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2017
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(1 of 7)

2018

HOLLYFRONTIER.

June 15, 2018

Mr. Carl Chavez
New Mexico Energy, Minerals and Natural Resources Department
Oil Conservation Division
1220 South St. Francis Drive
Santa Fe, NM 87505

Re: Submittal of the *2017 Annual Discharge Report* and the *2017 Annual Groundwater Monitoring Report* for the HollyFrontier Navajo Refining LLC, Artesia Refinery Discharge Permit GW-028

Dear Mr. Chavez:

Please find enclosed the original and one electronic copy of the *2017 Annual Discharge Report* and the *2017 Annual Groundwater Monitoring Report*, which fulfill requirements of Section 2.E of Discharge Permit GW-028.

If you have any questions or comments regarding this report, please feel free to contact me at 575-746-5487 or Randy Dade at 575-746-5281.

Sincerely,

Scott M. Denton
Environmental Manager
HollyFrontier Navajo Refining LLC

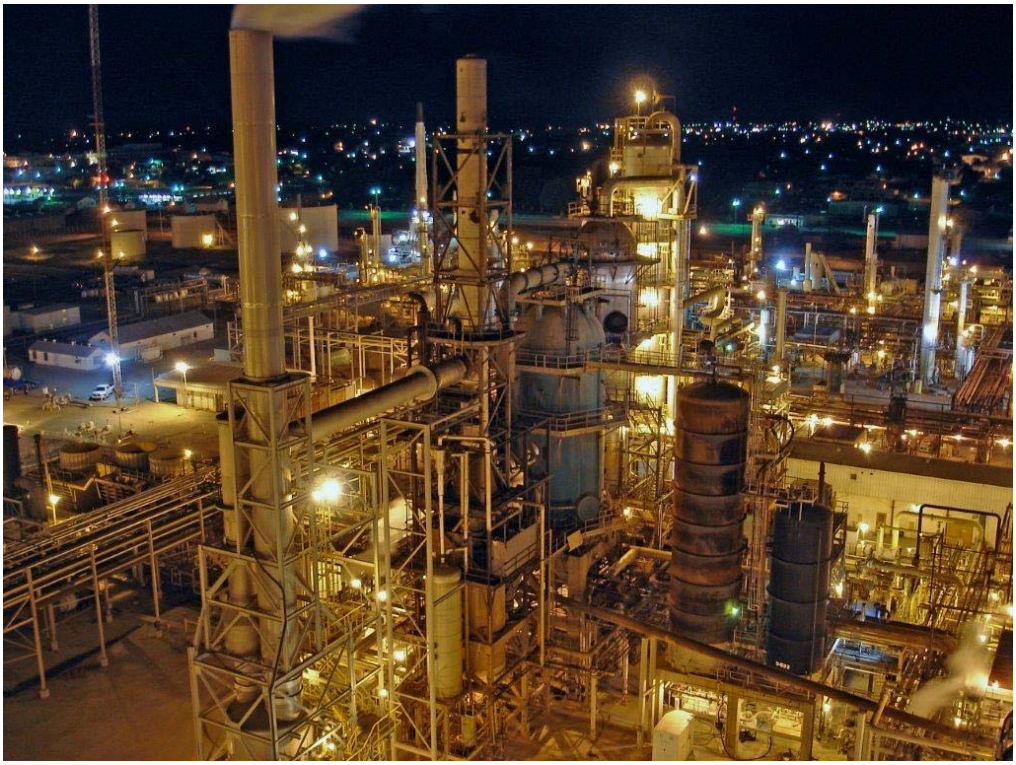
Gabriela McVace-Combs for Scott M. Denton.

cc: HFC: R. Dade, R. Combs, A. Sahba
TRC: J. Speer, C. Smith

Env. File: Env\OCD\OCD-Annual Report\2017\Artesia

2017 Annual Groundwater Monitoring Report

NMD048918817 and DP GW-028



HollyFrontier Navajo Refining LLC
Artesia Refinery
Artesia, New Mexico

February 2018

Prepared for:

HOLLYFRONTIER

HollyFrontier Navajo Refining LLC
Artesia, New Mexico

Prepared for:

TRC

TRC Environmental Corporation
Austin, Texas

2017 Annual Groundwater Monitoring Report

NMD048918817 and DP GW-028

HollyFrontier Navajo Refining LLC
Artesia Refinery
Artesia, New Mexico

Prepared for:

HollyFrontier Navajo Refining LLC
Artesia, New Mexico

Prepared by:

TRC Environmental Corporation
Austin, Texas

TRC Project No. 270077

February 2018

TRC Lead _____

Julie Speer, Project Manager

Certification

I certify under penalty of law that this document and all attachments were prepared under my direction or 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.

Scott M. Denton

Environmental Manager, HollyFrontier Navajo Refining LLC

EXECUTIVE SUMMARY

This *2017 Annual Groundwater Monitoring Report* documents groundwater monitoring and recovery activities conducted at the HollyFrontier Navajo Refining LLC (Navajo) Artesia Refinery (refinery) located at 501 East Main Street in Artesia, New Mexico. The refinery is subject to a Post-Closure Care Permit (PCC Permit) issued by the New Mexico Environment Department (NMED) in October 2003 and later modified in December 2010; as well as Discharge Permit GW-028 issued by New Mexico Energy, Minerals and Natural Resources Department Oil Conservation Division (OCD) on May 25, 2017. Both the PCC Permit and Discharge Permit require Navajo to conduct facility wide groundwater monitoring to evaluate the presence, nature, and extent of groundwater impacts; and to remediate impacted groundwater. This report provides the results of all groundwater monitoring and remedial activities that were conducted to satisfy both the NMED PCC Permit and the OCD Discharge Permit.

The groundwater monitoring program consists of semiannual well gauging and groundwater sampling in accordance with the *2016 Facility Wide Groundwater Monitoring Work Plan* (2016 FWGMWP) that was submitted to the NMED and OCD in June 2016 and approved on December 7, 2016, and the 2017 FWGMWP that was submitted to the NMED and OCD in June 2017 and approved with modifications on October 11, 2017. Remedial activities consist of recovery of phase-separated hydrocarbons (PSH) and impacted groundwater. The groundwater monitoring and remediation program covers the following refinery areas:

- The closed Tetra Ethyl Lead (TEL) Impoundment;
- The closed North Colony Landfarm (NCL);
- The inactive Evaporation Ponds (EPs)
- Three Mile Ditch (TMD); and
- The impacted vadose zone located beneath the refinery in the following other areas: Field East of Refinery, North Refinery, South Refinery, Reverse Osmosis (RO) Reject Fields, Cross-gradient of Refinery, and Up-gradient of Refinery.

The 2017 groundwater monitoring results indicate physical and chemical groundwater conditions are generally consistent with historical data. Groundwater predominantly flows to the east beneath the refinery towards the Pecos River, and to the southeast beneath the EPs. Measurable PSH was present in wells located at or near the EPs, Field East of Refinery, North Refinery, and South Refinery areas in 2017, with a maximum measured thickness of 2.45 feet during the first semiannual event and 1.25 feet during the second semiannual event. The presence and distribution of PSH in 2017 was generally consistent with historical data and measured PSH thicknesses are stable to decreasing over time. The following constituents of concern (COCs) were detected in groundwater at concentrations in exceedance of critical groundwater screening levels

(CGWSLs): total petroleum hydrocarbons (TPH) diesel range organics (DRO); select volatile organic compounds (VOCs) including target COCs benzene, toluene, ethylbenzene, xylenes, methyl tert-butyl ether (MTBE), and naphthalene; select total metals including target COC arsenic; and water quality parameters chloride, fluoride, sulfate, total dissolved solids (TDS), and nitrate/nitrite. COC concentrations in groundwater are generally stable to decreasing over time with the exception of occasional fluctuations. Increasing COC concentration trends observed in some wells since 2011 have generally exhibited stabilizing trends over the most recent three to six sampling events.

PSH and impacted groundwater were continually recovered at the refinery from a system of recovery trenches and recovery wells throughout 2017. An estimated 5,189,384 gallons of groundwater and 24,492 gallons of PSH were recovered through operation of the automated recovery systems in 2017.

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LIST OF ACRONYMS AND ABBREVIATIONS

1,2,4-TMB	1,2,4-Trimethylbenzene
1,3,5-TMB	1,3,5-Trimethylbenzene
cis-1,2,-DCE	cis-1,2,-Dicholoroethene
CGWSL	Critical Groundwater Screening Level
COC(s)	Constituent(s) of Concern
DRO	Diesel Range Organics
EP(s)	Evaporation Pond(s)
ESC	ESC Lab Sciences
FWGMWP	Facility Wide Groundwater Monitoring Workplan
GRO	Gasoline Range Organics
HMI	Hydrologic Monitoring, LLC
HWB	Hazardous Waste Bureau
Navajo	HollyFrontier Navajo Refining LLC
MCL	Maximum Contaminant Level
mg/L	Milligram per liter
MTBE	Methyl Tert-Butyl Ether
NCL	North Colony Landfarm
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
NWS	National Weather Service
O&M	Operation and Maintenance
OCD	New Mexico Energy, Minerals and Natural Resources Department Oil Conservation Division
ORP	Oxidation-Reduction Potential
PCC Permit	Post-Closure Care Permit
PSH	Phase-Separated Hydrocarbons
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act
RO	Reverse Osmosis
SWMU	Solid Waste Management Units
TDS	Total Dissolved Solids

TEL	Tetra Ethyl Lead
TMD	Three Mile Ditch
TPH	Total Petroleum Hydrocarbons
TRC	TRC Environmental Corporation
USEPA	United States Environmental Protection Agency
VOCs	Volatile Organic Compounds
WQCC	Water Quality Control Commission

1.0 INTRODUCTION

On behalf of HollyFrontier Navajo Refining LLC (Navajo), TRC Environmental Corporation (TRC) prepared this *2017 Annual Groundwater Monitoring Report* (report) to summarize the results of groundwater monitoring and recovery activities conducted in 2017 at the Navajo Artesia Refinery (refinery) located at 501 East Main Street in Artesia, New Mexico. The location of the refinery is shown on Figure 1. The Refinery has been in operation since the 1920s and processes crude oil into asphalt, fuel oil, gasoline, diesel, jet fuel, and liquefied petroleum gas.

The refinery is regulated under the Resource Conservation and Recovery Act (RCRA). In October 2003, the Secretary of the New Mexico Environment Department (NMED) issued a Post-Closure Care Permit (PCC Permit) to Navajo for the Artesia Refinery Facility (United States Environmental Protection Agency [US EPA] ID number NMD048918817). The PCC Permit was modified and reissued in December 2010 (NMED 2010). The PCC Permit authorizes and requires Navajo (the Permittee) to conduct post-closure care at the closed tetra ethyl lead (TEL) surface impoundment and the North Colony Landfarm (NCL) and to take appropriate actions to achieve RCRA closure of the inactive Evaporation Ponds (EPs). These areas and the locations of all existing monitoring and recovery wells are shown on Figure 2.

The PCC Permit requires Navajo to maintain a groundwater monitoring program to evaluate the effectiveness of the corrective action program for groundwater and to meet the requirements of New Mexico Administrative Code (NMAC) 20.4.1.500 (incorporating 40 Code of Federal Regulations Part 264, Subpart F) during the post-closure care period. The PCC Permit also requires Navajo to recover phase-separated hydrocarbon (PSH), where present, from the shallow groundwater.

The refinery is also regulated by the New Mexico Energy, Minerals and Natural Resources Department – Oil Conservation Division (OCD). The OCD issued a renewal to Discharge Permit GW-028 (OCD 2017) on May 25, 2017. Among other requirements, the Discharge Permit requires semiannual facility-wide groundwater monitoring and submittal of an annual report summarizing the groundwater monitoring and remediation conducted throughout each year.

This report provides the results of all groundwater monitoring and remedial activities that were conducted during 2017 to satisfy both the NMED PCC Permit and the OCD Discharge Permit. The format of this report follows specifications in Appendix E.4 of the PCC Permit.

Groundwater monitoring activities conducted in 2017 consisted of semiannual well gauging and groundwater sampling. The first semiannual monitoring event was performed in accordance with the *2016 Facility Wide Groundwater Monitoring Work Plan* (2016 FWGMWP; TRC 2016) that was submitted to the NMED and OCD in June 2016 and approved on December 7, 2016 (NMED 2016). The second semiannual monitoring event was performed in accordance with the 2017 FWGMWP (TRC 2017) that was submitted to the NMED and OCD in June 2017

and approved on October 11, 2017 (NMED 2017b). Remedial activities conducted in 2017 consisted of recovery of PSH and impacted groundwater and periodic gauging of recovery wells. The groundwater monitoring and remediation activities were performed in the following areas of interest:

- The closed TEL Impoundment;
- The closed NCL;
- The inactive EPs;
- Three Mile Ditch (TMD); and
- The impacted vadose zone located beneath the refinery in the following other areas:
  - Field East of Refinery,
  - North Refinery,
  - South Refinery,
  - Reverse Osmosis (RO) Reject Fields (North and South),
  - Cross-gradient of Refinery, and
  - Up-gradient of Refinery.

2.0 SCOPE OF SERVICES

Groundwater monitoring, remedial, and other associated activities performed in 2017 are summarized in this section. The first semiannual groundwater monitoring event was conducted from April 25 to April 27, 2017. The second semiannual groundwater sampling event was conducted from October 3 to October 4, 2017. Routine remedial activities were conducted throughout 2017.

2.1 Monitoring Well Installation, Maintenance, and Repairs

No wells were installed or abandoned in 2017. The following well maintenance and repairs were performed in 2017:

- Locking J-plugs and locks were replaced on various monitoring wells as required throughout 2017.
- Surface completion improvements were made to various wells in November and December 2017 (after completion of semiannual groundwater monitoring activities) as described below. All wells were surveyed after surface completion improvements were complete.
  - The protective steel stickup casing was replaced, the top of well casing was modified as necessary, a locking steel cover was installed, and a concrete pad was installed at wells MW-3, MW-4A, and MW-7A.
  - A concrete pad was installed at wells MW-10, OCD-3, OCD-4, OCD-5, OCD-6, and OCD-8A.
  - The top of well casing was modified at wells OCD-1R and MW-18 to allow secure closure of the locking steel cover.
  - Well MW-49 was converted from stickup surface completions to flush-mount surface completions, the top of well casing was modified as necessary, and a concrete pad was installed.
- PSH absorbent socks were installed and maintained in wells MW-7, MW-64, MW-65, MW-85, MW-86, and KWB-8.

2.2 Phase-Separated Hydrocarbon and Water Level Measurements

Synoptic fluid gauging was conducted by Hydrologic Monitoring, LLC (HMI) at the beginning of the first semiannual monitoring event in accordance with the 2016 FWGMWP, and at the beginning of the second semiannual monitoring event in accordance with the 2017 FWGMWP. Wells were gauged to determine the groundwater elevation, flow direction, and gradient, the presence or absence of PSH, and apparent PSH thickness. A decontaminated oil-

water interface probe was used to measure depth to PSH (if present), depth to water, and total depth in the monitoring and recovery wells. All measurements were recorded to the nearest 0.01-foot from the surveyed datum marking on each well casing. If the survey datum mark was not visible, measurements were obtained from the northern side of each well riser. Measurements were recorded on the field data sheets for each event.

The first semiannual gauging event was conducted on April 25, 2017. No rainfall was recorded at the refinery, or at a National Weather Service (NWS) gauging station located approximately 6 miles south of the refinery, during the day gauging occurred. A total of 1.09 inches of rainfall was recorded at the NWS gauging station during the month of April 2017. A copy of the NWS data for April 2017 is provided in Appendix A.

The second semiannual gauging event was conducted on October 3, 2017. No rainfall was recorded at the refinery or the NWS gauging station during the day gauging occurred. A total of 0.43 inches of rainfall was recorded at the NWS gauging station during the month of October 2017, all of which occurred after completion of gauging and sampling activities. A copy of the NWS data for October 2017 is provided in Appendix A.

Results of the 2017 semiannual gauging events are summarized in Table 1. Potentiometric surface maps of the shallow saturated zone and valley fill zone are provided as Figures 4 through 7. PSH thickness maps are provided as Figures 8 and 9.

2.3 Groundwater Sample Collection and Handling

Semiannual groundwater sampling was conducted by HMI in accordance with the 2016 FWGMWP during the first semiannual event and in accordance with the 2017 FWGMWP during the second semiannual event. No sample was collected from a well containing PSH with a measured thickness greater than or equal to 0.03 feet. The following wells were not sampled during each 2017 semiannual event due to the presence of PSH with a thickness greater than or equal to 0.03 feet:

- First semiannual event: MW-85, MW-86, MW-92, MW-97, MW-112, MW-132, MW-133, KWB-4, RW-5R, RW-6, RW-13R, RW-14R, RW-19, RW-20A, RW-20B, and RW-22
- Second semiannual event: MW-85, MW-86, MW-92, MW-94, MW-97, MW-112, MW-132, MW-133, KWB-4, RW-8, RW-19, RW-22, and TEL-3

Groundwater was purged and sampled from monitoring and recovery wells with a peristaltic pump and dedicated tubing using low-flow methods in accordance with the NMED Hazardous Waste Bureau (HWB) Position Paper "Use of Low-Flow and Other Non-Traditional Sampling Techniques for Compliance Groundwater Monitoring" (NMED 2001). Groundwater was purged and sampled from irrigation wells by attaching a decontaminated or dedicated hose

barb to the available spigot. The spigot was located at a point before the water supply is introduced into any storage tanks or treatment units. The method by which each well was purged and sampled is provided in Table 2.

A multi-parameter water quality meter with flow-through cell and hand-held turbidity meter were used during the purging process of monitoring and recovery wells to monitor for field water quality parameters (pH, temperature, specific conductance, oxidation-reduction potential [ORP], dissolved oxygen, and turbidity) and demonstrate stabilization. Water quality parameters were recorded approximately every three minutes during purging on a groundwater sampling form. The water quality parameters, depth to water (in non-irrigation wells only), and a qualitative description of the water quality (e.g., turbidity, sheen, odor) were also recorded during the purging process. Copies of the groundwater sampling forms are provided in Appendix A.

Irrigation wells were purged and sampled from a sampling point (i.e., tap or spigot) located at or near the well head or pump house and before the water supply is introduced into any storage tank or treatment unit. The wells were purged at the sample point to remove any standing water from the well casing and surface piping. Grab readings of geochemical parameters including pH, temperature, conductivity, ORP, dissolved oxygen, and turbidity were also collected during the purging process.

The purging process was considered complete and groundwater sampling commenced when at least four of the purge parameters had stabilized. The specified stabilization criteria was +/- 0.2 standard unit for pH, +/- 0.2 degree Celsius for temperature, +/- 0.2 milligram per liter (mg/L) for DO, +/- 0.02 Siemen per meter for specific conductance, and +/- 20 millivolts for ORP. The final stabilized water quality parameters measured at each well are summarized in Table 2. In addition, other observations of relative water quality (color and odor) are included in Table 2.

Groundwater samples were collected directly from the dedicated tubing or irrigation sampling point into laboratory-provided sample containers. Care was taken to not overflow the containers and potentially remove preservatives from pre-preserved containers. Samples that were to be analyzed for dissolved metals were field-filtered by attaching a disposable 0.45 micron filter to the tubing and directing the flow through the filter into the sample container.

Sample labels were placed on each container and included the well name, sample name, date and time, sampler's initials, and analytical method(s) to be performed. Glass sample containers were placed in padded packing sleeves to prevent breakage. All samples were placed on wet ice in a shipping container. All groundwater samples collected during the 2017 semiannual events were submitted to ESC Lab Sciences (ESC) in Mount Juliet, Tennessee under appropriate chain-of-custody documentation for laboratory analyses specified in the 2016 and 2017 FWGMWPs. Shipping containers were sent overnight to ESC via Federal Express. Copies of the chain-of- custody forms are included in Appendix B with the analytical data reports.

2.4 Equipment Decontamination Procedures

The oil-water interface probes used to gauge the PSH and water levels were the only equipment that was placed within multiple wells. This equipment was decontaminated between uses at each well to prevent cross-contamination between wells. The probe and the attached measuring tape were washed in a mixture of water and non-phosphate detergent (Alconox™). The equipment was then rinsed with water. Distilled water purchased from a local store was used for washing and rinsing the equipment.

The flow-through cell and probes of the water quality meters used for low-flow purging was also decontaminated between uses at each well. Decontamination of this equipment included submersing the flow-through cell in a mixture of water and non-phosphate detergent (Alconox™), washing the cell with a soft brush, submersing the probe end of the meters in the soapy water mixture, and brushing the end of the probe with a soft brush. The equipment was then rinsed with distilled water purchased from a local store.

Dedicated tubing was used for sample collection from each well; therefore, decontamination of sample collection tubing was not required. The dedicated tubing was left in the well between sampling events, with the upper portion coiled to ensure that the lower portion did not remain in the water column. At the beginning of each sampling event, the tubing was inspected and replaced if staining or mold was observed.

2.5 Investigation-Derived Waste

All purge water and decontamination liquids were temporarily contained in a portable tank in the sampling truck trailer. The liquids were disposed daily in the refinery process wastewater system upstream of the oil/water separator, by releasing the liquids into a sump designated by refinery personnel (i.e., sump adjacent to the North Bundle Cleaning Pad). The volumes of purge water collected at each well were recorded on the HMI groundwater sampling forms and copies of these forms are provided in Appendix A.

Solid wastes generated during sampling activities included disposable gloves, paper towels, plastic bags, and tubing. All solid waste was contained in plastic bags and placed in the refinery trash receptacles for later disposal.

2.6 Exceptions to Groundwater Monitoring Work Plan

The following exceptions to the 2016 FWGMWP occurred during the first semiannual monitoring event conducted from April 25 to April 27, 2017:

- Wells KWB-3AR and KWB-9 were not gauged or sampled, and RA-1227 was not sampled because access was denied by the landowner (Jack Joy). The landowner has not granted Navajo access to these wells since 2011.
- Well RW-11 was not sampled because it was dry.

The following exception to the 2017 FWGMWP occurred during the second semiannual monitoring event conducted from October 3 to October 4, 2017:

- Wells KWB-3AR and KWB-9 were not gauged or sampled, and RA-1227 was not sampled because access was denied by the landowner (Jack Joy). The landowner has not granted Navajo access to these wells since 2011.

3.0 REGULATORY CRITERIA

Regulatory standards used to evaluate the data collected for the groundwater monitoring program are based on the presumption that the shallow groundwater might be used as a source of drinking water. Use of these standards are conservative because the shallow groundwater is not a documented source of drinking water. The screening level value used for each constituents of concern (COC) is the lower value of either the New Mexico Water Quality Control Commission (WQCC) standards from 20.6.2.3103 NMAC or the Maximum Contaminant Level (MCL) from the United States Environmental Protection Agency (USEPA) Regional Screening Levels (RSLs) (USEPA 2017). For COCs where neither a WQCC standard or MCL exists, the screening level value used is the NMED Groundwater Screening Level listed in the NMED Risk Assessment Guidance for Investigations and Remediation updated in March 2017 (NMED 2017a). If no NMED Groundwater Screening Level value is available, then the screening level value used is the USEPA Tap Water RSL value (USEPA 2017).

Available regulatory screening levels and the applicable Critical Groundwater Screening Level (CGWSL) for each COC is presented in Table 3. The CGWSL for each COC is also provided for comparison in the analytical data summary tables, as discussed later in this report.

The 2017 NMED guidance document included new screening methods and values for total petroleum hydrocarbons (TPH) in groundwater. The screening level value historically used for TPH diesel range organics (DRO) at the refinery, in all areas except the EPs, was the TPH screening value for potable groundwater for "unknown oil" included in Table 6-2 of the 2012 guidance document (NMED 2012). The screening value for potable groundwater for "Diesel #2/New Crankcase Oil" (Table 6-2, NMED 2012) was historically used for TPH DRO in the EP area in accordance with the approved investigation report for the EPs (Arcadis 2015a). The 2017 TPH DRO groundwater data, in all areas except the EPs, was screened against the groundwater screening level for "unknown oil" included in Table 6-4 of the 2017 guidance document (NMED 2017). The 2017 TPH DRO groundwater data for the EPs was screened against the groundwater screening level for "Diesel #2/New Crankcase Oil" in Table 6-4 of the 2017 NMED guidance document. The 2017 TPH screening levels were approximately one order of magnitude less than the 2012 levels.

An evaluation of background (or baseline) groundwater quality was conducted between July 2014 and June 2015 for the purpose of determining the concentrations of COCs that may be present in the background. The evaluation was performed according to an approved work plan (Arcadis 2014) and a report summarizing the evaluation was submitted to NMED and OCD in September 2015 (Arcadis 2015b). The background groundwater investigation included statistical evaluation of COCs and calculation of upper tolerance limits, where a statistically valid set of data was available. Navajo requested to use the background groundwater evaluation to develop alternative screening standards for specific COCs where the background data set demonstrates that

the COCs are present above the WQCC standards or MCLs. Alternative standards development is pending further discussion and approval from OCD and NMED and so they are not included in this report. However, it should be noted that concentrations of manganese, chloride, fluoride, sulfate, nitrate/nitrite and TDS that exceed the screening levels using the WQCC standards or USEPA MCLs may not exceed background concentrations.

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4.0 MONITORING RESULTS

Results of the 2017 semiannual groundwater monitoring events are summarized in this section.

4.1 Groundwater Gauging Results

Well gauging was conducted on April 25, 2017, and October 3, 2017. Depth to water measurements, depth to PSH (if present) measurements, and groundwater elevations are presented in Table 1. For wells with PSH present, the groundwater elevation was corrected for the presence of PSH (with a specific gravity of 0.8). Groundwater potentiometric surface maps based on the 2017 semiannual gauging results for the shallow saturated zone and the valley fill zone are presented in Figures 4 through 7.

The 2017 gauging results indicate groundwater predominantly flows eastward beneath the refinery towards the Pecos River, with localized variations in both the shallow saturated zone and the valley fill zone. The groundwater flow direction beneath the EPs is generally to the southeast. The 2017 gauging results are consistent with historical results.

Groundwater mounding, related with the discharge of RO reject water to the RO reject fields, was observed around wells MW-114 and MW-115 during both semiannual gauging events. Localized groundwater sinks were observed around various recovery wells during both semiannual gauging events due to active groundwater pumping at those recovery wells.

4.2 Phase-Separated Hydrocarbons

The presence of PSH and measured PSH thicknesses are shown on Figures 8 and 9 for the 2017 first and second semiannual events, respectively. Consistent with previous results, PSH is present in four general areas at the refinery: isolated wells in the north portion of the refinery (North Refinery Area), isolated wells in the southwestern portion of the refinery (South Refinery Area), in a segmented area across multiple wells in the southeastern portion of the refinery (South Refinery Area) extending east through the field owned by Navajo east of the refinery (Field East of Refinery) and Bolton Road, and one isolated area on the western end of the EPs near the former discharge point into Pond 1. Plots presenting PSH thicknesses and groundwater elevations over time for wells that have historically contained measurable PSH are provided in Appendix C. PSH thicknesses across all areas of interest are stable to declining over time. PSH thicknesses appear to be inversely affected by fluctuations in groundwater elevations, which have generally increased across the refinery since September 2011 and March 2014 (two major inflection points). However, groundwater elevations measured during both 2017 semiannual events were generally lower than those measured in October 2016.

The presence of PSH within each area of interest is discussed in the following subsections. PSH recovery activities and results are provided in Section 6.

4.2.1 North Colony Landfarm – PSH Gauging Results

No measurable PSH was present in any of the wells in the vicinity of the NCL during the 2017 semiannual events.

4.2.2 Tetra Ethyl Lead Surface Impoundment – PSH Gauging Results

No measurable PSH was present in any TEL wells in April 2017. PSH was measured in well TEL-3 at a thickness of 0.05 feet in October 2017. PSH has intermittently been present in well TEL-3 since 2008, which correlates with reductions in groundwater elevations during those corresponding monitoring periods.

4.2.3 Evaporation Ponds – PSH Gauging Results

PSH was measured in EP wells MW-85 and MW-86 at thicknesses of 0.72 and 0.03 feet, respectively, in April 2017; and 1.25 and 0.34 feet, respectively, in October 2017. These wells are located near the original discharge point in EP 1 (Pond 1). PSH thicknesses in these two wells have overall decreased over time, despite PSH thickness fluctuations between the gauging events attributable to fluctuations in groundwater elevations.

4.2.4 Three Mile Ditch – PSH Gauging Results

No measurable PSH was present in any wells along the TMD during either 2017 semiannual event.

4.2.5 North Refinery Area – PSH Gauging Results

PSH was measured in wells MW-92, MW-97, and RW-2R in April 2017 with reported thicknesses ranging from 0.01 feet in RW-2R to 0.04 feet in MW-92. In October 2017, PSH was measured in MW-92, MW-94, MW-97, and RW-8 with reported thicknesses ranging from 0.04 feet in RW-8 to 0.84 feet in MW-97.

PSH thicknesses in these wells have overall decreased over time, despite minor fluctuations of PSH thickness in these wells that are likely due to fluctuations in groundwater elevation and the influence of active PSH and groundwater recovery. PSH and groundwater are routinely removed from this plume by automated pumping from RW-1R, RW-2R, RW-7R, and RW-8R. Measurable volumes of PSH (as measured by the automated recovery system) were recovered from recovery well RW-2R and RW-8 in 2017. The recovered PSH is pumped to Tank 49 within the refinery and then to crude tanks for processing.

4.2.6 South Refinery Area – PSH Gauging Results

PSH was measured in wells KWB-4, RW-5R, RW-6, and RW-19 during both semiannual monitoring events. In April 2017, PSH thicknesses ranged from 0.03 feet in RW-19 to 0.13 feet in RW-5R. In October 2017, PSH thicknesses ranged from 0.09 feet in RW-6 to 0.28 feet in KWB-

4. PSH has previously been present at measurable thicknesses in wells MW-65 and RW-15, but was not present in these wells in 2017.

PSH thicknesses in these wells have overall decreased over time, despite minor fluctuations of PSH thickness in these wells that are likely due to fluctuations of groundwater elevation and the influence of active PSH recovery. PSH and groundwater is routinely removed from this plume by automated pumping from RW-4R, RW-5R, RW-6R, RW-15, and RW-19. Measurable volumes of PSH (as measured by the automated recovery system) were recovered from recovery well RW-19 in 2017. The recovered PSH is pumped to Tank 49 within the refinery and then to crude tanks for processing.

4.2.7 Field East of Refinery – PSH Gauging Results

PSH was measured in wells KWB-8, MW-112, MW-132, MW-133, RW-13R, RW-14R, RW-20A, RW-20B, and RW-22 in April 2017, with thicknesses ranging from 0.01 feet in KWB-8 to 2.45 feet in RW-22. In October 2017, PSH was measured in wells KWB-7, KWB-8, MW-112, MW-129, MW-132, MW-133, RW-13R, RW-14R, RW-20A, RW-20B, and RW-22, with thicknesses ranging from 0.01 feet in wells KWB-7, KWB-8, and MW-129 to 1.12 feet in RW-14R.

PSH thicknesses generally decreased over time in most of these wells. PSH thicknesses fluctuate in the wells with active PSH recovery. PSH and groundwater is routinely removed from this plume by automated pumping from RW-12R, RW-13R, RW-14R, RW-20, and RW-22. Measurable volumes of PSH (as measured by the automated recovery system) were recovered from all of these recovery wells in 2017 with the exception of RW-12R, which has no measurable PSH. The recovered PSH is pumped to Tank 49 within the refinery and then to crude tanks for processing.

4.2.8 Cross-Gradient and Up-Gradient Areas – PSH Gauging Results

No measurable PSH was present in any wells located up-gradient or cross-gradient of the refinery during either 2017 semiannual event.

4.2.9 RO Reject Discharge Fields – PSH Gauging Results

No measurable PSH was present in any wells located within the North or South RO Reject Fields during either 2017 semiannual event.

5.0 CHEMICAL ANALYTICAL DATA

The chemical laboratory analyses and results of groundwater samples collected at the refinery in 2017 are summarized in this section.

5.1 Sample Laboratory Analyses

Groundwater samples collected during the 2017 semiannual sampling events were submitted for laboratory analysis of one or more of the following COCs by the associated analytical methods in accordance with the 2016 and 2017 FWGMWPs:

- TPH DRO by Method 8015 Modified
- TPH gasoline range organics (GRO) by Method 8015 Modified
- Volatile organic compounds (VOCs) by Method 8260
- Metals by Methods 6010/6020 or 7470 (arsenic, barium, chromium, iron, lead, manganese, and selenium in all wells that were analyzed for metals; boron, cadmium, cobalt, mercury, nickel, uranium, and vanadium were additionally analyzed in select wells)
  - Total metals were analyzed during both the first and second semiannual events
  - Dissolved metals were analyzed during the first semiannual event (for the same list of metals as the total metal list)
- Cyanide by Method 4500
- Major cations and anions by Methods 6020 or 300 (calcium, chloride, fluoride, potassium, sodium, and sulfate)
- Nitrates/nitrites (as nitrogen) by Method 300
- Total dissolved solids (TDS) by Method 2540

The specific analytical suite for each groundwater sample was accordance with Table 1 of the approved 2016 and 2017 FWGMWPs. Laboratory analytical reports are provided in Appendix B.

