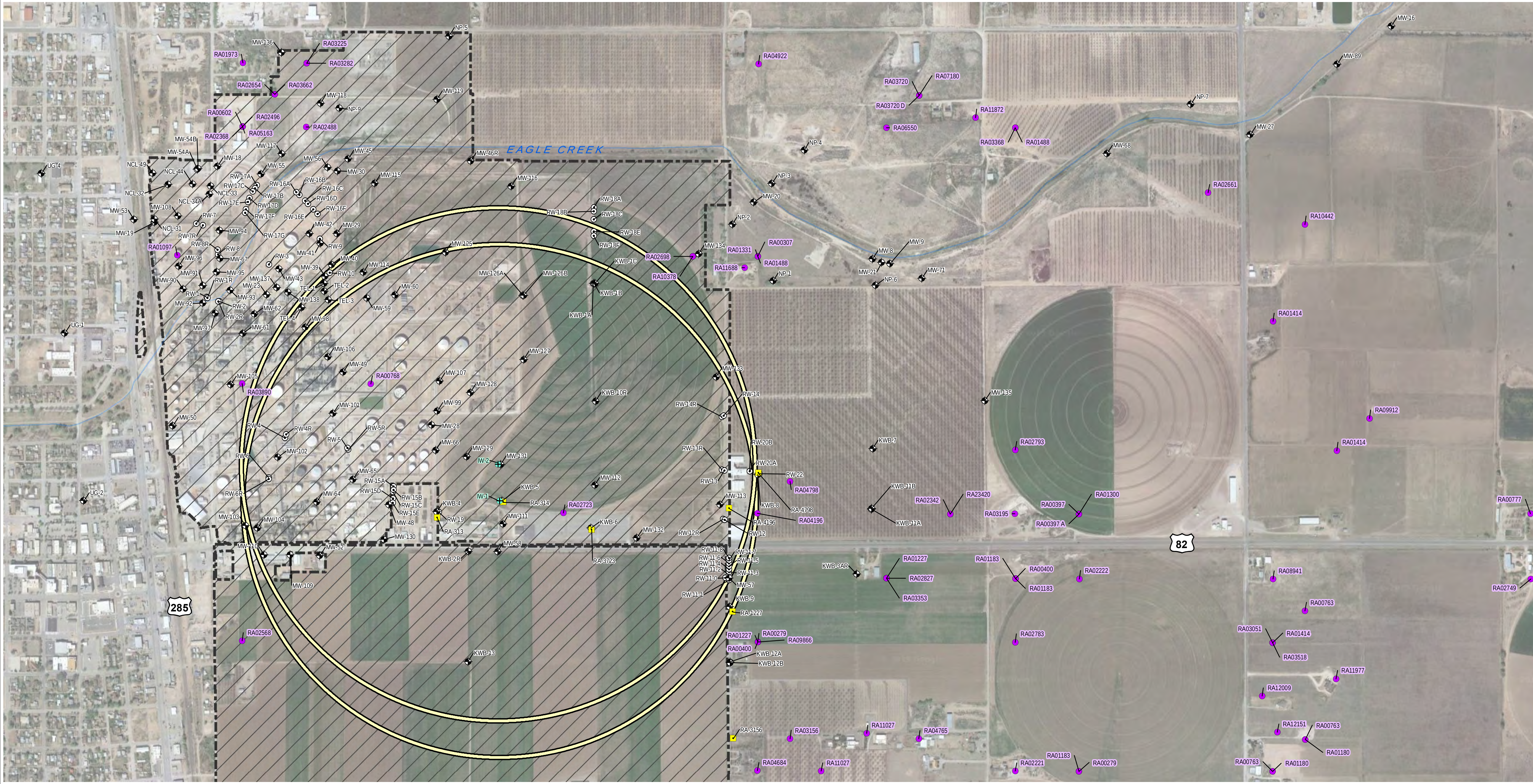
(1) The name of the injection formation and, if applicable, the field or pool name.
Shallow Saturated Zone (10-30' bgs)

(2) The injection interval and whether it is perforated or open-hole.
TBD; expected 5-10 feet across the gravel/sand interval in the saturated zone; perforated

(3) State if the well was drilled for injection or, if not, the original purpose of the well.
Injection (In Situ Groundwater Remediation Injection Well)

(4) Give the depths of any other perforated intervals and detail on the sacks of cement or bridge plugs used to seal off such perforations.
None

(5) Give the depth to and the name of the next higher and next lower oil or gas zone in the area of the well, if any.
None



LEGEND

- MONITORING WELL
- RECOVERY WELL
- IRRIGATION WELL IN MONITORING PROGRAM
- PROPOSED INJECTION WELL
- POTENTIAL WATER WELL (SEE NOTE 1)
- NAVAJO PROPERTY BOUNDARY
- 0.5 MILE RADIUS

NOTES:

1. POTENTIAL WATER WELL IDENTIFIED IN NEW MEXICO OFFICE OF THE STATE ENGINEER (NMOSE) NEW MEXICO WATER RIGHTS REPORTING SYSTEM (NMWRRS).
2. LEASE INFORMATION NOT PROVIDED BECAUSE PROPOSED INJECTION NOT IN PRODUCTION ZONE.

0 500 1,000 Feet

1 " = 1,000 '

1:12,000

BASEMAP: GOOGLE EARTHAND THEIR DATA PARTNERS, 3/12/2016

PROJECT: **GROUNDWATER AND PHASE-SEPARATED HYDROCARBON RECOVERY SYSTEM ENHANCEMENTS: REINJECTION PILOT TEST WORK PLAN HOLLYFRONTIER NAVAJO REFINERY LLC ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO**

TITLE: **AREA MAP, APPLICATION FOR AUTHORIZATION TO INJECT FORM C-108, ITEM V**

DRAWN BY:	MHORN	PROJ. NO.:	326693
CHECKED BY:	JSPEER	**C-108 MAP**	
APPROVED BY:			
DATE:	APRIL 2019		

TRC

505 East Huntland Drive, Suite 250
Austin, TX 78752
Phone: 512.329.6080
www.trcsolutions.com

FILE NO.: 326693_C-108.mxd

Coordinate System: NAD 1983 2011 StatePlane New Mexico East FIPS 3001 Ft US (Foot US)
Map Rotation: 0

Plot Date: 4/11/2019, 12:59:33 PM by MHORN -- LAYOUT: ANSI B(11"x17")
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TRC - GIS

Tabulation of Data on Wells of Public Record within Area of Review

Application for Authorization to Inject, FORM C-108, Item VI

Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements: Reinjection Pilot Test Work Plan

HollyFrontier Navajo Refining LLC, Artesia Refinery, Eddy County, New Mexico

Well ID	Well Type	Install Date	Well Diameter (inch)	Screen Interval[(1)] (ft bgs)	Surface Finish	Water Bearing Zone	X	Y
KWB-1A	Monitoring	2/11/1992	2	18 to 32	stickup	Shallow Saturated	-104.38268671500	32.85000646230
KWB-1B	Monitoring	2/15/1992	4	18 to 32	stickup	Shallow Saturated	-104.38265525800	32.85000586960
KWB-1C	Monitoring	9/29/1992	4	30.5 to 49.5	stickup	Valley Fill	-104.38261641000	32.85000401640
KWB-2R	Monitoring	--	2	--	flush mount	Shallow Saturated	-104.38686253400	32.84241334810
KWB-4	Monitoring	2/17/1992	2	20 to 39	stickup	Shallow Saturated	-104.38792192700	32.84353746700
KWB-5	Monitoring	2/11/1992	2	24.7 to 38.7	stickup	Shallow Saturated	-104.38573378800	32.84384946550
KWB-6	Monitoring	2/12/1992	2	17.5 to 36.5	stickup	Shallow Saturated	-104.38275666500	32.84308053640
KWB-9	Monitoring	2/13/1992	2	20 to 34	stickup	Shallow Saturated	-104.37810826000	32.84085165740
KWB-10R	Monitoring	10/1/2010	4	9 to 29	flush mount	Shallow Saturated	-104.38260444100	32.84667300710
KWB-13	Monitoring	--	2	--	flush mount	Shallow Saturated	-104.38687750300	32.83930672220
MW-28	Monitoring	7/8/1982	6	25 to 30	stickup	Shallow Saturated	-104.38808910200	32.84598917580
MW-39	Monitoring	6/13/1984	2	14 to 24	stickup	Shallow Saturated	-104.39166919400	32.85019604540
MW-48	Monitoring	12/14/1994	2	19 to 34	flush mount	Shallow Saturated	-104.38952434300	32.84373743570
MW-49	Monitoring	12/20/1994	2	19 to 34	flush mount	Shallow Saturated	-104.39105570200	32.84748150570
MW-52	Monitoring	1/14/1995	2	19 to 34	flush mount	Shallow Saturated	-104.39183314500	32.84229568000
MW-57	Monitoring	9/8/2003	2	10 to 30	flush mount	Shallow Saturated	-104.37813128600	32.84167011090
MW-58	Monitoring	9/5/2003	4	13 to 28	flush mount	Shallow Saturated	-104.38588441700	32.84241384470
MW-59	Monitoring	9/4/2003	2	15 to 30	stickup	Shallow Saturated	-104.39026470100	32.84957869030
MW-60	Monitoring	9/4/2003	2	15 to 30	stickup	Shallow Saturated	-104.38932368700	32.84967509680
MW-64	Monitoring	4/28/2005	4	15 to 30	flush mount	Shallow Saturated	-104.39193957000	32.84380955170
MW-65	Monitoring	4/26/2005	4	14.5 to 29.5	flush mount	Shallow Saturated	-104.39072500100	32.84445106830
MW-66	Monitoring	4/26/2005	4	14.6 to 29.6	flush mount	Shallow Saturated	-104.38796330000	32.84527235990
MW-98	Monitoring	7/3/2007	4	13 to 23	stickup	Shallow Saturated	-104.39232778200	32.84875971420
MW-99	Monitoring	7/5/2007	4	12 to 27	flush mount	Shallow Saturated	-104.38789990000	32.84638544690
MW-101	Monitoring	7/6/2007	4	8 to 23	stickup	Shallow Saturated	-104.39139427600	32.84631716520
MW-102	Monitoring	7/6/2007	4	12 to 27	stickup	Shallow Saturated	-104.39324807200	32.84507514580
MW-103	Monitoring	8/18/2008	4	7 to 22	stickup	Shallow Saturated	-104.39431870500	32.84313917690
MW-104	Monitoring	8/19/2008	4	3 to 18	stickup	Shallow Saturated	-104.39392259400	32.84307835020
MW-106	Monitoring	2/9/2009	4	0 to 11	flush mount	Shallow Saturated	-104.39156473400	32.84790824230
MW-107	Monitoring	2/24/2009	4	12 to 22	flush mount	Shallow Saturated	-104.38783298300	32.84723441900
MW-109	Monitoring	1/6/2011	2	15 to 29.5	flush mount	Shallow Saturated	-104.39282778600	32.84231997670
MW-110	Monitoring	1/5/2011	2	15 to 29.5	flush mount	Shallow Saturated	-104.39370310900	32.84231977760
MW-111	Monitoring	2/2/2013	2	25 to 40	stickup	Shallow Saturated	-104.38570153100	32.84320264290
MW-112	Monitoring	2/1/2013	2	25 to 35	stickup	Shallow Saturated	-104.38262699400	32.84429350520
MW-113	Monitoring	2/2/2013	2	20 to 35	stickup	Shallow Saturated	-104.37844189100	32.84375404280
MW-114	Monitoring	1/28/2013	2	20 to 35	stickup	Shallow Saturated	-104.39037998800	32.85031389640
MW-125	Monitoring	2/5/2014	2	15 to 25	stickup	Shallow Saturated	-104.38763152800	32.85088092510
MW-126A	Monitoring	1/29/2014	2	19 to 34	stickup	Shallow Saturated	-104.38504123400	32.84966624730
MW-126B	Monitoring	1/27/2014	2	40 to 50	stickup	Valley Fill	-104.38502113900	32.84965957700
MW-127	Monitoring	1/23/2014	2	20 to 50	stickup	Shallow Saturated	-104.38502077300	32.84784809000
MW-128	Monitoring	1/29/2014	2	15 to 35	flush mount	Shallow Saturated	-104.38680183900	32.84691797440
MW-129	Monitoring	1/22/2014	2	20 to 50	stickup	Shallow Saturated	-104.38693210300	32.84510104350
MW-130	Monitoring	2/7/2014	2	30 to 45	flush mount	Shallow Saturated	-104.38968949000	32.84275324020
MW-131	Monitoring	1/23/2014	2	20 to 50	stickup	Shallow Saturated	-104.38578564600	32.84488095180
MW-132	Monitoring	1/30/2014	2	15 to 40	stickup	Shallow Saturated	-104.38122260900	32.84279923230
MW-133	Monitoring	2/4/2014	2	15 to 35	stickup	Shallow Saturated	-104.37856491100	32.84736045400
RA-313	Irrigation	10/1/1940	10	904 to 1157	--	Artesian	-104.38789775400	32.84335683720
RA-314	Irrigation	--	--	--	--	Artesian	-104.38568775500	32.84380778820
RA-00768	Industrial	--	--	--	--	Artesian	-104.39013000000	32.84715100000
RA-3723	Irrigation	--	--	--	--	Artesian	-104.38273433100	32.84302823820
RA-4196	Irrigation	4/26/1960	8	280 to 292	--	Artesian	-104.37812725700	32.84363079660
RW-4R*	Recovery	10/21/2013	12	14.5 to 34.5	recovery vault	Shallow Saturated	-104.39300924600	32.84562930160
RW-5R*	Recovery	8/24/2011	12	13 to 33	recovery vault	Shallow Saturated	-104.39088750900	32.84529974480
RW-6R*	Recovery	10/22/2013	12	14.5 to 34.5	recovery vault	Shallow Saturated	-104.39355308100	32.84450518000
RW-10	Recovery	--	36	--	recovery vault	Shallow Saturated	-104.39151829600	32.85029690850
RW-11*	Recovery	--	36	--	recovery vault	Shallow Saturated	-104.37825293400	32.84167710390
RW-12R*	Recovery	8/21/2011	12	15 to 35	recovery vault	Shallow Saturated	-104.37832690300	32.84333821500
RW-13R*	Recovery	8/21/2011	12	15 to 35	recovery vault	Shallow Saturated	-104.37836817800	32.84473140100
RW-14R*	Recovery	8/21/2011	12	15 to 35	recovery vault	Shallow Saturated	-104.37837638900	32.84622489660
RW-15*	Recovery	--	36	--	recovery vault	Shallow Saturated	-104.38938436200	32.84409773490
RW-18*	Recovery	--	36	--	recovery vault	Shallow Saturated	-104.38267521600	32.85146909610
RW-19	Recovery	8/20/2011	12	11 to 46	recovery vault	Shallow Saturated	-104.38785500600	32.84352389010
RW-20*	Recovery	--	4	--	recovery vault	Shallow Saturated	-104.37744272800	32.84468415180
TEL-1	Monitoring	--	2	13 to 23	stickup	Shallow Saturated	-104.39170198400	32.84999491320
TEL-2	Monitoring	--	2	13 to 23	stickup	Shallow Saturated	-104.39168077100	32.84977385070
TEL-3	Monitoring	--	2	13 to 23	stickup	Shallow Saturated	-104.39155022700	32.84952697420
TEL-4	Monitoring	--	2	13 to 23	stickup	Shallow Saturated	-104.39245582300	32.84930646650

[(1)] Well total depth is equivalent to the bottom of the screen interval.

