MARATHON

**Western Refining Southwest LLC**
A subsidiary of Marathon Petroleum Corporation
I-40 Exit 39
Jamestown, NM 87347

January 26, 2024

Mr. Ricardo Maestas, Acting Chief
New Mexico Environment Department
Hazardous Waste Bureau
2905 Rodeo Park Drive East, Building 1
Santa Fe, NM 87505

**RE: Response to Disapproval**
**Area of Concern 15 – New API Separator and Area of Concern 16 – New API Separator Overflow Tanks Investigation Work Plan**
**Western Refining Southwest LLC, D/B/A Marathon Gallup Refinery**
**EPA ID #NMD000333211**
**HWB-WRG-22-004**

Dear Mr. Maestas:

Attached please find the response to comments contained in the New Mexico Environment Department Disapproval letter dated October 31, 2023 regarding the Response to Disapproval, Area of Concern (AOC) 15 – New American Petroleum Institute (API) Separator and AOC 16 – New API Separator Overflow Tanks Investigation Revised Work Plan. A timeline of the AOC 15 and AOC 16 Investigation Work Plan is provided below:

- Investigation Report, submitted March 31, 2022
- Disapproval, received August 22, 2022
- Response to Disapproval, submitted May 24, 2023
- Second Disapproval, received October 31, 2023

Two hard copies and an electronic version of the revised Work Plan are included. A redline-strikeout version in electronic format is also included.

If you have any questions or comments regarding the information contained herein, please do not hesitate to contact Mr. John Moore at (505) 879-7643 or Ms. Kateri Luka at (714) 713-1218.

**Western Refining Southwest LLC**
A subsidiary of Marathon Petroleum Corporation
I-40 Exit 39
Jamestown, NM 87347

## Certification

*I certify under penalty of law that this document and all attachments were prepared under my direction of supervision according to a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.*

Sincerely,
Western Refining Southwest LLC, D/B/A Marathon Gallup Refinery

Timothy J. Peterkoski
Director of Environment and Climate Strategy

Enclosure

cc:
L. Andress, NMED HWB
M. Suzuki, NMED HWB
L. Barr, NMOCD
K. Luka, Marathon Petroleum Corporation
L. King, EPA Region 6
N. Dhawan, NMED HWB
J. Moore, Marathon Gallup Refinery
H. Jones, Trihydro Corporation

# ATTACHMENT A

# RESPONSE TO COMMENTS

# New Mexico Environment Department (NMED) to Western Refining Southwest LLC (Western) Comment Letter "Second Disapproval, Area of Concern 15 – New API Separator and Area of Concern 16 – New API Separator Overflow Tanks Investigation Work Plan" (October 31, 2023)

| NMED Comment | Western Response |
|---|---|
| **Comment 1:** | **Response 1:** |
| In the response to NMED's Disapproval Comment 1, the Permittee states, "[a]ny water observed in the East Bay is the result of accumulated precipitation." According to the 2022 Groundwater Monitoring Report (2022 Report), the benzene concentrations in the wastewater samples collected from the East leak detection unit (LDU) significantly exceeded the screening level of 5 µg/L during all quarters of 2022. The wastewater samples collected in the East LDU are unlikely a result of rainwater accumulated in the East Bay due to the presence of multiple constituents. Reevaluate the cause of detection of fluids in the East Bay and provide a discussion in the revised Work Plan. | The Refinery believes that the water observed in the East Bay is the result of rainwater. On November 28, 2023, a sample was collected from the East Bay and analyzed for several constituents, including benzene which was non-detect with a reporting limit of 1 microgram per Liter (µg/L). This indicates that the secondary containment is intact and not contributing to contamination in the east LDU The Refinery believes that the East Leak Detection Unit (LDU) concentrations are due to nearby groundwater infiltrating the LDU rather than water from the East Bay. Analytical results from this sampling are provided in Attachment D. |
| **Comment 2:** | **Response 2:** |
| In the response to NMED's Disapproval Comment 1, the Permittee states, "the higher water head in the West Bay would drive more fluid into the interstitial space of the West Bay, which is connected to the West LDU. In contrast, the East Bay, was empty, and any recharge was limited to drainage of the interstitial space." Address the following:<br>a) The Depth to Water (DTW) readings from the LDUs are not included in the 2022 Annual Report. All future annual groundwater monitoring reports must include DTW readings collected from the LDUs. Acknowledge this provision in the response letter.<br>b) Although the Permittee's response provides the basis for the slower recharge rate for the East LDU under current conditions, it does not provide any discussion for switching the New American Petroleum Institute Separator (NAPIS) operation from the West to the East Bay, as required by Comment 1. Include the required discussion in the revised Work Plan and propose to investigate the recharge rates for both LDUs | a) If depth to water readings are collected from the LDUs, this information will be included in future annual groundwater monitoring reports.<br>b) The Refinery acknowledges no discussion was provided for switching New American Petroleum Institute Separator (NAPIS) operation from the West to the East Bay as currently there are no plans for the Refinery to operate the East Bay. To bring the East Bay back into service would require a large effort and based on current operating conditions, only one Bay is necessary to run the wastewater treatment facility. Therefore, the Work Plan will only use the West Bay during this investigation and there is no need to investigate the recharge rates at this time. |

| NMED Comment | Western Response |
|---|---|
| under comparable conditions (e.g., equal head) in the revised Work Plan. | |
| **Comment 3:** | **Response 3:** |
| In the response to NMED's Disapproval Comment 4, Phase 1 and Phase 2, Step 2c, the Permittee states, "[t]he first phase will include sampling groundwater in the area to establish background levels of naturally occurring bromide. The second phase will include bromide tracer testing by adding a solution of sodium bromide to the NAPIS Bays and monitor the surrounding area for the increased presence of Bromide and [b]romide tracer testing will be conducted in each of the NAPIS Bays using a solution of bromide with a concentration of 10 milligrams per liter (mg/L) and monitoring the areas surrounding the unit for the increased presence of bromide, [and a]fter first bi-weekly sampling, the inactive East NAPIS Bay will be filled with water and the same amount of sodium bromide will be added to the East Bay to achieve a concentration of 10 mg/L of bromide." Address the following:<br>a) Bromide has been detected in the samples collected from multiple wells within the facility. The bromide concentrations were previously reported as greater than 100 mg/L in some of the samples collected from the evaporation ponds. The initial bromide concentration in the NAPIS Bay must be notably higher than the background concentration in order to accommodate dilution with the surrounding groundwater. If the background bromide concentration exceeds the detection limit (i.e., 0.05 mg/L), a tracer chemical other than bromide may be more appropriate for use. Include this provision in the revised Work Plan.<br>b) Since the use of the same tracer chemical (i.e., bromide) in both East and West Bays will not identify leakage specific to each Bay, it is more appropriate to use separate tracer chemicals for each Bay. For example, | a) Elevated bromide concentrations are expected in the evaporation ponds due to the concentrating effects of the evaporation process. Evaporation of the discharged water would result in higher concentrations of salts in the area. This investigation is not concerned with concentrations in the evaporation ponds, rather locations near the NAPIS. Locations downgradient of the NAPIS will be sampled in Phase I of the investigation to verify that the proposed concentration of 1,000 milligrams per liter (mg/L) is sufficient for other monitoring wells. The Refinery is proposing to increase the concentration of bromide to 1,000 mg/L, as described in Comment 12. It has also been proposed to detect a concentration of 10 mg/L bromide in downgradient wells to reduce the chance of detecting background concentrations.<br>b) The Refinery acknowledges that it could be difficult to discern where increased concentrations of bromide may be coming from if both the East and West Bays were tested with the same tracer chemical. However, as previously discussed in Comment 1, it is unlikely the East Bay will come back into service from the Refinery's present idled state. The Refinery is proposing to complete bromide tracer testing solely in the West Bay to determine the integrity of the Bay. If the Refinery were to decide to put the East Bay into operation, the East Bay will be tested to determine the integrity of the Bay prior to operation. |

| NMED Comment | Western Response |
|---|---|
| iodide and hydrogen borate can also be used as water tracers. Propose to use a different tracer for the East Bay in the revised Work Plan. | |
| **Comment 4:** | **Response 4:** |
| In the response to NMED's Disapproval Comment 4, Phase 2, the Permittee states, "536 grams of sodium bromide will be added [in] 11,000 gallons of water in the active West NAPIS Bay and dissolved into solution, to achieve a concentration of 10 mg/L of bromide, as shown in Appendix A." Address the following:<br>a) The NAPIS is likely to be operating while the tracer test is being conducted. If so, the Bay will not be a closed batch system (i.e., holds constant volume and concentration of the tracer solution). Since the calculation shown in Appendix A (Bromide Concentration Calculation) assumes that the Bay is a closed batch system, the calculation in Appendix A must be revised to account for the retention time of the wastewater in the NAPIS Bay. Revise the Work Plan accordingly.<br>b) Since the retention time of the wastewater in the NAPIS Bay is likely to be very short (e.g., one minute), all of the tracer chemical amended to the wastewater in the NAPIS Bay will almost instantaneously be drained out of the Bay and will temporarily be stored in Tank 35 before the wastewater is treated in the sanitary treatment pond (STP-1). Include a provision to collect wastewater samples from Tank 35 for the tracer chemical analysis during the duration of the tracer test in the revised Work Plan.<br>c) A single tracer amendment event will not provide any meaningful test result because the retention time of the wastewater in the Bay is likely to be very short. In order to provide a sufficient retention time for the tracer solution in the Bay, the NAPIS operation may need to be halted during the entire duration of the tracer test; otherwise, the concentrated | a) The Refinery has taken this into consideration and the West Bay and the wastewater treatment facility will be taken out of service for the duration of this investigation and wastewater will be held in Tank 35 for storage, until the investigation is complete. Tank 35 has an approximate capacity of one million gallons and is capable to handle the wastewater that will be generated at the Refinery during the test. This will ensure that the West Bay operates as a closed batch system. No revisions to the Work Plan have been made. Following completion of the investigation, wastewater will then be returned to the wastewater treatment facility.<br>b) As stated above the West Bay will be taken out of service for this investigation, making it a closed batch system.<br>c) The concentrated tracer solution will not to be continuously amended per the above statements. |

| NMED Comment | Western Response |
|---|---|
| tracer chemical solution must be continuously amended to the Bay so that the initial concentration of the tracer chemical (i.e., $C_1$ as discussed in the NMED's Disapproval Comment 6 can be maintained.<br>NMED understands that halting the NAPIS operation for the entire duration of the tracer test may not be plausible and that the Permittee may need to continuously amend the tracer to the Bay. If the concentrated tracer chemical solution will continuously be amended to the Bay, provide a detailed description about the method to maintain the initial concentration ($C_1$) in the Bay (e.g., procedures and design calculation) in the revised Work Plan. | |
| **Comment 5:** | **Response 5:** |
| In the response to NMED's Disapproval Comment 4, Phase 2, Step 1, the Permittee states, "[u]p to five 2-inch polyvinyl chloride (PVC) temporary bromide monitoring wells may be installed along the west wall of the NAPIS (Figure 4). These locations may be adjusted slightly to the west to maximize the potential for intercepting bromide." Address the following:<br>a) NMED's Disapproval Comment 4 states, "if the temporary wells are located too close to the NAPIS wall, potential breakthrough may not be detected because the location of a potential leak (e.g., holes, cracks) may not be aligned with the groundwater flow path (e.g., cross-gradient from potential leak locations). Therefore, it is important that the temporary wells be sufficiently distanced from the westside of the NAPIS wall to detect potential breakthrough. The minimum distance from the temporary wells necessary from the NAPIS wall must be evaluated and discussed in the revised Work Plan." According to Figure 4 (Proposed Bromide Monitoring Well and Sampling Locations), the proposed tracer monitoring wells are located directly adjacent to the | a) The Refinery is of the opinion that the location of the temporary wells are not too close to the west wall of the NAPIS, and furthermore the placement of these wells is constrained by existing infrastructure. In addition, there are three permanent monitoring wells (NAPIS-2, NAPIS-3, and KA-3) located downgradient of the NAPIS that will be monitored to detect potential breakthrough. These wells are approximately 15 feet (ft) west from the west wall of the NAPIS as shown in Figure 4.<br>b) In order to ensure that there is enough coverage, a total of 8 wells will be used for sampling during the test. No modeling is proposed at this time. Figure 4 depicts the five temporary monitoring wells, three shallow vadose and two monitoring wells. Two of the three shallow vadose wells will be installed in the same boring as the groundwater well as indicated in Figure 4. These will be installed in between the NAPIS wall and the three permanent monitoring wells to the west, providing a total of eight wells to sample from. Figure 4 has been updated to include the three permanent monitoring wells. Section 4.2, |

| NMED Comment | Western Response |
|---|---|
| West Bay. It appears that NMED's comment was not addressed in the Work Plan. Explain if the temporary wells were sufficiently distanced from the secondary containment wall or evaluate the minimum distance between the temporary wells and the NAPIS secondary containment wall necessary to detect the tracer leaked from a hole or crack that are not aligned with the direct flow path to the temporary wells. Note that dispersion of the tracer in conjunction with bulk motion of groundwater may be the only mechanism that transports the tracer cross-gradient from potential leak origins. Provide a discussion regarding the minimum distance in the revised Work Plan.<br>b) According to Figure 4, two proposed tracer monitoring wells and one proposed shallow vadose monitoring well are depicted along the west wall of the NAPIS. Although the Permittee states, "[u]p to five 2-inch polyvinyl chloride (PVC) temporary bromide monitoring wells may be installed along the west wall of the NAPIS," the Permittee did not discuss how it was determined that three monitoring wells were sufficient to capture potential tracer breakthrough at the site. The Permittee must explain how the number of wells were determined or evaluate the specific number of monitoring wells to be installed at the site based on the minimum distance from the west wall of the NAPIS, as required by Comment 5a above. It is NMED's opinion that a simulation mode (e.g., MODFLOW/MT3D) may be useful to determine the appropriate number of wells necessary to capture potential tracer breakthrough.<br>c) According to Figure 4, there are no tracer monitoring wells or shallow vadose monitoring wells proposed along the east wall of the NAPIS. Since the integrity of the east Bay must also be investigated, propose to install an appropriate number of tracer monitoring and | Page 15 of 18, Part 2, Step 2a has been revised to state "[S]ampling for bromide in the temporary monitoring wells located 5 ft of the west NAPIS wall, permanent monitoring wells (NAPIS-2, NAPIS-3, and KA-3) located 15 ft of the west NAPIS wall".<br>c) The Refinery is proposing to complete the bromide tracer testing solely in the West Bay. Please see response 3b above. Additionally, due to existing infrastructure, the east side of the NAPIS is inaccessible for the installation of monitoring wells. Furthermore, the east side of the NAPIS is upgradient of the groundwater flow direction, therefore monitoring for the tracer solution is unnecessary. Refer to Figure 3 of this Work Plan. |

| NMED Comment | Western Response |
|---|---|
| shallow vadose monitoring wells along the east wall of the NAPIS Bay in the revised Work Plan. Explain how the number of monitoring wells and the installation distance from the east wall of the NAPIS were determined in the revised Work Plan. | |
| **Comment 6:** | **Response 6:** |
| In the response to NMED's Disapproval Comment 4, Phase 2, Step 1a, the Permittee states, "[t]here will also be three shallow vadose wells installed above the groundwater to expedite the time for detection of the bromide (Figure 4)." It is not clear how the installation of shallow vadose wells screened above the water table will expedite detection of the tracer solution. Note that the wastewater leaking from the wall above the water table is not expected to move laterally in the soil. Provide an explanation in the revised Work Plan. | The intention of the shallow vadose wells is to potentially expedite the detection of the tracer solution by removing several feet of distance to the water table and to cover the possibility of lateral movement (e.g. the tracer solution following a thin permeable lens), and to prevent the tracer solution from being carried away by groundwater. |
| **Comment 7:** | **Response 7:** |
| In the response to NMED's Disapproval Comment 4, Phase 2, Step 1b, the Permittee states, "[t]wo of the three shallow vadose wells will be installed in the same boring as the groundwater wells… One of [the] shallow wells will be installed in a boring of its own, to approximately 6 ft bgs." Clarify whether the other two shallow vadose wells will be constructed as nested wells or state if these groundwater wells will be constructed with extended screened intervals that cover the vadose zone in the revised Work Plan. | This Comment is acknowledged and the Section 3.1, Page 10 of 18, Phase 2, Step 1b has been revised to state, "[T]wo of the three shallow vadose wells will be nested within the deeper groundwater wells." |
| **Comment 8:** | **Response 8:** |
| In the response to NMED's Disapproval Comment 4, Phase 2, Step 2a, the Permittee states, "[a] sampling schedule will be conducted as follows, bi-weekly for the first month, then monthly for the next six months, then quarterly for a year. Observations will be recorded in a logbook and groundwater samples will be submitted to a laboratory for | See Response 12 for the revisions to the calculations and the duration of the monitoring period. |

| NMED Comment | Western Response |
|---|---|
| analysis." Depending on the initial tracer concentration and the volume of wastewater released from the secondary containment wall of the NAPIS Bay, the timing of potential breakthrough will vary. The duration of the monitoring period must be estimated based on the calculation required by NMED's Disapproval Comment 6. Refer to the Comment 12c below for the details. Revise the Work Plan accordingly. | |
| **Comment 9:** | **Response 9:** |
| In the response to NMED's Disapproval Comment 4, Phase 2, Step 2c, the Permittee states, "[a]fter first bi-weekly sampling, the inactive East NAPIS Bay will be filled with water and the same amount of sodium bromide will be added to the East Bay to achieve a concentration of 10 mg/L of bromide." Since the use of the same tracer chemical (i.e., bromide) in both the East and West Bays will not identify leakages specific to each Bay, it would be more appropriate to use different tracer chemicals for each Bay. Propose to use different tracer chemicals for the East and West Bays (see comment 4b above) and to simultaneously conduct the test for both Bays to accelerate the testing progress in the revised Work Plan. | This comment is acknowledged, however, the Work Plan will only use the West Bay during the investigation. Refer to Response 3b above. |
| **Comment 10:** | **Response 10:** |
| In the response to NMED's Disapproval Comment 4, Phase 2, Step 2d, the Permittee states, "[o]bservation of the fluid in the LDUs and temporary bromide monitoring wells will be conducted per the schedule listed in step 2a above and recorded in the logbook." Before initiating the tracer test, the remaining fluids in the LDUs must be emptied. The remaining fluids in the LDUs may prevent the tracer from entering the LDUs due to existing head pressure. Include this provision in the revised Work Plan. If an accumulation of the fluids is observed in the LDUs after initiation of the tracer study, propose to collect the samples | Section 3.1, Page 10 of 18, Phase 2, Step 2a has been revised to state "A sampling schedule for groundwater and LDUs will be conducted as follows, bi-weekly for the first month, then monthly for the next six months, and then quarterly for three and a half years, for a total of up to four years and one month, or until bromide is detected, whichever occurs first. Please note that prior to the application of the bromide solution, the LDUs will be purged dry to prevent any interference of detection from existing head pressure." |

### New Mexico Environment Department (NMED) to Western Refining Southwest LLC (Western) Comment Letter "Second Disapproval, Area of Concern 15 – New API Separator and Area of Concern 16 – New API Separator Overflow Tanks Investigation Work Plan" (October 31, 2023)

| NMED Comment | Western Response |
|---|---|
| from the LDUs for the tracer chemical analysis per the schedule listed in Step 2a in the revised Work Plan. | |
| **Comment 11:** | **Response 11:** |
| In the response to NMED's Disapproval Comment 5, the Permittee states, "[t]his comment is acknowledged. In addition, Section 3.1 has been revised." Multiple portions of the text were revised in Section 3.1, as seen on the redline-strikeout (RLSO) version of the Work Plan. To facilitate NMED's review, indicate which texts were revised in Section 3.1 in the response to NMED's Disapproval Comment 5. Furthermore, all future responses involving revisions to sections of the submittal must describe where the revisions were made. | This comment is acknowledged. The following text in Section 3.1, Step 1b, page 10 of 18, was revised to address NMED's August 22, 2022 Disapproval Comment 5, "[T]herefore, the northern temporary shallow vadose well will be installed to approximately 6 ft bgs and the southern temporary shallow vadose well will be installed to approximately 11 ft bgs if groundwater is not encountered. One of the shallow wells will be installed in a boring of its own, to approximately 6 ft bgs." |
| **Comment 12:** | **Response 12:** |
| In the response to NMED's Disapproval Comment 6, and Appendix A (Bromide Concentration Calculation), Calculations, Number 13, Sheet 3, the Permittee states, "[b]ased on the observed leakage rates of 0.03 ml/min from the East Bay and a rate of 0.16 mL/min from the [W]est bay, the time required to reach the detectable concentration in a volume covered by the detection wells is on the order of three years,[and a]t an assumed leakage rate of 0.03 mL/min, the required time is 0.03 mL/min * (1 liter/1000mL) * (1 gal/3.48 liter) * X min = 8.84 gallons. X = 1,025,440 minutes or 712 days." Address the following:<br>a) There is a typographical error in reporting the conversion factor from liters to gallons. One (1) gallon is equal to 3.78 liters rather than 3.48 liters. Use the correct conversion factors to recalculate the duration which the tracer is continuously applied to the NAPIS Bay in the revised Work Plan.<br>b) The response to NMED's Disapproval Comment 4 states, "[a] sampling schedule will be conducted as follows, bi-weekly for the first | a) Appendix A, Calculations Item 12, has been corrected with the conversion factor from liters to gallons. The duration which the tracer is continuously applied will be approximately 1.5 days at a minimum.<br>b) The Refinery proposes to use a concentration of 1,000 mg/L. All applicable sections have revised to use a concentration of 1,000 mg/L for a minimum of 1.5 days in a closed batch system, including Sections 3.1, Phase 2, and Appendix A.<br>c) The calculation in Appendix A, Calculation Item 9 of the Work Plan has been revised to incorporate the equation provided by NMED in Comment 6 of the first disapproval (dated August 22, 2022). A concentration of 1,000 mg/L of the bromide tracer will be maintained in the West Bay for minimum of 1.5 days (rounding up from 1.45 days in Appendix A). |

**New Mexico Environment Department (NMED) to Western Refining Southwest LLC (Western) Comment Letter "Second Disapproval, Area of Concern 15 – New API Separator and Area of Concern 16 – New API Separator Overflow Tanks Investigation Work Plan" (October 31, 2023)**

| NMED Comment | Western Response |
|---|---|
| month, then monthly for the next six months, then quarterly for a year." The observation of tracer breakthrough may take longer than one year based on the assumptions. Propose to increase the initial tracer concentration ($C_1$) and also increase the duration which the tracer chemical is applied to the Bay to achieve faster breakthrough, and/or extend the monitoring period to accommodate the anticipated breakthrough time (i.e., three years.). Revise the Work Plan accordingly.<br>c) The parameter "F" reported in NMED's Disapproval Comment 6 is the "duration which tracer is continuously applied to the NAPIS bay," rather than the time required to observe breakthrough at the well location. The Permittee appears to have assumed that the parameter "F" was the time required to observe breakthrough at the well location, which is not accurate. NMED's Disapproval Comment 6 states, "[t]wo parameters ($C_1$ and T) should be optimized using hypothetical input parameters defined above." The following calculation demonstrates an example of optimization using the hypothetical input parameters that are consistent with the ones used in Appendix A:<br>$C_1$ = concentration of the tracer in the NAPIS Bay to be maintained (variable)<br>$C_2$ = minimum detectable concentration of the tracer in the well = 0.05 mg/L<br>$V_2$ = pore volume between the NAPIS wall and the well = 236.35 ft$^3$ = 6,700 L<br>$V_1$ = volume of wastewater (tracer) discharged from the secondary containment wall<br>$V_1$ = T x F<br>where: | |

| NMED Comment | Western Response |
|---|---|
| T = duration which tracer is continuously applied to the NAPIS Bay (variable)<br>F = discharge rate from the NAPIS wall = 0.03 mL/min<br>Then, $C_1 = \frac{C_2V_2}{V1} = \frac{C_2V_2}{TF} = \frac{1.12x10^7}{T}$<br>If $C_1$ = 10 mg/L, T = $1.12x10^6$ minutes = 2.1 years of continuous tracer application<br>If $C_1$ = 100 mg/L, T = $1.12x10^5$ minutes = 2.4 months of continuous tracer application<br>Correct the calculations in all applicable sections and appendices of the Work Plan and optimize the initial concentration of the tracer chemical and the duration which tracer is applied to the NAPIS Bay in the revised Work Plan. | |
| **Comment 13:** | **Response 13:** |
| In the response to NMED's Disapproval Comment 7, the Permittee states, "[t]racer sampling will be completed bi-weekly for the first month, monthly for six months, and then quarterly for up to two and a half years. Sampling will continue until bromide is detected for three years, whichever occurs first." NMED agrees that the proposed sampling duration of three years for the tracer chemical is acceptable based on the proposed initial concentration of the bromide tracer. However, the Permittee's response to NMED's Disapproval Comment 4 contradicts the response to NMED's Disapproval Comment 7, which states "[a] sampling schedule will be conducted as follows, bi-weekly for the first month, then monthly for the next six months, then quarterly for a year." Correct all applicable section(s) of the Work Plan to resolve the discrepancy in the revised Work Plan. | The Refinery acknowledges this comment and Section 3.1, Page 10 of 18, Phase 2, Step 2a has been revised to state, "[a]nd then quarterly for three and a half years." |

| NMED Comment | Western Response |
|---|---|
| **Comment 14:** | **Response 14:** |
| In the response to NMED's Disapproval Comment 8, the Permittee states, "[a] concentration of 10 mg/L [bromide] will be applied to the West and East Bays." As stated in Comment 3b, "the use of the same tracer chemical (i.e., bromide) in both East and West Bays will not identify leakage specific to each Bay and it is more appropriate to use separate tracer chemicals for each Bay. For example, iodide and hydrogen borate can also be used as water tracers. Propose to use a different tracer for the East Bay in the revised Work Plan." The same tracer (i.e., bromide) must not be used for both West and East Bays. Revise the Work Plan accordingly. | This comment is acknowledged, however, this Work Plan will only use the West Bay during the investigation. Refer to Response 3b above. No revisions to the Work Plan have been made. |
| **Comment 15:** | **Response 15:** |
| In the response to NMED's Disapproval Comment 9, the Permittee states, "[a]s described in Sections 3.1, Phase 2 and 4.2, Phase 2, bromide sampling will be completed bi-weekly for the first month, monthly for six months, and then quarterly for up to two and a half years. Sampling will continue until bromide is detected or three years, which occurs first." Address the following:<br>a) The Permittee's response is confusing. The Permittee states that sampling will be completed "quarterly for up to two and a half years in the first sentence; then, states that sampling will continue for three years in the second sentence. Clarify the statement in the revised Work Plan.<br>b) It is also not clear whether the maximum monitoring duration is two and a half years or three years. The sampling duration must be estimated based on the initial tracer concentration and the duration which the tracer is applied to the Bay (see Comment 12 above). Clearly state the monitoring duration for the tracer test and revise the Work Plan accordingly. | a) Sections 3.1, Phase 2 and 4.2, Part 2, step 2a, have been revised to state, "[b]i-weekly for the first month, then monthly for the next six months, and then quarterly for three and a half years, for a total of up to four years and one month or until bromide is detected, whichever occurs first."<br>b) The monitoring duration will be up to four years and one month or until bromide is detected, whichever occurs first. This proposed sampling duration exceeds the estimated travel time for the bromide tracer to reach the NAPIS monitoring wells, the furthest located detection wells, of 477 days (Appendix A, Calculation 15) |

| NMED Comment | Western Response |
|---|---|
| **Comment 16:** | **Response 16:** |
| In the response to NMED's Disapproval Comment 11, the Permittee states, "[d]ata collected under this work plan would only aid in excavation of EP-1. Therefore, this investigation will be completed following NMED approval." According to Figure 4, the proposed soil sampling locations in AOC 16 coincide with the footprint of the staging area for the SWMU-1 evacuation of EP-1 (see the SWMU-1 Closure Plan). Because the staging area for the excavated contaminated soils from the SWMU-1 removal will be within the footprint of AOC 16, it is possible that the staging of these soils from SWMU-1 may impact AOC 16. To avoid repeating investigation activities, NMED recommends investigating AOC 16 after excavation activities are complete and all waste has been removed from the staging area within AOC 16 and shipped off site. If the Permittee wishes to collect data to aid in determining the excavation boundaries of EP-1, boreholes can be drilled as part of the SWMU-1 investigation. The data obtained from these pre-excavation boreholes may be used to inform both the SWMU-1 excavation and the AOC-16 investigation. In the revised Work Plan, propose to collect samples which address NMED's Disapproval Comment 11 after excavation activities at SWMU-1 are complete. | The Refinery acknowledges this and respectfully disagrees with this comment. This area is merely a possible staging location for SWMU-1 excavation. If it is determined by the contractor that this space will be used, a high-density polyethylene liner will be laid down to prevent any cross contamination. |
| **Comment 17:** | **Response 17:** |
| In the response to NMED's Disapproval Comment 12, the Permittee states, "VOCs and SVOCs that have exceeded a standard will be retained as potential contaminants of concern (PCOCs)." Since AOCs 15 and 16 are located in the vicinity of the wastewater treatment system where per- and polyfluoroalkyl substances (PFAS) may be released to the environment, the presence or absence of PFAS must also be evaluated. Propose to include PFAS analysis for the soil samples | The Refinery respectfully disagrees that sampling for PFAS is necessary at this time. There is currently no proof that the wastewater treatment system is currently leaking and releases PFAS into the environment. |

| NMED Comment | Western Response |
|---|---|
| collected from the area in the revised Work Plan. Refer to the May 23, 2023 *Disapproval, OW-63 PFAS Investigation Work Plan* letter for specific directions associated with the collection of PFAS samples and incorporate the requirements in this investigation. | |
| **Comment 18:** | **Response 18:** |
| In Section 4.1 (Sample Collection Procedures), page 12 of 17, paragraph 2, the Permittee states, "[a]ll equipment will be decontaminated with Simple Green™ (or equivalent) using a four-stage decontamination system consisting of a two detergent/water washes and two deionized water rinses and recorded in the field logbook." NMED prefers that Alconox®, Liquinox®, or Citranox®, be used for equipment decontamination associated with PFAS sampling because these detergents do not contain any chemicals that may interfere with the analytes of concern. Otherwise, the Permittee must demonstrate that the proposed cleaner (i.e., Simple Green™) does not interfere with the analytes of concern. State which cleaner will be used in the revised Work Plan. | The Refinery acknowledges this comment and Section 4.1, page 13 of 18, paragraph 1, has been revised to state, "[a]ll equipment will be decontaminated with Liquinox®, (or equivalent) using a four-stage decontamination system consisting of a two detergent/water washes and two deionized water rinses and recorded in the field logbook." |
| **Comment 19:** | **Response 19:** |
| In Appendix A (Bromide Concentration Calculation), Assumptions, number 6, sheet 1, the Permittee states, "[t]he recharge rate into the LDU wells observed during the investigation (Trihydro 2021) is approximately 0.03 milliliters per min (mL/min). For the purpose of estimating the time period for bromide testing, this rate is assumed to be the leakage rate from the NAPIS into local groundwater where leak test observation wells are located. Leak test observation wells are located approximately 5 ft downgradient (west) of the NAPIS." Address the following: | a) The Refinery acknowledges this comment and Appendix A, Assumptions number 7, Sheet 1, has been revised to remove the term "well".<br>b) This comment is acknowledged.<br>c) The Refinery acknowledges that should the monitoring wells 5 ft from the NAPIS have no detects above the background levels, this does not prove the lack of a leak but would be the fastest method to prove a leak exists. Based on Appendix A, calculation number 14, bromide is |

| NMED Comment | Western Response |
|---|---|
| a) Note that the LDUs are not wells; therefore, they must not be called wells to avoid confusion. Revise the Work Plan accordingly.<br>b) The Permittee's July 31, 2021 *Response to Approval with Modifications Annual Groundwater Monitoring Report Gallup Refinery – 2019* indicates that the highest recharge rates in the West and East LDUs are recorded as 98.12 and 11.48 mL/min, respectively. Although the recharge rate into the LDUs (0.03 mL/min) is not a leakage rate from the secondary containment well of the NAPIS, NMED finds that the assumption is conservative and acceptable. No revision is required.<br>c) Demonstrate that the distance of five (5) feet between the NAPIS wall and the wells is sufficient to account for dilution, dispersion, and detection of the tracer chemical, assuming that the release location(s) on the wall of the second containment (i.e., hole) is farthest from any observation wells in the revised Work Plan (see Comment 5 above). | estimated to reach the monitoring wells 5 ft from the NAPIS after approximately 159 days. NAPIS wells (NAPIS 2, NAPIS-3, and KA-3) are the backup wells and would also require values to remain below the background levels for the four years and one month of testing (approximately 477 days). |

# ATTACHMENT B

# REVISED REPORT

# Area of Concern 15 – New API Separator and Area of Concern 16 – New API Separator Overflow Tanks Investigation Revised Work Plan

## Western Refining Southwest LLC

## (D/B/A Marathon Gallup Refinery)

## Gallup, New Mexico

*EPA ID# NMD000333211*

**February 2, 2024**

# Executive Summary

Western Refining Southwest LLC, D/B/A Marathon Gallup Refinery (Refinery) is submitting this work plan for investigation of soil at Area of Concern (AOC) 15 – New American Petroleum Institute (API) Separator (NAPIS) and soil and groundwater at AOC 16 – NAPIS Overflow Tanks. The New Mexico Environment Department (NMED) requested further investigation into the AOC 15 area in Comment 13 of the NMED "Response to Approval with Modifications, Annual Groundwater Monitoring Report Gallup Refinery – 2019" letter dated September 28, 2021 (NMED 2021a), and into the AOC 16 area in the "AOC 16 (New API Separator Overflow Tanks)" paragraph of the NMED "Determination of Area of Concern (AOC) Entry to the Permit" letter dated August 19, 2021 (NMED 2021b). The AOC 15 investigation will include soil sampling around the NAPIS to investigate impacts from historical releases as well as bromide tracer testing, in a phased approach, the West Bay to investigate and ensure no leaks are occurring from the secondary NAPIS containment. The AOC 16 investigation will include soil and groundwater sampling in the areas where the former NAPIS overflow tanks had historical releases.

The Refinery will prepare an investigation report summarizing the sampling results and investigation conclusions within 120 days of the receipt of the analytical data.

# Table of Contents

## List of Figures

## List of Appendices

## List of Acronyms

| | |
|---|---|
| % | percent |
| amsl | above mean sea level |
| AOC | Area of Concern |
| API | American Petroleum Institute |
| bgs | below ground surface |
| BTEX | benzene, toluene, ethylbenzene, and total xylenes |
| COC | chain of custody |
| DGF | dissolved gas floatation |
| DPT | direct push technology |
| DRO | diesel range organics |
| ft | foot or feet |
| GRO | gasoline range organics |
| I-40 | Interstate 40 |
| LDU | Leak Detection Units |
| mg/L | milligrams per Liter |
| MRO | motor oil range organics |
| MTBE | methyl tert-butyl ether |
| NAPIS | New American Petroleum Institute Separator |
| NMED | New Mexico Environment Department |
| PID | photoionization detector |
| PVC | polyvinyl chloride |
| QA/QC | quality assurance/quality control |
| Refinery | Western Refining Southwest LLC, D/B/A Marathon Gallup Refinery |
| RCRA | Resource Conservation and Recovery Act |
| SPH | separate phase hydrocarbon |
| SSL | Soil Screening Level |
| SVOC | semivolatile organic compound |
| TPH | total petroleum hydrocarbons |
| VOC | volatile organic compound |
| WQCC | Water Quality Control Commission |

# 1.0 Introduction

The Western Refining Southwest LLC, D/B/A Marathon Gallup Refinery (Refinery), is located approximately 17 miles east of Gallup, New Mexico along the north side of Interstate 40 (I-40) (Figure 1). The physical address is I-40, Exit #39 Jamestown, New Mexico 87347. The Refinery property covers approximately 810 acres. The Refinery has been indefinitely idled since August 2020.

This work plan outlines the details of the proposed investigation at Area of Concern (AOC) 15 – New American Petroleum Institute (API) Separator (NAPIS) and AOC 16 – NAPIS Overflow Tanks (Figure 2). The New Mexico Environment Department (NMED) requested development of this investigation work plan in two regulatory communications as described below.

On July 31, 2021, the “NAPIS Inspection Report” was submitted to NMED as Attachment 3 to the “Response to Approval with Modifications, Annual Groundwater Monitoring Report Gallup Refinery – 2019” letter (Western 2021). The NAPIS inspection was completed in July 2021, and the findings suggested that the NAPIS primary containment may be leaking to the secondary containment but that the secondary containment was not leaking. In Comment 13 of the “Response to Approval with Modifications, Annual Groundwater Monitoring Report Gallup Refinery – 2019” letter dated September 28, 2021 (RTAwM – 2019 Annual Groundwater Report) (NMED 2021a), NMED stated that “the primary containment wall of the East and West Bays have been leaking” based upon the presence of fluids in the Leak Detection Units (LDUs) (NMED 2021a). As such, NMED requested this work plan to investigate the integrity of the secondary containment walls of the East and West NAPIS Bays.

The East Bay of the NAPIS was removed from service and all liquids pumped out on May 12, 2021, and no liquids were observed as documented during weekly inspections. Any water observed in the East Bay is the result of accumulated precipitation. Observation of the East Bay on October 12, 2022, confirmed the presence of liquid in the bay that resulted from the accumulation of precipitation over several weeks. One reasonable explanation for the observed higher recharge rate into the West LDU from the West Bay is that the West Bay was operational (full) during the observation period. As a result, the higher water head in the West Bay would drive more fluid into the interstitial space of the West Bay, which is connected to the West LDU. In contrast, the East Bay, was empty, and any recharge was limited to drainage of the interstitial space. This assumes other variables being equal.

Additionally, this work plan includes soil sampling to determine if there are impacts to soil in the area around the NAPIS (AOC 15) from fluid releases prior to 2010. There are three groundwater monitoring wells downgradient of the NAPIS, which are sampled quarterly; therefore, no additional monitoring well installation is planned, and no additional groundwater sample collection is proposed for AOC 15.

With respect to AOC 16 (NAPIS Overflow Tanks), NMED requested an assessment to determine if corrective action is needed in the “AOC 16 (NAPIS Overflow Tanks)” paragraph of the “Determination of Area of Concern (AOC) Entry to the Permit” letter dated August 19, 2021 (NMED 2021b). Prior to NAPIS overflow being routed to Tank 35 in 2010, five 20,000-gallon Baker frac tanks were used as NAPIS overflow tanks. During storm events in 2007, 2009, and 2010, both the NAPIS (AOC 15) and the NAPIS overflow tanks (AOC 16) had fluid releases to the surrounding soils. The AOC 16 overflow tanks were removed from service in 2010 and the dissolved gas flotation (DGF) tank was installed in 2012 in the AOC 16 area (Figure 3).

Sampling and excavation of the impacted soils in AOC 16 occurred after two releases in 2009, but there is no documentation of cleanup after two additional releases in 2010. NMED "Disapproval Assessment Report for AOC 16-API Overflow Area" letter, dated April 23, 2019, Comment 4 indicates "additional assessment and possibly corrective action may be necessary for AOC 16" (NMED 2019).

In summary, this work plan proposes to combine the requested investigations at AOC 15 and AOC 16, in order to:

1. Evaluate the integrity of the NAPIS West Bay secondary containment, and
2. Assess possible impacts to the soils of AOC 15, and
3. Assess possible impacts to the soils and groundwater of AOC 16.

The investigation results will be used to discern if there are potential impacts remaining from previous releases and determine if additional remediation is required.

## 2.0 Site Conditions

The Refinery has been indefinitely idled since August 2020. Historically, the Refinery processed crude oil transported to the facility by pipeline or tanker truck. During active operation, various process units were operated at the Refinery, including alkylation, blending gas, crude distillation, diesel hydro-treating, fluid catalytic cracker, gas conditioning, isomerization, naphtha hydro-treating, reformer, saturated gas, sulfur recovery, ammonium thiosulfate and merox treater units. Past refinery operations have produced gasoline, diesel fuels, jet fuels, kerosene, propane, butane, and residual fuel.

The NAPIS West Bay has been used to process only remediation and stormwater fluids since the idling of the Refinery in August 2020. The NAPIS East Bay was taken out of service when the Refinery idled, due to the reduction in process fluids which eliminated the need for redundant bays.

### 2.1 Surface Conditions

Local site topographic features include high ground in the southeast gradually decreasing to a lowland fluvial plain to the northwest. Elevations on the refinery property range from 6,860 feet (ft) above mean sea level (amsl) to 7,040 ft amsl. The AOC 15 and AOC 16 areas are approximately 6918 ft amsl.

### 2.2 Subsurface Conditions

The shallow subsurface soil (alluvium) is comprised of clay and silt with some inter-bedded sand layers. Beneath the alluvium is the Petrified Forest Member of the Chinle Group, which primarily consists of interbedded mudstone, siltstone, and sandstone. The depth of the Alluvium/Chinle interface ranges from 15 ft below ground surface (bgs) to over 32 ft bgs.

## 3.0 Scope of Activities

The investigative activities proposed herein will help evaluate the potential for impacts, and if confirmed, the extent of impacted soils and groundwater from the NAPIS system. Additionally, the investigation will assess the integrity of the NAPIS West Bay secondary containment. Pending NMED approval, the Refinery anticipates the investigation work to be completed during 2024.

### 3.1 AOC 15 – NAPIS

Six soil samples will be collected to determine the possible extent of impacts to the area caused by releases prior to 2010. The soil borings will be installed using a decontaminated hand auger to a depth of 5 ft bgs. Samples will be collected using a Terracore sampling device (or equivalent Method 5035A device) at 0-1 ft bgs (surface), the interval with the highest photoionization detector (PID) reading, and 5 ft bgs. While performing field screening, if evidence (e.g., visual, olfactory, PID reading) of hydrocarbons is observed at the termination depth above the water table, the borings will be extended to the depth where the contamination is no longer detected, or alternately, at a minimum of five ft below the water table. Soil samples must then be collected from the extended termination depth to delineate the vertical extent of contamination. Proposed soil sample locations are shown as yellow triangles and pink squares on Figure 4.

Soils will be field screened using a PID at each sample interval. Soil samples will be analyzed by an accredited laboratory for methyl tert-butyl ether (MTBE) and benzene, toluene, ethylbenzene, and total xylenes (BTEX) by Method 8260; total petroleum hydrocarbons (TPH)- gasoline range organics (GRO), TPH-diesel range organics (DRO), and TPH-motor oil range organics (MRO) by Method 8015; and Resource Conservation and Recovery Act (RCRA) 8 metals by Method 6010. These constituents were selected as indicators of impacts from NAPIS releases. Analytical results will be compared to their respective NMED Residential, Industrial, and Construction Worker Soil Screening Levels (SSLs) (NMED 2021c).

A preliminary soil investigation took place in February 2023 to evaluate the presence of separate phase hydrocarbons (SPH) in the soil within the NAPIS area and evaluate its fluorescing properties. It was determined that the application of dye tracer would not be feasible around the NAPIS due to the soil fluorescing under black light. Because of this, it is proposed to complete the investigation using bromide tracer testing as a method of leak detection.

This work plan will be completed in two Phases. The first phase will include sampling groundwater in the area to establish background levels of naturally occurring bromide. The second phase will include bromide tracer testing by adding a solution of sodium bromide to the NAPIS West Bay and monitor the surrounding area for the increased presence of bromide. More details regarding the two phases are presented below.

## Phase 1

To ensure that bromide tracer testing is feasible, four baseline samples will be taken from the area within the NAPIS. Three groundwater samples will be taken from existing monitoring wells within the NAPIS area (one will be taken from an up gradient well NAPIS-1, two samples will be taken from down gradient wells NAPIS-2, KA-3). The remaining sample will be taken from onsite water sources (one sample of the onsite well water that will be used to fill NAPIS West Bay). NMED will be contacted when the results of the baseline sampling are received regardless of the results.

## Phase 2

This phase is proposed to address NMED's concern that the persistence of fluid in the East and West LDUs may indicate ongoing leaking from the NAPIS secondary containment. As such, the integrity of the NAPIS secondary containment will be examined. Bromide tracer testing will be conducted in West NAPIS Bays using a solution of bromide with a concentration of 1,000 milligrams per Liter (mg/L) and monitoring the areas surrounding the unit for the increased presence of bromide. Bromide tracer testing is a method of leak detection conducted by adding sodium bromide to a fluid containment unit (e.g., pipe, well, tank, etc.). The bromide tracer is detectable at 0.05 mg/L. The bromide tracer test will be conducted as follows:

1. Up to five 2-inch polyvinyl chloride (PVC) temporary bromide monitoring wells may be installed along the west wall of the NAPIS (Figure 4). These locations may be adjusted slightly to the west to maximize the potential for intercepting bromide.
    a. There will be two temporary wells installed using an air-knife rig or a hand auger to a depth of 2 ft below groundwater (if groundwater is encountered) or 1 ft below the bottom of the NAPIS, with sand pack and PVC well screen installed to 2 ft bgs. There will also be three shallow vadose wells installed above the groundwater to expedite the time for detection of the bromide (Figure 4).
    b. Two of the three shallow vadose wells will be nested within the deeper groundwater wells. The NAPIS varies in depth, as shown in Appendix A. Therefore, the northern temporary shallow vadose well will be installed to approximately 6 ft bgs and the southern temporary shallow vadose well will be installed to approximately 11 ft bgs if groundwater is not encountered. One of shallow wells will be installed in a boring of its own, to approximately 6 ft bgs.
2. 53,500 grams of sodium bromide will be added to 11,000 gallons of water in the West NAPIS Bay and dissolved into solution, to achieve a concentration of 1,000 mg/L of bromide, as shown in Appendix A. The bromide solution will be left in the West NAPIS bay for minimum 1.5 days.
    a. A sampling schedule for groundwater and LDUs will be conducted as follows, bi-weekly for the first month, then monthly for the next six months, and then quarterly for three and a half years, for a total of up to four years and one month or until bromide is detected, whichever occurs first. Please note that prior to the application of the bromide solution, the

LDUs will be purged dry to prevent any interference of detection from existing head pressure..

b. Groundwater will be analyzed using Method 300.0. This method can achieve a method detection limit of 0.05 mg/L.

c. Observation of the fluid in the LDUs and temporary bromide monitoring wells will be conducted per the schedule listed in step 2a above and recorded in the logbook.

In addition to the bromide tracer tests, NAPIS influent samples will be collected for laboratory analyses. This sampling will include a) fluid samples collected prior to entering the West NAPIS Bay and b) fluid samples collected from the water within the West Bay. These samples will be analyzed for total and dissolved metals for two consecutive monitoring events.

## 3.2 AOC 16 – NAPIS Overflow Tanks

AOC 16 consists of an approximately 80 ft by 190 ft area where five temporary Baker frac tanks were used as NAPIS overflow tanks between 2007 and 2010. The frac tanks were installed approximately in 2007 and removed in 2010, when the NAPIS was connected to Tank 35. The former location of the overflow frac tanks is shown on Figure 3. The DGF tank was installed in 2012 in a portion of AOC 16 (Figure 4).

Investigation into surface and subsurface soils and groundwater will be conducted using a Geoprobe direct push technology (DPT) rig to install 16 borings. Three soil samples will be collected per boring at:

1. The surface (0-1 ft bgs).
2. The interval with the highest PID reading.
3. Above the water table, or at the bottom of the boring (10 ft bgs) if groundwater is not encountered.
4. While performing field screening, if evidence (e.g., visual, olfactory, PID reading) of hydrocarbons is observed at the termination depth above the water table, the borings will be extended to the depth where the contamination is no longer detected, or alternately, at a minimum of five ft below the water table. Soil samples will then be collected from the extended termination depth in order to delineate the vertical extent of contamination.

Some of the proposed sample locations are not accessible by the drill rig. In particular, the proposed sample locations represented by the two southern green triangles on Figure 4 are not accessible by the drill rig and samples will therefore be collected with a hand auger at the surface (0-1 ft bgs) and at 5 ft bgs. Samples will be collected using a Terracore sampling device (or equivalent Method 5035A device). Soil from each sample interval will be screened using a PID. Additionally, groundwater samples will be collected using the DPT rig and Hydropunch methods (Appendix B) from borings downgradient of historical overflow tanks; proposed locations are shown as blue squares on Figure 4. Soil and groundwater samples will be analyzed by an accredited laboratory for MTBE and BTEX by Method 8260; TPH-GRO, TPH-DRO, and TPH-MRO by Method 8015; and RCRA 8 metals by Method 6010.