5.2 Data Validation

Laboratory analytical results were reviewed and validated following the guidelines of the PCC Permit. The data validation and a discussion of any data quality exceptions are provided in Appendix D. Data qualifier flags were added to the data based on the data validation results and are summarized in tabulated form in Appendix B.

Although some data quality exceptions were noted, the analytical results are generally usable for the intended purpose.

5.3 Laboratory Analytical Results

Laboratory analytical results of all wells sampled in 2017, and during at least the three previous sampling events, are summarized in Tables 4A through 4C, as follows:

- Table 4A – GRO, DRO, and select VOCs (VOCs that have had at least one detected value reported above the CGWSL in at least one well in 2017)
- Table 4B – Total Metals
- Table 4C – Water quality parameters (TDS, nitrate/nitrite, major cations, major anions) and Cyanide

Analytical results of the 2017 monitoring events and the three prior sampling events are included in the tables as required by the PCC Permit. The timeframe required to provide data for the three prior sampling events varies by well because wells are sampled semiannually, annually, or biennially. Wells that are sampled on a biennial basis are sampled during odd calendar years and therefore were sampled during 2017. For consistency of the timeframe summarized in the analytical results tables, no data prior to 2013 is included for the wells that are sampled biennially or were not sampled during this timeframe for whatever reason (e.g., PSH present at a thickness greater than or equal to 0.03 feet, lack of well access, etc.). Analytical results in Tables 4A through 4C are organized by the major area of interest in which each well is located. The applicable CGWSL is provided at the top of each data table and exceedances of the CGWSL are highlighted in yellow. Analytical results of all detected COCs are summarized in tables organized by well in numeric order that are included in Appendix B.

Plots of historical concentrations of target COCs are provided in Appendix C for wells with historical exceedances of CGWSLs. These plots are organized by well within major areas of interest and include concentration plots for the following target COCs: GRO, DRO, benzene, ethylbenzene, toluene, total xylenes, methyl tert-butyl ether (MTBE), naphthalene, and arsenic.

Figures 10 through 19 present the extent of the CGWSL exceedance areas of the following target COCs for both the first and second semiannual 2017 sampling events: DRO, arsenic, benzene, naphthalene, and MTBE.

Figures 20 through 29 depict the extent of CGWSL exceedance areas of the following water quality parameters for both the first and second semiannual 2017 events in accordance with the Discharge Permit requirements: chloride, fluoride, sulfate, nitrate/nitrite, and TDS.

The 2017 analytical results in each major area of interest are summarized in the following subsections.

5.3.1 North Colony Landfarm – Analytical Results

Groundwater monitoring is ongoing beneath and near the closed NCL. Analytical results of groundwater samples collected from wells located in and near the NCL in 2017 indicate COCs are present in groundwater in excess of their respective CGWSLs, as highlighted in Tables 4A through 4C and discussed in the following subsections.

Total Petroleum Hydrocarbons – Diesel Range Organics, NCL

In 2017, groundwater samples were collected from the following wells located in and near the NCL for analysis of DRO:

- First Semiannual Event (14 wells): MW-18, MW-45, MW-53, MW-54A, MW-54B, MW-55, MW-56, MW-108, NCL-31, NCL-32, NCL-33, NCL-34A, NCL-44, and NCL-49.
- Second Semiannual Event (10 wells): MW-45, MW-54A, MW-55, MW-108, NCL-31, NCL-32, NCL-33, NCL-34A, NCL-44, and NCL-49.

As highlighted in Table 4A, DRO was detected in exceedance of the CGWSL of 0.0398 mg/L in all NCL wells sampled during the first 2017 semiannual event (maximum concentration of 11.4 mg/L in NCL-34A) and in all NCL wells sampled except for NCL-49 during the second 2017 semiannual event (maximum concentration of 7.93 mg/L in MW-108). As shown in the COC concentration plots included in Appendix C, DRO concentrations in NCL wells MW-18, MW-54A, MW-54B, MW-55, MW-56, MW-108, NCL-31, NCL-32, NCL-33, NCL-34A, and NCL-44 have overall increased since 2011, but have exhibited a stable to decreasing trend over the most recent three to six sampling events. DRO concentrations in these wells will be watched closely during future monitoring events.

Total Petroleum Hydrocarbons – Gasoline Range Organics, NCL

Groundwater samples collected from well MW-54B during the first 2017 semiannual event and well MW-55 during both 2017 semiannual events were analyzed for GRO. GRO was detected above the method detection limit in MW-55 during the second 2017 semiannual event at a concentration of 0.0634 J mg/L, which is the historical maximum concentration detected in this well.

Volatile Organic Compounds, NCL

In 2017, groundwater samples were collected from the following wells located in and near the NCL for analysis of VOCs:

- First Semiannual Event (14 wells): MW-18, MW-45, MW-53, MW-54A, MW-54B, MW-55, MW-56, MW-108, NCL-31, NCL-32, NCL-33, NCL-34A, NCL-44, and NCL-49.

- Second Semiannual Event (10 wells): MW-45, MW-54A, MW-55, MW-108, NCL-31, NCL-32, NCL-33, NCL-34A, NCL-44, and NCL-49.

Benzene and 1,2,4-trimethylbenzene (1,2,4-TMB) were detected at concentrations in exceedance of their respective CGWSLs in wells MW-108 and NCL-34A during both 2017 semiannual events, as highlighted in Table 4A. The maximum benzene concentration was detected in NCL-34A during each semiannual event (1.78 mg/L in April 2017 and 0.805 mg/L in October 2017). The maximum 1,2,4-TMB concentration was detected in MW-108 during each semiannual event (0.0605 mg/L in April 2017 and 0.0451 mg/L in October 2017). No other VOC was detected above its respective CGWSL during either semiannual event.

The 2017 VOC results in groundwater beneath and near the NCL were consistent with historical results. Concentrations of target VOCs in wells located in and near the NCL are overall stable to declining, as shown in the COC concentration plots included in Appendix C, with the exception of MTBE in MW-55. MTBE concentrations in MW-55 exhibited an increasing trend since April 2015, but remains below the CGWSL.

Total Metals, NCL

Groundwater samples were collected from the following wells located in and near the NCL for analysis of the standard total metals list (arsenic, barium, chromium, iron, lead, manganese, and selenium):

- First Semiannual Event (14 wells): MW-18, MW-45, MW-53, MW-54A, MW-54B, MW-55, MW-56, MW-108, NCL-31, NCL-32, NCL-33, NCL-34A, NCL-44, and NCL-49.
- Second Semiannual Event (10 wells): MW-45, MW-54A, MW-55, MW-108, NCL-31, NCL-32, NCL-33, NCL-34A, NCL-44, and NCL-49.

In addition, groundwater samples collected from wells MW-18, MW-45, and MW-55 were analyzed for the expanded total metals list (boron, cadmium, cobalt, mercury, nickel, uranium, and vanadium).

Barium, cadmium, chromium, cobalt, lead, mercury, nickel, selenium, and vanadium were not detected above their respective CGWSLs in any of the wells sampled during either 2017 semiannual event. Arsenic, boron, iron, manganese, and uranium were detected at concentrations in exceedance of their respective CGWSLs in at least one well, as highlighted in Table 4B and described below:

- Arsenic exceeded the CGWSL of 0.010 mg/L in well NCL-44 during the first 2017 semiannual event at a concentration of 0.0348 mg/L; and in two wells sampled (NCL-

31 and NCL-44) during the second 2017 semiannual event at a maximum concentration of 0.0479 mg/L in NCL-44.

- Boron exceeded the CGWSL of 1.00 mg/L in two wells sampled (MW-18 and MW-55) during the first 2017 semiannual event at a maximum concentration of 1.71 mg/L in MW-18; and in well MW-55 during the second 2017 semiannual event at a concentration of 1.52 mg/L.
- Iron exceeded the CGWSL of 1.00 mg/L in two wells sampled (MW-45 and NCL-33) during the first 2017 semiannual event at a maximum concentration of 1.29 mg/L in MW-45; and in three wells sampled (MW-45, NCL-33, and NCL-44) during the second 2017 semiannual event at a maximum concentration of 2.27 mg/L in MW-45.
- Manganese exceeded the CGWSL of 0.200 mg/L in eight wells sampled during the first 2017 semiannual event at a maximum concentration of 2.19 mg/L in NCL-31; and in five wells sampled during the second 2017 semiannual event at a maximum concentration of 2.26 mg/L in NCL-31.
- Uranium exceeded the CGWSL of 0.030 mg/L in well MW-55 during both 2017 semiannual events at a concentration of 0.0406 mg/L during the first event and 0.0466 mg/L during the second event.

The total metals results in groundwater beneath and near the NCL were generally consistent with or less than historical results, with the following exceptions:

- Manganese increased in well MW-54B from 0.165 mg/L in the 2015 biennial event (April 2015) to 0.253 mg/L in the 2017 biennial event (April 2017), which is the first exceedance of the CGWSL of 0.200 mg/L during the three most recent biennial sampling events.

Concentrations of target COC arsenic in wells located in and near the NCL are overall stable to declining, as shown in the COC concentration plots included in Appendix C.

Cyanide, NCL

Groundwater samples collected from wells MW-18, MW-45, and MW-55 during both 2017 semiannual events were analyzed for cyanide. Cyanide was not detected above the CGWSL in groundwater samples collected from these wells.

Water Quality Parameters, NCL

In 2017, groundwater samples were collected from the following wells located in and near the NCL for analysis of water quality parameters (calcium, chloride, fluoride, potassium, sodium, sulfate, TDS, and nitrate/nitrite [as nitrogen]):

- First Semiannual Event (14 wells): MW-18, MW-45, MW-53, MW-54A, MW-54B, MW-55, MW-56, MW-108, NCL-31, NCL-32, NCL-33, NCL-34A, NCL-44, and NCL-49.
- Second Semiannual Event (10 wells): MW-45, MW-54A, MW-55, MW-108, NCL-31, NCL-32, NCL-33, NCL-34A, NCL-44, and NCL-49.

No CGWSLs are applicable for calcium, potassium, or sodium. Chloride, fluoride, nitrate/nitrite, sulfate, and TDS were detected at concentrations in exceedance of their respective CGWSLs in groundwater samples from various wells in and near the NCL, as highlighted in Table 4C. The reported concentrations of these constituents exhibit an overall stable trend across the NCL, with some seasonal fluctuations between the first and second semiannual events. Fluoride and nitrate/nitrite concentrations in MW-18 have exhibited an increasing trend over the four most recent sampling events.

5.3.2 Tetra Ethyl Lead Surface Impoundment – Analytical Results

Groundwater monitoring beneath the closed TEL surface impoundment is ongoing. Groundwater samples were collected from the TEL area wells MW-49, TEL-1, TEL-2, TEL-3, and TEL-4 during the first 2017 semiannual event; and from wells MW-49, TEL-1, TEL-2, and TEL-4 during the second 2017 semiannual event. Groundwater samples collected from these TEL area wells were all analyzed for GRO, DRO, the standard total metals list (arsenic, barium, chromium, iron, lead, manganese, and selenium), and water quality parameters (calcium, chloride, fluoride, potassium, sodium, sulfate, TDS, and nitrate/nitrite). In addition, groundwater samples collected from MW-49 were analyzed for the expanded total metals list (boron, cadmium, cobalt, mercury, nickel, uranium, and vanadium) and cyanide.

Analytical results of groundwater samples collected from TEL wells in 2017 indicate COCs are present in groundwater in excess of their respective CGWSLs, as highlighted in Tables 4A through 4C and discussed in the following subsections.

Total Petroleum Hydrocarbons – Diesel Range Organics, TEL

DRO was detected in exceedance of the CGWSL of 0.0398 mg/L in all TEL area wells sampled during both 2017 semiannual events, as highlighted in Table 4A. The maximum DRO concentration was detected in TEL-2 during each semiannual event (14.8 mg/L in April 2017 and 22.8 mg/L in October 2017). DRO concentrations in most TEL area wells have exhibited a stable to fluctuating trend over the seven most recent sampling events, as shown in the COC concentration plots included in Appendix C. DRO concentrations in wells TEL-1 and TEL-2 increased from 9.45 mg/L and 14.8 mg/L, respectively, in the first 2017 semiannual event to historical maximums of 12.7 mg/L and 22.8 mg/L, respectively, in the second 2017 semiannual event. DRO concentrations in these wells will be watched closely during future events.

Total Petroleum Hydrocarbons – Gasoline Range Organics, TEL

GRO was detected in all TEL area wells sampled during both 2017 semiannual events with maximum concentrations detected in well TEL-2 during the first semiannual event (3.02 mg/L) and in well MW-49 during the second semiannual event (2.51 mg/L). GRO concentrations in TEL area wells exhibited stable trends over time despite occasional fluctuations between sampling events, as shown in the COC concentration plots included in Appendix C. There is no applicable CGWSL for GRO, but previous NMED guidance (NMED 2012) required analysis of VOCs when GRO is present for comparison to applicable individual VOC screening levels. VOC results are discussed in the following subsection.

Volatile Organic Compounds, TEL

As highlighted in Table 4A, benzene and 1,2,4-TMB were detected at concentrations in exceedance of their respective CGWSLs in all TEL area wells sampled during both 2017 semiannual events except in well TEL-1. The maximum benzene concentration was detected in TEL-2 during each semiannual event (0.556 mg/L in April 2017 and 0.590 mg/L in October 2017). The maximum 1,2,4-TMB concentration was detected in TEL-2 during the first semiannual event (0.0706 mg/L) and in MW-49 during the second semiannual event (0.118 mg/L). No other VOC was detected above its respective CGWSL in TEL area wells during either 2017 semiannual event.

The 2017 VOC results of groundwater in TEL area wells were consistent with historical results. Concentrations of target VOCs in TEL area wells exhibited stable trends over time with occasional fluctuations, as shown in the COC concentration plots included in Appendix C.

Total Metals, TEL

Barium, boron, cadmium, cobalt, lead, mercury, nickel, selenium, uranium, and vanadium were not detected above their respective CGWSLs in any of the TEL area wells sampled during either 2017 semiannual event. Arsenic, chromium, iron, and manganese were detected at concentrations in exceedance of their respective CGWSLs in at least one well, as highlighted in Table 4B and described below:

- Arsenic exceeded the CGWSL of 0.010 mg/L in TEL-2 during the first 2017 semiannual event at a concentration of 0.0123 mg/L; and in two wells sampled (TEL-1 and TEL-2) during the second 2017 semiannual event at a maximum concentration of 0.0140 mg/L in TEL-2.
- Chromium exceeded the CGWSL of 0.050 mg/L in two wells sampled (TEL-3 and TEL-4) during the first 2017 semiannual event at a maximum concentration of 0.790 mg/L in TEL-4; and in TEL-4 during the second 2017 semiannual event at a concentration of 0.236 mg/L.

- Iron exceeded the CGWSL of 1.00 mg/L in TEL-4 during both 2017 semiannual events at concentrations of 1.45 mg/L during the first event and 1.03 mg/L during the second event.
- Manganese exceeded the CGWSL of 0.200 mg/L in two wells sampled (MW-49 and TEL-4) during the first 2017 semiannual event at a maximum concentration of 0.973 mg/L in TEL-4; and in TEL-4 during the second 2017 semiannual event at a concentration of 1.05 mg/L.

The 2017 total metals results in TEL wells were generally consistent with historical results, with the exception of chromium in TEL-3 which has exhibited an increasing trend over the five most recent sampling events. Chromium concentrations in this well will be watched closely during 2018 monitoring events. Concentrations of target COC arsenic increased in TEL-1 from 0.0052 mg/L in April 2017 to 0.0139 mg/L in October 2017, which is the first exceedance of the CGSWL in this well over the six most recent sampling events. However, groundwater concentrations of target COC arsenic in all TEL area wells have overall declined since historical maximum concentrations in 2011, as shown in the COC concentration plots included in Appendix C.

Cyanide, TEL

Groundwater samples collected from MW-49 during both 2017 semiannual events were analyzed for cyanide. Cyanide was not detected above the CGWSL in groundwater samples collected from this well during both 2017 semiannual events.

Water Quality Parameters, TEL

Chloride, fluoride, sulfate, and TDS were detected at concentrations in exceedance of their respective CGWSLs in groundwater samples from various TEL area wells, as highlighted in Table 4C. The reported concentrations of these constituents in 2017 were overall consistent with historical results, with the exception of sulfate in TEL-2 which increased from 865 mg/L in April 2017 to 1,160 mg/L in October 2017. Nitrate/nitrite was not detected above the CGWSL in any TEL area well, which is consistent with historical results.

No CGWSLs are applicable for calcium, potassium, or sodium. Analytical results of these analytes in all TEL area wells were consistent with or less than historical results.

5.3.3 Evaporation Ponds Analytical – Results

Groundwater monitoring is ongoing beneath the inactive EPs. Analytical results of groundwater samples collected from EP wells in 2017 indicate COCs are present in groundwater in excess of their respective CGWSLs, as highlighted in Tables 4A through 4C and discussed in the following subsections.

Total Petroleum Hydrocarbons – Diesel Range Organics, EPs

In 2017, groundwater samples were collected from the following EP wells during each semiannual event for analysis of DRO:

- First Semiannual Event (51 wells): MW-1R, MW-2A, MW-3, MW-4A, MW-4B, MW-5A, MW-5B, MW-5C, MW-6A, MW-6B, MW-7A, MW-7B, MW-10, MW-11A, MW-11B, MW-15, MW-18A, MW-18B, MW-22A, MW-22B, MW-70, MW-72, MW-73, MW-74, MW-75, MW-76, MW-77, MW-78, MW-79, MW-80, MW-81, MW-82, MW-83, MW-84, MW-87, MW-88, MW-120, MW-121, MW-122, MW-123, MW-124, OCD-1R, OCD-2A, OCD-3, OCD-4, OCD-5, OCD-6, OCD-7AR, OCD-7B, OCD-8A, and OCD-8B.
- Second Semiannual Event (30 wells): MW-2A, MW-3, MW-4A, MW-5A, MW-7A, MW-10, MW-18A, MW-22A, MW-70, MW-74, MW-75, MW-76, MW-79, MW-83, MW-84, MW-87, MW-88, MW-120, MW-121, MW-122, MW-123, MW-124, OCD-1R, OCD-2A, OCD-3, OCD-4, OCD-5, OCD-6, OCD-7AR, and OCD-8A.

DRO was detected at concentrations in exceedance of the CGWSL of 0.0473 mg/L in 46 EP wells sampled during the first 2017 semiannual event (maximum concentration of 59.1 mg/L in MW-78) and in all 30 EP wells samples sampled during the second 2017 semiannual event (maximum concentration of 67.0 mg/L in MW-84), as highlighted in Table 4A. As shown in the COC concentration plots included in Appendix C, DRO concentrations in EP wells MW-3, MW-4A, MW-5C, MW-6A, MW-6B, MW-10, MW-22B, MW-73 through MW-78, MW-80, MW-81, MW-82, MW-83, MW-84, and OCD-7AR have exhibited an overall increasing trend since approximately 2011. However, in all of these wells except MW-6A, the DRO concentrations have exhibited a stable trend over the most recent three to eight sampling events. DRO concentrations in these wells will be watched closely during future sampling events.

Total Petroleum Hydrocarbons – Gasoline Range Organics, EPs

In 2017, groundwater samples were collected from the following EP wells during each semiannual event for analysis of GRO:

- First Semiannual Event (49 wells): MW-2A, MW-3, MW-4A, MW-4B, MW-5A, MW-5B, MW-5C, MW-6A, MW-6B, MW-7A, MW-7B, MW-10, MW-11A, MW-11B, MW-15, MW-18B, MW-22A, MW-22B, MW-70, MW-72, MW-73, MW-74, MW-75, MW-76, MW-77, MW-78, MW-79, MW-80, MW-81, MW-82, MW-83, MW-84, MW-87, MW-88, MW-120, MW-121, MW-122, MW-123, MW-124, OCD-1R, OCD-2A, OCD-3, OCD-4, OCD-5, OCD-6, OCD-7AR, OCD-7B, OCD-8A, and OCD-8B.
- Second Semiannual Event (29 wells): MW-2A, MW-3, MW-4A, MW-5A, MW-7A, MW-10, MW-22A, MW-70, MW-74, MW-75, MW-76, MW-79, MW-83, MW-84,

MW-87, MW-88, MW-120, MW-121, MW-122, MW-123, MW-124, OCD-1R, OCD-2A, OCD-3, OCD-4, OCD-5, OCD-6, OCD-7AR, and OCD-8A.

GRO was detected above the method detection limit in 27 EP wells sampled during the first 2017 semiannual event and in 24 EP wells sampled during the second 2017 semiannual event. The maximum GRO concentration was detected in well MW-22A during each semiannual event (4.22 mg/L in April 2017 and 4.51 mg/L in October 2017). As shown in the COC concentration plots included in Appendix C, GRO concentrations in EP wells are overall stable over time despite occasional fluctuations. There is no applicable CGWSL for GRO, but previous NMED guidance (NMED 2012) required analysis of VOCs when GRO is present for comparison to applicable individual VOC screening levels. VOC results are discussed in the following subsection.

Volatile Organic Compounds, EPs

No VOCs were detected at concentrations above CGWSLs in any EP wells sampled during either 2017 semiannual events. Concentrations of target VOCs in EP wells are stable to declining over time, as shown in the COC concentration plots included in Appendix C.

Total Metals, EPs

In 2017, groundwater samples were collected from the following EP wells during each semiannual event for analysis of the standard total metals list (arsenic, barium, chromium, iron, lead, manganese, and selenium):

- First Semiannual Event (51 wells): MW-1R, MW-2A, MW-3, MW-4A, MW-4B, MW-5A, MW-5B, MW-5C, MW-6A, MW-6B, MW-7A, MW-7B, MW-10, MW-11A, MW-11B, MW-15, MW-18A, MW-18B, MW-22A, MW-22B, MW-70, MW-72, MW-73, MW-74, MW-75, MW-76, MW-77, MW-78, MW-79, MW-80, MW-81, MW-82, MW-83, MW-84, MW-87, MW-88, MW-120, MW-121, MW-122, MW-123, MW-124, OCD-1R, OCD-2A, OCD-3, OCD-4, OCD-5, OCD-6, OCD-7AR, OCD-7B, OCD-8A, and OCD-8B.
- Second Semiannual Event (30 wells): MW-2A, MW-3, MW-4A, MW-5A, MW-7A, MW-10, MW-18A, MW-22A, MW-70, MW-74, MW-75, MW-76, MW-79, MW-83, MW-84, MW-87, MW-88, MW-120, MW-121, MW-122, MW-123, MW-124, OCD-1R, OCD-2A, OCD-3, OCD-4, OCD-5, OCD-6, OCD-7AR, and OCD-8A.

In addition, groundwater samples collected from wells MW-18A and OCD-8A were analyzed for the expanded total metals list (boron, cadmium, cobalt, mercury, nickel, uranium, and vanadium).

Barium, cadmium, cobalt, chromium, lead, mercury, nickel, and vanadium were not detected above their respective CGWSLs in any of the EP wells sampled during either 2017 semiannual event. Arsenic, boron, iron, manganese, selenium, and uranium were detected at

concentrations in exceedance of their respective CGWSLs in at least one well, as highlighted in Table 4B and described below:

- Arsenic exceeded the CGWSL of 0.010 mg/L in 29 EP wells sampled during the first 2017 semiannual event at a maximum concentration of 0.220 mg/L in MW-75; and in 21 wells sampled during the second 2017 semiannual event at a maximum concentration of 0.296 mg/L in MW-75.
- Boron exceeded the CGWSL of 0.75 mg/L in both EP wells sampled (MW-18A and OCD-8A) sampled during both 2017 semiannual events, with maximum concentrations in MW-18A of 2.04 mg/L during the first event and 2.53 mg/L during the second event.
- Iron exceeded the CGWSL of 1.00 mg/L in 29 EP wells sampled during the first 2017 semiannual event at a maximum concentration of 17.0 mg/L in OCD-5; and in 22 EP wells sampled during the second 2017 semiannual event at a maximum concentration of 12.6 mg/L in OCD-5.
- Manganese exceeded the CGWSL of 0.200 mg/L in 46 EP wells sampled during the first 2017 semiannual event at a maximum concentration of 7.35 mg/L in MW-4B; and in all 30 EP wells sampled during the second 2017 semiannual event at a maximum concentration of 6.52 mg/L in MW-22A.
- Selenium exceeded the CGWSL of 0.050 mg/L in well MW-74 during both 2017 semiannual events at a concentration of 0.156 mg/L during the first event and 0.144 mg/L during the second event.
- Uranium exceeded the CGWSL of 0.030 mg/L in well MW-18A during both 2017 semiannual events at a concentration of 0.0305 mg/L during the first event and 0.0302 J mg/L during the second event.

The 2017 analytical results of total metals in groundwater samples collected from EP wells were generally consistent with historical results, with the following exceptions:

- Arsenic concentrations in wells OCD-3 and OCD-4 increased from 0.00141 J mg/L and 0.00227 mg/L, respectively, during the first 2017 semiannual event to 0.0104 mg/L and 0.0105 mg/L, respectively, during the second 2017 semiannual event. However, arsenic concentrations in these wells remain below their respective historical maximum.
- Iron concentrations have exhibited increasing to fluctuating trends in wells MW-18A, MW-84, MW-124, OCD-3, OCD-4, OCD-5, OCD-6, and OCD-7AR over at least the four most recent sampling events. Iron concentrations have fluctuated in a majority of EP wells over time.

- Manganese concentrations in MW-18A exhibited an increasing trend over the six most recent sampling events. Iron concentrations in MW-18A increased from 0.637 mg/L during the first 2017 semiannual event to 1.47 mg/L during the second 2017 semiannual event, which is the first exceedance of the CGWSL over the six most recent sampling events.

Concentrations of target COC arsenic in EP wells are overall stable despite occasional fluctuations, as shown in the COC concentration plots included in Appendix C.

Cyanide, EPs

Groundwater samples collected from EP wells MW-18A and OCD-8A during both 2017 semiannual events were analyzed for cyanide. Cyanide was not detected above the CGWSL in groundwater samples collected from these wells.

Water Quality Parameters, EPs

In 2017, groundwater samples were collected from the following EP wells during each semiannual event for analysis of water quality parameters (calcium, chloride, fluoride, potassium, sodium, sulfate, TDS, and nitrate/nitrite [as nitrogen]):

- First Semiannual Event (51 wells): MW-1R, MW-2A, MW-3, MW-4A, MW-4B, MW-5A, MW-5B, MW-5C, MW-6A, MW-6B, MW-7A, MW-7B, MW-10, MW-11A, MW-11B, MW-15, MW-18A, MW-18B, MW-22A, MW-22B, MW-70, MW-72, MW-73, MW-74, MW-75, MW-76, MW-77, MW-78, MW-79, MW-80, MW-81, MW-82, MW-83, MW-84, MW-87, MW-88, MW-120, MW-121, MW-122, MW-123, MW-124, OCD-1R, OCD-2A, OCD-3, OCD-4, OCD-5, OCD-6, OCD-7AR, OCD-7B, OCD-8A, and OCD-8B.

- Second Semiannual Event (25 wells): MW-2A, MW-3, MW-4A, MW-5A, MW-7A, MW-10, MW-11A, MW-18A, MW-22A, MW-74, MW-75, MW-76, MW-79, MW-83, MW-84, MW-120, MW-121, MW-122, MW-123, MW-124, OCD-1R, OCD-5, OCD-6, OCD-7AR, and OCD-8A.

No CGWSLs are applicable for calcium, potassium, or sodium. Chloride, fluoride, nitrate/nitrite, sulfate, and TDS were detected at concentrations in exceedance of their respective CGWSLs in groundwater samples from various EP wells, as highlighted in Table 4C. The reported concentrations of these constituents in 2017 were overall consistent with historical results, with the exception of nitrate/nitrite in MW-10 during the first 2017 semiannual event. Nitrate/nitrite concentrations in MW-10 increased from 0.0970 J mg/L in the second 2016 semiannual event (October 2016) to 593 mg/L in the first 2017 semiannual event, but then decreased to not detected above a method detection limit of 0.0197 mg/L in the second 2017 semiannual event. The

nitrate/nitrite result in MW-10 during the first 2017 semiannual event appears to be anomalous based on historical and nearby results.

5.3.4 Three Mile Ditch – Analytical Results

Groundwater monitoring is ongoing along the inactive TMD. Analytical results of groundwater samples collected from TMD wells in 2017 indicate COCs are present in groundwater in excess of their respective CGWSLs, as highlighted in Tables 4A through 4C and discussed in the following subsections.

Total Petroleum Hydrocarbons – Diesel Range Organics, TMD

In 2017, groundwater samples were collected from the following TMD wells during each semiannual event for analysis of DRO:

- First Semiannual Event (11 wells): MW-8, MW-16, MW-20, MW-21, MW-25, MW-26, MW-27, MW-46R, MW-68, MW-71, and MW-89.
- Second Semiannual Event (2 wells): MW-21 and MW-46R.

DRO was detected at concentrations in exceedance of the CGWSL of 0.0398 mg/L in all 11 TMD wells sampled during the first 2017 semiannual event (maximum concentration of 2.15 mg/L in MW-89) and in well MW-21 during the second 2017 semiannual event (0.106 mg/L), as highlighted in Table 4A. However, DRO concentrations reported for a majority of these TMD wells (MW-21, MW-25, MW-26, MW-27, MW-46R. MW-68, and MW-71) in 2017 did not exceed the previous CGWSL (NMED 2012) of 0.2 mg/L. As shown in the COC concentration plots included in Appendix C, DRO concentrations in TMD wells MW-8, MW-16, MW-20, MW-21, MW-25, MW-27, MW-68, and MW-89 have exhibited an overall increasing trend since 2011. However, in all of these wells except MW-16 and MW-20, the DRO concentrations have exhibited a stable trend over at least the three most recent sampling events. DRO concentrations in these wells will be watched closely during future sampling events.

Total Petroleum Hydrocarbons – Gasoline Range Organics, TMD

Groundwater samples collected from MW-8 during the first 2017 semiannual event and from MW-21 during both 2017 semiannual events were analyzed for GRO. GRO was detected in in both wells MW-8 and MW-21 during the first 2017 semiannual event at concentrations of 0.585 mg/L and 0.0721 J mg/L, respectively. GRO was detected in MW-21 during the second 2017 semiannual event at a concentration of 0.0416 J mg/L. GRO concentrations increased in both TMD wells sampled in 2017 from non-detected to above the method detection limit.

There is no applicable CGWSL for GRO, but previous NMED guidance (NMED 2012) required analysis of VOCs when GRO is present for comparison to applicable individual VOC screening levels. VOC results are discussed in the following subsection.

Volatile Organic Compounds, TMD

In 2017, groundwater samples collected from the following TMD wells during each semiannual event were analyzed for VOCs:

- First Semiannual Event (13 wells): MW-8, MW-16, MW-20, MW-21, MW-25, MW-26, MW-27, MW-46R, MW-68, MW-71, MW-89, NP-1, and NP-6.
- Second Semiannual Event (3 wells): MW-21, MW-46R, and NP-1.

MTBE was detected in exceedance of its CGWSL of 0.143 mg/L in TMD well NP-1 during both 2017 semiannual events (0.391 mg/L in April 2017 and 0.407 mg/L in October 2017), as highlighted in Table 4A. No other VOC was detected above its respective CGWSL during either semiannual event. The 2017 VOC results for groundwater samples collected from TMD wells were consistent with historical results. As shown in the COC concentration plots included in Appendix C, concentrations of target VOCs in TMD wells are overall stable, with the exception of MTBE in NP-1 and NP-6 which have exhibited an increasing trend over the three most recent sampling events. MTBE remains below the CGWSL in NP-6.

Total Metals, TMD

In 2017, groundwater samples were collected from the following TMD wells during each semiannual event for analysis of the standard total metals list (arsenic, barium, chromium, iron, lead, manganese, and selenium):

- First Semiannual Event (11 wells): MW-8, MW-16, MW-20, MW-21, MW-25, MW-26, MW-27, MW-46R, MW-68, MW-71, and MW-89.
- Second Semiannual Event (2 wells): MW-21 and MW-46R.

In addition, the groundwater sample collected from TMD well MW-71 during the first 2017 semiannual event was analyzed for the expanded total metals list (boron, cadmium, cobalt, mercury, nickel, uranium, and vanadium).