-- = information is not available or applicable

* = recovery well with one or more additional associated recovery well(s) completed within the same recovery trench

ft bgs = feet below ground surface

Appendix B

Underground Discharge System (Class V) Inventory Sheet

FOR SAMPLE USE ONLY – COMPARABLE FORMAT ACCEPTABLE

UNDERGROUND DISCHARGE SYSTEM (CLASS V) INVENTORY SHEET

(see instructions on back)

1. Name of facility: HollyFrontier Navajo Refining LLC (HFNR) Artesia Refinery

   Address of facility: 501 E. Main St

   City/Town: Artesia State: NM Zip Code: 88210

   County: Eddy County Location: See Figure 1

   Contact Person: Scott Denton Phone Number: 575-746-5487

2. Name of Owner or Operator: HollyFrontier Navajo Refining LLC

   Address of Owner or Operator: P.O. Box 159

   City/Town: Artesia State: NM Zip Code: 88211-0159

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3. Type & number of system(s): 0 Drywell(s) 0 Septic System(s) 2 Other(describe): In Situ GW Remediation Injection Wells
   Attach a schematic of the system. Attach a map or sketch of the location of the system at the facility.

4. Source of discharge into system: Groundwater extracted from Refinery extraction wells located ~200 feet downgradient
   Navajo Artesia Refinery SIC code 2911 (Petroleum Refining); EPA ID No. NMD048918817; Discharge Permit GW-028

5. Fluids discharged: Amended groundwater

6. Treatment before discharge: Sulfate and ammonia solution (2% sulfate, 0.05% ammonia). See Table 1 for details

7. Status of underground discharge system: ☐ Existing ☐ Unused/Abandoned ☐ Under Construction ☒ Proposed

   Approved/Permitted by: NA Date constructed: NA

CERTIFICATION

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment. (Ref. 40 CFR 144.32).

Signature: ____________________ Date: __________

Name (printed): ____________________

Official Title: ____________________

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5

UNDERGROUND DISCHARGE SYSTEM (CLASS V) INVENTORY SHEET INSTRUCTIONS

Complete one sheet for each different kind of underground discharge or drainage system (Class V well) at your facility or location. For example, several storm water drainage wells of a similar construction can all go on one sheet. Another example could be a business with a single septic system (septic tank with drainfield) that accepts fluids from a paint shop sink in one area, their vehicle maintenance garage floor drains in another area and also serves the employee kitchenette and washroom: this can all go on one form.

The numbers below correspond to the numbers on the front of the sheet.

1. Supply the name and street address of the facility where the Class V well(s) is located. Please be sure to include the County name. If available, provide the Latitude/Longitude of the discharge system. If there is no street address for the discharge system(s), provide a description of the location and show the location on a map. Include the name and phone number of a person to contact if there are any questions regarding the underground discharge system(s) and/or the wastewaters discharged at the facility.

2. Provide the name and mailing address of the owner of the facility or if the facility is operated by lease, the operator of the facility.

3. Provide the number of underground discharge systems at the facility (or location) for the type of system that is described on this sheet. Please use a separate sheet for each different type of system present. If the type of system is "Other", please describe (e.g., french drain, leachfield, improved sinkhole, cesspool, etc.).

   Provide a sketch, diagram or blueprints of the construction of the system including the depth below the ground surface that the fluids are released into the soil, sediment or formation. Also provide a map or sketch of the layout of the pluming or drainage system, including all the connections, and if applicable, indicate each fluid source connection (i.e., floor drains, shop sink, process tank discharge, restrooms, etc.) and any pre-treatment, etc.

4. Describe the kind of business practice that generates the fluids being discharged into the underground system (e.g., body shop, drycleaner, carwash, print shop, restaurant, etc.), and/or if more appropriate, the source of the fluids (e.g., employee & customer restrooms, parking lot drainage, etc.). If available, include the Standard Industrial Classification (SIC) Codes for this facility.

5. List the kinds of fluids that can enter the underground system (e.g., storm water run-off, sanitary waste, solvents, biodegradable soap wash & rinse water, snowmelt from trucks, photo developing fluids, ink, paint & thinner, non-contact cooling water, etc.). Please be as specific as you can about the kinds of fluids or products that can be drained into the system. Generally, good sources for this information are the Material Safety Data Sheets (MSDS) (copies of MSDS could be attached instead of listing all the products). If available, also attach a copy of any chemical analysis for the fluids discharged.

6. Describe the kinds of treatment (if any) that the fluids go through before disposal. Examples of treatment are: grease trap, package plant, oil/water separator, catch basin, metal recovery unit, sand filter, grit cleanser, etc.

7. Select the status of the underground discharge system and include the date the system was constructed. If the status is “Existing” but it is not being used, is unusable, will not be used, or is temporarily abandoned, mark the box for “Unused/Abandoned”. If state or local government approval was given for construction of the system, or a permit was issued for the system, please provide the name of the approving authority. Provide an estimated date of construction if the actual date is unknown.

The person signing the submittal should read the certification statement before signing and dating the sheet.

If you have any questions about whether or not you may have an EPA regulated system, or about how to complete this sheet, please call (312) 886-1492. You may also try our website at www.epa.gov/r5water/uic/uic.htm for information.

Please send completed sheets to: U.S. EPA Region 5
Underground Injection Control Branch
ATTN: Lisa Perenchio (WU-16J)
77 W. Jackson Blvd.
Chicago, IL 60604

8/02

SUPPLEMENTAL INFORMATION
UNDERGROUND DISCHARGE SYSTEM (CLASS V) INVENTORY SHEET
GROUNDWATER PHASE SEPARATED HYDROCARBON (PSH) RECOVERY SYSTEM ENHANCEMENTS
REINJECTION PILOT TESTING WORK PLAN
HOLLYFRONTIER NAVAJO REFINING LLC (HFNR)

The numbers below correspond to the numbers on the second page of the Underground Discharge System (Class V) Inventory Sheet.

1.

Supply the name and street address of the facility where the Class V well(s) is located. Please be sure to include the County name. If available, provide the Latitude/Longitude of the discharge system. If there is no street address for the discharge system(s), provide a description of the location and show the location on a map. Include the name and phone number of a person to contact if there are any questions regarding the underground discharge system(s) and/or the wastewaters discharged at the facility.

HollyFrontier Navajo Refining LLC

Artesia Refinery

501 E Main Street in Artesia, New Mexico 88210

Artesia, Eddy County, New Mexico

Location and Map provided in Figure 1, Figure 2a, and Figure 2b of the attached document "Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements: Reinjection Pilot Test Work Plan"

Contact: Scott Denton; 575-746-5487

2.

Provide the name and mailing address of the owner of the facility or if the facility is operated by lease, the operator of the facility.

HollyFrontier Navajo Refining LLC

Artesia Refinery

Attn: Scott Denton

501 E Main Street in Artesia, New Mexico 88210

Artesia, Eddy County, New Mexico

SUPPLEMENTAL INFORMATION
UNDERGROUND DISCHARGE SYSTEM (CLASS V) INVENTORY SHEET
GROUNDWATER PHASE SEPARATED HYDROCARBON (PSH) RECOVERY SYSTEM ENHANCEMENTS
REINJECTION PILOT TESTING WORK PLAN
HOLLYFRONTIER NAVAJO REFINING LLC (HFNR)

3.

Provide the number of underground discharge systems at the facility (or location) for the type of system that is described on this sheet. Please use a separate sheet for each different type of system present. If the type of system is "Other", please describe (e.g., french drain, leachfield, improved sinkhole, cesspool, etc.).

Two groundwater recirculation systems, near existing wells KWB-5 and MW-131. System design described in Section 4 and Section 5 of the attached document "Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements: Reinjection Pilot Test Work Plan"

Provide a sketch, diagram or blueprints of the construction of the system including the depth below the ground surface that the fluids are released into the soil, sediment or formation. Also provide a map or sketch of the layout of the plumbing or drainage system, including all the connections, and if applicable, indicate each fluid source connection (i.e., floor drains, shop sink, process tank discharge, restrooms, etc.) and any pre-treatment, etc.

Diagram and Sketch provided in Figure 3 of the attached document "Groundwater & Phase Separated Hydrocarbon Recovery System Enhancements: Reinjection Pilot Testing Work Plan".

4.

Describe the kind of business practice that generates the fluids being discharged into the underground system (e.g., body shop, drycleaner, carwash, print shop, restaurant, etc.), and/or if more appropriate, the source of the fluids (e.g., employee & customer restrooms, parking lot drainage, etc.). If available, include the Standard Industrial Classification (SIC) Codes for this facility.

The refinery (SIC Code 2911) plans to recirculate amended groundwater as part of site remediation, as described in Section 4 and Section 5 of the attached document "Groundwater and Phase-Separated Hydrocarbon, Recovery System Enhancements: Reinjection Pilot Test Work Plan"

5.

List the kinds of fluids that can enter the underground system (e.g., storm water run-off, sanitary waste, solvents, biodegradable soap wash & rinse water, snowmelt from trucks, photo developing fluids, ink, paint & thinner, non-contact cooling water, etc.). Please be as specific as you can about the kinds of fluids or products that can be drained into the system. Generally, good sources for this information are the Material Safety Data Sheets (MSDS) (copies of MSDS could be attached instead of listing all the products). If available, also attach a copy of any chemical analysis for the fluids discharged.

Recirculated treated groundwater, as described in Section 4 and Section 5 of the attached document "Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements: Reinjection Pilot Test Work Plan".

SDS for Magnesium Sulfate (Epsom Salts) and 9% Ammonia Solution, and most recent analytical results for MW-131 and KBW-5 attached below.

SUPPLEMENTAL INFORMATION
UNDERGROUND DISCHARGE SYSTEM (CLASS V) INVENTORY SHEET
GROUNDWATER PHASE SEPARATED HYDROCARBON (PSH) RECOVERY SYSTEM ENHANCEMENTS
REINJECTION PILOT TESTING WORK PLAN
HOLLYFRONTIER NAVAJO REFINING LLC (HFNR)

6.

Describe the kinds of treatment (if any) that the fluids go through before disposal. Examples of treatment are: grease trap, package plant, oil/water separator, catch basin, metal recovery unit, sand filter, grit cleanser, etc.

Injection wells will not be used for disposal. Wells are In Situ Groundwater Remediation Injection Wells. Groundwater is treated with a sulfate and ammonia solution, as described in Section 5 of the attached document "Groundwater and Phase-Separated Hydrocarbon Recovery System Enhancements: Reinjection Pilot Test Work Plan"

7.

Select the status of the underground discharge system and include the date the system was constructed. If the status is "Existing" but it is not being used, is unusable, will not be used, or is temporarily abandoned, mark the box for "Unused/Abandoned". If state or local government approval was given for construction of the system, or a permit was issued for the system, please provide the name of the approving authority. Provide an estimated date of construction if the actual date is unknown.

Not yet constructed; Estimated construction date: second half 2019.