## 4.0 Investigation Methods

Soils obtained will be visually inspected and classified in general accordance with American Society for Testing and Materials D2487 (Unified Soil Classification System) and D2488 (Description and Identification of Soils). Detailed boring logs will be compiled in the field by qualified staff. Samples will be field screened using a PID for evidence of volatile organic compounds (VOCs). PID results will be recorded on the boring logs. Groundwater samples will be field screened for temperature, pH, salinity, conductivity, total dissolved solids, dissolved oxygen, and oxygen reduction potential using a YSI field parameter probe. Field parameters will be collected before and after fluid sample collection and recorded on the boring logs.

### 4.1 Sample Collection Procedures

Soil samples will be collected in accordance with the "Standard Operating Procedure – Soil Sampling" (Appendix C). Groundwater samples will be collected using Hydropunch methods as described in "Groundwater Sampling and Monitoring with Direct Push Technologies" (Appendix B). Details related to sample collection will be documented on the boring log field forms (Appendix D). General observations recorded on the field forms for each soil sample location will include sampling start and end times, weather, site conditions, sampling team members, and other personnel present. Sample-specific information will include field sample identification, time of sample collection, sample start and end depth, collection method, sample type (i.e., composite or aliquot), soil classification and characteristics, any deviations from or clarification of sampling procedures, and other observations. All reusable sampling equipment will be decontaminated prior to installing a boring and collecting a new sample. All equipment will be decontaminated with Liquinox®(or equivalent) using a four-stage decontamination system consisting of a two detergent/water washes and two deionized water rinses and recorded in the field logbook.

Soil samples will be collected from representative locations using a Geoprobe direct push drill rig with split spoons and acetate liners. If necessary, several cores may be collected from each location to provide adequate sample volume for the laboratory. If necessary, additional cores will be collected from within 6 lateral inches of the original boring, and additional sample volume will be collected from the same depth interval as the original boring. It should be noted that samples collected in this manner will not be collected as composite samples. The Geoprobe direct push drill rig will be decontaminated between sampling locations; the drill rig will not be decontaminated between sampling intervals at the same location due to the acetate liners.

PID readings will be collected at sample intervals (beginning with a surface sample) and analytical samples will be collected at the intervals proposed in Sections 3.1 and 3.2 for AOC 15 and AOC 16, respectively and split into two aliquots. Aliquot #1 will be placed into a plastic bag and used for PID screening. Aliquot #2 will be placed into appropriate sample containers with appropriate preservatives (e.g., methyl chloride), sealed, placed in a cooler, and stored on ice for potential VOC laboratory analysis. Aliquot #1 materials will not be submitted for laboratory analysis.

Aliquot #1 will be shaken gently to expose the soil to the air trapped in the container. Aliquot #1 will be allowed to rest while vapors equilibrate. Vapors present within the sample bag's headspace will be measured by inserting the probe of the PID in Aliquot #1's container (plastic bag). The maximum value and the ambient air temperature will be recorded on the field boring log for each interval. Note that if samples are cold (i.e., below 32 degrees Fahrenheit), they will be sealed in airtight bags and warmed in a heated building and/or vehicle before screening.

After collecting the PID reading, the selected sample depths corresponding to Aliquot #2 will be labeled and placed in the laboratory cooler. Before shipment, each cooler will be packed with ice and a laboratory-provided trip blank. A chain of custody (COC) form will accompany each sample shipment. Coolers will be sealed and delivered to an accredited laboratory.

## 4.2 AOC 15 Investigation

A summary of the proposed sampling activities is provided below.

## Part 1:

1. Installation of six soil borings via hand auger, visual screening/logging, and collection of soil samples. Samples will be collected from:
    a. The surface (0-1 ft bgs)
    b. The interval with the highest PID reading
    c. 5 ft bgs
    d. While performing field screening, if evidence (e.g., visual, olfactory, PID reading) of hydrocarbons is observed at the termination depth above the water table, the borings will be extended to the depth where the contamination is no longer detected, or alternately, at a minimum of five ft below the water table. Soil samples must then be collected from the extended termination depth in order to delineate the vertical extent of contamination.
2. Collection of PID readings at the surface and at each sample interval.
3. Submit samples to an accredited laboratory. Samples will be analyzed for:
    a. MTBE and BTEX by Method 8260
    b. TPH-GRO, TPH-DRO, and TPH-MRO by Method 8015
    c. RCRA 8 metals by Method 6010
    d. VOCs and semivolatile organic compounds (SVOCs) that have exceeded the applicable NMED standard in monitoring wells NAPIS-1, NAPIS-2, NAPIS-3, and KA-3 within the past five years as identified in the Annual Groundwater Monitoring Report by Methods 8260 and 8270, respectively.

4. Analytical results will be compared to their respective NMED Residential, Industrial, and Construction Worker SSLs (NMED 2021c). Metals results are compared to the 2022 NMED Soil Leachate-SSLs with a DAF of 20.

## Part 2:

1. Installation of three temporary shallow vadose wells and two temporary bromide monitoring wells along the west side of the NAPIS to 2 ft or 1 ft below NAPIS containment (if groundwater is not encountered).
2. Add the sodium bromide solution to the West NAPIS Bay.
    a. Sampling for bromide in the temporary monitoring wells located 5 ft of the west NAPIS wall, permanent monitoring wells (NAPIS-2, NAPIS-3, and KA-3) located 15 ft of the west NAPIS wall, and LDUs for the presence of bromide will be completed as follows: bi-weekly for the first month, then monthly for the next six months, and then quarterly for three and a half years, for a total of up to four years and one month or until bromide is detected, whichever occurs first.. Log observations in a field notebook.

## 4.3 AOC 16 Investigation

A summary of the proposed sampling activities is provided below:

1. Installation of 16 soil borings via Geoprobe DPT drill rig, visual screening/logging, and collection of soil samples. Samples will be collected from:
    a. the surface (0-1 ft bgs)
    b. the interval with the highest PID reading
    c. above the water table, or at the bottom of the boring (10 ft bgs) if groundwater is not encountered.
    d. While performing field screening, if evidence (e.g., visual, olfactory, PID reading) of hydrocarbons is observed at the termination depth above the water table, the borings will be extended to the depth where the contamination is no longer detected, or alternately, at a minimum of five ft below the water table. Soil samples must then be collected from the extended termination depth in order to delineate the vertical extent of contamination.
2. If a sample location is not accessible by DPT drill rig, samples will be collected via hand auger and Terracore sampling device (or equivalent) from:
    a. 0 – 1 ft bgs (surface sample)
    b. 5 ft bgs (or where there is evidence of impacts)
3. Collection of PID readings at each sample interval.

4. Collections of six Hydropunch groundwater samples from boring locations downgradient of the former location of the NAPIS overflow tanks.
5. Submit samples to an accredited laboratory. Soil and groundwater samples will be analyzed for:
    a. MTBE and BTEX by Method 8260
    b. TPH-GRO, TPH-DRO, and TPH-MRO by Method 8015
    c. RCRA 8 metals by Method 6010
    d. VOCs and SVOCs that have exceeded the applicable NMED standard in monitoring wells NAPIS-1, NAPIS-2, NAPIS-3, and KA-3 within the past five years as identified in the Annual Groundwater Monitoring Report by Methods 8260 and 8270, respectively.
6. Analytical results will be compared to their respective NMED Residential, Industrial, and Construction Worker SSLs (NMED 2021c).
7. Compare analytical groundwater data with applicable NMED Water Quality Control Commission (WQCC) groundwater quality standards (NMED 2018).

## 4.4 Data Quality and Validation

Quality assurance/quality control (QA/QC) samples will be collected during sampling to monitor the validity of the sample collection procedures. Field duplicates will be collected at a rate of 10 percent (%), at a minimum of one per day. Equipment blanks will be collected from re-usable equipment at a rate of 10% at a minimum of one per day. One field blank per day will be collected when groundwater samples are collected. One trip blank per cooler will accompany the samples to the laboratory. The field duplicates, equipment blank samples, field blanks, and trip blanks will be submitted to the laboratory along with the samples. QA/QC samples will be recorded on the field forms and the COCs. All data will undergo Tier II data validation.

## 4.5 Data Evaluation and Waste Management

The analytical results will be compared to applicable NMED Residential, Industrial, and Construction Worker SSLs (NMED 2021c) and applicable NMED WQCC groundwater quality standards (NMED 2018). The results will be submitted to NMED in a subsequent investigation report. If impacted soils are recovered during sampling, they will be placed in drums, labeled, and stored on the 90-Day Pad. Soils without elevated PID readings will be placed back in the borehole. Waste characterization will be conducted prior to disposal. Waste characterization analysis will include testing for VOCs by Method 8260, SVOCs by Method 8270, and RCRA 8 Metals by Method 6010. Any wastes determined to be hazardous will be disposed at a landfill regulated under RCRA subtitle C.

## 5.0 Schedule

Pending NMED approval, the Refinery anticipates the investigation to be completed during 2024. Once the investigation has been completed, the Refinery will prepare an investigation report summarizing the sampling results and investigation conclusions. The investigation report will be submitted to NMED within 120 days of the receipt of the analytical data.

# 6.0 References

New Mexico Environment Department (NMED). 2018. Water Quality Control Commission, New Mexico Administrative Code Title 20, Part 6, Chapter 2. December 21.

NMED. 2019. Disapproval Assessment Report for AOC 16 – API Overflow Area, Marathon Petroleum Company LP, Gallup Refinery (Formerly Western Refining Southwest Inc.), EPA ID#NMD000333211, HWB-WRG-19-001. April 23.

NMED. 2021a. Response to Approval with Modifications, Annual Groundwater Monitoring Report Gallup Refinery – 2019, Western Refining Southwest Inc., Gallup Refinery, McKinley County, Gallup, New Mexico, EPA ID#NMD000333211, HWB-WRG-20-013. September 28.

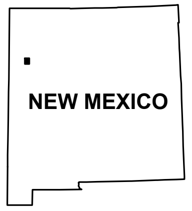
NMED. 2021b. Determination of Area of Concern (AOC) Entry to the Permit, Western Refining Southwest Inc., Gallup Refinery, EPA ID #NMD000333211, HWB-WRG-MISC. August 19.

NMED. 2021c. Risk Assessment Guidance for Site Investigations and Remediation, Volume I Soil Screening Guidance for Human Health Risk Assessments. November.

Western Refining Southwest, LLC. 2021. Response to Approval with Modifications Annual Groundwater Monitoring Report Gallup Refinery – 2019, Western Refining Inc., Marathon Gallup Refinery, EPA ID #NMD000333211, HWB-WRG-20-013. July 31.

# Figures

Image Cite: National Agriculture Imagery Program (NAIP) Colored Orthophoto, Mckinley County, New Mexico, Publication: 2014



**QUADRANGLE LOCATION**

**NOTE:**
SITE LEGAL DESCRIPTION -
TOWNSHIP 15 NORTH,
RANGE 15 WEST, SECTION 33

**EXPLANATION**

| | |
|---|---|
| 40 | INTERSTATE HIGHWAY |
| AOC | AREA OF CONCERN |

N

0 2 MILES

**Trihydro**
CORPORATION
1252 Commerce Drive
Laramie, Wyoming 82070
www.trihydro.com
(P) 307/745.7474 (F) 307/745.7729

## FIGURE 1

## SITE LOCATION MAP
## AOC 15 AND AOC 16 INVESTIGATION WORK PLAN

WESTERN REFINING SOUTHWEST, LLC
D/B/A MARATHON GALLUP REFINERY
GALLUP, NEW MEXICO

| | | | | |
|---|---|---|---|---|
| Drawn By: REP | Checked By: JP | Scale: 1" = 2 MILES | Date: 2/2/2022 | File: 697-SITELOC-202202 |

M:\ITON\MARATHON\CADD\GALLUP_REPORTS\AOC\AOC15_NAPIS\697-SITELOC-202202

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

**EXPLANATION**

🟥 AOC 15 - NEW API SEPARATOR AND
AOC 16 - NEW API SEPARATOR
OVERFLOW TANKS

**NOTE:**

AOC - AREA OF CONCERN
API - AMERICAN PETROLEUM INSTITUTE

**FIGURE 2**

**SITE LOCATION**
**AOC 15 AND AOC 16 INVESTIGATION WORK PLAN**

**WESTERN REFINING SOUTHWEST LLC**
**D/B/A MARATHON GALLUP REFINERY**
**GALLUP, NEW MEXICO**

Trihydro
CORPORATION
1252 Commerce Drive
Laramie, WY 82070
www.trihydro.com
(P) 307/745.7474 (F) 307/745.7729

| | | | | |
|---|---|---|---|---|
| Drawn By: KEJ | Checked By: EC | Scale: 1 " = 400 ' | Date: 2/21/22 | File: 2_SiteLoc_AOC15_AOC16_Fig2.mxd |

M:\ITON\MARATHON\GIS\GALLUP\MAPPING\AOC\AOC_15_NAPIS\REPORTS\202204_IWP\2_SITELOC_AOC15_AOC16_FIG2.MXD

Image Cite: Google Earth Pro, Publication: March, 2016.

## EXPLANATION

| | |
|---|---|
| 🟧 | AOC 15 NAPIS |
| 🟩 | AOC 16 NAPIS OVERFLOW TANKS |
| ▭ | ESTIMATED FORMER LOCATION OF NAPIS OVERFLOW TANKS |
| ← | ESTIMATED GROUNDWATER FLOW DIRECTION |
| AOC | AREA OF CONCERN |
| NAPIS | NEW AMERICAN PETROLEUM INSTITUTE SEPARATOR |

Trihydro
CORPORATION
1252 Commerce Drive
Laramie, Wyoming 82070
www.trihydro.com
(P) 307/745.7474 (F) 307/745.7729

FIGURE 3

AOC 15 AND AOC 16
AOC 15 AND AOC 16 INVESTIGATION WORK PLAN

WESTERN REFINING SOUTHWEST LLC
D/B/A MARATHON GALLUP REFINERY
GALLUP, NEW MEXICO

Drawn By: REP | Checked By: BM | Scale: 1" = 30' | Date: 2/9/2022 | File: 697-AOC-15-16

M:\TON\MARATHON\CADD\GALLUP_REPORTS\AOC\AOC15_NAPIS\697-AOC-15-16

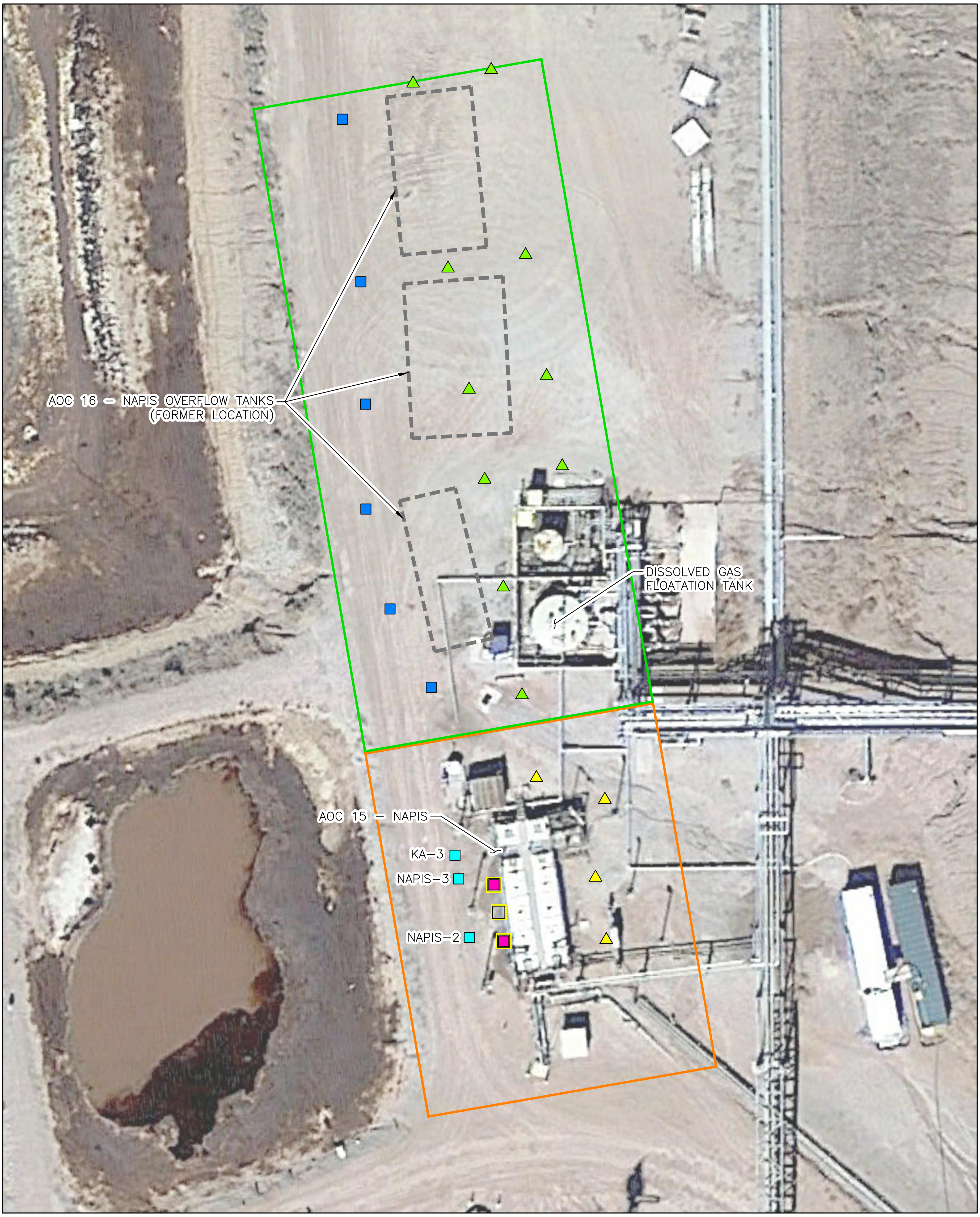
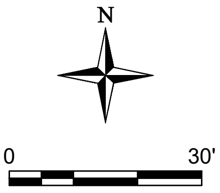


Image Cite: Google Earth Pro, Publication: March, 2016.

## EXPLANATION

| | |
|---|---|
| ▭ | AOC 15 NAPIS |
| ▭ | AOC 16 NAPIS OVERFLOW TANKS |
| ▭ | ESTIMATED FORMER LOCATION OF NAPIS OVERFLOW TANKS |
| ▲ | AOC 15 - PROPOSED SOIL SAMPLE LOCATION |
| ▲ | AOC 16 - PROPOSED SOIL SAMPLE LOCATION |
| ☐ | AOC 15 - PROPOSED SHALLOW VADOSE BROMIDE MONITORING WELL LOCATION |
| ■ | AOC 15 - PROPOSED BROMIDE MONITORING WELL AND SOIL SAMPLE LOCATION |
| ■ | AOC 16 - PROPOSED SOIL AND GROUNDWATER SAMPLE LOCATION |
| ■ NAPIS–2 | PERMANENT MONITORING WELL AND DESIGNATION |
| AOC | AREA OF CONCERN |
| NAPIS | NEW AMERICAN PETROLEUM INSTITUTE SEPARATOR |



Trihydro
CORPORATION
1252 Commerce Drive
Laramie, Wyoming 82070
www.trihydro.com
(P) 307/745.7474 (F) 307/745.7729

FIGURE 4
PROPOSED BROMIDE
MONITORING WELL AND SAMPLE LOCATIONS
AOC 15 AND AOC 16 INVESTIGATION WORK PLAN
WESTERN REFINING SOUTHWEST LLC
D/B/A MARATHON GALLUP REFINERY
GALLUP, NEW MEXICO

| Drawn By: REP | Checked By: AW | Scale: 1" = 30' | Date: 12/15/2023 | File: 697-AOC-15-16-SAMPLOCS-2023 |
|---|---|---|---|---|

\\TRIHYDRO.COM\CLIENTS\ITON\MARATHON\CADD\GALLUP_REPORTS\AOC\AOC15_NAPIS\697-AOC-15-16-SAMPLOCS-2023

# Appendix A – Bromide Concentration Calculation

Project Name/Calc Title New American Petroleum Institute Separator Installation Cross Section Bromide Calculation Concentration

Project Number 697-097-001 -01b
Calculations For Marathon Gallup Refinery Reference Drawings none Sheet No 1 of 4
Designed By JPietz;BButler Date 09/06/2022; 05/10/2023; 12/27/2023
Checked By TAnton;THanson Date 11/15/2022; 04/10/2023; 12/29/2023

## Purpose

Calculate the flux of groundwater across the New American Petroleum Institute Separator (NAPIS) length-wise cross section and determine the minimum leakage rate from the NAPIS that is detectable given an initial concentration of bromide.

## Methodology

1. Use the groundwater gradient and the local hydraulic conductivity from prior Marathon Gallup Refinery (Marathon) reports (cite references where used).
2. Determine submerged cross-sectional area of the NAPIS from available drawings.
3. Using the laboratory detection limit for bromide of 0.050 milligrams per liter (mg/L), calculate dilution ratio of bromide and assess detectability in terms of minimum leakage rate at this detection limit.

## Background

1. The New Mexico Environment Department (NMED) has commented on the investigation work plan (IWP), proposed by Marathon to dye leak test the NAPIS unit at the Gallup refinery. The NMED requested a calculation of the lowest leakage rate of dye from the NAPIS that is detectable given the published dye detection limit. The time to achieve the detectable concentration is also estimated. Subsequent field testing of a dye indicated that it was not suitable for use because of interference with background soil hydrocarbon levels, and bromide was proposed.

## Assumptions

1. Phase I includes collecting groundwater samples from the downgradient monitoring wells for potential background bromide concentrations. It is assumed that the background bromide concentrations will be non-detect.
2. Perfect, complete mixing of any leaked bromide with the flux of groundwater that is in contact with the NAPIS, ignoring any distortion of groundwater flow lines or blockage caused by the NAPIS, which is partially submerged in groundwater.
3. Locally measured hydraulic conductivity in a yield test from Test Pit Well 3 is 0.44 feet (ft)/day (Marathon 2021).
4. Groundwater flow direction at the NAPIS is essentially east to west, perpendicular to the NAPIS East Wall.
5. NAPIS operating water level is approximately 33 inches below the top wall of the NAPIS (Trihydro 2021).

6. The water bearing unit consists of silty-clayey sand with a porosity of 0.35.
7. The recharge rate into the Leak Detection Unit (LDU) observed during the investigation (Trihydro 2021) is approximately 0.03 milliliters per min (mL/min). For the purpose of estimating the time period for bromide testing, this rate is assumed to be the leakage rate from the NAPIS into local groundwater where leak test observation wells are located. Leak test observation wells are located approximately 5 feet (ft) downgradient (west) of the NAPIS.
8. Vadose zone or unsaturated zone transport of bromide to the observation wells is not considered; any leak from the NAPIS is assumed to be in communication with local groundwater.
9. Bromide concentration in the west NAPIS tank will be approximately 1,000 milligrams per Liter (mg/L).

## Calculations

1. Groundwater gradient across NAPIS. As shown in Attachment 1 (copy of Figure 3 from Trihydro 2021), distance between NAPIS-1 and NAPIS-2 is 60 ft. Groundwater elevations at these wells, respectively, are 6910 and 6908.5 feet above mean sea level (ft amsl). Local groundwater gradient across the NAPIS is

   (6910 ft amsl - 6908.5 ft amsl) / 60 ft = 0.025
2. Darcy groundwater velocity is v=ki, where k is hydraulic conductivity (ft/day) and i is the local groundwater gradient. Assumption 1 states k is 0.44 ft/day.

   v = 0.44 ft/day * 0.025 = 0.011 ft/day
3. Approximate depth of groundwater at the NAPIS is shown in Attachment 1 (~3 ft thick at the deepest part of the NAPIS).
4. Attachment 2 shows the cross-sectional area for the groundwater flux calculation. Total cross-sectional area for the groundwater flux is 135 square ft (ft$^2$).
5. Using the Darcy velocity and the flux area, the calculated groundwater volumetric flowrate across this cross-section is

   v * A = 0.011 ft/day * 135 ft$^2$ = 1.5 cubic feet (ft$^3$)/day or 11.1 gallons (gal)/day.
6. NAPIS bay volume calculation. Assumption 4 operating depth is 2.8 ft (33 inches). From Attachment 2, cross sectional area of an operating bay is 222 ft$^2$ (upper rectangle) + 40 ft$^2$ = 262 ft$^2$. From Attachment 3, the width of a NAPIS bay is 5.5 ft.
7. Total operating volume is

   262 ft$^2$ * 5.5 ft = 1441 ft$^3$ or 10,779 gal.
8. Add sufficient sodium (Na) bromide (Br) per 10,779 gal (rounded to 11,000 gal) as follows:

   1,000 mg/L = X mg / 11,000 gal * 1 gal/3.78 liters

   X = 1,000 mg/L * 11,000 gal * 3.78 L/gal = 41,580,000 mg or 41,580 grams

   This will be as bromide, so we need to find the weight of sodium bromide.

   Sodium bromide molecular weight in grams per mol (g/mol) = 79.9 (Br) + 22.9 (Na) = 102.8

Weight fraction bromide = 79.9 / 102.8 = 0.77

41,580 g bromide = X g Sodium bromide * 0.77

X = 53,500 grams sodium bromide or 53,500/454 grams per pound (g/lb) = 118 lb sodium bromide

9. Assuming 10 mg/L is the leak concentration limit, the dilution factor for this concentration limit is

   10E-3 * X (dilution factor) = 10E-5 (concentration limit). X = 0.01

10. From this dilution factor and the groundwater volumetric flow rate of 11.1 gal per day across the NAPIS, the target concentration leakage rate is

    11.1 gal/day * 0.01 = 0.11 gal/day

11. Using the cross-section area of 135 $ft^2$ (see #4 above), a width of 5 ft, and a porosity of 0.35, the total volume of groundwater within the observation well zone is 236.25 $ft^3$.
12. To calculate the time required to maintain a concentration of 1,000 mg/L in the West Bay, the following equation was considered.

    $C_1V_1=C_2V_2$

    Where $C_1$ = 1,000 mg/L, $V_1$ = the volume of tracer discharged from the NAPIS wall or the duration which the tracer is continuously applied to the Bay (T) X the discharge rate from the Bay (0.16 mL/min), $C_2$ = 0.05 mg/L, and $V_2$ = pore volume between the Bay and the well (236.25 $ft^3$).

    $V_1=TF$

    $T = C_2V_2/C_1F$

    Where, $1Ft^3=28{,}316.8mL$

    F = 2,090 minutes or 1.45 days

13. Vadose monitoring wells at an approximate distance of 5 ft from the NAPIS are also proposed, which allows for leak detection in the unsaturated zone. As stated in Assumption 7 above, travel time under unsaturated conditions were not considered in this calculation.
14. Given the NAPIS monitoring wells (NAPIS-2, NAPIS-3, and KA-3) are the furthest detection wells and are located at an approximate distance of 15 ft. from the West Bay, the estimated travel time to reach these well would be (15ft * 0.35)/ 0.011ft/day = 477 days. The proposed monitoring wells (5 ft from the NAPIS) are estimated to have bromide reach them in (5 ft * 0.35)/0.011 ft/day = 159 days.

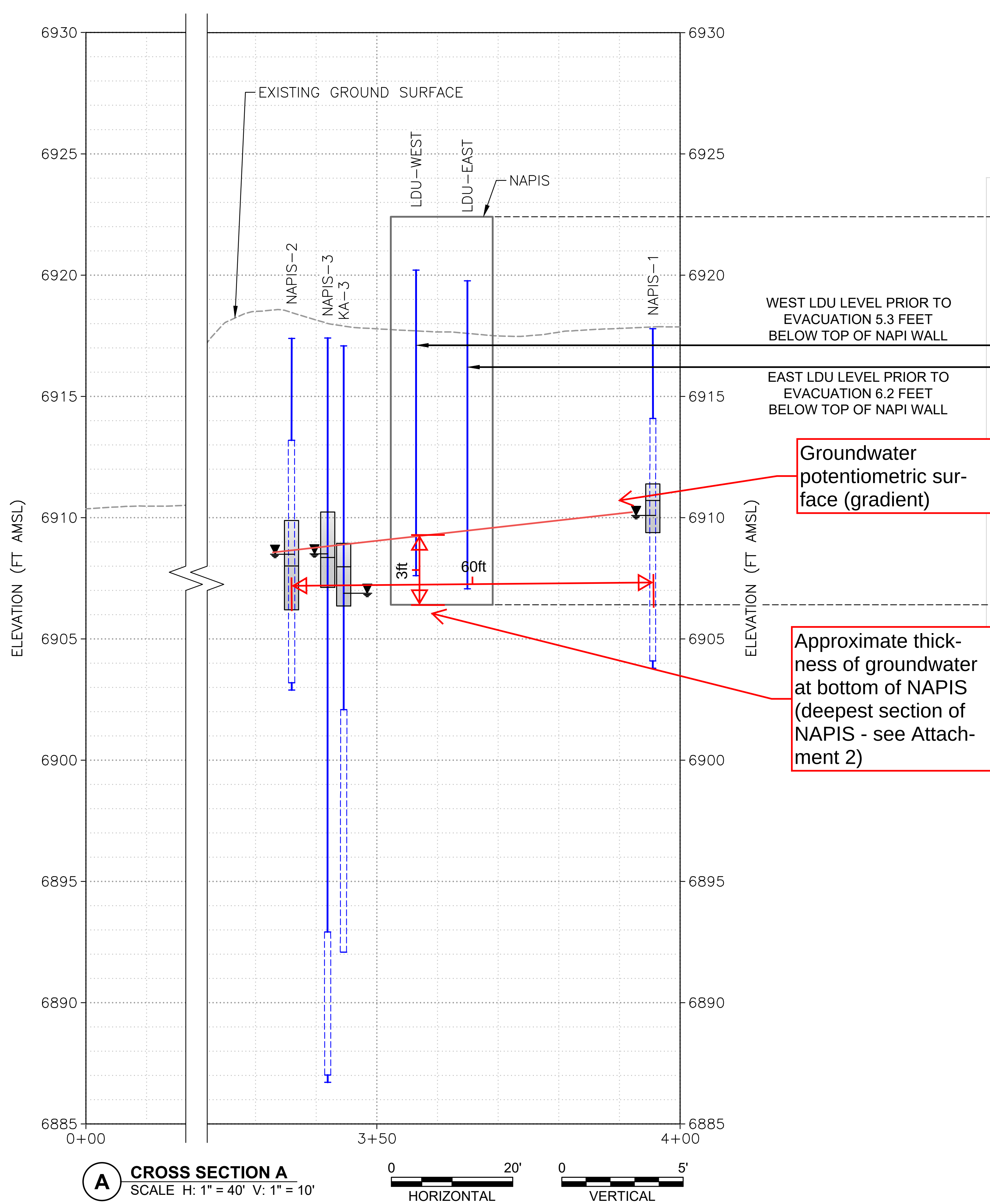
Project Name/Calc Title New American Petroleum Institute Separator Installation Cross Section Bromide Calculation Concentration

Project Number 697-097-001 -01b
Calculations For Marathon Gallup Refinery Reference Drawings none Sheet No 4 of 4
Designed By JPietz;BButler Date 09/06/2022; 05/10/2023; 12/27/2023
Checked By TAnton;THanson Date 11/15/2022; 04/10/2023; 12/29/2023

## References

Marathon Gallup Refinery (Marathon). 2021. SWMU-1 Test Pit Installation Letter Report Western Refining Southwest LLC D/B/A, Marathon Gallup Refinery EPA ID# NMD000333211 October 22 "M:\ItoN\Marathon\ProjectDocs\Gallup\SWMU\SWMU 1_AerationBas\Reports\TestPitReport\1-Text\202110_SWMU-1TestPits_Signed_LTR.pdf"

Trihydro Corporation (Trihydro). 2021. NAPIS Inspection - Summary of Findings Marathon Petroleum Company Gallup Refinery Division. November 29 "M:\ItoN\Marathon\ProjectDocs\Gallup\AOC\AOC15_NAPIS\Reports\LDU\1-Text\202112_NAPIS_Inspection_LTRRPT_Revised.docx"

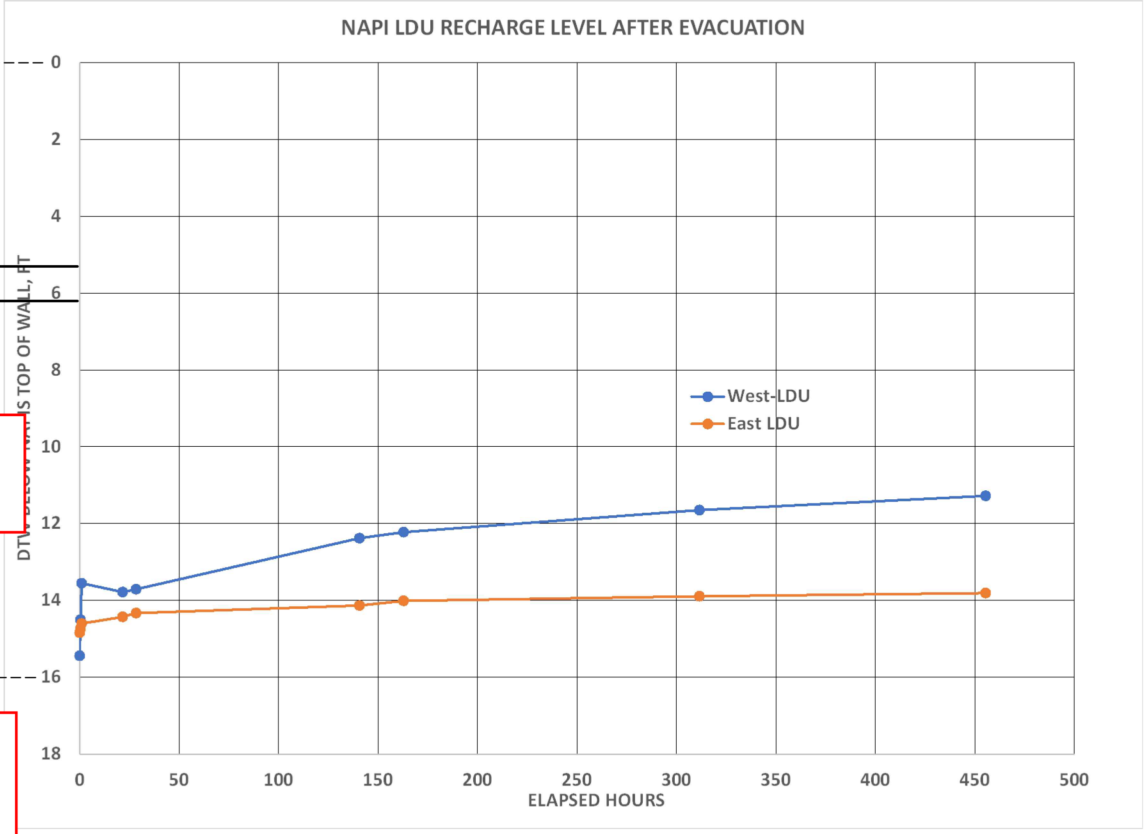


WEST LDU LEVEL PRIOR TO EVACUATION 5.3 FEET BELOW TOP OF NAPI WALL

EAST LDU LEVEL PRIOR TO EVACUATION 6.2 FEET BELOW TOP OF NAPI WALL

Groundwater potentiometric surface (gradient)

Approximate thickness of groundwater at bottom of NAPIS (deepest section of NAPIS - see Attachment 2)



## CROSS SECTION A

SCALE H: 1" = 40' V: 1" = 10'

0 20' HORIZONTAL

0 5' VERTICAL

## EXPLANATION

| | |
|---|---|
| ▼ | WATER LEVEL (JUNE 8, 2021 DTW) |
| ▭ | MINIMUM DTW (2011-2020)<br>AVERAGE DTW (2011-2020)<br>MAXIMUM DTW (2011-2020) |
| DTW | DEPTH TO WATER |
| FT AMSL | FEET ABOVE MEAN SEA LEVEL |
| LDU | LEAK DETECTION UNIT WELL |
| NAPIS | NEW API SEPARATOR |

NAPIS–1 DESIGNATION

WELL/TEST PIT

SCREENED INTERVAL

NAPIS REFERENCE DRAWINGS
NAPIS 42400-100, NAPIS 42400-106

| REV. | DATE | DESCRIPTION | BY | CHK'D |
|---|---|---|---|---|
| | | | | |

REVISIONS

DRAWN BY: PAC
CHECKED BY: JP
DATE: 6/15/2021
SCALE: AS SHOWN
FILE: 697-SWMU1-XSEC202106

Trihydro CORPORATION
1252 Commerce Drive
Laramie, Wyoming 82070
www.trihydro.com
(P) 307/745.7474 (F) 307/745.7729

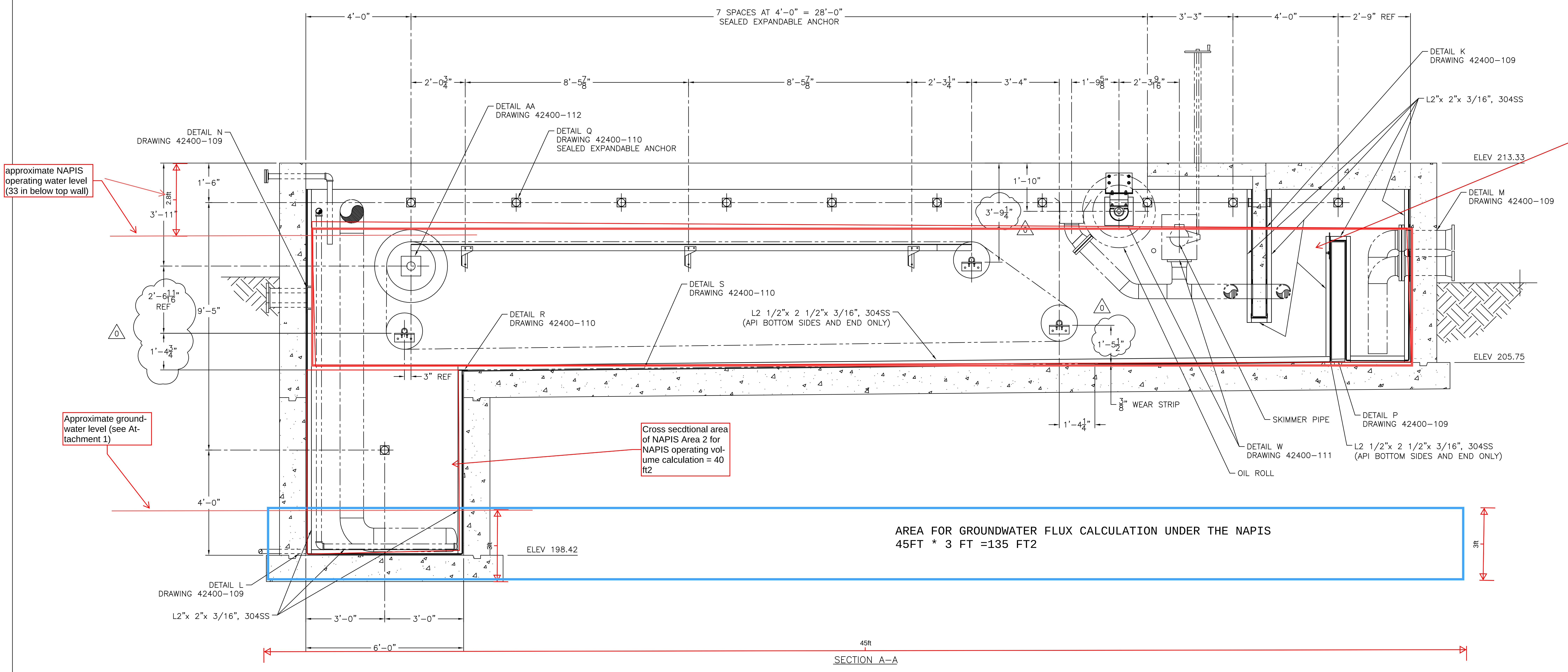
NAPIS LDU RECOVERY TEST DATA SUMMARY

MARATHON PETROLEUM COMPANY
GALLUP REFINING DIVISION
GALLUP, NEW MEXICO

FIGURE 3

REV: -

\\TRIHYDRO.COM\CLIENTS\TON\MARATHON\CADD\GALLUP_REPORTS\SWMU1_EVAPPONDCLOSURE\CROSSSECTION\697-SWMU1-XSEC202106



SECTION A-A

| REV | DESCRIPTION | DATE | DWN | CHKD | APVD | ECN |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| 0 | ISSUED FOR CONSTRUCTION REVISED PER 06/06/07 SITE MEETING | 06/12/07 | DJS | JLF | JLF | |
| A | ISSUED FOR APPROVAL AND INTERNAL REVIEW | 05/22/07 | DJS | JLF | JLF | |

STD: 1-0200-24X36D1

INTL REF:

BAR = 1" AT PLOT SCALE

| | |
|---|---|
| DESIGNER<br>DJS | DATE<br>05/14/07 |
| CHECKER<br>JLF | DATE<br>05/15/07 |
| ENGINEER | DATE |
| MANAGER<br>JLF | DATE<br>05/15/07 |
| FILE: | |
| SCALE: 1/2"=1'0" | |

TITLE
GENERAL ARRANGEMENT
API SEPARATOR AND OIL RECOVERY SUMP
ELEVATION VIEW LINER INSTALLATION

CLIENT
GIANT INDUSTRIES, INC
CINIZA REFINERY, GALLUP, NM

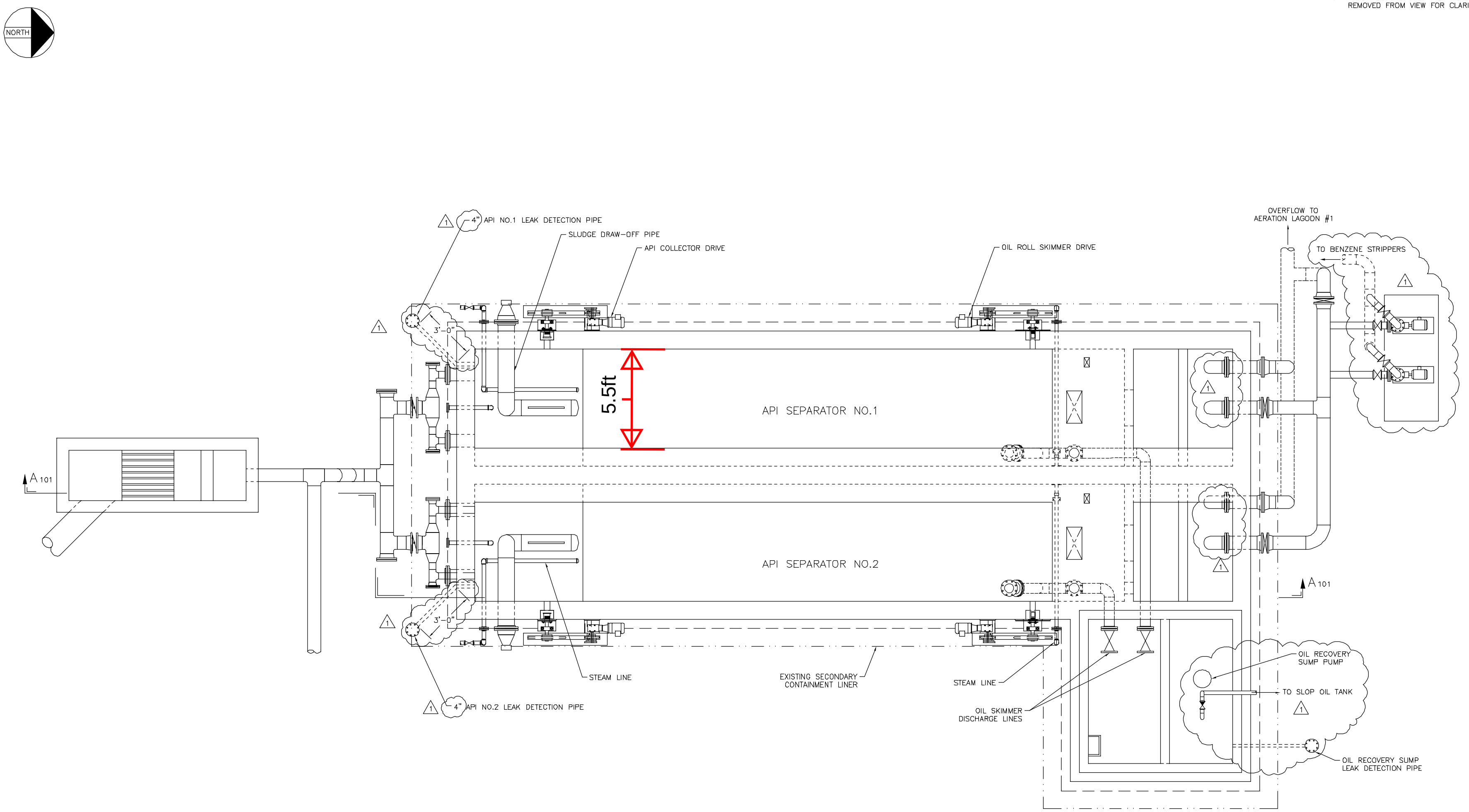
SIEMENS Water Technologies
WAUKESHA, WI
262-547-0141

| PROJECT | CODE | DRAWING | SHEET | REV |
|---|---|---|---|---|
| S00062 | | 42400-106 | 1 OF 1 | 0 |

A

NOTES:

1. VAPOR COVERS AND INTERNAL EQUIPMENT COMPONENTS REMOVED FROM VIEW FOR CLARITY.



| REV | DESCRIPTION | DATE | DWN | CHKD | APVD | ECN |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| | | | | | | |
| 1 | REVISED PER 06/06/07 SITE MEETING | 06/12/07 | DJS | JLF | JLF | |
| 0 | ISSUE FOR CONSTRUCTION | 05/01/07 | DJS | JLF | JLF | |
| A | ISSUED FOR APPROVAL | 04/19/07 | DJS | JLF | JLF | |

COMPANY CONFIDENTIAL
THIS DOCUMENT AND ALL INFORMATION CONTAINED HEREIN ARE THE PROPERTY OF SIEMENS AND/OR ITS AFFILIATES. THE DESIGN CONCEPTS AND INFORMATION CONTAINED HEREIN ARE PROPRIETARY TO SIEMENS AND ARE SUBMITTED IN CONFIDENCE. THEY ARE NOT TRANSFERABLE AND MUST BE USED ONLY FOR THE PURPOSE FOR WHICH THE DOCUMENT IS EXPRESSLY LOANED. THEY MUST NOT BE DISCLOSED, REPRODUCED, LOANED OR USED IN ANY OTHER MANNER WITHOUT THE EXPRESS WRITTEN CONSENT OF SIEMENS. IN NO EVENT SHALL THEY BE USED IN ANY MANNER DETRIMENTAL TO THE INTEREST OF SIEMENS. ALL PATENT RIGHTS ARE RESERVED. UPON THE DEMAND OF SIEMENS, THIS DOCUMENT, ALONG WITH ALL COPIES AND EXTRACTS, AND ALL RELATED NOTES AND ANALYSES, MUST BE RETURNED TO SIEMENS OR DESTROYED, AS INSTRUCTED BY SIEMENS. ACCEPTANCE OF THE DELIVERY OF THIS DOCUMENT CONSTITUTES AGREEMENT TO THESE TERMS AND CONDITIONS.

| | |
|---|---|
| DESIGNER DJS | DATE 04/16/07 |
| CHECKER JLF | DATE 04/18/07 |
| ENGINEER | DATE |
| MANAGER JLF | DATE 04/18/07 |
| FILE: | |
| SCALE: 3/8"=1'0" | |

TITLE API SEPARATOR AND OIL RECOVERY SUMP
PLAN VIEW

CLIENT GIANT INDUSTRIES, INC
CINIZA REFINERY, GALLUP, NM

SIEMENS Water Technologies
WAUKESHA, WI
262-547-0141

| PROJECT | CODE | DRAWING | SHEET | REV |
|---|---|---|---|---|
| S00062 | | 42400-100 | 1 OF 1 | 1 |

STD: 1-0200-24X36D1

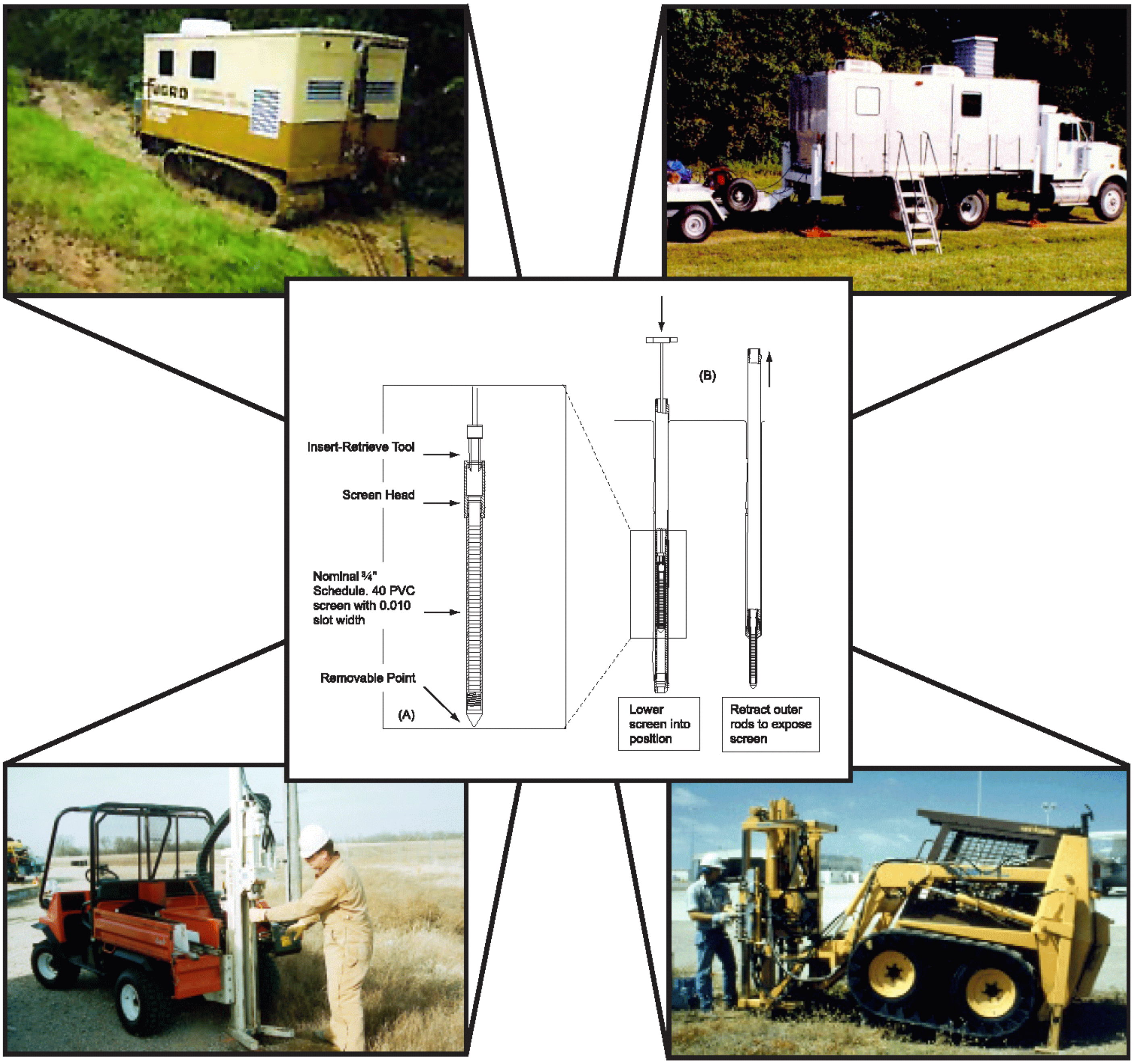
INTL REF:

BAR = 1" AT PLOT SCALE

# Appendix B – Groundwater Sampling and Monitoring with Direct Push Technologies

United States Environmental Protection Agency

# Groundwater Sampling and Monitoring with Direct Push Technologies



Solid Waste and
Emergency Response
(5204G)

OSWER No. 9200.1-51
EPA 540/R-04/005
August 2005
www.epa.gov

# Groundwater Sampling and Monitoring with Direct Push Technologies

U.S. Environmental Protection Agency
Office of Solid Waste and Emergency Response
Washington, DC 20460

This page left intentionally blank

# NOTICE AND DISCLAIMER

This report has been funded wholly by the United States Environmental Protection Agency (EPA) under Contract Number 68-W-02-033. The report is not intended, nor can it be relied upon to create any rights enforceable by any party in litigation with the United States. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

Copies of this report are available free of charge from the National Service Center for Environmental Publications (NSCEP), P.O. Box 42419, Cincinnati, OH 45242-0419; telephone (800) 490-9198 or (513) 490-8190; or facsimile (513) 489-8695. Refer to document EPA 540/R-04/005, *Groundwater Sampling and Monitoring with Direct Push Technologies.*

This page left intentionally blank

# Table of Contents

---

# Figures

# Tables

# Abbreviations

| | |
|---|---|
| ASTM | American Society for Testing and Materials |
| CPT | cone penetrometer testing |
| CSP | centrifugal submersible pump |
| DCE | dichloroethene |
| DNAPL | dense non-aqueous phase liquid |
| DO | dissolved oxygen |
| DPT | direct push technology |
| DQO | data quality objectives |
| FID | flame ionization detector |
| GC | gas chromatograph |
| ID | inner diameter |
| LIF | laser-induced fluorescence |
| LNAPL | light non-aqueous phase liquid |
| MIP | membrane interface probe |
| OD | outer diameter |
| ORP | oxidation/reduction potential |
| PAH | polycyclic aromatic hydrocarbon |
| PCB | polychlorinated biphenyl |
| PE | polyethylene |
| PP | polypropylene |
| PTFE | polytetrafluoroethylene |
| PVC | polyvinyl chloride |
| QC | quality control |
| RCRA | Resource Conservation and Recovery Act |
| ROST | Rapid Optical Screening Tool |
| SC | specific conductivity |
| SVOC | semi-volatile organic compound |
| TCE | trichloroethene |
| EPA | United States Environmental Protection Agency |
| UV | ultraviolet |
| VOC | volatile organic compound |

This page is intentionally blank.