Arsenic, barium, boron, cadmium, cobalt, chromium, iron, lead, mercury, nickel, and vanadium were not detected above their respective CGWSLs in any of the TMD wells sampled during either 2017 semiannual event. Manganese, selenium, and uranium were detected at concentrations in exceedance of their respective CGWSLs in at least one TMD well, as highlighted in Table 4B and described below:

- Manganese exceeded the CGWSL of 0.200 mg/L in four wells sampled (MW-8, MW-21, MW-25, and MW-26) during the first 2017 semiannual event at a maximum concentration of 0.560 mg/L in MW-26; and in well MW-21 during the second semiannual event at a concentration of 0.607 mg/L.

- Selenium exceeded the CGWSL of 0.050 mg/L in well MW-89 during the first 2017 semiannual event at a concentration of 0.0534 mg/L.
- Uranium exceeded the CGWSL of 0.030 mg/L in well MW-71 during the first 2017 semiannual event at a concentration of 0.0534 mg/L.

The 2017 analytical results of total metals in groundwater samples collected from TMD wells were generally consistent with historical results, with the exception of selenium in MW-89. Selenium concentrations exhibited an increasing trend in MW-89 over the five most recent sampling events and exceeded the CGWSL in 2017 for the first time over the five most recent sampling events. Concentrations of target COC arsenic in TMD wells are overall stable, as shown in the COC concentration plots included in Appendix C.

Cyanide, TMD

Cyanide was not detected above the method detection limit or the CGWSL in the groundwater sample collected from TMD well MW-71 during the first 2017 semiannual event.

Water Quality Parameters, TMD

In 2017, groundwater samples were collected from the following TMD wells during each semiannual event for analysis of water quality parameters (calcium, chloride, fluoride, potassium, sodium, sulfate, TDS, and nitrate/nitrite [as nitrogen]):

- First Semiannual Event (12 wells): MW-8, MW-16, MW-20, MW-21, MW-25, MW-26, MW-27, MW-46R, MW-68, MW-71, MW-89, and NP-1.
- Second Semiannual Event (2 wells): MW-21 and MW-46R.

No CGWSLs are applicable for calcium, potassium, or sodium. Chloride, fluoride, nitrate/nitrite, sulfate, and TDS were detected at concentrations in exceedance of their respective CGWSLs in groundwater samples from TMD wells, as highlighted in Table 4C. The reported concentrations of these constituents in 2017 were consistent with historical results.

5.3.5 North Refinery Area – Analytical Results

Groundwater monitoring is ongoing in the northern portion of the active refinery (i.e., North Refinery Area). Analytical results of groundwater samples collected from wells located within the North Refinery Area in 2017 indicate COCs are present in groundwater in excess of their respective CGWSLs, as highlighted in Tables 4A through 4C and discussed in the following subsections.

Total Petroleum Hydrocarbons – Diesel Range Organics, North Refinery Area

Groundwater samples were collected from the following North Refinery Area wells during each 2017 semiannual event for analysis of DRO:

- First Semiannual Event (29 wells): MW-23, MW-29, MW-39, MW-40, MW-41, MW-42, MW-43, MW-59, MW-60, MW-61, MW-62, MW-67, MW-90, MW-91, MW-93, MW-94, MW-95, MW-96, MW-98, MW-137, MW-138, RW-1R, RW-2R, RW-7R, RW-8, RW-9, RW-10, RW-16, and RW-17.
- Second Semiannual Event (14 wells): MW-23, MW-29, MW-39, MW-43, MW-60, MW-61, MW-62, MW-67, MW-90, MW-91, MW-96, MW-98, MW-137, and MW-138.

As highlighted in Table 4A, DRO was detected at concentrations in exceedance of the CGWSL in all 29 North Refinery Area wells sampled during the first 2017 semiannual event at a maximum concentration of 21.5 mg/L in RW-1R and in all 14 North Refinery Area wells sampled during the second 2017 semiannual event at a maximum concentration of 32.0 mg/L in MW-23. As shown in the COC concentration plots included in Appendix C, DRO concentrations in North Refinery Area wells MW-29, MW-40, MW-59, MW-60, MW-67, MW-91, MW-92, MW-95, MW-96, RW-1R, RW-2R, RW-9, and RW-17 have exhibited an overall increasing trend over time. However, the DRO concentrations have exhibited a stable trend over the most recent three sampling events in all these wells except MW-29, MW-60, MW-92, RW-1R and RW-17. DRO concentrations in the remaining North Refinery Area wells were overall stable over time.

Total Petroleum Hydrocarbons – Gasoline Range Organics, North Refinery Area

Groundwater samples were collected from the following North Refinery Area wells during each 2017 semiannual event for analysis of GRO:

- First Semiannual Event (27 wells): MW-23, MW-29, MW-39, MW-40, MW-41, MW-42, MW-43, MW-59, MW-60, MW-61, MW-62, MW-67, MW-90, MW-91, MW-93, MW-94, MW-95, MW-96, MW-98, MW-137, MW-138, RW-1R, RW-2R, RW-7R, RW-9, RW-10, and RW-17.
- Second Semiannual Event (14 wells): MW-23, MW-29, MW-39, MW-43, MW-60, MW-61, MW-62, MW-67, MW-90, MW-91, MW-96, MW-98, MW-137, and MW-138.

GRO was detected above the method detection limit in 25 North Refinery Area wells sampled during the first 2017 semiannual event at a maximum concentration of 29.6 mg/L in MW-43 and in 13 North Refinery Area wells sampled during the second 2017 semiannual event at a

maximum concentration of 33.1 mg/L in MW-137. GRO analytical results in groundwater samples collected from North Refinery Area wells in 2017 were consistent with historical results except in wells RW-10 and RW-17. GRO was detected in these two wells above the method detection limit for the first time during the first 2017 semiannual event at concentrations of 0.207 mg/L and 0.0622 J mg/L, respectively. As shown in the COC concentration plots included in Appendix C, GRO concentrations in all other North Refinery Area wells are stable to fluctuating over time.

There is no applicable CGWSL for GRO, but previous NMED guidance (NMED 2012) required analysis of VOCs when GRO is present for comparison to applicable individual VOC screening levels. VOC results are discussed in the following subsection.

Volatile Organic Compounds, North Refinery Area

Groundwater samples were collected from the following North Refinery Area wells during each 2017 semiannual event for analysis of VOCs:

- First Semiannual Event (29 wells): MW-23, MW-29, MW-39, MW-40, MW-41, MW-42, MW-43, MW-59, MW-60, MW-61, MW-62, MW-67, MW-90, MW-91, MW-93, MW-94, MW-95, MW-96, MW-98, MW-137, MW-138, RW-1R, RW-2R, RW-7R, RW-8, RW-9, RW-10, RW-16, and RW-17.
- Second Semiannual Event (14 wells): MW-23, MW-29, MW-39, MW-43, MW-60, MW-61, MW-62, MW-67, MW-90, MW-91, MW-96, MW-98, MW-137, and MW-138.

Benzene, ethylbenzene, toluene, o-xylenes, total xylenes, MTBE, naphthalene, 1,2,4-TMB, 1,3,5,-trimethylbenzene (1,3,5-TMB), cis-1,2,-dichoroethene (cis-1,2-DCE), and trichloroethene (TCE) were detected at concentrations in exceedance of their respective CGWSLs in at least one North Refinery Area well, as highlighted in Table 4A and described below:

- Benzene exceeded the CGWSL of 0.005 mg/L in 18 wells sampled during the first 2017 semiannual event at a maximum concentration of 9.69 mg/L in MW-137; and in 11 wells sampled during the second 2017 semiannual event at a maximum concentration of 12.5 mg/L in MW-137.
- Ethylbenzene exceeded the CGWSL of 0.7 mg/L in three wells sampled (MW-98, MW-137, and RW-2R) during the first 2017 semiannual event at a maximum concentration of 1.53 mg/L in MW-137; and in two wells sampled (MW-98 and MW-137) during the second 2017 semiannual event at a maximum concentration of 1.53 mg/L in MW-137.

- Toluene exceeded the CGWSL of 0.75 mg/L in two wells sampled (MW-91 and MW-137) during both 2017 semiannual events with maximum detected concentrations in MW-137 of 2.08 mg/L during the first event and 1.54 mg/L during the second event.
- o-Xylene exceeded the CGWSL of 0.193 mg/L in four wells sampled (MW-43, MW-91, MW-94, and MW-137) during the first 2017 semiannual event at a maximum concentration of 0.539 mg/L in MW-43; and in three wells sampled (MW-43, MW-91, and MW-137) during the second 2017 semiannual event at a maximum concentration of 0.421 mg/L in MW-43.
- Total xylenes exceeded the CGWSL of 0.62 mg/L in five wells sampled (MW-43, MW-62, MW-91, MW-98, and MW-137) during both 2017 semiannual events with maximum detected concentrations in MW-98 of 1.88 mg/L during the first event and 2.21 mg/L during the second event.
- MTBE exceeded the CGWSL of 0.143 mg/L in five wells sampled (MW-67, MW-94, MW-96, RW-8, and RW-17) during the first 2017 semiannual event at a maximum concentration of 30.6 mg/L in MW-96; and in three wells sampled (MW-67, MW-96, and MW-138) during the second 2017 semiannual event at a maximum concentration of 40.0 mg/L in MW-96.
- Naphthalene exceeded the CGWSL of 0.03 mg/L in 11 wells sampled during the first 2017 semiannual event at a maximum concentration of 0.272 mg/L in MW-137; and in seven wells sampled during the second 2017 semiannual event at a maximum concentration of 0.317 mg/L in MW-137.
- 1,2,4-TMB exceeded the CGWSL of 0.015 mg/L in 11 wells sampled during the first 2017 semiannual event at a maximum concentration of 0.646 mg/L in MW-62; and in seven wells sampled during the second 2017 semiannual event at a maximum concentration of 0.839 mg/L in MW-43.
- 1,3,5-TMB exceeded the CGWSL of 0.12 mg/L in well MW-62 during the first 2017 semiannual event at a concentration of 0.149 mg/L; and in three wells sampled (MW-43, MW-62, and MW-137) during the second 2017 semiannual event at a maximum concentration of 0.182 mg/L in MW-43.
- cis-1,2,-DCE exceeded the CGWSL of 0.07 mg/L in two wells sampled (RW-1R and RW-2R) during the first 2017 semiannual event at a maximum concentration of 0.828 mg/L in RW-2R; and in no wells sampled during the second 2017 semiannual event.

- TCE exceeded the CGWSL of 0.005 mg/L in two wells sampled (RW-1R and RW-2R) during the first 2017 semiannual event at a maximum concentration of 0.0249 J mg/L in RW-2R; and in no the wells sampled during the second 2017 semiannual event.

The 2017 analytical results of target VOCs in groundwater samples collected from North Refinery Area wells were generally consistent with historical results. As shown in the COC concentration plots included in Appendix C, concentrations of target VOCs in North Refinery Area wells have exhibited an overall stable to fluctuating trend over time, with the following exception:

- Benzene, ethylbenzene, toluene, MTBE, and naphthalene concentrations have overall increased in MW-43 since 2012. However, concentrations of these target VOCs have exhibited a stable to decreasing trend over the four most recent sampling events.

Total Metals, North Refinery Area

In 2017, groundwater samples were collected from the following North Refinery Area wells during each semiannual event for analysis of the standard total metals list (arsenic, barium, chromium, iron, lead, manganese, and selenium):

- First Semiannual Event (29 wells): MW-23, MW-29, MW-39, MW-40, MW-41, MW-42, MW-43, MW-59, MW-60, MW-61, MW-62, MW-67, MW-90, MW-91, MW-93, MW-94, MW-95, MW-96, MW-98, MW-137, MW-138, RW-1R, RW-2R, RW-7R, RW-8, RW-9, RW-10, RW-16, and RW-17.

- Second Semiannual Event (14 wells): MW-23, MW-29, MW-39, MW-43, MW-60, MW-61, MW-62, MW-67, MW-90, MW-91, MW-96, MW-98, MW-137, and MW-138.

In addition, groundwater samples collected from North Refinery Area wells MW-43, MW-60, MW-67, MW-137, and MW-138 were analyzed for the expanded metals list (boron, cadmium, cobalt, mercury, nickel, uranium, and vanadium) during both 2017 semiannual events.

Cadmium, cobalt, chromium, mercury, nickel, uranium, and vanadium were not detected above their respective CGWSLs in any of the North Refinery Area wells sampled during either 2017 semiannual event. Arsenic, barium, boron, iron, lead, manganese, and selenium were detected at concentrations in exceedance of their respective CGWSLs in at least one North Refinery Area well, as highlighted in Table 4B and described below:

- Arsenic exceeded the CGWSL of 0.010 mg/L in six wells sampled during the first 2017 semiannual event at a maximum concentration of 0.0496 mg/L in MW-137; and in three wells sampled during the second 2017 semiannual event at a maximum concentration of 0.0156 mg/L in MW-137.

- Barium exceeded the CGWSL of 1.00 mg/L in well MW-23 during both 2017 semiannual events at a concentration of 9.82 mg/L during the first event and 10.5 mg/L during the second event.
- Boron exceeded the CGWSL of 0.75 mg/L in three wells sampled (MW-43, MW-137, and MW-138) during both 2017 semiannual events with maximum concentrations in MW-43 of 1.21 mg/L during the first event and 1.43 mg/L during the second event.
- Iron exceeded the CGWSL of 1.00 mg/Lin three wells sampled (MW-90, RW-1R, and RW-8) during the first 2017 semiannual event at a maximum concentration of 9.50 mg/L in RW-8; and in no wells sampled during the second 2017 semiannual event.
- Lead did not exceed the CGWSL of 0.015 mg/L in any area wells sampled during the first 2017 semiannual event; but did exceed in MW-23 during the second 2017 semiannual event at a concentration of 0.0172 mg/L.
- Manganese exceeded the CGWSL of 0.200 mg/L in 10 wells sampled during the first 2017 semiannual event at a maximum concentration of 1.13 mg/L in RW-7R; and in three wells sampled during the second 2017 semiannual event at a maximum concentration of 0.382 mg/L in MW-29.
- Selenium exceeded the CGWSL of 0.050 mg/L in MW-40 during the first 2017 semiannual event at a concentration of 0.0704 mg/L; and in two wells (MW-61 and MW-62) sampled during the second 2017 semiannual event at a maximum concentration of 0.0554 mg/L in MW-62.

The 2017 analytical results of total metals in groundwater samples collected from North Refinery Area wells were generally consistent with historical results, with the following exceptions:

- Arsenic concentrations in RW-1R exhibited an increasing trend over the three most recent sampling events and exceeded the CGWSL for the first time over the three most recent sampling events during the first 2017 semiannual event. However, the 2017 arsenic result was less than the historical maximum detected in this well in 2010. Arsenic results have fluctuated above and below the CGWSL in various North Refinery Area wells over time.
- Arsenic, iron, and manganese concentrations increased in RW-8 during the first 2017 semiannual event by at least one order of magnitude from the most recent sampling event conducted at this well in April 2015. These metals also exceeded their respective CGWSLs in this well in 2017 for the first time. There is limited data available for this well due to the historical presence of PSH greater than 0.03 feet in this well.

- Manganese increased in MW-137 from 0.113 mg/L in the first 2017 semiannual event to 0.209 mg/L in the second 2017 semiannual event, which was the first exceedance of the CGWSL in this well over at least the five most recent sampling events. Manganese results have fluctuated above and below the CGWSL in various North Refinery Area wells over time.

- Selenium concentrations increased to above the CGWSL in wells MW-40 and MW-62 during the first and second 2017 semiannual event, respectively, which were the first exceedance of the CGWSL in these wells over at least the four most recent sampling events. Selenium results have fluctuated above and below the CGWSL in various North Refinery Area wells over time.

Concentrations of target COC arsenic in North Refinery Area wells are overall stable to declining, despite occasional fluctuating, as shown in the COC concentration plots included in Appendix C. Arsenic concentrations have fluctuated above and below the CGWSL over time in wells MW-23, MW-29, MW-41, MW-43, MW-60, MW-62, MW-67, MW-90, MW-91, MW-93, and RW-1R.

Cyanide, North Refinery Area

Groundwater samples collected from North Refinery Area wells MW-43, MW-60, MW-67, MW-137, and MW-138 during both 2017 semiannual events were analyzed for cyanide. Cyanide was not detected above the CGWSL in groundwater samples collected from these wells.

Water Quality Parameters, North Refinery Area

In 2017, groundwater samples were collected from the following North Refinery Area wells during each semiannual event for analysis of water quality parameters (calcium, chloride, fluoride, potassium, sodium, sulfate, TDS, and nitrate/nitrite [as nitrogen]):

- First Semiannual Event (29 wells): MW-23, MW-29, MW-39, MW-40, MW-41, MW-42, MW-43, MW-59, MW-60, MW-61, MW-62, MW-67, MW-90, MW-91, MW-93, MW-94, MW-95, MW-96, MW-98, MW-137, MW-138, RW-1R, RW-2R, RW-7R, RW-8, RW-9, RW-10, RW-16, and RW-17.

- Second Semiannual Event (14 wells): MW-23, MW-29, MW-39, MW-43, MW-60, MW-61, MW-62, MW-67, MW-90, MW-91, MW-96, MW-98, MW-137, and MW-138.

No CGWSLs are applicable for calcium, potassium, or sodium. Chloride, fluoride, sulfate, and TDS were detected at concentrations in exceedance of their respective CGWSLs in groundwater samples from various North Refinery Area wells as highlighted in Table 4C. The reported concentrations of these constituents were generally consistent with historical results.

Sulfate concentrations in wells RW-7R and RW-8 have exhibited an overall increasing trend since 2015.

5.3.6 South Refinery Area – Analytical Results

Groundwater monitoring is ongoing in the southern portion of the active refinery (i.e., South Refinery Area). Analytical results of groundwater samples collected from wells located within the South Refinery Area in 2017 indicate COCs are present in groundwater in excess of their respective CGWSLs, as highlighted in Tables 4A through 4C and discussed in the following subsections.

Total Petroleum Hydrocarbons – Diesel Range Organics, South Refinery Area

Groundwater samples were collected from the following South Refinery Area wells during each 2017 semiannual event for analysis of DRO:

- First Semiannual Event (22 wells): KWB-2R, KWB-5, KWB-6, MW-28, MW-48, MW-50, MW-52, MW-64, MW-65, MW-66, MW-99, MW-101, MW-102, MW-103, MW-104, MW-105, MW-106, MW-107, MW-109, MW-110, RW-4R, and RW-15.
- Second Semiannual Event (18 wells): KWB-2R, KWB-5, KWB-6, MW-28, MW-48, MW-50, MW-52, MW-64, MW-65, MW-66, MW-99, MW-101, MW-102, MW-104, MW-105, MW-106, MW-109, and MW-110.

As highlighted in Table 4A, DRO was detected at concentrations in exceedance of the CGWSL 0.0473 mg/L in all South Refinery Area wells sampled during both 2017 semiannual events with maximum concentrations in well MW-106 of 17.9 mg/L during the first event and 22.2 mg/L during the second event. DRO concentrations in South Refinery Area wells MW-28, MW-48, MW-50, MW-52, MW-64, MW-65, MW-102, MW-104, MW-105, MW-109, and RW-6R have exhibited an overall fluctuating to increasing trend over time, as shown in the COC concentration plots included in Appendix C. However, DRO concentrations have exhibited a stable trend in all these wells except MW-48, MW-104, and RW-6R over at least the four most recent sampling events. DRO concentrations in these wells will be watched closely during future sampling events.

Total Petroleum Hydrocarbons – Gasoline Range Organics, South Refinery Area

Groundwater samples were collected from the following South Refinery Area wells during each 2017 semiannual event for analysis of GRO:

- First Semiannual Event (16 wells): MW-28, MW-48, MW-52, MW-64, MW-65, MW-66, MW-99, MW-101, MW-102, MW-103, MW-104, MW-105, MW-106, MW-107, MW-109, and MW-110.

- Second Semiannual Event (14 wells): MW-28, MW-48, MW-52, MW-64, MW-65, MW-66, MW-99, MW-101, MW-102, MW-104, MW-105, MW-106, MW-109, and MW-110.

GRO was detected above the method detection limit in all South Refinery Area wells sampled during both 2017 semiannual events except in MW-52, with maximum concentrations of 109 mg/L in MW-64 during the first event and 335 mg/L in MW-102 during the second event. As shown in the COC concentration plots included in Appendix C, GRO analytical results in groundwater samples collected from South Refinery Area wells in 2017 were overall consistent with historical results except in MW-48 and MW-102. GRO concentrations exhibited an increasing trend in MW-48 over the five most recent monitoring events. GRO concentrations in MW-102 were historically stable, but increased from 26.4 mg/L in the first 2017 semiannual event to 335 mg/L in the second 2017 semiannual event. These wells will be watched closely during future monitoring events.

There is no applicable CGWSL for GRO, but previous NMED guidance (NMED 2012) required analysis of VOCs when GRO is present for comparison to applicable individual VOC screening levels. VOC results are discussed in the following subsection.

Volatile Organic Compounds, South Refinery Area

Groundwater samples were collected from the following South Refinery Area wells during each 2017 semiannual event for analysis of VOCs:

- First Semiannual Event (23 wells): KWB-2R, KWB-5, KWB-6, MW-28, MW-48, MW-50, MW-52, MW-64, MW-65, MW-66, MW-99, MW-101, MW-102, MW-103, MW-104, MW-105, MW-106, MW-107, MW-109, MW-110, RA-313, RW-4R, and RW-15.

- Second Semiannual Event (18 wells): KWB-2R, KWB-5, KWB-6, MW-28, MW-48, MW-50, MW-52, MW-64, MW-65, MW-66, MW-99, MW-101, MW-102, MW-104, MW-105, MW-106, MW-109, and MW-110.

Benzene, ethylbenzene, toluene, o-xylenes, total xylenes, MTBE, naphthalene, 1,2,4-TMB, and 1,3,5-TMB were detected at concentrations in exceedance of their respective CGWSLs in at least one South Refinery Area well, as highlighted in Table 4A and described below:

- Benzene exceeded the CGWSL of 0.005 mg/L in 20 wells sampled during the first 2017 semiannual event at a maximum concentration of 19.1 mg/L in RW-15; and in 14 wells sampled during the second 2017 semiannual event at a maximum concentration of 30.7 mg/L in MW-64.

- Ethylbenzene exceeded the CGWSL of 0.7 mg/L in five wells sampled during the first 2017 semiannual event at a maximum concentration of 4.19 mg/L in RW-15; and in four wells sampled during the second 2017 semiannual event at a maximum concentration of 3.2 mg/L in MW-64.
- Toluene exceeded the CGWSL of 0.75 mg/L in MW-64 during both 2017 semiannual events at a concentration of 13.2 mg/L during the first event and 9.81 mg/L during the second event.
- o-Xylene exceeded the CGWSL of 0.193 mg/L in two wells sampled (MW-64 and RW-15) during the first 2017 semiannual event at a maximum concentration of 2.09 mg/L in MW-64; and in MW-64 during the second 2017 semiannual event at a concentration of 1.44 mg/L.
- Total xylenes exceeded the CGWSL of 0.62 mg/L in three wells sampled (MW-48, MW-64, and RW-15) during the first 2017 semiannual event at a maximum concentration of 7.58 mg/L in MW-64; and in two wells sampled (MW-48 and MW-64) during the second 2017 semiannual event at a maximum concentration of 6.01 mg/L in MW-64.
- MTBE exceeded the CGWSL of 0.143 mg/L in 11 wells sampled during the first 2017 semiannual event at a maximum concentration of 8.84 mg/L in KWB-5; and in seven wells sampled during the second 2017 semiannual event at a maximum concentration of 12.4 mg/L in KWB-5.
- Naphthalene exceeded the CGWSL of 0.03 mg/L in 10 wells sampled during the first 2017 semiannual event at a maximum concentration of 0.383 mg/L in RW-15; and in six wells sampled during the second 2017 semiannual event at a maximum concentration of 0.483 mg/L in MW-102.
- 1,2,4-TMB exceeded the CGWSL of 0.015 mg/L in 12 wells sampled during the first 2017 semiannual event at a maximum concentration of 1.46 mg/L in RW-15; and in nine wells sampled during the second 2017 semiannual event at a maximum concentration of 0.643 mg/L in MW-64.
- 1,3,5-TMB exceeded the CGWSL of 0.12 mg/L in two wells sampled (MW-64 and RW-15) during the first 2017 semiannual event at a maximum concentration of 0.231 mg/L in RW-15; and in MW-64 during the second 2017 semiannual event at a concentration of 0.130 mg/L.

The 2017 analytical results of target VOCs in groundwater samples collected from South Refinery Area wells were generally consistent with historical results. As shown in the COC

concentration plots included in Appendix C, concentrations of target VOCs in South Refinery Area wells have exhibited overall stable to fluctuating trends over time, with the following exceptions:

- Benzene concentrations have exhibited increasing trends in wells MW-48 and MW-109 since 2014, but appear to be stabilizing over the four most recent sampling events conducted in 2016 and 2017. Benzene concentrations in these wells will be watched closely during future monitoring events.
- Ethylbenzene, toluene, and total xylene concentrations have overall increased over time in wells MW-48, MW-64, and MW-99. However, concentrations of these VOCs have exhibited a stabilizing trend in these wells over at the four most recent monitoring events.
- MTBE concentrations have overall increased over time in wells MW-48, MW-99, MW-102, and RW-4/RW-4R since approximately 2011. However, MTBE concentrations have exhibited a stabilizing trend over at least the five most recent monitoring events in MW-48, MW-99, and MW-102. There is limited historical data available for RW-4R, but MTBE concentrations have stabilized over the three most recent monitoring events.
- Naphthalene concentrations increased in KWB-2R from 0.00609 mg/L during the first 2017 semiannual event to 0.0675 mg/L during the second 2017 semiannual event, which was the first exceedance of the CGWSL over the six most recent sampling events. However, the 2017 concentrations remain below the historical maximum (0.51 mg/L) detected in this well in November 2014. Naphthalene concentrations have fluctuated above and below the CGWSL in several South Refinery Area wells over time, but naphthalene concentrations in these wells will be watched closely during future monitoring events.

Total Metals, South Refinery Area

In 2017, groundwater samples were collected from the following South Refinery Area wells during each semiannual event for analysis of the standard total metals list (arsenic, barium, chromium, iron, lead, manganese, and selenium):

- First Semiannual Event (22 wells): KWB-2R, KWB-5, KWB-6, MW-28, MW-48, MW-50, MW-52, MW-64, MW-65, MW-66, MW-99, MW-101, MW-102, MW-103, MW-104, MW-105, MW-106, MW-107, MW-109, MW-110, RW-4R, and RW-15.
- Second Semiannual Event (18 wells): KWB-2R, KWB-5, KWB-6, MW-28, MW-48, MW-50, MW-52, MW-64, MW-65, MW-66, MW-99, MW-101, MW-102, MW-104, MW-105, MW-106, MW-109, and MW-110.

In addition, groundwater samples collected from South Refinery Area wells MW-28, MW-52, and MW-66 were also analyzed for the expanded metals list (boron, cadmium, cobalt, mercury, nickel, uranium, and vanadium) during both 2017 semiannual events.

Cadmium, cobalt, chromium, lead, mercury, nickel, uranium, and vanadium were not detected above their respective CGWSLs in any of the South Refinery Area wells sampled during either 2017 semiannual event. Arsenic, barium, boron, iron, manganese, and selenium were detected at concentrations in exceedance of their respective CGWSLs in at least one well, as highlighted in Table 4B and described below:

- Arsenic exceeded the CGWSL of 0.010 mg/L in nine wells sampled during both 2017 semiannual events with maximum concentrations in MW-101 of 0.0659 mg/L during the first event and 0.0824 mg/L during the second event.
- Barium exceeded the CGWSL of 1.00 mg/L in nine wells sampled during the first 2017 semiannual event at a maximum concentration of 8.12 mg/L in MW-103; and in six wells sampled during the second 2017 semiannual event a maximum concentration of 5.52 mg/L in MW-102.
- Boron did not exceed the CGWSL of 0.75 mg/L in any wells sampled during the first 2017 semiannual event; but did exceed in well MW-52 during the second 2017 semiannual event at a concentration of 0.852 mg/L.
- Iron exceeded the CGWSL of 1.00 mg/L in four wells sampled (KWB-5, MW-65, MW-101, and MW-107) during the first 2017 semiannual event at a maximum concentration of 5.17 mg/L in MW-107; and in five wells sampled (KWB-5, MW-64, MW-65, MW-101, and MW-102) during the second 2017 semiannual event at a maximum concentration of 2.99 mg/L in MW-101.
- Manganese exceeded the CGWSL of 0.200 mg/L in 10 wells sampled during the first 2017 semiannual event at a maximum concentration of 1.91 mg/L in KWB-6; and in nine wells sampled during the second 2017semiannual event at a maximum concentration of 2.15 mg/L in KWB-6.
- Selenium exceeded the CGWSL of 0.050 mg/L in well MW-99 during the first 2017 semiannual event at a concentration of 0.0857 mg/L; and in MW-48 during the second 2017 semiannual event at a concentration of 0.0669 mg/L.

The total metals results in groundwater in South Refinery Area wells were generally consistent with historical results, with the following exceptions:

- Arsenic concentrations in MW-104 have exhibited an increasing trend over the six most recent monitoring events. Arsenic concentrations increased in this well from the 2016

semiannual events (0.00195 J mg/L in April 2016 and 0.0194 mg/L in October 2016) to the 2017 semiannual events (0.0570 mg/L in April 2017 and 0.0602 mg/L in October 2017), which were the historical maximums detected in this well. This well will be watched closely during future monitoring events.

- Boron concentrations in MW-52 increased from 0.702 mg/L during the first 2017 semiannual event to 0.852 mg/L during the second 2017 semiannual event, which is the first exceedance of the CGWSL in this well. There is limited historical data available for this metal as it was first included in the groundwater monitoring program in 2016.

- Iron concentrations increased in wells MW-102 and MW-107 during their most recent 2017 monitoring event. Iron concentrations increased in MW-102 from 0.201 mg/L during the first 2017 semiannual event to 1.12 mg/L during the second 2017 semiannual event, which was the first exceedance of the CGWSL over the six most recent monitoring events. Iron concentrations increased in MW-107 from 0.158 mg/L during the first 2016 semiannual event (April 2016) to 5.17 mg/L during the first 2017 semiannual event. Iron concentrations have fluctuated above and below the CGWSL in several South Refinery Area wells over time, including in MW-107.

- Selenium concentrations increased in wells MW-48 and MW-99 during at least one of the 2017 monitoring events. Selenium concentrations increased in MW-48 from 0.000838 J mg/L during the first 2017 semiannual event to 0.0669 mg/L during the second 2017 semiannual event, which was the first exceedance of the CGWSL over the six most recent monitoring events. Selenium concentrations increased in MW-99 from not detected above the method detection limit of 0.00038 mg/L during the second 2016 semiannual event (October 2016) to 0.0857 mg/L during the first 2017 semiannual event, which was the first exceedance of the CGWSL over the four prior monitoring events. However, selenium was not detected above the method detection limit of 0.00038 mg/L during the second 2017 semiannual event. Selenium concentrations have fluctuated above and below the CGWSL in several South Refinery Area wells over time

Concentrations of target COC arsenic in South Refinery Area wells are overall stable to fluctuating, as shown in the COC concentration plots included in Appendix C. Arsenic concentrations have fluctuated above and below the CGWSL over time in wells MW-28, MW-48, MW-52, MW-66, MW-99, MW-102, MW-104 through MW-107, MW-109, and MW-110.

Cyanide, South Refinery Area

Groundwater samples collected from South Refinery Area wells MW-28, MW-52, and MW-66 were analyzed for cyanide during both 2017 semiannual events. Cyanide was not detected

above the method detection limit or the CGWSL in groundwater samples collected from these wells.

Water Quality Parameters, South Refinery Area

In 2017, groundwater samples were collected from the following South Refinery Area wells during each semiannual event for analysis of water quality parameters (calcium, chloride, fluoride, potassium, sodium, sulfate, TDS, and nitrate/nitrite [as nitrogen]):

- First Semiannual Event (23 wells): KWB-2R, KWB-5, KWB-6, MW-28, MW-48, MW-50, MW-52, MW-64, MW-65, MW-66, MW-99, MW-101, MW-102, MW-103, MW-104, MW-105, MW-106, MW-107, MW-109, MW-110, RA-313, RW-4R, and RW-15.
- Second Semiannual Event (18 wells): KWB-2R, KWB-5, KWB-6, MW-28, MW-48, MW-50, MW-52, MW-64, MW-65, MW-66, MW-99, MW-101, MW-102, MW-104, MW-105, MW-106, MW-109, and MW-110.

No CGWSLs are applicable for calcium, potassium, or sodium. Chloride, fluoride, nitrate/nitrite, sulfate, and TDS were detected at concentrations in exceedance of their respective CGWSLs in groundwater samples from at least one South Refinery Area wells as highlighted in Table 4C. The reported concentrations of these constituents exhibit an overall stable trend across the South Refinery Area, with the following exceptions:

- Chloride concentrations increased from the 2016 semiannual events (208 mg/L in April 2016 and 192 mg/L in October 2016) to the 2017 semiannual events (284 mg/L in April 2017 and 256 mg/L in October 2017), which were the first exceedances of the CGWSL in this well over the six most recent monitoring events.
- TDS concentrations have increased between each of the four most recent sampling events in MW-103, ranging from 3,820 mg/L in April 2014 to 22,300 mg/L in April 2017.