Date Start/Finish: 1/23/14 **Drilling Company:** National EWP **Drilling Method:** Hollow Stem Auger **Sampling Method:** Split Spoon **Rig Type:** CME 85 **Auger Size:** 8 1/4"	**Northing:** 670346.80 **Easting:** 526629.79 **Casing Elevation:** 3357.12 **Borehole Depth:** 50' bgs **Surface Elevation:** 3354.3 **Descriptions By:** Eric Bergersen	**Well/Boring ID: MW-131** **Client:** **Location:** Artesia, NM

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Well/Boring Construction
	3355								Stick-up (3' ags)
0–5	3350	1	HA	5	0, 0	X		SANDY SILT (0,20,80,0), Yellowish Red (5YR5/6), very fine grained, loose, soft, no stain/odor	2" OD PVC Casing
5–10	3345	2	SS	5	0, 0			SILTY CLAY (0,0,40,60), Yellowish Red (5YR5/6), dry, stiff, no plasticity, no odor/stain SILTY CLAY (0,0,20,80), Reddish Brown (5YR4/4), dry, stiff, no plasticity, no odor/stain	Grout (0-15' bgs)
10–15	3340	3	SS	5	0, 0, 2.4, 27.2	open circle, open circle		Same as above with black staining and hydrocarbon odor SILTY CLAY (0,0,25,75), Gray (GLEY1 5/N), dry, stiff, no plasticity, stain and odor present	
15–20	3335	4	SS	5	37.1, 516, 239	shaded circle X, X, shaded circle X, shaded circle X			Bentonite Seal (15'-18' bgs)
20–25	3330	5	SS	5	0, 0, 0	shaded circle X, X		SANDY SILT (0,20,80,0), Dark Gray (GLEY1 4/N), very fine grained, loose, wet, strong odor and stain GRAVEL (95,0,5,0), Dark Gray (GLEY1 4/N), poorly sorted, 0.5"-2.5" subangular to subrounded, stain and odor present	Initial GW Encountered During Drilling @ 23.5' bgs

Remarks: bgs = below ground surface; amsl = above mean sea level; HA = Hand Auger; ppm = parts per million; NA = not applicable/available; SS = split spoon, ags = above ground surface

Lithology described as a percentage (Gravel, Sand, Silt, Clay)

Analytical Column: X= designates soil sample; circle shaded in= positive soil shake test, open circle= negative soil shake test

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Project: TX000931.0004
Data File:MW-131.dat

Created/Edited by:ESB
Date: 4/20/2014

Date Start/Finish: 1/23/14
Drilling Company: National EWP
Drilling Method: Hollow Stem Auger
Sampling Method: Split Spoon
Rig Type: CME 85
Auger Size: 8 1/4"

Northing: 670346.80
Easting: 526629.79
Casing Elevation: 3357.12
Borehole Depth: 50' bgs
Surface Elevation: 3354.3
Descriptions By: Eric Bergersen

Well/Boring ID: MW-131
Client: Navajo
Location: Artesia, NM

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Well/Boring Construction
25–30	3325	6	SS	5	0, 0			SILTY CLAY (0,0,10,90), White (5YR8/1), moist, high plasticity, medium stiffness, no stain/odor SILTY CLAY (0,0,30,70), Light Bluish Gray (GLEY2 7/10B), stiff, no plasticity, dry, light stain, no odor	GW Elevation During GW Sampling @ 24.35' bgs
30–35	3320	7	SS	5	0, 0, 0			SILTY CLAY (0,0,30,70), Greenish Gray (GLEY2 6/10BG), soft, high plasticity, moist, no stain/odor SILTY CLAY (0,5,35,60), Light Reddish Brown (5YR6/4), stiff, medium plasticity, dry, no stain/odor	10/20 Silica Sand Pack (18'-50' bgs) 2" OD 0.020" Slot Screen (20'-50' bgs)
35–40	3315	8	SS	5	0, 0			Same as above with calcareous nodules	
40–45	3310	9	SS	5	0, 0, 0			CLAYEY SILT (0,0,60,40), Light Gray (5YR7/1), soft, medium plasticity, moist, no stain/odor Same as above, stiff, dry, no plasticity	
45–50	3305	10	SS	5	0, 0			SILTY CLAY (0,0,30,70), Pale Olive (5Y6/3), stiff, low-medium plasticity, slightly moist, no stain/odor CLAY (0,0,0,100), Yellowish Red (5YR5/8), very stiff, no plasticity, dry, no stain/odor	

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Remarks: bgs = below ground surface; amsl = above mean sea level; HA = Hand Auger; ppm = parts per million; NA = not applicable/available; SS = split spoon, ags = above ground surface

Lithology described as a percentage (Gravel, Sand, Silt, Clay)

Analytical Column: X= designates soil sample; circle shaded in= positive soil shake test, open circle= negative soil shake test

Project: TX000931.0004
Data File:MW-131.dat

Created/Edited by:ESB
Date: 4/20/2014

Sym	Samp Loc	P (ppm)	Depth (Feet)
			2
			4
			6
			8
			10
			12
			14
			16
			18
			20
			22
			24
			26
			28
			30
			32
			34
			36
			38
			40
			42
			44
			46
			48
			50

Geologic Description

0–9' SANDY CLAY, brown, moist to dry, becoming lighter in color with decreasing moisture.

9–10' CLAY, brown, moist.

10–15' SANDY CLAY, brown, dry to moist, gray hydrocarbon staining starting at 14'.

15–29' CLAYEY SAND, gray staining with strong hydrocarbon smell, dry to moist.

29–31' SANDY CLAY, gray staining, strong odor, moist.

31–38' SATURATED SILT, brown, strong odor, sheen.

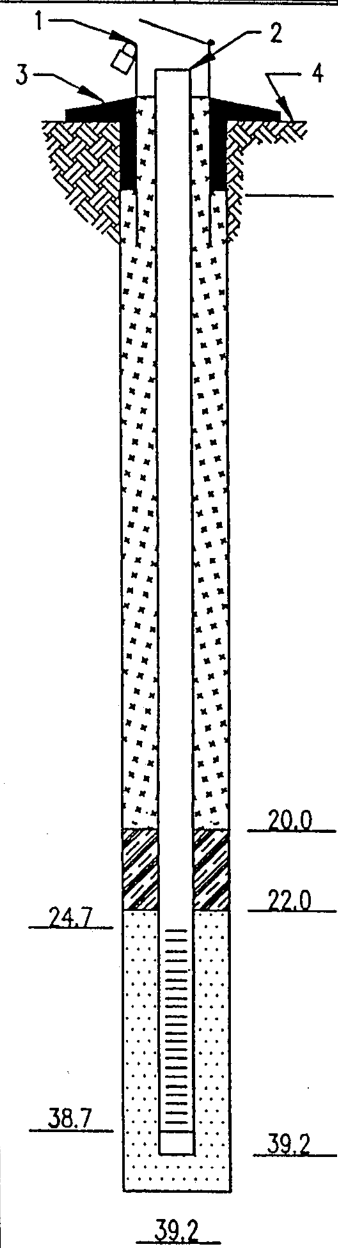
38–39.5' CLAY, brown, stiff, dry.

TD = 39.2'

NOTE: 5 foot core barrel recovery system used as sampling technique

ST=Shelby Tube | SS=Split Spoon | C=Cuttings

Mo[...]g Well / Piezometer



Depths in Feet from Ground Surface (Not to Scale)

Design Specification[...]

Elevations: (feet MSL) 1 3363.02 2 3362.87 3 3360.92 4 3360.6

Coordinates: X 2928.10 Y 4245.94

Type of Casing: ☒ PVC Sched. 40 Flush Thread ☐ Stainless Steel ☐

Casing Diameter: ☒ 2" ☐ 3" ☐ 4" ☐ 6" ☐

Screen Slot: ☐ 0.008 ☒ 0.010 ☐

Screen Style: ☒ Machine Slot ☐ Wire Wrap ☐

Sand Pack: CSSI 16-40

Bentonite Seal: ☐ 1/2" Pellets ☐ Hole Plug ☐ Slurry ☒ 1/4" Pellets ☐

Grout Type: Portland Weight:

Bore Hole Diameter: 8"

Drill Rig: ☒ Hollow Stem ☐ Rotary ☐

Drilled By: PRECISION ENGINEERING

Logged By: PHILIP CADARETTE

Completion Date: FEBRUARY 11, 1992

Date	D-T-P	MSL	D-T-W	Field pH	Field EC
2/19/92			23.1		
3/10/92	23.3	3339.6	23.4		

Comments: Concrete with 5% bentonite used to grout from seal to ground surface.

KWBES

KWB5

Project: 622092001-237 (KWB5)

Location: ARTESIA, NEW MEXICO

Trade Name: **Epsom Salt, Magnesium Sulfate, U.S.P.**
Date Prepared: **April 5, 2012**

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product name:	**Epsom Salt, Magnesium Sulfate, U.S.P.**
Product description:	**Magnesium sulfate, heptahydrate**
Product Use:	**Food grade, medicinal uses**
Manufacturer:	**PQ Corporation** **P. O. Box 840, Valley Forge, PA USA** **Phone number: 610-651-4200**
Supplier:	**National Silicates** **429 Kipling Ave, Toronto, ON M8Z 5C7** **Phone number: 416-255-7771**
In case of emergency call:	**1 416-255-7771**

2. COMPOSITION/INFORMATION ON INGREDIENTS

Chemical and Common Name	*CAS Registry Number*	*Wt. %*	*OSHA PEL*	*ACGIH TLV*
Magnesium sulfate, heptahydrate; Epsom salt	**10034-99-8***	**100%**	**Not Established**	**Not Established**

***** Under the Toxic Substances Control Act (TSCA), hydrates are considered as mixtures of their anhydrous salt and water. Accordingly, the CAS Numbers 7487-88-9, 7732-18-5 are used for purposes of TSCA.

3. HAZARDS IDENTIFICATION

Emergency Overview:	**White or transparent crystalline odorless powder. Non-combustible. At very high temperatures, magnesium oxide, sulfur dioxide, and sulfur trioxide may be generated. Causes mild eye irritation.**
Eye contact:	**Causes mild irritation to the eyes.**
Skin contact:	**No known adverse effects.**
Inhalation:	**Causes nausea, vomiting, abdominal cramps, and diarrhea.**
Ingestion:	**Causes nausea, vomiting, abdominal cramps, and diarrhea.**
Chronic hazards:	**No known chronic hazards. Not listed by NTP, IARC or OSHA as a carcinogen.**
Physical hazards:	**Spilled material can be slippery.**

4. FIRST AID MEASURES

Eye:	**In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Get medical attention if irritation persists.**
Skin:	**Not applicable.**
Inhalation:	**Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.**
Ingestion:	**If large quantities of this material are swallowed, call a physician immediately. Do NOT induce vomiting unless directed to do so by a physician. Never give anything by mouth to an unconscious person.**

5. FIRE FIGHTING MEASURES

Flammable limits:	**This material is non-combustible.**
Extinguishing Media:	**This material is compatible with all extinguishing media**
Hazards to fire-fighters:	**See Section 3 for information on hazards when this material is present in the area of a fire.**

Fire-fighting equipment:	**The following protective equipment for fire fighters is recommended when this material is present in the area of a fire: chemical goggles, body-covering protective clothing, self-contained breathing apparatus.**

6. ACCIDENTAL RELEASE MEASURES

Personal protection:	**Wear chemical goggles, See section 8.**
Environmental Hazards:	**Sinks and mixes with water. No adverse effects known. Not a listed toxic chemical under SARA Title III, §313 40 CFR Part 372. Not a CERCLA Hazardous Substance under 40 CFR Part 302.**
Small spill cleanup:	**Sweep, scoop or vacuum discharged material. Flush residue with water. Observe environmental regulations.**
Large spill cleanup:	**Keep unnecessary people away; isolate hazard area and deny entry. Do not touch or walk through spilled material. Sweep, scoop or vacuum discharged material. Flush residue with water. Observe environmental regulations.**
CERCLA RQ (US):	**There is no CERCLA Reportable Quantity for this material.**

7. HANDLING AND STORAGE

Handling:	**Avoid breathing dust. Promptly clean up spills.**
Storage:	**Keep containers closed. Protect from extremes of temperature and humidity during storage. Recommended storage conditions 68-110º F and 54-87% relative humidity.**

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering controls:	**Use with adequate ventilation. Safety shower and eyewash fountain should be within direct access.**
Respiratory protection:	**Use a NIOSH-approved dust respirator where dust occurs. Observe Provincial regulations for respirator use.**
Skin protection:	**Wear gloves if abrasion or irritation occurs.**
Eye protection:	**Wear chemical goggles.**

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance:	**Crystalline odourless powder.**
Color:	**White or transparent.**
Odour:	**Odourless.**
pH:	**Approximately 6-7**
Specific gravity:	**1.76 g/cm^3, Bulk Density Approximately 1.05 g/cm^3**
Solubility in water:	**71g/100 ml at 20º C, 91g/100 ml at 40º C**

10. STABILITY AND REACTIVITY

Stability:	**This material is stable under all conditions of use and storage.**
Conditions to avoid:	**None.**
Materials to avoid:	**Metal hydrides and other water reactive materials.**
Hazardous decomposition products:	**At very high temperatures, magnesium oxide, sulfur dioxide, and sulfur trioxide may be generated.**

11. TOXICOLOGICAL INFORMATION

Acute Data: **When tested for primary irritation potential, this material caused mild eye irritation. RTECS reports Oral TDLo= 428 mg/kg in man 351 mg/kg in women**

12. ECOLOGICAL INFORMATION

Eco toxicity: **Data not available.**
Environmental Fate: **This material is not persistent in aquatic systems and does not contribute to BOD. It does not bioconcentrate up the food chain.**
Physical/Chemical: **Sinks and mixes with water.**

13. DISPOSAL CONSIDERATIONS

Disposal Method: **Dispose in accordance with federal, provincial and local regulations.**

14. TRANSPORT INFORMATION

TDG UN Status: **This material is not regulated hazardous material for transportation.**

15. REGULATORY INFORMATION

WHMIS (Canada): **Not a WHMIS controlled product**
DSL (Canada): **All components of this formulation are listed on the CEPA-DSL**
CERCLA (US): **No CERCLA Reportable Quantity has been established for this material.**
SARA TITLE III (US): **Not an Extremely Hazardous Substance under §302. Not a Toxic Chemical under §313. Hazard Categories under §§311/312: Acute**
TSCA (US): **All ingredients of this material are listed on the TSCA inventory.**
FDA: **Magnesium sulfate is authorized by FDA GRAS substance pursuant to 21 CFR 184.1443.**

16. OTHER INFORMATION

Prepared by: **EHS Dept**
Supersedes revision of: **March 10, 2009**

THE INFORMATION ON THIS SAFETY DATA SHEET IS BELIEVED TO BE ACCURATE AND IT IS THE BEST INFORMATION AVAILABLE TO NATIONAL SILICATES THIS DOCUMENT IS INTENDED ONLY AS A GUIDE TO THE APPROPRIATE PRECAUTIONS FOR HANDLING A CHEMICAL BY A PERSON TRAINED IN CHEMICAL HANDLING. NATIONAL SILICATES MAKES NO WARRANTY OF MERCHANTABILITY OR ANY OTHER WARRANTY, EXPRESS OR IMPLIED WITH RESPECT TO SUCH INFORMATION OR THE PRODUCT TO WHICH IT RELATES, AND WE ASSUME NO LIABILITY RESULTING FROM THE USE OR HANDLING OF THE PRODUCT TO WHICH THIS SAFETY DATA SHEET RELATES. USERS AND HANDLERS OF THIS PRODUCT SHOULD MAKE THEIR OWN INVESTIGATIONS TO DETERMINE THE SUITABILITY OF THE INFORMATION PROVIDED HEREIN FOR THEIR OWN PURPOSES.