# Section 1: Introduction

## Background

Direct push technology (DPT, also known as “direct drive,” “drive point,” or “push technology”) refers to a growing family of tools used for performing subsurface investigations by driving, pushing, and/or vibrating small-diameter hollow steel rods into the ground. By attaching sampling tools to the end of the steel rods they can be used to collect soil, soil-gas, and groundwater samples. DPT rods can also be equipped with probes that provide continuous in-situ measurements of subsurface properties (e.g., geotechnical characteristics and contaminant distribution). Interest in understanding how DPT groundwater collection methods compare with traditional monitoring well sampling methods has steadily increased since the mid-1980s when DPT first started being used for this purpose. Although environmental professionals recognize that DPT provide a cost-effective alternative to conventional approaches to subsurface sampling, some have been reluctant to use it for groundwater sampling because of uncertainty regarding the quality of samples that the technology can provide. This guidance is designed to encourage more widespread consideration of DPT by clarifying how DPT can be used to meet a variety of data quality requirements for a variety of site conditions.

## Intended Audience

The primary audience for this guidance is EPA regional folks working on CERCLA, RCRA, and other related programs. It also may be useful for environmental professionals who oversee or undertake the collection of groundwater samples at contaminated sites and have a basic scientific understanding of groundwater sampling. Information is provided on the application and limitations of DPT for groundwater sampling activities. Although this document is not intended to provide substantial background information, Section 2 provides a general overview of DPT groundwater sampling and an extensive list of resources is cited within the text and listed in the reference section.

## Scope and Limitations

This document focuses on groundwater sampling issues related to DPT, in particular those regarding the quality and usability of the groundwater data. Two general types of DPT groundwater sampling methods are discussed: “point-in-time” or “grab” sampling and sampling with direct push installed monitoring wells. In order to provide a concise and readable document, references are provided so that readers can access more detailed information where needed. Other uses of DPT, such as soil sampling, soil-gas sampling, and deployment of continuous logging equipment, generally are not controversial; therefore, they are not discussed at length. In addition, this guidance assumes a basic level of understanding of DPT equipment. Readers unfamiliar with DPT equipment should refer to:

- Expedited Site Assessment Tools for Underground Storage Tank Sites: A Guide for Regulators (EPA, 1997). Chapter V of this guide, Direct Push Technologies, provides a good overview of the tools and their capabilities. It is available at: http://www.epa.gov/swerust1/pubs/sam.htm.

- The Field Analytical Technology Encyclopedia (FATE) contains a section on Direct Push Platforms. It is available at: http://fate.clu-in.org.

- ASTM direct push standards, Standard Guide for Installation of Direct Push Ground Water Monitoring Wells, D 6724-01; Standard Practice for Direct Push Installation of Prepacked Screen Monitoring Wells in Unconsolidated Aquifers, D 6725-01; Standard Guide for Direct-Push Water Sampling for Geoenvironmental Investigations, D-6001; and Standard Guide for Direct Push Soil Sampling for Environmental Site Characterization, D-6282. They are available for purchase at: http://www.astm.org.

This guidance is not intended to replace the knowledge and advice of an experienced hydrogeologist. Site-specific situations may dictate that an expert familiar with site conditions and project goals be involved in the planning and implementation of any groundwater sampling event. Furthermore, Federal and State regulatory requirements can vary substantially among jurisdictions and the appropriate regulatory and State agencies must be consulted to ensure that legal requirements are met.

## Advantages and Limitations of Direct Push Technologies

Direct push technologies are a valuable tool for environmental investigations because they can offer a number of advantages over conventional well installation and sampling methods and can provide many other types of data to a project team (e.g., in-situ detection of contaminants, real-time geotechnical data). Some of the typical advantages of using DPT over monitoring wells drilled and installed with conventional tools, such as hollow stem augers, include:

- Faster sampling capability that helps to provide more data, thereby improving site decision making and facilitates the use of a dynamic work plan strategy;
- In general, lower cost when greater data density is needed;
- Greater variety of equipment and methods resulting in greater flexibility in meeting project goals;
- Capability of collecting depth-discrete groundwater samples to locate contaminated layers;
- Better vertical profiling capability for generating three-dimensional profiles of a site that improve the conceptual site model; and
- Less investigation-derived waste generated, thereby saving additional time and money while minimizing the potential for exposure to hazardous substances.

However, DPT cannot completely replace the use of conventional monitoring wells. Rather, DPT provides environmental professionals with additional choices from which to select equipment and methods for collecting groundwater samples. Conventional methods still have a number of potential advantages over DPT, including:

- Fewer limitations for deployment in a variety of geologic and hydrogeologic settings. For example, conventional DPT may not be able to penetrate some caliches, bedrock, or unconsolidated layers with significant amounts of gravel or cobbles. DPT is not recommended where telescoped wells are needed to prevent contaminant migration below confining layers;
- Deeper limit of subsurface penetration than DP rigs in most geologic settings; and
- Easier collection of large sample volumes.

Consequently, DPT and conventional monitoring well technologies may both be useful for groundwater sampling. They can provide environmental professionals with a variety of options to collect data sufficient for decision making, even when high quality groundwater samples are needed.

## How to Use This Guidance

This guidance is divided into four major sections designed to expose the reader to potential issues and solutions regarding groundwater sampling with DPT:

- *Section 2: Summary of Direct Push Technology Groundwater Sampling Methods*: provides an overview of the different types of equipment available with DPT to collect groundwater.
- *Section 3: Data Quality Objectives for Groundwater Sampling*: provides the reader with a summary of groundwater data quality issues that should be considered while planning a groundwater sample collection activity.
- *Section 4: Recommended Methods for Collecting Representative Groundwater Samples*: provides the reader with information on filter packs, well development, and low-flow sampling methods as they relate to DPT.
- *Section 5: Recommended Methods for Minimizing the Potential for Cross-Contamination*: provides the reader with information on drag-down, hydraulic conduits, decontaminating equipment, and decommissioning DPT boreholes.

This page is intentionally blank.

# Section 2: Summary of Direct Push Technology Groundwater Sampling Methods

---

DPT groundwater sampling equipment generally falls into one of two broad categories:

- **Point-in-time groundwater samplers:** These tools or devices, also referred to as "temporary samplers" or "grab samplers," are used to rapidly collect samples to define groundwater conditions during one sampling event. They are usually less than two inches outside diameter (OD) and are generally constructed of steel or stainless steel. Direct push methods (percussion or static weight) are used to advance point-in-time samplers below the static water level in unconsolidated formations. Generally, groundwater flows into the sampler from an exposed screen under ambient hydrostatic pressure. Groundwater may be collected from the sampler using bailers or pumps, or the sampler may be retracted to the surface to obtain the water sample. Once sampling is completed, these devices are removed and the boring should be abandoned in accordance with local regulations.

- **DPT-installed groundwater monitoring wells:** These monitoring wells are installed by direct push methods to permit short-term or long-term monitoring of groundwater and are usually two inches in diameter or less and constructed of PVC and/or stainless steel. Since monitoring wells are installed for periods of several months to several years, the annulus of the boring around the well casing is usually sealed to prevent migration of contaminants into the aquifer. Surface protection is required to prevent tampering with the well. A slotted or screened section permits groundwater to flow into the well under ambient hydrostatic pressure. Groundwater may be collected from monitoring wells using bailers, various pumps, or passive sampling devices.

Point-in-time sampling tools are typically used during site characterization to identify plume boundaries or hot spots. They cannot be used for long-term monitoring or trend analysis since the boreholes need to be decommissioned upon completion of sampling. In contrast, temporary and permanent monitoring wells are typically used to provide trend analysis of contaminant groundwater concentrations over an extended period of time. DPT can be used to install small-diameter (e.g., up to 2 inches outside diameter [OD]) monitoring wells.

Ideally, both DPT point-in-time and monitoring well groundwater sampling equipment should be used together to maximize their effectiveness. Point-in-time sampling techniques are generally better for identifying plume boundaries, hot spots, preferred pathways, or other monitoring points of interest. Once this information is collected, DPT monitoring wells, as well as conventional monitoring wells, can be optimally placed to provide project teams with the most useful monitoring data.

This section summarizes the various types of point-in-time sampling tools and DPT monitoring well installation techniques. Since DPT groundwater sampling methods are often used to their best advantage in combination with other specialized DPT measurement and logging tools, these associated tools are also discussed at the end of this section. This information is intended to provide the reader with an easily accessible summary of available

DPT tools. Other resources listed in the *Introduction* could also be used for a more comprehensive survey of available tools and their capabilities. Table 2.1 provides a list of some of the major DPT equipment available for groundwater investigations. It summarizes the capabilities of the equipment and helps the reader to sort through the variety of tools and how they may be useful for specific project goals. Because this section provides a basic overview of existing equipment, readers already familiar with the capabilities of DPT equipment may wish to proceed to Section 3 for information on how these tools can be used to collect groundwater samples to meet project objectives.

## Point-in-Time Sampling

A variety of point-in-time groundwater sampling tools are available for site characterization, including:

- Sealed-screen sampling;
- Multi-level sampling (or vertical profiling); and
- Open-hole sampling.

With these techniques, the time needed to retrieve the sample will vary according to the hydraulic conductivity of the sampling zone. In general, sampling within coarse-grained sediments takes minutes while fine-grained sediments can take several hours or more. In situations where slow recharge inhibits the timely collection of groundwater samples, the sampler may be left in place to recharge while the DPT rig is moved to a new sampling location.

### Sealed-Screen Samplers

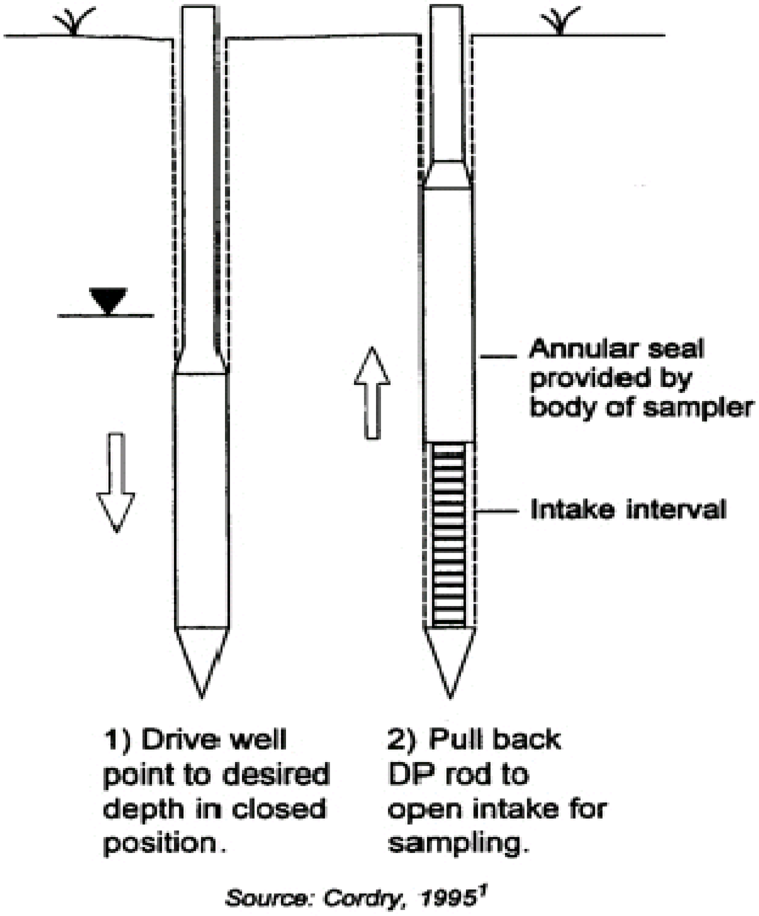
Sealed-screen samplers typically consist of a short (e.g., 6-inch to 3-foot) screen nested within a sealed, water-tight tool body (Figure 2.1). Because the screen is not exposed to the formation as the sampler is advanced into the subsurface, the screen does not become plugged or damaged. In addition, the potential for cross contamination is greatly reduced and a true depth-discrete sample that is representative of the target sampling zone can be collected. The sample volume collected with some sealed-screen samplers is limited by the volume of the sample chamber (e.g., 500 mL for the Hydropunch I™; 1.2 L for the Hydropunch II™; and 35 to 120 mL for each vial in the BAT™).

To collect the sample, the sealed-screen sampler is advanced to the target sampling depth and the protective outer rod is retracted, exposing the screen to groundwater. Groundwater flows through the screen under the hydraulic head conditions that exist at that depth and into the drive rods or sample chamber. O-ring seals placed between the drive tip and the tool body help ensure that the sampler is water tight as it is driven to the target sampling interval. The integrity of the seal can often be checked by lowering an electronic water level indicator into the sampler prior to retracting the protective outer rod.

## Table 2.1
## Comparison of Various Direct Push Technology Sampling and Data Collection Capabilities

| EQUIPMENT | CAPABILITIES | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Evaluate Strati-graphy | Measure Pore Pressure | Measure Soil Conduc-tivity | Detect Hydrocarbon | Detect VOC | Sample Soil | Sample Soil Gas | Sample Ground-water | Sample Pore Water | Evaluate Vadose Zone | Measure Water Level | Install Small Diameter Wells |
| Sealed-Screen Samplers | | | | | | | | | | | | |
| BAT GMS | | | | | | | | ✓ | ✓ | | | |
| BAT Enviroprobe | | | | | | | ✓ | ✓ | | | | |
| Dual-Tube Samplers | ✓ | | | | | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ |
| HydroPunch I and II™ | | | | | | | | ✓ | | | | |
| PowerPunch™ | | | | | | | | | | ✓ | ✓ | ✓ |
| Screen Point 15 | | | | | | | | ✓ | | | ✓ | |
| SimulProbe® | | | | | | ✓ | ✓ | ✓ | | | | |
| Multi-Level Samplers | | | | | | | | | | | | |
| Geoprobe | ✓ | | ✓ | | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ |
| Envirocore | ✓ | | | | | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ |
| Vertek ConeSipper® | ✓ | ✓ | ✓ | | | | ✓ | ✓ | | ✓ | ✓ | |
| Waterloo Profiler | | | | | | | ✓ | ✓ | | ✓ | ✓ | |
| Specialized Measurement and Logging Tools | | | | | | | | | | | | |
| Cone Penetrometer | ✓ | ✓ | ✓ | | | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ |
| Instrumented CPTs | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | | |

**Figure 2-1**
**Sealed-Screen Sampler**



*Source: Cordry, 1995*[1]

Sampling fine-grained formations may be difficult because of the long time it takes to fill the sampler with groundwater. Sample collection times in formations with low hydraulic conductivity may exceed several hours for some tools, compared to several minutes or tens of minutes in formations of high to moderate hydraulic conductivity (Zemo et al., 1994; Zemo et al., 1995). However, to avoid downtime, the samplers can be left in the borehole to recharge while the installing rig moves off the hole to another location to sample. To decrease sample collection time, samples can be collected from samplers with longer, 30- to 42-inch screens (e.g., Geoprobe® Screen Point 15) while the tool is downhole. A bailer or pump is needed to collect the sample from the target zone.

Sealed-screen samplers generally are limited to collecting one sample per advance of the sampler. However, depending upon the system used, multi-level sampling in a single borehole can be accomplished with sealed-screen samplers by retrieving the sampler and decontaminating it or replacing it with a clean sampler before reentering the hole to collect another sample.

### Multi-Level Samplers

Multi-level samplers, most of which are exposed-screen samplers, are DPT equipment capable of collecting groundwater samples at multiple intervals as the sampling tool is advanced, without having to withdraw the tool for sample collection or decontamination. The terminal end of a typical multi-level sampling tool has a 6-inch- to 3-foot-long screen made up of fine-mesh, narrow slots, or small holes. The screen remains open to formation materials and water while the tool is advanced (Figure 2.2). This allows samples to be collected either continuously or periodically as the tool is advanced to vertically profile groundwater chemistry and aqueous-phase contaminant distribution.

Multi-level samplers can be used to measure water levels at discrete intervals within moderate- to high-yield formations to assist in defining vertical head distribution and gradient. Additionally, some of these tools can be used to conduct hydraulic tests at specific intervals to characterize the hydraulic conductivity in formation materials to identify possible preferential flow pathways and barriers to flow (Butler et al., 2000; and McCall et al., 2000).

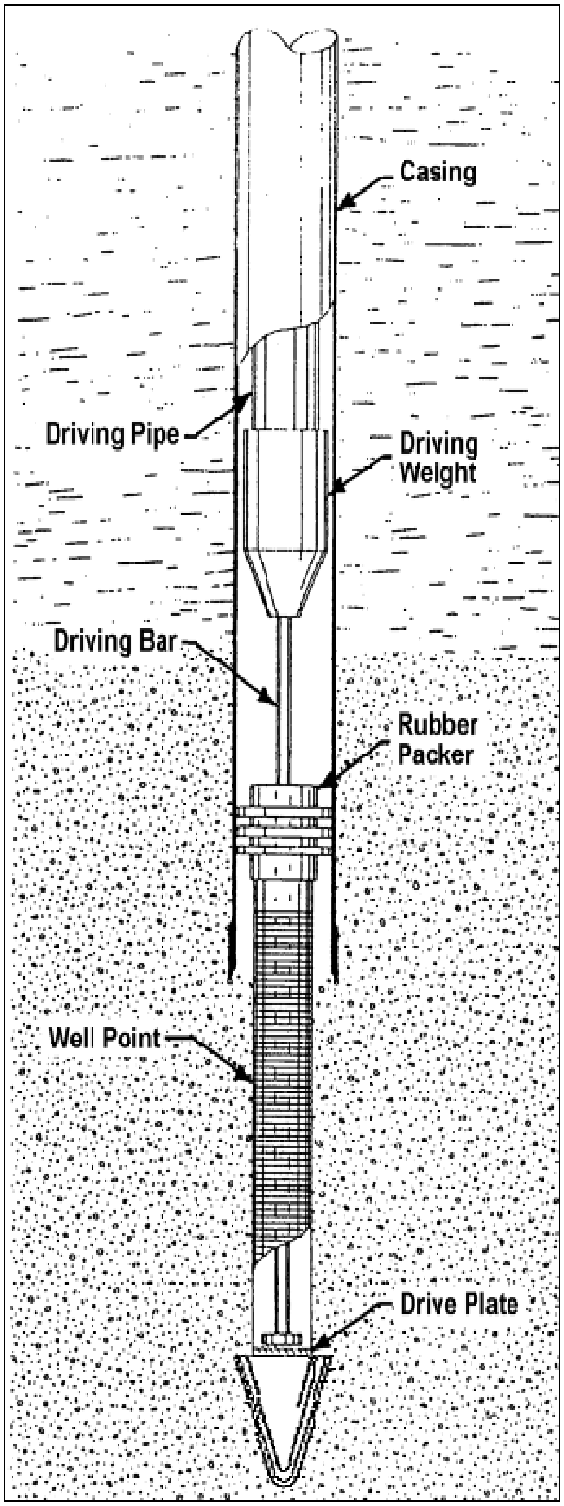
A drawback to multi-level sampling is the possible drag-down by the screen of contamination from zones above the desired sampling interval (Figure 2.3) (Pitkin et al., 1999). The Waterloo Profiler minimizes the potential for cross- contamination. It uses a 6-inch long, uniform diameter, stainless-steel sampling tool into which several inlets or sampling ports have been drilled and covered with fine-mesh screen. As the tool is advanced, distilled or deionized organic-free water is slowly pumped down tubing that runs inside the drive rod and leads to the sampling ports in the tool (Figure 2.4). The water keeps groundwater from entering the tool while it is advanced. A peristaltic pump is typically used for depths less than 25 feet; a double-valve pump can be used for sampling at greater depths.

After the first target interval is reached, the flow of the pump is reversed and the sampling tube is purged so water representative of the aquifer is obtained. After the sample is collected, the pump is reversed and distilled or deionized water is again pumped through the sampling ports. The tool is then advanced to the next target interval where the process is repeated (Figure 2.5).

Several field studies (Cherry, et al., 1992; Pitkin, et al., 1994; Pitkin, et al., 1999) have demonstrated that the Waterloo Profiler is capable of providing a very detailed view of contaminant plumes—particularly in complex stratified geological materials—without the effects of drag-down and the cross contamination of samples. However, because a peristaltic pump is typically used to collect samples when the sampling depth is less than 25 ft below ground surface (bgs), there may be a negative bias in samples collected for analysis of VOCs or dissolved gases. To avoid this potential bias, VOC samples should be collected in-line, ahead of the pump, and a sufficient volume of water should be pumped through the system to account for the initial filling of the containers when a negative head space was present.

Another multi-level sampler, the VERTEK ConeSipper®, attaches directly behind a standard cone penetrometer to collect groundwater as the cone penetrometer testing (CPT) is advanced. An inert gas flows to the ConeSipper® to control the rate of sample collection and to purge and decontaminate the device down hole. The ConeSipper® is equipped with two filters, which help minimize turbidity in the samples. The primary filter is a stainless steel screen whose openings can range in size from 51 to 254 µm. A secondary filter, which can be made from sintered stainless steel and comes with opening sizes ranging from 40 to 100 µm or regular

### Figure 2.2
### Exposed-Screen Sampler–Well Point Driven below the Base of a Borehole



Source: ASTM (2001e)

**Figure 2.3**

**Schematic Illustration of Degrees of Drag Down Potentially Induced by Direct Push Sampling Devices**

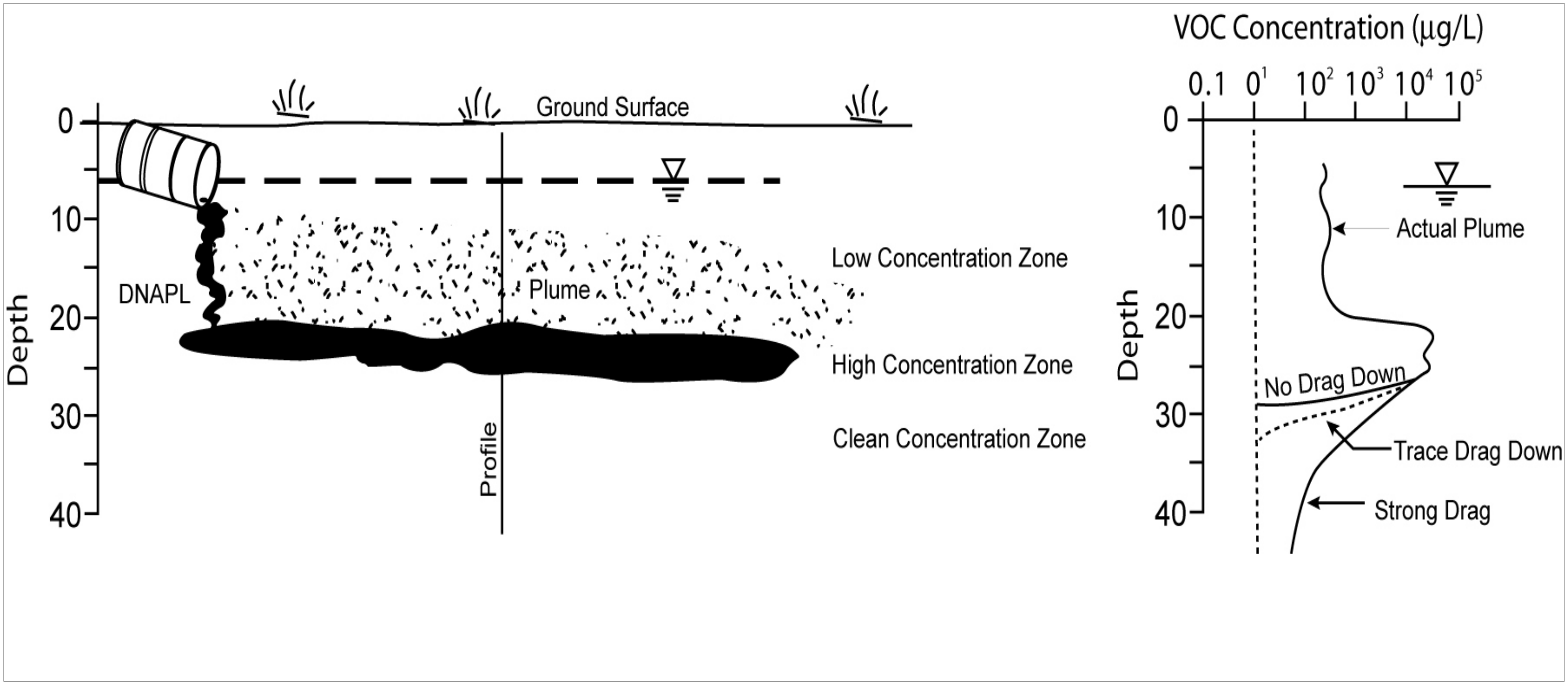
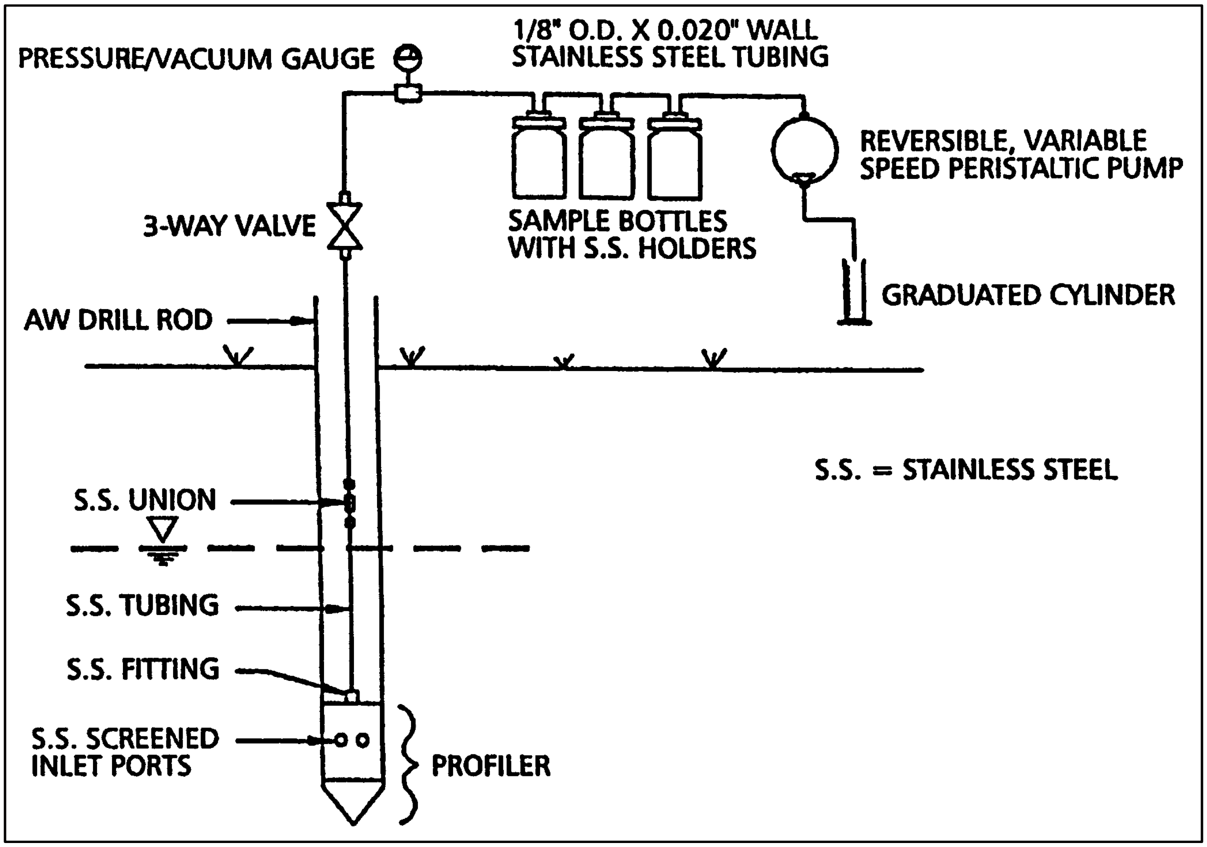


**Figure 2.4**
**Operation of the Waterloo Profiler**



Source: Pitkin et al. (1999)

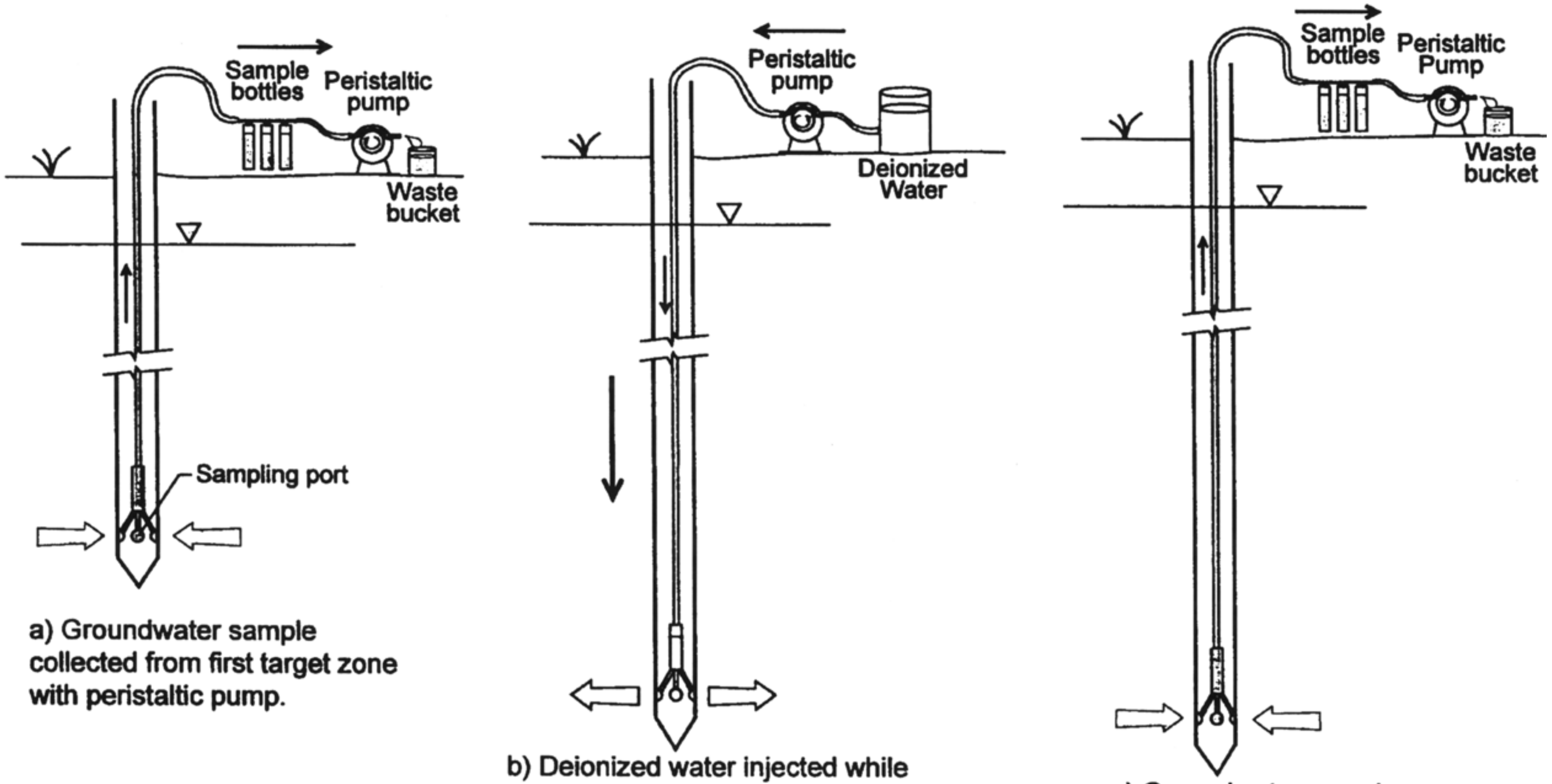
stainless steel with openings ranging in size from 38 to 74 µm, removes fines (Applied Research Associates, 2004).

## Open-Hole Sampling Methods

Open-hole sampling is conducted by advancing drive rods with a drive point to the desired sampling depth. Upon reaching the sampling depth, the rods are withdrawn slightly which separates them from the drive tip and allow water to enter the rods. The water can be sampled by lowering a bailer into the rods or by pumping. The open-hole method is only feasible within formations that are fairly cohesive, otherwise the formation may flow upwards into the rods when they are withdrawn, preventing samples from being collected.

With single-rod systems, open-hole sampling can only be conducted at one depth within a borehole because the borehole cannot be flushed out between sampling intervals and cross-contamination may occur. Dual-tube systems, on the other hand, can be used to conduct multi-level sampling.

Figure 2.5
Collecting Samples From Discrete Depths (Profiling) Using the Waterloo Drive-Point Profiler



a) Groundwater sample collected from first target zone with peristaltic pump.

b) Deionized water injected while advancing tool to prevent sampling ports from becoming plugged.

c) Groundwater sample collected from second target zone with peristaltic pump.

*Source: Precision Sampling, Inc.*

Dual-tube samplers are typically advanced into the subsurface to collect continuous soil cores; however, groundwater samples can be collected at the end of each core run. Dual-tube samplers have an outer casing that is driven to the target soil coring depth. The outer casing holds the hole open and seals off the surrounding formation as an inner rod (with a sample liner for soil sampling) is lowered into the outer casing and both are driven into the undisturbed formation below. Once the soil core is retrieved, groundwater can be sampled by lowering a bailer or pump into the outer casing The borehole can continue to be advanced so that multiple groundwater samples can be retrieved from multiple depths in the same borehole. The water should be purged from the casing with subsequent advances of casing and inner rod so that groundwater from overlying intervals do not cross-contaminate the sample.

The amount of water that needs to be purged depends upon the type of sampling equipment that is used. For pumping systems, purging procedures similar to those designed for wells (low-flow purging) and described in Section 4, should be used. If bailers are used, then it is important that all the water contained in the outer casing be removed to ensure that the water the bailer is passing through comes from the interval of interest. The accepted procedure for traditionally completed wells when bailers are used is to remove at least three volumes of water and measure water quality indicators (e.g., pH, specific conductance) until they stabilize. The use of a bailer in this situation may preclude the collection of some parameters that may be sensitive to the iron in the outer casing (See Low-flow Purging Section 4.)

A dual-tube profiling system has been developed so that a simple screen can be inserted through the cutting shoe of a dual-tube soil sampling device (Figure 2.6). This system enables the operator to collect soil samples and then insert a screen at selected intervals, which they can then use for sampling or conducting slug tests to locate preferential migration pathways (Butler et al., 2000; McCall et al., 2000). This system also allows for bottom-up grouting to assure proper boring abandonment.

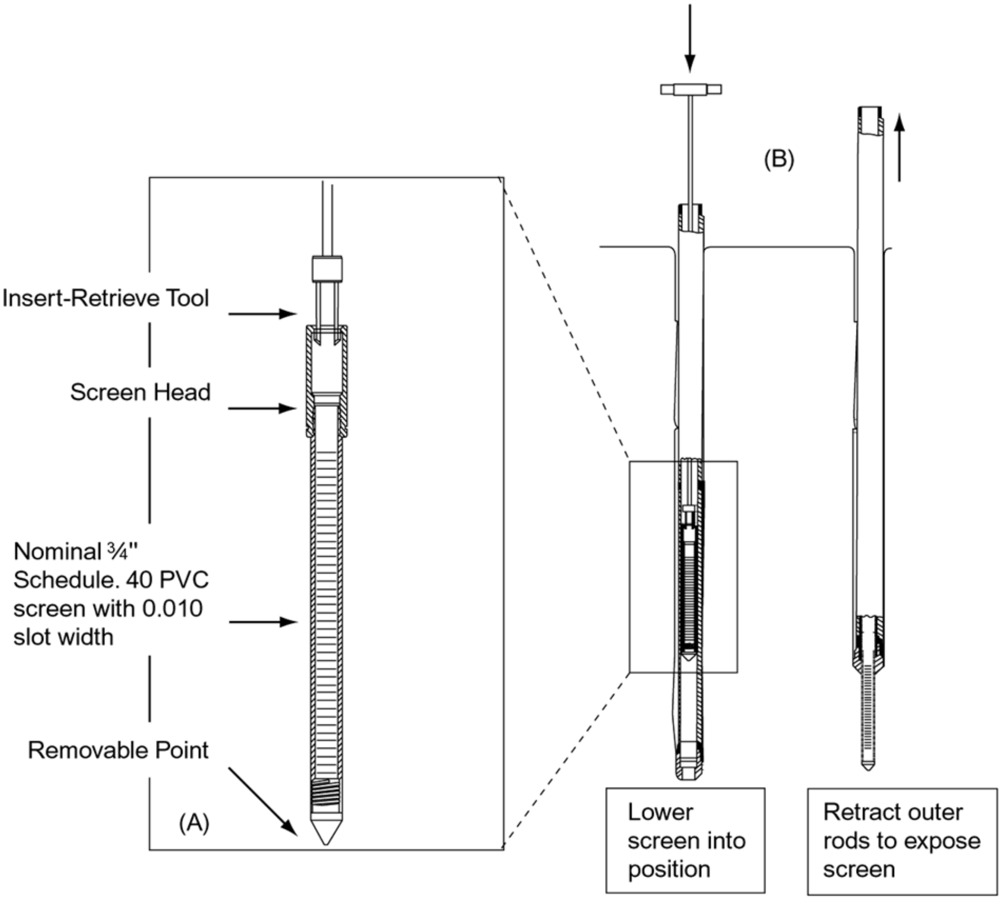
## DPT Monitoring Well Installation

A variety of DPT methods are available for installing temporary or permanent monitoring wells. The two main installation methods used are exposed-screen and protected-screen wells. These methods are discussed in detail in ASTM D-6724 and D-6725 (ASTM, 2003a and 2003b) and are summarized here. As with conventional well installations, hydraulic connections should not be created between otherwise isolated water-bearing strata. In addition, precautions should be taken to minimize turbidity during the installation of filter packs and the development and sampling of wells (Section 4).

### Exposed-Screen Well Installation Methods

With exposed-screen well installation methods, the well casing and screen are driven to the target depth using a single string of rods. Because the screen is exposed to formation materials while it is advanced, proper well development (as discussed in Section 4) is important to remove soil from screen slots. This method is not recommended for installing well screens within or beneath contaminated zones because drag-down of contaminants with the screen may cross-contaminate sampling zones and make acquisition of samples representative of the target zone impossible. Exposed-screen well installation methods should only be used in upgradient

## Figure 2.6
## Schematic of the Geoprobe® DT21 Profiler



A) Screen components for insertion through the dual-tube system for slug testing and sampling.

B) The profiling screen is lowered through the outer rods after the inner rods are removed. Once the screen is at the base of the outer rods, they are retracted as the screen is held in position for accurate placement.

Source: www.geoprobe.com

---

areas that are known to be uncontaminated. Also, some states prohibit allowing the formation to collapse around a well screen in the construction of a monitoring well**.** Therefore, state regulations should be consulted before selecting exposed-screen techniques.

In one type of exposed-screen installation, the PVC well screen and casing are assembled and placed around a shaft of a drive rod connected to a metal drive tip. The casing and screen, which rest on top of the drive tip, are advanced to the target depth by driving the rod to avoid placing pressure on the screen. The drive tip slightly enlarges the hole to reduce friction between the formation and the well screen and casing, and remains in the hole plugging the bottom of the screen. The filter pack surrounding the well screen commonly is derived from formation materials that are allowed to collapse around the screen. Rigorous well development improves the hydraulic connection between the screen and the formation and generally is necessary to remove formation fines and the effects of well installation, which may include borehole smearing or the compaction of formation materials. Due to the very small annulus (if any) that surrounds a well constructed using the exposed-screen method, it is not generally possible to introduce a filter pack or annular seal from the surface.

Exposed-screen methods also can be used to install well points—simple wells used for rapid collection of water level data, groundwater samples, and hydraulic test data in shallow unconfined aquifers. Well points are generally constructed of slotted steel pipe or continuous-wrap, wire-wound, steel screens with a tapered tip on the bottom. They can be driven into unconsolidated formations and used for either point-in-time sampling and decommissioned after the sample is collected, or left in place for the duration of the sampling program—possibly requiring the installation of a seal to prevent infiltration of water from the ground surface to the screened interval.

The optimum conditions for well point installations are shallow sandy materials. Predominantly fine-grained materials such as silt or clay can plug the screen slots as the well point is advanced. Because well points are driven directly into the ground with little or no annular space, the formation materials are allowed to collapse around the screen, and the well point needs to be developed to prepare it for sampling.

### Protected-Screen Well Installation Methods

When installing a protected-screen well, the well casing and screen are either advanced within or lowered into a protective outer drive rod that has already been driven to the target depth. Once the well casing and screen are in place, the drive rod is removed. Alternatively, the casing, screen, and a retractable shield may be driven simultaneously to the target depth. Once in place, the screen is exposed and the entire unit remains in the ground. If there is sufficient clearance between the inside of the drive rod and the outside of the well casing and screen, a filter pack and annular seal may be installed by tremie from the surface as the drive casing is removed from the hole. Several filter packing and annular sealing approaches are available, depending on the equipment used for the installation (ASTM D5092 and D6725; ASTM, 2003b and 2003c). Regardless of the method of installation, the filter pack should be sized appropriately to retain most of the formation materials (refer to Driscoll, 1986 or ASTM D5092-02).

The most common protected-screen method for installing DPT wells is to advance an outer drive casing equipped with an expendable drive tip to the target depth. The well casing and screen are then assembled, lowered inside the drive casing, and anchored to the drive tip. The drive casing seals off the formations through which it has been advanced, protecting the well casing and screen from clogging and from passing through potentially contaminated intervals. The position and length of the screen should be selected to match the thickness of the monitoring zone, which can be determined by using additional information, such as CPT logs or continuous soil boring logs.

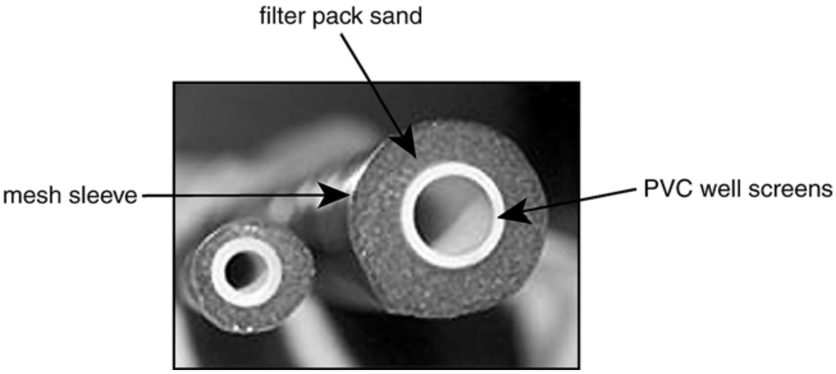
When DPT wells are installed in non-cohesive, coarse-grained formations, the formation can be allowed to collapse around the screen (if this technique is not prohibited by state well installation regulations) after it is placed at the target depth since turbidity problems are unlikely. When turbidity is likely to pose a problem for groundwater sample quality (see Section 3), a number of methods for installing filter packs are available. The filter pack can be poured or tremied into place as the drive casing is removed. Depending on the relative size of the drive casing and well, however, it may be difficult to introduce filter pack or annular seal materials downhole unless the hole is in a cohesive formation that will remain open as the drive casing is removed. Typical inside diameters of DPT wells range from 0.5-inch (schedule 80 PVC) to 2 inches (schedule 40 PVC), and the maximum inside diameter of drive casing is 3.5 inches. Table 2.2 provides a reference for understanding the relationship between inside diameters of DPT drive casing, the outside diameter of well casing and screen, and the annular space available for filter packs.