5.3.7 Field East of Refinery – Analytical Results

Groundwater monitoring is ongoing in the field east of the refinery located between the refinery and the EPs. Analytical results of groundwater samples collected from wells located within the field east of the refinery in 2017 indicate COCs are present in groundwater in excess of their respective CGWSLs, as highlighted in Tables 4A through 4C and discussed in the following subsections.

Total Petroleum Hydrocarbons – Diesel Range Organics, Field East of Refinery

Groundwater samples were collected from the following wells located within the field east of the refinery during each 2017 semiannual event for analysis of DRO:

- First Semiannual Event (25 wells): KWB-1A, KWB-1C, KWB-7, KWB-8, KWB-10R, KWB-11A, KWB-11B, KWB-12A, KWB-12B, KWB-P4, MW-57, MW-58, MW-111, MW-113, MW-125, MW-126A, MW-126B, MW-127, MW-128, MW-129, MW-130, MW-131, MW-134, MW-135, and RW-12R.

- Second Semiannual Event (21 wells): KWB-1A, KWB-7, KWB-8, KWB-10R, KWB-11A, KWB-11B, KWB-12A, KWB-12B, MW-57, MW-58, MW-111, MW-113, MW-125, MW-126A, MW-126B, MW-127, MW-128, MW-130, MW-131, MW-134, and MW-135.

DRO was detected at concentrations in exceedance of the CGWSL of 0.0398 mg/L in 22 wells sampled during the first 2017 semiannual event (maximum concentration of 7.23 mg/L in MW-58) and in all 21 wells samples sampled during the second 2017 semiannual event (maximum concentration of 12.2 mg/L in KWB-11A), as highlighted in Table 4A. As shown in the COC concentration plots included in Appendix C-7, DRO concentrations in wells KWB-7, KWB-11A, KWB-11B, MW-58, and MW-134 have exhibited an overall fluctuating to increasing trend over time. However, DRO concentrations have stabilized in these wells over at least the five most recent sampling events except in KWB-11A, KWB-11B, and MW-134.

DRO concentrations in these wells will be watched closely during future sampling events.

Total Petroleum Hydrocarbons – Gasoline Range Organics, Field East of Refinery

Groundwater samples were collected from the following wells located within the field east of the refinery during each 2017 semiannual event for analysis of GRO:

- First Semiannual Event (17 wells): KWB-11A, KWB-11B, KWB-12A, KWB-12B, MW-57, MW-111, MW-113, MW-125, MW-126A, MW-126B, MW-127, MW-128, MW-129, MW-130, MW-131, MW-134, and MW-135.

- Second Semiannual Event (16 wells): KWB-11A, KWB-11B, KWB-12A, KWB-12B, MW-57, MW-111, MW-113, MW-125, MW-126A, MW-126B, MW-127, MW-128, MW-130, MW-131, MW-134, and MW-135.

GRO was detected above the method detection limit in 8 wells sampled during the first 2017 semiannual event (maximum concentration of 6.81 mg/L in MW-131) and in 8 wells sampled during the second 2017 semiannual event (maximum concentration of 4.95 mg/L in MW-131). GRO analytical results in groundwater samples collected from wells located in the field east of the

refinery in 2016 were overall consistent with historical results, as shown in the COC concentration plots included in Appendix C.

There is no applicable CGWSL for GRO, but previous NMED guidance (NMED 2012) required analysis of VOCs when GRO is present for comparison to applicable individual VOC screening levels. VOC results are discussed in the following subsection.

Volatile Organic Compounds, Field East of Refinery

Groundwater samples were collected from the following wells located in the field east of the refinery during each 2017 semiannual event for analysis of VOCs:

- First Semiannual Event (28 wells): KWB-1A, KWB-1C, KWB-7, KWB-8, KWB-10R, KWB-11A, KWB-11B, KWB-12A, KWB-12B, KWB-P4, MW-57, MW-58, MW-111, MW-113, MW-125, MW-126A, MW-126B, MW-127, MW-128, MW-129, MW-130, MW-131, MW-134, MW-135, RA-4196, RA-4798, RW-12R, and RW-18.
- Second Semiannual Event (23 wells): KWB-1A, KWB-7, KWB-8, KWB-10R, KWB-11A, KWB-11B, KWB-12A, KWB-12B, MW-57, MW-58, MW-111, MW-113, MW-125, MW-126A, MW-126B, MW-127, MW-128, MW-129, MW-130, MW-131, MW-134, MW-135, RA-4196, and RA-4798.

Benzene, ethylbenzene, o-xylenes, total xylenes, MTBE, naphthalene, and 1,2,4-TMB were detected at concentrations in exceedance of their respective CGWSLs in at least one well located in the field east of the refinery, as highlighted in Table 4A and described below:

- Benzene exceeded the CGWSL of 0.005 mg/L in 10 wells sampled during the first 2017 semiannual event at a maximum concentration of 5.62 mg/L in KWB-8; and in nine wells sampled during the second 2017 semiannual event at a maximum concentration of 12.5 mg/L in KWB-8.
- Ethylbenzene exceeded the CGWSL of 0.7 mg/L in two wells sampled (KWB-8 and MW-58) during the first 2017 semiannual event at a maximum concentration of 1.24 mg/L in KWB-8; and in no wells sampled during the second 2017 semiannual event.
- o-Xylene exceeded the CGWSL of 0.193 mg/L in KWB-10R during the first 2017 semiannual event at a concentration of 0.198 mg/L; and in no wells sampled during the second 2017 semiannual event.
- Total xylenes exceeded the CGWSL of 0.62 mg/L in two wells sampled (KWB-8 and KWB-10R) during both 2017 semiannual events with maximum concentrations in KWB-8 at 2.07 mg/L during the first event and 0.795 mg/L during the second event.

- MTBE exceeded the CGWSL of 0.143 mg/L in six wells sampled during the first 2017 semiannual event at a maximum concentration of 4.34 mg/L in MW-129; and in five wells sampled during the second 2017 semiannual event at a maximum concentration of 5.41 mg/L in KWB-10R.

- Naphthalene exceeded the CGWSL of 0.03 mg/L in three wells sampled (KWB-8, KWB-10R, and MW-58) during the first 2017 semiannual event at a maximum concentration of 0.191 mg/L in MW-58; and in four wells sampled (KWB-8, KWB-10R, MW-58, and MW-131) during the second 2017 semiannual event at a maximum concentration of 0.152 mg/L in KWB-10R.

- 1,2,4-TMB exceeded the CGWSL of 0.015 mg/L in five wells sampled during the first 2017 semiannual event at a maximum concentration of 0.517 mg/L in MW-58; and in seven wells sampled during the second 2017 semiannual event at a maximum concentration of 0.302 mg/L in KWB-10R.

The 2017 analytical results of target VOCs in groundwater samples collected from wells located in the field east of the refinery were generally consistent with historical results. As shown in the COC concentration plots included in Appendix C, concentrations of target VOCs in wells located in the field east of the refinery have wells have exhibited stable to fluctuating trends over time, with the following exceptions:

- Benzene, ethylbenzene, total xylenes, and naphthalene concentrations in MW-58 have overall increased since 2011. However, concentrations of these VOCs in MW-58 have exhibited a decreasing trend over the seven most recent sampling events.

- 1,2,4-TMB concentrations increased in MW-113 from 0.00448 mg/L during the first 2017 semiannual event to 0.0229 mg/L during the second 2017 semiannual event, which was the first exceedance of the CGWSL over those most recent six sampling events. 1,2,4-TMB concentrations increased in RW-12R from 0.0145 mg/L during the first 2016 semiannual event (April 2016) to 0.0338 mg/L during the first 2017 semiannual event, which was the first exceedance of the CGWSL in this well over the two most recent sampling events. There is limited historical data available for RW-12R due to the historical presence of PSH at greater than 0.03 feet in this well.

Total Metals, Field East of Refinery

In 2017, groundwater samples were collected from the following wells located in the field east of the refinery during each 2017 semiannual event for analysis of the standard total metals list (arsenic, barium, chromium, iron, lead, manganese, and selenium):

- First Semiannual Event (25 wells): KWB-1A, KWB-1C, KWB-7, KWB-8, KWB-10R, KWB-11A, KWB-11B, KWB-12A, KWB-12B, MW-57, MW-58, MW-111, MW-113,

MW-125, MW-126A, MW-126B, MW-127, MW-128, MW-129, MW-130, MW-131, MW-134, MW-135, RW-12R, and RW-18.

- Second Semiannual Event (21 wells): KWB-1A, KWB-7, KWB-8, KWB-10R, KWB-11A, KWB-11B, KWB-12A, KWB-12B, MW-57, MW-58, MW-111, MW-113, MW-125, MW-126A, MW-126B, MW-127, MW-128, MW-130, MW-131, MW-134, and MW-135.

In addition, groundwater samples collected from wells KWB-1A, KWB-7, KWB-8, KWB-11A, KWB-11B, KWB-12A, KWB-12B, and MW-58 during both 2017 semiannual events were analyzed for the expanded metals list (boron, cadmium, cobalt, mercury, nickel, uranium, and vanadium).

Cadmium, cobalt, chromium, lead, mercury, nickel, selenium, and vanadium were not detected above their respective CGWSLs in any of the wells sampled in the field east of the refinery during either 2017 semiannual event. Arsenic, barium, iron, manganese, and uranium were detected at concentrations in exceedance of their respective CGWSLs in at least one well, as highlighted in Table 4B and described below:

- Arsenic exceeded the CGWSL of 0.010 mg/L in six wells sampled during the 2017 semiannual event at a maximum concentration of 0.0583 mg/L in MW-128; and in four wells sampled during the second 2017 semiannual event a maximum concentration of 0.0554 mg/L in MW-128.

- Barium exceeded the CGWSL of 1.00 mg/L in two wells sampled (KWB-10R and MW-131) during the first 2017 semiannual event at a maximum concentration of 3.82 mg/L in KWB-10R; and in three wells sampled (KWB-10R, MW-58, and MW-131) during the second 2017 semiannual event a maximum concentration of 3.85 mg/L in KWB-10R.

- Boron exceeded the CGWSL of 0.75 mg/L in well KWB-8 during the second 2017 semiannual event at a concentration of 0.769 mg/L; and in no wells during the second 2017 semiannual event.

- Iron exceeded the CGWSL of 1.00 mg/L in seven wells sampled during the first 2017 semiannual event at a maximum concentration of 6.15 mg/L in MW-111; and in six wells sampled during the second 2017 semiannual event at a maximum concentration of 7.15 mg/L in MW-111.

- Manganese exceeded the CGWSL of 0.200 mg/L in 16 wells sampled during the first 2017 semiannual event at a maximum concentration of 3.44 mg/L in KWB-7; and in

12 wells sampled during the second 2017 semiannual event at a maximum concentration of 3.22 mg/L in KWB-7.

- Uranium exceeded the CGWSL of 0.030 mg/L in well KWB-12B during the first 2017 semiannual event at a concentration of 0.0307 mg/L; and in no wells during the second 2017 semiannual event.

The 2017 groundwater analytical results of total metals in wells located in the field east of the refinery were generally consistent with historical results, with the following exceptions:

- Arsenic concentrations increased in MW-127 from 0.00383 mg/L during the first 2017 semiannual event to 0.0114 mg/L during the second 2017 semiannual event, which was the first exceedance of the CGWSL and the historical maximum in this well. Arsenic concentrations in this well will be watched closely during future monitoring events.
- Boron concentrations in KWB-8 increased from 0.632 mg/L during the first 2017 semiannual event to 0.769 mg/L during the second 2017 semiannual event, which is the first exceedance of the CGWSL in this well. There is limited historical data available for this metal as it was first included in the groundwater monitoring program in 2016.

Concentrations of target COC arsenic in wells located in the field east of the refinery are overall stable to fluctuating, as shown in the COC concentration plots included in Appendix C. Arsenic concentrations have fluctuated above and below the CGWSL over time in wells KWB-1A, KWB-1C, KWB-7, MW-58, MW-135, and RW-18.

Cyanide, Field East of Refinery

Groundwater samples collected from wells KWB-1A, KWB-7, KWB-8 KWB-11A, KWB-11B, KWB-12A, KWB-12B, and MW-58 during both 2017 semiannual events were analyzed for cyanide. Cyanide was not detected above the method detection limit or the CGWSL in groundwater samples collected from these wells during either semiannual event.

Water Quality Parameters, Field East of Refinery

In 2017, groundwater samples were collected from the following wells located in the field east of the refinery during each semiannual event for analysis of water quality parameters (calcium, chloride, fluoride, potassium, sodium, sulfate, TDS, and nitrate/nitrite [as nitrogen]):

- First Semiannual Event (27 wells): KWB-1A, KWB-1C, KWB-7, KWB-8, KWB-10R, KWB-11A, KWB-11B, KWB-12A, KWB-12B, MW-57, MW-58, MW-111, MW-113, MW-125, MW-126A, MW-126B, MW-127, MW-128, MW-129, MW-130, MW-131, MW-134, MW-135, RA-4196, RA-4798, RW-12R, and RW-18.

- Second Semiannual Event (23 wells): KWB-1A, KWB-7, KWB-8, KWB-10R, KWB-11A, KWB-11B, KWB-12A, KWB-12B, MW-57, MW-58, MW-111, MW-113, MW-125, MW-126A, MW-126B, MW-127, MW-128, MW-130, MW-131, MW-134, MW-135, RA-4196, and RA-4798.

No CGWSLs are applicable for calcium, potassium, or sodium. Chloride, fluoride, nitrate/nitrite, sulfate, and TDS were detected at concentrations in exceedance of their respective CGWSLs in groundwater samples from at least one well within the field east of the refinery as highlighted in Table 4C. The reported concentrations of these constituents exhibit an overall stable trend, with some seasonal fluctuations between the first and second historical semiannual events.

5.3.8 Areas Cross-Gradient and Up-Gradient of Refinery – Analytical Results

Groundwater monitoring is ongoing in areas both cross-gradient and up-gradient of the refinery. Cross-gradient wells KWB-13 (located south of the refinery), RA-3156 (located across southeast of the refinery), and MW-136 (located north of the refinery) were sampled during both 2016 semiannual events. Up-gradient wells UG-1, UG-2, and UG-3R, which all are located to the west of the refinery, were sampled during the first semiannual event. Analytical results of groundwater samples collected from cross-gradient and up-gradient wells in 2017 indicate COCs are present in groundwater in excess of their respective CGWSLs, as highlighted in Tables 4A through 4C and discussed in the following subsections.

Total Petroleum Hydrocarbons – Diesel Range Organics, Areas Cross-gradient and Up-gradient of Refinery

In 2017, groundwater samples were collected from the following cross-gradient and up-gradient wells during each semiannual event for analysis of DRO:

- First Semiannual Event (seven wells): KWB-13, MW-136, NP-5, UG-1, UG-2, UG-3R, and UG-4.

- Second Semiannual Event (one well): MW-136

DRO was detected at concentrations in exceedance of the CGWSL of 0.0398 mg/L in four up-gradient wells (UG-1, UG-2, UG-3R, and UG-4) during the first 2017 semiannual event and in one cross-gradient well (MW-136) during both 2017 semiannual events, as shown in Table 4A. However, DRO concentrations reported for these cross-gradient and up-gradient wells in 2017 did not exceed the previous CGWSL (NMED 2012) of 0.2 mg/L. The maximum DRO concentration detected in these wells in 2017 was 0.0818 J mg/L in UG-2 during the first semiannual event and 0.0937 J mg/L in MW-136 during the second semiannual event.

DRO concentrations in cross-gradient and up-gradient wells are stable overtime, as shown in the COC concentration plots included in Appendix C. DRO concentrations in each up-gradient well increased slightly in 2017 by approximately 0.01 to 0.03 mg/L from the previous monitoring

event conducted in April 2016, but were less than historical maximums in each well (except in UG-4 which has only been sampled during two monitoring events).

Total Petroleum Hydrocarbons – Gasoline Range Organics, Areas Cross-Gradient and Up-Gradient of Refinery

In 2017, groundwater samples were collected from the following cross-gradient and up-gradient wells during each semiannual event for analysis of GRO:

- First Semiannual Event (five wells): MW-136, UG-1, UG-2, UG-3R, and UG-4.
- Second Semiannual Event (one well): MW-136

GRO was not detected above the method detection limit in any sample collected from the up-gradient and cross-gradient wells during either 2017 semiannual event.

Volatile Organic Compounds, Areas Cross-Gradient and Up-Gradient of Refinery

In 2017, groundwater samples collected from the following cross-gradient and up-gradient wells during each semiannual event were analyzed for VOCs:

- First Semiannual Event (eight wells): KWB-13, NP-5, RA-3156, MW-136, UG-1, UG-2, UG-3R, and UG-4.
- Second Semiannual Event (one well): MW-136.

No VOCs were detected above the method detection limits or their respective CGWSL during either 2017 semiannual event, as shown in Table 4A. The 2017 VOC results for groundwater samples collected from cross-gradient and up-gradient wells were consistent with historical results.

Total Metals, Areas Cross-Gradient and Up-Gradient of Refinery

In 2017, groundwater samples were collected from the following cross-gradient and up-gradient wells during each semiannual event for analysis of the standard total metals list (arsenic, barium, chromium, iron, lead, manganese, and selenium):

- First Semiannual Event (seven wells): KWB-13, NP-5, MW-136, UG-1, UG-2, UG-3R, and UG-4.
- Second Semiannual Event (one well): MW-136

In addition, groundwater samples collected from wells KWB-13, UG-1, UG-2, UG-3R, and UG-4 during the first 2017 semiannual event and from well MW-136 during both 2017 semiannual events were analyzed for the expanded metals list (boron, cadmium, cobalt, mercury, nickel, uranium, and vanadium).

Arsenic, barium, cadmium, cobalt, chromium, lead, manganese, mercury, nickel, selenium, and vanadium were not detected above their respective CGWSLs in any of the cross-gradient or up-gradient wells sampled during either 2017 semiannual event. Iron, boron, and uranium were detected at concentrations in exceedance of their respective CGWSLs in at least one well, as highlighted in Table 4B and described below:

- Boron exceeded the CGWSL of 0.75 mg/L in well UG-4 during the first 2017 semiannual event at a concentration of 1.02 mg/L; and in no wells during the second 2017 semiannual event.
- Iron exceeded the CGWSL of 1.00 mg/L in well KWB-13 during the first 2017 semiannual event at a concentration of 1.02 mg/L; and in no wells during the second 2017 semiannual event.
- Uranium exceeded the CGWSL of 0.030 in two wells sampled (MW-136 and UG-4) during the first 2017 semiannual event at a maximum concentration of 0.0664 mg/L in MW-136; and in well MW-136 during the second 2017 semiannual event at a concentration of 0.0729 mg/L.

The 2017 analytical results of total metals in groundwater samples collected from cross-gradient and up-gradient wells were generally consistent with historical results. Concentrations of target COC arsenic in cross-gradient and up-gradient wells are overall stable, as shown in the COC concentration plots included in Appendix C.

Cyanide, Areas Cross-Gradient and Up-Gradient of Refinery

Cyanide was not detected above the method detection limit or the CGWSL in groundwater samples collected from cross-gradient and up-gradient wells KWB-13, MW-136, UG-1, UG-2, UG-3R, and UG-4 during either 2017 semiannual events.

Water Quality Parameters, Areas Cross-Gradient and Up-Gradient of Refinery

In 2017, groundwater samples were collected from the following cross-gradient and up-gradient wells during each semiannual event for analysis of water quality parameters (calcium, chloride, fluoride, potassium, sodium, sulfate, TDS, and nitrate/nitrite [as nitrogen]):

- First Semiannual Event (eight wells): KWB-13, NP-5, RA-3156, MW-136, UG-1, UG-2, UG-3R, and UG-4.
- Second Semiannual Event (one well): MW-136

No CGWSLs are applicable for calcium, potassium, or sodium. Chloride, fluoride, nitrate/nitrite, sulfate, and TDS were detected at concentrations in exceedance of their respective CGWSLs in groundwater samples from cross-gradient and up-gradient wells, as highlighted in

Table 4C. The reported concentrations of these constituents in 2017 were consistent with historical results with the exception of nitrate/nitrite in up-gradient well UG-2 which increased from 5.46 mg/L during the first 2016 semiannual event (April 2017) to 16.3 mg/L during the first 2017 semiannual event.

5.3.9 RO Reject Discharge Fields – Analytical Results

The reject water from Navajo's RO system is discharged to agricultural fields located north of the refinery in accordance with the Discharge Permit. These areas are referred to as the North and South RO Reject Fields. Groundwater samples were collected from the three North RO Reject Field wells (MW-117, MW-118, and MW-119) and three South RO Reject Field wells (MW-114, MW-115, and MW-116) during both 2017 semiannual events. Groundwater samples collected from these wells were all analyzed for GRO, DRO, the standard total metals list (arsenic, barium, chromium, iron, lead, manganese, and selenium), and water quality parameters (calcium, chloride, fluoride, potassium, sodium, sulfate, TDS, and nitrate/nitrite).

Analytical results of groundwater samples collected from RO Reject Field wells in 2017 indicate COCs are present in groundwater in excess of their respective CGWSLs, as highlighted in Tables 4A through 4C and discussed in the following subsections.

Total Petroleum Hydrocarbons – Diesel Range Organics, RO Reject Discharge Fields

DRO was detected at concentrations in exceedance of the CGWSL of 0.0398 mg/L in three RO Reject Field wells (MW-115, MW-116, and MW-119) during the first 2017 semiannual event and in five wells (MW-114, MW-115, MW-117, MW-118, and MW-119) during the second 2017 semiannual event, as shown in Table 4A. However, DRO concentrations reported for RO Reject Field wells in 2017 did not exceed the previous CGWSL (NMED 2012) of 0.2 mg/L except in MW-117 during the first 2017 semiannual event. The maximum DRO concentration detected in these wells in 2017 was 0.0657 J mg/L in MW-115 during the first semiannual event and 0.385 mg/L in MW-117 during the second semiannual event.

As shown in the COC concentration plots included in Appendix C, DRO concentrations in RO Reject Field wells are stable overtime except in MW-117 which increased from not detected above the method detection limit of 0.0247 mg/L during the first 2017 semiannual event to a historical maximum of 0.385 mg/L during the second 2017 semiannual event.

Total Petroleum Hydrocarbons – Gasoline Range Organics, RO Reject Discharge Fields

GRO was not detected above the method detection limit in the six RO Reject Field wells sampled during either 2017 semiannual event, which is consistent with historical results.

Volatile Organic Compounds, RO Reject Discharge Fields

VOCs were not detected above the method detection limit or their respective CGWSLs in the six RO Reject Field wells sampled during either 2017 semiannual event, with the exception of benzene in MW-116 at an estimated j-flagged concentration of 0.00043 J mg/L during the first 2017 semiannual event. The 2017 VOC results in RO Reject Field wells are consistent with historical results.

Total Metals, RO Reject Discharge Fields

Barium, chromium, lead, and selenium were not detected above their respective CGWSLs in any of the RO Reject Field wells sampled during either 2017 semiannual event. Arsenic, iron, and manganese were detected at concentrations in exceedance of their respective CGWSLs in at least one well, as highlighted in Table 4B and described below:

- Arsenic exceeded the CGWSL of 0.010 mg/L in MW-118 during both 2017 semiannual events at a concentration of 0.0105 mg/L during the first event and 0.0109 mg/L during the second event.
- Iron exceeded the CGWSL of 1.00 mg/L in MW-117 during both 2017 semiannual events at a concentration of 1.11 mg/L during the first event and 1.15 mg/L during the second event.
- Manganese exceeded the CGWSL of 0.200 mg/L in MW-114 during both 2017 semiannual events at a concentration of 0.944 mg/L during the first event and 0.873 mg/L during the second event.

The 2017 analytical results of total metals in groundwater samples collected from RO Reject Field wells were consistent with historical results.

Cyanide, RO Reject Discharge Fields

Groundwater samples collected from RO Reject Field wells in 2017 were not analyzed for cyanide.

Water Quality Parameters, RO Reject Discharge Fields

Chloride, fluoride, sulfate, and TDS were detected at concentrations in exceedance of their respective CGWSLs in groundwater samples collected from some RO Reject Field wells, as highlighted in Table 4C. The reported concentrations of these constituents in 2017 were generally consistent with historical results, with the exception of chloride in MW-114 during the first 2017 semiannual event. Chloride concentrations increased in MW-114 from 231 mg/L in the second 2016 semiannual event (October 2016) to 266 mg/L in the first 2017 semiannual event, which was the first exceedance of the CGWSL over the six most recent sampling events. However, chloride concentrations reduced to 157 mg/L below the CGWSL during the second 2017 semiannual event.

Chloride concentrations have historically fluctuated above and below the CGWSL in RO Reject Field wells and other wells located across the refinery

No CGWSLs are applicable for calcium, potassium, or sodium. The 2017 results of these analytes were consistent with historical results.

6.0 REMEDIATION SYSTEM MONITORING

The PCC Permit and Discharge Permit both require recovery of PSH present in the shallow groundwater within and adjacent to the refinery. PSH and impacted groundwater are recovered at the refinery from a system of recovery trenches and recovery wells. A summary of the recovery system and recovery results are summarized in this section.

6.1 Recovery System

The recovery system consists of automated pumping of PSH and groundwater from recovery wells using dedicated groundwater and PSH pumps (both types of fluid pumps installed in each well). Pumps are installed, operated, and removed from each well based on PSH thicknesses and observed recovery during operation and maintenance (O&M) activities. The pumps are typically operated automatically, with remote data sensing and recording. Recovered PSH is pumped into centralized holding tanks, then pumped to Tank 49, associated with the wastewater treatment system, which then transfers the product to crude tank(s) (Tank 1225 or 437) for processing within the refinery. Recovered groundwater is pumped to the nearest process wastewater sump and directed to the process wastewater treatment system. Thus, recovered PSH is recycled into the refinery process while groundwater is treated to remove residual hydrocarbons.

O&M of the recovery system was conducted throughout 2017 on an approximate weekly basis. O&M activities included gauging wells recovery wells RW-1R, RW-2R, RW-4R, RW-5R, RW-6R, RW-7R, RW-8R, RW-12R, RW-13R, RW-14R, RW-15, RW-19, RW-20, and RW-22 in order to assess the effectiveness of the recovery system and to determine in which wells to install and operate PSH and groundwater pumps. Measurable PSH was not observed in RW-1R during 2017.

6.2 Estimated Volume of Fluids Recovered

Volumes of groundwater and PSH recovered by the recovery system during 2017 are summarized in Table 5 and additional recovery details are provided in Appendix E. An estimated 5,189,384 gallons of groundwater and an estimated 24,492 gallons of PSH were recovered through operation of the automated recovery system in 2017. The majority of recovered PSH during 2017 was from RW-13R, RW-14R, and RW-22. The greatest volume of PSH was recovered during the third quarter (primarily July and August), which correlated with the timeframe of increased PSH thicknesses measured in the recovery wells, likely due to reduced groundwater levels.

7.0 CONCLUSIONS

Conclusions based on the results of groundwater monitoring and remedial activities conducted during 2017 and comparison to historical results are discussed below.

Groundwater flow direction was generally consistent with previous monitoring events with flow predominantly eastward beneath the refinery towards the Pecos River and to the southeast beneath the EPs. Discharge of the RO reject water to the RO reject fields creates localized mounding. Localized groundwater sinks are occasionally observed around various recovery wells due to active pumping of groundwater.

The presence and distribution of PSH were generally consistent with previous monitoring results, with minor fluctuations. PSH thicknesses across all areas of interest are stable to declining over time. PSH thicknesses are inversely affected by fluctuations in groundwater elevations, which have generally increased since 2011 despite reductions in 2017.

Concentrations of COCs in groundwater have generally remained stable over time, although increasing trends were noted in select wells in specific areas of interest. The limited number of increasing COC concentration trends observed since 2011 have general exhibited stabilizing trends over the most recent three to six sampling events. During 2017 and previous years, the following COCs were detected in groundwater at concentrations in exceedance of their respective CGWSL:

- DRO;
- Select VOCs including target COCs benzene, toluene, ethylbenzene, xylenes, MTBE, and naphthalene;
- Select total metals including target COC arsenic; and
- Water quality parameters chloride, fluoride, sulfate, TDS, and nitrate/nitrite.

It should be noted, that many of the concentrations of inorganic COCs (manganese, chloride, fluoride, nitrate/nitrite, sulfate, TDS) depicted as "exceedances" in this report may actually be similar to and reflective of background groundwater concentrations, as detailed in the background evaluation that was submitted to NMED and OCD in September 2015 (Arcadis 2015b).

The PSH and groundwater recovery system operated throughout 2017. An estimated 5,189,384 gallons of groundwater and an estimated 24,492 gallons of PSH were recovered in 2017.

According to the requirements of the updated PCC Permit, an updated FWGMWP will be submitted in June 2018.

8.0 References

Arcadis 2014. Background Groundwater Evaluation Work Plan, NMD048918817 and DP GW-028. July 2014.

Arcadis 2015a. Evaporation Ponds Phase IV Corrective Action Investigation Report - Revised, NMD048918817. May 2015.

Arcadis 2015b. Background Groundwater Investigation Report, RCRA Permit NMD048918817, OCD Discharge Permit GW-028. September 2015.

NMED 2010. Navajo Refining Company, Artesia Refinery, Post-Closure Care Permit. December 2010.

NMED 2012. Risk Assessment Guidance for Site Investigations and Remediation. February 2012.

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NMED 2017b. Approval with Modifications, 2017 Facility Wide Groundwater Monitoring Work Plan, June 2017, HollyFrontier Navajo Refining LLC - Artesia Refinery. October 2017.

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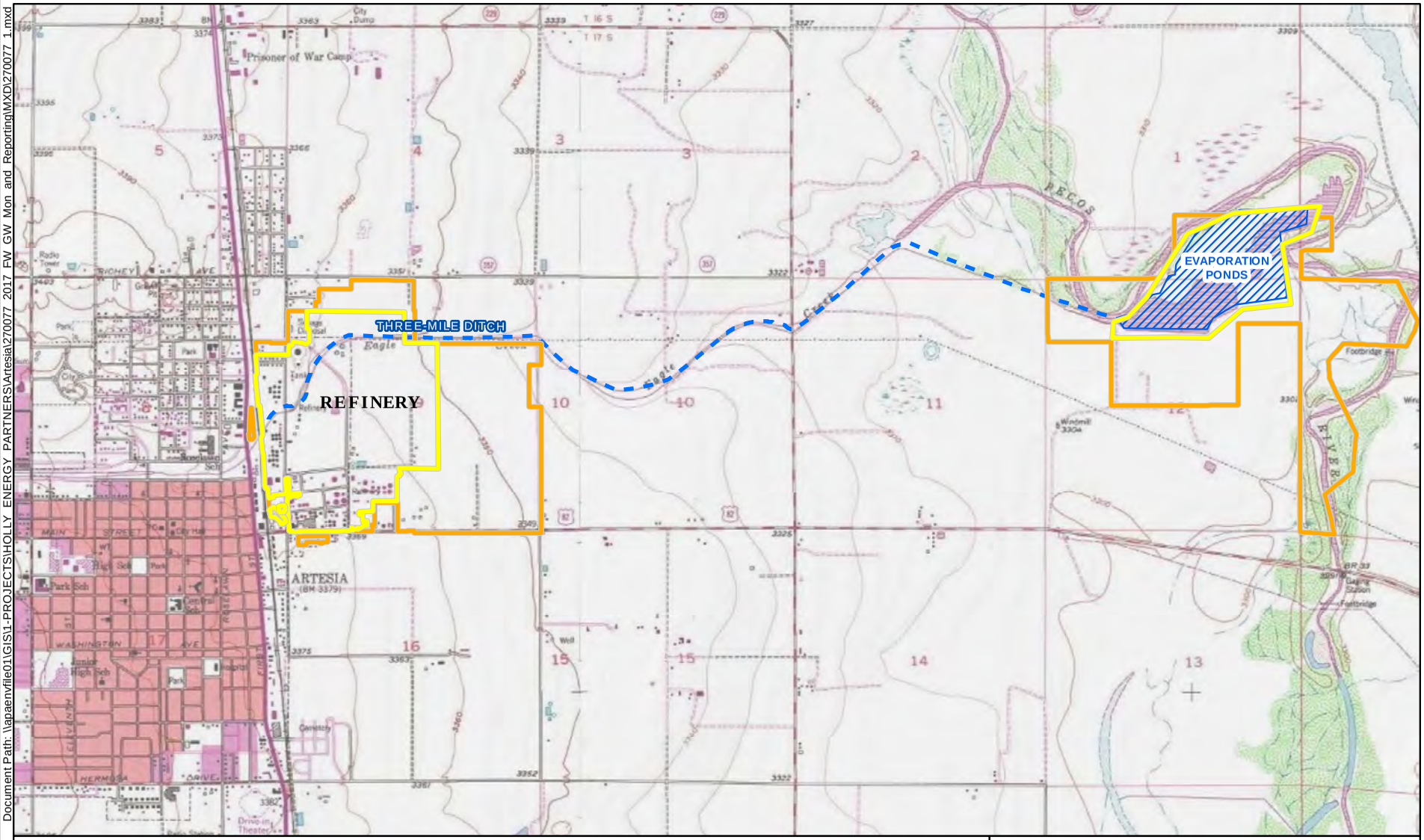
TRC 2016. 2016 Facility-Wide Groundwater Monitoring Work Plan - Artesia Refinery. June 2017.