SAFETY DATA SHEET

Aqua Ammonia (5-19.9%)

Section 1. Identification

GHS product identifier : Aqua Ammonia (5-19.9%)

Other means of identification : Aqua Ammonia, Ammonium Hydroxide

Product use : Synthetic/Analytical chemistry.

Synonym : Aqua Ammonia, Ammonium Hydroxide

SDS # : 001196

Supplier's details : Airgas USA, LLC and its affiliates
259 North Radnor-Chester Road
Suite 100
Radnor, PA 19087-5283
1-610-687-5253

24-hour telephone : 1-866-734-3438

Section 2. Hazards identification

OSHA/HCS status : This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200).

Classification of the substance or mixture : SKIN CORROSION/IRRITATION - Category 1B
SPECIFIC TARGET ORGAN TOXICITY (SINGLE EXPOSURE) (Respiratory tract irritation) - Category 3
AQUATIC HAZARD (ACUTE) - Category 1

GHS label elements

Hazard pictograms :

Signal word : Danger

Hazard statements : May displace oxygen and cause rapid suffocation.
Causes severe skin burns and eye damage.
May cause respiratory irritation.
Very toxic to aquatic life.

Precautionary statements

General : Read label before use. Keep out of reach of children. If medical advice is needed, have product container or label at hand.

Prevention : Wear protective gloves. Wear eye or face protection. Wear protective clothing. Use only outdoors or in a well-ventilated area. Avoid release to the environment. Avoid breathing vapor. Wash hands thoroughly after handling.

Response : Collect spillage. IF INHALED: Remove person to fresh air and keep comfortable for breathing. Immediately call a POISON CENTER or physician. IF SWALLOWED: Immediately call a POISON CENTER or physician. Rinse mouth. Do NOT induce vomiting. IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water or shower. Wash contaminated clothing before reuse. Immediately call a POISON CENTER or physician. IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Immediately call a POISON CENTER or physician.

Storage : Store locked up.

Disposal : Dispose of contents and container in accordance with all local, regional, national and international regulations.

Hazards not otherwise classified : None known.

Section 3. Composition/information on ingredients

Substance/mixture : Mixture

Other means of identification : Aqua Ammonia, Ammonium Hydroxide

CAS number/other identifiers

CAS number : Not applicable.

Product code : 001196

Ingredient name	%	CAS number
Aqua Ammonia	100	1336-21-6
WATER	80.1 - 95	7732-18-5
ammonia, anhydrous	5 - 19.9	7664-41-7

Any concentration shown as a range is to protect confidentiality or is due to batch variation.

There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.

Occupational exposure limits, if available, are listed in Section 8.

Section 4. First aid measures

Description of necessary first aid measures

Eye contact : Get medical attention immediately. Call a poison center or physician. Immediately flush eyes with plenty of water, occasionally lifting the upper and lower eyelids. Check for and remove any contact lenses. Continue to rinse for at least 10 minutes. Chemical burns must be treated promptly by a physician.

Inhalation : Get medical attention immediately. Call a poison center or physician. Remove victim to fresh air and keep at rest in a position comfortable for breathing. If it is suspected that fumes are still present, the rescuer should wear an appropriate mask or self-contained breathing apparatus. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband. In case of inhalation of decomposition products in a fire, symptoms may be delayed. The exposed person may need to be kept under medical surveillance for 48 hours.

Skin contact : Get medical attention immediately. Call a poison center or physician. Flush contaminated skin with plenty of water. Remove contaminated clothing and shoes. Wash contaminated clothing thoroughly with water before removing it, or wear gloves. Continue to rinse for at least 10 minutes. Chemical burns must be treated promptly by a physician. Wash clothing before reuse. Clean shoes thoroughly before reuse.

Ingestion : Get medical attention immediately. Call a poison center or physician. Wash out mouth with water. Remove dentures if any. Remove victim to fresh air and keep at rest in a position comfortable for breathing. If material has been swallowed and the exposed person is conscious, give small quantities of water to drink. Stop if the exposed person feels sick as vomiting may be dangerous. Do not induce vomiting unless directed to do so by medical personnel. If vomiting occurs, the head should be kept low so that vomit does not enter the lungs. Chemical burns must be treated promptly by a physician. Never give anything by mouth to an unconscious person. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Most important symptoms/effects, acute and delayed

Potential acute health effects

Eye contact : No known significant effects or critical hazards.

Inhalation : May cause respiratory irritation.

Skin contact : Causes severe burns.

Frostbite : Try to warm up the frozen tissues and seek medical attention.

Section 4. First aid measures

Ingestion	: No known significant effects or critical hazards.

Over-exposure signs/symptoms

Eye contact	: Adverse symptoms may include the following:, pain, watering, redness
Inhalation	: Adverse symptoms may include the following:, respiratory tract irritation, coughing
Skin contact	: Adverse symptoms may include the following:, pain or irritation, redness, blistering may occur
Ingestion	: Adverse symptoms may include the following:, stomach pains

Indication of immediate medical attention and special treatment needed, if necessary

Notes to physician	: In case of inhalation of decomposition products in a fire, symptoms may be delayed. The exposed person may need to be kept under medical surveillance for 48 hours.
Specific treatments	: No specific treatment.
Protection of first-aiders	: No action shall be taken involving any personal risk or without suitable training. If it is suspected that fumes are still present, the rescuer should wear an appropriate mask or self-contained breathing apparatus. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Wash contaminated clothing thoroughly with water before removing it, or wear gloves.

See toxicological information (Section 11)

Section 5. Fire-fighting measures

Extinguishing media

Suitable extinguishing media	: Use an extinguishing agent suitable for the surrounding fire.
Unsuitable extinguishing media	: None known.

Specific hazards arising from the chemical	: In a fire or if heated, a pressure increase will occur and the container may burst. This material is very toxic to aquatic life. Fire water contaminated with this material must be contained and prevented from being discharged to any waterway, sewer or drain.
Hazardous thermal decomposition products	: Decomposition products may include the following materials: nitrogen oxides
Special protective actions for fire-fighters	: Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training.
Special protective equipment for fire-fighters	: Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

Personal precautions, protective equipment and emergency procedures

For non-emergency personnel	: No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Do not touch or walk through spilled material. Do not breathe vapor or mist. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment.
For emergency responders	: If specialised clothing is required to deal with the spillage, take note of any information in Section 8 on suitable and unsuitable materials. See also the information in "For non-emergency personnel".

Environmental precautions	: Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air). Water polluting material. May be harmful to the environment if released in large quantities. Collect spillage.

Section 6. Accidental release measures

Methods and materials for containment and cleaning up

Small spill : Stop leak if without risk. Move containers from spill area. Dilute with water and mop up if water-soluble. Alternatively, or if water-insoluble, absorb with an inert dry material and place in an appropriate waste disposal container. Dispose of via a licensed waste disposal contractor.

Large spill : Stop leak if without risk. Move containers from spill area. Approach release from upwind. Prevent entry into sewers, water courses, basements or confined areas. Wash spillages into an effluent treatment plant or proceed as follows. Contain and collect spillage with non-combustible, absorbent material e.g. sand, earth, vermiculite or diatomaceous earth and place in container for disposal according to local regulations (see Section 13). Dispose of via a licensed waste disposal contractor. Contaminated absorbent material may pose the same hazard as the spilled product. Note: see Section 1 for emergency contact information and Section 13 for waste disposal.

Section 7. Handling and storage

Precautions for safe handling

Protective measures : Put on appropriate personal protective equipment (see Section 8). Do not get in eyes or on skin or clothing. Do not breathe vapor or mist. Do not ingest. Avoid release to the environment. Use only with adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Keep in the original container or an approved alternative made from a compatible material, kept tightly closed when not in use. Empty containers retain product residue and can be hazardous. Do not reuse container.

Advice on general occupational hygiene : Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Remove contaminated clothing and protective equipment before entering eating areas. See also Section 8 for additional information on hygiene measures.

Conditions for safe storage, including any incompatibilities : Store in accordance with local regulations. Store in original container protected from direct sunlight in a dry, cool and well-ventilated area, away from incompatible materials (see Section 10) and food and drink. Store locked up. Keep container tightly closed and sealed until ready for use. Containers that have been opened must be carefully resealed and kept upright to prevent leakage. Do not store in unlabeled containers. Use appropriate containment to avoid environmental contamination.

Section 8. Exposure controls/personal protection

Control parameters

Occupational exposure limits

Ingredient name	Exposure limits
Aqua Ammonia	None.
WATER	None.
ammonia, anhydrous	**ACGIH TLV (United States, 3/2016).** STEL: 24 mg/m³ 15 minutes. STEL: 35 ppm 15 minutes. TWA: 17 mg/m³ 8 hours. TWA: 25 ppm 8 hours. **NIOSH REL (United States, 10/2013).** STEL: 27 mg/m³ 15 minutes. STEL: 35 ppm 15 minutes. TWA: 18 mg/m³ 10 hours. TWA: 25 ppm 10 hours. **OSHA PEL (United States, 2/2013).** TWA: 35 mg/m³ 8 hours. TWA: 50 ppm 8 hours. **OSHA PEL 1989 (United States, 3/1989).** STEL: 27 mg/m³ 15 minutes. STEL: 35 ppm 15 minutes.

Section 8. Exposure controls/personal protection

Appropriate engineering controls : Use only with adequate ventilation. If user operations generate dust, fumes, gas, vapor or mist, use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits.

Environmental exposure controls : Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

Individual protection measures

Hygiene measures : Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing. Ensure that eyewash stations and safety showers are close to the workstation location.

Eye/face protection : Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists, gases or dusts. If contact is possible, the following protection should be worn, unless the assessment indicates a higher degree of protection: chemical splash goggles and/ or face shield. If inhalation hazards exist, a full-face respirator may be required instead.

Skin protection

Hand protection : Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary. Considering the parameters specified by the glove manufacturer, check during use that the gloves are still retaining their protective properties. It should be noted that the time to breakthrough for any glove material may be different for different glove manufacturers. In the case of mixtures, consisting of several substances, the protection time of the gloves cannot be accurately estimated.

Body protection : Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Other skin protection : Appropriate footwear and any additional skin protection measures should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Respiratory protection : Use a properly fitted, air-purifying or air-fed respirator complying with an approved standard if a risk assessment indicates this is necessary. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator.

Section 9. Physical and chemical properties

Appearance

Physical state : Liquid.

Color : Colorless.

Boiling/condensation point : Lowest known value: 38°C (100.4°F) (ammonia). Weighted average: 68.21°C (154.8°F)

Melting/freezing point : 22ºF (5% solution) to -34ºF (19.9% solution)

Critical temperature : Not available.

Odor : Pungent.

Odor threshold : Not available.

pH : Approx. 11.6 for 1 N Sol'n. in water

Flash point : Not available.

Burning time : Not applicable.

Burning rate : Not applicable.

Evaporation rate : Not available.

Flammability (solid, gas) : Not available.

Section 9. Physical and chemical properties

Lower and upper explosive (flammable) limits : Not available.

Vapor pressure : Not available.

Vapor density : Highest known value: 0.6 to 1.2 (Air = 1) (ammonia).

Gas Density (lb/ft ^{3}) : Weighted average: 0.33

Relative density : Not available.

Solubility : Not available.

Solubility in water : Complete

Partition coefficient: n-octanol/water : Not available.

Auto-ignition temperature : Not available.

Decomposition temperature : Not available.

SADT : Not available.

Viscosity : Not available.

Section 10. Stability and reactivity

Reactivity : No specific test data related to reactivity available for this product or its ingredients.

Chemical stability : The product is stable.

Possibility of hazardous reactions : Under normal conditions of storage and use, hazardous reactions will not occur.

Conditions to avoid : No specific data.

Incompatible materials : No specific data.

Hazardous decomposition products : Under normal conditions of storage and use, hazardous decomposition products should not be produced.

Hazardous polymerization : Under normal conditions of storage and use, hazardous polymerization will not occur.