For the best control of filter pack placement and grain size, "sleeved" or "prepacked" well screens can be used (Figure 2.7). Pre-packed screens are generally composed of a rigid Type I PVC screen surrounded by a pre-sized filter pack. The filter pack is held in place by a stainless-steel wire mesh (for organic contaminants) or food-grade plastic mesh (for inorganic contaminants), such as polyethylene, that is anchored to the top and bottom of the screen. Sleeved screens consist of a stainless-steel wire mesh jacket filled with a pre-sized filter-pack material, which can be slipped over a PVC pipe base with slots of any size. Although sleeve thickness generally ranges from only 0.25 to 0.5 inch, it has been shown to provide an effective filter pack (Kram et al., 2000).

### Table 2.2
### Annular Space for Well Completion Based on Size of Well Casing and Screen

| Inside Diameter of Well Casing and Screen (inches) | Outside Diameter of Well Casing and Screen (inches) | Annular Space with 1.5-inch Inside Diameter (1.8-inch OD) Drive Casing (inches) | Annular Space with 3-inch Inside Diameter (3.5-inch OD) Drive Casing (inches) |
|---|---|---|---|
| 0.5 | 0.84 | 0.66 | 2.16 |
| 0.75 | 1.05 | 0.45 | 1.95 |
| 1 | 1.32 | 0.18 | 1.68 |
| 1.25 | 1.66 | Not applicable | 1.34 |

### Figure 2.7
### Photograph of Pre-Packed Well Screens



Courtesy Geoprobe® Systems, 1996.

Annular seals and grout should be placed above the filter pack to prevent infiltration of surface runoff and to maintain the hydraulic integrity of confining or semi-confining layers, where present. The sealing method used depends on the formation, the well installation method, and the regulatory requirements of state or local agencies. Most protected-screen installations tremie a high-solids (at least 20% solids) bentonite slurry or neat cement grout into place as the drive casing is removed from the hole. (Additional guidance on grout mixtures is available in ASTM D6725 (ASTM, 2003b).) A barrier of fine sand or granular or pelletized bentonite (where water is present) may be placed above the primary filter pack before grouting to protect it from grout infiltration, which could alter the water chemistry in the screened zone. Similar to the pre-packed and sleeved screens mentioned above, modular bentonite sleeves that attach to the well screens and are advanced with the well during installation are also available. As depicted in Figure 2.8, some manufacturers provide a foam seal that expands immediately when the casing is withdrawn to form a temporary seal above the screen[1]. A bentonite sleeve above the seal expands more slowly after the casing is withdrawn but forms a permanent seal once it hydrates.

To ensure a complete seal of the annular space from the top of the annular seal to the ground surface, the grout or slurry should be placed from the bottom up. By using a high pressure grout pump and nylon tremie tube (Figure 2.9) it is possible to perform bottom-up grouting in the small annular spaces of DPT equipment. Slurries of 20-30% bentonite or neat cement grout are most commonly used to meet state regulatory requirements.

A properly constructed DPT-installed monitoring well (Figure 2.10) can provide representative water quality samples and protect groundwater resources. A 1997 study (McCall et al., 1997) demonstrated that DPT wells installed in this manner beneath highly contaminated source zones consistently provided non-detect values. In addition, as with conventional wells, a properly constructed DPT well should have a flush-mount or above-ground well protection to prevent physical damage or tampering of the well. Small locking well plugs are also available for even 0.5-inch nominal PVC casing.

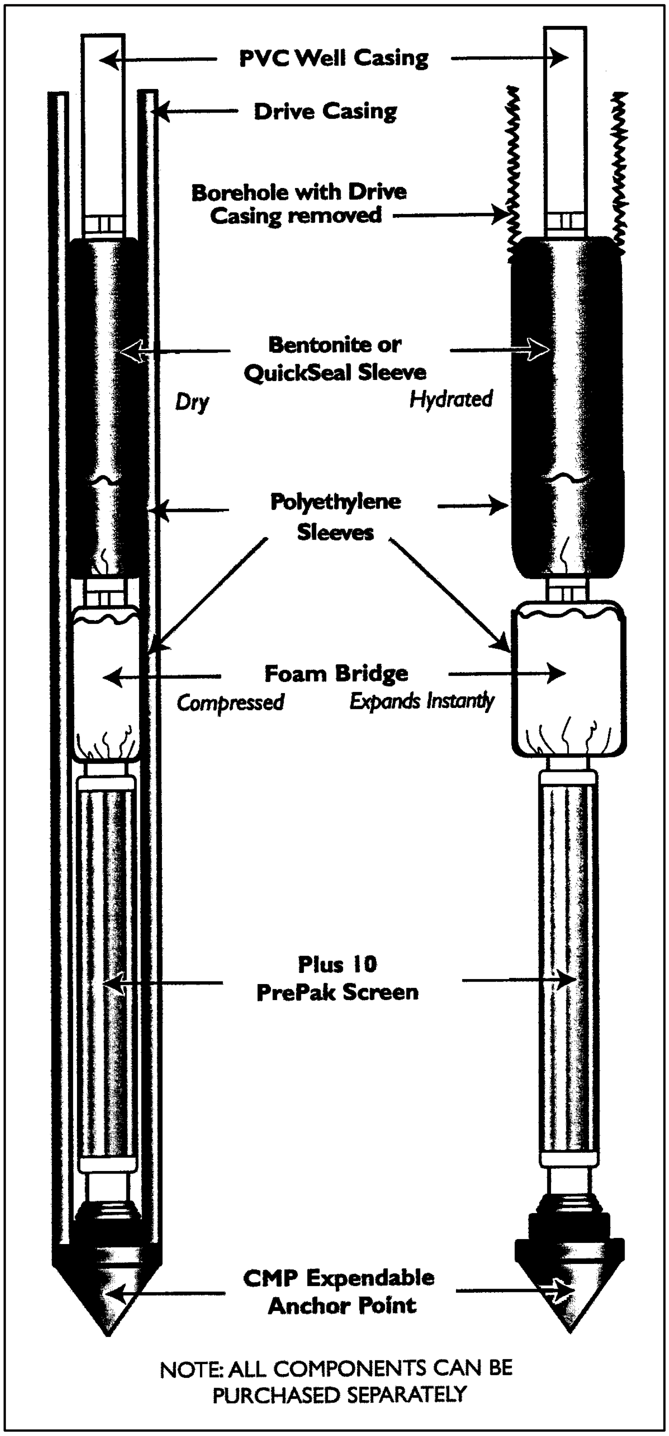
## Specialized Measurement and Logging Tools

There are a number of specialized measurement and logging tools available that can be used with DPT equipment to optimize the number and location of groundwater samples. These tools can estimate geotechnical, geophysical, hydrogeologic, and analytical parameters in the subsurface. They are particularly useful when the subsurface is highly stratified or contains laterally discontinuous layers. In such situations, characterizing or monitoring a dissolved-phase plume may require identifying preferred groundwater flow pathways, such as zones of high hydraulic conductivity, for sampling. For example, if the presence of DNAPL is suspected, then possible locations where DNAPL has pooled should be targeted by mapping the surface and areal

---

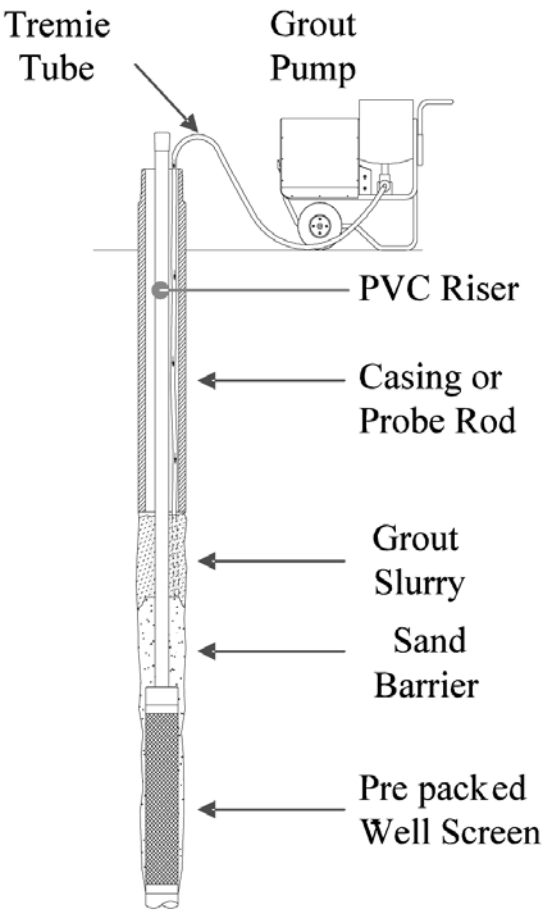
[1] The foam bridge is constructed of a polyethylene cover over polyurethane foam. In choosing to use this device, it should be kept in mind that polyethylene is permeable to many dissolved organic constituents and polyurethane foam will bind organic constituents that come in contact with it. Whether this will affect the quality of the sample is not known. However, purging the well should take care of any potential problems.

## Figure 2.8
## Small Diameter DPT Well Components



Source: GeoInsight Inc. product literature

**Figure 2.9**
**Bottom-Up Method for Grouting Small Annular Spaces of DPT Wells**



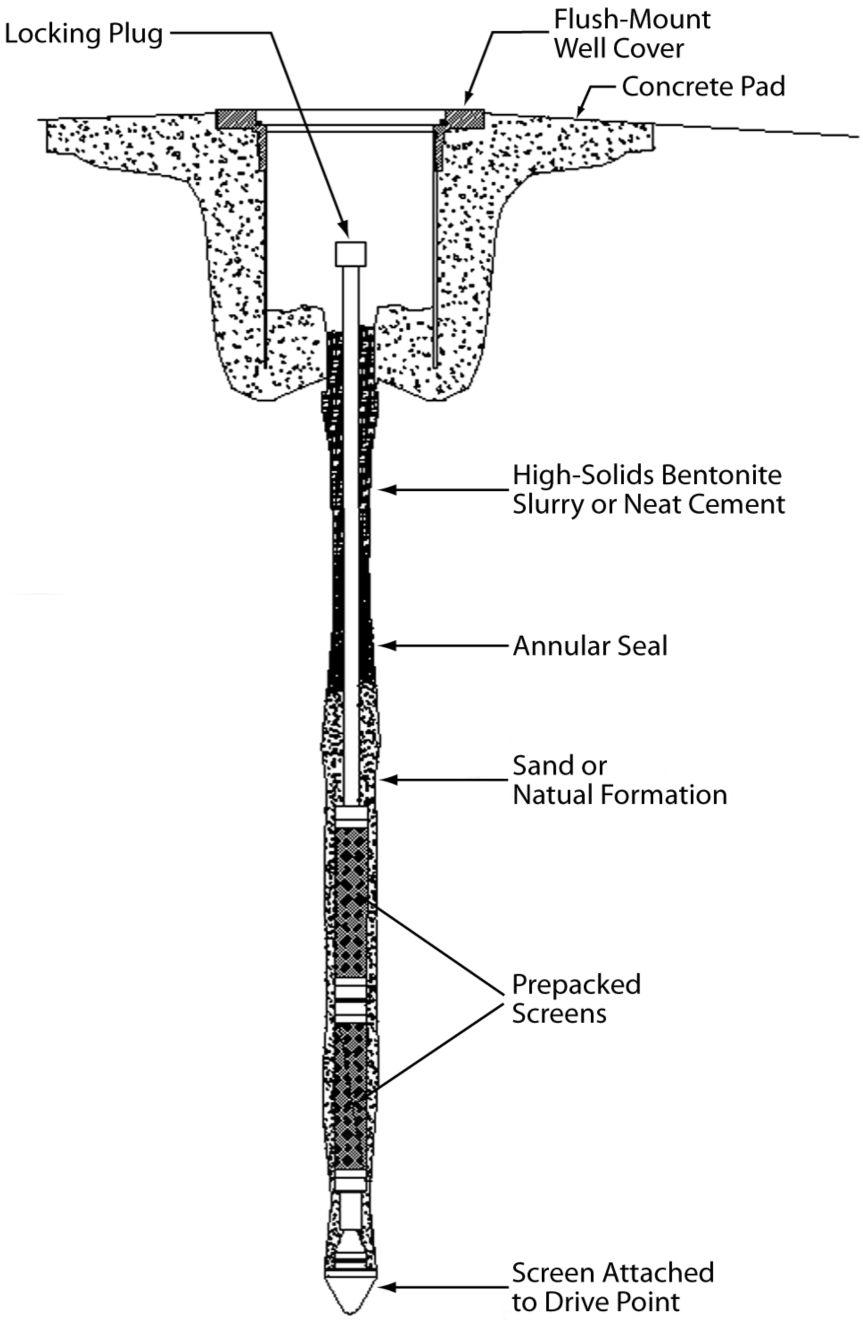
Adapted from Geoprobe®, 1996.

extent of an aquitard. The following section describes some of the specialized measurement and logging tools that are currently available. Since new tools are continually being developed, the list provided in this guide should not be considered complete and is directed at tools specifically concerned with groundwater quality.

## Geotechnical

The most common type of DPT geotechnical measurements are conducted with a three-channel cone as part of a CPT rig. It simultaneously measures the tip resistance, sleeve resistance, and inclination of the cone. The ratio of sleeve resistance and tip resistance is used to interpret the soil behavior types encountered (Chiang et al., 1992). In general, sandy soils have high tip resistance and low sleeve resistance, whereas clayey soils have low tip resistance and higher sleeve resistance. The data are recorded in real time on a computer at the ground surface and compiled to generate logs that show soil behavior type and relative density with depth. Actual soil samples are needed to correlate CPT soil behavior data to site soil types.

## Figure 2.10
## Example of a Properly Constructed DPT Well Installation with Prepacked Well Screen



Adapted from Geoprobe®, 1996.

### Geophysical

A number of geophysical measurements can be collected with probes or cones attached to direct push rods. The most common equipment is a conductivity probe that measures the bulk conductivity (or resistivity) of the adjacent soil as it is advanced. The differences in conductivity can be related to changes in stratigraphy. Although actual soil logs are important to correlate probe readings with actual site conditions, in general, finer-grained sediments (e.g., mineral clays) are more conductive than coarser sediments (e.g., sands, gravels). Conductivity probes are also affected by soil water content and ionic strength so they can be used to locate contaminant plumes that have a different salt content than naturally occurring water/soils. In addition, these instruments can sometimes be used for detecting DNAPL masses, which have low conductivities, when there is a sufficiently large conductivity difference between the DNAPL and the surrounding soil matrix. Although these probes will detect LNAPLs as well, there are generally simpler and more reliable ways of locating them than using conductivity probes. Electrical resistivity can also be measured with probes and cones to obtain similar information.

### Hydrogeologic

CPT rigs can be equipped with piezocones that measure dynamic pore water pressure as the tool is advanced through the soil layers. The pore water pressure data can be used to determine the depth to the water table and the relative permeability of the layers. Advancement of the penetrometer can be paused at selected intervals to run dissipation tests to obtain estimates of hydraulic conductivity. The combined results of the CPT and piezocone tests can help identify potential preferential contaminant transport pathways in the subsurface. These pathways are especially useful for targeting groundwater sampling locations. Using point-in-time DPT sampling to identify which of these pathways are contaminated can further define optimum intervals for monitoring well screens.

### Analytical

There are a number of probes that can be attached to DPT rigs to detect contaminants in the subsurface. These include induced fluorescence systems and volatilization and removal systems.

#### Induced Fluorescence Systems

Two widely available systems used with CPT rigs are the Site Characterization Analysis Penetrometer System, or SCAPS, and the Rapid Optical Screening Tool, or ROST™. Both use a CPT-deployed laser-induced fluorescence (LIF) probe to qualitatively identify the types and relative concentrations of petroleum hydrocarbons present. This is accomplished by transmitting ultraviolet (UV) light from a nitrogen laser through a sapphire window into the soil. The UV light causes polynuclear aromatic hydrocarbon (PAH) components to fluoresce, and the varying intensity of the fluorescence is indicative of the amounts of the PAHs present. The spectrum of the fluorescence describes the distribution of PAHs present in the hydrocarbon (or often contaminant mass), which can be used for rough fingerprinting of the type of hydrocarbon (Knowles, 1995).

Another induced fluorescence technology, sometimes referred to as a fuel fluorescence detector (FFD), is very similar to LIF except that it generally uses a mercury lamp as its light source, and the light is located in the probe at the sapphire window. This lamp provides a continuous source of light rather than the pulsed technique of the LIF. Although downhole detectors are available, fluorescence intensities from the soil are generally returned to the surface for measurement via fiber optic cable. It generally reads total fluorescence. Some vendors have filtering capabilities to limit wavelength reception to their detectors that allows some differentiation between contaminant types.

## Volatilization and Removal Systems

There are two established systems for analysis of VOCs by volatilizing the contaminants in the subsurface and transporting them with a carrier gas to the surface for analysis. The membrane interface probe (MIP), used with percussion or hydraulic driven DPT rigs, heats the surrounding soil to promote diffusion of VOCs through a permeable membrane. Once VOCs enter the probe, they are transported to the surface to a detector (e.g., a photoionization detector or flame ionization detector) with a carrier gas. The probe is generally driven at a rate of one foot per minute to maintain operating temperatures. The presence or absence of VOCs and their relative distribution among sampling locations can be estimated. If more chemical specific information is needed, the MIP can be used in combination with a direct sampling ion trap mass spectrometer (DSITMS). Since this instrument does not have a separation column in front of it, it may not be able to differentiate between chemicals having the same major ion signature.

The SCAPS Hydrosparge™ can be used with either CPT or percussion rigs and is equipped with a module that is lowered into a sealed-screen sampler once the drive rods are retracted to expose the screen. The module uses helium gas at a calibrated flow rate to purge VOCs from the groundwater and transfer them via a Teflon tube directly into a detector at the surface for real time analysis. One sample per location can be analyzed. To collect additional samples at other depths, the sealed-screen sampler can be re-advanced at other locations adjacent to the sampled hole. Data from the hydrosparge is semi-quantitative because of uncertainty associated with sample volume measured.

This page is intentionally blank.

# Section 3: Data Quality Objectives for Groundwater Sampling

Before selecting an approach to collecting environmental samples, EPA requires that EPA-funded projects use a systematic planning process to plan the collection of project data (EPA, 2000). To help planners select the best methods for obtaining data of the appropriate type, quality, and quantity for their intended use, EPA has developed a seven-step recommended data quality objective (DQO) process. DQOs are designed to provide qualitative and quantitative statements that clarify study objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that can be used as the basis for establishing the quality and quantity of data needed to support decisions. Because DQOs are intended to be project specific, they should be developed as part of the process for determining the goals for their activity. For some groundwater investigations, a DQO may be needed that describes the type of samples needed to characterize a groundwater plume; or a DQO may be needed to describe the type of samples required to establish that contamination is no longer a threat to drinking water. Although these DQOs may demand very different types of activities, the factors that should be evaluated for DPT groundwater sampling projects typically include:

- Determining the potential direction and degree of sampling bias;
- Evaluating whether the sample volume is sufficient for the selected analytical methods; and
- Minimizing the potential for contamination drag-down or creating a conduit for contaminant transport.

These factors are often issues for both DPT and conventional methods. Techniques exist for resolving problems for both methods, however, this section summarizes how they apply to DPT groundwater collection techniques.

## Sample Bias

Sample bias generally is the systematic or persistent distortion of a measurement process that causes errors in one direction. In other words, sample measurements can be consistently different than the samples' true values. There are several potential sources of sample bias when sampling groundwater with any method, including DPT, but one of the most critical factors typically is the type of sampling equipment used to retrieve the sample (Nielsen and Yeates, 1985). Three of the most common sources of bias, due to sampling equipment and methods, include:

- Sample turbidity;
- Sample disturbance; and
- Sampling interval.

Sample turbidity can cause bias as a result of the adsorption of chemicals onto, or the release of chemicals from, the surface of particles in the sample. There also are several sources of bias that can result from sample disturbance. These sources are summarized in Table 3.1. Because sampling interval can have an impact on all analytes in a similar way, (i.e., errors do not necessarily result in one direction), it is not included in the table. The table helps to clarify what factors may have significant impacts on specific analytes and which would have little or no impact by indicating the direction of bias ("P" for positive bias and "N" for negative bias)

## Table 3.1
## Potential Impacts of Sources of Bias on Specific Analytes During Sampling

| **Analyte** | **Potential Source of Bias** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Sample Disturbance** | | | | | | **Turbidity** | |
| | **Pressure Decreases** | **Temperature Increases** | **Exposure to Atmospheric Conditions** | **Adsorption onto Sampler Materials (Plastics & Metals)** | **Desorption from Sampler Materials** | **Agitation/ Aeration During Sample Collection** | **Adsorption onto Particles (a)** | **Releases from Particles (a)** |
| VOCs | N+++ | N+++ | N+++/P+++ (b) | N+ | P+ | N++ | 0 | 0 |
| Dissolved Gases & ORP | N+++ | N+++ | N+++/P+++ (b) | N++ to N+++ (c) | P+ | N++ | 0 | 0 |
| Semi-Volatiles | N+ | N++ | N++ | N+ | P++ | N+ | N++ | P++ |
| Pesticides | N+ | N+ | N+ | N+ | 0 | N+ | N++ | P++ |
| Trace Metals | N+ | N+ | N+++ | N+ to N+++ (d) | P+ | N+ | N+++ | P+++ |
| Radionuclides | N+ | N+ | N+ | N+ | 0 | 0 | N+++ | P++ |
| Major Ions (Inorganic Anions & Cations) | 0 | 0 | N+ | N+ | 0 | 0 | N+ | P+ |

Legend:

| Bias Type: | Relative Degree of Impact: | |
|---|---|---|
| N = Negative | + | Weak |
| P = Positive | ++ | Moderate |
| 0 = None | +++ | Strong |

(a) Adsorption to and release from particles is directly related to the level of turbidity and will also depend heavily on particle size and type. Adsorption is a greater factor when fine-grained, organic-rich particles are present.

(b) Depending on the analyte concentrations in the sample or the ambient atmosphere, concentrations in the sample may increase or decrease significantly.

(c) Reaction of the dissolved oxygen in groundwater with iron in the drive rods will significantly reduce measured dissolved oxygen and oxidation/reduction potential (ORP) due to oxidation of the zero valent iron under ambient conditions. Therefore, the sample must be isolated from steel drive rods to minimize this effect.

(d) Some trace metals can complex with hydrous iron oxides (rust) forming soluble ferrous iron. Therefore, the sample must be isolated from steel drive rods to minimize this effect.

and the degree of bias ("+" for weak, "++" for strong, and "+++" for very strong) when sampling for various analytes. For example, if investigators are interested in collecting groundwater samples for VOC analysis, they should be concerned about any changes in temperature or pressure of those samples because it would likely have a negative bias on results. However, if they were collecting the same samples for analysis of major, naturally occurring, inorganic anions and cations (e.g., $Ca^{2+}$, $Na^{+}$, $K^{+}$, $SO_4^{2-}$, $CO_3{}^{2-}$, $NO^{3-}$, $Cl^{-}$), they normally would not have to be concerned about pressure or temperature changes since they normally would not affect results.

The iron in steel drive rods of point-in-time samplers can have a significant affect on measured concentrations of analytes, such as dissolved oxygen, iron, and some trace metals as well as changing oxygen-reducing potentials. As discussed in Section 4, these affects can be minimized by placing the pump intake within the screened interval to be sampled and pumping at a low-flow rate to avoid drawdown of standing water in contact with the rods into the intake interval.

To minimize sampling bias, sampling equipment that meets project DQOs should be selected. For DPT, the primary difficulty in collecting groundwater samples typically is caused by the small inside diameter of many sampling points—generally 0.75-inch or less for the rods used with DPT sampling tools and 1 to 2 inches for DPT-installed wells. For DPT tools of these sizes, the available sampling devices are usually limited to less than 1-inch OD. For rods or well casing/screen with inside diameters less than 2 inches, sampling equipment usually is limited to bailers, inertial-lift pumps, suction-lift (e.g., peristaltic) pumps, gas-drive pumps, centrifugal pumps, and bladder pumps. For 2 inches and larger, additional devices available include gas-operated piston pumps and several designs of electric submersible pumps (e.g., gear-drive, helical rotor, or progressing cavity).

Bladder pumps (Pohlman et al., 1990; Unwin and Maltby, 1988; Parker, 1994; Barcelona et al., 1984), gear-drive electric submersible pumps (Imbrigiotta et al., 1988; Backhus et al., 1993), centrifugal pumps, and helical rotor pumps have consistently outperformed other pumps in their ability to deliver a representative sample for a wide variety of analytes under a wide range of field conditions. These devices are recommended for use in collecting samples for all classes of analytes. Each of the other devices has limitations that may affect the representativeness of samples for one or more classes of analytes (Nielsen and Yeates, 1985; Herzog et al., 1991; Parker, 1994; Pohlman et al., 1994; Pohlman and Hess, 1988; Pearsall and Eckhardt, 1897; Unwin and Maltby, 1988; Imbrigiotta et al., 1988; Pohlman et al., 1990). However, some of these devices may be appropriate for collecting samples for some sets of analytes.

A detailed discussion of the operational characteristics of sampling devices is provided in the Appendix. In addition, Table 3.2 provides a summary of some important operational characteristics related to DPT applications and the appropriateness of each device for sampling analyte classes. For example, the table shows that bailers are adequate for sampling narrow diameter wells when the analytes of concern are inorganic ions. If trace VOCs are being analyzed, bailers may not be as reliable for providing high quality samples as other methods. In addition, choosing a sampling tool is often related to the specific use the data acquired will be put. For example, bailers might be completely acceptable when sampling VOCs to locate a DNAPL source zone when the dissolved values in the water are very high and marginal losses are not important.

# Table 3.2
# Typical Operational Characteristics and Appropriateness of Groundwater Sampling Devices for Specific Analytes

| Device | Approx. Minimum Well Diameter | Approx. Maximum Useful Depth to Groundwater | Approx. Minimum/ Maximum Sample Delivery Rate | Field Indicators | | | | Inorganics | | | Organics | | Radioactive | | Biological |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | SC | pH | ORP | DO | Major Ions | Trace Metals | Salts | VOCs | SVOCs | Radio-nuclides | Gamma α/β | Coliform |
| Bailer | ½" | unlimited | highly variable | ✓ | | | | ✓ | | ✓ | | | ✓ | | ✓ |
| Inertial-Lift Pump | ½” | unlimited | highly variable | ✓ | | | | ✓ | | ✓ | | | ✓ | | ✓ |
| Suction-Lift Pump (Peristaltic) | ½" | 25' | 50 mL - 4 L/min | ✓ | | | | ✓ | | ✓ | | | ✓ | | ✓ |
| Gas-Drive Pump* | ½" | 250' | 50 mL - 20 L/min | ✓ | ✓ | | | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ |
| Bladder Pump | ½" | 300' | 25 mL - 8 L/min | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Piston Pump | 2" | 1000' | 100 mL - 8 L/min | ✓ | ✓ | | | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ |
| **Electric Submersible Pumps:** | | | | | | | | | | | | | | | |
| Gear-Drive | 2" | 300' | 50 mL - 12 L/min | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Helical Rotor | 2" | 180' | 100 mL - 6 L/min | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Centrifugal | 1.75” | 220' | 100 mL - 34 L/min | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

✓ = Device compatible with analyte

* Presumes use of inert drive gas

Abbreviations

SC - specific conductivity
ORP - oxidation/reduction potential
DO - dissolved oxygen

VOCs - volatile organic compounds
SVOCs - semivolatile organic compounds

α - alpha
β - beta

### Sample Turbidity

In groundwater sampling, turbidity generally refers to the presence of suspended particles in the sample. These particles may be entrained in the groundwater when the subsurface is disturbed, such as when a DPT sampling tool or well is advanced and installed. The disturbance may cause some compaction and disaggregation of granular material as well as the breakage of grain coatings and cementing agents. The largest particles (i.e., silts) typically will settle out quickly but much can remain suspended in the water column. Depending on their type and size, some particles are neutrally buoyant, remaining suspended once they have become suspended. Turbidity can also be generated during sampling activities due to the relatively high entrance velocity of groundwater into the well when water is withdrawn by sampling tools, such as high-speed submersible pumps, or sealed-screen samplers when the screen is opened to the formation.

Although turbidity can be present in samples from sand and gravel formations, it particularly can be a problem when sampling in fine-grained formations. High turbidity also can be associated with the DPT sampling tools that lack screens or filter packs to keep the fines from entering the sampling tool or well. Conventional wells can also produce samples with high turbidity, especially if the slot size of the screen or the grain size of the filter pack are incorrectly sized for the formation.

The term “artifactual turbidity” is sometimes used to distinguish particles stirred up during drilling and sampling, which would not be mobile under ambient groundwater flow conditions, from those particles that are mobile under ambient conditions—colloids. Colloids are typically clays, hydroxyls, and humic materials that are 1 to 1000 µm in diameter. Although colloidal transport may be considered important in formations made up of materials coarser than fine sand (Dragun, 1988; Mason, 1991), under most ambient conditions, colloids are immobile in the subsurface. Because most turbidity is artifactual in origin, for the purpose of this discussion it is just referred to as “turbidity”.

Sample turbidity can be important because it can be a common source of significant bias, both negative and positive, in groundwater samples, particularly when metals and semi-volatile organic compounds (SVOCs) are the analytes of concern (see Table 3.1). For example, some clay colloids can artificially increase the measured concentration of dissolved metals because metals are found in their structure (e.g., aluminum, magnesium, and iron) and as similarly sized impurities associated with them. The surficial negative charge of the colloids and impurities attracts and loosely typically binds the positively charged metal cations in groundwater. The risk of positive bias can be further increased when acid is used to preserve a sample because it will cause the metals to dissolve back into the sample. On the other hand, if the dissolved metals bind to the colloids, and the sample is then filtered to remove high turbidity levels, the concentration of dissolved metals in the groundwater may be significantly reduced and the sample normally would not be representative of actual conditions.

In a similar way, colloids can become a “source” or a “sink” for organic constituents. Although organic chemicals of concern generally do not occur naturally in clays, they can sorb to colloids and naturally occurring organic matter. The level of sorption that will occur depends on the individual chemical, whether it was in equilibrium with the suspended colloids before being collected, and the analytical preparation method used. If groundwater sampling creates or occurs under non-equilibrium conditions, then significant sorption may occur. In addition, if organic constituents in groundwater have bound to clays or humic acids in the subsurface, causing them to become immobile, the sampling process can disturb these immobile constituents and cause them to become dissolved in the groundwater sample.

One method of determining whether the level of turbidity will significantly impact the concentration of an organic constituent by causing it to become bound to colloids is to examine the logarithm of the *n*-octanol/water partition coefficient (log $K_{ow}$) because the log $K_{ow}$ is a measure of a compound's tendency to remain dissolved in water. The higher the $K_{ow}$ value, the more likely the chemical is to partition from the water onto suspended organic particles. Table 3.3 contains the log $K_{ow}$ of a number of common organic chemicals.

This information can also be used as a quality control check on groundwater sample results. In general, the compounds with the higher log $K_{ow}$ levels are SVOCs. If the groundwater concentrations for these chemicals approach or exceed their solubility, then the measured concentrations may have been artificially inflated by turbidity and other sampling data should be evaluated (e.g., nephelometric turbidity units [NTU], a measure of turbidity, dissolved oxygen). Alternatively, turbidity may not be a source of bias in a sample if the constituents of concern are organic compounds with low log $K_{ow}$ values (e.g., $< 2.5$). In this situation, other issues, such as stability of groundwater indicator parameters during sampling, may be more important in evaluating groundwater sample quality. A paper by Paul and Puls (1997) helps to illustrate the significance of these numbers. In the study, which included analysis of both laboratory and field samples spiked with kaolinite and sodium montmorillonite clays, the researchers demonstrated that TCE, *cis*-DCE, and vinyl chloride concentrations were statistically unaffected by turbidity levels. This group of chemicals has low log $K_{ow}$ values ($\leq 2.42$). The report concluded that the presence of solids in the groundwater samples had little or no effect on the VOC concentrations evaluated in the study. Losses of VOC due to volatilization during the sampling process were thought to have a greater effect on concentrations. As a word of caution, however, matrix effects can affect the tendency of some compounds to sorb more than their low log $K_{ow}$ values would indicate. This increased level of sorption generally occurs when the soil matrix contains a substantial amount of organic materials, which can range from humic and fulvic acids to organic debris (roots leaves) and peat. Site-specific factors, such as total organic carbon (TOC), should be considered when deciding to take measures to reduce turbidity in groundwater samples. High levels of TOC in groundwater samples can yield analytical results that indicate higher levels of dissolved VOCs than are actually present. These higher levels can drive a risk assessment, even though the VOCs are actually sorbed to particles and are immobile.

When turbidity is a concern for groundwater sampling, steps can be taken to minimize it, provided adequate quality control (QC) procedures, described in Section 4, are followed, such as installation of filter packs (also discussed in Section 2), developing the well, and using low-flow sampling. In addition, DPT methods that promote high turbidity levels, such as open-hole sampling or exposed-screen methods, should be avoided. A representative sample cannot be salvaged with filtering if inappropriate sampling techniques have already compromised the sample. If filtering is justified by a project's DQOs, proper filtering techniques should be used. For more information on filtering, readers should refer to *Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers* (EPA, 2002).

## Table 3.3

## Log *n*-Octanol/Water Partition Coefficients (Log $K_{ow}$) of Common Organic Contaminants

| Chemical | Log $K_{ow}$[a] | Chemical | Log $K_{ow}$ |
|---|---|---|---|
| Acenaphthene | 4.07 | Ethylbenzene | 3.13 |
| Acetone | -0.24 | Ethylene Glycol | -1.36 |
| Aldrin | 5.52 | Fluoranthene | 5.22 |
| Anthracene | 4.45 | Fluorene | 4.12 |
| Arochlor 1221 | 2.8 estimated | Heptachlor | 5.44 |
| Arochlor 1242 | 5.58 | Hexachlorobutadiene | 4.78 |
| Arochlor 1260 | 6.91 | Indeno(1,2,3-cd)pyrene | 7.7 |
| Benzene | 2.13 | Lindane | 3.7 |
| Benzo(a)anthracene | 5.61 | Methoxychlor | 4.3 |
| Benzo(k)fluoranthene | 6.85 | Methyl Ethyl Ketone | 0.29 |
| Benzo(g,h,i)perylene | 7.1 | Methyl t-Butyl Ether | 1.24 |
| Benzo(a)pyrene | 5.99 | Naphthalene | 3.59 |
| Bis(2-ethylhexyl)phthalate | 4.20, 5.11 | Pentachlorophenol | 5.01 |
| Carbon Tetrachloride | 2.83 | Phenanthrene | 4.468 |
| Chlordane | 6 | Phenol | 1.48 |
| Chlorobenzene | 2.84 | Pyrene | 5.18 |
| Chloroform | 1.97 | Styrene | 2.95 |
| Chrysene | 5.6 | 1,1,2,2-Tetrachloroethane | 2.39 |
| p, p-DDT | 6.36 | Tetrachloroethene (PCE) | 3.4 |
| Dibenz(a,h)anthracene | 6.36 | Toluene | 2.73 |
| Dibenzofuran | 4.17 | Toxaphene | 3.3 |
| 1,1-Dichloroethane | 1.79 | 1,1,1-Trichloroethane | 2.49 |
| 1,2-Dichloroethane | 1.48 | 1,1,2-Trichloroethane | 2.07 |
| *cis*-1,2-Dichloroethene | 1.86 | Trichloroethene | 2.42 |
| Dieldrin | 5.16 | Tetrahydrofuran1,4-Dioxane | -0.27 |
| 1,4-Dioxane | -0.27 | Vinyl Chloride | 0.6 |
| Endrin | 5.16 | m-Xylene | 3.2 |

[a] Log $K_{ow}$ values taken from Howard et al., 1993a and 1993b and from Montgomery and Welkom, 1991.

## Sample Disturbance

If groundwater samples are disturbed during the collection process (e.g., agitation, allowing sample temperature to increase, or creating a situation for sample materials to adsorb or desorb analytes) there is a risk of negative impacts on groundwater sample quality, beyond the issue of generating turbidity, because it may result in the:

- Volatilization of any VOCs that are present;
- Dissolution of dissolved gases; or
- Oxidation/reduction of metals.

Sampling methods should be carefully selected in order to minimize disturbance during sampling. As shown in Table 3.2, bladder pumps and to a lesser extent centrifugal pumps generally are the best equipment for all analytes when sampling rods or wells less than 2-inches in diameter and where high quality samples are needed. Research has shown that suction lift pumps (e.g., peristaltic pumps—see Appendix) cause a negative bias in VOC and dissolved gas measurements because of the negative pressure generated by the pumping action. When point-in-time sampling is conducted in situations where volatilization of VOCs is a concern, sealed-screen samplers, such as the BAT Enviroprobe™ or Hydropunch™, which maintain in-situ pressure conditions, should be considered.

## Sampling Interval

The most appropriate sampling interval to use at a site should be determined because the location and length of a sampling interval can bias a sample. Short or long sampling screens can be used with both DPT and conventional monitoring wells; however, DPT point-in-time methods are generally more economical and better designed to target smaller sampling intervals than conventional wells. When selecting discrete sampling intervals (e.g., 6-inch interval), there is a risk of missing contaminants that may be migrating through sections of the aquifer that do not fall within the screened interval(s). When selecting long sampling intervals (e.g., 5 to 15 feet), there is a risk that a highly contaminated but discrete interval will be diluted by larger uncontaminated intervals.

To determine the most appropriate sampling interval, a number of sources of existing information should be evaluated and, if necessary, additional subsurface data collected. DPT equipment can provide many cost-effective and comprehensive methods for collecting subsurface data for this purpose, including continuous soil logs, detailed stratigraphic logs using specialized measurement and logging tools (e.g., cone penetrometer testing, membrane interface probe, induced fluorescence), multi-level discrete groundwater samples to create a vertical profile of contamination, and piezometric data over a wide area to determine groundwater flow direction (see U.S. EPA, 1997 for more details). Based on this information, as well as slug tests and/or aquifer tests to estimate hydraulic conductivity for specific stratigraphic zones, contaminant source locations can be estimated. At this point the appropriate sampling intervals can be selected, thereby minimizing the installation of extraneous and ineffective wells or the risk of missing or diluting important transport pathways.

## Sample Volume

There are three sample volume issues that can be particularly relevant to collecting groundwater samples with DPT:

- Point-in-time methods can be extremely slow in fine-grained formations (e.g., several hours or more).
- Sample chamber volume of some sealed-screen, point-in-time samplers is quite small (e.g., less than one liter), which can make it difficult to collect the larger volumes needed for some types of analyses (e.g., SVOCs, PCBs/pesticides).
- Both DPT wells and point-in-time samplers often have a smaller diameter than their conventional well counterparts. The smaller volume of the DPT wells may require lower-flow purge rates to avoid significant drawdown during sampling.

Consequently, subsurface conditions and the required analytical suite should be considered when selecting a DPT method to sample groundwater. Depending on the site conditions and site DQOs, larger volume samplers or low-flow purge equipment capable of very low-flow rates (discussed in Section 4) may be needed, or a sampler can be left in place to recharge while other locations are sampled. If a sampler is left in place to recharge, sample quality can be compromised if the sample container is filled in increments collected over a period of time. This is a concern primarily when filling sample vials for volatile organic analysis, which need to be filled completely with one sampling effort. Otherwise, volatile compounds may partition into the headspace above the sample.

## Sample Cross-Contamination

Any groundwater sampling method can cause cross-contamination that affects groundwater sample quality and/or long-term water quality in at least three ways:

- Causing contaminant drag-down;
- Creating hydraulic conduits; and
- Biasing samples from improperly decontaminated equipment.

In evaluating the potential for cross-contamination and developing a sampling plan, the site geology, the types of contaminants present, and the sampling methods and equipment used should be examined. For example, drilling a hole through an aquitard creates a potential conduit for contaminant migration. If DNAPLs are perched on top of the aquitard and precautions are not taken, they may migrate down the borehole and contaminate a previously uncontaminated aquifer.

Although cross-contamination can be a serious concern that may pose additional challenges when using DPT equipment, DPT methods also provide many strategies for minimizing or eliminating the risk of cross-contamination. Section 5 reviews these methods and additional resources that can provide specific details needed in the appropriate use of DPT equipment.

## Selecting a DPT Groundwater Sampling Tool

DPT tools can be considered for a wide range of groundwater field applications, and they can meet project DQOs in a broad variety of cases. Sampling bias, sample volume, and cross-contamination are potential problems whether DPT or conventional monitoring wells are used. It is important to understand the limitations of equipment being used and how they relate to project needs. The first step in selecting equipment should be narrowing down the categories of appropriate tools. With DPT equipment, that can be done by deciding whether qualitative, semi-quantitative, or quantitative data are needed. Table 3.4 provides a summary of the applications of DPT tools, emphasizing the basic concept that the project objectives should be considered when selecting equipment and methods.

**Table 3.4**
**Recommended DPT Groundwater Tools for Various Field Applications**

| General Field Application | Specialized Measurement and Logging Tools (a) | Point-in-Time Groundwater Sampler | DPT-Installed Monitoring Well |
|---|---|---|---|
| Presence of contamination (i.e., qualitative sampling goals) | ✓ | ✓ | |
| Approximation of contaminant zone/level (i.e., semi-quantitative sampling goals) | ✓ | ✓ | |
| Define specific contaminants and accurate concentrations (i.e., quantitative sampling goals) | | ✓ | ✓ |
| Long-term monitoring | | | ✓ |

(a) Includes induced fluorescence and volatilization and removal systems.

# Section 4: Recommended Methods for Collecting Representative Groundwater Samples

---

Collecting groundwater samples that are representative of in-situ aquifer conditions generally is important in any groundwater investigation. One of the most important factors in meeting this goal, for many analytes, typically is to minimize turbidity. This is because particles from formation materials that are suspended in a sample, but are not normally suspended in groundwater, can provide a substrate for various analytes to adsorb or desorb. This process can create a positive or negative bias for analytical results. In addition, although the causes of turbidity and their solutions for both DPT and conventional groundwater sampling methods generally are similar, the relatively narrow rod diameters of DPT systems can create additional hurdles. This section focuses on the activities that can minimize turbidity, specifically for DPT systems.

As discussed in Section 3, turbidity can cause substantial bias, both negative and positive, when sampling metals and SVOCs, but typically is much less an issue when sampling VOCs. There are several precautions that can be taken to minimize turbidity in DPT groundwater samples. Important techniques to consider include:

- Installation of a filter pack;
- Well development; and
- Low-flow purging or passive sampling protocols.

Each of these techniques can be applied to monitoring wells installed with DPT, but not all are possible with point-in-time samplers. For example, filter packs normally cannot be installed when using point-in-time samplers. Furthermore, well development and low-flow/passive sampling protocols normally can only be used with those point-in-time samplers that provide access to the sample location from the surface (See Section 2). Usually, samplers that rely on a sealed sample chamber to retrieve groundwater cannot be developed, nor can low-flow or passive sampling protocols be followed. However, there are some samplers in this category that may work, such as one of the BAT™ system samplers, that sample water through a ceramic or polymer tip that acts as an in-situ filter to prevent turbidity. The decision to use a specific type of point-in-time sampler should be weighed against project DQOs.

## Installation of a Filter Pack

As mentioned in Section 2, installing a filter pack in monitoring wells can be an important means of minimizing sample turbidity. However, its installation is not always possible or necessary, depending on project objectives. A common construction technique for DPT wells is to let the formation collapse around the screened interval, rather than installing a filter pack. In fact, this is the only option for exposed-screen well installations since there is no annular space between the drive rods and the borehole walls to accommodate a filter pack. Similarly, DPT point-in-time sampling techniques do not allow for the installation of filter packs due to the lack of annular space between the drive rods/sample tool and the formation. Wells installed using protected-screen methods, however, may have adequate annular space for a filter pack and should be selected where data quality objectives dictate. Please refer back to Section 2 for more information on filter pack installation techniques, including the use of pre-packed and sleeved well screens.

## Well Development

Wells should be developed after completing the installation and allowing sufficient time for the annular seal to completely set (typically two weeks, but not less than 48 hours). The purpose of well development or development of a point-in-time sampler generally is to repair borehole damage caused by advancement and installation procedures, such as the smearing of fine-grained particles along the borehole walls and the generation of turbidity. Development generally is designed to remove these particles to improve the hydraulic connection between the well and formation so that groundwater can enter more freely. Development also is designed to remove the groundwater impacted by well installation so that groundwater representative of ambient conditions can be sampled.

Like conventionally installed wells, DPT-installed monitoring wells should be developed. This process typically involves block surging and pumping or bailing groundwater until certain water quality parameters (e.g., pH, specific conductance, dissolved oxygen, redox potential, and temperature) have stabilized and turbidity has been removed or decreased as much as possible. Wells are surged by raising and lowering a surge block (any tool that is slightly smaller than the inside diameter of the well casing) within the screened interval to mechanically backwash the well screen. These activities help to dislodge particles smeared within the borehole and the particles clogging the screen so they can be removed. In-line turbidimeters can be used during development or purging procedures to judge turbidity levels and their potential impact on sample quality.

Due to the way some point-in-time samplers are constructed and used, they may not accommodate a pump or bailer for development. Those samplers that can accommodate a pump or bailer can be developed similar to the method described above for wells, although due to the generally smaller diameters of point-in-time samplers, smaller diameter surge blocks, pumps, and bailers usually will be needed. In general, if DQOs recommend development for groundwater samples to meet quality standards, then many point-in-time samplers may not be appropriate for the situation.

## Low-Flow Purging and Sampling

Low-flow purging, also referred to as low-stress purging, low-impact purging, and minimal drawdown purging, is a method of preparing a well for sampling which, unlike traditional purging methods, does not require the removal of large volumes of water from the well. The term “low-flow” refers to the velocity at which groundwater moves through the pore spaces of the formation adjacent to the screen during pumping. It does not necessarily reflect the flow rate of the water discharged by the pump at the ground surface. The focus of low-flow purging and sampling is on collecting high-quality samples by minimizing the impact of pumping on well hydraulics and aquifer chemistry. Because the flow rate used for purging is, in many cases, the same as or only slightly higher than the flow rate used for sampling, the process is a continuum and is referred to as "low-flow purging and sampling." Although minimizing the disturbance of sampling on the aquifer is important for all types of groundwater sampling devices, it can be particularly important for DPT point-in-time samplers and exposed screen wells because installation of a filter pack generally is not feasible with these tools.

Low-flow purging and sampling generally are appropriate for collecting groundwater samples in a wide variety of situations. It can be used to sample all categories of aqueous phase contaminants and naturally occurring analytes, including VOCs, SVOCs, trace metals and other inorganics, pesticides, PCBs, radionuclides, and microbiological constituents and often is particularly appropriate for situations where colloidal transport is an issue (i.e., radionuclides, metals, and hydrophobic compounds). However, low-flow methods generally are not applicable to the collection of NAPLs because they do not respond to the effects of pumping in the same manner as groundwater.

## Theoretical and Research Basis for Low-Flow Purging and Sampling

Groundwater sampling research has demonstrated that water standing in a well casing for a protracted time is not representative of ambient groundwater quality (Gillham et al., 1985; Miller, 1982; Marsh and Lloyd, 1980; Barcelona and Helfrich, 1996). Hence, this water should not be collected as part of the sample for analysis. In addition, the water within the screened interval of nearly all wells generally is representative, provided that the well has been designed, installed, developed, and maintained properly and the aquifer has a sufficient flow rate to ensure the water in the screened interval is being replaced.

Based on these findings, recommended low-flow sampling protocols have been developed so that groundwater can be collected from the screened interval without significant mixing with the water standing in the casing. Research has shown that this method does indeed provide high quality, representative groundwater samples (Backhus et al., 1993; Bangsund et al., 1994; Barcelona et al., 1994; Karklins, 1996; Kearl et al., 1994; Kearl et al., 1992; McCarthy and Shevenell, 1998; Puls and Paul, 1995; Puls and Barcelona, 1996; Puls and Barcelona, 1989; Puls and Powell, 1992; Puls et al., 1992; Puls et al., 1991; Serlin and Kaplan, 1996; Shanklin et al., 1995).