TRC 2017. 2017 Facility-Wide Groundwater Monitoring Work Plan - Artesia Refinery. June 2017.

USEPA 2017. Regional Screening Level (RSL) Summary Table. November 2017.



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LEGEND

- FENCELINE
- NAVAJO PROPERTY BOUNDARY (FENCELINE SHOWN WHERE COINCIDENT)
- THREE-MILE DITCH
- EVAPORATION PONDS

SOURCE: BASE MAP USGS 7.5 MINUTE SERIES QUADS, ARTESIA AND SPRINGLAKE QUADRANGLES, 1955, PHOTOREVISED 1983.

N

0 1,600 3,200
Feet

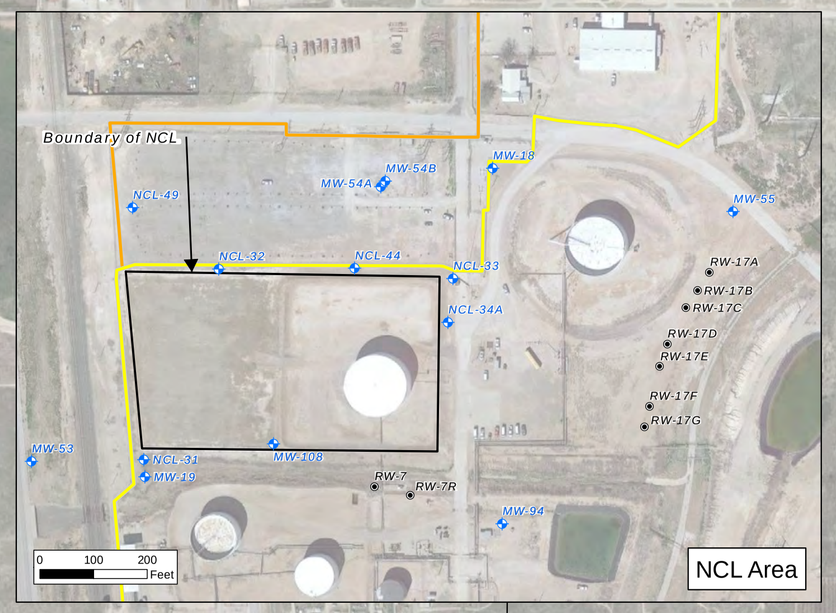
SITE LOCATION MAP

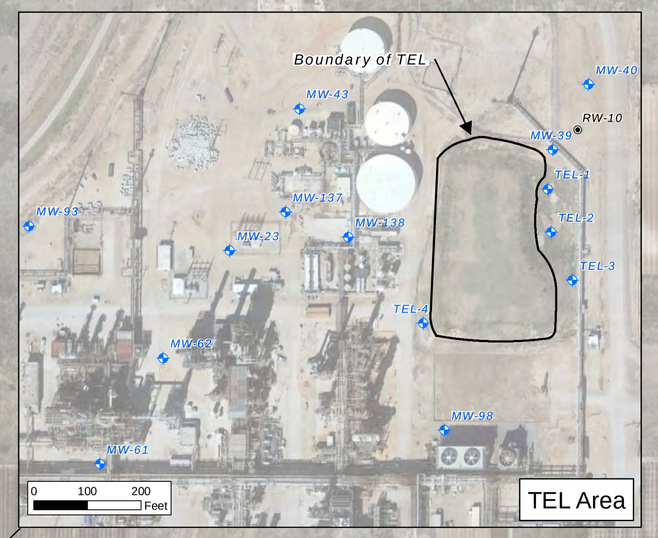
2017 ANNUAL GROUNDWATER REPORT
HOLLYFRONTIER NAVAJO REFINING LLC
ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO

PROJECT NUMBER: 270077	FILE NAME: 270077_1
AUTHOR: MREEVES	DATE: 2/27/2018

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

FIGURE
1





LEGEND

- IRRIGATION WELL
- MONITORING WELL
- RECOVERY WELL
- FENCELINE
- NAVAJO PROPERTY BOUNDARY (FENCELINE SHOWN WHERE COINCIDENT)

N W E S

0 750 1,500 Feet

1 IN = 750 FT

NEW MEXICO

WELL LOCATION MAP

2017 ANNUAL GROUNDWATER REPORT
HOLLYFRONTIER NAVAJO REFINING LLC
ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO

AUTHOR: MREEVES	SAVED: 2/27/2018	MXD: 270077_2

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

FIGURE 2

AERIAL IMAGERY SOURCE: GOOGLE AND THEIR DATA PARTNERS 2017

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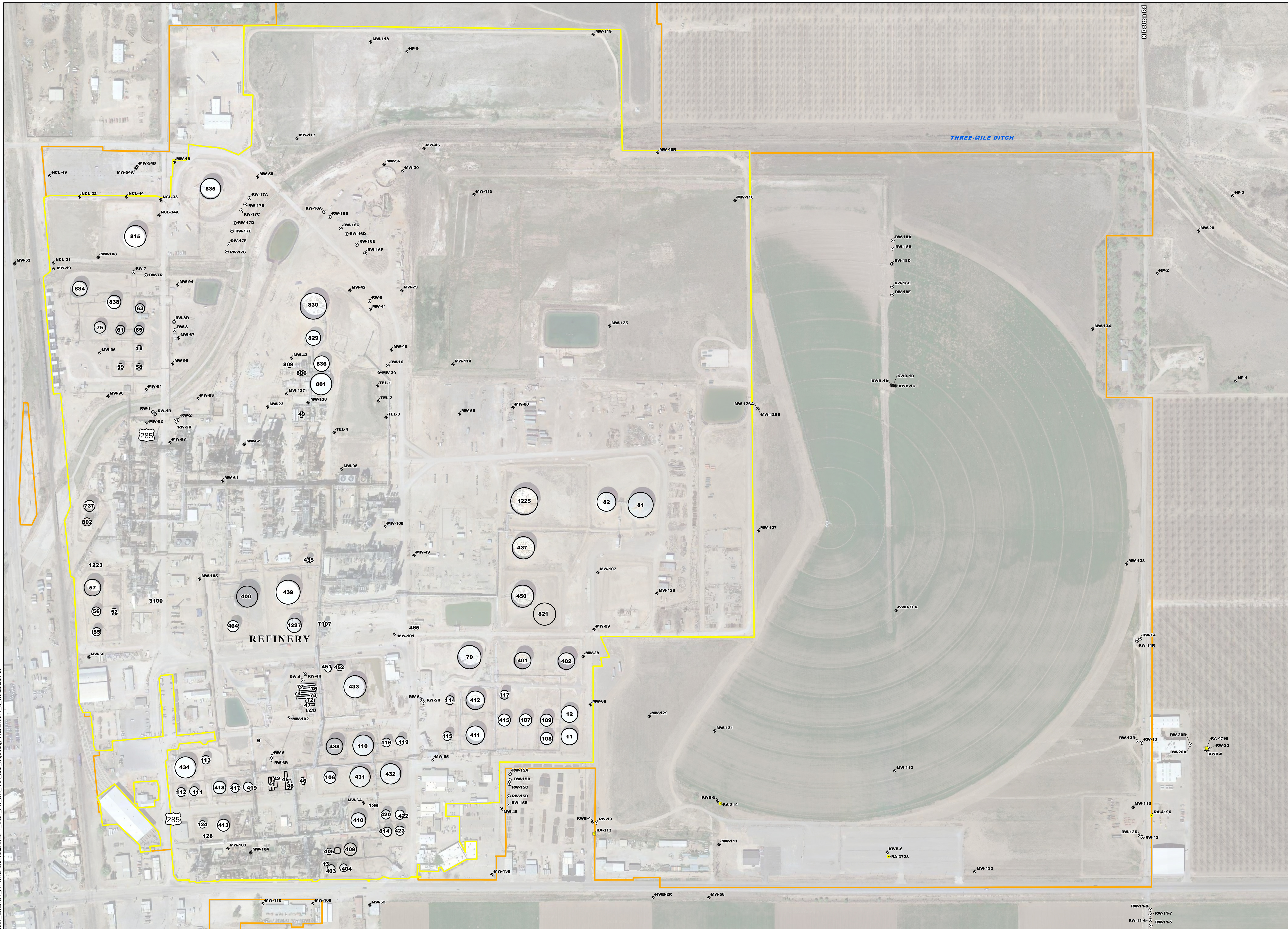

Tank Number	Location in Relation to AOCs & SWMUs	Diameter (ft)	Height / Length (ft)	Capacity (bbls)	Date Constructed	Contents
6	RW-6 between AOC 3 & AOC 4					Out of Service
11	AOC 3	89	29	31,500	B. 1983	Reformate
12	AOC 3	89	29	31,500	B. 1983	Reformate
13	AOC 8	10	20	250	1990	Slop
18	SWMU 17	29	24	2,250	B. 1979	Out of Service
40	Between AOC 3 & AOC 4	9	72	730	B. 1973	Spent Caustic
41	Between AOC 3 & AOC 4	9	72	730	B. 1973	Spent Caustic
42	Between AOC 3 & AOC 4	9	67	700		Wild Naphtha
45	Between AOC 3 & AOC4	11	90	1,400		Butane
46	Between AOC 3 & AOC 4	12	47	920		Isobutane
47	West of AOC 3	11	36	700		Out of Service
48	Between AOC 3 & AOC 4	11	36	700		Butane
52	AOC 7					Out of Service
55	AOC 7	45	36	10,800	RBLT 1979	Stripped Sour Water
56	AOC 7	48	36	10,800	B. 1976	Sweet Naphtha
57	AOC 7	90	49	55,000	1981	Benfree Unit Feed
58	SWMU 17	35	30	4,700	B. 1979	Out of Service
59	SWMU 17	35	30	4,700	B. 1979	Light Cycle Oil
61	SWMU 17	50	30	9,700	B. 1987	Light Cycle Oil
63	SWMU 17	51	30	10,000	B. 1987	Carbon Black Oil
65	SWMU 17	50	30	10,380	1999	Carbon Black Oil
71	West of AOC 3	10.5	44	714		Propane
72	West of AOC 3	10.5	44	714		Propane
73	West of AOC 3	10	103	1,525		Propane
74	West of AOC	3	10	103	1,525	Propane
75	SWMU 17	65	32	18,900	2003	Carbon Black Oil
76	West of AOC 3	11	79			Propane
77	West of AOC 3	11	79			Propane
79	AOC 3	125	40	70,000	2008	Reformate
81	AOC 6	108.5	40	60,000	2009	PG Asphalt
82	AOC 6	140	40	100,000	2009	PG Asphalt
106	AOC 3	67	40	22,500	B. 1971	Sour Water
107	AOC 3	67	40	22,500	B. 1971	Isomerate
108	AOC 3	67	40	22,500	1951	Alkylate
109	AOC 3	67	40	22,500	B. 1971	Alkylate
110	AOC 3	108	35	54,000	1929	Asphalt
111	AOC 4	49	30	9,100	B. 1981	Gasoline
112	AOC 4	49	30	9,100	B. 1981	Splitter Bottoms
113	AOC 4	48		10,300		Out of Service
114	AOC 3	38		5,100		N-Butane
115	AOC 3	51		12,300		N-Butane
116	AOC 3	48				Isobutane
117	AOC 3	48	48	15,470	1960	Splitter Bottoms
119	AOC 3	51		12,300		Isobutane
124	AOC 4	40	30	6,700	1955	Gasoline
400	AOC 5	120	48	96,786	1983	Gas Oil
401	AOC 3	90	50	55,000	1982	Benfree Product
402	AOC 3	90	50	55,000	1983	Light Cat Naphtha
403	AOC 8	45	36	8,250		Out of Service
404	AOC 8	45	36	8,250		Out of Service
405	AOC 8	37	28	4,575		Out of Service
406	AOC 8	38	28	5,400		Out of Service
409	AOC 8	67	40	21,450		Out of Service
410	AOC 8	79	40	30,850	B. 1973	Asphalt
411	AOC 3	100	40	52,000	1951	Isomerate
412	AOC 3	100	40	52,000	1951	Gasoline Blend
413	AOC 4	67	39	22,500	about 1960	Raw Kerosene
415	AOC 3	67	40	25,000	1953	Alkylate
417	AOC 4	50	30	9,300	B. 1981	Gasoline
418	AOC 4	67	33	25,000	B. 1987	Raw Kerosene
419	AOC 4	53	28	10,300	B. 1981	Diesel
420	AOC 8	50	30	8,200	B. 1989	Asphalt
422	AOC 8	50	30	8,200	B. 1973	Light Cycle Oil
423	AOC 8	50	30	8,200	B. 1970	Light Cycle Oil
431	AOC 3	109	32	45,800	B. 1984	Fuel Oil
432	AOC 3	109	32	45,800	B. 1973	Fuel Oil
433	AOC 3	117	42	72,500	B. 1984	Gas Oil
434	AOC 4	117	42	7,600	1979	Raw Diesel
435	AOC 5	30	40	5,000	Reloc. 1997	Sour Water
437	AOC 6	120	45	80,000	1976/2009	Crude Oil
438	AOC 3	90	48	54,500	1978	Gas Oil
439	AOC 5	130	46	107,900	1978	Sour Naphtha
450	AOC 3	120	40	80,570	1997	Sour Naphtha
451	AOC 3	35	40	6,800	2015	Biodiesel
452	AOC 3	35	40	6,800	2015	Ethanol
464	AOC 5	60	40	20,000	2016	RO Permeate
465	North of AOC 3					Fresh Water
737	AOC 7	63	40	20,000	2009	Sour Water
801	AOC 9	110	32	54,000	1987	Wastewater
802	AOC 7	45	40	10,000	2002	Sour Water
806	AOC 11	30	7	800		Separator (OOS)
809	West of AOC 11	20	16	850	1954	Treated Wastewater
814	AOC 8	50	32	10,000	2005	Pitch
821	AOC 3	105	40	65,000	2016	Light Cat Naphtha
815	SWMU 6	116	43	90,000	2005	ULSD
829	North of AOC 9	105	40	30,500	2015	Wastewater
830	North of AOC 9	150	40	100,000	2011	Stormwater (slop)
834	AOC 1	85	40	40,000	1967	Diesel
835	Northeast of SWMU 6	111	40	68,000		Diesel
836	AOC 9	82.5	32	30,460	1998	Wastewater
838	AOC 1	74	40	29,900		Diesel
1223	AOC 7	25	24	2,000	2002	Caustic
1225	AOC 6	150	40	100,000	2009	Crude Oil
1227	AOC 5	77	40	30,000	2009	Pitch
7107	East of AOC 5	25	40	3,300	2015	Treated Wastewater

TANK TABLE NOTES:
AOC = AREA OF CONCERN
SWMU = SOLID WASTE MANAGEMENT UNIT
ft = FEET
bbls = BARRELS
B. = BEFORE DATE SHOWN, ACTUAL DATE UNKNOWN
RBLT = REBUILT DATE SHOWN
RO = REVERSE OSMOSIS
OOS = OUT OF SERVICE
ULSD = ULTRA-LOW-SULFUR-DIESEL

LEGEND
IRRIGATION WELL
MONITORING WELL
RECOVERY WELL
FENCELINE
NAVAJO PROPERTY BOUNDARY (FENCELINE SHOWN WHERE COINCIDENT)
TANK

0 250 500
Feet
1 IN = 250 FT

NEW MEXICO

WELL LOCATIONS AND TANK INFORMATION WITHIN REFINERY

2017 ANNUAL GROUNDWATER REPORT
HOLLYFRONTIER NAVAJO REFINING LLC
ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO

AUTHOR: MREEVES | SAVED: 2/27/2018 | MXD: 270077_3_WellLocs

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

FIGURE 3

AERIAL IMAGERY SOURCE: GOOGLE AND THEIR DATA PARTNERS 2017

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LEGEND

- MONITORING WELL
- RECOVERY WELL
- SHALLOW SATURATED ZONE POTENTIOMETRIC SURFACE CONTOURS (FEET ABOVE MEAN SEA LEVEL)
- GROUNDWATER FLOW DIRECTION
- FENCELINE
- 3351.83 GROUNDWATER ELEVATION (FEET)

N W E S

0 750 1,500
Feet

1 IN = 750 FT

NOTE:
1. GROUNDWATER ELEVATION COULD NOT BE MEASURED IN RECOVERY WELL BECAUSE TOP OF RECOVERY PUMP WAS ABOVE GROUNDWATER.
2. GROUNDWATER ELEVATION NOT USED IN POTENTIOMETRIC SURFACE CONTOURING.

AERIAL IMAGERY SOURCE: GOOGLE AND THEIR DATA PARTNERS 2017

Document Path: \\patxmvfile01\GIS\1-PROJECTS\HOLLY_ENERGY_PARTNERS\Artesia\270077_2017_FIV_GW_Mon_and_Reporting\MXD\270077_4_ShallowPot_Spring.mxd

SHALLOW SATURATED ZONE POTENTIOMETRIC SURFACE MAP 2017 FIRST SEMIANNUAL EVENT

2017 ANNUAL GROUNDWATER REPORT
HOLLYFRONTIER NAVAJO REFINING LLC
ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO

AUTHOR: MREEVES	SAVED: 2/27/2018	MXD: 270077_4_ShallowPot_Spring

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FIGURE 4

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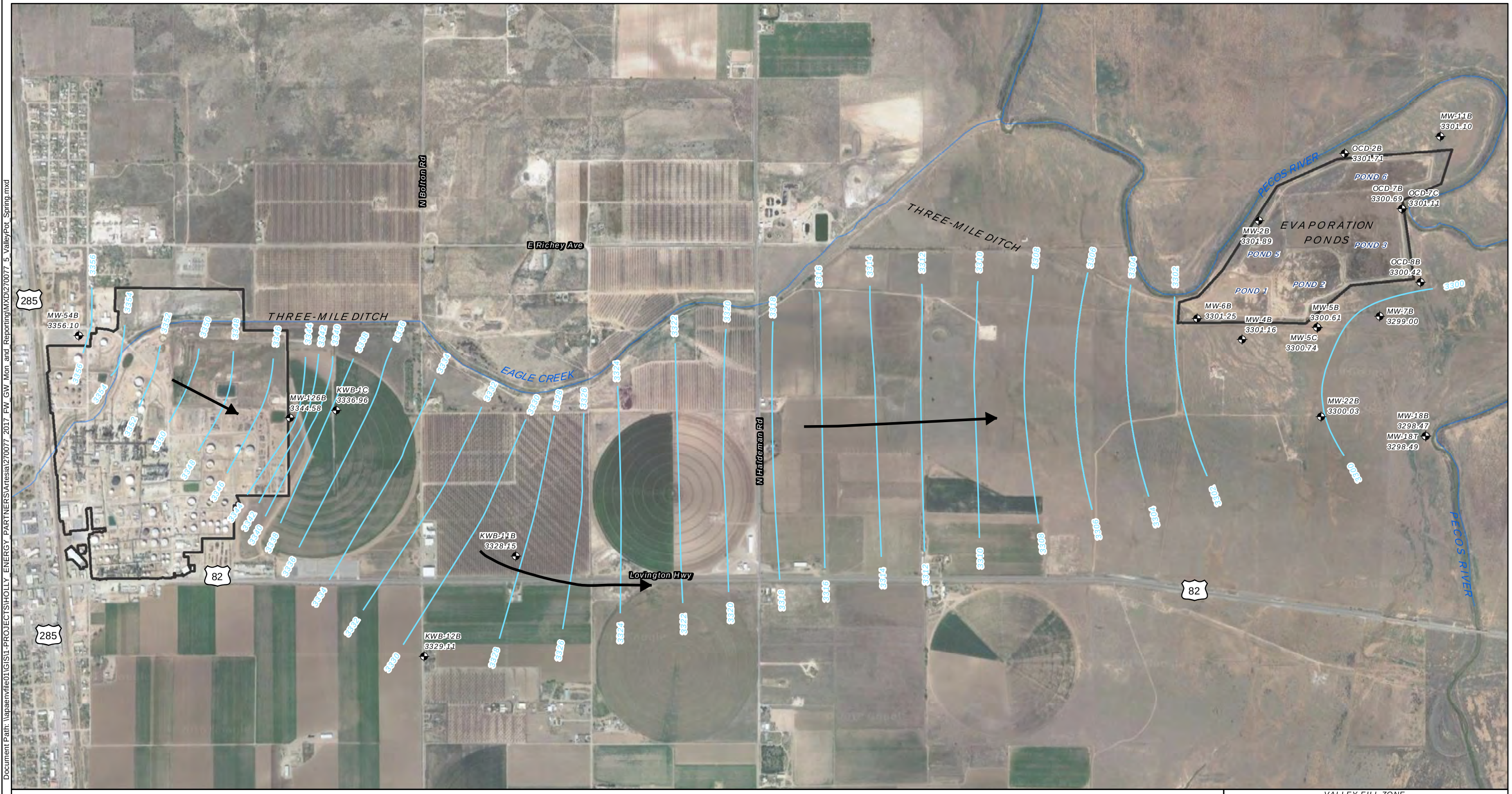

LEGEND

- MONITORING WELL
- FENCELINE
- VALLEY FILL ZONE POTENTIOMETRIC SURFACE CONTOURS (FEET ABOVE MEAN SEA LEVEL)
- GROUNDWATER FLOW DIRECTION
- 3301.10 GROUNDWATER ELEVATION (FEET)

N W E S

0 1,500 3,000

Feet

1 inch = 1,500 feet

AERIAL IMAGERY SOURCE: GOOGLE AND THEIR DATA PARTNERS, 2017.

VALLEY FILL ZONE POTENTIOMETRIC SURFACE MAP 2017 FIRST SEMIANNUAL EVENT

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AUTHOR: MREEVES	SAVED: 2/27/2018	MXD: 270077_5_ValleyPot_Spring

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FIGURE 5

LEGEND

- MONITORING WELL
- RECOVERY WELL
- SHALLOW SATURATED ZONE POTENTIOMETRIC SURFACE CONTOURS (FEET ABOVE MEAN SEA LEVEL)
- GROUNDWATER FLOW DIRECTION
- FENCELINE
- 3344.47 GROUNDWATER ELEVATION (FEET)

N W E S

0 750 1,500
Feet

1 IN = 750 FT

NOTE:
1. WELL NOT GAUGED IN ACCORDANCE WITH WORK PLAN.
2. GROUNDWATER ELEVATION NOT USED IN POTENTIOMETRIC SURFACE CONTOURING.

NEW MEXICO

AERIAL IMAGERY SOURCE: GOOGLE AND THEIR DATA PARTNERS 2017

SHALLOW SATURATED ZONE POTENTIOMETRIC SURFACE MAP 2017 SECOND SEMIANNUAL EVENT

2017 ANNUAL GROUNDWATER REPORT
HOLLYFRONTIER NAVAJO REFINING LLC
ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO

AUTHOR: MRIEEVES	SAVED: 2/27/2018	MXD: 270077_6_ShallowPot_Fall

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FIGURE 6

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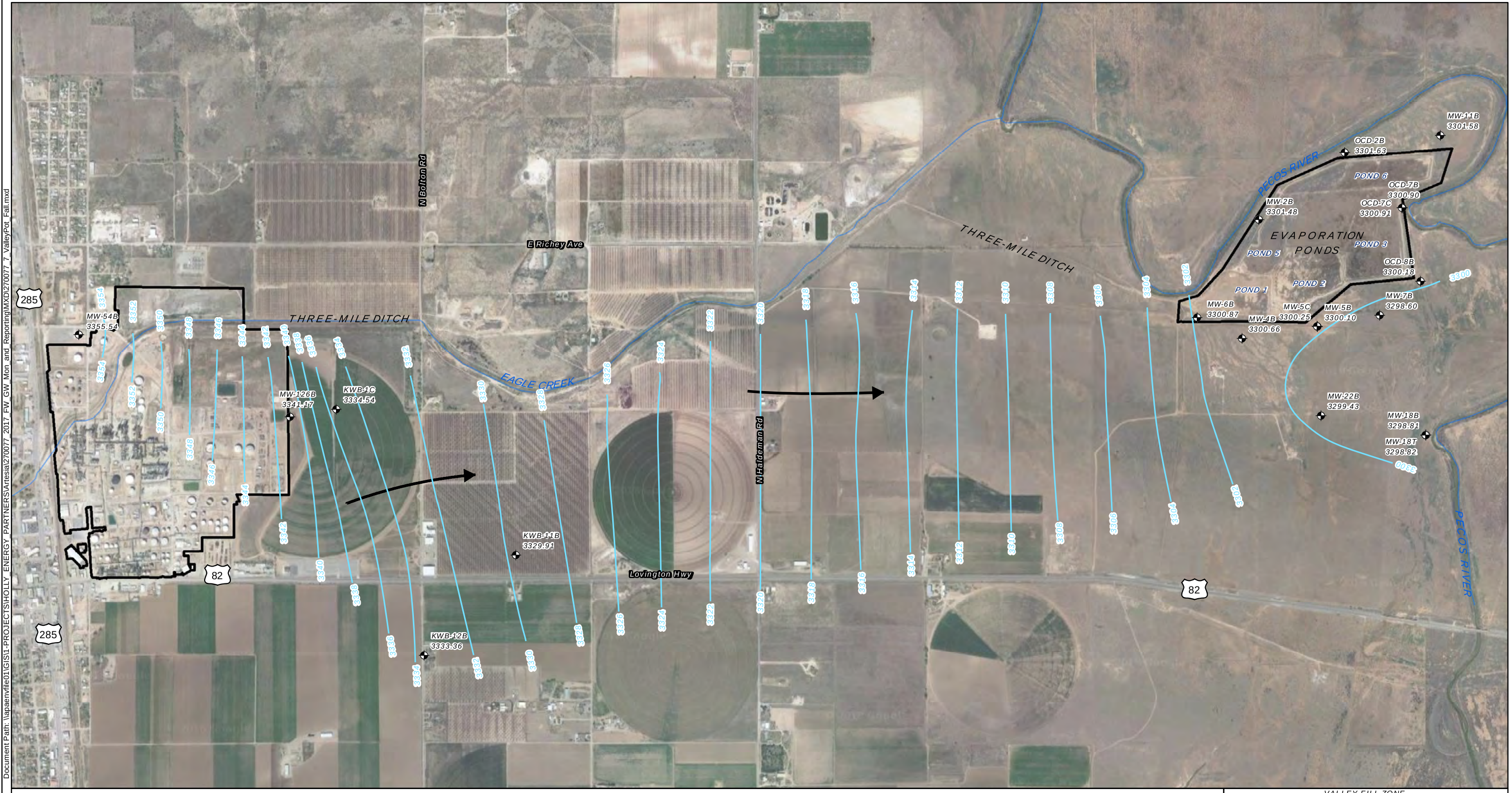

LEGEND

- MONITORING WELL
- FENCELINE
- VALLEY FILL ZONE POTENTIOMETRIC SURFACE CONTOURS (FEET ABOVE MEAN SEA LEVEL)
- GROUNDWATER FLOW DIRECTION
- 3301.48 GROUNDWATER ELEVATION (FEET)

N W E S

0 1,500 3,000
Feet

1 inch = 1,500 feet

NEW MEXICO

AERIAL IMAGERY SOURCE: GOOGLE AND THEIR DATA PARTNERS, 2017.

VALLEY FILL ZONE
POTENTIOMETRIC SURFACE MAP
2017 SECOND SEMIANNUAL EVENT

2017 ANNUAL GROUNDWATER REPORT
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FIGURE 7

LEGEND

- RECOVERY WELL
- MONITORING WELL
- IRRIGATION WELL
- FENCELINE

WELLS WITH PSH

- MONITORING WELL
- RECOVERY WELL

PSH THICKNESS IN

- 0.01 - 2.45 FEET
- RW-22 2.45 — PSH THICKNESS
- RW-15A — WELL NOT GAUGED

NOTE:

1. ALL PHASE-SEPARATED HYDROCARBON (PSH) THICKNESSES PROVIDED IN FEET.

2. PSH PRESENT, BUT TOTAL PSH THICKNESS IN RECOVERY WELLS RW-20A AND RW-20B COULD NOT BE MEASURED BECAUSE GROUNDWATER ELEVATION BELOW TOP OF RECOVERY PUMP.