Section 11. Toxicological information

Information on toxicological effects

Acute toxicity

Product/ingredient name	Result	Species	Dose	Exposure
Aqua Ammonia ammonia, anhydrous	LD50 Oral LC50 Inhalation Gas.	Rat Rat	350 mg/kg 7338 ppm	- 1 hours

Irritation/Corrosion

Product/ingredient name	Result	Species	Score	Exposure	Observation
Aqua Ammonia	Eyes - Severe irritant	Rabbit	-	250 Micrograms	-
	Eyes - Severe irritant	Rabbit	-	0.5 minutes 1 milligrams	-

Sensitization

Not available.

Mutagenicity

Not available.

Section 11. Toxicological information

Carcinogenicity

Not available.

Reproductive toxicity

Not available.

Teratogenicity

Not available.

Specific target organ toxicity (single exposure)

Name	Category	Route of exposure	Target organs
Aqua Ammonia	Category 3	Not applicable.	Respiratory tract irritation

Specific target organ toxicity (repeated exposure)

Not available.

Aspiration hazard

Not available.

Information on the likely routes of exposure : Not available.

Potential acute health effects

Eye contact : No known significant effects or critical hazards.

Inhalation : May cause respiratory irritation.

Skin contact : Causes severe burns.

Ingestion : No known significant effects or critical hazards.

Symptoms related to the physical, chemical and toxicological characteristics

Eye contact : Adverse symptoms may include the following:, pain, watering, redness

Inhalation : Adverse symptoms may include the following:, respiratory tract irritation, coughing

Skin contact : Adverse symptoms may include the following:, pain or irritation, redness, blistering may occur

Ingestion : Adverse symptoms may include the following:, stomach pains

Delayed and immediate effects and also chronic effects from short and long term exposure

Short term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Long term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Potential chronic health effects

Not available.

General : No known significant effects or critical hazards.

Carcinogenicity : No known significant effects or critical hazards.

Mutagenicity : No known significant effects or critical hazards.

Teratogenicity : No known significant effects or critical hazards.

Developmental effects : No known significant effects or critical hazards.

Fertility effects : No known significant effects or critical hazards.

Section 11. Toxicological information

Numerical measures of toxicity

Acute toxicity estimates

Not available.

Section 12. Ecological information

Toxicity

Product/ingredient name	Result	Species	Exposure
Aqua Ammonia ammonia, anhydrous	Acute LC50 37 ppm Fresh water Acute EC50 29.2 mg/l Marine water Acute LC50 2080 µg/l Fresh water Acute LC50 0.53 ppm Fresh water Acute LC50 300 µg/l Fresh water Chronic NOEC 0.204 mg/l Marine water	Fish - Gambusia affinis - Adult Algae - Ulva fasciata - Zoea Crustaceans - Gammarus pulex Daphnia - Daphnia magna Fish - Hypophthalmichthys nobilis Fish - Dicentrarchus labrax	96 hours 96 hours 48 hours 48 hours 96 hours 62 days

Persistence and degradability

Not available.

Bioaccumulative potential

Product/ingredient name	$LogP_{ow}$	BCF	Potential
WATER	-1.38	-	low

Mobility in soil

Soil/water partition coefficient (K_{OC}) : Not available.

Other adverse effects : No known significant effects or critical hazards.

Section 13. Disposal considerations

Disposal methods : The generation of waste should be avoided or minimized wherever possible. Disposal of this product, solutions and any by-products should at all times comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Waste should not be disposed of untreated to the sewer unless fully compliant with the requirements of all authorities with jurisdiction. Waste packaging should be recycled. Incineration or landfill should only be considered when recycling is not feasible. This material and its container must be disposed of in a safe way. Care should be taken when handling emptied containers that have not been cleaned or rinsed out. Empty containers or liners may retain some product residues. Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers.

Section 14. Transport information

Section 14. Transport information

	DOT	TDG	Mexico	IMDG	IATA
UN number	UN2672	UN2672	UN2672	UN2672	UN2672
UN proper shipping name	Ammonium Hydroxide or Ammonia solutions	AMMONIA SOLUTION	AMMONIA SOLUTION	AMMONIA SOLUTION	Ammonia solution
Transport hazard class(es)	8	8	8	8	8
Packing group	III	III	III	III	III
Environment	No.	No.	No.	Yes.	No.
Additional information	This product is not regulated as a marine pollutant when transported on inland waterways in sizes of ≤5 L or ≤5 kg or by road, rail, or inland air in non-bulk sizes, provided the packagings meet the general provisions of §§ 173.24 and 173.24a. **Reportable quantity** 1000 lbs / 454 kg Package sizes shipped in quantities less than the product reportable quantity are not subject to the RQ (reportable quantity) transportation requirements.	Product classified as per the following sections of the Transportation of Dangerous Goods Regulations: 2.40-2.42 (Class 8), 2.7 (Marine pollutant mark). The marine pollutant mark is not required when transported by road or rail.	-	The marine pollutant mark is not required when transported in sizes of ≤5 L or ≤5 kg.	The environmentally hazardous substance mark may appear if required by other transportation regulations.

“Refer to CFR 49 (or authority having jurisdiction) to determine the information required for shipment of the product.”

Special precautions for user : **Transport within user’s premises:** always transport in closed containers that are upright and secure. Ensure that persons transporting the product know what to do in the event of an accident or spillage.

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code : Not available.

Section 15. Regulatory information

U.S. Federal regulations : **TSCA 8(a) CDR Exempt/Partial exemption**: Not determined

United States inventory (TSCA 8b): All components are listed or exempted.

Clean Water Act (CWA) 311: ammonia; ammonia, anhydrous

Clean Air Act (CAA) 112 regulated toxic substances: ammonia, anhydrous

Clean Air Act Section 112 (b) Hazardous Air Pollutants (HAPs) : Not listed

Clean Air Act Section 602 Class I Substances : Not listed

Clean Air Act Section 602 Class II Substances : Not listed

Section 15. Regulatory information

DEA List I Chemicals (Precursor Chemicals) : Not listed

DEA List II Chemicals (Essential Chemicals) : Not listed

SARA 302/304

Composition/information on ingredients

Name	%	EHS	SARA 302 TPQ		SARA 304 RQ	
			(lbs)	(gallons)	(lbs)	(gallons)
ammonia, anhydrous	5 - 19.9	Yes.	500	-	100	-

SARA 304 RQ : 502.5 lbs / 228.1 kg

SARA 311/312

Classification : Immediate (acute) health hazard

Composition/information on ingredients

Name	%	Fire hazard	Sudden release of pressure	Reactive	Immediate (acute) health hazard	Delayed (chronic) health hazard
Aqua Ammonia ammonia, anhydrous	100 5 - 19.9	No. Yes.	No. Yes.	No. No.	Yes. Yes.	No. No.

SARA 313

	Product name	CAS number	%
Form R - Reporting requirements	ammonia ammonia, anhydrous	1336-21-6 7664-41-7	100 5 - 19.9
Supplier notification	ammonia ammonia, anhydrous	1336-21-6 7664-41-7	100 5 - 19.9

SARA 313 notifications must not be detached from the SDS and any copying and redistribution of the SDS shall include copying and redistribution of the notice attached to copies of the SDS subsequently redistributed.

State regulations

Massachusetts : The following components are listed: AMMONIUM HYDROXIDE; AMMONIUM WATER; AMMONIA; AMMONIA, ANHYDROUS

New York : The following components are listed: Ammonium hydroxide; Ammonia

New Jersey : The following components are listed: AMMONIUM HYDROXIDE; AMMONIA

Pennsylvania : The following components are listed: AMMONIUM HYDROXIDE; AMMONIA

International regulations

International lists

National inventory

Australia : All components are listed or exempted.

Canada : All components are listed or exempted.

China : All components are listed or exempted.

Europe : All components are listed or exempted.

Japan : All components are listed or exempted.

Malaysia : All components are listed or exempted.

New Zealand : All components are listed or exempted.

Philippines : All components are listed or exempted.

Republic of Korea : All components are listed or exempted.

Taiwan : All components are listed or exempted.

Canada

Section 15. Regulatory information

WHMIS (Canada) : Class D-1A: Material causing immediate and serious toxic effects (Very toxic).
Class E: Corrosive material

CEPA Toxic substances: The following components are listed: Ammonia dissolved in water
Canadian ARET: None of the components are listed.
Canadian NPRI: The following components are listed: Ammonia (total); Ammonia (total)
Alberta Designated Substances: None of the components are listed.
Ontario Designated Substances: None of the components are listed.
Quebec Designated Substances: None of the components are listed.

Section 16. Other information

Canada Label requirements : Class D-1A: Material causing immediate and serious toxic effects (Very toxic).
Class E: Corrosive material

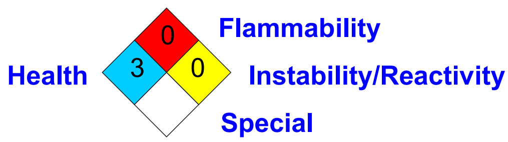
Hazardous Material Information System (U.S.A.)

Health	3
Flammability	0
Physical hazards	0

Caution: HMIS® ratings are based on a 0-4 rating scale, with 0 representing minimal hazards or risks, and 4 representing significant hazards or risks Although HMIS® ratings are not required on SDSs under 29 CFR 1910. 1200, the preparer may choose to provide them. HMIS® ratings are to be used with a fully implemented HMIS® program. HMIS® is a registered mark of the National Paint & Coatings Association (NPCA). HMIS® materials may be purchased exclusively from J. J. Keller (800) 327-6868.

The customer is responsible for determining the PPE code for this material.

National Fire Protection Association (U.S.A.)



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Copyright ©2001, National Fire Protection Association, Quincy, MA 02269. This warning system is intended to be interpreted and applied only by properly trained individuals to identify fire, health and reactivity hazards of chemicals. The user is referred to certain limited number of chemicals with recommended classifications in NFPA 49 and NFPA 325, which would be used as a guideline only. Whether the chemicals are classified by NFPA or not, anyone using the 704 systems to classify chemicals does so at their own risk.

Procedure used to derive the classification

Classification	Justification
Skin Corr. 1B, H314 STOT SE 3, H335 Aquatic Acute 1, H400	Expert judgment Calculation method Calculation method

History

Date of printing : 12/20/2016
Date of issue/Date of revision : 12/20/2016
Date of previous issue : 12/20/2016
Version : 0.07

Section 16. Other information

Key to abbreviations : ATE = Acute Toxicity Estimate
BCF = Bioconcentration Factor
GHS = Globally Harmonized System of Classification and Labelling of Chemicals
IATA = International Air Transport Association
IBC = Intermediate Bulk Container
IMDG = International Maritime Dangerous Goods
LogPow = logarithm of the octanol/water partition coefficient
MARPOL 73/78 = International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978. ("Marpol" = marine pollution)
UN = United Nations

References : Not available.

Indicates information that has changed from previously issued version.

Notice to reader

To the best of our knowledge, the information contained herein is accurate. However, neither the above-named supplier, nor any of its subsidiaries, assumes any liability whatsoever for the accuracy or completeness of the information contained herein.
Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

Gravimetric Analysis by Method 2540 C-2011

Analyte	Result mg/l	Qualifier	MDL mg/l	RDL mg/l	Dilution	Analysis date / time	Batch
Dissolved Solids	1730		2.82	10.0	1	04/11/2018 16:40	WG1096156

Wet Chemistry by Method 353.2

Analyte	Result mg/l	Qualifier	MDL mg/l	RDL mg/l	Dilution	Analysis date / time	Batch
Nitrate-Nitrite	1.93		0.0197	0.100	1	04/11/2018 16:18	WG1096186

Wet Chemistry by Method 9056A

Analyte	Result mg/l	Qualifier	MDL mg/l	RDL mg/l	Dilution	Analysis date / time	Batch
Chloride	546		1.04	20.0	20	04/08/2018 22:25	WG1095124
Fluoride	0.861		0.00990	0.100	1	04/08/2018 22:10	WG1095124
Sulfate	9.96		0.0774	5.00	1	04/08/2018 22:10	WG1095124

Metals (ICPMS) by Method 6020

Analyte	Result mg/l	Qualifier	MDL mg/l	RDL mg/l	Dilution	Analysis date / time	Batch
Arsenic	0.0201		0.000250	0.00200	1	04/15/2018 09:18	WG1095826
Arsenic,Dissolved	0.0152		0.000250	0.00200	1	04/22/2018 14:53	WG1095181
Barium	5.09		0.000360	0.00500	1	04/15/2018 09:18	WG1095826
Barium,Dissolved	3.15		0.000360	0.00500	1	04/22/2018 14:53	WG1095181
Calcium	233		0.0460	1.00	1	04/15/2018 09:18	WG1095826
Chromium	U		0.000540	0.00200	1	04/15/2018 09:18	WG1095826
Chromium,Dissolved	0.00359		0.000540	0.00200	1	04/22/2018 14:53	WG1095181
Iron	1.21		0.0150	0.100	1	04/15/2018 09:18	WG1095826
Iron,Dissolved	1.89		0.0150	0.100	1	04/22/2018 14:53	WG1095181
Lead	0.000758	B J	0.000240	0.00200	1	04/15/2018 09:18	WG1095826
Lead,Dissolved	U		0.000240	0.00200	1	04/22/2018 14:53	WG1095181
Manganese	1.29		0.000250	0.00500	1	04/15/2018 09:18	WG1095826
Manganese,Dissolved	1.14		0.000250	0.00500	1	04/22/2018 14:53	WG1095181
Potassium	1.95		0.0370	1.00	1	04/15/2018 09:18	WG1095826
Selenium	U		0.000380	0.00200	1	04/15/2018 09:18	WG1095826
Selenium,Dissolved	U		0.000380	0.00200	1	04/22/2018 14:53	WG1095181
Sodium	215		0.110	1.00	1	04/15/2018 09:18	WG1095826