Because they are sampled almost immediately, point-in-time DPT tools should not develop a stagnant water column that will affect most analytical results. However, a standing water column for even a short period of time can affect some inorganic analytes (e.g., iron, nitrogen, and hexavalent chromium) and sensitive geochemical parameters (e.g., dissolved oxygen, oxygen reducing potential, and pH) if the water is in contact with steel drive rods. The zero valent iron in the rods can quickly react with any dissolved oxygen in the groundwater causing alteration of the analytes and parameters and potentially complexing with metal analytes. As a result, water being collected should be isolated from contact with the drive rods when sampling for these analytes or parameters. Placing the pump intake within the screened interval and pumping at a low-flow rate to avoid drawdown of water in contact with the drive rods should help isolate the sample from the rods. Although there is little concern about the water column affecting organic analytes when sampling with point-in-time DPT samplers, when turbidity is a concern, low-flow sampling may help to lower turbidity to acceptable levels (McCall et al., 1997; EPA, 1996a).

## Low-Flow Purging and Sampling Protocols

To conduct low-flow purging and sampling, a pump that can be operated at a low-flow rate normally is needed. For large wells (e.g., 2-inch diameter or greater), less than 500 mL/min is often needed; for small diameter DPT wells and point-in-time samplers, flow rates as low as 100 mL/min may be needed. As a result of their design, bailers generally are inappropriate for low-flow purging and sampling. Inertial-lift pumps, or other well sampling devices that agitate the water column also generally cannot be used for low-flow purging and sampling

Before purging and sampling can begin, the hydraulic conductivity of the screened interval normally needs to be evaluated to ensure that low-stress pumping is maintained. To begin, the water level should be measured to determine when drawdown in the well stabilizes. As water is purged from the well, water quality indicator parameters (e.g., pH, temperature, specific conductance, dissolved oxygen, redox potential, and in some cases turbidity) generally need to be measured to determine when the readings stabilize and samples can be collected. The results can then be used to define well-specific, low-flow procedures.

## Passive Sampling Protocols

In situations where a sampling point cannot yield sufficient water to support low-flow sampling, a passive sampling (also referred to as micropurging) approach generally is preferred (Powell and Puls, 1993; Puls and Barcelona, 1996). Passive sampling involves placing the pump intake within the screened interval and purging a minimal volume of groundwater from the well or sampler—a single volume of the pump chamber and discharge tubing, rather than the greater volumes purged by low-flow sampling or the multiple well volumes purged using other techniques. The goal of passive sampling generally is to obtain groundwater within the well screen or sampler screen, which is most representative of ambient groundwater quality, without disturbing the water column and introducing the stagnant water above. The sample should be collected immediately after purging the small volume of groundwater.

Passive sampling methods may be appropriate for use in a variety of situations and can be applied to most wells in which there is sufficient water to ensure that a pump intake is submerged throughout purging and sample collection. They are most often applied to wells and samplers installed in low-yield formations. In very low yield formations, however, the water in the screened interval may be of equivalent quality to that in the casing above and not representative of formation water. The application of passive sampling methods, therefore, should be evaluated on a site-specific basis.

Passive sampling typically is easiest to apply when dedicated pumps are used. The flow rates used for passive sampling are lower than those used for low-flow purging and sampling—generally less than 100 mL/min. Because very low hydraulic conductivity formations do not yield sufficient water to satisfy the demands of a pump, even at these low-flow rates, drawdown may occur. Thus, to determine the volume of water available for sampling, the volume of water within the well screen above the pump intake should be calculated. Only this volume, which normally will be very small for most DPT wells, should be collected. Sampling should not continue once water from the top of the screen is drawn close to the pump because casing water should not be collected as part of the sample. Since indicator parameters are not typically analyzed, this method does not normally provide any evidence that the sample taken is representative of formation water. When non-dedicated equipment is used, there is a higher risk of mixing casing and screened interval water which can add to the uncertainty of the representativeness of the sample. Table 4.1 provides a comparison between low-flow and passive sampling methods.

### Table 4.1
### Comparison of Some Key Elements of Low-Flow and Passive Sampling

| | Low-Flow Sampling | Passive Sampling |
|---|---|---|
| **Hydraulic Conductivity** | Sufficient to maintain steady water level during sampling | Too low to allow low-flow sampling |
| **Analyte Applicability** | All analytes except NAPLs | All analytes except NAPLs |
| **Pump Discharge Rate** | 500 mL/min to100 mL/min depending on well/sampling point size and hydraulic conductivity. | <100 mL/min |
| **Purge Volume** | Continuous until parameters (e.g., specific conductance, turbidity, $O_2$, redox) stabilize | Greater than the volume of the pump and the submerged tubing |

# Section 5: Recommended Methods for Minimizing Potential for Cross-Contamination

---

As mentioned in Section 3, the potential for cross-contamination should be considered when advancing any type of groundwater sampling tool or monitoring well into the subsurface because it can result in sample bias, incorrect decisions, or the spread of contaminants. Methods for avoiding cross-contamination should be discussed and accounted for in project planning with respect to:

- Avoiding drag-down;
- Avoiding the creation of hydraulic conduits;
- Decontaminating equipment; and,
- Decommissioning DPT wells and borings.

These issues typically apply to both DPT and conventional wells; however, because of the different methods of construction, the solutions often differ even though the results are often the same. This section provides guidance on how these issues can relate to DPT methods because the methods for conventional wells are well established.

## Avoiding Drag-Down

Drag-down of contamination is commonly considered to be less of a problem with DPT methods than with conventional well drilling techniques, such as hollow stem augering, where contaminants have a better chance of sticking to the augers as they advance. As DPT rods are advanced, the action of pushing the drive rods through new soil generally wipes away old soil. In fact, researchers have demonstrated the lack of drag-down with DPT in a number of studies (Cherry, et al. 1992; Pitkin et al., 1994; McCall et al., 1997; Pitkin et al., 1999); however, as with conventional drilling techniques, it is unlikely that DNAPL or certain soils, such as sticky clays, would be completely wiped clean as the rods advance. In addition, certain DPT methods can result in drag-down if used in inappropriate situations. This is primarily a problem with advancing multi-level samplers in contaminated fine-grained soil, which can clog the screens, and with advancing exposed screen monitoring well installations, which can carry shallow contaminated soil and groundwater to the target sampling depth. Thus, exposed screen well installations should not be considered for use in contaminated areas.

Where drag-down is a concern, use of DPT equipment that will minimize drag-down potential, such as protected-screen point-in-time samplers, the Waterloo Profiler, or sealed-screen monitoring wells should be considered. In addition, the DPT sampler or well should be properly developed to remove the affected soil and groundwater.

## Avoiding the Creation of Hydraulic Conduits

Creation of hydraulic conduits that allow the downward flow of groundwater and contaminants can be avoided by sealing off the borehole annulus—the space between the borehole wall and the rod string. This issue is of particular concern when the borehole hydraulically connects previously unconnected hydrogeologic units, or when DNAPLs with low viscosity are present that can migrate downward along the vertical conduit. In addition to using grout to seal the annulus, an important method of reducing downward migration along the rod string is to minimize the borehole annulus. Two important considerations include:

- Using a drive tip that is the same diameter or smaller than the drive rods; and
- Using rods and samplers with the same diameter.

The absence of an annulus, however, does not necessarily prohibit contaminant migration because there may not be an effective seal between the steel rods and the borehole wall. This issue is not unique to DPT methods and should also be considered when drilling boreholes using conventional techniques.

DPT techniques are not recommended for installing monitoring wells with screens set in an interval below a confining layer if there is a real danger of contaminating the lower layer. Instead, construction of a “telescoped” monitoring well using conventional drilling methods should be used. This type of well involves drilling into the top of the aquitard, placing a steel casing in the hole and grouting it into place by tremieing grout into the annulus. The hole is then advanced using a drill bit that fits inside the steel casing. Upon reaching the target depth, the well screen and casing are lowered into place and the well completion materials are installed as the casing is slowly retracted. Multiple casings can be telescoped inside the other if more than one aquitard is present. DPT cannot be used for telescoped well construction because the annulus is too narrow to allow for an adequate grout seal to be installed along the drive casing.

## Decontaminating Equipment

As with all groundwater sampling equipment, DPT equipment should be decontaminated before sampling at a new location to avoid cross-contamination. In addition, disposable material should be discarded properly. Some sampling tools, by virtue of their design, may be difficult to disassemble for cleaning. In these cases, when replacing associated tubing, hose, or pipe is not feasible, it may be more practical to clean these tools by circulating cleaning solutions and rinses through the device in accordance with appropriate guidance (e.g., ASTM D5088, ASTM, 2001g; RCRA Ground-Water Monitoring Draft Technical Guidance, EPA, 1992). Where field decontamination is not practical or possible, it may be simpler to use dedicated sampling devices or take a number of portable sampling devices into the field and decontaminate them later at a more appropriate location. Following any cleaning procedure, equipment rinseate blanks should be collected to assess the effectiveness of the cleaning procedure.

## Decommissioning DPT Wells and Borings

As with conventional soil borings or abandoned monitoring wells, DPT boreholes for point-in-time sampling and abandoned DPT monitoring wells should be decommissioned to avoid creating a conduit for contaminant migration, either from the surface or between subsurface geologic units. Several methods are available for decommissioning DPT holes, but the method chosen should be capable of backfilling the hole completely with grout or a bentonite slurry, from bottom to top and without gaps. The most appropriate method will depend on a number of factors, including the type and size of DPT equipment being used, site-specific subsurface conditions, and state and/or local regulations. The type of slurry selected may also depend on the remedial action anticipated at the site. For example, a silica flour grout mixture may be selected for sites that may be treated with in-situ thermal technology.

The methods available for decommissioning DPT boreholes include:

- Retraction grouting;
- Re entry grouting; and
- Surface pouring.

These methods are detailed in ASTM D6001 (ASTM, 2001e), EPA (1997), and Lutenegger and DeGroot (1995). Figure 5.1 illustrates the use of these methods, and the following paragraphs summarize the techniques and their applications.

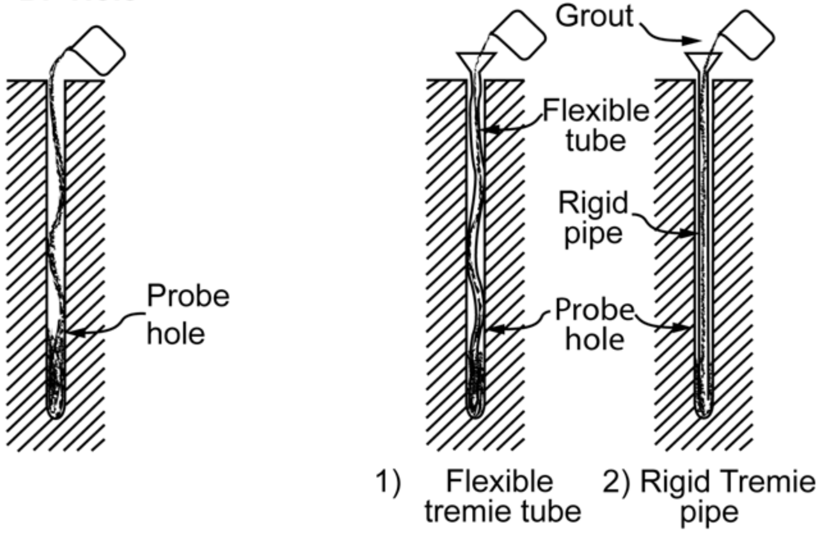
### Retraction Grouting

Retraction grouting typically involves pumping a high-solids bentonite and water mixture or a neat cement grout through the rod and tool string and out the bottom of the sampling tool as the tool is withdrawn from the hole. To use this method, a port is needed at the end or sides of the tool or an expendable tip is necessary on the terminal end of the tool through which the grout can be pumped. Because the hole is grouted as the tool is withdrawn, this method ensures that the borehole is sealed throughout its length. Retraction grouting is generally considered to be the most reliable borehole sealing technique.

### Re entry Grouting

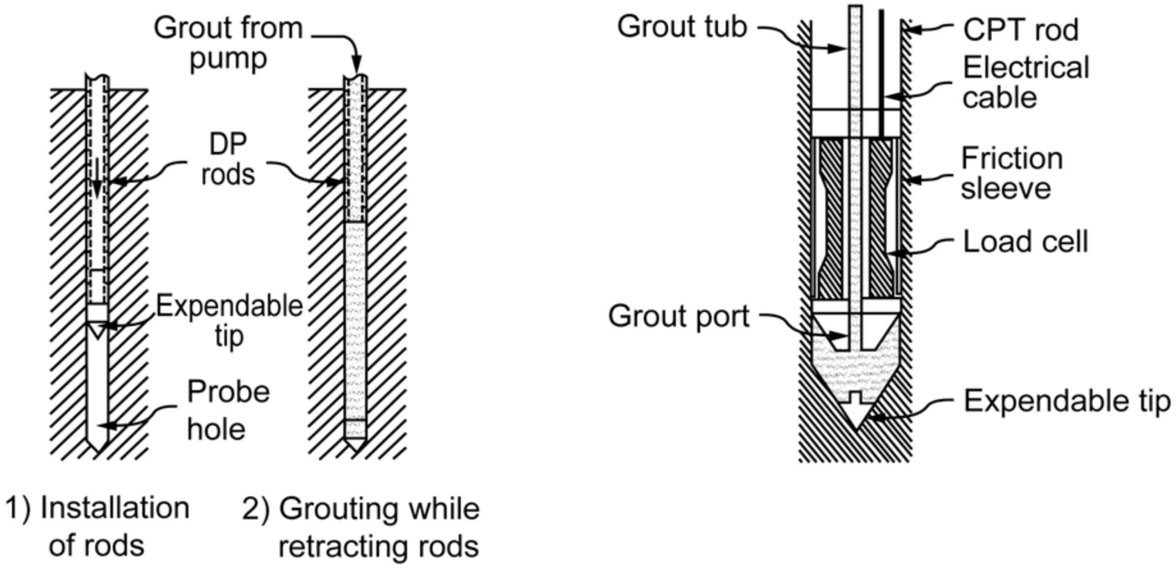
Re entry grouting typically involves pumping grout through a tremie pipe (a rigid pipe, usually Schedule 40 or 80 Type I PVC) inserted into the borehole immediately following withdrawal of the rod string. Alternatively, the rod string may be reinstalled in the borehole, without the sampling tool, so that grout may be pumped through the open rods. The grout should be pumped continuously from the bottom of the hole to the top as the tremie pipe (or rod string) is withdrawn to avoid gaps and bridging (i.e., plugging the hole before grout reaches total depth) of the grout. Typically, re entry grouting is effective only if the hole remains open until tremie pipe or rods can be extended to the bottom of the borehole. If a portion of the borehole collapses, the tremie pipe or rods will not penetrate to the total depth of the hole. In this situation, it may be necessary to put an expendable tip on the end of the rod string, push the string to the total depth of the hole,

**Figure 5.1**
**Sample Methods for Sealing Direct Push Technology Holes**



**a) Surface Pouring Method of Sealing DP Hole**

**b) Re-entry Methods of Sealing DP Holes**



**c) Re-entry Grouting with DP Rods and Expendable Tip**

**d) Retraction Grouting Through Expendable Tip in CPT Cone**

*Source: Adapted from Lutenegger & DeGroot, 1995* knock out the tip, and pump grout through the rods as they are withdrawn. Re entry grouting by this method may not provide a reliable seal if the DPT rods do not follow the original borehole, but the original borehole should provide the path of least resistance under most conditions.

By using a high pressure grout pump and nylon tremie tube it is possible to perform bottom-up grouting in the small annular spaces of DPT equipment. Slurries of 20-30% bentonite or neat cement grout are most commonly used to meet state regulatory requirements.

## Surface Pouring

Surface pouring normally is the simplest method of borehole decommissioning; however, it may not be as effective as the other methods in most situations. It involves pouring either dry bentonite (granules, chips, or pellets), bentonite slurry, or neat cement grout from the surface down the open borehole after the rod string and tool are removed. Surface pouring may be effective if the borehole does not collapse after the rods are removed, and if the borehole is relatively shallow (less than about 10 or 15 feet). Where dry bentonite materials are proposed for use, it normally will only be effective if the bentonite is either hydrated from the surface immediately after installation or if it is installed beneath the water table. Maintaining a seal in the borehole requires that the soil moisture content be sufficient to keep the bentonite hydrated after installation. In deep holes, dry bentonite products can bridge, resulting in an incomplete seal. In situations where boreholes partially collapse, materials poured from the surface will not seal the borehole properly. This method can be improved by using a flexible tremie tube or a rigid tremie pipe to reenter the hole and fill it from the bottom up, however, if the hole collapses before the tremie can be installed, the tremie may not be effective either.

# Section 6: Conclusions

Direct push technologies can be valuable tools for environmental investigations and facilitate the use of a dynamic work plan strategy. They have a number of potential advantages over conventional groundwater sampling methods and they can have the added benefit of being able to provide numerous other types of detailed subsurface data, such as geophysical, analytical, and hydrogeologic data. The diversity and capabilities of DPT equipment and methods are large enough that under many situations DPT can be used to provide the level of groundwater data quality needed for projects where the subsurface conditions and depth of investigation are amenable to pushing techniques. When techniques common to conventional well installation are followed, such as adequate well development, low-flow purging and sampling, proper decontamination of equipment, and preventing the creation of a hydraulic conduit, quality groundwater samples can be obtained.

DPT will not be appropriate for all situations. DPT methods typically are more limited in their depth of penetration and the types of materials they can penetrate than conventional drilling methods. Some methods may not be able to provide sufficient sample volume or sufficiently low turbidity. Use of DPT may be limited in lower yield formations. Conventional wells with larger diameters may be required to minimize the affect of lower yield formations. Lastly, DPT methods cannot always be used where confining layers are present and there is a danger of creating a vertical hydraulic conduit that could contaminate underlying layers. In these instances, telescoped wells may be needed to prevent downward migration of contaminants beneath a confining layer. As a result, DPT cannot completely replace the use of conventional monitoring wells. Rather, DPT provides additional choices to select equipment and methods for collecting environmental data.

This page is intentionally blank.

# References

---

Ahrens, T.P. 1957. Well design criteria: part one, *Water Well Journal*, Vol. 11, No. 4, pp. 13-30.

ASTM. 2001a. *Standard Test Method for Deep, Quasi-Static, Cone and Friction-Cone Penetration Tests of Soils,* ASTM D3441. American Society for Testing and Materials. West Conshohocken, PA, 7 pp.

ASTM. 2001b. *Standard Test Method for Performing Electronic Friction Cone and Piezocone Penetration Testing of Soils,* ASTM D5778. American Society for Testing and Materials. West Conshohocken, PA 18 pp.

ASTM. 2001c. *Standard Practice for Cone Penetrometer Technology Characterization of Petroleum Contaminated Sites with Nitrogen Laser-Induced Fluorescence,* ASTM D6167. American Society for Testing and Materials. West Conshohocken, PA, 7 pp.

ASTM. 2001d. *Standard Guide for Direct Push Soil Sampling for Environmental Site Characterization,* ASTM D6282. American Society for Testing and Materials. West Conshohocken, PA, 19 pp.

ASTM. 2001e. *Standard Guide for Direct-Push Water Sampling for Geoenvironmental Investigations,* ASTM D6001. American Society for Testing and Materials. West Conshohocken, PA.

ASTM. 2001f. *Standard Guide for Development of Ground-Water Monitoring Wells in Granular Aquifers*, ASTM D5521. American Society for Testing and Materials. West Conshohocken, PA, 15 pp.

ASTM. 2001g. *Standard Practice for Decontamination of Field Equipment Used at Nonradioactive Waste Sites*, ASTM D5088. American Society for Testing and Materials. West Conshohocken, PA, 20 pp.

ASTM. 2001h. *Standard Practice for Decontamination of Field Equipment Used at Low Level Radioactive Waste Sites*, ASTM D5608. American Society for Testing and Materials. West Conshohocken, PA, 8 pp.

ASTM. 2001i. *Standard Guide for the Selection of Purging and Sampling Devices for Ground-Water Monitoring Wells,* ASTM D6634. American Society for Testing and Materials. West Conshohocken, PA, 14 pp.

ASTM. 2002. *Standard Test Method for Particle-Size Analysis of Soils,* ASTM D422-63. American Society for Testing and Materials. West Conshohocken, PA, 8 pp.

ASTM. 2003a. *Guide for Installation of Direct Push Ground Water Monitoring Wells,* ASTM D6724-01. American Society for Testing and Materials. West Conshohocken, PA, 9 pp.

ASTM. 2003b. *Standard Practice for Direct Push Installation of Prepacked Screen Monitoring Wells in Unconsolidated Aquifers*, ASTM D6725-01. American Society for Testing and Materials. West Conshohocken, PA, 15 pp.

ASTM. 2003c. *Standard Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers*, ASTM D5092-02. American Society for Testing and Materials. West Conshohocken, PA, 14 pp.

Applegate, J.L. and D.M. Fitton. 1997. Rapid site assessment applied to the Florida Department of Environmental Protection's drycleaning solvent cleanup program. HazWaste World Superfund XVIII Conference Proceedings, December 1997, Washington DC, pp. 695-703.

Backhus, D.A., J.N. Ryan, D.M. Groher, J.K. MacFarlane, and P.M. Gschwend. 1993. Sampling colloids and colloid-associated contaminants in ground water. *Ground Water*, Vol. 31, No. 3, pp. 466-479.

Baerg, D.L., R.C. Storr, J.A. Cherry, and D.J.A. Smyth. 1992. Performance testing of conventional and innovative downhole samplers and pumps for VOCs in a laboratory monitoring well. Proceedings, National Ground Water Sampling Symposium, Washington, DC November 1992, pp. 71-76.

Bangsund, W. J., C.G. Peng, and W.R. Mattsfield. 1994. Investigation of contaminant migration by low-flow rate sampling techniques. Proceedings, Eighth Annual Outdoor Action Conference, National Ground Water Association, Dublin, OH, pp. 311-326.

Barcelona, M.J., J.P. Gibb, J.A. Helfrich, and E.E. Garske, 1985, *Practical Guide for Ground-Water Sampling*. Illinois State Water Survey Contract Report 374, Champaign, IL, 94 pp.

Barcelona, M.J., J.P. Gibb, and R.A. Miller. 1983. *A Guide to the Selection of Materials for Monitoring Well Construction and Ground-Water Sampling*. Illinois State Water Survey Contract Report 327, Champaign, IL, 78 pp.

Barcelona, M.J. and J.A. Helfrich. 1986. Well construction and purging effects on ground-water samples. *Environmental Science and Technology*, Vol. 20, No. 11, pp. 1179- 1184.

Barcelona, M.J., J.A. Helfrich, E.E. Garske and J.P. Gibb. 1984. A laboratory evaluation of ground water sampling mechanisms. *Ground Water Monitoring Review*, Vol. 4, No. 2, pp. 32-41.

Barcelona, M. J., H.A. Wehrmann, and M.D. Varljen. 1994. Reproducible well-purging procedures and VOC stabilization criteria for ground water sampling. *Ground Water*, Vol. 32, No. 1, pp. 12-22.

Barker, J.F. and R. Dickhout. 1988. An evaluation of some systems for sampling gas-charged ground water for volatile organic analysis. *Ground Water Monitoring Review*, Vol. 8, No. 4, pp. 112-120.

Bergren, C.L., R.C. Tuckfield, and N.M. Park. 1990. Suitability of the hydropunch for assessing ground water contaminated by volatile organics. In: Proceedings of Fourth National Outdoor Action Conference on Aquifer Restoration, Ground Water Monitoring and Geophysical Methods, Volume 2, National Ground Water Association, Dublin, OH, pp. 387-401.

Berzins, N.A. 1992. Use of the cone penetrometer test and BAT ground water monitoring system to assess deficiencies in monitoring well data. Proceedings of the Sixth National Outdoor Action Conference, Las Vegas, NV May 1992, National Ground Water Association, Westerville, OH, pp. 327-339.

BP Corporation North America, Inc. 2002. *Monitoring Well Comparison Study: An Evaluation of Direct-Push Versus Conventional Monitoring Wells*. May 1, 2002, 80 pp. (available at www.epa.gov/swerust1/cat/wellstdy.pdf).

Buddemeier, R.W. and J.R. Hunt. 1988. Transport of colloidal contaminants in ground water. Radionuclide migration at the Nevada Test Site. *Applied Geochemistry*, Vol. 3 pp. 535-548.

Butler, J., et al. 2002. Hydraulic tests with direct-push equipment. *Ground Water*, Vol. 40, No. 1, pp. 25-36.

Canova, J.L. and M.G. Muthig. 1991. The effect of latex gloves and nylon cord on ground-water sample quality. *Ground Water Monitoring Review*, Vol. 11, No. 1, pp. 98-103.

Clark, L. and K.M. Baxter. 1989. Ground water sampling techniques for organic micropollutants: UK experience. *Quarterly Journal of Engineering Geology*, Vol. 22, pp. 159- 168.

Cherry, J.A. 1992. Ground water monitoring: some current deficiencies and alternative approaches, Chapter 13. In: *Hazardous Waste Site Investigations: Toward Better Decisions*, R.B. Gammage and B.A. Berven, editors, Lewis Publishers, Boca Raton, FL, pp.119-134.

Cherry, J.A., R.A. Ingleton, D.K. Solomon, and N.D. Farrow. 1992. Low technology approaches for drive point profiling of contaminant distributions. In: Proceedings, National Ground Water Sampling Symposium, pp. 109-111.

Crumbling, D. 2000. Improving the cost-effectiveness of hazardous waste site characterization and monitoring. Special Report #6, *Failsafe*, January 2000, 10 pp.

Devlin, J.F. 1987. Recommendations concerning materials and pumping systems used in the sampling of ground water contaminated with volatile organics. *Water Pollution Research Journal of Canada*, Vol. 22, No. 1, pp. 65-72.

Dragun, J. 1988. *The Soil Chemistry of Hazardous Materials*. Hazardous Materials Control Research Institute, Silver Spring, MD.

Driscoll, F.G. 1986. *Groundwater and Wells* (Second Edition). Johnson Division, UOP, Inc., St. Paul, MN.

Edge, R.W. and K. Cordry. 1989. The hydropunch: an in-situ sampling tool for collecting ground water from unconsolidated sediments. *Ground Water Monitoring Review*, Vol. 9, No. 3, pp. 177-183.

Eichholz, G.G., B.G. Wahlig, G.F. Powell, and T.F. Craft. 1982. Subsurface migration of radioactive waste materials by particulate transport. *Nuclear Technology*, Vol. 58, pp. 511-519.

Enfield, C.G. and G. Bengtsson. 1988. Macromolecular transport of hydrophobic contaminants in aqueous environments. *Ground Water*, Vol. 26, No. 1 pp. 64-70.

Enfield, C.G., G. Bengtsson, and R. Lindquist. 1989. Influence of macromolecules on chemical transport. *Environmental Science & Technology*, Vol. 23, No. 10, pp. 1278-1286.

Geoprobe. 1996. *Geoprobe® 0.5-in. x 1.4-in. OD and 0.75-in. x 1.4-in. OD Prepacked Screen Monitoring Wells, Standard Operating Procedure.* Technical Bulletin No. 962000, September, revised June 2002.

Gibb, J.P., R.M. Schuller, and R.A. Griffin. 1981. *Procedures for the Collection of Representative Water Quality Data from Monitoring Wells*. Illinois State Water Survey/Geological Survey Cooperative Ground-Water Report No. 7, Champaign, IL.

Gibs, J. and T.E. Imbrigiotta. 1990. Well purging criteria for sampling purgeable organic compounds. *Ground Water*, Vol. 28, No. 1, pp. 68-78.

Gibs, J., T.E. Imbrigiotta, J.H. Ficken, J.F. Pankow, and M.E. Rosen. 1994. Effect of sample isolation and handling on the recovery of purgeable organic compounds. *Ground Water Monitoring and Remediation*, Vol. 9, No. 2, pp. 142-152.

Gillham, R.W. and S.F. O'Hannesin. 1990. Sorption of aromatic hydrocarbons by materials used in construction of ground-water sampling wells. In: Proceedings, ASTM Symposium on Standards Development for Ground Water and Vadose Zone Monitoring Investigations, ASTM Special Technical Publication 1053, pp. 108-124.

Gillham, R.W., M.J.L. Robin, J.F. Barker, and J.A. Cherry. 1985. *Field Evaluation of Well Purging Procedures*. American Petroleum Institute Publication 4405, Environmental Affairs Department, 109 pp.

Gillham, R.W., M.J.L. Robin, J.F. Barker, and J.A. Cherry. 1983. *Ground-Water Monitoring and Sample Bias.* American Petroleum Institute Publication 4367, 206 pp.

Grolimund, D., M. Borkovec, K. Barmettler, and H. Sticher. 1996. Colloid-facilitated transport of strongly sorbing contaminants in natural porous media: a laboratory column study. *Environmental Science & Technology*, American Chemical Society, Vol. 30, No. 10, pp. 3118-3123.

Gschwend, P.M., D.A. Backhus, J.K. MacFarlane, and A.L. Page. 1990. Mobilization of colloids in ground water due to infiltration of water at a coal ash disposal site. *Journal of Contaminant Hydrology*, Vol. 6 pp. 307-320.

Gschwend, P.M. and M.D. Reynolds. 1987. Monodisperse ferrous phosphate colloids in an anoxic ground water plume. *Journal of Contaminant Hydrology*, Vol. 1, pp. 309-327.

Heidlauf, D.T. and T.R. Bartlett. 1993. Effects of monitoring well purge and sampling techniques on the concentration of metal analytes in unfiltered ground water samples. In: Proceedings, Seventh Outdoor Action Conference and Exposition, National Ground Water Association, Dublin, OH, pp. 437-450.

Henebry, B.J. and G.A. Robbins. 2000. Reducing the influence of skin effects on hydraulic conductivity determinations in multi-level samples installed with direct push methods, *Ground Water*, Vol. 38, No. 6, pp. 882-886.

Herzog, B., J. Pennino, and G. Nielsen. 1991. Ground-water sampling, Chapter 11 in *The Practical Handbook of Ground-Water Monitoring*. D.M. Nielsen, editor, Lewis Publishers, Chelsea, MI, pp. 449-499.

Hewitt, A.D. 1992. Potential of common well casing materials to influence aqueous metal concentrations. *Ground Water Monitoring and Remediation*, Vol. 12, No. 2, pp. 131-136.

Ho, James 1983. Effect of sampling variables on recovery of volatile organics in water. *Journal of the American Water Works Association*, Vol. 75, No. 11, pp. 583-586.

Holm, T.R., G.K. George, and M.J. Barcelona. 1988. Oxygen transfer through flexible tubing and its effects on ground-water sampling results. *Ground Water Monitoring Review*, Vol. 8, No. 3, pp. 83-89.

Howard, P., et al. 1993a. *Handbook of Environmental Fate and Exposure Data for Organic Chemicals, Volume II Solvents*. Lewis Publishers.

Howard, P., et al., 1993b. *Handbook of Environmental Fate and Exposure Data for Organic Chemicals, Volume IV Solvents 2*. Lewis Publishers.

Houghton, R.L. and M.E. Berger. 1984. Effects of well-casing composition and sampling method on apparent quality of ground water. Proceedings of the Fourth National Symposium on Aquifer Restoration and Ground Water Monitoring, Columbus, OH, May, 1984, National Water Well Association, Worthington, OH, pp. 203-213.

Huntzinger, T.L. and L.E. Stullken. 1988. *An Experiment in Representative Ground-Water Sampling for Water-Quality Analysis*. U.S. Geological Survey, Water Res. Inv. Report 88-4178, Reston, VA.

Iles, D.L., P.D. Hammond, and L.D. Schulz. 1992. Effects of sampling methods on inorganic water chemistry results. In: Proceedings, National Ground Water Sampling Symposium, Washington, DC November 1992, pp. 41-70.

Imbrigiotta, T.E., J. Gibs, T.V. Fusillo, G.R. Kish, and J.J. Hochreiter. 1988. Field evaluation of seven sampling devices for purgeable organic compounds in ground water. In: Ground-Water Contamination: Field Methods, ASTM STP 963, A.G. Collins and A.J. Johnson, editors, American Society for Testing and Materials, Philadelphia, PA, pp. 258-273.

Kaback, D.S., C.L. Bergren, C.A. Carlson, and C.L. Carlson. 1990. Testing a ground water sampling tool: are the samples representative? In: Proceedings, Fourth National Outdoor Action Conference on Aquifer Restoration, Ground Water Monitoring and Geophysical Methods, Volume 2, National Ground Water Association, Dublin, OH, pp. 403-417.

Karklins, S. 1996. *Ground Water Sampling Desk Reference.* Wisconsin Department of Natural Resources Publication #PUBL-DG-037 96, Wisconsin DNR Bureau of Drinking Water and Ground Water, 165 pp.

Kearl, P.M., N.E. Korte, M. Stites, and J. Baker. 1994. Field comparison of micropurging vs. traditional ground water sampling. *Ground Water Monitoring and Remediation*, Vol. 14, No. 4, pp. 183-190.

Kearl, P.M., N.E. Korte, and T.A. Cronk. 1992. Suggested modifications to ground water sampling procedures based on observations from the colloidal borescope. *Ground Water Monitoring Review*, Vol. 12, No. 2, pp. 155-161.

Keely, J.F. and K. Boateng. 1987. Monitoring well installation, purging and sampling techniques part 1: conceptualizations. *Ground Water,* Vol. 25, No. 3, pp.300-313.

Knobel, L.L. and L.J. Mann. 1993. Sampling for purgeable organic compounds using positive-displacement piston and centrifugal pumps: a comparative study. *Ground Water Monitoring and Remediation*, Vol. 13 No. 2, pp. 142-148.

Kram, Mark, et al. 2003. Direct-push wells prove effective for long-term ground water monitoring. *Water Well Journal*, Vol. 57, No. 4, pp. 16 and 18.

Kram, Mark, 2001. Personal communication with David M. Nielsen.

Kram, M., D. Lorenzana, J. Michaelsen, and E. Lam. 2000. *Performance Comparison: Direct-Push Wells Versus Drilled Wells*. NFESC Technical Report TR-2120-ENV, October 2000, Naval Facilities Engineering Command, Washington, DC, 55 pp.

Lee, G. F. and R.A. Jones. 1983. Guidelines for sampling ground water. *Journal of the Water Pollution Control Federation*, Vol. 55, No. 1, pp. 92-96.

Lutenegger, A.J. and D.J. DeGroot. 1995. Techniques for sealing cone penetrometer holes. *Canadian Geotechnical Journal*, Vol. 32, No. 5, pp. 880-891.

MacFarlane, I.D., J.L. Kocornik, F.T. Barranco, and A.R. Bonas. 1992. The application of slow pumping at a manufactured gas plant. Proceedings of the Sixth National Outdoor Action Conference, Las Vegas, NV, May 1992, National Ground Water Association, Westerville, OH, pp. 413-426.

Marsh, M.J. and J.W. Lloyd. 1980. Details of hydrochemical variations in flowing wells. *Ground Water*, Vol. 18, No. 4, pp. 366-373.

Mason, S.A., J. Barkach, and J. Dragun. 1992. Discussion of “literature review and model (COMET) for colloidal/metals transport in porous media.” *Ground Water*, Vol. 30, No. 1, pp.104-106.

McCall, W., et al. 2002. A dual-tube direct-push method for vertical profiling of hydraulic conductivity in unconsolidated formations. *Environmental & Engineering Geoscience*, Vol. VIII, No. 2, pp. 75-84.

McCall, W. 2000. Innovative direct-push ground-water monitoring compared to conventional methods. In: Proceedings of the Second International Conference on Remediation of Chlorinated and Recalcitrant Compounds, Battelle Press, Columbus, OH, Vol. C2-1, pp. 71-78.

McCall, W., S. Stover, C. Enos, and G. Fuhrmann. 1997. Field comparison of direct push prepacked screen wells to paired HSA 2" PVC wells. In: Proceedings Vol. 2, HazWasteWorld Superfund XVIII Conference, December 1997, Washington, DC, pp. 647-655.

McCarthy, J.F. and C. Degueldre. 1993. Sampling and characterization of colloids and particles in ground water for studying their role in contaminant transport. In: *Environmental Particles*, J. Buffle, and H.P. van Leeuwen, editors, Lewis Publishers, pp. 247-315.

McCarthy, J. and L. Shevenell. 1998. Obtaining representative ground-water samples in a fractured and karstic formation. *Ground Water*, Vol. 36, No. 2, pp. 251-260.

McCarthy, J.F. and J.M. Zachara. 1989. Subsurface transport of contaminants: binding to mobile and immobile phases in ground water aquifers. *Environmental Science and Technology*, Vol. 23, No. 5, pp. 496-504.

McDowell-Boyer, L.M., J.R. Hunt, and N. Sitar. 1986. Particle transport through porous media. *Water Resources Research*, Vol. 22, No. 13, pp. 1901-1921.

Miller, G.D. 1982. Uptake and release of lead, chromium and trace level volatile organics exposed to synthetic well casings. In: Proceedings, Second National Symposium on Aquifer Restoration and Ground Water Monitoring, National Ground Water Association, Worthington, Ohio, pp. 236 - 245.

Montgomery, J. and L. Welkom. 1991. *Groundwater Chemicals Desk Reference*. Lewis Publishers.

Moylan, J.E. 1991. *Data Gaps in Remedial Design*. U.S. EPA/U.S. Army Corps of Engineers Engineering Issue, July, 1991, 5 pp.

Muska, C.F., W.P. Colven, V.D. Jones, J.T. Scogin, B.B. Looney, and V. Price, Jr. 1986. Field evaluation of ground water sampling devices for volatile organic compounds. In: Proceedings of the Sixth National Symposium and Exposition on Aquifer Restoration and Ground Water Monitoring, National Water Well Association, Dublin, OH, pp. 235-245.

NWWA/PPI. 1980. *Manual on the Selection and Installation of Thermoplastic Water Well Casing*. National Water Well Association, Worthington, OH, 64 pp.

Nielsen, D.M. (editor). 1991. *The Practical Handbook of Ground-Water Monitoring*. Lewis Publishers, Chelsea, MI, 717 pp.

Nielsen, D.M. 1995a. The relationship of monitoring well design, construction and development to turbidity in wells, and related implications for ground water sampling, In: *Ground Water Sampling—A Workshop Summary*, EPA 600/R-94/205. U.S. EPA Office of Research and Development, Washington DC, p. 16.

Nielsen, D.M. 1995b. Building a better monitoring well using ASTM standards to improve well construction and cut monitoring costs. Workshop Presented at the Ninth National Outdoor Action Conference and Exposition, Las Vegas, NV, May 1995, National Ground Water Association, Westerville, OH, pp. 47-59.

Nielsen, D.M. and G.L. Nielsen. 1995. Understanding the ramifications of change: developments in monitoring well purging and ground-water sample filtration. Workshop Presented at the Ninth National Outdoor Action Conference and Exposition, Las Vegas, NV, May 1995, National Ground Water Association, Westerville, OH, pp. 233-239.

Nielsen, D.M. and G.L. Nielsen. 1999. *Technical Guidance on Low-Flow Purging & Sampling and Passive Sampling.* Nielsen Environmental Field School Publication, NEFS-TG001-99, Galena, OH, 57 pp.

Nielsen, D.M. and R. Schalla. 1991. Design and installation of ground-water monitoring wells. Chapter 7 in *The Practical Handbook of Ground-Water Monitoring*, D.M. Nielsen, Editor. Lewis Publishers, Chelsea, MI, pp. 239-332.

Nielsen, D.M. and G.L. Yeates. 1985. A comparison of sampling mechanisms available for small-diameter ground water monitoring wells. *Ground Water Monitoring Review*, Vol. 5, No. 2, pp. 83-89.

O'Melia, C.R. 1990. Kinetics of colloid chemical processes in aquatic systems. In *Aquatic Chemical Kinetics*, W. Stumm editor. Wiley & Sons, NY, NY, pp. 447-474.

Oneacre, J. and D. Figueras. 1996. Ground water variability at sanitary landfills: causes and solutions. In Proceedings, ASCE Conference on Uncertainty in the Geologic Environment, Madison, WI, July 31 - August 3, 1996, pp. 965-987.

Parker, L. 1991. Suggested guidelines for the use of PTFE, PVC and stainless steel in samplers and well casings. In: *Current Practices in Ground Water and Vadose Zone Investigations*, ASTM STP 1118, D.M. Nielsen and M.N. Sara, editors. American Society for Testing and Materials, Philadelphia, PA. 13 pp.

Parker, L. 1994. The effects of ground water sampling devices on water quality: a literature review. *Ground Water Monitoring and Remediation*, Vol. 14, No. 2, pp. 130-141.

Parker, L.V., A.D. Hewitt, and T.F. Jenkins. 1990. Influence of casing materials on trace-level chemicals in well water. *Ground Water Monitoring Review*, Vol. 10 No. 2, pp. 146-156.

Paul, D.G., C.D. Palmer, and D.S. Cherkauer. 1988. The effect of construction, installation and development on the turbidity of water in monitoring wells in fine-grained glacial till. *Ground Water Monitoring Review*, Vol. 8, No. 1, pp. 73-82.

Paul, C.J. and R.W. Puls. 1997. Impact of turbidity on TCE and degradation products in ground water. *Ground Water Monitoring and Remediation*, No. 17 No. 1, pp. 128-133.

Pearsall, K.A. and D.A.V. Eckhardt. 1987. Effects of selected sampling equipment and procedures on the concentrations of trichloroethylene and related compounds in ground water samples. *Ground Water Monitoring Review*, Vol. 7, No. 2, pp. 64-73.

Penrose, W.R., W.L. Polzer, E.H. Essington, D.M. Nelson, and K.A. Orlandin. 1990. Mobility of plutonium and americium through a shallow aquifer in a semi-arid region. *Environmental Science and Technology*, Vol. 24, pp. 228-234.

Pitkin, S., R.A. Ingleton, and J.A. Cherry. 1994. Use of a drive point sampling device for detailed characterization of a PCE plume in a sand aquifer at a dry cleaning facility. In: Proceedings, Eighth National Outdoor Action Conference and Exposition, National Ground Water Association, Dublin, OH, pp. 395-412.

Pitkin, S.E., J.A. Cherry, R.A. Ingleton, and M. Broholm. 1999. Field demonstrations using the Waterloo Ground Water Profiler. *Ground Water Monitoring and Remediation*, Vol. 19, No. 2, pp. 122-131.

Pohlmann, K.F., G.A. Icopini, R.D. McArthur, and C.G., Rosal. 1994. *Evaluation of Sampling and Field-Filtration Methods for Analysis of Trace Metals in Ground Water*, EPA 600/R-94/119. U.S. EPA Office of Research and Development, Las Vegas, NV.

Pohlmann, K.F. and J.W. Hess. 1988. Generalized ground water sampling device matrix. *Ground Water Monitoring Review*, Vol. 8, No. 4, pp. 82-83.

Pohlmann, K.F., R.P. Blegen, and J.W. Hess. 1991. *Field Comparison of Ground-Water Sampling Devices for Hazardous Waste Sites: An Evaluation Using Volatile Organic Compounds*, EPA 600/4-90/028. U.S. EPA Office of Research and Development, Las Vegas, NV, 102 pp.

Powell, R.M. and R.W. Puls. 1993. Passive sampling of ground water monitoring wells without purging: multilevel well chemistry and tracer disappearance. *Journal of Contaminant Hydrology*, Vol. 12, pp. 51-77.

Powell, R.M. and R.W. Puls. 1997. Hitting the bull's-eye in ground water sampling. *Pollution Engineering*, pp. 51-54.

Puls, R.W. 1990. Colloidal considerations in ground water sampling and contaminant transport predictions. *Nuclear Safety*, Vol. 31, pp. 58-65.

Puls, R.W. and C.J. Paul. 1995. Low-flow purging and sampling of ground-water monitoring wells with dedicated systems. *Ground Water Monitoring and Remediation*, Vol. 15, No. 1, pp. 116-123.

Puls, R.W. and J.F. McCarthy. 1995. Well Purging and Sampling (Workshop Group Summary), Ground Water Sampling - A Workshop Summary, EPA 600/R-94/205, U.S. EPA Office of Research and Development, Washington, DC, pp. 82-87.

Puls, R.W. and M.J. Barcelona. 1996. *Low Flow (Minimal Drawdown) Ground Water Sampling Procedures*, U.S. EPA Ground Water Issue, EPA 540/5-95/504. U.S. EPA Office of Solid Waste and Emergency Response, Washington, DC, 12 pp.

Puls, R.W. and M.J. Barcelona. 1989. *Ground Water Sampling for Metals Analysis*, U.S. EPA Superfund Ground Water Issue, EPA 540/4-89/001. U.S. EPA Office of Solid Waste and Emergency Response, Washington, DC, 6 pp.

Puls, R.W. and J.H. Eychaner. 1990. Sampling ground water for inorganics— pumping rate, filtration and oxidation effects. In: Proceedings, Fourth National Outdoor Action Conference on Aquifer Restoration, Ground Water Monitoring and Geophysical Methods, National Water Well Association, Dublin, OH, pp. 313-327.

Puls, R.W. and R.M. Powell, 1992a. Acquisition of representative ground-water quality samples for metals. *Ground Water Monitoring Review*, Vol. 12, No. 3, pp. 167-176.

Puls, R.W. and R.M. Powell. 1992b. Transport of inorganic colloids through natural aquifer material: implications for contaminant transport. *Environmental Science and Technology*, Vol. 26 No. 3, pp. 614-621.

Puls, R.W., D.A. Clark, B. Bledsoe, R.M. Powell, and C.J. Paul. 1992. Metals in ground water: sampling artifacts and reproducibility. *Hazardous Waste and Hazardous Materials*, Vol. 9, No. 9, pp. 149-162.

Puls, R.W., R.M. Powell, D.A. Clark, and C.J. Paul. 1991. *Facilitated Transport of Inorganic Contaminants in Ground Water: Part II, Colloidal Transport*, EPA 600/M-91/040. Robert S. Kerr Laboratory, U.S. EPA, Ada, OK.

Puls, R.W., J.H. Eychaner, and R.M. Powell. 1990. *Facilitated Transport of Inorganic Contaminants in Ground Water: Part I. Sampling Considerations*, EPA 600/M-90/023. Robert S. Kerr Laboratory, U.S. EPA, Ada, OK, 12 pp.

Reynolds, M.D. 1985. *Colloids in Ground Water*, Masters Thesis. Massachusetts Institute of Technology, Cambridge, MA.

Robertson, W.D., J.F. Barker, Y. LeBeau, and S. Marcoux. 1984. Contamination of an unconfined sand aquifer by waste pulp liquor: a case study. *Ground Water*, Vol. 22, pp. 192-197.

Robin, M.J.L. and R.W. Gillham. 1987. Field evaluation of well purging procedures. *Ground Water Monitoring Review*, Vol. 7, No. 4, pp. 85-93.

Robbins, G.A. and J.M. Martin-Hayden. 1991. Mass balance evaluation of monitoring well purging, part 1. Theoretical models and implications for representative sampling. *Journal of Contaminant Hydrology*, Vol. 8, pp. 203-224.

Ryan, J.N. and P.M. Gschwend. 1990. Colloidal mobilization in two atlantic coastal plain aquifers: field studies, *Water Resources Research*, Vol. 26, pp. 307-322.

Ryan, J. N., S. Mangion, and R. Willey. 1995. Turbidity and colloid transport (working group summary), *Ground Water Sampling—A Workshop Summary*, EPA 600/R-94/205. U.S. EPA Office of Research and Development, Washington, DC, pp. 88-92.

Serlin, C.L. and L.M. Kaplan. 1996. Field comparison of micropurge and traditional ground-water sampling for volatile organic compounds. In: Proceedings, Petroleum Hydrocarbons and Organic Chemicals in Ground Water, National Ground Water Association, Westerville, OH, pp. 177-190.

Shanklin, D.E., W.C. Sidle, and M.E. Ferguson. 1995. Micropurge low-flow sampling of uranium-contaminated ground water at the Fernald environmental management project. *Ground Water Monitoring and Remediation*, Vol. 15, No. 3, pp. 168-176.

Smolley M. and J.C. Kappmeyer. 1991. Cone penetrometer tests and hydropunch sampling: a screening technique for plume definition. *Ground Water Monitoring Review*, Vol. 11, No. 2, pp. 101-106.

Stolzenburg, T.R. and D.G. Nichols. 1985. *Preliminary Results on Chemical Changes in Ground Water Samples Due to Sampling Devices*. EPRI Report EA-4118, 53 pp.