N W E S

0 750 1,500
Feet

1 IN = 750 FT

NEW MEXICO

AERIAL IMAGERY SOURCE: GOOGLE AND THEIR DATA PARTNERS 2017

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PHASE-SEPARATED HYDROCARBON THICKNESS MAP 2017 FIRST SEMIANNUAL EVENT

2017 ANNUAL GROUNDWATER REPORT
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ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO

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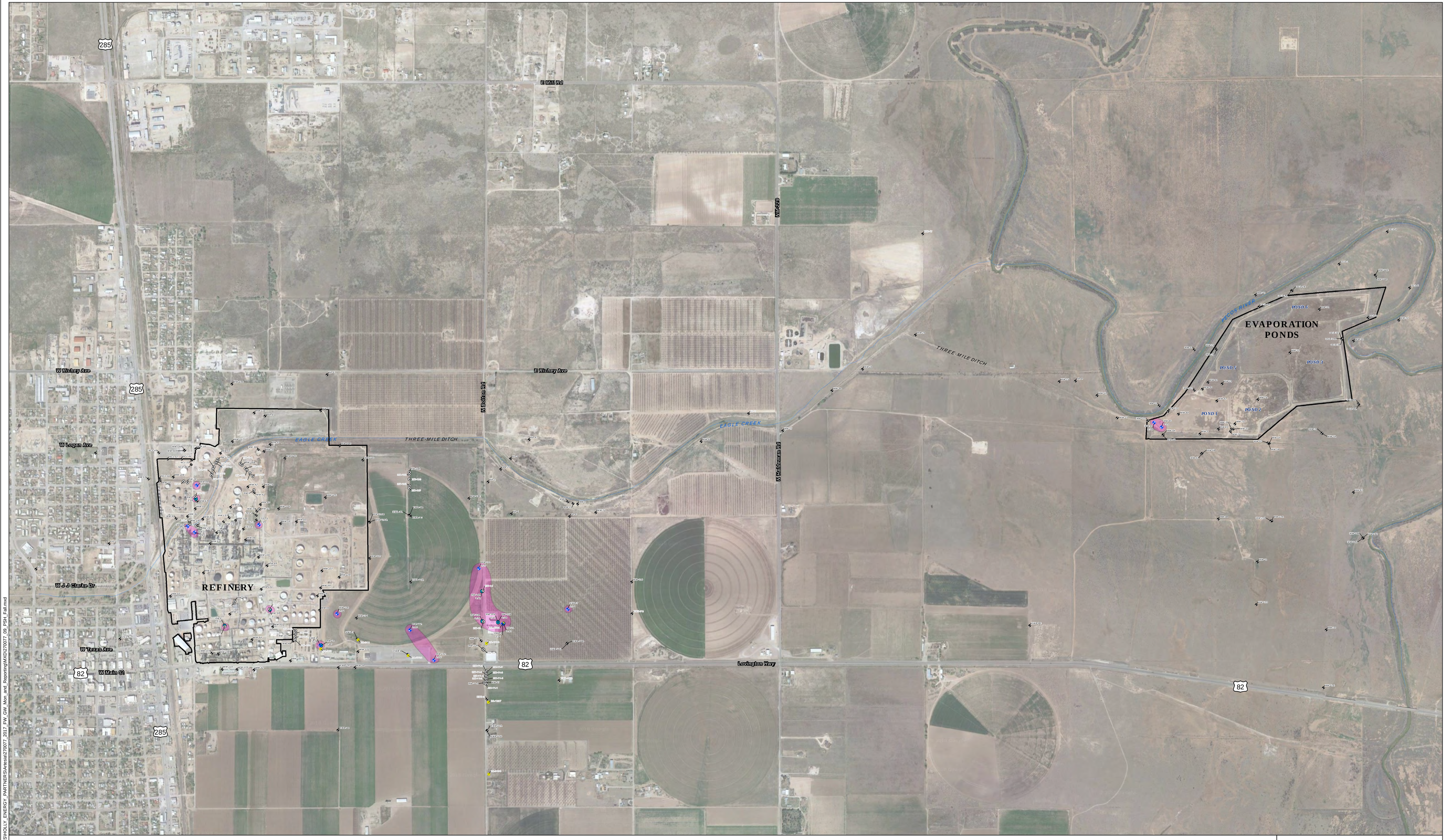
FIGURE 8



LEGEND

- RECOVERY WELL
- MONITORING WELL
- IRRIGATION WELL
- FENCELINE

WELLS WITH PSH

- MONITORING WELL
- RECOVERY WELL

PSH THICKNESS IN FEET

- 0.01 - 1.25 FEET
- RW-22 0.43 — PSH THICKNESS
- RW-15A — WELL NOT GAUGED

NOTE:

1. ALL PHASE-SEPARATED HYDROCARBON (PSH) THICKNESSES PROVIDED IN FEET.

N W E S

0 750 1,500
Feet

1 IN = 750 FT

PHASE-SEPARATED HYDROCARBON THICKNESS MAP 2017 SECOND SEMIANNUAL EVENT

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ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO

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FIGURE 9

AERIAL IMAGERY SOURCE: GOOGLE AND THEIR DATA PARTNERS 2017

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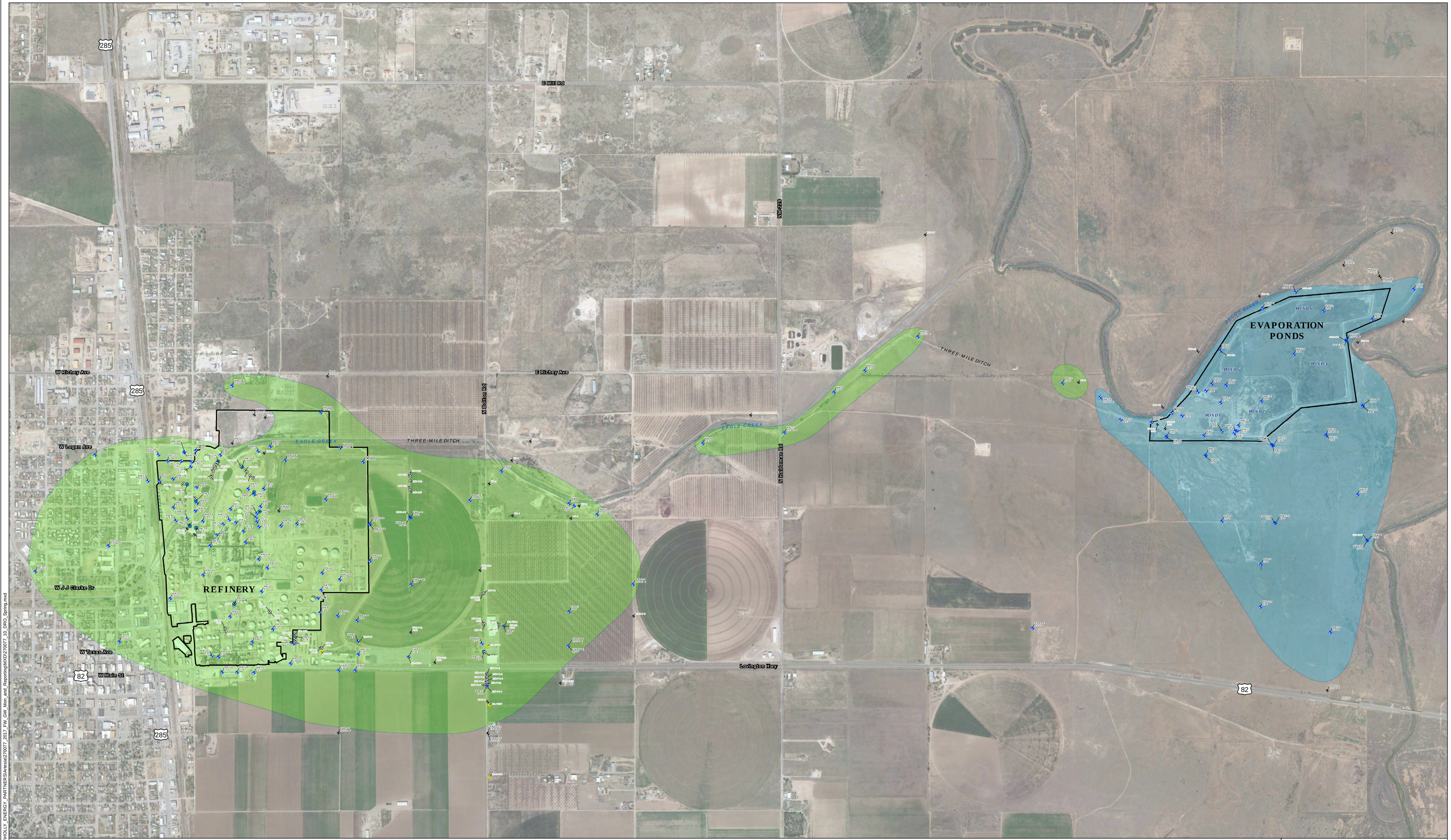

LEGEND

- MONITORING WELL EXCEEDS SCREENING LEVELS
- MONITORING WELL
- IRRIGATION WELL
- RECOVERY WELL EXCEEDS SCREENING LEVELS
- RECOVERY WELL
- 1.06 DRO CONCENTRATION
- MW-11A WELL NOT SAMPLED
- PSH PHASE-SEPARATED HYDROCARBON PRESENT IN WELL (> 0.03 FEET THICK)
- DRO CRITICAL GROUNDWATER SCREENING LEVEL EXCEEDANCE AREA (CONCENTRATION > 0.0398 mg/L)
- DRO CRITICAL GROUNDWATER SCREENING LEVEL EXCEEDANCE AREA, EVAPORATION PONDS (CONCENTRATION > 0.0473 mg/L)
- FENCELINE

AERIAL IMAGERY SOURCE: GOOGLE AND THEIR DATA PARTNERS 2016

NOTES:

1. ALL CONCENTRATIONS ARE IN MILLIGRAMS PER LITER (mg/L).
2. DRO = DIESEL RANGE ORGANICS
3. J = CONCENTRATION QUALIFIED AS AN ESTIMATED VALUE.

N W E S

0 750 1,500
Feet

1 IN = 750 FT

NEW MEXICO

DRO CRITICAL GROUNDWATER SCREENING LEVEL EXCEEDANCE MAP 2017 FIRST SEMIANNUAL EVENT

2017 ANNUAL GROUNDWATER REPORT
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FIGURE 10

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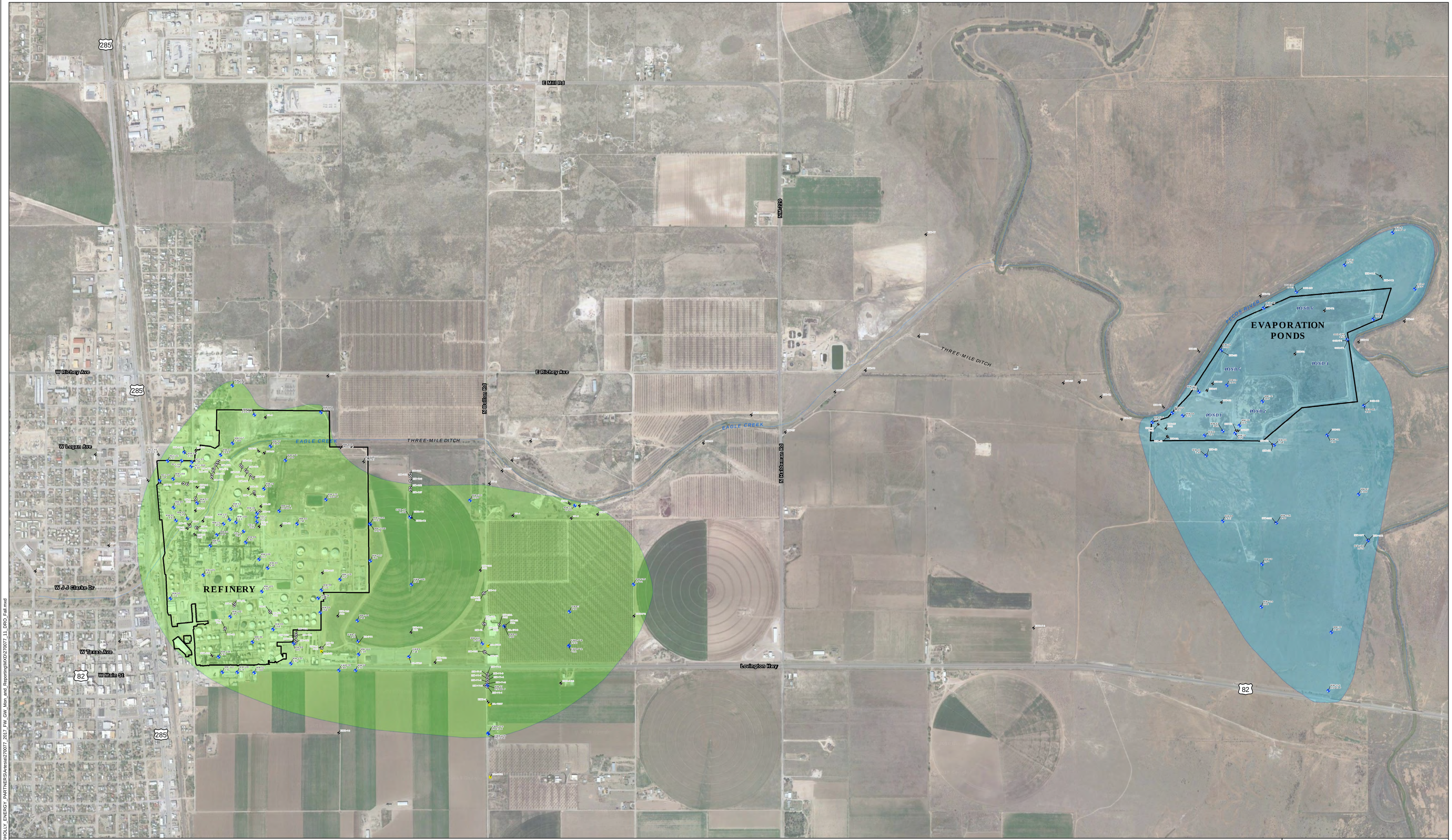

LEGEND

- MONITORING WELL EXCEEDS SCREENING LEVELS
- MONITORING WELL
- IRRIGATION WELL
- RECOVERY WELL
- 9.77 DRO CONCENTRATION
- MW-11A WELL NOT SAMPLED
- PSH PHASE-SEPARATED HYDROCARBON PRESENT IN WELL (> 0.03 FEET THICK)
- DRO CRITICAL GROUNDWATER SCREENING LEVEL EXCEEDANCE AREA (CONCENTRATION > 0.0398 mg/L)
- DRO CRITICAL GROUNDWATER SCREENING LEVEL EXCEEDANCE AREA, EVAPORATION PONDS (CONCENTRATION > 0.0473 mg/L)
- FENCELINE

NOTES:

1. ALL CONCENTRATIONS ARE IN MILLIGRAMS PER LITER (mg/L).
2. DRO = DIESEL RANGE ORGANICS
3. J = CONCENTRATION QUALIFIED AS AN ESTIMATED VALUE.

N W E S

0 750 1,500
Feet

1 IN = 750 FT

NEW MEXICO

DRO CRITICAL GROUNDWATER SCREENING LEVEL EXCEEDANCE MAP 2017 SECOND SEMIANNUAL EVENT

2017 ANNUAL GROUNDWATER REPORT
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ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO

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FIGURE 11

AERIAL IMAGERY SOURCE: GOOGLE AND THEIR DATA PARTNERS 2016

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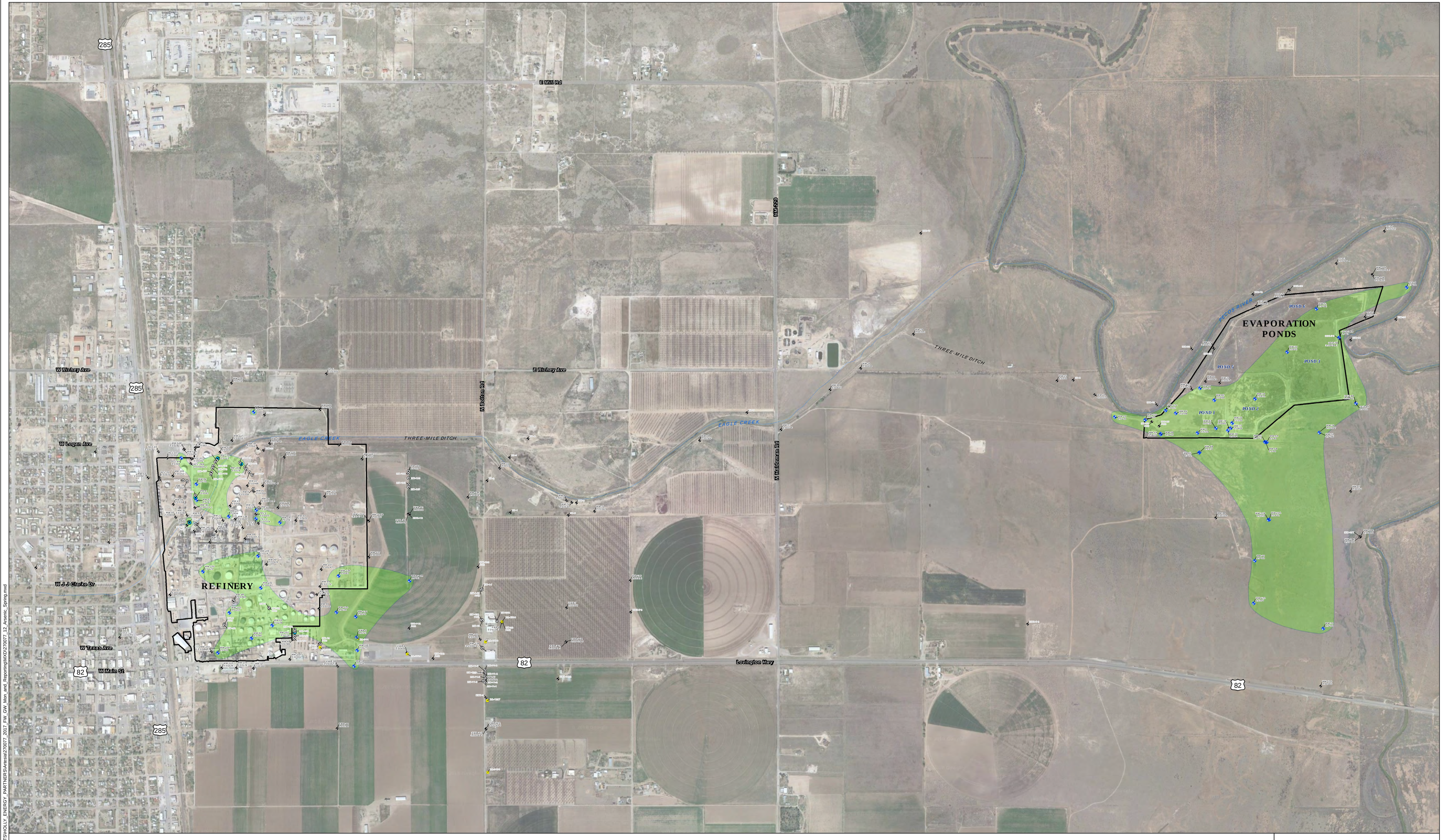

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LEGEND

- MONITORING WELL EXCEEDS SCREENING LEVELS
- MONITORING WELL
- IRRIGATION WELL
- RECOVERY WELL EXCEEDING SCREENING LEVELS
- RECOVERY WELL

- 0.0798 ARSENIC CONCENTRATION
- MW-69 WELL NOT SAMPLED
- PSH PHASE-SEPARATED HYDROCARBON PRESENT IN WELL (>0.03 FEET THICK)
- ARSENIC CRITICAL GROUNDWATER SCREENING LEVEL EXCEEDANCE AREA (CONCENTRATION > 0.01 mg/L)
- FENCELINE

NOTES:

1. ALL CONCENTRATIONS ARE IN MILLIGRAMS PER LITER (mg/L).
2. J = CONCENTRATION QUALIFIED AS AN ESTIMATED VALUE.

N W E S

0 750 1,500
Feet

1 IN = 750 FT

NEW MEXICO

AERIAL IMAGERY SOURCE: GOOGLE AND THEIR DATA PARTNERS 2017

ARSENIC CRITICAL GROUNDWATER SCREENING LEVEL EXCEEDANCE MAP 2017 FIRST SEMIANNUAL EVENT

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HOLLYFRONTIER NAVAJO REFINING LLC
ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO

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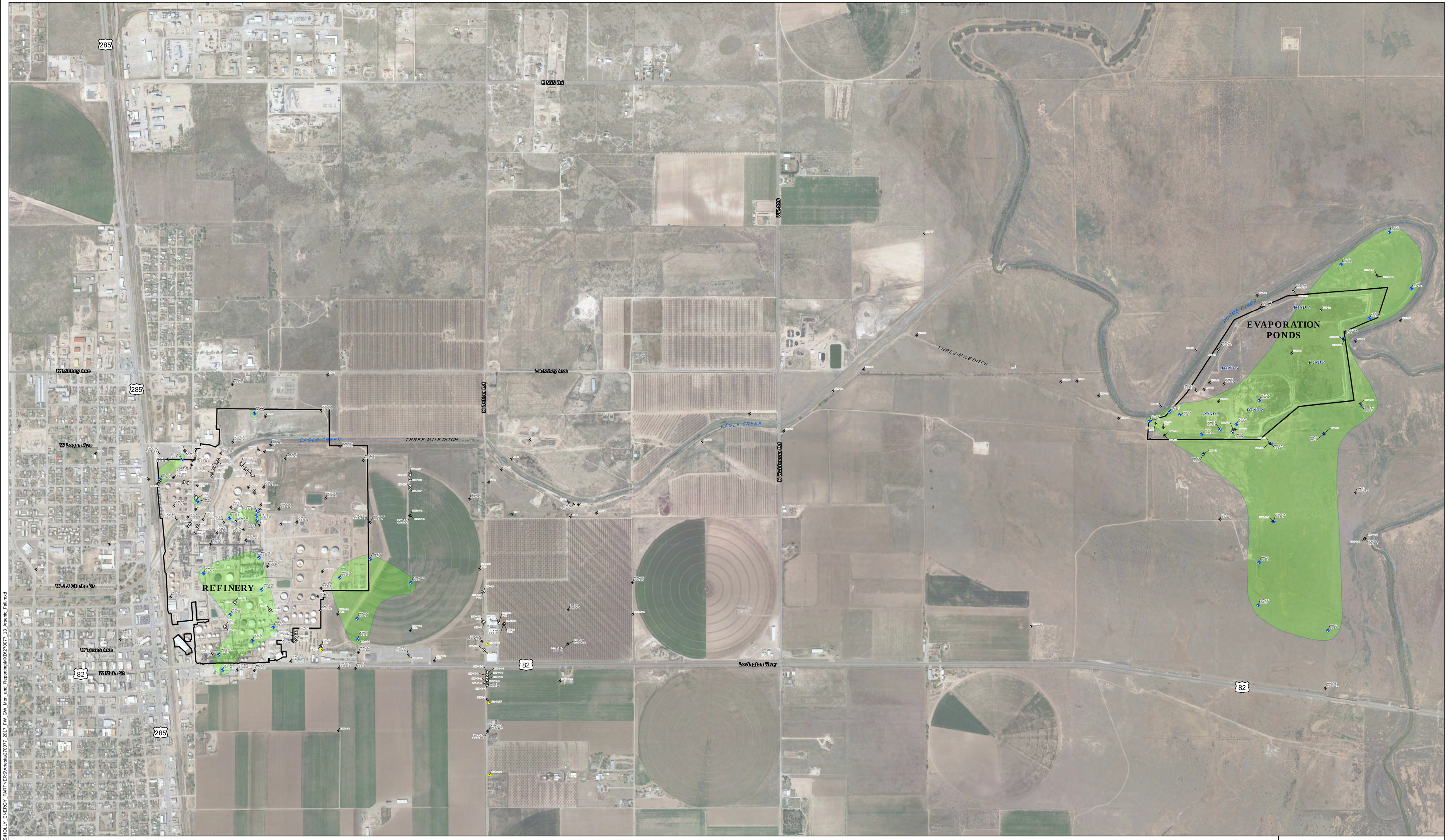
FIGURE 12



LEGEND

- MONITORING WELL EXCEEDS SCREENING LEVELS
- MONITORING WELL
- IRRIGATION WELL
- RECOVERY WELL

- 0.0520 ARSENIC CONCENTRATION
- MW-69 WELL NOT SAMPLED
- PSH PHASE-SEPARATED HYDROCARBON PRESENT IN WELL (> 0.03 FEET THICK)
- ARSENIC CRITICAL GROUNDWATER SCREENING LEVEL EXCEEDANCE AREA (CONCENTRATION > 0.01 mg/L)
- FENCELINE

NOTES:

1. ALL CONCENTRATIONS ARE IN MILLIGRAMS PER LITER (mg/L).
2. J = CONCENTRATION QUALIFIED AS AN ESTIMATED VALUE.

N W E S

0 750 1,500
Feet

1 IN = 750 FT

NEW MEXICO

AERIAL IMAGERY SOURCE: GOOGLE AND THEIR DATA PARTNERS 2017

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ARSENIC CRITICAL GROUNDWATER SCREENING LEVEL EXCEEDANCE MAP 2017 SECOND SEMIANNUAL EVENT

2017 ANNUAL GROUNDWATER REPORT
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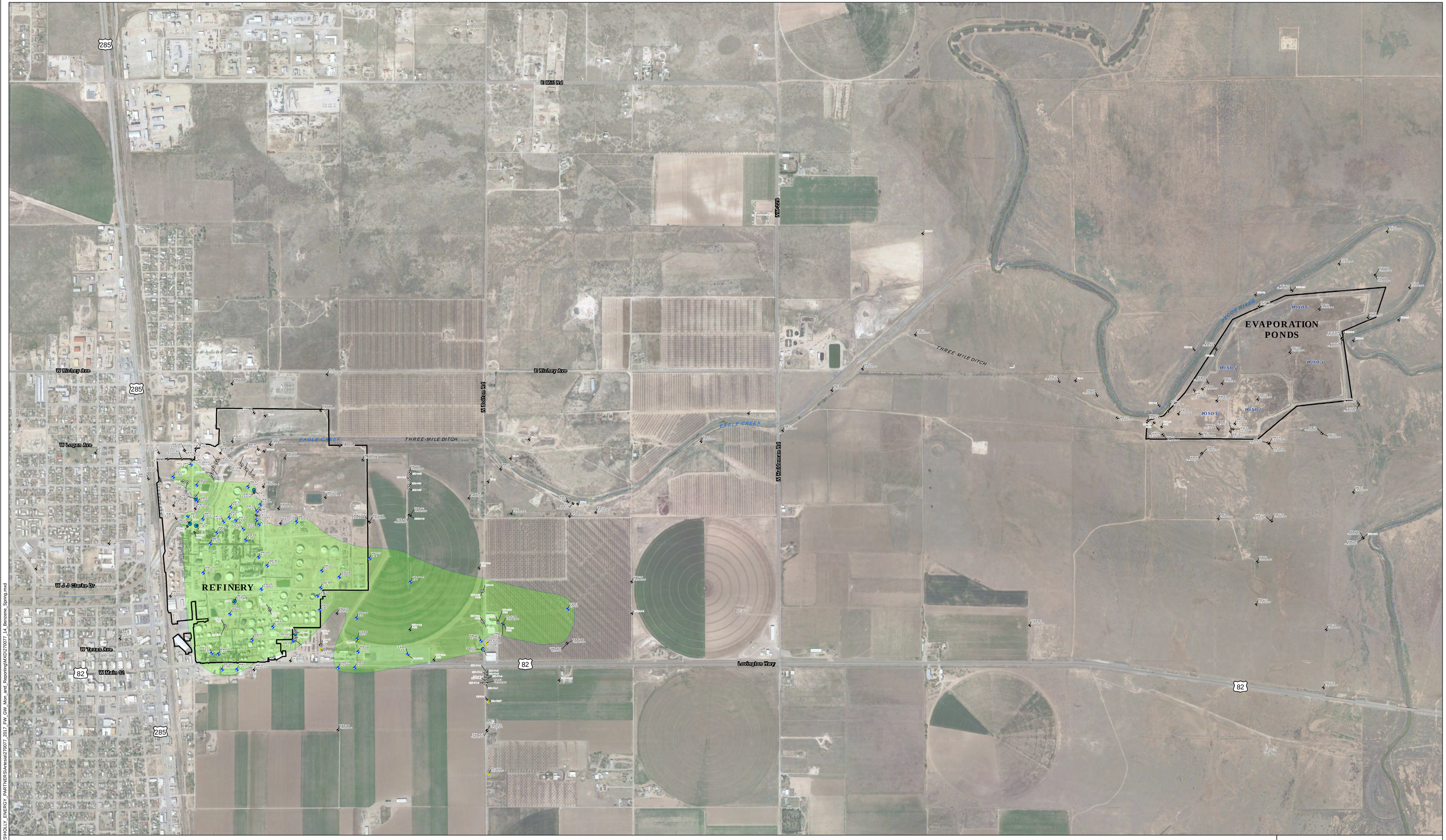
FIGURE 13



LEGEND

- MONITORING WELL EXCEEDS SCREENING LEVELS
- MONITORING WELL
- IRRIGATION WELL
- RECOVERY WELL EXCEEDING SCREENING LEVELS
- RECOVERY WELL

- 5.62 BENZENE CONCENTRATION
- <0.00331 BENZENE NOT DETECTED ABOVE METHOD DETECTION LIMIT
- MW-69 WELL NOT SAMPLED
- PSH PHASE-SEPARATED HYDROCARBON PRESENT IN WELL (> 0.03 FEET THICK)
- BENZENE CRITICAL GROUNDWATER SCREENING LEVEL EXCEEDANCE AREA (CONCENTRATION > 0.005 mg/L)
- FENCELINE

NOTES:

1. ALL CONCENTRATIONS ARE IN MILLIGRAMS PER LITER (mg/L).
2. J = CONCENTRATION QUALIFIED AS AN ESTIMATED VALUE.

N W E S

0 750 1,500
Feet

1 IN = 750 FT

NEW MEXICO

AERIAL IMAGERY SOURCE: GOOGLE AND THEIR DATA PARTNERS 2017

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BENZENE CRITICAL GROUNDWATER SCREENING LEVEL EXCEEDANCE MAP 2017 FIRST SEMIANNUAL EVENT

2017 ANNUAL GROUNDWATER REPORT
HOLLYFRONTIER NAVAJO REFINING LLC
ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO

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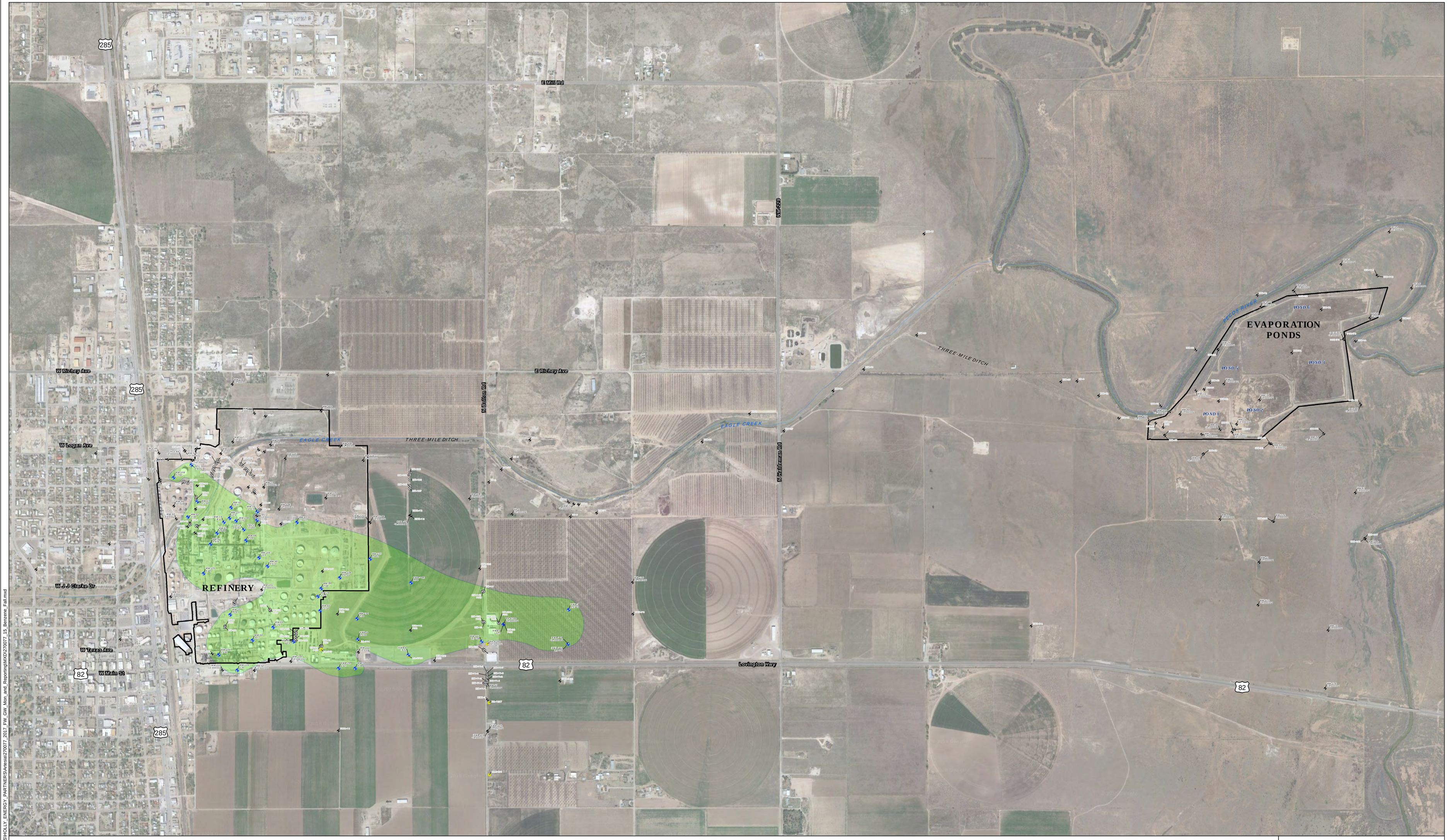
FIGURE 14



LEGEND

- MONITORING WELL EXCEEDS SCREENING LEVELS
- MONITORING WELL
- IRRIGATION WELL
- RECOVERY WELL

- 9.24 BENZENE CONCENTRATION
- <0.00331 BENZENE NOT DETECTED ABOVE METHOD DETECTION LIMIT
- MW-69 WELL NOT SAMPLED
- PSH PHASE-SEPARATED HYDROCARBON PRESENT IN WELL (> 0.03 FEET THICK)
- BENZENE CRITICAL GROUNDWATER SCREENING LEVEL EXCEEDANCE AREA (CONCENTRATION > 0.005 mg/L)
- FENCELINE

NOTES:

1. ALL CONCENTRATIONS ARE IN MILLIGRAMS PER LITER (mg/L).
2. J = CONCENTRATION QUALIFIED AS AN ESTIMATED VALUE.

N W E S

0 750 1,500
Feet

1 IN = 750 FT

NEW MEXICO

AERIAL IMAGERY SOURCE: GOOGLE AND THEIR DATA PARTNERS 2017

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BENZENE CRITICAL GROUNDWATER SCREENING LEVEL EXCEEDANCE MAP 2017 SECOND SEMIANNUAL EVENT