Volatile Organic Compounds (GC/MS) by Method 8260B

Analyte	Result mg/l	Qualifier	MDL mg/l	RDL mg/l	Dilution	Analysis date / time	Batch
Acetone	U		2.50	12.5	250	04/07/2018 20:52	WG1095231
Benzene	0.411		0.0828	0.250	250	04/07/2018 20:52	WG1095231
Bromodichloromethane	U		0.0950	0.250	250	04/07/2018 20:52	WG1095231
Bromoform	U		0.117	0.250	250	04/07/2018 20:52	WG1095231
Bromomethane	U		0.216	1.25	250	04/07/2018 20:52	WG1095231
n-Butylbenzene	U		0.0902	0.250	250	04/07/2018 20:52	WG1095231
sec-Butylbenzene	U		0.0912	0.250	250	04/07/2018 20:52	WG1095231
Carbon disulfide	U		0.0688	0.250	250	04/07/2018 20:52	WG1095231
Carbon tetrachloride	U		0.0948	0.250	250	04/07/2018 20:52	WG1095231
Chlorobenzene	U		0.0870	0.250	250	04/07/2018 20:52	WG1095231
Chlorodibromomethane	U		0.0818	0.250	250	04/07/2018 20:52	WG1095231
Chloroethane	U		0.113	1.25	250	04/07/2018 20:52	WG1095231
Chloroform	U		0.0810	1.25	250	04/07/2018 20:52	WG1095231
Chloromethane	U		0.0690	0.625	250	04/07/2018 20:52	WG1095231
1,2-Dibromoethane	U		0.0952	0.250	250	04/07/2018 20:52	WG1095231
1,1-Dichloroethane	U		0.0648	0.250	250	04/07/2018 20:52	WG1095231

Volatile Organic Compounds (GC/MS) by Method 8260B

Analyte	Result mg/l	Qualifier	MDL mg/l	RDL mg/l	Dilution	Analysis date / time	Batch
1,2-Dichloroethane	U		0.0902	0.250	250	04/07/2018 20:52	WG1095231
1,1-Dichloroethene	U		0.0995	0.250	250	04/07/2018 20:52	WG1095231
cis-1,2-Dichloroethene	U		0.0650	0.250	250	04/07/2018 20:52	WG1095231
trans-1,2-Dichloroethene	U		0.0990	0.250	250	04/07/2018 20:52	WG1095231
1,2-Dichloropropane	U		0.0765	0.250	250	04/07/2018 20:52	WG1095231
cis-1,3-Dichloropropene	U		0.104	0.250	250	04/07/2018 20:52	WG1095231
trans-1,3-Dichloropropene	U		0.105	0.250	250	04/07/2018 20:52	WG1095231
Ethylbenzene	U		0.0960	0.250	250	04/07/2018 20:52	WG1095231
Isopropylbenzene	U		0.0815	0.250	250	04/07/2018 20:52	WG1095231
p-Isopropyltoluene	U		0.0875	0.250	250	04/07/2018 20:52	WG1095231
2-Butanone (MEK)	U		0.982	2.50	250	04/07/2018 20:52	WG1095231
2-Hexanone	U		0.955	2.50	250	04/07/2018 20:52	WG1095231
Methylene Chloride	U		0.250	1.25	250	04/07/2018 20:52	WG1095231
4-Methyl-2-pentanone (MIBK)	U		0.535	2.50	250	04/07/2018 20:52	WG1095231
Methyl tert-butyl ether	10.3		0.0918	0.250	250	04/07/2018 20:52	WG1095231
Naphthalene	U		0.250	1.25	250	04/07/2018 20:52	WG1095231
n-Propylbenzene	U		0.0872	0.250	250	04/07/2018 20:52	WG1095231
Styrene	U		0.0768	0.250	250	04/07/2018 20:52	WG1095231
1,1,1,2-Tetrachloroethane	U		0.0962	0.250	250	04/07/2018 20:52	WG1095231
1,1,2,2-Tetrachloroethane	U		0.0325	0.250	250	04/07/2018 20:52	WG1095231
Tetrachloroethene	U		0.0930	0.250	250	04/07/2018 20:52	WG1095231
Toluene	U		0.103	0.250	250	04/07/2018 20:52	WG1095231
1,1,1-Trichloroethane	U		0.0798	0.250	250	04/07/2018 20:52	WG1095231
1,1,2-Trichloroethane	U		0.0958	0.250	250	04/07/2018 20:52	WG1095231
Trichloroethene	U		0.0995	0.250	250	04/07/2018 20:52	WG1095231
1,2,4-Trimethylbenzene	U		0.0932	0.250	250	04/07/2018 20:52	WG1095231
1,3,5-Trimethylbenzene	U		0.0968	0.250	250	04/07/2018 20:52	WG1095231
Vinyl chloride	U		0.0648	0.250	250	04/07/2018 20:52	WG1095231
o-Xylene	U		0.0852	0.250	250	04/07/2018 20:52	WG1095231
m&p-Xylene	U		0.180	0.500	250	04/07/2018 20:52	WG1095231
Xylenes, Total	U		0.265	0.750	250	04/07/2018 20:52	WG1095231
(S) Toluene-d8	*107*			*80.0-120*		*04/07/2018 20:52*	WG1095231
(S) Dibromofluoromethane	*101*			*76.0-123*		*04/07/2018 20:52*	WG1095231
(S) 4-Bromofluorobenzene	*95.1*			*80.0-120*		*04/07/2018 20:52*	WG1095231

Sample Narrative:

L983865-18 WG1095231: Non-target compounds too high to run at a lower dilution.

Semi-Volatile Organic Compounds (GC) by Method 3511/8015

Analyte	Result mg/l	Qualifier	MDL mg/l	RDL mg/l	Dilution	Analysis date / time	Batch
TPH (GC/FID) High Fraction	1.70		0.0247	0.100	1	04/11/2018 03:37	WG1095394
(S) o-Terphenyl	*115*			*31.0-160*		*04/11/2018 03:37*	WG1095394

1 Cp
2 Tc
3 Ss
4 Cn
5 Sr
6 Qc
7 Gl
8 Al
9 Sc

Gravimetric Analysis by Method 2540 C-2011

Analyte	Result mg/l	Qualifier	MDL mg/l	RDL mg/l	Dilution	Analysis date / time	Batch
Dissolved Solids	1230		2.82	10.0	1	05/03/2017 14:39	WG975911

Wet Chemistry by Method 353.2

Analyte	Result mg/l	Qualifier	MDL mg/l	RDL mg/l	Dilution	Analysis date / time	Batch
Nitrate-Nitrite	U		0.197	1.00	10	05/04/2017 11:36	WG976256

Sample Narrative:

353.2 L905668-62 WG976256: Dilution due to matrix

Wet Chemistry by Method 9056A

Analyte	Result mg/l	Qualifier	MDL mg/l	RDL mg/l	Dilution	Analysis date / time	Batch
Chloride	285		1.04	20.0	20	05/03/2017 20:28	WG975914
Fluoride	0.773		0.00990	0.100	1	05/03/2017 21:50	WG975914
Sulfate	10.3		0.0774	5.00	1	05/03/2017 21:50	WG975914

Metals (ICPMS) by Method 6020

Analyte	Result mg/l	Qualifier	MDL mg/l	RDL mg/l	Dilution	Analysis date / time	Batch
Arsenic	0.0214		0.000250	0.00200	1	05/04/2017 12:42	WG975078
Arsenic,Dissolved	0.0183		0.000250	0.00200	1	05/02/2017 23:29	WG975069
Barium	2.75		0.000360	0.00500	1	05/04/2017 12:42	WG975078
Barium,Dissolved	2.48		0.000360	0.00500	1	05/02/2017 23:29	WG975069
Calcium	151		0.0460	1.00	1	05/04/2017 12:42	WG975078
Chromium	U		0.000540	0.00200	1	05/04/2017 12:42	WG975078
Chromium,Dissolved	U		0.000540	0.00200	1	05/02/2017 23:29	WG975069
Iron	1.29		0.0150	0.100	1	05/04/2017 12:42	WG975078
Iron,Dissolved	U		0.0150	0.100	1	05/02/2017 23:29	WG975069
Lead	U		0.000240	0.00200	1	05/04/2017 12:42	WG975078
Lead,Dissolved	U		0.000240	0.00200	1	05/02/2017 23:29	WG975069
Manganese	0.294		0.000250	0.00500	1	05/04/2017 12:42	WG975078
Manganese,Dissolved	0.309		0.000250	0.00500	1	05/02/2017 23:29	WG975069
Potassium	0.275	J	0.0370	1.00	1	05/04/2017 12:42	WG975078
Selenium	U		0.000380	0.00200	1	05/04/2017 12:42	WG975078
Selenium,Dissolved	0.000632	B J	0.000380	0.00200	1	05/02/2017 23:29	WG975069
Sodium	153		0.110	1.00	1	05/04/2017 12:42	WG975078

Volatile Organic Compounds (GC) by Method 8015D/GRO

Analyte	Result mg/l	Qualifier	MDL mg/l	RDL mg/l	Dilution	Analysis date / time	Batch
TPH (GC/FID) Low Fraction	6.81		0.0314	0.100	1	05/01/2017 04:31	WG975304
(S) a,a,a-Trifluorotoluene(FID)	*82.6*			*77.0-122*		*05/01/2017 04:31*	WG975304

Volatile Organic Compounds (GC/MS) by Method 8260B

Analyte	Result mg/l	Qualifier	MDL mg/l	RDL mg/l	Dilution	Analysis date / time	Batch
Acetone	U		0.0100	0.0500	1	05/02/2017 17:59	WG975483
Benzene	3.09		0.00662	0.0200	20	05/03/2017 23:07	WG975483
Bromodichloromethane	U		0.000380	0.00100	1	05/02/2017 17:59	WG975483
Bromoform	U		0.000469	0.00100	1	05/02/2017 17:59	WG975483
Bromomethane	U		0.000866	0.00500	1	05/02/2017 17:59	WG975483
n-Butylbenzene	0.00255		0.000361	0.00100	1	05/02/2017 17:59	WG975483

Volatile Organic Compounds (GC/MS) by Method 8260B

Analyte	Result mg/l	Qualifier	MDL mg/l	RDL mg/l	Dilution	Analysis date / time	Batch
sec-Butylbenzene	0.00331		0.000365	0.00100	1	05/02/2017 17:59	WG975483
Carbon disulfide	U		0.000275	0.00100	1	05/02/2017 17:59	WG975483
Carbon tetrachloride	U		0.000379	0.00100	1	05/02/2017 17:59	WG975483
Chlorobenzene	U		0.000348	0.00100	1	05/02/2017 17:59	WG975483
Chlorodibromomethane	U		0.000327	0.00100	1	05/02/2017 17:59	WG975483
Chloroethane	U		0.000453	0.00500	1	05/02/2017 17:59	WG975483
Chloroform	U		0.000324	0.00500	1	05/02/2017 17:59	WG975483
Chloromethane	U		0.000276	0.00250	1	05/02/2017 17:59	WG975483
1,2-Dibromoethane	U		0.000381	0.00100	1	05/02/2017 17:59	WG975483
1,1-Dichloroethane	U		0.000259	0.00100	1	05/02/2017 17:59	WG975483
1,2-Dichloroethane	U		0.000361	0.00100	1	05/02/2017 17:59	WG975483
1,1-Dichloroethene	U		0.000398	0.00100	1	05/02/2017 17:59	WG975483
cis-1,2-Dichloroethene	U		0.000260	0.00100	1	05/02/2017 17:59	WG975483
trans-1,2-Dichloroethene	U		0.000396	0.00100	1	05/02/2017 17:59	WG975483
1,2-Dichloropropane	U		0.000306	0.00100	1	05/02/2017 17:59	WG975483
cis-1,3-Dichloropropene	U		0.000418	0.00100	1	05/02/2017 17:59	WG975483
trans-1,3-Dichloropropene	U		0.000419	0.00100	1	05/02/2017 17:59	WG975483
Ethylbenzene	0.0532		0.000384	0.00100	1	05/02/2017 17:59	WG975483
Isopropylbenzene	0.0206		0.000326	0.00100	1	05/02/2017 17:59	WG975483
p-Isopropyltoluene	0.000554	J	0.000350	0.00100	1	05/02/2017 17:59	WG975483
2-Butanone (MEK)	U		0.00393	0.0100	1	05/02/2017 17:59	WG975483
2-Hexanone	U		0.00382	0.0100	1	05/02/2017 17:59	WG975483
Methylene Chloride	U		0.00100	0.00500	1	05/02/2017 17:59	WG975483
4-Methyl-2-pentanone (MIBK)	U		0.00214	0.0100	1	05/02/2017 17:59	WG975483
Methyl tert-butyl ether	3.99		0.0367	0.100	100	05/08/2017 01:06	WG975483
Naphthalene	0.0295		0.00100	0.00500	1	05/02/2017 17:59	WG975483
n-Propylbenzene	0.0338		0.000349	0.00100	1	05/02/2017 17:59	WG975483
Styrene	U		0.000307	0.00100	1	05/02/2017 17:59	WG975483
1,1,1,2-Tetrachloroethane	U		0.000385	0.00100	1	05/02/2017 17:59	WG975483
1,1,2,2-Tetrachloroethane	U		0.000130	0.00100	1	05/02/2017 17:59	WG975483
Tetrachloroethene	U		0.000372	0.00100	1	05/02/2017 17:59	WG975483
Toluene	0.153		0.000412	0.00100	1	05/02/2017 17:59	WG975483
1,1,1-Trichloroethane	U		0.000319	0.00100	1	05/02/2017 17:59	WG975483
1,1,2-Trichloroethane	U		0.000383	0.00100	1	05/02/2017 17:59	WG975483
Trichloroethene	U		0.000398	0.00100	1	05/02/2017 17:59	WG975483
1,2,4-Trimethylbenzene	0.0137		0.000373	0.00100	1	05/02/2017 17:59	WG975483
1,3,5-Trimethylbenzene	0.00348		0.000387	0.00100	1	05/02/2017 17:59	WG975483
Vinyl chloride	U		0.000259	0.00100	1	05/02/2017 17:59	WG975483
o-Xylene	0.0406		0.000341	0.00100	1	05/02/2017 17:59	WG975483
m&p-Xylene	0.0735		0.000719	0.00200	1	05/02/2017 17:59	WG975483
Xylenes, Total	0.114		0.00106	0.00300	1	05/02/2017 17:59	WG975483
(S) Toluene-d8	*101*			*80.0-120*		*05/03/2017 23:07*	WG975483
(S) Toluene-d8	*103*			*80.0-120*		*05/02/2017 17:59*	WG975483
(S) Toluene-d8	*106*			*80.0-120*		*05/08/2017 01:06*	WG975483
(S) Dibromofluoromethane	*75.6*	J2		*76.0-123*		*05/02/2017 17:59*	WG975483
(S) Dibromofluoromethane	*104*			*76.0-123*		*05/08/2017 01:06*	WG975483
(S) Dibromofluoromethane	*113*			*76.0-123*		*05/03/2017 23:07*	WG975483
(S) 4-Bromofluorobenzene	*92.7*			*80.0-120*		*05/03/2017 23:07*	WG975483
(S) 4-Bromofluorobenzene	*102*			*80.0-120*		*05/08/2017 01:06*	WG975483
(S) 4-Bromofluorobenzene	*102*			*80.0-120*		*05/02/2017 17:59*	WG975483