Stolzenburg, T.R. and D.G. Nichols. 1986. Effects of filtration method and sampling device on inorganic chemistry of sampled well water. In: Proceedings, Sixth National Symposium and

Exposition on Aquifer Restoration and Ground Water Monitoring, National Ground Water Association, Worthington, OH, pp. 216-234.

Stumm, W. and J.J. Morgan. 1981. *Aquatic Chemistry*. New York Interscience, 583 pp.

Stumm, W. and J. J. Morgan. 1996. *Aquatic Chemistry: Chemical Equilibria and Rates in Natural Waters, Third Edition.* John Wiley and Sons, Inc., New York, NY.

Tai, D.Y., K.S. Turner, and L.A. Garcia. 1991. The use of a standpipe to evaluate ground-water samplers. *Ground Water Monitoring Review*, Vol. 11, No. 1, pp. 125-132.

Thornton, D., S. Ita, and K. Larsen. 1997. Broader use of innovative ground water access technologies. In: Proceedings Vol. 2, HazWasteWorld Superfund XVIII Conference Proceedings, December 1997, Washington, DC, pp. 639-646.

Unwin, J.T. 1982. *A Guide to Ground Water Sampling*, Technical Bulletin 362. National Council of the Paper Industry for Air and Stream Improvements, New York, NY.

Unwin, J.T. and V. Maltby. 1988. *Investigations of Techniques for Purging Ground Water Monitoring Wells and Sampling Ground Water for Volatile Organic Compounds*. ASTM Special Technical Publication 963, ASTM, Philadelphia, PA, pp. 240-252.

U.S. EPA. 1989. *Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells*, EPA 600/4-89/034. Environmental Monitoring Systems Laboratory, Office of Research and Development, Las Vegas, NV, October 1989, 398 pp.

U.S. EPA. 1992. *RCRA Ground-Water Monitoring: Draft Technical Guidance*. Office of Solid Waste, November 1992.

U.S. EPA. 1996a. *Low Stress (Low Flow) Purging and Sampling Procedures for the Collection of Ground-Water Samples from Monitoring Wells.* U.S. EPA Region 1, SOP#GW0001, Boston, MA, 13 pp.

U.S. EPA. 1996b. *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual*. U.S. EPA Region 4, Atlanta, GA.

U.S. EPA. 1997. *Expedited Site Assessment Tools for Underground Storage Tank Sites, A Guide for Regulators*, EPA 510-B-97-001. Office of Underground Storage Tanks, Washington, DC.

U.S. EPA. 2000a. *Guidance for the Data Quality Objectives Process, QA/G-4*, EPA 600/R-96/055. Office of Environmental Information, Washington, DC.

U.S. EPA. 2000b. *Data Quality Objectives Process for Hazardous Waste Site Investigations: EPA QA/G-HHW Final*, EPA 600/R-00/007. Office of Environmental Information, Washington, DC.

U.S. EPA. 2002. *Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers*, http://www.epa.gov/tio/tsp/download/gw_sampling_guide.pdf.

Walker, S.E. 1983. Background ground-water quality monitoring: well installation trauma. In: Proceedings, Third National Symposium on Aquifer Restoration and Ground Water Monitoring, National Water Well Association, Worthington, OH, pp. 235-246.

Yeskis, D., K. Chiu, S. Meyers, J. Weiss, J., and T. Bloom. 1988. A field study of various sampling devices and their effects on volatile organic contaminants. In: Proceedings of Second National Conference on Aquifer Restoration, Ground Water Monitoring and Geophysical Methods, National Water Well Association, Dublin, OH, pp. 471-479.

Zemo, D.A., T.A. Delfino, J.D. Gallinatti, V.A. Baker, and L.R. Hilpert. 1995. Field comparison of analytical results from discrete-depth ground water samplers. *Ground Water Monitoring and Remediation*, Vol. 15, No. 1, pp. 133-141.

Zemo, D.A., Y.G. Pierce, and J.D. Gallinatti. 1994. Cone penetrometer testing and discrete-depth ground water sampling techniques: a cost-effective method of site characterization in a multiple-aquifer setting, *Ground Water Monitoring and Remediation*, Vol. 14, No. 4, pp. 176-182.

This page is intentionally blank.

# Appendix: Purging and Sampling Devices

A wide variety of purging and sampling equipment is available for use in DPT sampling points. Available devices can be classified into five general categories:

- Grab mechanisms (including bailers, thief samplers, and syringes);
- Suction-lift mechanisms (including surface centrifugal and peristaltic pumps);
- Centrifugal submersible pumps;
- Positive displacement mechanisms (including gas displacement pumps, bladder pumps, piston pumps, progressing cavity pumps and gear pumps); and
- Inertial-lift pumps.

Though frequently used in the groundwater industry for well development, the gas-lift method is generally considered unsuitable for purging and sampling because the extensive mixing of drive gas and water is likely to strip dissolved gasses from the groundwater and alter the concentration of other dissolved constituents (Gillham et al., 1983). This method is not discussed for this reason.

## Grab Sampling Devices

Bailers, thief samplers (e.g., messenger samplers), and syringes are all examples of grab sampling devices. These devices are lowered into the sampling point on a cable, rope, string, chain, or tubing to the desired sampling depth and then retrieved for purge water discharge, sample transfer, or direct transport of the device to the laboratory for sample transfer and analysis.

The most commonly used grab samplers are bailers, which are available in both single check valve and dual check valve designs. The single check valve bailer is lowered to the sampling point, and water entering the bailer opens the check valve and fills the bailer. During retrieval, gravity and the weight of the water inside the bailer closes the check valve. There is some potential for the contents of the bailer to mix with the surrounding water column during retrieval. If mixing is not desirable, then a dual check valve bailer is advisable. Dual check valve bailers are intended to prevent mixing of the sample with the water column upon retrieval. Water passes through the dual check valve bailer as it is lowered. Upon retrieval, both check valves seat, retaining the aliquot of water inside the bailer. Groundwater investigators can minimize mixing by raising the bailer in a steady upward motion with no pausing or slight downward motion, which can occur if the retrieval is done manually.

The thief sampler, employs a mechanical, electrical, or pneumatic trigger to actuate plugs or valves at either end of an open tube to open and/or close the chamber after lowering it to the desired sampling depth, thus sampling from a discrete interval within the well.

The syringe sampler is divided into two chambers by a moveable piston or float. The upper chamber is attached to a flexible air line that extends to the ground surface. The lower chamber is the sample chamber. The device is lowered into the sampling point and activated by applying a suction to the upper chamber, thereby drawing the piston or float upward and allowing water to enter the lower chamber. In situations where the pressure exerted on the lower chamber by submergence is great enough to cause the piston or float to move upward prior to achieving the desired sampling depth, the upper chamber can be pressurized to prevent piston movement. The device is then activated by slowly releasing the pressure from the upper chamber, allowing water to fill the lower chamber.

Samples collected with grab samplers, especially various types of bailers, exhibit variable accuracy and precision in sample chemistry, often due to operator technique (Puls et al., 1992; Barcelona et al., 1984; Gillham et al., 1983; Pohlmann et al., 1991; Unwin and Maltby, 1988; Tai et al., 1991). Grab samplers can aerate and/or agitate a sample, causing sample oxidation, degassing, and stripping of VOCs from the sample. Care should be taken to avoid sample agitation during transfer of the sample from a grab sampler to the sample container. Pouring water from the top of a bailer either directly into the sample container or to a transfer vessel may agitate/aerate the sample and cause alteration of sample chemistry. These devices can also increase the turbidity of a sample through the surging action created in the well as the device moves through the water column. Grab samplers generally do not subject the sample to pressure changes, though some change may be imparted to a sample when using a syringe sampler activated with a suction. A potential for sample contamination exists due to exposure of the grab sampling device to the surface environment during repeated removal and reinsertion of the device during use. Also, the suspension cord or cable used with grab samplers could contribute contaminants to groundwater samples (Canova and Muthig, 1991).

## Suction-Lift Pumps

Surface centrifugal pumps and peristaltic pumps are two common suction-lift pumps. These pumps are usually placed at or above ground level during purging and sampling. They draw water to the surface by applying suction to an intake line through the use of impellers or rotors typically driven by an electric motor. Surface centrifugal pumps use impellers that are typically constructed of brass or mild steel, plastic, or synthetic rubber. A peristaltic pump consists of a rotor with rollers that squeeze flexible tubing as they revolve within a stator housing. This action generates a reduced pressure at one end of the tubing and an increased pressure at the other end. Several types of elastomeric material can be used for the tubing, although silicone rubber is the most common.

Suction-lift pumps may be unacceptable for some groundwater sampling applications. Exertion of a reduced pressure on the sample can cause volatilization or may result in degassing, which can cause changes in the pH, redox potential, and other gas-sensitive parameters (Barcelona et al., 1983; Ho, 1983; Barker and Dickhout, 1988). Peristaltic pumps may be satisfactory for some analytes that are not affected by changes in the sample that can be caused by application of reduced pressure when used under low-flow rate and low lift conditions (Barcelona et al., 1983; Puls and Powell, 1992; Backhus et al., 1993).

Because surface centrifugal pumps can cause cavitation, they are not appropriate for collection of samples to be analyzed for dissolved gases, VOCs, or gas-sensitive parameters such as trace metals. Because the pumped water contacts the pump mechanism, artifacts from sample contact with these materials should be considered when evaluating these pumps for sampling. In addition, these pumps can mix air from small leaks in the suction circuit into a sample, which can cause sample bias. These pumps are typically difficult to adequately decontaminate between uses. To avoid the limitations posed by the effects of pumping or undesirable pump materials, an intermediate vessel could be used on the suction side of the pump circuit.

Peristaltic pumps do not usually cause cavitation but, as in all suction-lift pumps, the exertion of a reduced pressure on the sample can bias the sample. The flexible tubing required for use in a peristaltic pump mechanism may also cause sample bias.[2]

## Centrifugal Submersible Pumps

A centrifugal submersible pump (CSP) consists of impellers housed within diffuser chambers that are attached to a sealed electric motor, which drives the impellers through a shaft and seal arrangement. Water enters the CSP by pressure of submergence, is pressurized by centrifugal force generated by the impellers, and discharged to the surface through tubing, hose, or pipe. A CSP is suspended in a well by its discharge line and/or a support line. Electric power is supplied to the motor through a braided or flat multiple-conductor insulated cable.

Flow rate and depth capability for all designs are wide ranging. For variable-speed CSPs, the discharge rate can be reduced by regulating the frequency of the electrical power supply and controlling the motor speed to reduce flow rate.

While there is no available peer-reviewed literature addressing the sampling effects of small-diameter variable-speed CSPs on dissolved gases or VOCs, one study found these pumps produced samples for some dissolved metals that were comparable to samples from bladder pumps (Pohlmann et al., 1994). With all CSPs, heat generated by the motor could increase sample temperature, which could result in loss of dissolved gases and VOCs from the sample.

CSPs are only available in diameters that will fit into sampling points 1.75 inches or larger in diameter. CSPs can be damaged when used in silty or sandy water, requiring repair or replacement of pump components and/or motor. If overheating occurs, there are three possible consequences. First, where the motor has internal water or oil in it for improved cooling characteristics, some of this liquid could be released into the sampling point, which could potentially contaminate the sampling point or samples. Because of this, motors that contain oil should not be used if the oil could interfere with the analytes of interest. Further, water used in motors should be of known chemistry. Second, when this type of motor eventually cools, it can draw in water from the sampling point, which could cause future cross-contamination problems. Proper decontamination of the pump should include changing internal cooling fluid if the pump is

---

[2] For example, the plasticizers in flexible PVC can contaminate samples with phthalate esters. The use of silicone rubber tubing, which contains no plasticizers, can obviate this problem; however, the potential for sample bias due to sorption/desorption exists with both materials (Barcelona et al., 1985). These pumps can be used with the intermediate vessel system described above, so that the sample contacts only the intake tubing and vessel, avoiding contact with the pump mechanism tubing. Alternatively, using silicone rubber tubing at the pump head only can minimize this problem (Ho, 1983; Barker and Dickhout, 1988).

to be used in non-dedicated applications. As an alternative, dry sealed motors can be used to avoid these potential problems. Third, extensive or long-term overheating problems may result in motor failure, usually requiring replacement of the motor. CSPs should not be allowed to operate dry, or damage may occur to the pump seals and/or motor. Some CSP designs may be difficult to disassemble in the field for cleaning or repair. For these pumps, if used portably, cleaning is usually performed by flushing the pump and discharge line and washing the exterior surfaces in accordance with ASTM D5088 (ASTM, 2001h).

### Gas-Drive Pumps

Gas-drive or gas-displacement pumps are distinguished from gas-lift pumps by the method of water transport. A gas displacement pump forces a discrete column of water to the surface via pressure-induced lift without the extensive mixing of drive gas and water produced by gas-lift devices. Hydrostatic pressure opens the inlet check valve and fills the pump chamber (fill cycle). The inlet check valve closes by gravity after the chamber is filled. Pressurized gas is applied to the chamber, displacing the water up the discharge line (discharge cycle). By releasing the pressure, the cycle can be repeated. A check valve in the discharge line maintains the water in the line above the pump. A pneumatic logic unit, or controller, is used to control the application and release of the drive gas pressure. The lift capability of a gas-displacement pump is directly related to the pressure of the drive gas used.

Although there is a limited interface in gas-displacement pumps between the drive gas and the water, the potential exists for loss of dissolved gases and VOCs across this interface (Barcelona et al., 1983; Gillham et al., 1983). This potential greatly increases if the pump is allowed to discharge completely, which would cause drive gas to be blown up the discharge line. Contamination of the sample may also result from impurities in the drive gas. Typical lifts for gas displacement pumps rarely exceed 250 feet using single-stage compressors; greater lifts can be achieved using two-stage compressors or compressed-gas cylinders. Gas-displacement pumps are available for sampling points as small as 1/2 inch in diameter.

### Bladder Pumps

Bladder pumps, also known as gas-operated squeeze pumps or diaphragm pumps, consist of a flexible membrane (bladder) enclosed by a rigid housing. Water enters the bladder under hydrostatic pressure through a check valve at the pump bottom. The inlet check valve closes by gravity after the bladder is filled. Compressed gas is applied to the annular space between the outside of the bladder and pump housing, which squeezes the bladder. This action forces the water out of the bladder and up the discharge line to the surface. By releasing the gas pressure, this cycle can be repeated; a check valve in the discharge line prevents discharged water from re-entering the bladder. In some bladder pump designs, the water and air chambers are reversed, with water entering the annular space between the pump housing and bladder; the bladder is then inflated to displace the water. A pneumatic logic controller controls the application and release of drive gas pressure to the pump. The lift capability of bladder pumps is directly related to the pressure of the drive gas source.

Bladder pumps provide representative samples under a wide range of field conditions. There is no contact between the drive gas and the water in a bladder pump, eliminating the potential for stripping of dissolved gasses and VOCs and the potential for sample contamination by the drive gas. Pressure gradients applied to the sample can be controlled by reducing the drive gas pressure applied to the bladder, thus minimizing disturbance to the sample chemistry. Bladder pumps are recommended for sampling all parameters under a wide variety of field conditions (Parker, 1994; Kearl et al., 1992; Puls et al., 1992; Barcelona et al., 1983; Pohlmann et al., 1991; Unwin and Maltby, 1988; Tai et al., 1991; Pohlmann et al., 1994).

Bladder pump designs are available for use in sampling points as small as 1/2 inch in diameter. Bladder pump flow rates are controlled by adjusting the drive gas pressure or the discharge and refill cycle timing. Where maximum flow rates are too low for purging, secondary purging pumps or packers can be used in conjunction with bladder sampling pumps in order to reduce purge time requirements.

## Dual-Acting Piston Pumps

Dual-acting piston pumps consist of a plunger or set of plungers (pistons) moving inside a stationary submerged barrel (cylinder). As the piston travels back and forth in the cylinder, it alternately draws water into the cylinder under suction, then displaces the water from the cylinder. In a dual-acting piston pump, water is simultaneously discharged and drawn in both directions of piston travel. A check valve in each discharge port or in the discharge line is used to prevent discharge water from re-entering the pump. The piston can be cycled manually, or through the use of a pneumatic or mechanical actuator.

Piston pumps can provide representative samples for some parameters (Barcelona et al., 1983; Knobel and Mann, 1993). Samples may be altered due to the suction produced during refill of the pump; this effect is reduced as the pump cycling rate is decreased. Likewise, reducing the pump cycling rate also reduces the pressure applied to the sample, minimizing the potential for sample alteration. If a flow restrictor or valve is used to reduce the discharge rate, the resultant pressure changes could alter sample chemistry (Barcelona et al., 1983; Gillham et al., 1983).

Currently available designs of dual-acting piston pumps will only fit in sampling points that are 2 inches in diameter or larger. The flow rate of a piston pump depends on the inside diameter of the pump cylinder and the stroke length and rate. The ability to control the minimum flow rate for sampling is dependent on the degree to which the stroke rate can be controlled.

## Helical Rotor Pumps

Helical rotor pumps, also referred to as progressing cavity pumps, utilize a down-hole rotor and stator assembly driven by an electric motor to displace water through a discharge line to ground surface. Rotation of the helical rotor causes the cavity between the rotor and stator to progress upward, thereby pushing water in a continuous flow upward through the discharge line. In some progressing cavity pumps, the discharge rate can be varied by adjusting the speed of the pump motor between 50 and 500 rpm. The progressing cavity pump is typically suspended in a well by its discharge line or by a suspension cable. A two-conductor electric cable supplies power from a 12-volt DC power supply and control box to the pump motor.

The operating principle of progressing cavity pumps makes them suitable for collection of samples to be analyzed for VOCs (Imbrigiotta et al., 1988). There is some evidence these pumps may not be suitable for sampling trace metals and other inorganic analytes at higher flow rates due to increased turbidity (Barcelona et al., 1983); to control turbidity, a variable speed pump controller should be used to reduce flow rate. The pressure applied to a sample is directly related to the motor speed, and can be controlled in designs using variable-speed motor controls. Overheating of the motor may raise the temperature of the sample (Parker, 1994).

Progressing cavity pumps require sampling point diameters of at least 2 inches. The relatively low discharge rates attainable with most progressing cavity pumps makes them most useful in applications where purging does not require removal of large volumes of water from monitoring wells. With variable flow rate progressing cavity pumps, once purging is complete the discharge rate may be reduced before samples are collected.

## Gear-Drive Pumps

Another type of positive displacement electric submersible pump is the gear-drive pump. In this type of pump, an electric motor drives a pair of PTFE gears. As these gears rotate, their advancing teeth draw water into the pump through the pump intake port and push it through the gears in a continuous flow up the discharge line. The discharge rate can be varied by using the pump controls to adjust the speed of the pump motor. As with many other submersible pumps, the gear-drive pump is usually suspended in a well by its discharge line. Electric power is supplied to the 24-volt DC motor through a cable from the power source and control box at ground surface.

Gear-drive pumps provide good recoveries of dissolved gases, VOCs, trace metals and other inorganics, and mobile colloids (Backhus et al., 1993; Imbrigiotta et al., 1988). However cavitation may occur if the pump is run at high rpm, which could affect dissolved gases or VOCs. The potential for cavitation can be reduced by controlling motor speed. The pressure applied by a gear-drive pump to a sample is directly related to the motor speed, and can be controlled by using the variable-speed motor controls. Gear-drive pumps are constructed of materials acceptable for sampling sensitive groundwater parameters; pump bodies are commonly constructed entirely of stainless steel materials while the gears are constructed of PTFE.

Gear-drive pumps require a sampling point diameter of at least 2 inches. Maximum discharge rates for gear-drive pumps range from more than 3 gallons per minute at lifts of less than 20 feet to 0.25 gallons per minute at lifts of 250 feet. Discharge rates are easily controlled by using the flow control, which adjusts the power supplied to run the pump motor; pump discharge can be adjusted to less than 50 ml/min.

## Inertial Lift Pumps

Inertial lift pumps consist of a discharge line (either flexible tubing or rigid pipe) with a ball-check foot valve attached to the lower end of this line. In operation, the pump is lowered into a water column and cycled through reciprocating motion, either through manual action or through the use of a reciprocating mechanical arm mechanism driven by an electric motor or internal combustion engine, to achieve discharge of water. As the pump is moved upward, water that has entered the pump under hydrostatic pressure is lifted upward, held in the pump by the seated foot valve. When the upward motion of the pump is stopped, the inertia of the water column inside the pump carries it up and out of the discharge line. As the pump is pushed downward, the foot valve opens, allowing the pump to refill, and the cycle is repeated to pump water from the sampling point.

Inertial lift pumps can be constructed of any flexible tubing material or rigid discharge pipe that has sufficient strength to tolerate the pump cycling. Typically, these materials include rigid and flexible PVC, PE, PP, and PTFE. Tubing diameters of ¼ inch or ⅜ inch can be used to collect samples from sampling points as small as ½ inch in diameter.

If inertial-lift pumps are cycled rapidly prior to or during sample collection, some loss of VOCs and/or dissolved gasses could occur in the discharge stream. Inertial lift pumps do not cause pressure changes in the sample. However, the cycling action of an inertial lift pump in a sampling point can significantly increase sample turbidity and agitate and aerate the water column within the sampling point. This can result in alteration of concentrations of a wide variety of analytes (including dissolved gases, VOCs, and trace metals) and interference with analytical determinations in the laboratory.

The flow rate of an inertial lift pump is directly related to the cycling rate of the pump. Flexing of the tubing in the sampling point can cause the flow rate to drop. To achieve discharge rates suitable for sample collection, it is necessary to insert a short length of small-diameter flexible tubing into the discharge line to divert a portion of the discharge stream into sample containers.

# Appendix C – Standard Operating Procedure – Soil Sampling

# memorandum

**To:** Sampling Team Members
**From:** Project Manager
**Date:** May 24, 2023
**Re:** Standard Operating Procedure – Soil Sampling for the AOC 15 and 16 Investigation

---

## 1.0 INTRODUCTION

Soil sampling related to site characterization and site clean-up is expected to involve source sampling of potentially impacted soils for characterization and profiling. Soil sampling is expected to occur around the Western Refining Southwest LLC (D/B/A Marathon Gallup Refinery) (Refinery) Area of Concern (AOC) 15 – New American Petroleum Institute Separator (NAPIS) and AOC 16 – NAPIS Overflow Tanks.

All personnel involved in soil sampling projects are required to review this Standard Operating Procedure (SOP) before sampling to ensure the continued generation of reliable data. This SOP is based on experience gained from collecting soil samples and the latest information available in guidance manuals. This SOP may be updated as additional experience and information are acquired.

## 2.0 PRE-FIELD ACTIVITIES

Several activities will be conducted prior to departure for the project site. A project team will be assigned, and the members will begin coordinating the sample collection event with the Refinery. Field equipment will be checked and organized. Access to the areas to be sampled will be checked, and provisions made to pack the necessary equipment for delivery to the project site.

## 3.0 PREPARATION

The Project Manager will review the current sampling and analysis plans and work plans to determine if any documents need to be brought to the site during monitoring. The Project Manager will also evaluate whether any changes have been made in the sampling and analytical procedures and notify the appropriate personnel.

All field screening equipment will be inspected prior to departure, ensuring that it is in proper working order. For soil sampling, the only field monitoring equipment used will be a photoionization detector (PID) and it should be calibrated and operated and according to manufacturer's recommendations.

The PID should be checked to ensure that the PID has the appropriate lamp strength for the investigation. The most common lamp used in a PID is a 10.6 electron volt (eV) lamp, which will ionize compounds with ionization potentials from 8.0 eV to 10.6 eV. The range of 8.0 eV to 10.6 eV is representative of gasoline- and diesel-type constituents. For example, benzene, naphthalene, and toluene have ionization potentials of 9.25 eV, 8.13 eV, and 8.82 eV, respectively (see link below). A list of ionization potentials for a variety of compounds has been published by RAE systems, the manufacturer of the PID most used by Trihydro. The list can be found at the following link: https://gastech.com/sites/default/files/RAE%20Systems%20Technical%20Note%20106%20v14%20Correction%20Factors.pdf

## 4.0 EQUIPMENT

The following equipment is recommended for soil sampling:

- Required personal protective equipment (PPE), listed in the site-specific health and safety plan (HASP)
- Soil sampling devices (i.e., hand auger, hand shovel, Geoprobe direct push drill rig core sleeves, etc.)
- Sampling beaker, bottles, labels, and preservatives
- Gloves
- Chain-of-custody/sample-analysis-request forms
- PID
- Global Positioning System (GPS) unit
- Opaque Cooler(s) and bagged ice or frozen Blue Ice
- Detergent or solvent for cleaning monitoring equipment
- Brushes dedicated for decontamination
- Decontamination containers dedicated for wash, rinse 1, and rinse 2
- Paper towels
- Trash bags
- Field logbook

## 5.0 SAMPLE COLLECTION

A critical aspect of any sampling program is selection and implementation of an appropriate sampling technique. Selection of equipment and technique should be appropriate for the volume of material required and the type of analysis to be performed. In general, the sampling equipment and technique will be chosen to minimize, to the extent possible, the amount of handling a sample will undergo prior to analysis. In many cases, the material to be sampled will be easy to access, and simple "grab" samples collected using a shovel, trowel, or drive sampler are appropriate. In other cases, such as underwater or heavily saturated samples, the soils may be difficult to access, and sampling will involve the use of specialized soil sampling equipment. Specific analytical requirements and sampling frequencies are specified in the work plan.

Soil samples located in dry areas will be collected from representative locations using a Geoprobe direct push drill rig with split spoons and acetate liners.

If necessary, several cores may be collected from each location to provide adequate sample volume for the laboratory. If necessary, additional cores will be collected from within 6 lateral inches of the original boring, and additional sample volume will be collected from the same depth interval as the original boring. It should be noted that samples collected in this manner will not be collected as composite samples. The sample containers will be labeled with indelible ink. Filled sample containers should be wiped dry and placed in a cooler with ice (or equivalent) for storage at the time of collection. Enough ice and protective packing material should be used to cool the samples to 4 degrees Celsius and ensure that the container remains intact prior to final packing and shipment.

Field screening may involve the use of a PID. In this case, the sample will be split into two aliquots. Aliquot #1 will be placed into a plastic bag and used for PID screening. Aliquot #2 will be placed into appropriate sample containers with appropriate preservatives (e.g., methyl chloride), sealed, placed in a cooler, and stored on ice for potential laboratory analysis. Aliquot #1 materials will not be submitted for laboratory analysis.

The bag containing Aliquot #1 will be sealed and shaken gently to expose the soil to the air trapped in the container. The sealed container will be allowed to rest while vapors equilibrate. Vapors present within the sample bag's headspace will be measured by inserting the probe of the instrument in a small opening in the bag. The maximum value and the ambient air temperature will be recorded on the field boring log for each interval. Note that if samples are cold (i.e., below 32 degrees Fahrenheit) they will be sealed in airtight bags and warmed in a heated building and/or vehicle before screening. All samples shall be screened at as close to the same temperature as possible to obtain consistent results.

After collecting the reading, aliquot #2 sample containers will be labeled and placed in a cooler. Before shipment, each cooler will be packed with ice and a laboratory-provided trip blank. A chain of custody form will accompany each sample shipment. Coolers will be sealed and delivered to an accredited laboratory.

Sampling devices will be decontaminated between sampling locations using a four-stage decontamination system consisting of a two detergent/water washes and two deionized water rinses. The Geoprobe direct push drill rig will be decontaminated between sampling locations; the drill rig will not be decontaminated between sampling intervals at the same location due to the acetate liners. Sample locations will be recorded with a GPS unit to accurately map the sampling locations.

Field logbooks, Soil Sampling Field Log, and photograph logs will provide a written record of field data gathered, field observations, field equipment calibrations, the samples collected for analysis, and sample custody. Color photographs will be used to substantiate and augment the field notes, if necessary. Field records will be maintained in the project file.

697-097-001

# Appendix D – Example Boring Log

Trihydro
CORPORATION

# Lithology Log

Sheet ___ of ___

| | | | |
|---|---|---|---|
| LOCID | | | |
| Project Name | Project Number | Site ID | |
| Drilling Company | Driller | Ground Elevation | Total Drilled Depth |
| Drilling Equipment | Drilling Method | Borehole Diameter | Date/Time Drilling Started |
| Date/Time Total Depth Reached | | | |
| Type of Sampling Device | Water Level (bgs)<br>First<br>Final | | |
| Sample Hammer<br>Type<br>Driving Wt.<br>Drop | Geologist/Engineer | Checked by/Date | |
| Weather | Other Personnel Present | | |
| Site Conditions | | | |
| Location Description (include sketch in field logbook) | | | |

| Depth | Interval | Recovery | Blow Counts | Description<br>(Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable) | ASTM Code | Lithology | Water Content | Estimate % of | | | Remarks<br>(Include all sample types, times, and depth, odor, organic vapor measurements, etc.) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Gr | Sa | Fi | |
| | | | | | | | | | | | |

Trihydro
CORPORATION

## Lithology Log (continued)

Sheet ___ of ___

LOCID

| Depth | Interval | Recovery | Blow Counts | Description<br>(Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable) | ASTM Code | Lithology | Water Content | Estimate % of |  |  | Remarks<br>(Include all sample types & depth, odor, organic vapor measurements, etc.) |
|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  |  | Gr | Sa | Fi |  |
|  |  |  |  |  |  |  |  |  |  |  |  |

# ATTACHMENT C

(PLEASE SEE ATTACHED CD)

RED-LINE/STRIKE-OUT REPORT

# Area of Concern 15 – New API Separator and Area of Concern 16 – New API Separator Overflow Tanks Investigation Revised Work Plan

---

## Western Refining Southwest LLC

## (D/B/A Marathon Gallup Refinery)

## Gallup, New Mexico

*EPA ID# NMD000333211*

February 2, 2024

~~May 2023~~

# Executive Summary

Western Refining Southwest LLC, D/B/A Marathon Gallup Refinery (Refinery) is submitting this work plan for investigation of soil at Area of Concern (AOC) 15 – New American Petroleum Institute (API) Separator (NAPIS) and soil and groundwater at AOC 16 – NAPIS Overflow Tanks. The New Mexico Environment Department (NMED) requested further investigation into the AOC 15 area in Comment 13 of the NMED "Response to Approval with Modifications, Annual Groundwater Monitoring Report Gallup Refinery – 2019" letter dated September 28, 2021 (NMED 2021a), and into the AOC 16 area in the "AOC 16 (New API Separator Overflow Tanks)" paragraph of the NMED "Determination of Area of Concern (AOC) Entry to the Permit" letter dated August 19, 2021 (NMED 2021b). The AOC 15 investigation will include soil sampling around the NAPIS to investigate impacts from historical releases as well as bromide tracer testing, in a phased approach, ~~the NAPIS East and~~ the West Bay~~s~~ to investigate and ensure no leaks are occurring from the secondary NAPIS containment. The AOC 16 investigation will include soil and groundwater sampling in the areas where the former NAPIS overflow tanks had historical releases.

The Refinery will prepare an investigation report summarizing the sampling results and investigation conclusions within 120 days of the receipt of the analytical data.

# Table of Contents

## List of Figures

## List of Appendices

## List of Acronyms

| | |
|---|---|
| % | percent |
| amsl | above mean sea level |
| AOC | Area of Concern |
| API | American Petroleum Institute |
| bgs | below ground surface |
| BTEX | benzene, toluene, ethylbenzene, and total xylenes |
| COC | chain of custody |
| DGF | dissolved gas floatation |
| DPT | direct push technology |
| DRO | diesel range organics |
| ft | foot or feet |
| GRO | gasoline range organics |
| I-40 | Interstate 40 |
| LDU | Leak Detection Units |
| mg/L | milligrams per ~~l~~Liter |
| MRO | motor oil range organics |
| MTBE | methyl tert-butyl ether |
| NAPIS | New American Petroleum Institute Separator |
| NMED | New Mexico Environment Department |
| PID | photoionization detector |
| ~~ppb~~ | ~~parts per billion~~ |
| PVC | polyvinyl chloride |
| QA/QC | quality assurance/quality control |
| Refinery | Western Refining Southwest LLC, D/B/A Marathon Gallup Refinery |
| RCRA | Resource Conservation and Recovery Act |
| SPH | separate phase hydrocarbon |
| SSL | Soil Screening Level |
| SVOC | semivolatile organic compound |
| TPH | total petroleum hydrocarbons |
| VOC | volatile organic compound~~s~~ |

| | |
|---|---|
| WQCC | Water Quality Control Commission |

# 1.0 Introduction

The Western Refining Southwest LLC, D/B/A Marathon Gallup Refinery (Refinery), is located approximately 17 miles east of Gallup, New Mexico along the north side of Interstate ~~Highway I-~~40 (I-40) (Figure 1). The physical address is I-40, Exit #39 Jamestown, New Mexico 87347. The Refinery property covers approximately 810 acres. The Refinery has been indefinitely idled since August 2020.

This work plan outlines the details of the proposed investigation at Area of Concern (AOC) 15 – New American Petroleum Institute (API) Separator (NAPIS) and AOC 16 – NAPIS Overflow Tanks (Figure 2). The New Mexico Environment Department (NMED) requested development of this investigation work plan in two regulatory communications as described below.

On July 31, 2021, the “NAPIS Inspection Report” was submitted to NMED as Attachment 3 to the “Response to Approval with Modifications, Annual Groundwater Monitoring Report Gallup Refinery – 2019” letter (Western 2021). The NAPIS inspection was completed in July 2021, and the findings suggested that the NAPIS primary containment may be leaking to the secondary containment but that the secondary containment was not leaking. In Comment 13 of the “Response to Approval with Modifications, Annual Groundwater Monitoring Report Gallup Refinery – 2019” letter dated September 28, 2021 (RTAwM – 2019 Annual Groundwater Report) (NMED 2021a), NMED stated that “the primary containment wall of the East and West Bays have been leaking” based upon the presence of fluids in the Leak Detection Units (LDUs) (NMED 2021a). As such, NMED requested this work plan to investigate the integrity of the secondary containment walls of the East and West NAPIS Bays.

The East Bay of the NAPIS was removed from service and all liquids pumped out on May 12, 2021, and no liquids were observed as documented during weekly inspections. Any water observed in the East Bay is the result of accumulated precipitation. Observation of the East Bay on October 12, 2022, confirmed the presence of liquid in the bay that resulted from the accumulation of precipitation over several weeks. One reasonable explanation for the observed higher recharge rate into the West LDU from the West Bay is that the West Bay was operational (full) during the observation period. As a result, the higher water head in the West Bay would drive more fluid into the interstitial space of the West Bay, which is connected to the West LDU. In contrast, the East Bay, was empty, and any recharge was limited to drainage of the interstitial space. This assumes other variables being equal.

Additionally, this work plan includes soil sampling to determine if there are impacts to soil in the area around the NAPIS (AOC 15) from fluid releases prior to 2010. There are three groundwater monitoring wells downgradient of the NAPIS, which are sampled quarterly; therefore, no additional monitoring well installation is planned, and no additional groundwater sample collection is proposed for AOC 15.

With respect to AOC 16 (NAPIS Overflow Tanks), NMED requested an assessment to determine if corrective action is needed in the “AOC 16 (NAPIS Overflow Tanks)” paragraph of the “Determination of Area of Concern (AOC) Entry to the Permit” letter dated August 19, 2021 (NMED 2021b). Prior to NAPIS overflow being routed to Tank 35 in 2010, five 20,000-gallon Baker frac tanks were used as NAPIS overflow tanks. During storm events in 2007, 2009, and 2010, both the NAPIS (AOC 15) and the NAPIS overflow tanks (AOC 16) had fluid releases to the surrounding soils. The AOC 16 overflow tanks were removed from service in 2010 and the dissolved gas flotation (DGF) tank ~~(DGF)~~ was installed in 2012 in the AOC 16 area (Figure 3).

Sampling and excavation of the impacted soils in AOC 16 occurred after two releases in 2009, but there is no documentation of cleanup after two additional releases in 2010. NMED "Disapproval Assessment Report for AOC 16-API Overflow Area" letter, dated April 23, 2019, Comment 4 indicates "additional assessment and possibly corrective action may be necessary for AOC 16" (NMED 2019).

In summary, this work plan proposes to combine the requested investigations at AOC 15 and AOC 16, in order to:

1. Evaluate the integrity of the NAPIS West Bay secondary containment, and
2. Assess possible impacts to the soils of AOC 15, and
3. Assess possible impacts to the soils and groundwater of AOC 16.

The investigation results will be used to discern if there are potential impacts remaining from previous releases and determine if additional remediation is required.

## 2.0 Site Conditions

The Refinery has been indefinitely idled since August 2020. Historically, the Refinery processed crude oil transported to the facility by pipeline or tanker truck. During active operation, various process units were operated at the Refinery, including alkylation, blending gas, crude distillation, diesel hydro-treating, fluid catalytic cracker, gas conditioning, isomerization, naphtha hydro-treating, reformer, saturated gas, sulfur recovery, ammonium thiosulfate and merox treater units. Past refinery operations have produced gasoline, diesel fuels, jet fuels, kerosene, propane, butane, and residual fuel.

The NAPIS West Bay has been used to process only remediation and stormwater fluids since the idling of the Refinery in August 2020. The NAPIS East Bay was taken out of service when the Refinery idled, due to the reduction in process fluids which eliminated the need for redundant bays.

### 2.1 Surface Conditions

Local site topographic features include high ground in the southeast gradually decreasing to a lowland fluvial plain to the northwest. Elevations on the refinery property range from 6,860 feet (ft) above mean sea level (amsl) to 7,040 ft amsl. The AOC 15 and AOC 16 areas are approximately 6918 ft amsl.

### 2.2 Subsurface Conditions

The shallow subsurface soil (alluvium) is comprised of clay and silt with some inter-bedded sand layers. Beneath the alluvium is the Petrified Forest Member of the Chinle Group, which primarily consists of interbedded mudstone, siltstone, and sandstone. The depth of the Alluvium/Chinle interface ranges from 15 ft below ground surface (bgs) to over 32 ft bgs.

## 3.0 Scope of Activities

The investigative activities proposed herein will help evaluate the potential for impacts, and if confirmed, the extent of impacted soils and groundwater from the NAPIS system. Additionally, the investigation will assess the integrity of the NAPIS West Bay secondary containment. Pending NMED approval, the Refinery anticipates the investigation work to be completed during ~~2023~~2024.

### 3.1 AOC 15 – NAPIS

Six soil samples will be collected to determine the possible extent of impacts to the area caused by releases prior to 2010. The soil borings will be installed using a decontaminated hand auger to a depth of 5 ft bgs. Samples will be collected using a Terracore sampling device (or equivalent Method 5035A device) at 0-1 ft bgs (surface), the interval with the highest photoionization detector (PID) reading, and 5 ft bgs. While performing field screening, if evidence (e.g., visual, olfactory, PID reading) of hydrocarbons is observed at the termination depth above the water table, the borings will be extended to the depth where the contamination is no longer detected, or alternately, at a minimum of five ft below the water table. Soil samples must then be collected from the extended termination depth to delineate the vertical extent of contamination. Proposed soil sample locations are shown as yellow triangles and pink squares on Figure 4.

Soils will be field screened using a~~-~~ PID at each sample interval. Soil samples will be analyzed by an accredited laboratory for methyl tert-butyl ether (MTBE) and benzene, toluene, ethylbenzene, and total xylenes (BTEX) by Method 8260; total petroleum hydrocarbons (TPH)- gasoline range organics (GRO), TPH-diesel range organics (DRO), and TPH-motor oil range organics (MRO) by Method 8015; and Resource Conservation and Recovery Act (RCRA) 8 metals by Method 6010. These constituents were selected as indicators of impacts from NAPIS releases. Analytical results will be compared to their respective NMED Residential, Industrial, and Construction Worker Soil Screening Levels (SSLs) (NMED 2021c).

A preliminary soil investigation took place in February 2023 to evaluate the presence of separate phase hydrocarbons (SPH) in the soil within the NAPIS area and evaluate its fluorescing properties. It was determined that the application of dye tracer would not be feasible around the NAPIS due to the soil fluorescing under black light. Because of this, it is proposed to complete the investigation using bromide tracer testing as a method of leak detection.

This work plan will be completed in two Phases. The first phase will include sampling groundwater in the area to establish background levels of naturally occurring bromide. The second phase will include bromide tracer testing by adding a solution of sodium bromide to the NAPIS West Bay~~s~~ and monitor the surrounding area for the increased presence of bromide. More details regarding the two phases are presented below.

## Phase 1

To ensure that bromide tracer testing is feasible, ~~five~~ four baseline samples will be taken from the area within the NAPIS. Three groundwater samples will be taken from existing monitoring wells within the NAPIS area (one will be taken from an up gradient well NAPIS-1, two samples will be taken from down gradient wells NAPIS-2, KA-3). The remaining ~~two~~ sample~~s~~ will be taken from onsite water sources (~~one will be taken from NAPIS West Bay, and~~ one sample of the onsite well water that will be used to fill NAPIS ~~East~~ West Bay). NMED will be contacted when the results of the baseline sampling are received regardless of the results.

## Phase 2

This phase is proposed to address NMED's concern that the persistence of fluid in the East and West LDUs may indicate ongoing leaking from the NAPIS secondary containment. As such, the integrity of the NAPIS secondary containment will be examined. Bromide tracer testing will be conducted in ~~each of the~~West NAPIS Bays using a solution of bromide with a concentration of ~~10~~ 1,000 milligrams per L~~l~~iter (mg/L) and monitoring the areas surrounding the unit for the increased presence of bromide. Bromide tracer testing is a method of leak detection conducted by adding sodium bromide to a fluid containment unit (e.g., pipe, well, tank, etc.). The bromide tracer is detectable at 0.05 mg/L. The bromide tracer test will be conducted as follows:

1. Up to five 2-inch polyvinyl chloride (PVC) temporary bromide monitoring wells may be installed along the west wall of the NAPIS (Figure 4). These locations may be adjusted slightly to the west to maximize the potential for intercepting bromide.
    a. There will be two temporary wells installed using an air-knife rig or a hand auger to a depth of 2 ft below groundwater (if groundwater is encountered) or 1 ft below the bottom of the NAPIS, with sand pack and PVC well screen installed to 2 ft bgs. There will also be three shallow vadose wells installed above the groundwater to expedite the time for detection of the bromide (Figure 4).
    b. Two of the three shallow vadose wells will be nested within the deeper groundwater wells. ~~Two of the three shallow vadose wells will be installed in the same boring as the groundwater wells.~~ The NAPIS varies in depth, as shown in Appendix A. Therefore, the northern temporary shallow vadose well will be installed to approximately 6 ft bgs and the southern temporary shallow vadose well will be installed to approximately 11 ft bgs if groundwater is not encountered. One of shallow wells will be installed in a boring of its own, to approximately 6 ft bgs.
2. ~~536~~ 53,500 grams of sodium bromide will be added to 11,000 gallons of water in the ~~active~~ West NAPIS Bay and dissolved into solution, to achieve a concentration of ~~10~~ 1,000 mg/L of bromide, as shown in Appendix A. The bromide solution will be left in the West NAPIS bay for minimum 1.5 days.

a. A sampling schedule for groundwater and LDUs will be conducted as follows, bi-weekly for the first month, then monthly for the next six months, and then quarterly for three and a half years, for a total of up to four years and one month or until bromide is detected, whichever occurs first. Please note that prior to the application of the bromide solution, t~~T~~he LDUs will be purged dry to prevent any interference of detection from existing head pressure.~~A sampling schedule will be conducted as follows, bi-weekly for the first month, then monthly for the next six months, then quarterly for a year. Sampling will continue until bromide is detected or three years, whichever occurs first. Observations will be recorded in a logbook and groundwater samples will be submitted to a laboratory for analysis~~.

b. Groundwater will be analyzed using Method 300.0. This method can achieve a method detection limit of 0.05 mg/L.

~~3. After the first bi-weekly sampling, the inactive East NAPIS Bay will be filled with water and the same amount of sodium bromide will be added to the East Bay to achieve a concentration of 10 mg/L of bromide.~~

~~a.~~c. Observation of the fluid in the LDUs and temporary bromide monitoring wells will be conducted per the schedule listed in step 2a above and recorded in the logbook.

In addition to the bromide tracer tests, NAPIS influent samples will be collected for laboratory analyses. This sampling will include a) fluid samples collected prior to entering the West NAPIS Bay~~s~~ and b) fluid samples collected from the water within the West Bay~~s~~. These samples will be analyzed for total and dissolved metals for two consecutive monitoring events.

## 3.2 AOC 16 – NAPIS Overflow Tanks

AOC 16 consists of an approximately 80 ft by 190 ft area where five temporary Baker frac tanks were used as NAPIS overflow tanks between 2007 and 2010. The frac tanks were installed approximately in 2007 and removed in 2010, when the NAPIS was connected to Tank 35. The former location of the overflow frac tanks is shown on Figure 3. The DGF tank was installed in 2012 in a portion of AOC 16 (Figure 4).

Investigation into surface and subsurface soils and groundwater will be conducted using a Geoprobe direct push technology (DPT) rig to install 16 borings. Three soil samples will be collected per boring at:

1. The surface (0-1 ft bgs).
2. The interval with the highest PID reading.
3. Above the water table, or at the bottom of the boring (10 ft bgs) if groundwater is not encountered.
4. While performing field screening, if evidence (e.g., visual, olfactory, PID reading) of hydrocarbons is observed at the termination depth above the water table, the borings will be extended to the depth where the contamination is no longer detected, or alternately, at a

minimum of five ft below the water table. Soil samples will then be collected from the extended termination depth in order to delineate the vertical extent of contamination.

Some of the proposed sample locations are not accessible by the drill rig. In particular, the proposed sample locations represented by the two southern green triangles on Figure 4 are not accessible by the drill rig and samples will therefore be collected with a hand auger at the surface (0-1 ft bgs) and at 5 ft bgs. Samples will be collected using a Terracore sampling device (or equivalent Method 5035A device). Soil from each sample interval will be screened using a PID. Additionally, groundwater samples will be collected using the DPT rig and Hydropunch methods (Appendix B) from borings downgradient of historical overflow tanks; proposed locations are shown as blue squares on Figure 4. Soil and groundwater samples will be analyzed by an accredited laboratory for MTBE and BTEX by Method 8260; TPH-GRO, TPH-DRO, and TPH-MRO by Method 8015; and RCRA 8 metals by Method 6010.

## 4.0 Investigation Methods

Soils obtained will be visually inspected and classified in general accordance with American Society for Testing and Materials D2487 (Unified Soil Classification System) and D2488 (Description and Identification of Soils). Detailed boring logs will be compiled in the field by qualified staff. Samples will be field screened using a PID for evidence of volatile organic compounds (VOCs). PID results will be recorded on the boring logs. Groundwater samples will be field screened for temperature, pH, salinity, conductivity, total dissolved solids, dissolved oxygen, and oxygen reduction potential using a YSI field parameter probe. Field parameters will be collected before and after fluid sample collection and recorded on the boring logs.

### 4.1 Sample Collection Procedures

Soil samples will be collected in accordance with the “Standard Operating Procedure – Soil Sampling” (Appendix C). Groundwater samples will be collected using Hydropunch methods as described in “Groundwater Sampling and Monitoring with Direct Push Technologies” (Appendix B). Details related to sample collection will be documented on the boring log field forms (Appendix D). General observations recorded on the field forms for each soil sample location will include sampling start and end times, weather, site conditions, sampling team members, and other personnel present. Sample-specific information will include field sample identification, time of sample collection, sample start and end depth, collection method, sample type (i.e., composite or aliquot), soil classification and characteristics, any deviations from or clarification of sampling procedures, and other observations. All reusable sampling equipment will be decontaminated prior to installing a boring and collecting a new sample. All equipment will be decontaminated with Liquinox® ~~Simple Green™~~ (or equivalent) using a four-stage decontamination system consisting of a two detergent/water washes and two deionized water rinses and recorded in the field logbook.

Soil samples will be collected from representative locations using a Geoprobe direct push drill rig with split spoons and acetate liners. If necessary, several cores may be collected from each location to provide adequate sample volume for the laboratory. If necessary, additional cores will be collected from within 6 lateral inches of the original boring, and additional sample volume will be collected from the same depth interval as the original boring. It should be noted that samples collected in this manner will not be collected as composite samples. The Geoprobe direct push drill rig will be decontaminated between sampling locations; the drill rig will not be decontaminated between sampling intervals at the same location due to the acetate liners.

PID readings will be collected at sample intervals (beginning with a surface sample) and analytical samples will be collected at the intervals proposed in Sections 3.1 and 3.2 for AOC 15 and AOC 16, respectively and split into two aliquots. Aliquot #1 will be placed into a plastic bag and used for PID screening. Aliquot #2 will be placed into appropriate sample containers with appropriate preservatives (e.g., methyl chloride), sealed, placed in a cooler, and stored on ice for potential VOC laboratory analysis. Aliquot #1 materials will not be submitted for laboratory analysis.