2017 ANNUAL GROUNDWATER REPORT
HOLLYFRONTIER NAVAJO REFINING LLC
ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO

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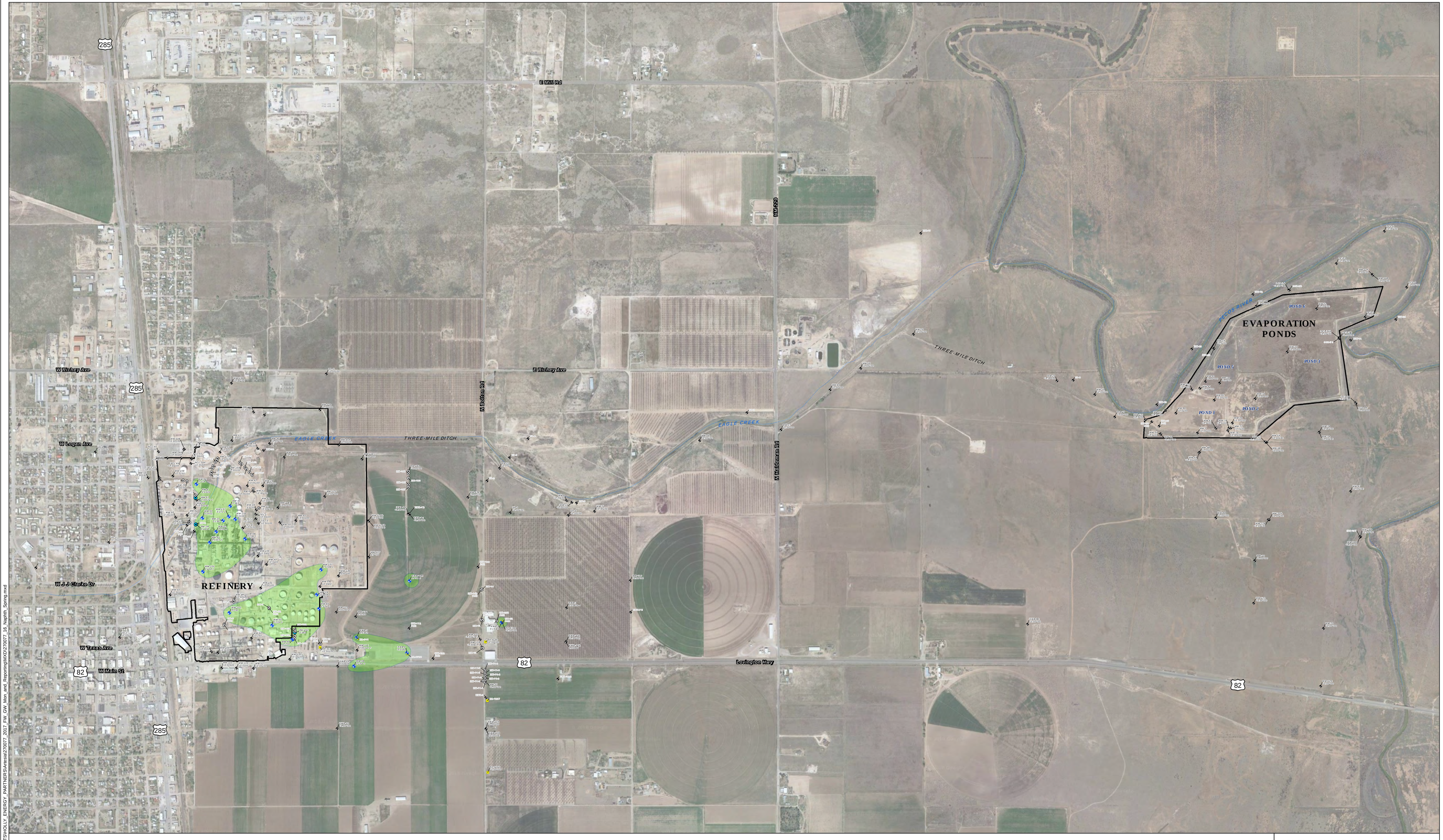
FIGURE 15



LEGEND

- MONITORING WELL EXCEEDS SCREENING LEVELS
- MONITORING WELL
- IRRIGATION WELL
- RECOVERY WELL EXCEEDING SCREENING LEVELS
- RECOVERY WELL

- 0.0668 NAPHTHALENE CONCENTRATION
- <0.00100 NAPHTHALENE NOT DETECTED ABOVE METHOD DETECTION LIMIT
- MW-69 WELL NOT SAMPLED
- PSH PHASE-SEPARATED HYDROCARBON PRESENT IN WELL (> 0.03 FEET THICK)
- NAPHTHALENE CRITICAL GROUNDWATER SCREENING LEVEL EXCEEDANCE AREA (CONCENTRATION > 0.03 mg/L)
- FENCELINE

NOTES:

1. ALL CONCENTRATIONS ARE IN MILLIGRAMS PER LITER (mg/L).
2. J = CONCENTRATION QUALIFIED AS AN ESTIMATED VALUE.

N W E S

0 750 1,500
Feet

1 IN = 750 FT

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NAPHTHALENE CRITICAL GROUNDWATER SCREENING LEVEL EXCEEDANCE MAP 2017 FIRST SEMIANNUAL EVENT

2017 ANNUAL GROUNDWATER REPORT
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ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO

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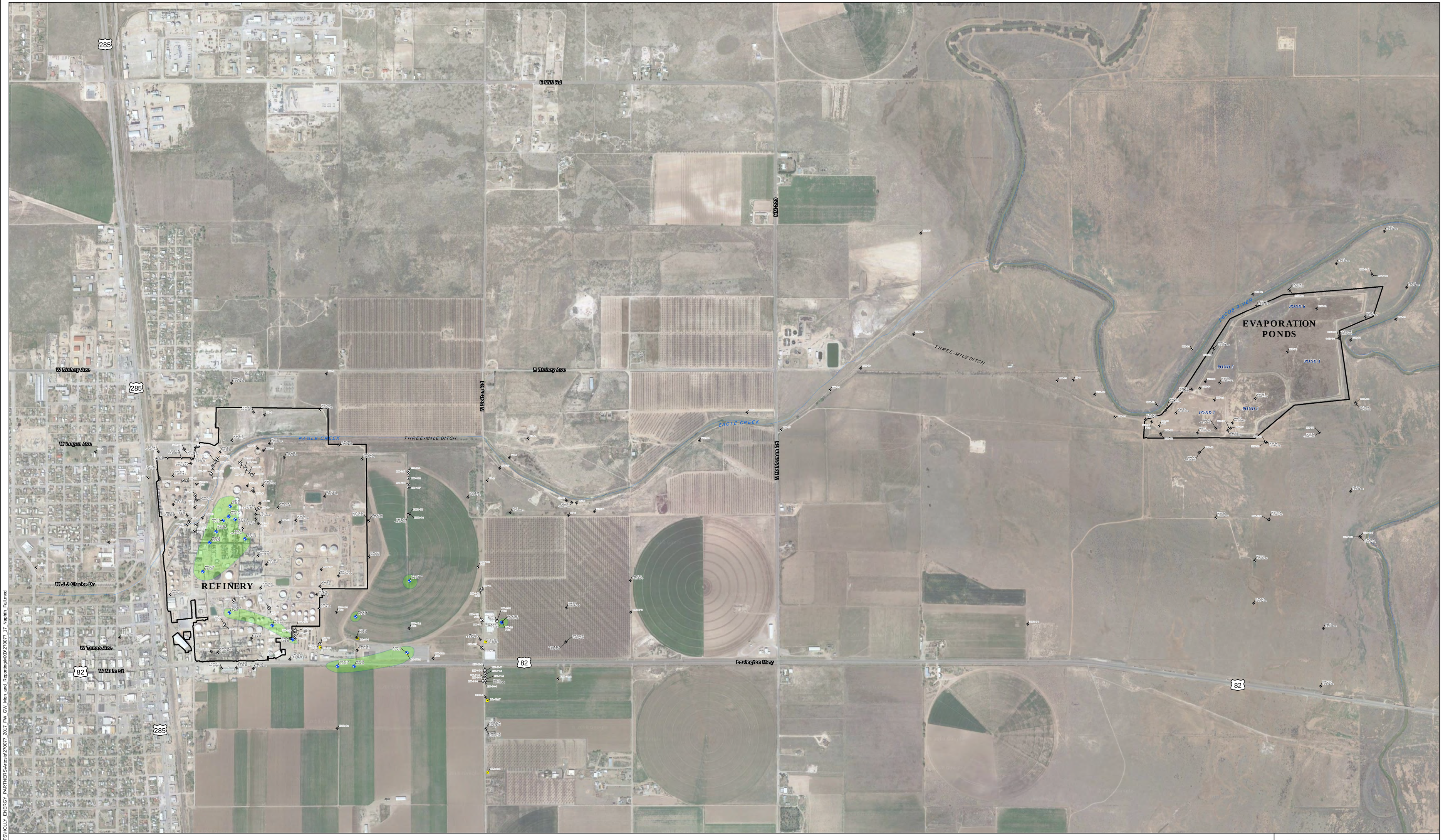
FIGURE 16



LEGEND

- MONITORING WELL EXCEEDS SCREENING LEVELS
- MONITORING WELL
- IRRIGATION WELL
- RECOVERY WELL

- 0.152 NAPHTHALENE CONCENTRATION
- < 0.00100 NAPHTHALENE NOT DETECTED ABOVE METHOD DETECTION LIMIT
- MW-69 WELL NOT SAMPLED
- PSH PHASE-SEPARATED HYDROCARBON PRESENT IN WELL (> 0.03 FEET THICK)
- NAPHTHALENE CRITICAL GROUNDWATER SCREENING LEVEL EXCEEDANCE AREA (CONCENTRATION > 0.03 mg/L)
- FENCELINE

NOTES:

1. ALL CONCENTRATIONS ARE IN MILLIGRAMS PER LITER (mg/L).
2. J = CONCENTRATION QUALIFIED AS AN ESTIMATED VALUE.

N W E S

0 750 1,500
Feet

1 IN = 750 FT

NEW MEXICO

NAPHTHALENE CRITICAL GROUNDWATER SCREENING LEVEL EXCEEDANCE MAP 2017 SECOND SEMIANNUAL EVENT

2017 ANNUAL GROUNDWATER REPORT
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ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO

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FIGURE 17

AERIAL IMAGERY SOURCE: GOOGLE AND THEIR DATA PARTNERS 2017

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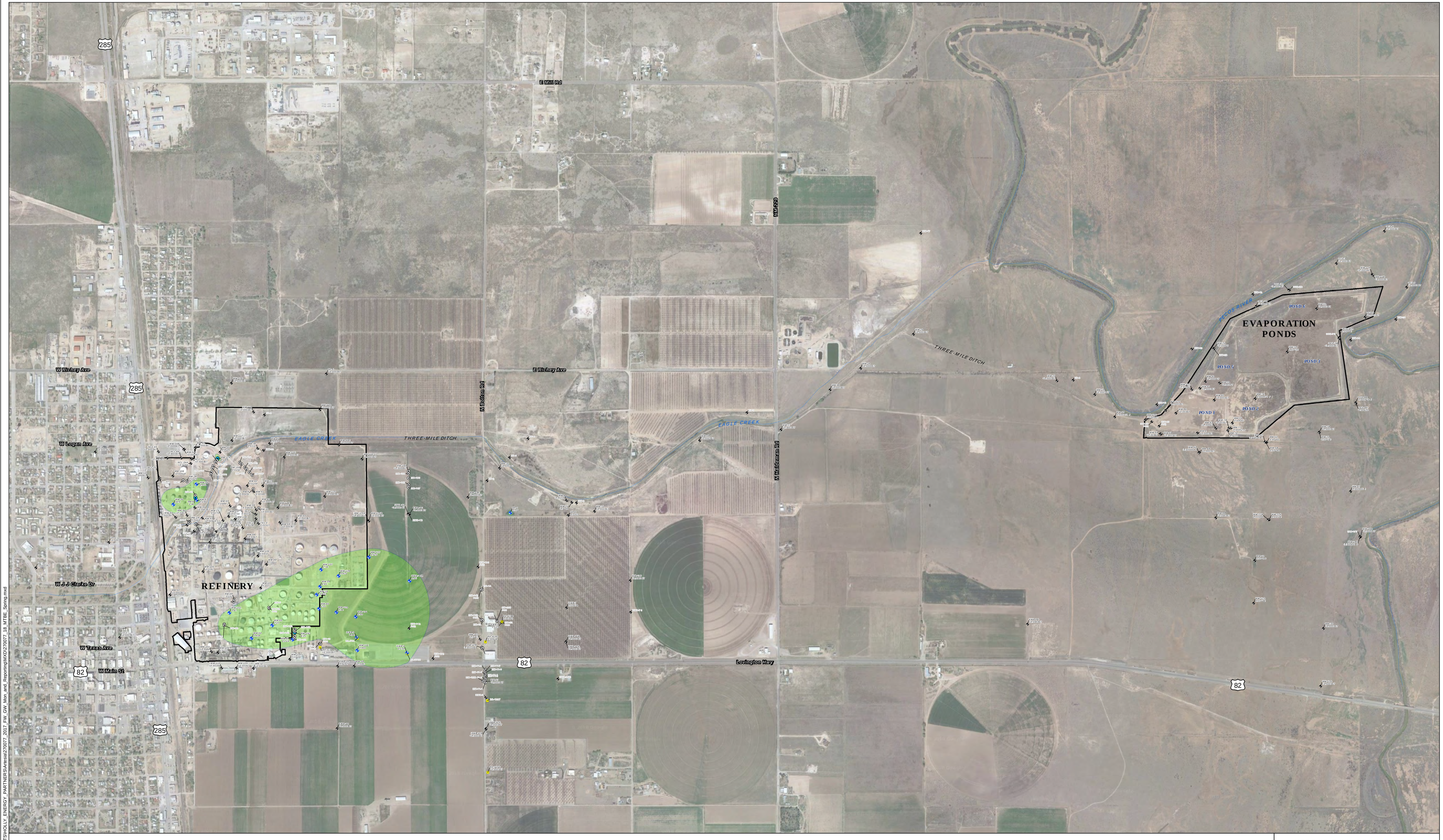

LEGEND

- MONITORING WELL EXCEEDS SCREENING LEVELS
- MONITORING WELL
- IRRIGATION WELL
- RECOVERY WELL EXCEEDING SCREENING LEVELS
- RECOVERY WELL

- 0.423 MTBE CONCENTRATION
- <0.000367 MTBE NOT DETECTED ABOVE METHOD DETECTION LIMIT
- MW-69 WELL NOT SAMPLED
- PSH PHASE-SEPARATED HYDROCARBON PRESENT IN WELL (> 0.03 FEET THICK)
- MTBE CRITICAL GROUNDWATER SCREENING LEVEL EXCEEDANCE AREA (CONCENTRATION > 0.143 mg/L)
- FENCELINE

NOTES:

1. ALL CONCENTRATIONS ARE IN MILLIGRAMS PER LITER (mg/L).
2. J = CONCENTRATION QUALIFIED AS AN ESTIMATED VALUE.
3. MTBE = METHYL TERT-BUTYL ETHER

N W E S

0 750 1,500
Feet

1 IN = 750 FT

NEW MEXICO

MTBE CRITICAL GROUNDWATER SCREENING LEVEL EXCEEDANCE MAP 2017 FIRST SEMIANNUAL EVENT

2017 ANNUAL GROUNDWATER REPORT
HOLLYFRONTIER NAVAJO REFINING LLC
ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO

AUTHOR: MREEVES	SAVED: 2/27/2018	MXD: 270077_18_MTBE_Spring

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FIGURE 18

AERIAL IMAGERY SOURCE: GOOGLE AND THEIR DATA PARTNERS 2017

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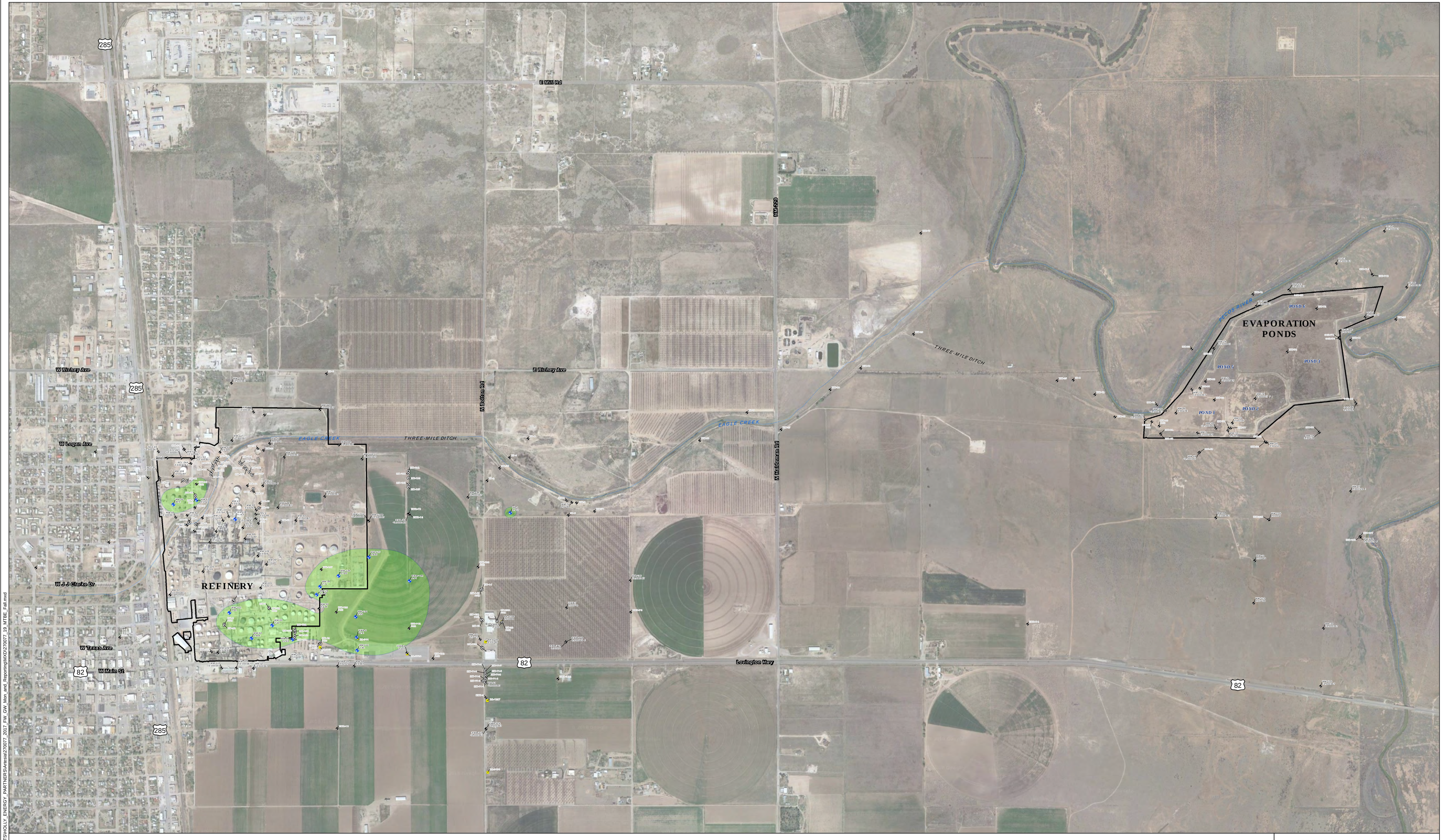

LEGEND

- MONITORING WELL EXCEEDS SCREENING LEVELS
- MONITORING WELL
- IRRIGATION WELL
- RECOVERY WELL

- 2.13 MTBE CONCENTRATION
- <0.0184 MTBE NOT DETECTED ABOVE METHOD DETECTION LIMIT
- MW-69 WELL NOT SAMPLED
- PSH PHASE-SEPARATED HYDROCARBON PRESENT IN WELL (> 0.03 FEET THICK)
- MTBE CRITICAL GROUNDWATER SCREENING LEVEL EXCEEDANCE AREA (CONCENTRATION > 0.143 mg/L)
- FENCELINE

NOTES:

1. ALL CONCENTRATIONS ARE IN MILLIGRAMS PER LITER (mg/L).
2. J = CONCENTRATION QUALIFIED AS AN ESTIMATED VALUE.
3. MTBE = METHYL TERT-BUTYL ETHER

N W E S

0 750 1,500
Feet

1 IN = 750 FT

NEW MEXICO

MTBE CRITICAL GROUNDWATER SCREENING LEVEL EXCEEDANCE MAP 2017 SECOND SEMIANNUAL EVENT

2017 ANNUAL GROUNDWATER REPORT
HOLLYFRONTIER NAVAJO REFINING LLC
ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO

AUTHOR: MREEVES	SAVED: 2/27/2018	MXD: 270077_19_MTBE_Fall

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FIGURE 19

AERIAL IMAGERY SOURCE: GOOGLE AND THEIR DATA PARTNERS 2017

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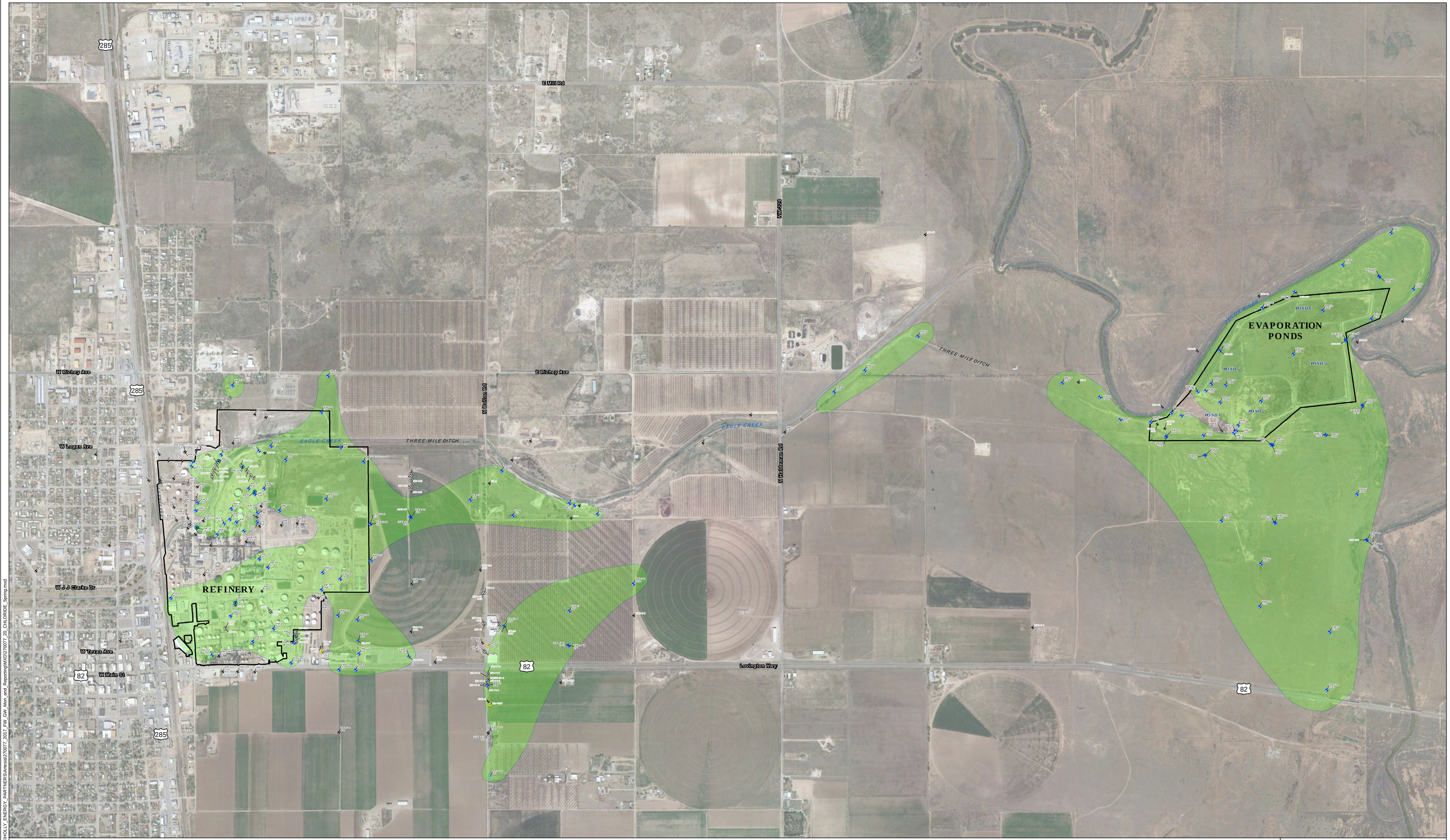

LEGEND

- MONITORING WELL EXCEEDS SCREENING LEVELS
- MONITORING WELL
- IRRIGATION WELL EXCEEDS SCREENING LEVELS
- IRRIGATION WELL
- RECOVERY WELL EXCEEDING SCREENING LEVELS
- RECOVERY WELL

- 456 CHLORIDE CONCENTRATION
- MW-69 WELL NOT SAMPLED
- PSH PHASE-SEPARATED HYDROCARBON PRESENT IN WELL (> 0.03 FEET THICK)
- CHLORIDE CRITICAL GROUNDWATER SCREENING LEVEL EXCEEDANCE AREA (CONCENTRATION > 250 mg/L)
- FENCELINE

NOTES:

1. ALL CONCENTRATIONS ARE IN MILLIGRAMS PER LITER (mg/L).

N W E S

0 750 1,500
Feet

1 IN = 750 FT

NEW MEXICO

AERIAL IMAGERY SOURCE: GOOGLE AND THEIR DATA PARTNERS 2017

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CHLORIDE CRITICAL GROUNDWATER SCREENING LEVEL EXCEEDANCE MAP 2017 FIRST SEMIANNUAL EVENT

2017 ANNUAL GROUNDWATER REPORT
HOLLYFRONTIER NAVAJO REFINING LLC
ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO

AUTHOR: MREEVES	SAVED: 2/27/2018	MXD: 270077_20_CHLORIDE_Spring

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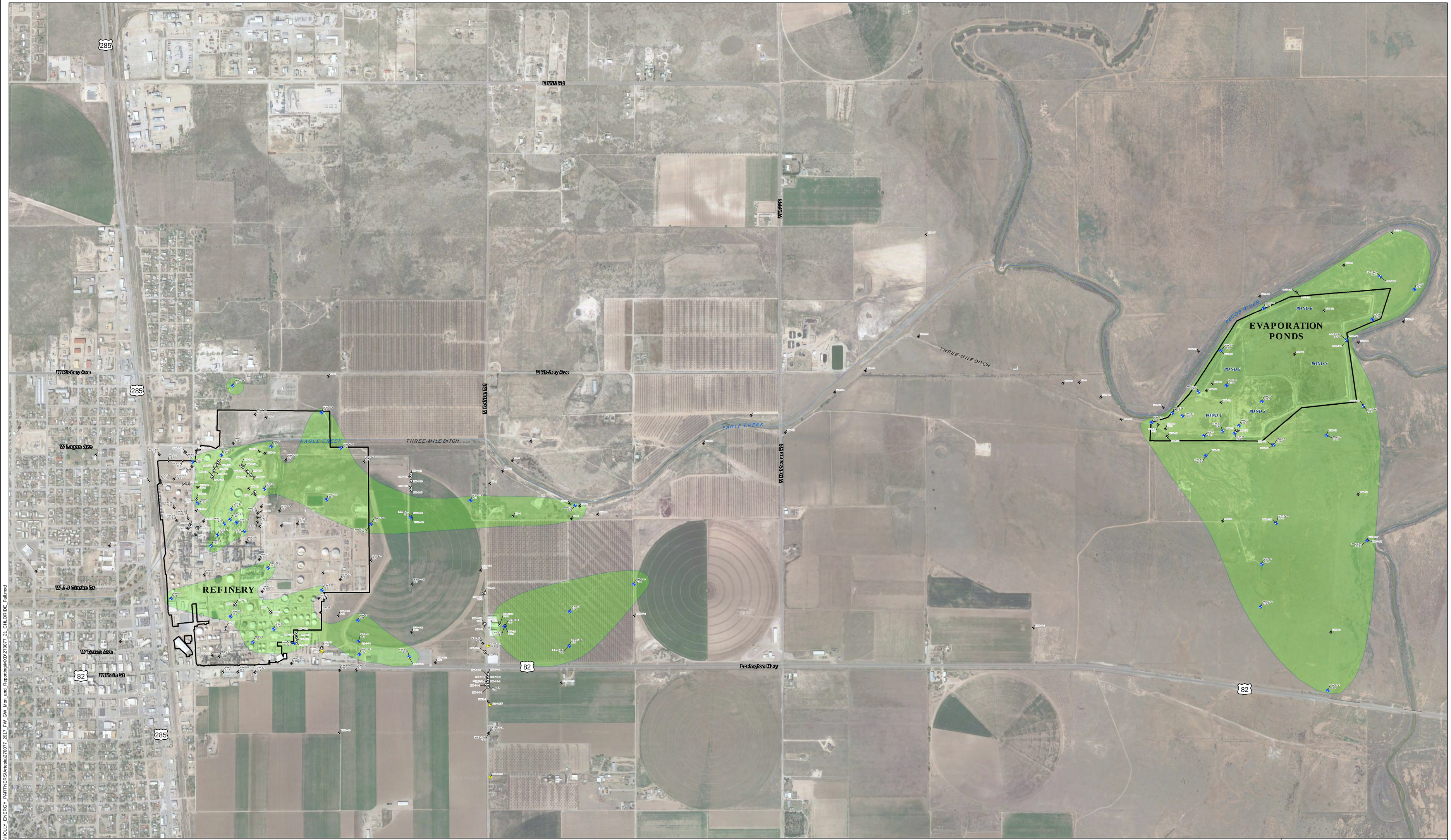
FIGURE 20



LEGEND

- MONITORING WELL EXCEEDS SCREENING LEVELS
- MONITORING WELL
- IRRIGATION WELL
- RECOVERY WELL

357 CHLORIDE CONCENTRATION
MW-69 WELL NOT SAMPLED
PSH PHASE-SEPARATED HYDROCARBON PRESENT IN WELL (> 0.03 FEET THICK)
CHLORIDE CRITICAL GROUNDWATER SCREENING LEVEL EXCEEDANCE AREA (CONCENTRATION > 250 mg/L)
FENCELINE

NOTES:

1. ALL CONCENTRATIONS ARE IN MILLIGRAMS PER LITER (mg/L).

N W E S

0 750 1,500
Feet

1 IN = 750 FT

NEW MEXICO

CHLORIDE CRITICAL GROUNDWATER SCREENING LEVEL EXCEEDANCE MAP 2017 SECOND SEMIANNUAL EVENT

2017 ANNUAL GROUNDWATER REPORT
HOLLYFRONTIER NAVAJO REFINING LLC
ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO

AUTHOR: MREEVES	SAVED: 2/27/2018	MXD: 270077_21_CHLORIDE_Fall

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FIGURE 21

AERIAL IMAGERY SOURCE: GOOGLE AND THEIR DATA PARTNERS 2017

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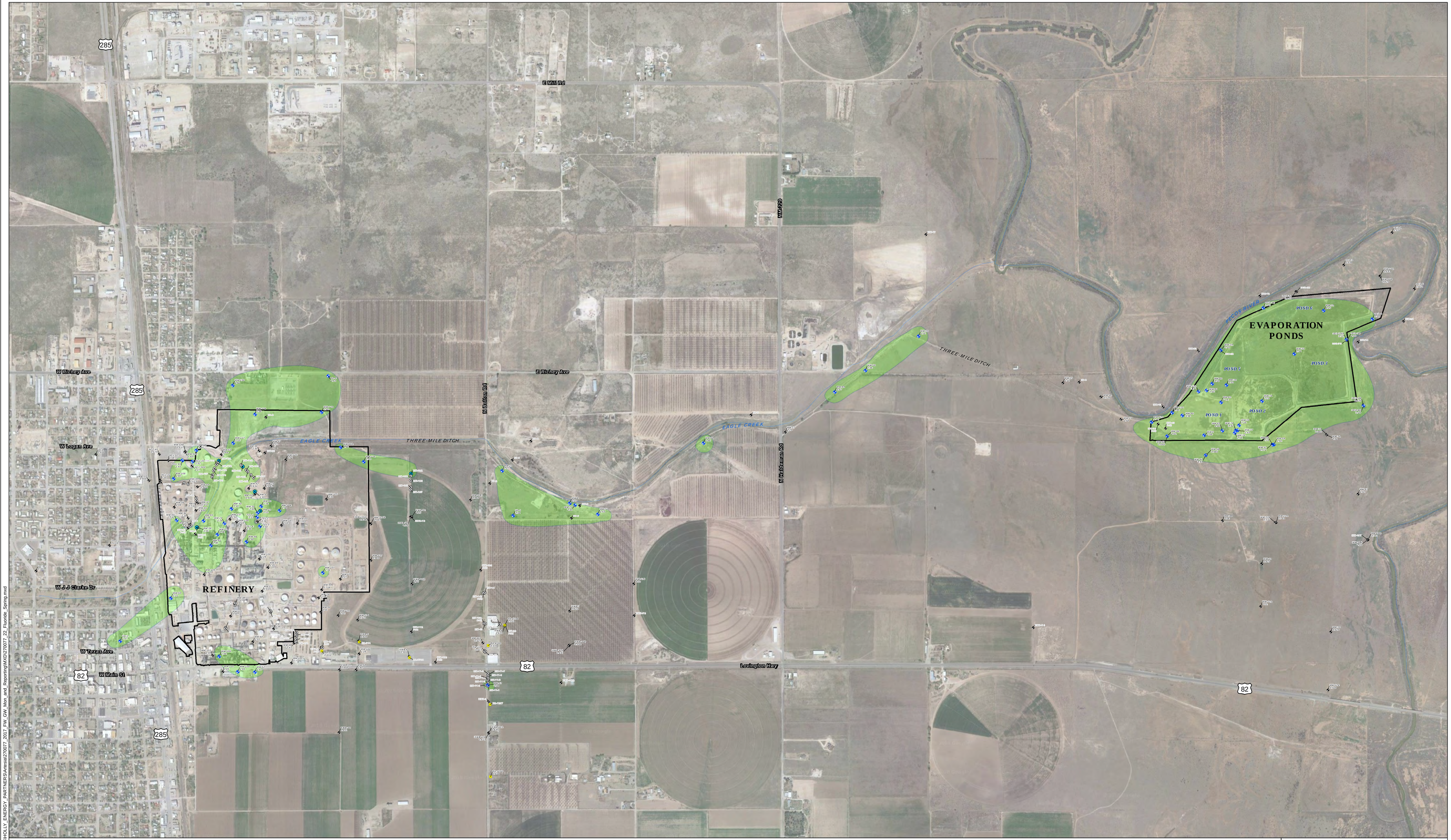