Semi-Volatile Organic Compounds (GC) by Method 3511/8015

Analyte	Result mg/l	Qualifier	MDL mg/l	RDL mg/l	Dilution	Analysis date / time	Batch
TPH (GC/FID) High Fraction	1.77		0.0247	0.100	1	05/02/2017 21:30	WG975552
(S) o-Terphenyl	*78.5*			*31.0-160*		*05/02/2017 21:30*	WG975552

1 Cp
2 Tc
3 Ss
4 Cn
5 Sr
6 Qc
7 Gl
8 Al
9 Sc

Appendix C

Class V Well Pre-Closure Notification Form

United States Environmental Protection Agency

UIC Federal Reporting System

Class V Well Pre-Closure Notification Form

1. **Name of facility:** HollyFrontier Navajo Refining LLC

   Address of facility: 501 E Main

   City/Town: Artesia **State:** New Mexico **Zip Code:** 88210

   County: Eddy **Location:** -104.3857337880 N **Lat./Long.:** 32.84384946550 W

2. **Name of Owner/Operator:** HollyFrontier Navajo Refining LLC

   Address of Owner/Operator: 501 E Main

   City/Town: Artesia **State:** New Mexico **Zip Code:** 88210

   Legal contact: Scott Denton **Phone number:** 575-746-5487

3. **Type of well(s):** In Situ Groundwater Remediation Injection Well **Number of well(s):** 2

4. **Well construction (check all that apply):**

☐ **Drywell** ☐ **Septic tank** ☐ **Cesspool**

☐ **Improved sinkhole** ☐ **Drainfield/leachfield** ☒ **Other**

5. **Type of discharge:** Recirculation of recovered groundwater amended with nutrients

6. **Average flow (gallons/day):** 24 (12 each well) 7. **Year of well construction:** 2019 (Proposed)

8. **Type of well closure (check all that apply):**

☐ **Sample fluids/sediments** ☐ **Clean out well**

☒ **Appropiate disposal of remaining fluids/sediments** ☐ **Install permanent plug**

☒ **Remove well & any contaminated soil** ☐ **Conversion to other well type**

☐ **Other (describe):**

9. **Proposed date of well closure:** June 30, 2021

10. **Name of preparer:** Jason Leik, P.E. **Date:** April 12, 2019

Certification

I certify under the penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment. (Ref. 40 CFR 144.32).

Name and Official Title (*Please type or print*)	Signature	Date Signed

INSTRUCTIONS FOR EPA FORM 7520-17

This form contains the minimum information that you must provide your UIC Program Director if you intend to close your Class V well. This form will be used exclusively where the EPA administers the UIC Program: AK, AS, AZ, CA, CO, DC, DE, HI, IA, IN, KY, MI, MN, MT, NY, PA, SD, TN, VA, VI, and on all Tribal Lands. If you are located in a different State or jurisdiction, ask the agency that administers the UIC Program in your State for the appropriate form.

If you are closing two or more Class V wells that are of similar construction at your facility (two dry wells, for example) you may use one form. If you are closing Class V wells of different construction (a septic system and a dry well, for example) use one form per construction type.

The numbers below correspond to the numbers on the form.

1. **Supply the name and street address of the facility where the Class V well(s) is located. Include the City/Town, State (U.S. Postal Service abbreviation) and Zip Code. If there is no street address for the Class V well, provide the route number or locate the well(s) on a map and attach it to this form. Under "Location," provide the Latitude/Longitude of the well, if available.**

2. **Provide the name and mailing address of the owner of the facility, or if the facility is operated by lease, the operator of the facility. Include the name and phone number of the legal contact for any questions regarding the information provided on this form.**

3. **Indicate the type of Class V well that you intend to close (for example, motor vehicle waste disposal well or cesspool). Provide the number of wells of this well type at your location that will be closed.**

4. **Mark an "X" in the appropriate box to indicate the type of well construction. Mark all that apply to your situation. For example, for a septic tank that drains into a drywell, mark both the "septic tank" and "drywell" boxes. Please provide a generalized sketch or schematic of the well construction if available.**

5. **List or describe the types of fluids that enter the Class V well. If available, attach a copy of the chemical analysis results and/or the Material Safety Data Sheets for the fluids that enter the well.**

6. **Estimate the average daily flow into the well in gallons per day.**

7. **Provide the year that the Class V well was constructed. If unknown, provide the length of time that your business has been at this location and used this well.**

8. **Mark an "X" in the appropriate box(s) to indicate briefly how the well closure is expected to proceed. Mark all that apply to your situation. For example, all boxes except the "Remove well & any contaminated soil" and "Other" would be marked if: the connection of an automotive service bay drain leading to a septic tank and drainfield will be closed, but the septic system will continue to be used for washroom waste disposal only, and the fluids and sludge throughout the system will be removed for proper disposal, the system cleaned, a cement plug placed in the service bay drain and the pipe leading to the washroom connection, and the septic tank/drainfield remains open for septic use only. In this example, the motor vehicle waste disposal well is being converted to another well type (a large capacity septic system).**

9. **Self explanatory.**

10. **Self explanatory.**

PLEASE READ . . .

The purpose of this form is to serve as the means for the Class V well owner or operator's notice to the UIC Director of his/her intent to close the well in accordance with Title 40 of the Code of Federal Regulations (40 CFR) Section 144.12(a). According to 40 CFR §144.86, you must notify the UIC Program Director at least 30 days prior to well closure of your intent to close and abandon your well. Upon receipt of this form, if the Director determines that more specific information is required to be submitted to ensure that the well closure will be conducted in a manner that will protect underground sources of drinking water (as defined in 40 CFR §144.3), the Director can require the owner/operator to prepare, submit and comply with a closure plan acceptable to, and approved by the Director.

Please be advised that this form is intended to satisfy Federal UIC requirements regarding pre-closure notification only. Other State, Tribal or Local requirements may also apply.

Paper Work Reduction Act Notice

The public reporting and record keeping burden for this collection of information is estimated to average 1.5 hours per respondent. Burden means the total time, effort, or financial resources expended by persons to generate, maintain, retain, or disclose or provide information to or for a Federal agency. This includes the time needed to review instructions, develop, acquire, install, and utilize technology and systems for the purposes of collecting, validating, and verifying information, processing and maintaining information, and disclosing and providing information, adjust the existing ways to comply with any previously applicable instructions and requirements; train personnel to be able to respond to a collection of information; search data sources; complete and review the collection of information; and transmit or otherwise disclose the information. An agency may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid OMB control number.

Send comments on the Agency's need for this information, the accuracy of the provided burden estimates, and any suggested methods for minimizing respondent burden, including thorough the use of automated collection techniques to the Director, Regulatory information Division, U.S. Environmental Protection Agency (2137), 401 M. Street, S.W., Washington, D.C. 20460. Include the OMB control number in any correspondence. Do not send the completed form to this address.

Chavez, Carl J, EMNRD

From: Chavez, Carl J, EMNRD
Sent: Thursday, February 14, 2019 2:38 PM
To: 'Combs, Robert'
Cc: Sanchez, Daniel J., EMNRD; Griswold, Jim, EMNRD; Tsinnajinnie, Leona, NMENV
Subject: Artesia Refinery (GW-28) Field Pilot Injection Well Study
Attachments: C-108.pdf; r5-uic-class-5-inventory-form.pdf

Robert:

GW-28: Class V Other Injection Well: Pilot Study will construct an in-situ ground water remediation well used to inject a fluid (magnesium sulfate and nutrients) that facilitates vadose zone or ground water remediation (WQCC Reg. 20.6.2.5002.B5dii NMAC)

For the pilot project injection well, OCD needs the following forms and/or one document that provides injection well related information:

1) C-108 Form (See attachment: Only applicable sections from the form need to be completed)
2) Class V Well Inventory Form (See attachment: Only applicable sections from the form need to be completed).

Please contact me if you have questions or need to narrow down a submittal that will address both types of form information for OCD's UIC Program.

Thank you.

Mr. Carl J. Chavez, CHMM (#13099)
New Mexico Oil Conservation Division
Energy Minerals and Natural Resources Department
1220 South St Francis Drive
Santa Fe, New Mexico 87505
Ph. (505) 476-3490
E-mail: CarlJ.Chavez@state.nm.us
"Why not prevent pollution, minimize waste to reduce operating costs, reuse or recycle, and move forward with the rest of the Nation?" (To see how, go to: http://www.emnrd.state.nm.us/OCD and see "Publications")

From: Combs, Robert <Robert.Combs@HollyFrontier.com>
Sent: Thursday, February 14, 2019 1:17 PM
To: Griswold, Jim, EMNRD <Jim.Griswold@state.nm.us>; Chavez, Carl J, EMNRD <CarlJ.Chavez@state.nm.us>; Cobrain, Dave, NMENV <dave.cobrain@state.nm.us>; Tsinnajinnie, Leona, NMENV <Leona.Tsinnajinnie@state.nm.us>
Cc: Holder, Mike <Michael.Holder@hollyfrontier.com>; Denton, Scott <Scott.Denton@HollyFrontier.com>
Subject: [EXT] RE: proposed agenda - discussion 2/13/19

All – thank you all for discussing these items with us yesterday. Please see below for our notes from the discussion. If there are any items that need to be added, please reply w/details. As mentioned, we intend to have documents submitted by end of March, which we will be discussing with you along the way (e.g., well locations, COC, etc.).

Thanks,

Robert

Meeting/Call Notes from 2/13/19

Pilot Test WP

- Walked thru agenda with questions along the way – will show below as captured from each person. The following are not sequential pieces from the discussion.
    - OCD Comments (Carl)
        - Will need to provide appropriate forms for installing the injection well and reporting forms (cited C-138)
        - WP will need to provide anticipated injection volumes/rates, depths and locations of all wells utilized to monitor the test
    - HWB Comments (Dave)
        - Asked if we were to perform bench scale – MH response: no, more and better info from pilot
        - Dave says Investigation WP outline is fine, but need to include sections to cover scope for 'aquifer test' and gather data to monitor and determine GW flow
        - Wants amended/injected water to be representative of water quality at fenceline (near injection point). Include assessment of current conditions vs. water quality injected. Determine baseline conditions in existing/new monitor wells before beginning pilot, possibly a few rounds of sampling to establish baseline at injection and monitoring points.
        - In scope, would like explanation for our recommended approach for determining amendment injection rates and when adjustments are needed
        - For review time, says they'll prioritize
        - They're available for call/WebEx to discuss WP as we get closer to finalizing for submittal

    - Mike H Comments
        - HF to set up a WebEx (or other) to discuss analyte list and monitoring locations proposed prior to submittal; this will ensure we address Dave's concern that monitoring locations are close enough to get data/see change in reasonable time period.