Aliquot #1 will be shaken gently to expose the soil to the air trapped in the container. Aliquot #1 will be allowed to rest while vapors equilibrate. Vapors present within the sample bag's headspace will be measured by inserting the probe of the PID in Aliquot #1's container (plastic bag). The maximum value and the ambient air temperature will be recorded on the field boring log for each interval. Note that if samples are cold (i.e., below 32 degrees Fahrenheit), they will be sealed in airtight bags and warmed in a heated building and/or vehicle before screening.

After collecting the PID reading, the selected sample depths corresponding to Aliquot #2 will be labeled and placed in the laboratory cooler. Before shipment, each cooler will be packed with ice and a laboratory-provided trip blank. A chain of custody (COC) form will accompany each sample shipment. Coolers will be sealed and delivered to an accredited laboratory.

## 4.2 AOC 15 Investigation

A summary of the proposed sampling activities is provided below.

## Part 1:

1. Installation of six soil borings via hand auger, visual screening/logging, and collection of soil samples. Samples will be collected from:
    a. The surface (0-1 ft bgs)
    b. The interval with the highest PID reading
    c. 5 ft bgs
    d. While performing field screening, if evidence (e.g., visual, olfactory, PID reading) of hydrocarbons is observed at the termination depth above the water table, the borings will be extended to the depth where the contamination is no longer detected, or alternately, at a minimum of five ft below the water table. Soil samples must then be collected from the extended termination depth in order to delineate the vertical extent of contamination.
2. Collection of PID readings at the surface and at each sample interval.
3. Submit samples to an accredited laboratory. Samples will be analyzed for:
    a. MTBE and BTEX by Method 8260
    b. TPH-GRO, TPH-DRO, and TPH-MRO by Method 8015
    c. RCRA 8 metals by Method 6010
    d. VOCs and semivolatile organic compounds (SVOCs) that have exceeded the applicable NMED standard in monitoring wells NAPIS-1, NAPIS-2, NAPIS-3, and KA-3 within the past five years as identified in the Annual Groundwater Monitoring Report by Methods 8260 and 8270, respectively.

4. Analytical results will be compared to their respective NMED Residential, Industrial, and Construction Worker SSLs (NMED 2021c). Metals results are compared to the 2022 NMED Soil Leachate-SSLs with a DAF of 20.

## Part 2:

1. Installation of three temporary shallow vadose wells and two temporary bromide monitoring wells along the west side of the NAPIS to 2 ft or 1 ft below NAPIS containment (if groundwater is not encountered).
2. Add the sodium bromide solution to the West NAPIS Bay.
    a. Sampling for bromide in the temporary monitoring wells located 5 ft of the west NAPIS wall, permanent monitoring wells (NAPIS-2, NAPIS-3, and KA-3) located 15 ft of the west NAPIS wall, and LDUs for the presence of bromide will be completed as follows: bi-weekly for the first month, then monthly for the next six months, and then quarterly for three and a half years, for a total of up to four years and one month or until bromide is detected, whichever occurs first. ~~Sampling will continue until bromide is detected or three years, whichever occurs first~~. Log observations in a field notebook.

~~3. Following the initial month of monitoring for the West NAPIS Bay, fill the East NAPIS Bay with water from the water source sampled in Part 1 and add the sodium bromide solution.~~

~~a. Observation of the fluid in the LDUs and temporary bromide monitoring wells will be conducted per the schedule listed in step 2a above and recorded in the logbook.~~

## 4.3 AOC 16 Investigation

A summary of the proposed sampling activities is provided below:

1. Installation of 16 soil borings via Geoprobe DPT drill rig, visual screening/logging, and collection of soil samples. Samples will be collected from:
    a. the surface (0-1 ft bgs)
    b. the interval with the highest PID reading
    c. above the water table, or at the bottom of the boring (10 ft bgs) if groundwater is not encountered.
    d. While performing field screening, if evidence (e.g., visual, olfactory, PID reading) of hydrocarbons is observed at the termination depth above the water table, the borings will be extended to the depth where the contamination is no longer detected, or alternately, at a minimum of five ft below the water table. Soil samples must then be collected from the extended termination depth in order to delineate the vertical extent of contamination.
2. If a sample location is not accessible by DPT drill rig, samples will be collected via hand auger and Terracore sampling device (or equivalent) from:

   a. 0 – 1 ft bgs (surface sample)
   b. 5 ft bgs (or where there is evidence of impacts)
3. Collection of PID readings at each sample interval.
4. Collections of six Hydropunch groundwater samples from boring locations downgradient of the former location of the NAPIS overflow tanks.
5. Submit samples to an accredited laboratory. Soil and groundwater samples will be analyzed for:
   a. MTBE and BTEX by Method 8260
   b. TPH-GRO, TPH-DRO, and TPH-MRO by Method 8015
   c. RCRA 8 metals by Method 6010
   d. VOCs and SVOCs that have exceeded the applicable NMED standard in monitoring wells NAPIS-1, NAPIS-2, NAPIS-3, and KA-3 within the past five years as identified in the Annual Groundwater Monitoring Report by Methods 8260 and 8270, respectively.
6. Analytical results will be compared to their respective NMED Residential, Industrial, and Construction Worker SSLs (NMED 2021c).
7. Compare analytical groundwater data with applicable NMED Water Quality Control Commission (WQCC) groundwater quality standards (NMED 2018).

## 4.4 Data Quality and Validation

Quality assurance/quality control (QA/QC) samples will be collected during sampling to monitor the validity of the sample collection procedures. Field duplicates will be collected at a rate of 10 percent (%), at a minimum of one per day. Equipment blanks will be collected from re-usable equipment at a rate of 10% at a minimum of one per day. One field blank per day will be collected when groundwater samples are collected. One trip blank per cooler will accompany the samples to the laboratory. The field duplicates, equipment blank samples, field blanks, and trip blanks will be submitted to the laboratory along with the samples. QA/QC samples will be recorded on the field forms and the COCs. All data will undergo Tier II data validation.

## 4.5 Data Evaluation and Waste Management

The analytical results will be compared to applicable NMED Residential, Industrial, and Construction Worker SSLs (NMED 2021c) and applicable NMED WQCC groundwater quality standards (NMED 2018). The results will be submitted to NMED in a subsequent investigation report. If impacted soils are recovered during sampling, they~~it~~ will be placed in drums, labeled, and stored on the 90-Day Pad. Soils without elevated PID readings will be placed back in the borehole. Waste characterization will be conducted prior to disposal. Waste characterization analysis will include testing for VOCs by Method 8260, ~~semi-volatile organic compounds~~SVOCs by Method 8270, and RCRA 8 Metals by Method

6010.  Any wastes determined to be hazardous will be disposed at a landfill regulated under RCRA subtitle C.

## 5.0 Schedule

Pending NMED approval, the Refinery anticipates the investigation to be completed during 2024~~3~~. Once the investigation has been completed, the Refinery will prepare an investigation report summarizing the sampling results and investigation conclusions. The investigation report will be submitted to NMED within 120 days of the receipt of the analytical data.

## 6.0 References

New Mexico Environment Department (NMED). 2018. Water Quality Control Commission, New Mexico Administrative Code Title 20, Part 6, Chapter 2. December 21.

NMED. 2019. Disapproval Assessment Report for AOC 16 – API Overflow Area, Marathon Petroleum Company LP, Gallup Refinery (Formerly Western Refining Southwest Inc.), EPA ID#NMD000333211, HWB-WRG-19-001. April 23.

NMED. 2021a. Response to Approval with Modifications, Annual Groundwater Monitoring Report Gallup Refinery – 2019, Western Refining Southwest Inc., Gallup Refinery, McKinley County, Gallup, New Mexico, EPA ID#NMD000333211, HWB-WRG-20-013. September 28.

NMED. 2021b. Determination of Area of Concern (AOC) Entry to the Permit, Western Refining Southwest Inc., Gallup Refinery, EPA ID #NMD000333211, HWB-WRG-MISC. August 19.

NMED. 2021c. Risk Assessment Guidance for Site Investigations and Remediation, Volume I Soil Screening Guidance for Human Health Risk Assessments. November.

Western Refining Southwest, LLC. 2021. Response to Approval with Modifications Annual Groundwater Monitoring Report Gallup Refinery – 2019, Western Refining Inc., Marathon Gallup Refinery, EPA ID #NMD000333211, HWB-WRG-20-013. July 31.

# Figures

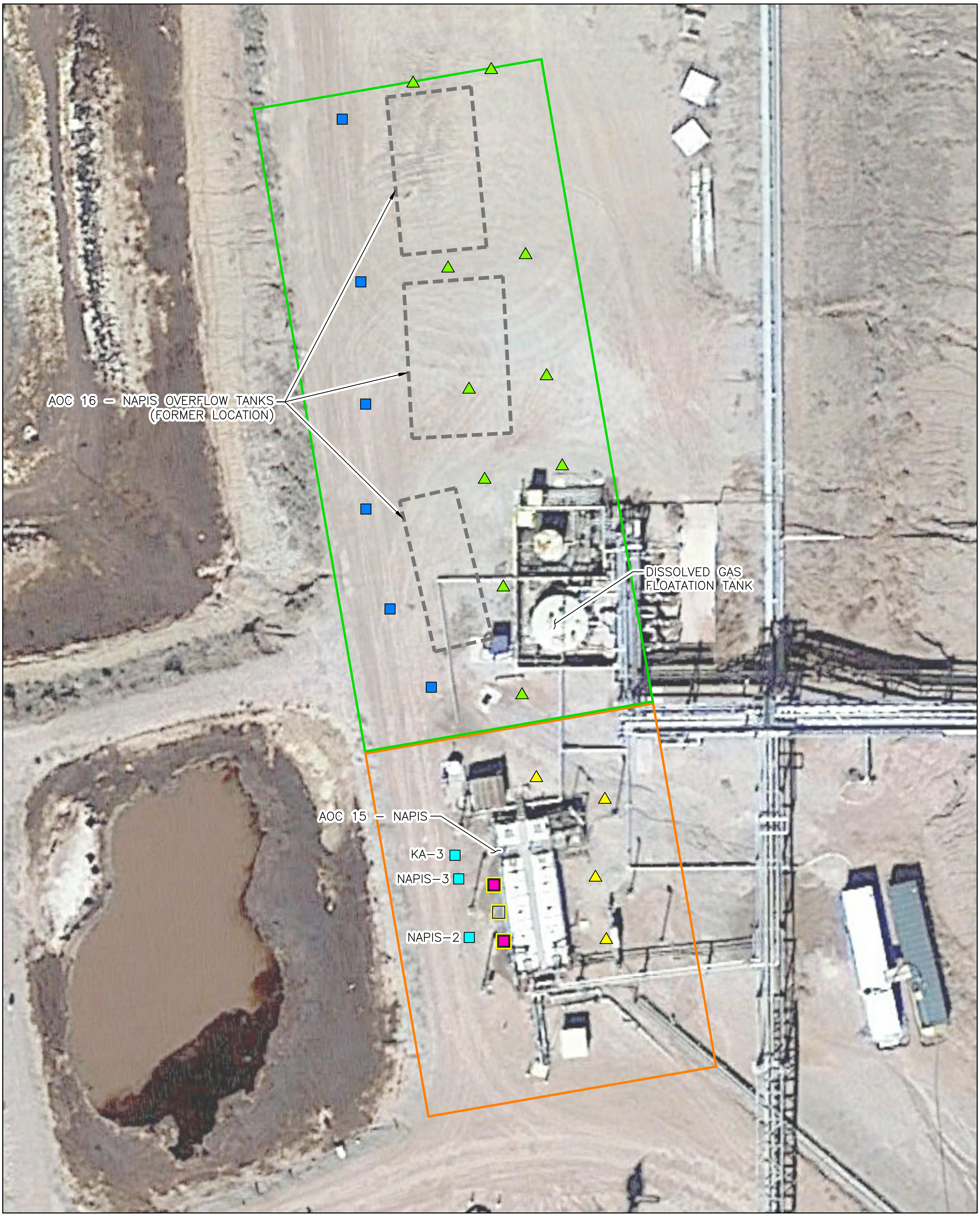
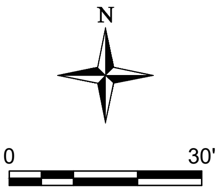


Image Cite: Google Earth Pro, Publication: March, 2016.

**EXPLANATION**

| | |
|---|---|
| 🟧 | AOC 15 NAPIS |
| 🟩 | AOC 16 NAPIS OVERFLOW TANKS |
| ☐ | ESTIMATED FORMER LOCATION OF NAPIS OVERFLOW TANKS |
| △ | AOC 15 - PROPOSED SOIL SAMPLE LOCATION |
| ▲ | AOC 16 - PROPOSED SOIL SAMPLE LOCATION |
| ☐ | AOC 15 - PROPOSED SHALLOW VADOSE BROMIDE MONITORING WELL LOCATION |
| ■ | AOC 15 - PROPOSED BROMIDE MONITORING WELL AND SOIL SAMPLE LOCATION |
| ■ | AOC 16 - PROPOSED SOIL AND GROUNDWATER SAMPLE LOCATION |
| ■ NAPIS–2 | PERMANENT MONITORING WELL AND DESIGNATION |
| AOC | AREA OF CONCERN |
| NAPIS | NEW AMERICAN PETROLEUM INSTITUTE SEPARATOR |



Trihydro
CORPORATION
1252 Commerce Drive
Laramie, Wyoming 82070
www.trihydro.com
(P) 307/745.7474 (F) 307/745.7729

**FIGURE 4**

**PROPOSED BROMIDE MONITORING WELL AND SAMPLE LOCATIONS AOC 15 AND AOC 16 INVESTIGATION WORK PLAN**

**WESTERN REFINING SOUTHWEST LLC**
**D/B/A MARATHON GALLUP REFINERY**
**GALLUP, NEW MEXICO**

| Drawn By: REP | Checked By: AW | Scale: 1" = 30' | Date: 12/15/2023 | File: 697-AOC-15-16-SAMPLOCS-2023 |
|---|---|---|---|---|

\\TRIHYDRO.COM\CLIENTS\TON\MARATHON\CADD\GALLUP_REPORTS\AOC\AOC15_NAPIS\697–AOC–15–16–SAMPLOCS–2023

# Appendix A – Bromide Concentration Calculation

Project Name/Calc Title ~~Groundwater flux across NAPIS and Bromide Test~~ New American Petroleum Institute Separator Installation Cross Section Bromide Calculation Concentration
Project Number 697-097-001 -01b
Calculations For Marathon Gallup Refinery Reference Drawings none Sheet No 1 of 4
Designed By JPietz;BButler Date 09/06/2022; 05/10/2023; 12/27/2023
Checked By TAnton;THanson Date 11/15/2022; 04/10/2023; 12/29/2023

## Purpose

Calculate the flux of groundwater across the New American Petroleum Institute Separator (NAPIS) length-wise cross section and determine the minimum leakage rate from the NAPIS that is detectable given an initial concentration of bromide.

## Methodology

1. Use the groundwater gradient and the local hydraulic conductivity from prior Marathon Gallup Refinery (Marathon) reports (cite references where used).
2. Determine submerged cross-sectional area of the NAPIS from available drawings.
3. Using the laboratory detection limit for bromide of 0.050 milligrams per liter (mg/L), calculate dilution ratio of bromide and assess detectability in terms of minimum leakage rate at this detection limit.

## Background

1. The New Mexico Environment Department (NMED) has commented on the investigation work plan (IWP), proposed by Marathon to dye leak test the NAPIS unit at the Gallup refinery. The NMED requested a calculation of the lowest leakage rate of dye from the NAPIS that is detectable given the published dye detection limit. The time to achieve the detectable concentration is also estimated. Subsequent field testing of a dye indicated that it was not suitable for use because of interference with background soil hydrocarbon levels, and bromide was proposed.

## Assumptions

1. Phase I includes collecting groundwater samples from the downgradient monitoring wells for potential background bromide concentrations. It is assumed that the background bromide concentrations will be non-detect.

~~1.~~2. Perfect, complete mixing of any leaked bromide with the flux of groundwater that is in contact with the NAPIS, ignoring any distortion of groundwater flow lines or blockage caused by the NAPIS, which is partially submerged in groundwater.

~~2.~~3. Locally measured hydraulic conductivity in a yield test from Test Pit Well 3 is 0.44 feet (ft)/day (Marathon 2021).

~~3.~~4. Groundwater flow direction at the NAPIS is essentially east to west, perpendicular to the NAPIS East Wall.

~~4.~~5. NAPIS operating water level is approximately 33 inches below the top wall of the NAPIS (Trihydro 2021).

Project Name/Calc Title ~~Groundwater flux across NAPIS and Bromide Test~~ New American Petroleum Institute Separator Installation Cross Section Bromide Calculation Concentration

Project Number 697-097-001 -01b

Calculations For Marathon Gallup Refinery Reference Drawings none Sheet No 2 of 4

Designed By JPietz;BButler Date 09/06/2022; 05/10/2023; 12/27/2023

Checked By TAnton;THanson Date 11/15/2022; 04/10/2023; 12/29/2023

~~5.~~6. The water bearing unit consists of silty-clayey sand with a porosity of 0.35.

~~6.~~7. The recharge rate into the Leak Detection Unit (LDU) ~~wells~~ observed during the investigation (Trihydro 2021) is approximately 0.03 milliliters per min (mL/min). For the purpose of estimating the time period for bromide testing, this rate is assumed to be the leakage rate from the NAPIS into local groundwater where leak test observation wells are located. Leak test observation wells are located approximately 5 feet (ft) downgradient (west) of the NAPIS.

~~7.~~8. Vadose zone or unsaturated zone transport of bromide to the observation wells is not considered;~~-~~ any leak from the NAPIS is assumed to be in communication with local groundwater.

~~8.~~9. Bromide concentration in the west NAPIS tank will be approximately 1,000 ~~parts per million~~milligrams per Liter~~-~~ (mg/L).

## Calculations

1. Groundwater gradient across NAPIS. As shown in Attachment 1 (copy of Figure 3 from Trihydro 2021), distance between NAPIS-1 and NAPIS-2 is 60 ft. Groundwater elevations at these wells, respectively, are 6910 and 6908.5 feet above mean sea level (ft amsl). Local groundwater gradient across the NAPIS is

   ~~1.~~ (6910 ft amsl - 6908.5 ft amsl) / 60 ft = 0.025

   ~~(6910 - 6908.5)/60= 0.025~~

2. Darcy groundwater velocity is v=ki, where k is hydraulic conductivity (ft/day) and i is the local groundwater gradient. Assumption 1 states k is 0.44 ft/day.

   ~~2.~~ v = 0.44 ft/day * 0.025 = 0.011 ft/day

3. Approximate depth of groundwater at the NAPIS is shown in Attachment 1 (~3 ft thick at the deepest part of the NAPIS).

4. Attachment 2 shows the cross-sectional area for the groundwater flux calculation. Total~~-~~ cross-sectional area for the groundwater flux is 135 square ft (ft$^2$).

5. Using the Darcy velocity and the flux area, the calculated groundwater volumetric flowrate across this cross-section is

   ~~5.~~ v * A = 0.011 ft/day * 135 ft$^2$ = 1.5 cubic feet (ft$^3$)/day or 11.1 gallons (gal)/day.

6. NAPIS bay volume calculation. Assumption 4 operating depth is 2.8 ft (33 inches). From Attachment 2, cross sectional area of an operating bay is 222 ft$^2$ (upper rectangle) + 40 ft$^2$ = 262 ~~-~~ft$^2$. From Attachment 3, the width of a NAPIS bay is 5.5 ft.

7. Total operating volume is

   ~~7.~~ 262 ft$^2$ * 5.5 ft = 1441 ft$^3$ or ~~(*7.48 gal/ft$^3$) =~~ 10,779 gal.

8. Add sufficient sodium (Na) bromide (Br) per 10,779 gal (rounded to 11,000 gal) as follows:~~.~~

   ~~10~~1,000 mg/L = ~~-~~X ~~milligrams (~~mg~~)~~ / 11,000 gal * 1 gal/3.78 liters

   X = ~~10~~1,000 mg/L * 11,000 gal * 3.78 L/gal = 41,5~~,~~80,0~~,~~0~~0~~0 mg or ~~416.4~~ 41,580 grams~~.~~

   This will be as bromide, s~~. S~~o we need to find the weight of sodium bromide.

Trihydro CORPORATION

Project Name/Calc Title ~~Groundwater flux across NAPIS and Bromide Test~~ New American Petroleum Institute Separator Installation Cross Section Bromide Calculation Concentration

Project Number 697-097-001 -01b
Calculations For Marathon Gallup Refinery Reference Drawings none Sheet No 3 of 4
Designed By JPietz;BButler Date 09/06/2022; 05/10/2023; 12/27/2023
Checked By TAnton;THanson Date 11/15/2022; 04/10/2023; 12/29/2023

S

~~S~~odium ~~(Na)~~ bromide ~~(Br)~~ molecular weight in grams per mol (g/mol) = 79.9 (Br) + 22.9 (Na) = 102.8

Weight fraction bromide = 79.9 / 102.8 = 0.77

~~416~~ 41,580 g bromide = X g Sodium bromide * 0.77

X = ~~536~~53,500 grams sodium bromide or ~~536~~53,500/454 grams per pound (g/lb) = ~~1.2~~ 118 lb sodium bromide

~~Assuming 50 parts per billion (0.05 mg/L) is the minimum detectable concentration, the dilution factor for this detection limit is 10 E-6 * X (dilution factor) = 50E-9 (detection limit). X = 0.005~~

9. Assuming ~~10 parts per million (~~10 mg/L~~)~~ is the ~~assumed~~ leak concentration limit, the dilution factor for this concentration limit is

~~8.~~ 10E-3 * X (dilution factor) = 10E-5 (concentration limit). X = 0.01

10. From this dilution factor and the groundwater volumetric flow rate of 11.1 gal per day across the NAPIS, the ~~minimum detectable~~ target concentration leakage rate is

~~9.~~ 11.1 gal/day * ~~0.00862~~~~0.005~~0.01 = ~~0.09568~~~~0.0555~~0.11 gal/day

~~10.~~ Using the cross-section area of 135 $ft^2$ (see #4 above), a width of 5 ft, and a porosity of 0.35, the total volume of groundwater within the observation well zone is 236.25~~236.35~~ $ft^3$.

~~11.~~

11.

~~12.~~ T~~he volume of the release required to attain the minimum detection limit~~~~target concentration is~~ ~~236.25236.35 ft³ * 0.008620.01 = 2.041.182.36 ft³, or (x7.48gal/ft³) = 15.248.841.77 gallons.~~ o calculate the time required to maintain a concentration of 1,000 mg/L in the West Bay, the following equation was considered.

12.

$C_1V_1=C_2V_2$

Where $C_1$ = 1,000 mg/L, $V_1$ = the volume of tracer discharged from the NAPIS wall or the duration which the tracer is continuously applied to the Bay (T) X the discharge rate from the Bay (0.16 mL/min), $C_2$ = 0.05 mg/L, and $V_2$ = pore volume between the Bay and the well (236.25 $ft^3$).

$V_1=TF$

$T = C_2V_2/C_1F$

Where, $1Ft^3$=28,316.8mL

FT = 2,090 minutes or 1.45 days

Project Name/Calc Title ~~Groundwater flux across NAPIS and Bromide Test~~ New American Petroleum Institute Separator Installation Cross Section Bromide Calculation Concentration

Project Number 697-097-001 -01b

Calculations For Marathon Gallup Refinery Reference Drawings none Sheet No 4 of 4

Designed By JPietz;BButler Date 09/06/2022; 05/10/2023; 12/27/2023

Checked By TAnton;THanson Date 11/15/2022; 04/10/2023; 12/29/2023

~~13. At an assumed leakage rate of 0.03 0.16 mL/min, the required time is 0.03 0.16mL/min * (1 liter/1000mL) * (1 gal/3.7853.48 liter) * X min = 15.248.841.77 gallons. X = 1,767,840 41,8041 min or 1228 290 days. Note that this assumes perfect mixing of this leakage rate in the monitored volume in #14. In addition, the groundwater velocity during this period was not considered. The estimated travel time distance during this period is the Darcy velocity (ft/day) * time/porosity, or 0.011 ft/day * 1228 290 days / 0.35 = 38.6 9.12 ft. The NAPIS wall may serve to block groundwater flow, and so ignoring groundwater flow is a reasonable assumption.~~

13. Vadose monitoring wells at an approximate distance of 5 ft from the NAPIS are also proposed, which ~~would the~~allows for leak detection in the unsaturated zone. As stated in Assumption 7 above, travel time under unsaturated conditions were not considered in this calculation.
14. Given the NAPIS monitoring wells (NAPIS-2, NAPIS-3, and KA-3) are the furthest detection wells and are located at an approximate distance of 15 ft. from the West Bay, the estimated travel time to reach these well would be (15ft * 0.35)/ 0.011ft/day = 477 days. The proposed monitoring wells (5 ft from the NAPIS) are estimated to have bromide reach them in (5 ft * * 0.35)/0.011 ft/day) = 159 days.

Project Name/Calc Title ~~Groundwater flux across NAPIS and Bromide Test~~ New American Petroleum Institute Separator Installation Cross Section Bromide Calculation Concentration

Project Number 697-097-001 -01b

Calculations For Marathon Gallup Refinery Reference Drawings none Sheet No 5 of 4

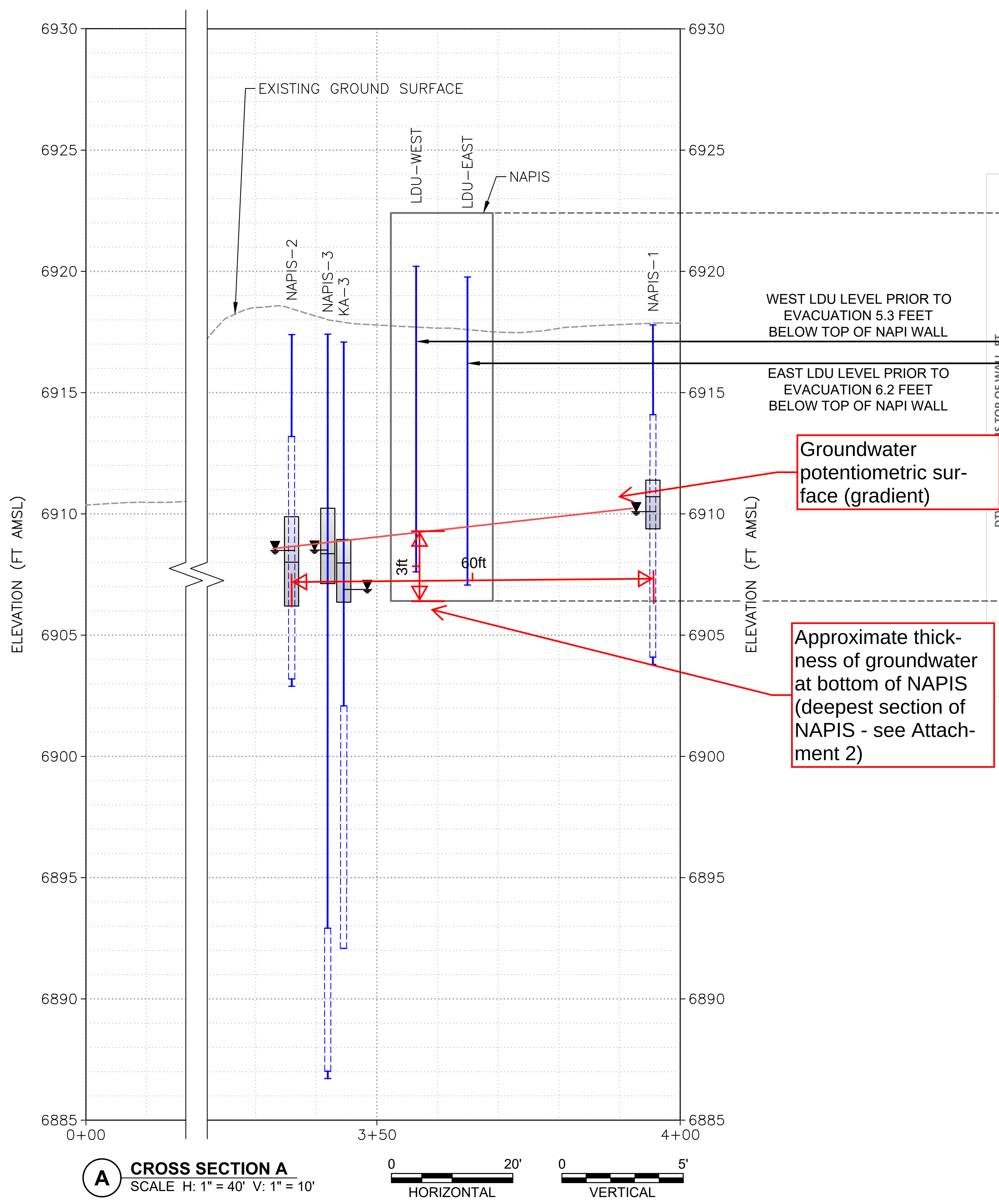
Designed By JPietz;BButler Date 09/06/2022; 05/10/2023; 12/27/2023

Checked By TAnton;THanson Date 11/15/2022; 04/10/2023; 12/29/2023

## References

Marathon Gallup Refinery (Marathon). 2021. SWMU-1 Test Pit Installation Letter Report Western Refining Southwest LLC D/B/A, Marathon Gallup Refinery EPA ID# NMD000333211 October 22 "M:\ItoN\Marathon\ProjectDocs\Gallup\SWMU\SWMU 1_AerationBas\Reports\TestPitReport\1-Text\202110_SWMU-1TestPits_Signed_LTR.pdf"

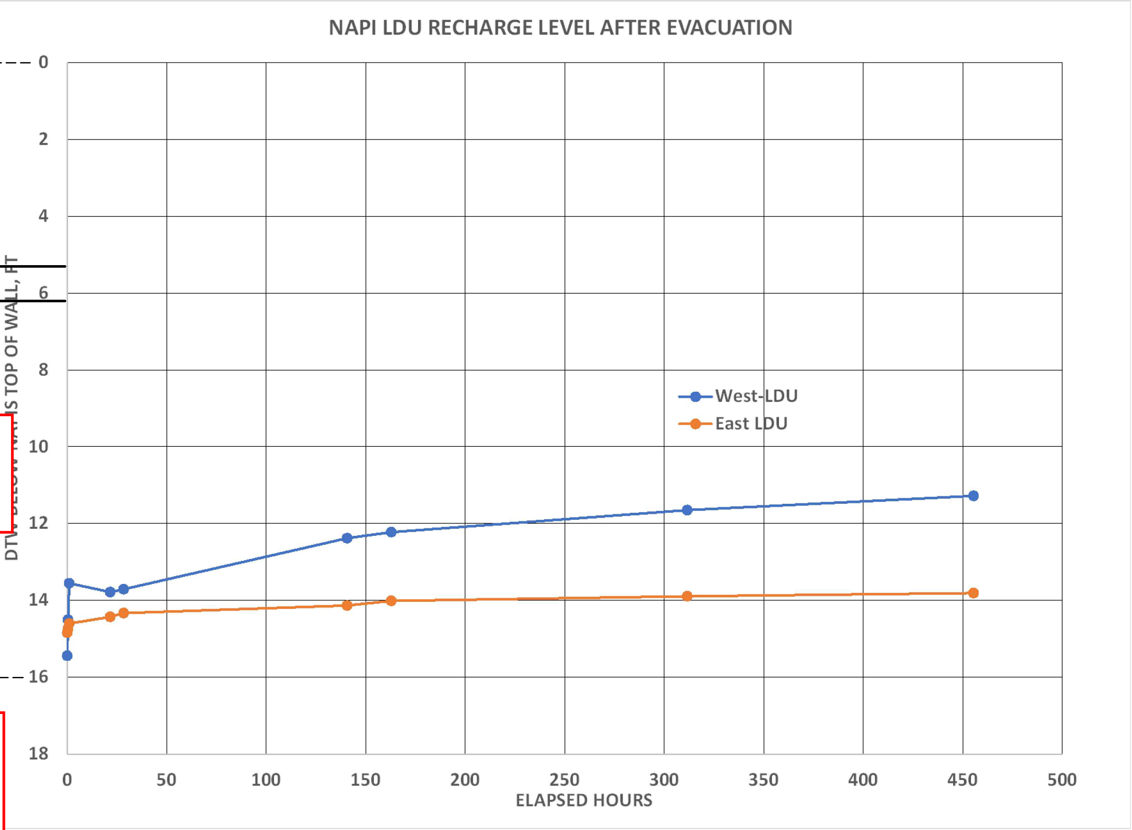
Trihydro Corporation (Trihydro). 2021. NAPIS Inspection - Summary of Findings Marathon Petroleum Company Gallup Refinery Division. November 29 "M:\ItoN\Marathon\ProjectDocs\Gallup\AOC\AOC15_NAPIS\Reports\LDU\1-Text\202112_NAPIS_Inspection_LTRRPT_Revised.docx"



**A** **CROSS SECTION A**
SCALE H: 1" = 40' V: 1" = 10'

0 20'
HORIZONTAL

0 5'
VERTICAL



## EXPLANATION

▼—— WATER LEVEL (JUNE 8, 2021 DTW)

MINIMUM DTW (2011-2020)
AVERAGE DTW (2011-2020)
MAXIMUM DTW (2011-2020)

| | |
|---|---|
| DTW | DEPTH TO WATER |
| FT AMSL | FEET ABOVE MEAN SEA LEVEL |
| LDU | LEAK DETECTION UNIT WELL |
| NAPIS | NEW API SEPARATOR |

NAPIS-1 — DESIGNATION
WELL/TEST PIT
SCREENED INTERVAL

NAPIS REFERENCE DRAWINGS
NAPIS 42400-100, NAPIS 42400-106

| REV. | DATE | DESCRIPTION | BY | CHK'D |
|---|---|---|---|---|

REVISIONS

DRAWN BY: PAC
CHECKED BY: JP
DATE: 6/15/2021
SCALE: AS SHOWN
FILE: 697-SWMU1-XSEC202106

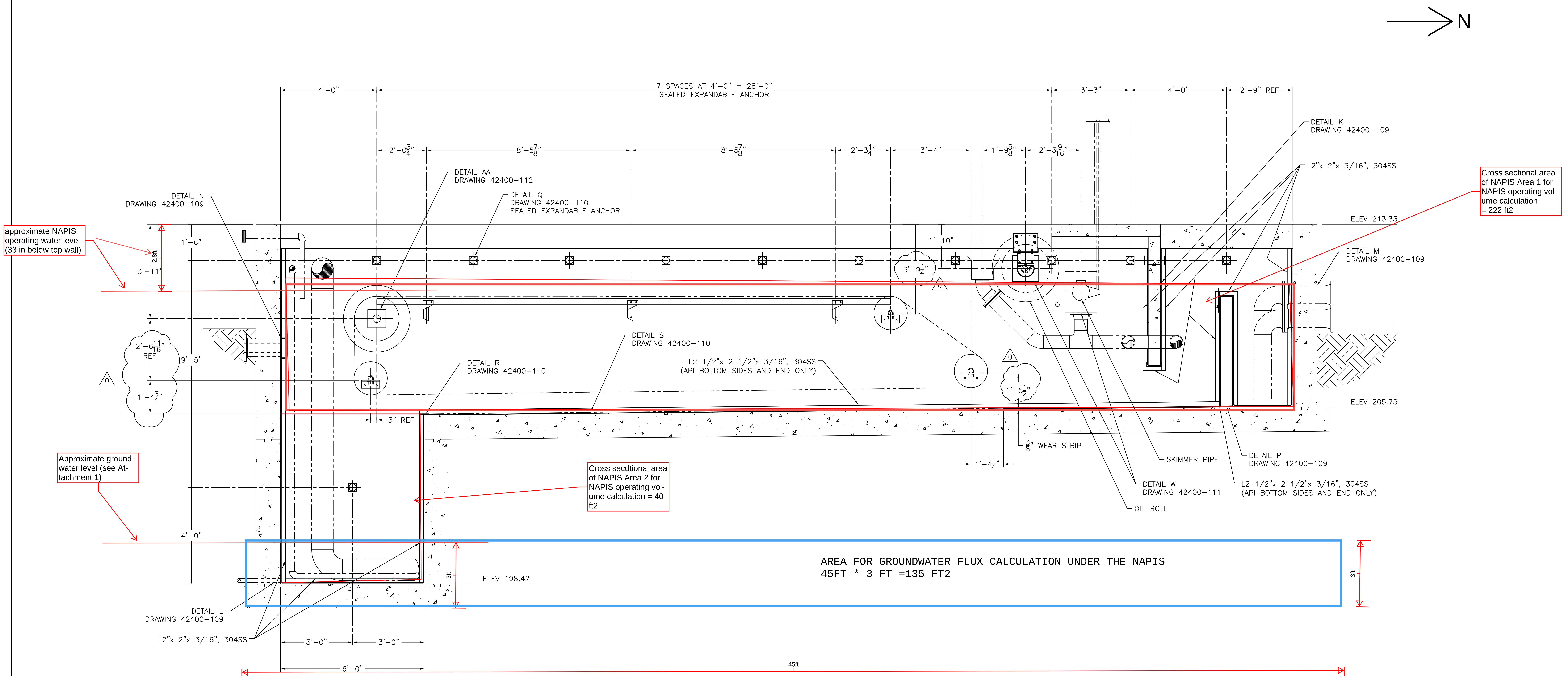
Trihydro CORPORATION
1252 Commerce Drive
Laramie, Wyoming 82070
www.trihydro.com
(P) 307/745.7474 (F) 307/745.7729

# NAPIS LDU RECOVERY TEST DATA SUMMARY

MARATHON PETROLEUM COMPANY
GALLUP REFINING DIVISION
GALLUP, NEW MEXICO

FIGURE 3
REV: -

\\TRIHYDRO.COM\CLIENTS\TON\MARATHON\CADD\GALLUP_REPORTS\SWMU1_EVAPPONDCLOSURE\CROSSSECTION\697-SWMU1-XSEC202106



SECTION A–A

| REV | DESCRIPTION | DATE | DWN | CHKD | APVD | ECN |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| 0 | ISSUED FOR CONSTRUCTION REVISED PER 06/06/07 SITE MEETING | 06/12/07 | DJS | JLF | JLF | |
| A | ISSUED FOR APPROVAL AND INTERNAL REVIEW | 05/22/07 | DJS | JLF | JLF | |

COMPANY CONFIDENTIAL

THIS DOCUMENT AND ALL INFORMATION CONTAINED HEREIN ARE THE PROPERTY OF SIEMENS AND/OR ITS AFFILIATES. THE DESIGN CONCEPTS AND INFORMATION CONTAINED HEREIN ARE PROPRIETARY TO SIEMENS AND ARE SUBMITTED IN CONFIDENCE. THEY ARE NOT TRANSFERABLE AND MUST BE USED ONLY FOR THE PURPOSE FOR WHICH THE DOCUMENT IS EXPRESSLY LOANED. THEY MUST NOT BE DISCLOSED, REPRODUCED, LOANED OR USED IN ANY OTHER MANNER WITHOUT THE EXPRESS WRITTEN CONSENT OF SIEMENS. IN NO EVENT SHALL THEY BE USED IN ANY MANNER DETRIMENTAL TO THE INTEREST OF SIEMENS. ALL PATENT RIGHTS ARE RESERVED. UPON THE DEMAND OF SIEMENS, THIS DOCUMENT, ALONG WITH ALL COPIES AND EXTRACTS, AND ALL RELATED NOTES AND ANALYSES, MUST BE RETURNED TO SIEMENS OR DESTROYED, AS INSTRUCTED BY SIEMENS. ACCEPTANCE OF THE DELIVERY OF THIS DOCUMENT CONSTITUTES AGREEMENT TO THESE TERMS AND CONDITIONS.

| | |
|---|---|
| DESIGNER<br>DJS | DATE<br>05/14/07 |
| CHECKER<br>JLF | DATE<br>05/15/07 |
| ENGINEER | DATE |
| MANAGER<br>JLF | DATE<br>05/15/07 |
| FILE: | |
| SCALE: 1/2"=1'0" | |

TITLE GENERAL ARRANGEMENT
API SEPARATOR AND OIL RECOVERY SUMP
ELEVATION VIEW LINER INSTALLATION

CLIENT GIANT INDUSTRIES, INC
CINIZA REFINERY, GALLUP, NM

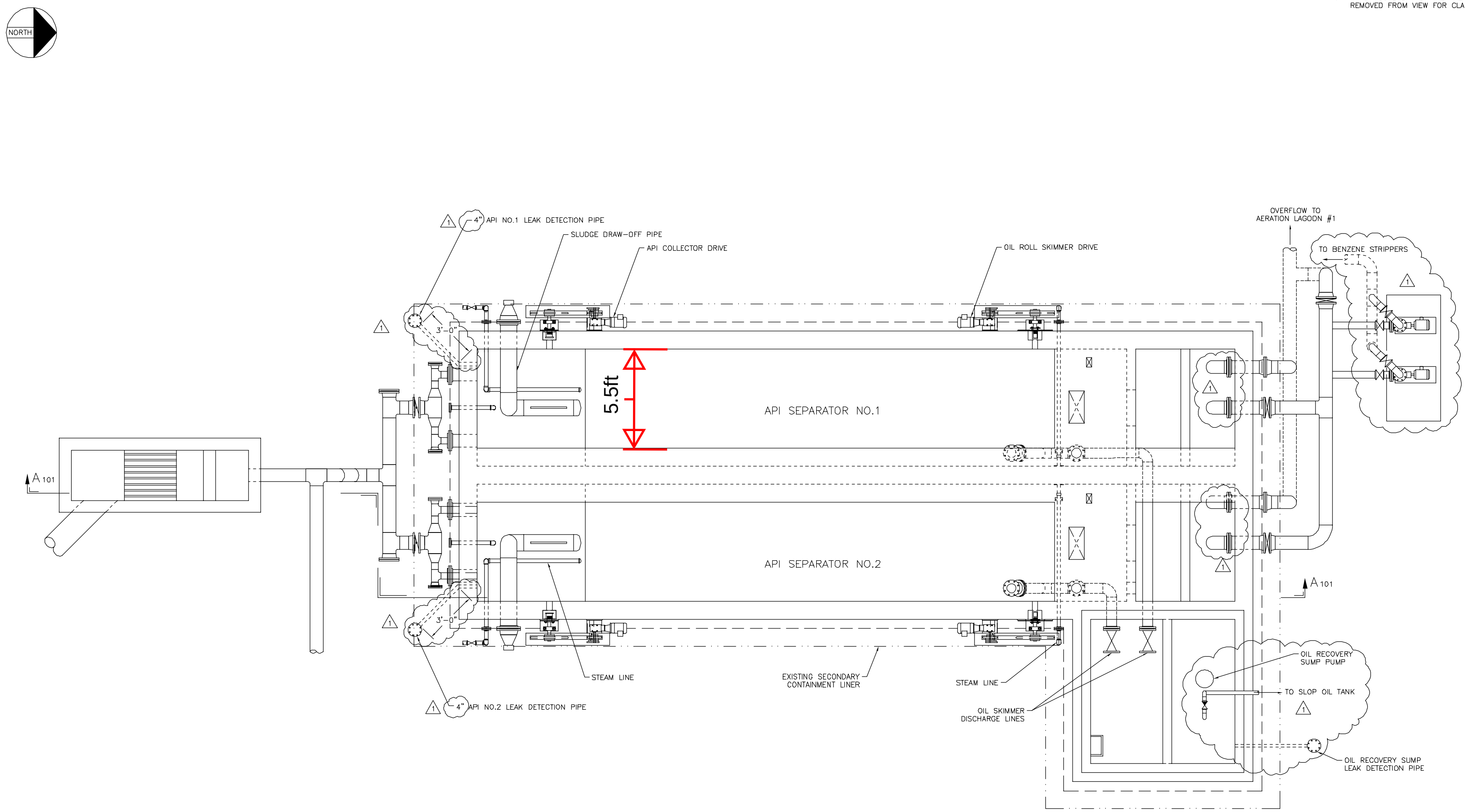
**SIEMENS** Water Technologies
WAUKESHA, WI
262–547–0141

| PROJECT | CODE | DRAWING | SHEET | REV |
|---|---|---|---|---|
| S00062 | | 42400–106 | 1 OF 1 | 0 |

STD: 1–0200–24X36D1
INTL REF:
BAR = 1" AT PLOT SCALE

NOTES:

1. VAPOR COVERS AND INTERNAL EQUIPMENT COMPONENTS REMOVED FROM VIEW FOR CLARITY.



| REV | DESCRIPTION | DATE | DWN | CHKD | APVD | ECN |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| | | | | | | |
| 1 | REVISED PER 06/06/07 SITE MEETING | 06/12/07 | DJS | JLF | JLF | |
| 0 | ISSUE FOR CONSTRUCTION | 05/01/07 | DJS | JLF | JLF | |
| A | ISSUED FOR APPROVAL | 04/19/07 | DJS | JLF | JLF | |

| | | |
|---|---|---|
| DESIGNER | DJS | DATE 04/16/07 |
| CHECKER | JLF | DATE 04/18/07 |
| ENGINEER | | DATE |
| MANAGER | JLF | DATE 04/18/07 |
| FILE: | | |
| SCALE: 3/8"=1'0" | | |

TITLE API SEPARATOR AND OIL RECOVERY SUMP
PLAN VIEW

CLIENT GIANT INDUSTRIES, INC
CINIZA REFINERY, GALLUP, NM

**SIEMENS** Water Technologies
WAUKESHA, WI
262-547-0141

| PROJECT | CODE | DRAWING | SHEET | REV |
|---|---|---|---|---|
| S00062 | | 42400-100 | 1 OF 1 | 1 |

STD: 1-0200-24X36D1
INTL REF:
BAR = 1" AT PLOT SCALE

# Appendix B – Groundwater Sampling and Monitoring with Direct Push Technologies

# Appendix C – Standard Operating Procedure – Soil Sampling

# Appendix D – Example Boring Log

# ATTACHMENT D

# LAB REPORT

Eurofins Environment Testing South Central, LLC
4901 Hawkins NE
Albuquerque, NM 87109
TEL: 505-345-3975 FAX: 505-345-4107
Website: www.hallenvironmental.com

January 12, 2024

Caitlin Fields

Marathon
92 Giant Crossing Rd
Gallup, NM 87301
TEL: (505) 722-3833
FAX:

RE: Gallup SMWU and AOC Investigation OrderNo.: 2311D11

Dear Caitlin Fields:

Eurofins Environment Testing South Central, LLC received 2 sample(s) on 11/29/2023 for the analyses presented in the following report.

These were analyzed according to EPA procedures or equivalent. To access our accredited tests please go to www.hallenvironmental.com or the state specific web sites. In order to properly interpret your results, it is imperative that you review this report in its entirety. See the sample checklist and/or the Chain of Custody for information regarding the sample receipt temperature and preservation. Data qualifiers or a narrative will be provided if the sample analysis or analytical quality control parameters require a flag. When necessary, data qualifiers are provided on both the sample analysis report and the QC summary report, both sections should be reviewed. All samples are reported, as received, unless otherwise indicated. Lab measurement of analytes considered field parameters that require analysis within 15 minutes of sampling such as pH and residual chlorine are qualified as being analyzed outside of the recommended holding time.

Please do not hesitate to contact Eurofins Albuquerque for any additional information or clarifications.

ADHS Cert #AZ0682 -- NMED-DWB Cert #NM9425 -- NMED-Micro Cert #NM0901

Sincerely,

Andy Freeman
Laboratory Manager
4901 Hawkins NE
Albuquerque, NM 87109

**Analytical Report**
Lab Order: **2311D11**
Date Reported: **1/12/2024**

# Hall Environmental Analysis Laboratory, Inc.

**CLIENT:** Marathon
**Project:** Gallup SMWU and AOC Investigation
**Lab ID:** 2311D11-001A

**Client Sample ID:** East NAPIS
**Collection Date:** 11/28/2023 9:45:00 AM
**Matrix:** Aqueous

| Analyses | Result | MDL | RL | Qual | Units | DF | Date Analyzed | Batch ID |
|---|---|---|---|---|---|---|---|---|
| **EPA METHOD 8015D: GASOLINE RANGE** | | | | | | | Analyst: **JJP** | |
| Gasoline Range Organics (GRO) | 0.012 | 0.0090 | 0.050 | J | mg/L | 1 | 12/2/2023 12:29:57 AM | GWW10 |
| Surr: BFB | 92.7 | 0 | 15-270 | | %Rec | 1 | 12/2/2023 12:29:57 AM | GWW10 |
| **EPA METHOD 8260B: VOLATILES** | | | | | | | Analyst: **CCM** | |
| Benzene | ND | 0.23 | 1.0 | | µg/L | 1 | 12/7/2023 3:51:00 PM | R10167 |
| Toluene | ND | 0.25 | 1.0 | | µg/L | 1 | 12/7/2023 3:51:00 PM | R10167 |
| Ethylbenzene | ND | 0.21 | 1.0 | | µg/L | 1 | 12/7/2023 3:51:00 PM | R10167 |
| Naphthalene | ND | 0.24 | 2.0 | | µg/L | 1 | 12/7/2023 3:51:00 PM | R10167 |
| 1-Methylnaphthalene | ND | 2.0 | 4.0 | | µg/L | 1 | 12/7/2023 3:51:00 PM | R10167 |
| 2-Methylnaphthalene | ND | 2.0 | 4.0 | | µg/L | 1 | 12/7/2023 3:51:00 PM | R10167 |
| Methylene Chloride | ND | 1.2 | 3.0 | | µg/L | 1 | 12/7/2023 3:51:00 PM | R10167 |
| Surr: 1,2-Dichloroethane-d4 | 97.3 | 0 | 70-130 | | %Rec | 1 | 12/7/2023 3:51:00 PM | R10167 |
| Surr: 4-Bromofluorobenzene | 104 | 0 | 70-130 | | %Rec | 1 | 12/7/2023 3:51:00 PM | R10167 |
| Surr: Dibromofluoromethane | 96.2 | 0 | 70-130 | | %Rec | 1 | 12/7/2023 3:51:00 PM | R10167 |
| Surr: Toluene-d8 | 92.4 | 0 | 70-130 | | %Rec | 1 | 12/7/2023 3:51:00 PM | R10167 |

Refer to the QC Summary report and sample login checklist for flagged QC data and preservation information.

**Qualifiers:**

| | | | |
|---|---|---|---|
| * | Value exceeds Maximum Contaminant Level. | B | Analyte detected in the associated Method Blank |
| D | Sample Diluted Due to Matrix | E | Above Quantitation Range/Estimated Value |
| H | Holding times for preparation or analysis exceeded | J | Analyte detected below quantitation limits |
| ND | Not Detected at the Reporting Limit | P | Sample pH Not In Range |
| PQL | Practical Quanitative Limit | RL | Reporting Limit |
| S | % Recovery outside of standard limits. If undiluted results may be estimated. | | |

**Analytical Report**
Lab Order: **2311D11**
Date Reported: **1/12/2024**

## Hall Environmental Analysis Laboratory, Inc.

| | | | |
|---|---|---|---|
| **CLIENT:** | Marathon | **Client Sample ID:** | East NAPIS |
| **Project:** | Gallup SMWU and AOC Investigation | **Collection Date:** | 11/28/2023 9:45:00 AM |
| **Lab ID:** | 2311D11-001B | **Matrix:** | Aqueous |

| Analyses | Result | MDL | RL | Qual | Units | DF | Date Analyzed | Batch ID |
|---|---|---|---|---|---|---|---|---|
| **EPA METHOD 8015M/D: DIESEL RANGE** | | | | | | | Analyst: **PRD** | |
| Diesel Range Organics (DRO) | ND | 0.58 | 1.0 | | mg/L | 1 | 12/2/2023 1:21:07 PM | 79076 |
| Motor Oil Range Organics (MRO) | ND | 1.3 | 5.0 | | mg/L | 1 | 12/2/2023 1:21:07 PM | 79076 |
| Surr: DNOP | 71.0 | 0 | 54.5-177 | | %Rec | 1 | 12/2/2023 1:21:07 PM | 79076 |

Refer to the QC Summary report and sample login checklist for flagged QC data and preservation information.

**Qualifiers:**

| | | | |
|---|---|---|---|
| * | Value exceeds Maximum Contaminant Level. | B | Analyte detected in the associated Method Blank |
| D | Sample Diluted Due to Matrix | E | Above Quantitation Range/Estimated Value |
| H | Holding times for preparation or analysis exceeded | J | Analyte detected below quantitation limits |
| ND | Not Detected at the Reporting Limit | P | Sample pH Not In Range |
| PQL | Practical Quanitative Limit | RL | Reporting Limit |
| S | % Recovery outside of standard limits. If undiluted results may be estimated. | | |

**Analytical Report**
Lab Order: **2311D11**
Date Reported: **1/12/2024**

## Hall Environmental Analysis Laboratory, Inc.

| | | | |
|---|---|---|---|
| **CLIENT:** | Marathon | **Client Sample ID:** | East NAPIS |
| **Project:** | Gallup SMWU and AOC Investigation | **Collection Date:** | 11/28/2023 9:45:00 AM |
| **Lab ID:** | 2311D11-001C | **Matrix:** | Aqueous |

| Analyses | Result | MDL | RL | Qual | Units | DF | Date Analyzed | Batch ID |
|---|---|---|---|---|---|---|---|---|
| **EPA METHOD 6020A: TOTAL METALS** | | | | | | | Analyst: **ELS** | |
| Arsenic | 0.00057 | 0.00050 | 0.0010 | J | mg/L | 1 | 12/4/2023 4:45:05 PM | 79067 |
| Lead | ND | 0.00060 | 0.0010 | | mg/L | 1 | 12/4/2023 4:45:05 PM | 79067 |
| Selenium | ND | 0.00080 | 0.0010 | | mg/L | 1 | 12/4/2023 4:45:05 PM | 79067 |
| **EPA METHOD 7470A: MERCURY** | | | | | | | Analyst: **tem** | |
| Mercury | ND | 0.000081 | 0.00020 | H | mg/L | 1 | 12/28/2023 11:29:12 AM | 79607 |
| **EPA 6010B: TOTAL RECOVERABLE METALS** | | | | | | | Analyst: **VP** | |
| Barium | 0.065 | 0.0022 | 0.010 | | mg/L | 5 | 12/6/2023 5:02:38 PM | 79067 |
| Cadmium | ND | 0.0061 | 0.010 | | mg/L | 5 | 12/6/2023 5:02:38 PM | 79067 |
| Chromium | ND | 0.0058 | 0.030 | | mg/L | 5 | 12/6/2023 5:02:38 PM | 79067 |
| Silver | ND | 0.0065 | 0.025 | | mg/L | 5 | 12/6/2023 5:02:38 PM | 79067 |

Refer to the QC Summary report and sample login checklist for flagged QC data and preservation information.

**Qualifiers:**

| | | | |
|---|---|---|---|
| * | Value exceeds Maximum Contaminant Level. | B | Analyte detected in the associated Method Blank |
| D | Sample Diluted Due to Matrix | E | Above Quantitation Range/Estimated Value |
| H | Holding times for preparation or analysis exceeded | J | Analyte detected below quantitation limits |
| ND | Not Detected at the Reporting Limit | P | Sample pH Not In Range |
| PQL | Practical Quanitative Limit | RL | Reporting Limit |
| S | % Recovery outside of standard limits. If undiluted results may be estimated. | | |

**Analytical Report**
Lab Order: **2311D11**
Date Reported: **1/12/2024**

## Hall Environmental Analysis Laboratory, Inc.

| | | | |
|---|---|---|---|
| **CLIENT:** | Marathon | **Client Sample ID:** | East NAPIS |
| **Project:** | Gallup SMWU and AOC Investigation | **Collection Date:** | 11/28/2023 9:45:00 AM |
| **Lab ID:** | 2311D11-001D | **Matrix:** | Aqueous |

| Analyses | Result | MDL | RL | Qual | Units | DF | Date Analyzed | Batch ID |
|---|---|---|---|---|---|---|---|---|
| **EPA METHOD 6020A: DISSOLVED METALS** | | | | | | | Analyst: **ELS** | |
| Arsenic | ND | 0.0025 | 0.0050 | | mg/L | 5 | 12/22/2023 10:54:44 AM | A102048 |
| Iron | 0.26 | 0.010 | 0.020 | | mg/L | 1 | 12/21/2023 10:57:17 AM | A102018 |
| Selenium | ND | 0.00080 | 0.0010 | | mg/L | 1 | 12/21/2023 10:57:17 AM | A102018 |
| **EPA METHOD 7470A: MERCURY** | | | | | | | Analyst: **tem** | |
| Mercury | ND | 0.000081 | 0.00020 | H | mg/L | 1 | 12/28/2023 11:38:24 AM | 79607 |
| **EPA METHOD 6010B: DISSOLVED METALS** | | | | | | | Analyst: **VP** | |
| Barium | 0.054 | 0.00074 | 0.020 | | mg/L | 1 | 12/13/2023 1:21:13 PM | A101811 |
| Cadmium | ND | 0.00083 | 0.0020 | | mg/L | 1 | 12/13/2023 1:21:13 PM | A101811 |
| Chromium | 0.0030 | 0.00099 | 0.0060 | J | mg/L | 1 | 12/13/2023 1:21:13 PM | A101811 |
| Silver | 0.0039 | 0.0012 | 0.0050 | J | mg/L | 1 | 12/13/2023 1:21:13 PM | A101811 |

Refer to the QC Summary report and sample login checklist for flagged QC data and preservation information.

**Qualifiers:**

| | | | |
|---|---|---|---|
| * | Value exceeds Maximum Contaminant Level. | B | Analyte detected in the associated Method Blank |
| D | Sample Diluted Due to Matrix | E | Above Quantitation Range/Estimated Value |
| H | Holding times for preparation or analysis exceeded | J | Analyte detected below quantitation limits |
| ND | Not Detected at the Reporting Limit | P | Sample pH Not In Range |
| PQL | Practical Quanitative Limit | RL | Reporting Limit |
| S | % Recovery outside of standard limits. If undiluted results may be estimated. | | |

**Analytical Report**
Lab Order: **2311D11**
Date Reported: **1/12/2024**

## Hall Environmental Analysis Laboratory, Inc.

| | | | |
|---|---|---|---|
| **CLIENT:** | Marathon | **Client Sample ID:** | Trip Blank |
| **Project:** | Gallup SMWU and AOC Investigation | **Collection Date:** | |
| **Lab ID:** | 2311D11-002A | **Matrix:** | Trip Blank |

| Analyses | Result | MDL | RL | Qual | Units | DF | Date Analyzed | Batch ID |
|---|---|---|---|---|---|---|---|---|
| **EPA METHOD 8260B: VOLATILES** | | | | | | | Analyst: **CCM** | |
| Benzene | ND | 0.23 | 1.0 | | µg/L | 1 | 12/7/2023 4:15:00 PM | R10167 |
| Toluene | ND | 0.25 | 1.0 | | µg/L | 1 | 12/7/2023 4:15:00 PM | R10167 |
| Ethylbenzene | ND | 0.21 | 1.0 | | µg/L | 1 | 12/7/2023 4:15:00 PM | R10167 |
| Naphthalene | ND | 0.24 | 2.0 | | µg/L | 1 | 12/7/2023 4:15:00 PM | R10167 |
| 1-Methylnaphthalene | ND | 2.0 | 4.0 | | µg/L | 1 | 12/7/2023 4:15:00 PM | R10167 |
| 2-Methylnaphthalene | ND | 2.0 | 4.0 | | µg/L | 1 | 12/7/2023 4:15:00 PM | R10167 |
| Methylene Chloride | ND | 1.2 | 3.0 | | µg/L | 1 | 12/7/2023 4:15:00 PM | R10167 |
| Surr: 1,2-Dichloroethane-d4 | 99.5 | 0 | 70-130 | | %Rec | 1 | 12/7/2023 4:15:00 PM | R10167 |
| Surr: 4-Bromofluorobenzene | 102 | 0 | 70-130 | | %Rec | 1 | 12/7/2023 4:15:00 PM | R10167 |
| Surr: Dibromofluoromethane | 101 | 0 | 70-130 | | %Rec | 1 | 12/7/2023 4:15:00 PM | R10167 |
| Surr: Toluene-d8 | 91.8 | 0 | 70-130 | | %Rec | 1 | 12/7/2023 4:15:00 PM | R10167 |

Refer to the QC Summary report and sample login checklist for flagged QC data and preservation information.

**Qualifiers:**

| | | | |
|---|---|---|---|
| * | Value exceeds Maximum Contaminant Level. | B | Analyte detected in the associated Method Blank |
| D | Sample Diluted Due to Matrix | E | Above Quantitation Range/Estimated Value |
| H | Holding times for preparation or analysis exceeded | J | Analyte detected below quantitation limits |
| ND | Not Detected at the Reporting Limit | P | Sample pH Not In Range |
| PQL | Practical Quanitative Limit | RL | Reporting Limit |
| S | % Recovery outside of standard limits. If undiluted results may be estimated. | | |

# QC SUMMARY REPORT

## Hall Environmental Analysis Laboratory, Inc.

WO#: **2311D11**

*12-Jan-24*

**Client:** Marathon

**Project:** Gallup SMWU and AOC Investigation

| Sample ID: **MB** | SampType: **MBLK** | TestCode: **EPA Method 6020A: Dissolved Metals** | | |
|---|---|---|---|---|
| Client ID: **PBW** | Batch ID: **A102018** | RunNo: **102018** | | |
| Prep Date: | Analysis Date: **12/21/2023** | SeqNo: **3764481** | Units: **mg/L** | |

| Analyte | Result | PQL | SPK value | SPK Ref Val | %REC | LowLimit | HighLimit | %RPD | RPDLimit | Qual |
|---|---|---|---|---|---|---|---|---|---|---|
| Iron | ND | 0.020 | | | | | | | | |
| Selenium | ND | 0.0010 | | | | | | | | |

| Sample ID: **LCSLL** | SampType: **LCSLL** | TestCode: **EPA Method 6020A: Dissolved Metals** | | |
|---|---|---|---|---|
| Client ID: **BatchQC** | Batch ID: **A102018** | RunNo: **102018** | | |
| Prep Date: | Analysis Date: **12/21/2023** | SeqNo: **3764482** | Units: **mg/L** | |

| Analyte | Result | PQL | SPK value | SPK Ref Val | %REC | LowLimit | HighLimit | %RPD | RPDLimit | Qual |
|---|---|---|---|---|---|---|---|---|---|---|
| Iron | 0.021 | 0.020 | 0.02000 | 0 | 104 | 70 | 130 | | | |
| Selenium | 0.0015 | 0.0010 | 0.001000 | 0 | 149 | 70 | 130 | | | S |

| Sample ID: **LCS** | SampType: **LCS** | TestCode: **EPA Method 6020A: Dissolved Metals** | | |
|---|---|---|---|---|
| Client ID: **LCSW** | Batch ID: **A102018** | RunNo: **102018** | | |
| Prep Date: | Analysis Date: **12/21/2023** | SeqNo: **3764483** | Units: **mg/L** | |

| Analyte | Result | PQL | SPK value | SPK Ref Val | %REC | LowLimit | HighLimit | %RPD | RPDLimit | Qual |
|---|---|---|---|---|---|---|---|---|---|---|
| Iron | 2.5 | 0.020 | 2.500 | 0 | 101 | 80 | 120 | | | |
| Selenium | 0.052 | 0.0010 | 0.05000 | 0 | 104 | 80 | 120 | | | |

| Sample ID: **MB** | SampType: **MBLK** | TestCode: **EPA Method 6020A: Dissolved Metals** | | |
|---|---|---|---|---|
| Client ID: **PBW** | Batch ID: **A102048** | RunNo: **102048** | | |
| Prep Date: | Analysis Date: **12/22/2023** | SeqNo: **3765927** | Units: **mg/L** | |

| Analyte | Result | PQL | SPK value | SPK Ref Val | %REC | LowLimit | HighLimit | %RPD | RPDLimit | Qual |
|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic | ND | 0.0010 | | | | | | | | |

| Sample ID: **LCSLL** | SampType: **LCSLL** | TestCode: **EPA Method 6020A: Dissolved Metals** | | |
|---|---|---|---|---|
| Client ID: **BatchQC** | Batch ID: **A102048** | RunNo: **102048** | | |
| Prep Date: | Analysis Date: **12/22/2023** | SeqNo: **3765928** | Units: **mg/L** | |

| Analyte | Result | PQL | SPK value | SPK Ref Val | %REC | LowLimit | HighLimit | %RPD | RPDLimit | Qual |
|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic | 0.0010 | 0.0010 | 0.001000 | 0 | 101 | 70 | 130 | | | |

| Sample ID: **LCS** | SampType: **LCS** | TestCode: **EPA Method 6020A: Dissolved Metals** | | |
|---|---|---|---|---|
| Client ID: **LCSW** | Batch ID: **A102048** | RunNo: **102048** | | |
| Prep Date: | Analysis Date: **12/22/2023** | SeqNo: **3765929** | Units: **mg/L** | |

| Analyte | Result | PQL | SPK value | SPK Ref Val | %REC | LowLimit | HighLimit | %RPD | RPDLimit | Qual |
|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic | 0.049 | 0.0010 | 0.05000 | 0 | 98.9 | 80 | 120 | | | |

**Qualifiers:**

| | | | |
|---|---|---|---|
| * | Value exceeds Maximum Contaminant Level. | B | Analyte detected in the associated Method Blank |
| D | Sample Diluted Due to Matrix | E | Above Quantitation Range/Estimated Value |
| H | Holding times for preparation or analysis exceeded | J | Analyte detected below quantitation limits |
| ND | Not Detected at the Reporting Limit | P | Sample pH Not In Range |
| PQL | Practical Quanitative Limit | RL | Reporting Limit |
| S | % Recovery outside of standard limits. If undiluted results may be estimated. | | |

# QC SUMMARY REPORT

## Hall Environmental Analysis Laboratory, Inc.

WO#: **2311D11**
*12-Jan-24*

**Client:** Marathon
**Project:** Gallup SMWU and AOC Investigation

Sample ID: **MB-79067** SampType: **MBLK** TestCode: **EPA Method 6020A: Total Metals**
Client ID: **PBW** Batch ID: **79067** RunNo: **101585**
Prep Date: **11/30/2023** Analysis Date: **12/4/2023** SeqNo: **3740888** Units: **mg/L**

| Analyte | Result | PQL | SPK value | SPK Ref Val | %REC | LowLimit | HighLimit | %RPD | RPDLimit | Qual |
|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic | ND | 0.0010 | | | | | | | | |
| Lead | ND | 0.0010 | | | | | | | | |
| Selenium | ND | 0.0010 | | | | | | | | |

Sample ID: **MSLCSLL-79067** SampType: **LCSLL** TestCode: **EPA Method 6020A: Total Metals**
Client ID: **BatchQC** Batch ID: **79067** RunNo: **101585**
Prep Date: **11/30/2023** Analysis Date: **12/4/2023** SeqNo: **3740889** Units: **mg/L**

| Analyte | Result | PQL | SPK value | SPK Ref Val | %REC | LowLimit | HighLimit | %RPD | RPDLimit | Qual |
|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic | 0.0012 | 0.0010 | 0.001000 | 0 | 119 | 70 | 130 | | | |
| Lead | 0.00093 | 0.0010 | 0.001000 | 0 | 92.9 | 70 | 130 | | | J |
| Selenium | 0.0011 | 0.0010 | 0.001000 | 0 | 112 | 70 | 130 | | | |

Sample ID: **MSLCS-79067** SampType: **LCS** TestCode: **EPA Method 6020A: Total Metals**
Client ID: **LCSW** Batch ID: **79067** RunNo: **101585**
Prep Date: **11/30/2023** Analysis Date: **12/4/2023** SeqNo: **3740890** Units: **mg/L**

| Analyte | Result | PQL | SPK value | SPK Ref Val | %REC | LowLimit | HighLimit | %RPD | RPDLimit | Qual |
|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic | 0.049 | 0.0010 | 0.05000 | 0 | 97.9 | 80 | 120 | | | |
| Lead | 0.050 | 0.0010 | 0.05000 | 0 | 101 | 80 | 120 | | | |
| Selenium | 0.051 | 0.0010 | 0.05000 | 0 | 101 | 80 | 120 | | | |

Sample ID: **2311D11-001CMSLL** SampType: **MS** TestCode: **EPA Method 6020A: Total Metals**
Client ID: **East NAPIS** Batch ID: **79067** RunNo: **101585**
Prep Date: **11/30/2023** Analysis Date: **12/4/2023** SeqNo: **3740982** Units: **mg/L**

| Analyte | Result | PQL | SPK value | SPK Ref Val | %REC | LowLimit | HighLimit | %RPD | RPDLimit | Qual |
|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic | 0.052 | 0.0010 | 0.05000 | 0.0005687 | 102 | 75 | 125 | | | |
| Lead | 0.052 | 0.0010 | 0.05000 | 0 | 105 | 75 | 125 | | | |

Sample ID: **2311D11-001CMSDL** SampType: **MSD** TestCode: **EPA Method 6020A: Total Metals**
Client ID: **East NAPIS** Batch ID: **79067** RunNo: **101585**
Prep Date: **11/30/2023** Analysis Date: **12/4/2023** SeqNo: **3740983** Units: **mg/L**

| Analyte | Result | PQL | SPK value | SPK Ref Val | %REC | LowLimit | HighLimit | %RPD | RPDLimit | Qual |
|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic | 0.042 | 0.0010 | 0.05000 | 0.0005687 | 82.1 | 75 | 125 | 21.8 | 20 | R |
| Lead | 0.042 | 0.0010 | 0.05000 | 0 | 83.4 | 75 | 125 | 22.6 | 20 | R |

**Qualifiers:**

| | | | |
|---|---|---|---|
| * | Value exceeds Maximum Contaminant Level. | B | Analyte detected in the associated Method Blank |
| D | Sample Diluted Due to Matrix | E | Above Quantitation Range/Estimated Value |
| H | Holding times for preparation or analysis exceeded | J | Analyte detected below quantitation limits |
| ND | Not Detected at the Reporting Limit | P | Sample pH Not In Range |
| PQL | Practical Quanitative Limit | RL | Reporting Limit |
| S | % Recovery outside of standard limits. If undiluted results may be estimated. | | |

# QC SUMMARY REPORT

## Hall Environmental Analysis Laboratory, Inc.

WO#: **2311D11**
*12-Jan-24*

**Client:** Marathon
**Project:** Gallup SMWU and AOC Investigation

| | | | | | |
|---|---|---|---|---|---|
| Sample ID: | **MB-79076** | SampType: | **MBLK** | TestCode: | **EPA Method 8015M/D: Diesel Range** |
| Client ID: | **PBW** | Batch ID: | **79076** | RunNo: | **101555** |
| Prep Date: | **11/30/2023** | Analysis Date: | **12/2/2023** | SeqNo: | **3739086** Units: **mg/L** |

| Analyte | Result | PQL | SPK value | SPK Ref Val | %REC | LowLimit | HighLimit | %RPD | RPDLimit | Qual |
|---|---|---|---|---|---|---|---|---|---|---|
| Diesel Range Organics (DRO) | ND | 1.0 | | | | | | | | |
| Motor Oil Range Organics (MRO) | ND | 5.0 | | | | | | | | |
| Surr: DNOP | 0.46 | | 0.5000 | | 91.3 | 54.5 | 177 | | | |

| | | | | | |
|---|---|---|---|---|---|
| Sample ID: | **LCS-79076** | SampType: | **LCS** | TestCode: | **EPA Method 8015M/D: Diesel Range** |
| Client ID: | **LCSW** | Batch ID: | **79076** | RunNo: | **101555** |
| Prep Date: | **11/30/2023** | Analysis Date: | **12/2/2023** | SeqNo: | **3739087** Units: **mg/L** |

| Analyte | Result | PQL | SPK value | SPK Ref Val | %REC | LowLimit | HighLimit | %RPD | RPDLimit | Qual |
|---|---|---|---|---|---|---|---|---|---|---|
| Diesel Range Organics (DRO) | 1.4 | 1.0 | 2.500 | 0 | 57.5 | 57 | 147 | | | |
| Surr: DNOP | 0.14 | | 0.2500 | | 56.7 | 54.5 | 177 | | | |

**Qualifiers:**

| | | | |
|---|---|---|---|
| * | Value exceeds Maximum Contaminant Level. | B | Analyte detected in the associated Method Blank |
| D | Sample Diluted Due to Matrix | E | Above Quantitation Range/Estimated Value |
| H | Holding times for preparation or analysis exceeded | J | Analyte detected below quantitation limits |
| ND | Not Detected at the Reporting Limit | P | Sample pH Not In Range |
| PQL | Practical Quanitative Limit | RL | Reporting Limit |
| S | % Recovery outside of standard limits. If undiluted results may be estimated. | | |

# QC SUMMARY REPORT

## Hall Environmental Analysis Laboratory, Inc.

WO#: **2311D11**

*12-Jan-24*

**Client:** Marathon

**Project:** Gallup SMWU and AOC Investigation

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sample ID: **2.5ug gro lcs-ii** | | SampType: **LCS** | | | TestCode: **EPA Method 8015D: Gasoline Range** | | | | | |
| Client ID: **LCSW** | | Batch ID: **GWW101533** | | | RunNo: **101533** | | | | | |
| Prep Date: | | Analysis Date: **12/1/2023** | | | SeqNo: **3739686** | | Units: **mg/L** | | | |
| Analyte | Result | PQL | SPK value | SPK Ref Val | %REC | LowLimit | HighLimit | %RPD | RPDLimit | Qual |
| Gasoline Range Organics (GRO) | 0.46 | 0.050 | 0.5000 | 0 | 91.8 | 70 | 130 | | | |
| Surr: BFB | 39 | | 20.00 | | 195 | 15 | 270 | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sample ID: **mb-ii** | | SampType: **MBLK** | | | TestCode: **EPA Method 8015D: Gasoline Range** | | | | | |
| Client ID: **PBW** | | Batch ID: **GWW101533** | | | RunNo: **101533** | | | | | |
| Prep Date: | | Analysis Date: **12/2/2023** | | | SeqNo: **3739688** | | Units: **mg/L** | | | |
| Analyte | Result | PQL | SPK value | SPK Ref Val | %REC | LowLimit | HighLimit | %RPD | RPDLimit | Qual |
| Gasoline Range Organics (GRO) | 0.0098 | 0.050 | | | | | | | | J |
| Surr: BFB | 18 | | 20.00 | | 91.4 | 15 | 270 | | | |

**Qualifiers:**

| | | | |
|---|---|---|---|
| * | Value exceeds Maximum Contaminant Level. | B | Analyte detected in the associated Method Blank |
| D | Sample Diluted Due to Matrix | E | Above Quantitation Range/Estimated Value |
| H | Holding times for preparation or analysis exceeded | J | Analyte detected below quantitation limits |
| ND | Not Detected at the Reporting Limit | P | Sample pH Not In Range |
| PQL | Practical Quanitative Limit | RL | Reporting Limit |
| S | % Recovery outside of standard limits. If undiluted results may be estimated. | | |

# QC SUMMARY REPORT

## Hall Environmental Analysis Laboratory, Inc.

WO#: **2311D11**

*12-Jan-24*

**Client:** Marathon

**Project:** Gallup SMWU and AOC Investigation

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sample ID: **100ng lcs** | | SampType: **LCS** | | | TestCode: **EPA Method 8260B: VOLATILES** | | | | | |
| Client ID: **LCSW** | | Batch ID: **R101678** | | | RunNo: **101678** | | | | | |
| Prep Date: | | Analysis Date: **12/7/2023** | | | SeqNo: **3746385** | | Units: **µg/L** | | | |
| Analyte | Result | PQL | SPK value | SPK Ref Val | %REC | LowLimit | HighLimit | %RPD | RPDLimit | Qual |
| Benzene | 20 | 1.0 | 20.00 | 0 | 100 | 70 | 130 | | | |
| Toluene | 19 | 1.0 | 20.00 | 0 | 93.9 | 70 | 130 | | | |
| Surr: 1,2-Dichloroethane-d4 | 9.9 | | 10.00 | | 98.9 | 70 | 130 | | | |
| Surr: 4-Bromofluorobenzene | 10 | | 10.00 | | 103 | 70 | 130 | | | |
| Surr: Dibromofluoromethane | 9.9 | | 10.00 | | 99.2 | 70 | 130 | | | |
| Surr: Toluene-d8 | 9.4 | | 10.00 | | 93.6 | 70 | 130 | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sample ID: **mb** | | SampType: **MBLK** | | | TestCode: **EPA Method 8260B: VOLATILES** | | | | | |
| Client ID: **PBW** | | Batch ID: **R101678** | | | RunNo: **101678** | | | | | |
| Prep Date: | | Analysis Date: **12/7/2023** | | | SeqNo: **3746386** | | Units: **µg/L** | | | |
| Analyte | Result | PQL | SPK value | SPK Ref Val | %REC | LowLimit | HighLimit | %RPD | RPDLimit | Qual |
| Benzene | ND | 1.0 | | | | | | | | |
| Toluene | ND | 1.0 | | | | | | | | |
| Ethylbenzene | ND | 1.0 | | | | | | | | |
| Naphthalene | ND | 2.0 | | | | | | | | |
| 1-Methylnaphthalene | ND | 4.0 | | | | | | | | |
| 2-Methylnaphthalene | ND | 4.0 | | | | | | | | |
| Methylene Chloride | ND | 3.0 | | | | | | | | |
| Surr: 1,2-Dichloroethane-d4 | 10 | | 10.00 | | 102 | 70 | 130 | | | |
| Surr: 4-Bromofluorobenzene | 10 | | 10.00 | | 103 | 70 | 130 | | | |
| Surr: Dibromofluoromethane | 10 | | 10.00 | | 101 | 70 | 130 | | | |
| Surr: Toluene-d8 | 9.3 | | 10.00 | | 93.0 | 70 | 130 | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sample ID: **2311D11-001ams** | | SampType: **MS** | | | TestCode: **EPA Method 8260B: VOLATILES** | | | | | |
| Client ID: **East NAPIS** | | Batch ID: **R101678** | | | RunNo: **101678** | | | | | |
| Prep Date: | | Analysis Date: **12/7/2023** | | | SeqNo: **3746395** | | Units: **µg/L** | | | |
| Analyte | Result | PQL | SPK value | SPK Ref Val | %REC | LowLimit | HighLimit | %RPD | RPDLimit | Qual |
| Benzene | 20 | 1.0 | 20.00 | 0 | 101 | 70 | 130 | | | |
| Toluene | 19 | 1.0 | 20.00 | 0 | 94.8 | 70 | 130 | | | |
| Surr: 1,2-Dichloroethane-d4 | 9.6 | | 10.00 | | 96.4 | 70 | 130 | | | |
| Surr: 4-Bromofluorobenzene | 10 | | 10.00 | | 103 | 70 | 130 | | | |
| Surr: Dibromofluoromethane | 10 | | 10.00 | | 99.6 | 70 | 130 | | | |
| Surr: Toluene-d8 | 9.3 | | 10.00 | | 93.2 | 70 | 130 | | | |

**Qualifiers:**

| | | | |
|---|---|---|---|
| * | Value exceeds Maximum Contaminant Level. | B | Analyte detected in the associated Method Blank |
| D | Sample Diluted Due to Matrix | E | Above Quantitation Range/Estimated Value |
| H | Holding times for preparation or analysis exceeded | J | Analyte detected below quantitation limits |
| ND | Not Detected at the Reporting Limit | P | Sample pH Not In Range |
| PQL | Practical Quanitative Limit | RL | Reporting Limit |
| S | % Recovery outside of standard limits. If undiluted results may be estimated. | | |

# QC SUMMARY REPORT

## Hall Environmental Analysis Laboratory, Inc.

WO#: **2311D11**

*12-Jan-24*

**Client:** Marathon

**Project:** Gallup SMWU and AOC Investigation

| | | | | | |
|---|---|---|---|---|---|
| Sample ID: | **2311D11-001amsd** | SampType: | **MSD** | TestCode: | **EPA Method 8260B: VOLATILES** |
| Client ID: | **East NAPIS** | Batch ID: | **R101678** | RunNo: | **101678** |
| Prep Date: | | Analysis Date: | **12/7/2023** | SeqNo: | **3746396** Units: **µg/L** |

| Analyte | Result | PQL | SPK value | SPK Ref Val | %REC | LowLimit | HighLimit | %RPD | RPDLimit | Qual |
|---|---|---|---|---|---|---|---|---|---|---|
| Benzene | 19 | 1.0 | 20.00 | 0 | 96.2 | 70 | 130 | 4.78 | 20 | |
| Toluene | 18 | 1.0 | 20.00 | 0 | 90.6 | 70 | 130 | 4.53 | 20 | |
| Surr: 1,2-Dichloroethane-d4 | 9.8 | | 10.00 | | 97.8 | 70 | 130 | 0 | 0 | |
| Surr: 4-Bromofluorobenzene | 10 | | 10.00 | | 102 | 70 | 130 | 0 | 0 | |
| Surr: Dibromofluoromethane | 9.7 | | 10.00 | | 97.3 | 70 | 130 | 0 | 0 | |
| Surr: Toluene-d8 | 9.2 | | 10.00 | | 92.3 | 70 | 130 | 0 | 0 | |

**Qualifiers:**

| | | | |
|---|---|---|---|
| * | Value exceeds Maximum Contaminant Level. | B | Analyte detected in the associated Method Blank |
| D | Sample Diluted Due to Matrix | E | Above Quantitation Range/Estimated Value |
| H | Holding times for preparation or analysis exceeded | J | Analyte detected below quantitation limits |
| ND | Not Detected at the Reporting Limit | P | Sample pH Not In Range |
| PQL | Practical Quanitative Limit | RL | Reporting Limit |
| S | % Recovery outside of standard limits. If undiluted results may be estimated. | | |

# QC SUMMARY REPORT

## Hall Environmental Analysis Laboratory, Inc.

WO#: **2311D11**

*12-Jan-24*

**Client:** Marathon

**Project:** Gallup SMWU and AOC Investigation

Sample ID: **MB-79607** SampType: **MBLK** TestCode: **EPA Method 7470A: Mercury**

Client ID: **PBW** Batch ID: **79607** RunNo: **102124**

Prep Date: **12/27/2023** Analysis Date: **12/28/2023** SeqNo: **3769287** Units: **mg/L**

| Analyte | Result | PQL | SPK value | SPK Ref Val | %REC | LowLimit | HighLimit | %RPD | RPDLimit | Qual |
|---|---|---|---|---|---|---|---|---|---|---|
| Mercury | ND | 0.00020 | | | | | | | | |

Sample ID: **LCSLL-79607** SampType: **LCSLL** TestCode: **EPA Method 7470A: Mercury**

Client ID: **BatchQC** Batch ID: **79607** RunNo: **102124**

Prep Date: **12/27/2023** Analysis Date: **12/28/2023** SeqNo: **3769288** Units: **mg/L**

| Analyte | Result | PQL | SPK value | SPK Ref Val | %REC | LowLimit | HighLimit | %RPD | RPDLimit | Qual |
|---|---|---|---|---|---|---|---|---|---|---|
| Mercury | 0.00013 | 0.00020 | 0.0001500 | 0 | 85.6 | 50 | 150 | | | J |

Sample ID: **LCS-79607** SampType: **LCS** TestCode: **EPA Method 7470A: Mercury**

Client ID: **LCSW** Batch ID: **79607** RunNo: **102124**

Prep Date: **12/27/2023** Analysis Date: **12/28/2023** SeqNo: **3769289** Units: **mg/L**

| Analyte | Result | PQL | SPK value | SPK Ref Val | %REC | LowLimit | HighLimit | %RPD | RPDLimit | Qual |
|---|---|---|---|---|---|---|---|---|---|---|
| Mercury | 0.0049 | 0.00020 | 0.005000 | 0 | 97.5 | 85 | 115 | | | |

**Qualifiers:**

| | | | |
|---|---|---|---|
| * | Value exceeds Maximum Contaminant Level. | B | Analyte detected in the associated Method Blank |
| D | Sample Diluted Due to Matrix | E | Above Quantitation Range/Estimated Value |
| H | Holding times for preparation or analysis exceeded | J | Analyte detected below quantitation limits |
| ND | Not Detected at the Reporting Limit | P | Sample pH Not In Range |
| PQL | Practical Quanitative Limit | RL | Reporting Limit |
| S | % Recovery outside of standard limits. If undiluted results may be estimated. | | |

# QC SUMMARY REPORT

## Hall Environmental Analysis Laboratory, Inc.

WO#: **2311D11**

*12-Jan-24*

**Client:** Marathon

**Project:** Gallup SMWU and AOC Investigation

| | | | | | |
|---|---|---|---|---|---|
| Sample ID: | **MB-A** | SampType: | **MBLK** | TestCode: | **EPA Method 6010B: Dissolved Metals** |
| Client ID: | **PBW** | Batch ID: | **A101811** | RunNo: | **101811** |
| Prep Date: | | Analysis Date: | **12/13/2023** | SeqNo: | **3754073** Units: **mg/L** |

| Analyte | Result | PQL | SPK value | SPK Ref Val | %REC | LowLimit | HighLimit | %RPD | RPDLimit | Qual |
|---|---|---|---|---|---|---|---|---|---|---|
| Barium | ND | 0.020 | | | | | | | | |
| Cadmium | ND | 0.0020 | | | | | | | | |
| Chromium | ND | 0.0060 | | | | | | | | |
| Silver | ND | 0.0050 | | | | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Sample ID: | **LCS-A** | SampType: | **LCS** | TestCode: | **EPA Method 6010B: Dissolved Metals** |
| Client ID: | **LCSW** | Batch ID: | **A101811** | RunNo: | **101811** |
| Prep Date: | | Analysis Date: | **12/13/2023** | SeqNo: | **3754075** Units: **mg/L** |

| Analyte | Result | PQL | SPK value | SPK Ref Val | %REC | LowLimit | HighLimit | %RPD | RPDLimit | Qual |
|---|---|---|---|---|---|---|---|---|---|---|
| Barium | 0.48 | 0.020 | 0.5000 | 0 | 95.2 | 80 | 120 | | | |
| Cadmium | 0.48 | 0.0020 | 0.5000 | 0 | 95.9 | 80 | 120 | | | |
| Chromium | 0.48 | 0.0060 | 0.5000 | 0 | 96.5 | 80 | 120 | | | |
| Silver | 0.47 | 0.0050 | 0.5000 | 0 | 94.5 | 80 | 120 | | | |

**Qualifiers:**

| | | | |
|---|---|---|---|
| * | Value exceeds Maximum Contaminant Level. | B | Analyte detected in the associated Method Blank |
| D | Sample Diluted Due to Matrix | E | Above Quantitation Range/Estimated Value |
| H | Holding times for preparation or analysis exceeded | J | Analyte detected below quantitation limits |
| ND | Not Detected at the Reporting Limit | P | Sample pH Not In Range |
| PQL | Practical Quanitative Limit | RL | Reporting Limit |
| S | % Recovery outside of standard limits. If undiluted results may be estimated. | | |

# QC SUMMARY REPORT

## Hall Environmental Analysis Laboratory, Inc.

WO#: **2311D11**

*12-Jan-24*

**Client:** Marathon

**Project:** Gallup SMWU and AOC Investigation

Sample ID: **MB-79067** SampType: **MBLK** TestCode: **EPA 6010B: Total Recoverable Metals**

Client ID: **PBW** Batch ID: **79067** RunNo: **101646**

Prep Date: **11/30/2023** Analysis Date: **12/6/2023** SeqNo: **3743753** Units: **mg/L**

| Analyte | Result | PQL | SPK value | SPK Ref Val | %REC | LowLimit | HighLimit | %RPD | RPDLimit | Qual |
|---|---|---|---|---|---|---|---|---|---|---|
| Barium | ND | 0.0020 | | | | | | | | |
| Cadmium | ND | 0.0020 | | | | | | | | |
| Chromium | ND | 0.0060 | | | | | | | | |
| Silver | ND | 0.0050 | | | | | | | | |

Sample ID: **LCS-79067** SampType: **LCS** TestCode: **EPA 6010B: Total Recoverable Metals**

Client ID: **LCSW** Batch ID: **79067** RunNo: **101646**

Prep Date: **11/30/2023** Analysis Date: **12/6/2023** SeqNo: **3743755** Units: **mg/L**

| Analyte | Result | PQL | SPK value | SPK Ref Val | %REC | LowLimit | HighLimit | %RPD | RPDLimit | Qual |
|---|---|---|---|---|---|---|---|---|---|---|
| Barium | 0.47 | 0.0020 | 0.5000 | 0 | 93.5 | 80 | 120 | | | |
| Cadmium | 0.46 | 0.0020 | 0.5000 | 0 | 91.4 | 80 | 120 | | | |
| Chromium | 0.45 | 0.0060 | 0.5000 | 0 | 89.0 | 80 | 120 | | | |
| Silver | 0.092 | 0.0050 | 0.1000 | 0 | 92.0 | 80 | 120 | | | |

**Qualifiers:**

| | | | |
|---|---|---|---|
| * | Value exceeds Maximum Contaminant Level. | B | Analyte detected in the associated Method Blank |
| D | Sample Diluted Due to Matrix | E | Above Quantitation Range/Estimated Value |
| H | Holding times for preparation or analysis exceeded | J | Analyte detected below quantitation limits |
| ND | Not Detected at the Reporting Limit | P | Sample pH Not In Range |
| PQL | Practical Quanitative Limit | RL | Reporting Limit |
| S | % Recovery outside of standard limits. If undiluted results may be estimated. | | |

eurofins
Environment Testing

*Eurofins Environment Testing South Central, LLC*
*4901 Hawkins NE*
*Albuquerque, NM 87109*
*TEL: 505-345-3975 FAX: 505-345-4107*
*Website: www.hallenvironmental.com*

# Sample Log-In Check List

Client Name: **Marathon**
Work Order Number: **2311D11**
RcptNo: **1**

Received By: **Cheyenne Cason** **11/29/2023 7:30:00 AM**
Completed By: **Cheyenne Cason** **11/29/2023 7:41:42 AM**
Reviewed By: JN 11/29/23

## Chain of Custody

1. Is Chain of Custody complete? Yes ☑ No ☐ Not Present ☐
2. How was the sample delivered? Courier

## Log In

3. Was an attempt made to cool the samples? Yes ☑ No ☐ NA ☐
4. Were all samples received at a temperature of >0° C to 6.0°C Yes ☑ No ☐ NA ☐
5. Sample(s) in proper container(s)? Yes ☑ No ☐
6. Sufficient sample volume for indicated test(s)? Yes ☑ No ☐
7. Are samples (except VOA and ONG) properly preserved? Yes ☑ No ☐
8. Was preservative added to bottles? Yes ☐ No ☑ NA ☐
9. Received at least 1 vial with headspace <1/4" for AQ VOA? Yes ☑ No ☐ NA ☐
10. Were any sample containers received broken? Yes ☐ No ☑
11. Does paperwork match bottle labels? Yes ☑ No ☐
(Note discrepancies on chain of custody)
12. Are matrices correctly identified on Chain of Custody? Yes ☑ No ☐
13. Is it clear what analyses were requested? Yes ☑ No ☐
14. Were all holding times able to be met? Yes ☑ No ☐
(If no, notify customer for authorization.)

# of preserved bottles checked for pH: 2
([✓ <2] or >12 unless noted)
Adjusted? NO
Checked by: SCM 11/29/23

## Special Handling (if applicable)

15. Was client notified of all discrepancies with this order? Yes ☐ No ☐ NA ☑

Person Notified:
Date:
By Whom:
Via: ☐ eMail ☐ Phone ☐ Fax ☐ In Person
Regarding:
Client Instructions:

16. Additional remarks: TRIP BLANKS NOT PROVIDED BY EUROFINS. SCM 11/29/23

17. Cooler Information

| Cooler No | Temp °C | Condition | Seal Intact | Seal No | Seal Date | Signed By |
|---|---|---|---|---|---|---|
| 1 | 1.7 | Good | Not Present | Morty | | |

# Chain-of-Custody Record

Client: Marathon Petroleum

Mailing Address: 92 Giant Crossing
Jamestown, NM, 87471
Phone #: (505) 430-9485
email or Fax#: hilariotrejo83@yahoo.com
QA/QC Package:
☒ Standard ☐ Level 4 (Full Validation)
Accreditation: ☐ Az Compliance
☐ NELAC ☐ Other
☐ EDD (Type)

Turn-Around Time:
☒ Standard ☐ Rush
Project Name:
Gallup SMWU and AOC Investigation
Project #:
00697-097-001
Project Manager:
Caitlin Fields
Sampler:
On Ice: ☒ Yes ☐ No Mary
# of Coolers: 1
Cooler Temp(including CF): 1.6+0.1=1.7 (°C)

**HALL ENVIRONMENTAL ANALYSIS LABORATORY**
www.hallenvironmental.com
4901 Hawkins NE - Albuquerque, NM 87109
Tel. 505-345-3975 Fax 505-345-4107

## Analysis Request

| Date | Time | Matrix | Sample Name | Container Type and # | Preservative Type | HEAL No. 2311011 | BTEX / MTBE / TMB's (8021) | TPH:8015D(GRO / DRO / MRO) | 8081 Pesticides/8082 PCB's | EDB (Method 504.1) | PAHs by 8310 or 8270SIMS | RCRA 8 Metals | Cl, F, Br, $NO_3$, $NO_2$, $PO_4$, $SO_4$ | 8260 (VOA) | 8270 (Semi-VOA) | Total Coliform (Present/Absent) | Metals /Dissolved/T | Mercury | Methylnaphtalene | 2 methylnaphtalene | Methylene chloride | Naphthalene |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11/28 | 9:45 | W | EAST NAPIS | 8 |  | 001 | X | X |  |  |  |  |  | X |  |  | X | X | X | X | X | X |
|  |  |  | Trip Blank |  |  | 002 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

| Date: | Time: | Relinquished by: | Received by: | Via: | Date | Time |
|---|---|---|---|---|---|---|
| 11/28 | 11:30 | Hilario Trejo | Ame | Courr | 11/29/23 | 0730 |
| Date: | Time: | Relinquished by: | Received by: | Via: | Date | Time |
|  |  |  |  |  |  |  |

Remarks:

If necessary, samples submitted to Hall Environmental may be subcontracted to other accredited laboratories. This serves as notice of this possibility. Any sub-contracted data will be clearly notated on the analytical report.

# Cheyenne Cason

**From:** Caitlin Fields <CFields@trihydro.com>
**Sent:** Wednesday, November 29, 2023 8:10 AM
**To:** Cheyenne Cason; hilariotrejo83@yahoo.com; Hilario Trejo
**Cc:** Desiree Dominguez
**Subject:** RE: Gallup SMWU and AOC Investigation

Hi Cheyenne,

I apologize for the miscommunication. Could you please sample the following analytes:

RCRA 8 Metals (Total and Dissolved)
Mercury (Total and Dissolved)
BTEX
1-methylnaphthalene
2-methylnaphthalene
Methylene chloride
Naphthalene

If there is enough sample remaining please also include DRO and GRO.

Thank you!
Caitlin

**From:** Cheyenne Cason <Cheyenne.Cason@et.eurofinsus.com>
**Sent:** Wednesday, November 29, 2023 7:57 AM
**To:** hilariotrejo83@yahoo.com; Caitlin Fields <CFields@trihydro.com>
**Cc:** Desiree Dominguez <Desiree.Dominguez@et.eurofinsus.com>
**Subject:** Gallup SMWU and AOC Investigation

Hi Hilario and Caitlin,

I am working on the 'Gallup SMWU and AOC Investigation' project we received today, I have a couple of questions. I need a list of metals you would like tested for as the COC only says "Metals/Dissolved Metals". I also wanted to let you know that we will be running 8260 but not 8021 since BTEX is included in that list. Also we were not provided a bottle for 8015DRO, we can pour off from the provided 1 Liter amber if you need but I wanted to make sure you do need it before I do anything. Please let me know as soon as possible so I can get these run.

*Cheyenne Cason*

**District I**
1625 N. French Dr., Hobbs, NM 88240
Phone:(575) 393-6161 Fax:(575) 393-0720
**District II**
811 S. First St., Artesia, NM 88210
Phone:(575) 748-1283 Fax:(575) 748-9720
**District III**
1000 Rio Brazos Rd., Aztec, NM 87410
Phone:(505) 334-6178 Fax:(505) 334-6170
**District IV**
1220 S. St Francis Dr., Santa Fe, NM 87505
Phone:(505) 476-3470 Fax:(505) 476-3462

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

CONDITIONS

Action 319231

## CONDITIONS

| | |
|---|---|
| Operator:<br>Western Refining Southwest LLC<br>539 South Main Street<br>Findlay, OH 45840 | OGRID:<br>267595 |
| | Action Number:<br>319231 |
| | Action Type:<br>[UF-DP] Discharge Permit (DISCHARGE PERMIT) |

**CONDITIONS**

| Created By | Condition | Condition Date |
|---|---|---|
| joel.stone | Approved for OCD record retention purposes. | 8/16/2024 |