VI/Receptor Study

- Walked thru agenda with questions along the way – will show below as captured from each person – as above
    - HWB Comments (Dave)
        - Review and follow NMED VI guidance; if our tabletop indicates a complete pathway, report findings, recommendations for investigation (WP to follow); testing (modeling, soil gas, etc.) – OCD (JG) agrees
        - Wants the bz at the property line to reach target screening levels
    - OCD (Carl)
        - Suggested area of interest selection – consider worst case indicator (suggested SO4, Cl)

Robert Combs
Environmental Specialist
The HollyFrontier Companies
P.O. Box 159

Artesia, NM 88211-0159
office: 575-746-5382
cell: 575-308-2718
fax: 575-746-5451
Robert.Combs@hollyfrontier.com

From: Combs, Robert
Sent: Tuesday, February 12, 2019 4:22 PM
To: Griswold, Jim, EMNRD; Carl (CarlJ.Chavez@state.nm.us); Dave Cobrain (dave.cobrain@state.nm.us); Leona Tsinnajinnie (Leona.Tsinnajinnie@state.nm.us)
Cc: Holder, Mike; Denton, Scott
Subject: proposed agenda - discussion 2/13/19

All – Please see below for the proposed agenda for tomorrow's meeting. I'll bring some copies. If there are other topics to discuss, please let us know.
Thanks,
Robert

Draft Agenda – OCD Meeting/NMED Call – Feb 12, 2019

Potential Vapor Intrusion Review and Potential Receptor Review

- Approach
    - water supplies, water distribution, water wells (purpose of use) in the area of interest
    - review soil boring logs – lithology, depth to water/plume(s)
    - review plume maps, COCs
    - residential or business locations relative to plume(s)
    - review monitoring network and program for potential modifications
- Deliverable
    - Report to agencies by 3/29/19

Pilot Test Workplan

- Approach
    - Investigation WP outline (from RCRA permit 2010).
    - Evaluate groundwater quality and dosing for magnesium sulfate and nutrients.
    - Install new injection and monitoring points as needed based (considering MW-66, MW-128, and MW-131 area).
    - Perform injection test, optimize pilot test injection well design and confirm full scale system update design. Will install required equipment.
    - Monitoring to include: potentiometric monitoring (injection well, surrounding monitoring wells), sampling of injectate and groundwater from down gradient monitoring wells (12-18 months).
    - Evaluate effectiveness of amendments and gradient control.
- Deliverable
    - Report to agencies by 3/29/19

Other Issues:

- Update on refinery water sales

- NMED – Regulations Updates (fees) – in review
- OCD – Lov LNAPL Updates
- OCD – Spill Rule Closure Items

Robert Combs
Environmental Specialist
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P.O. Box 159
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STATE OF NEW MEXICO
ENERGY, MINERALS AND NATURAL
RESOURCES DEPARTMENT

Oil Conservation Division
1220 South St. Francis Dr.
Santa Fe, New Mexico 87505

FORM C-108
Revised June 10, 2003

APPLICATION FOR AUTHORIZATION TO INJECT

I. PURPOSE: __________Secondary Recovery _________Pressure Maintenance _________Disposal _________Storage
Application qualifies for administrative approval? __________Yes __________No

II. OPERATOR: ______________________________

ADDRESS: ______________________________

CONTACT PARTY: ______________________________PHONE: ______________

III. WELL DATA: Complete the data required on the reverse side of this form for each well proposed for injection.
Additional sheets may be attached if necessary.

IV. Is this an expansion of an existing project? __________Yes __________No
If yes, give the Division order number authorizing the project: ______________________________

V. Attach a map that identifies all wells and leases within two miles of any proposed injection well with a one-half mile radius circle drawn around each proposed injection well. This circle identifies the well's area of review.

VI. Attach a tabulation of data on all wells of public record within the area of review which penetrate the proposed injection zone. Such data shall include a description of each well's type, construction, date drilled, location, depth, record of completion, and a schematic of any plugged well illustrating all plugging detail.

VII. Attach data on the proposed operation, including:

1. Proposed average and maximum daily rate and volume of fluids to be injected;
2. Whether the system is open or closed;
3. Proposed average and maximum injection pressure;
4. Sources and an appropriate analysis of injection fluid and compatibility with the receiving formation if other than reinjected produced water; and,
5. If injection is for disposal purposes into a zone not productive of oil or gas at or within one mile of the proposed well, attach a chemical analysis of the disposal zone formation water (may be measured or inferred from existing literature, studies, nearby wells, etc.).

*VIII. Attach appropriate geologic data on the injection zone including appropriate lithologic detail, geologic name, thickness, and depth. Give the geologic name, and depth to bottom of all underground sources of drinking water (aquifers containing waters with total dissolved solids concentrations of 10,000 mg/l or less) overlying the proposed injection zone as well as any such sources known to be immediately underlying the injection interval.

IX. Describe the proposed stimulation program, if any.

*X. Attach appropriate logging and test data on the well. (If well logs have been filed with the Division, they need not be resubmitted).

*XI. Attach a chemical analysis of fresh water from two or more fresh water wells (if available and producing) within one mile of any injection or disposal well showing location of wells and dates samples were taken.

XII. Applicants for disposal wells must make an affirmative statement that they have examined available geologic and engineering data and find no evidence of open faults or any other hydrologic connection between the disposal zone and any underground sources of drinking water.

XIII. Applicants must complete the "Proof of Notice" section on the reverse side of this form.

XIV. Certification: I hereby certify that the information submitted with this application is true and correct to the best of my knowledge and belief.

NAME: ______________________________TITLE: ______________

SIGNATURE: ______________________________DATE: ______________

E-MAIL ADDRESS: ______________________________

* If the information required under Sections VI, VIII, X, and XI above has been previously submitted, it need not be resubmitted.
Please show the date and circumstances of the earlier submittal: ______________________________

DISTRIBUTION: Original and one copy to Santa Fe with one copy to the appropriate District Office

III. WELL DATA

A. The following well data must be submitted for each injection well covered by this application. The data must be both in tabular and schematic form and shall include:

(1) Lease name; Well No.; Location by Section, Township and Range; and footage location within the section.

(2) Each casing string used with its size, setting depth, sacks of cement used, hole size, top of cement, and how such top was determined.

(3) A description of the tubing to be used including its size, lining material, and setting depth.

(4) The name, model, and setting depth of the packer used or a description of any other seal system or assembly used.

Division District Offices have supplies of Well Data Sheets which may be used or which may be used as models for this purpose. Applicants for several identical wells may submit a "typical data sheet" rather than submitting the data for each well.

B. The following must be submitted for each injection well covered by this application. All items must be addressed for the initial well. Responses for additional wells need be shown only when different. Information shown on schematics need not be repeated.

(1) The name of the injection formation and, if applicable, the field or pool name.

(2) The injection interval and whether it is perforated or open-hole.

(3) State if the well was drilled for injection or, if not, the original purpose of the well.

(4) Give the depths of any other perforated intervals and detail on the sacks of cement or bridge plugs used to seal off such perforations.

(5) Give the depth to and the name of the next higher and next lower oil or gas zone in the area of the well, if any.

XIV. PROOF OF NOTICE

All applicants must furnish proof that a copy of the application has been furnished, by certified or registered mail, to the owner of the surface of the land on which the well is to be located and to each leasehold operator within one-half mile of the well location.

Where an application is subject to administrative approval, a proof of publication must be submitted. Such proof shall consist of a copy of the legal advertisement which was published in the county in which the well is located. The contents of such advertisement must include:

(1) The name, address, phone number, and contact party for the applicant;

(2) The intended purpose of the injection well; with the exact location of single wells or the Section, Township, and Range location of multiple wells;

(3) The formation name and depth with expected maximum injection rates and pressures; and,

(4) A notation that interested parties must file objections or requests for hearing with the Oil Conservation Division, 1220 South St. Francis Dr., Santa Fe, New Mexico 87505, within 15 days.

NO ACTION WILL BE TAKEN ON THE APPLICATION UNTIL PROPER PROOF OF NOTICE HAS BEEN SUBMITTED.

NOTICE: Surface owners or offset operators must file any objections or requests for hearing of administrative applications within 15 days from the date this application was mailed to them.

INJECTION WELL DATA SHEET

OPERATOR: ______________________________

WELL NAME & NUMBER: ______________________________

WELL LOCATION: ______________________________

FOOTAGE LOCATION | UNIT LETTER | SECTION | TOWNSHIP | RANGE

WELLBORE SCHEMATIC

WELL CONSTRUCTION DATA

Surface Casing

Hole Size: ________________ Casing Size: ________________

Cemented with: ____________ sx. ***or*** ________________ ft^3

Top of Cement: ________________ Method Determined: ____________

Intermediate Casing

Hole Size: ________________ Casing Size: ________________

Cemented with: ____________ sx. ***or*** ________________ ft^3

Top of Cement: ________________ Method Determined: ____________

Production Casing

Hole Size: ________________ Casing Size: ________________

Cemented with: ____________ sx. ***or*** ________________ ft^3

Top of Cement: ________________ Method Determined: ____________

Total Depth: ________________

Injection Interval

________________ feet to ________________

(Perforated or Open Hole; indicate which)

INJECTION WELL DATA SHEET

Tubing Size: ______________________________ Lining Material: ______________________________

Type of Packer: ____

Packer Setting Depth: ______________________

Other Type of Tubing/Casing Seal (if applicable): ____

Additional Data

1. Is this a new well drilled for injection? _______Yes _______No

   If no, for what purpose was the well originally drilled? ____________________________________

   ____

2. Name of the Injection Formation: ____

3. Name of Field or Pool (if applicable): ____

4. Has the well ever been perforated in any other zone(s)? List all such perforated intervals and give plugging detail, i.e. sacks of cement or plug(s) used. ______________________

   ____

5. Give the name and depths of any oil or gas zones underlying or overlying the proposed injection zone in this area: ____

   ____

   ____

   ____

FOR SAMPLE USE ONLY – COMPARABLE FORMAT ACCEPTABLE

UNDERGROUND DISCHARGE SYSTEM (CLASS V) INVENTORY SHEET

(see instructions on back)

1. Name of facility: ____________________

   Address of facility: ____________________

   City/Town: ____________________ State: ________ Zip Code: ________

   County: ____________________ Location: ____________________

   ____

   Contact Person: ____________________ Phone Number: ____________________

2. Name of Owner or Operator: ____________________

   Address of Owner or Operator: ____________________

   City/Town: ____________________ State: ________ Zip Code: ________

---

3. Type & number of system(s): _____Drywell(s) _____Septic System(s) _____Other(describe): ____________
   Attach a schematic of the system. Attach a map or sketch of the location of the system at the facility.

4. Source of discharge into system: ____________________

   ____

   ____

5. Fluids discharged: ____________________

   ____

   ____

6. Treatment before discharge: ____________________

   ____

   ____

7. Status of underground discharge system: ☐ Existing ☐ Unused/Abandoned ☐ Under Construction ☐ Proposed

   Approved/Permitted by: ____________________ Date constructed: ____________

CERTIFICATION

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment. (Ref. 40 CFR 144.32).

Signature: ____________________ Date: ____________

Name (printed): ____________________

Official Title: ____________________

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5

UNDERGROUND DISCHARGE SYSTEM (CLASS V) INVENTORY SHEET INSTRUCTIONS

Complete one sheet for each different kind of underground discharge or drainage system (Class V well) at your facility or location. For example, several storm water drainage wells of a similar construction can all go on one sheet. Another example could be a business with a single septic system (septic tank with drainfield) that accepts fluids from a paint shop sink in one area, their vehicle maintenance garage floor drains in another area and also serves the employee kitchenette and washroom: this can all go on one form.

The numbers below correspond to the numbers on the front of the sheet.

1. Supply the name and street address of the facility where the Class V well(s) is located. Please be sure to include the County name. If available, provide the Latitude/Longitude of the discharge system. If there is no street address for the discharge system(s), provide a description of the location and show the location on a map. Include the name and phone number of a person to contact if there are any questions regarding the underground discharge system(s) and/or the wastewaters discharged at the facility.

2. Provide the name and mailing address of the owner of the facility or if the facility is operated by lease, the operator of the facility.

3. Provide the number of underground discharge systems at the facility (or location) for the type of system that is described on this sheet. Please use a separate sheet for each different type of system present. If the type of system is "Other", please describe (e.g., french drain, leachfield, improved sinkhole, cesspool, etc.).

   Provide a sketch, diagram or blueprints of the construction of the system including the depth below the ground surface that the fluids are released into the soil, sediment or formation. Also provide a map or sketch of the layout of the pluming or drainage system, including all the connections, and if applicable, indicate each fluid source connection (i.e., floor drains, shop sink, process tank discharge, restrooms, etc.) and any pre-treatment, etc.

4. Describe the kind of business practice that generates the fluids being discharged into the underground system (e.g., body shop, drycleaner, carwash, print shop, restaurant, etc.), and/or if more appropriate, the source of the fluids (e.g., employee & customer restrooms, parking lot drainage, etc.). If available, include the Standard Industrial Classification (SIC) Codes for this facility.

5. List the kinds of fluids that can enter the underground system (e.g., storm water run-off, sanitary waste, solvents, biodegradable soap wash & rinse water, snowmelt from trucks, photo developing fluids, ink, paint & thinner, non-contact cooling water, etc.). Please be as specific as you can about the kinds of fluids or products that can be drained into the system. Generally, good sources for this information are the Material Safety Data Sheets (MSDS) (copies of MSDS could be attached instead of listing all the products). If available, also attach a copy of any chemical analysis for the fluids discharged.

6. Describe the kinds of treatment (if any) that the fluids go through before disposal. Examples of treatment are: grease trap, package plant, oil/water separator, catch basin, metal recovery unit, sand filter, grit cleanser, etc.

7. Select the status of the underground discharge system and include the date the system was constructed. If the status is “Existing” but it is not being used, is unusable, will not be used, or is temporarily abandoned, mark the box for “Unused/Abandoned”. If state or local government approval was given for construction of the system, or a permit was issued for the system, please provide the name of the approving authority. Provide an estimated date of construction if the actual date is unknown.

The person signing the submittal should read the certification statement before signing and dating the sheet.

If you have any questions about whether or not you may have an EPA regulated system, or about how to complete this sheet, please call (312) 886-1492. You may also try our website at www.epa.gov/r5water/uic/uic.htm for information.

Please send completed sheets to: U.S. EPA Region 5
Underground Injection Control Branch
ATTN: Lisa Perenchio (WU-16J)
77 W. Jackson Blvd.
Chicago, IL 60604

8/02