LEGEND

- MONITORING WELL EXCEEDS SCREENING LEVELS
- MONITORING WELL
- IRRIGATION WELL
- RECOVERY WELL EXCEEDING SCREENING LEVELS
- RECOVERY WELL

- 9.91 FLUORIDE CONCENTRATION
- MW-69 WELL NOT SAMPLED
- PSH PHASE-SEPARATED HYDROCARBON PRESENT IN WELL (> 0.03 FEET THICK)
- FLUORIDE CRITICAL GROUNDWATER SCREENING LEVEL EXCEEDANCE AREA (CONCENTRATION > 1.6 mg/L)
- FENCELINE

NOTES:

1. ALL CONCENTRATIONS ARE IN MILLIGRAMS PER LITER (mg/L).

N W E S

0 750 1,500
Feet

1 IN = 750 FT

NEW MEXICO

AERIAL IMAGERY SOURCE: GOOGLE AND THEIR DATA PARTNERS 2017

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FLUORIDE CRITICAL GROUNDWATER SCREENING LEVEL EXCEEDANCE MAP 2017 FIRST SEMIANNUAL EVENT

2017 ANNUAL GROUNDWATER REPORT
HOLLYFRONTIER NAVAJO REFINING LLC
ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO

AUTHOR: MREEVES	SAVED: 2/27/2018	MXD: 270077_22_Fluoride_Spring

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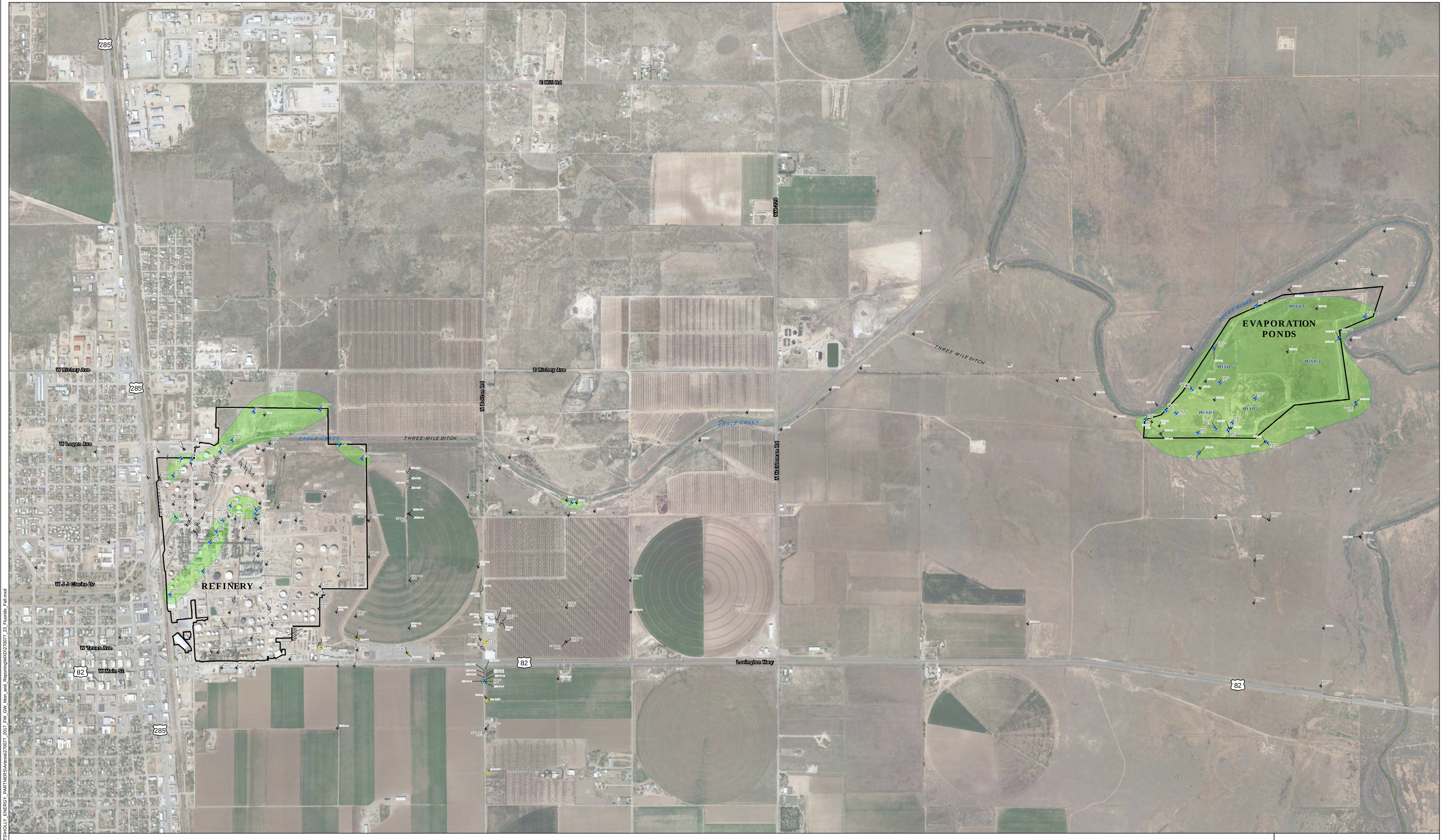
FIGURE 22



LEGEND

- MONITORING WELL EXCEEDS SCREENING LEVELS
- MONITORING WELL
- IRRIGATION WELL
- RECOVERY WELL

- 7.81 FLUORIDE CONCENTRATION
- MW-69 WELL NOT SAMPLED
- PSH PHASE-SEPARATED HYDROCARBON PRESENT IN WELL (> 0.03 FEET THICK)
- FLUORIDE CRITICAL GROUNDWATER SCREENING LEVEL EXCEEDANCE AREA (CONCENTRATION > 1.6 mg/L)
- FENCELINE

NOTES:

1. ALL CONCENTRATIONS ARE IN MILLIGRAMS PER LITER (mg/L).

N W E S

0 750 1,500
Feet

1 IN = 750 FT

NEW MEXICO

FLUORIDE CRITICAL GROUNDWATER SCREENING LEVEL EXCEEDANCE MAP 2017 SECOND SEMIANNUAL EVENT

2017 ANNUAL GROUNDWATER REPORT
HOLLYFRONTIER NAVAJO REFINING LLC
ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO

AUTHOR: MREEVES	SAVED: 2/27/2018	MXD: 270077_23_Fluoride_Fall

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FIGURE 23

AERIAL IMAGERY SOURCE: GOOGLE AND THEIR DATA PARTNERS 2017

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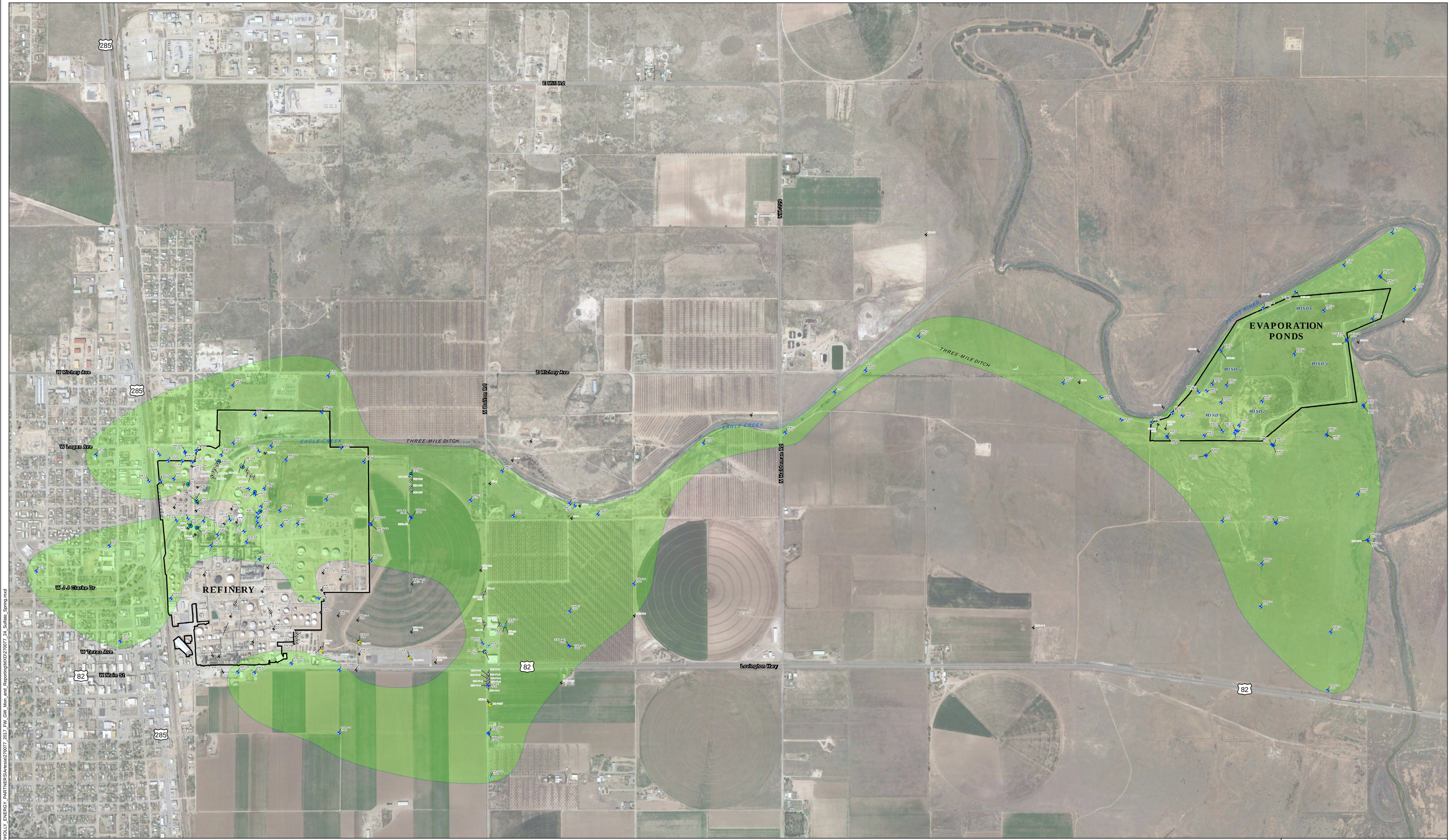

LEGEND

- MONITORING WELL EXCEEDS SCREENING LEVELS
- MONITORING WELL
- IRRIGATION WELL EXCEEDS SCREENING LEVELS
- IRRIGATION WELL
- RECOVERY WELL EXCEEDING SCREENING LEVELS
- RECOVERY WELL

- 3840 SULFATE CONCENTRATION
- MW-69 WELL NOT SAMPLED
- < 0.0774 SULFATE NOT DETECTED ABOVE METHOD DETECTION LIMIT
- PSH PHASE-SEPARATED HYDROCARBON PRESENT IN WELL (> 0.03 FEET THICK)
- SULFATE CRITICAL GROUNDWATER SCREENING LEVEL EXCEEDANCE AREA (CONCENTRATION > 600 mg/L)
- FENCELINE

NOTES:

1. ALL CONCENTRATIONS ARE IN MILLIGRAMS PER LITER (mg/L).
2. J = CONCENTRATION QUALIFIED AS AN ESTIMATED VALUE.

N W E S

0 750 1,500
Feet

1 IN = 750 FT

NEW MEXICO

AERIAL IMAGERY SOURCE: GOOGLE AND THEIR DATA PARTNERS 2017

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SULFATE CRITICAL GROUNDWATER SCREENING LEVEL EXCEEDANCE MAP 2017 FIRST SEMIANNUAL EVENT

2017 ANNUAL GROUNDWATER REPORT
HOLLYFRONTIER NAVAJO REFINING LLC
ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO

AUTHOR: MREEVES	SAVED: 2/27/2018	MXD: 270077_24_Sulfate_Spring

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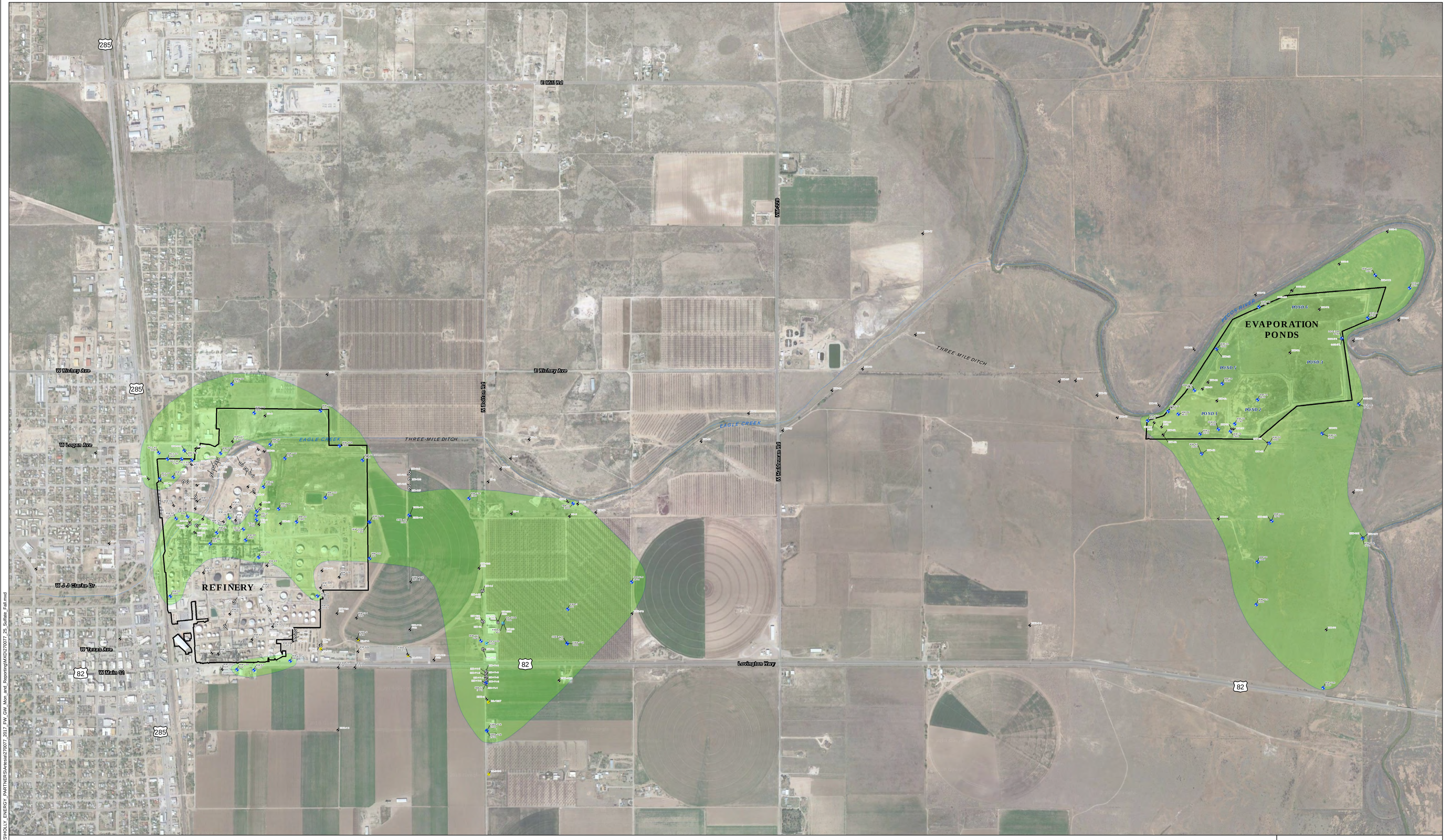
FIGURE 24



LEGEND

- MONITORING WELL EXCEEDS SCREENING LEVELS
- MONITORING WELL
- IRRIGATION WELL EXCEEDS SCREENING LEVELS
- IRRIGATION WELL
- RECOVERY WELL

907 SULFATE CONCENTRATION

MW-69 WELL NOT SAMPLED

PSH PHASE-SEPARATED HYDROCARBON PRESENT IN WELL (> 0.03 FEET THICK)

SULFATE CRITICAL GROUNDWATER SCREENING LEVEL EXCEEDANCE AREA (CONCENTRATION > 600 mg/L)

FENCELINE

NOTES:

1. ALL CONCENTRATIONS ARE IN MILLIGRAMS PER LITER (mg/L).
2. J = CONCENTRATION QUALIFIED AS AN ESTIMATED VALUE.

N W E S

0 750 1,500
Feet

1 IN = 750 FT

NEW MEXICO

AERIAL IMAGERY SOURCE: GOOGLE AND THEIR DATA PARTNERS 2017

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SULFATE CRITICAL GROUNDWATER SCREENING LEVEL EXCEEDANCE MAP 2017 SECOND SEMIANNUAL EVENT

2017 ANNUAL GROUNDWATER REPORT
HOLLYFRONTIER NAVAJO REFINING LLC
ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO

AUTHOR: MREEVES	SAVED: 2/27/2018	MXD: 270077_25_Sulfate_Fall

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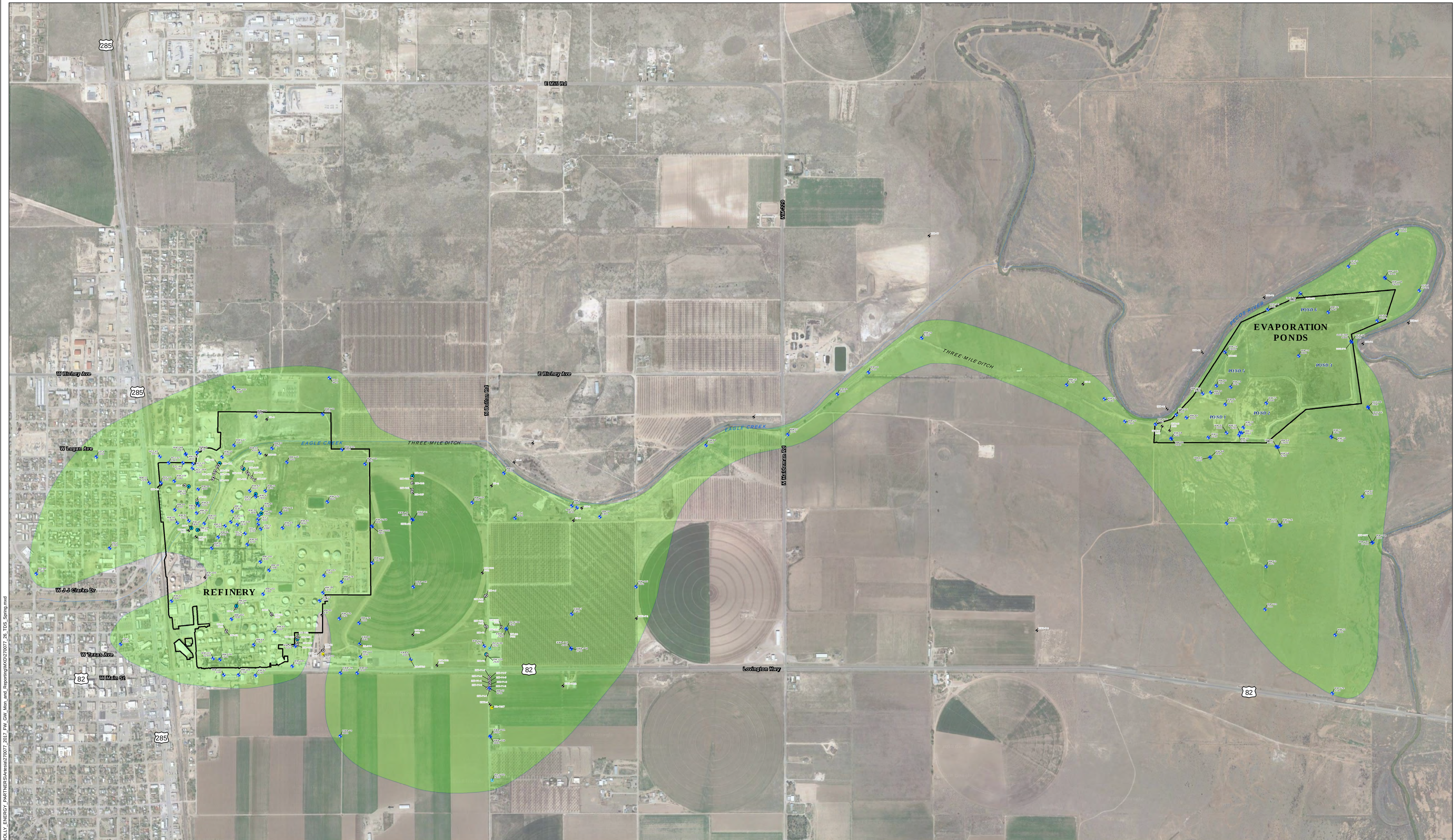
FIGURE 25



LEGEND

- MONITORING WELL EXCEEDS SCREENING LEVELS
- MONITORING WELL
- IRRIGATION WELL EXCEEDS SCREENING LEVELS
- IRRIGATION WELL
- RECOVERY WELL EXCEEDING SCREENING LEVELS
- RECOVERY WELL

- 3840 TOTAL DISSOLVED SOLIDS CONCENTRATION
- MW-69 WELL NOT SAMPLED
- PSH PHASE-SEPARATED HYDROCARBON PRESENT IN WELL (> 0.03 FEET THICK)
- TOTAL DISSOLVED SOLIDS CRITICAL GROUNDWATER SCREENING LEVEL EXCEEDANCE AREA (CONCENTRATION > 1000 mg/L)
- FENCELINE

NOTES:

1. ALL CONCENTRATIONS ARE IN MILLIGRAMS PER LITER (mg/L).

N W E S

0 750 1,500
Feet

1 IN = 750 FT

NEW MEXICO

AERIAL IMAGERY SOURCE: GOOGLE AND THEIR DATA PARTNERS 2017

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TOTAL DISSOLVED SOLIDS CRITICAL GROUNDWATER SCREENING LEVEL EXCEEDANCE MAP
2017 FIRST SEMIANNUAL EVENT
2017 ANNUAL GROUNDWATER REPORT
HOLLYFRONTIER NAVAJO REFINING LLC
ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO

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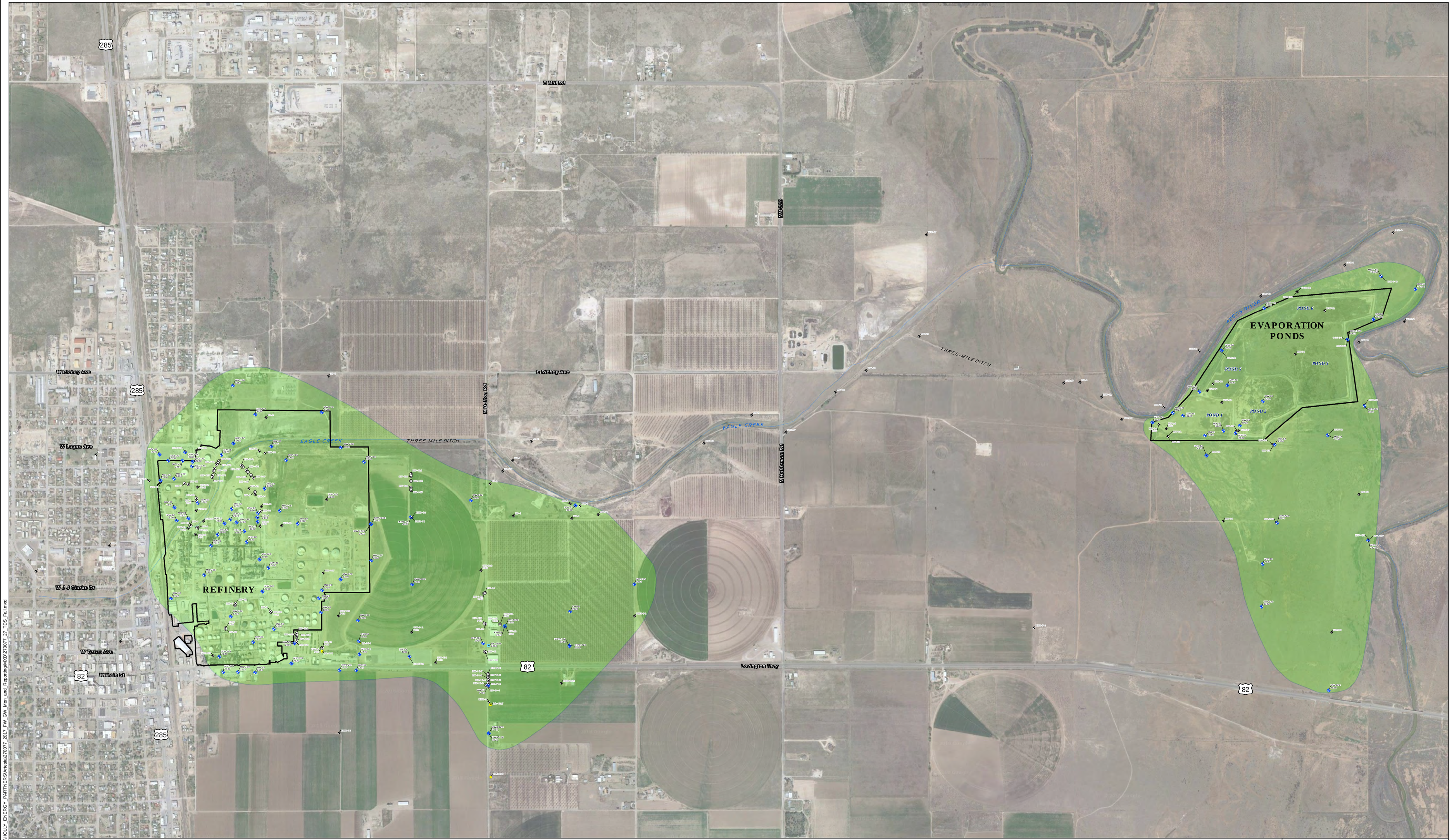
FIGURE 26



LEGEND

- MONITORING WELL EXCEEDS SCREENING LEVELS
- MONITORING WELL
- IRRIGATION WELL EXCEEDS SCREENING LEVELS
- IRRIGATION WELL
- RECOVERY WELL

8860 TOTAL DISSOLVED SOLIDS CONCENTRATION
MW-69 WELL NOT SAMPLED
PSH PHASE-SEPARATED HYDROCARBON PRESENT IN WELL (> 0.03 FEET THICK)
TOTAL DISSOLVED SOLIDS CRITICAL GROUNDWATER SCREENING LEVEL EXCEEDANCE AREA (CONCENTRATION > 1000 mg/L)
FENCELINE

NOTES:

1. ALL CONCENTRATIONS ARE IN MILLIGRAMS PER LITER (mg/L).

N W E S

0 750 1,500
Feet

1 IN = 750 FT

NEW MEXICO

TOTAL DISSOLVED SOLIDS CRITICAL GROUNDWATER SCREENING LEVEL EXCEEDANCE MAP
2017 SECOND SEMIANNUAL EVENT
2017 ANNUAL GROUNDWATER REPORT
HOLLYFRONTIER NAVAJO REFINING LLC
ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO

AUTHOR: MREEVES	SAVED: 2/27/2018	MXD: 270077_27_TDS_Fall

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FIGURE 27

AERIAL IMAGERY SOURCE: GOOGLE AND THEIR DATA PARTNERS 2017

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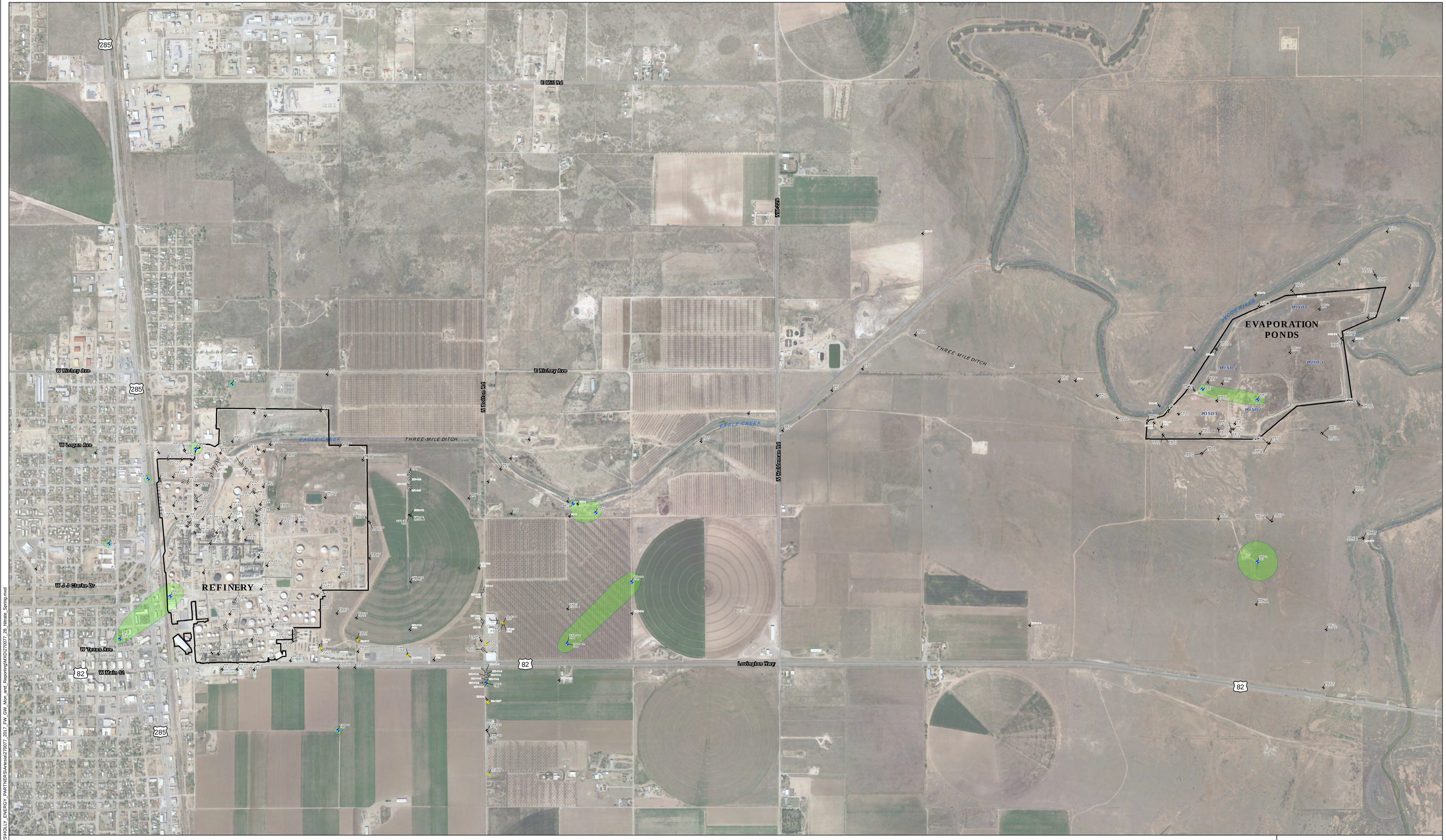

LEGEND

- MONITORING WELL EXCEEDS SCREENING LEVELS
- MONITORING WELL
- IRRIGATION WELL
- RECOVERY WELL

- 155 NITRATE/NITRITE CONCENTRATION
- < 0.197 NITRATE/NITRITE NOT DETECTED ABOVE METHOD DETECTION LIMIT
- MW-69 WELL NOT SAMPLED
- PSH PHASE-SEPARATED HYDROCARBON PRESENT IN WELL (> 0.03 FEET THICK)
- NITRATE/NITRITE CRITICAL GROUNDWATER SCREENING LEVEL EXCEEDANCE AREA (CONCENTRATION > 10 mg/L)
- FENCELINE

NOTES:

1. ALL CONCENTRATIONS ARE IN MILLIGRAMS PER LITER (mg/L).
2. J = CONCENTRATION QUALIFIED AS AN ESTIMATED VALUE.

N W E S

0 750 1,500
Feet

1 IN = 750 FT

NEW MEXICO

AERIAL IMAGERY SOURCE: GOOGLE AND THEIR DATA PARTNERS 2017

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NITRATE/NITRITE CRITICAL GROUNDWATER SCREENING LEVEL EXCEEDANCE MAP 2017 FIRST SEMIANNUAL EVENT

2017 ANNUAL GROUNDWATER REPORT
HOLLYFRONTIER NAVAJO REFINING LLC
ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO

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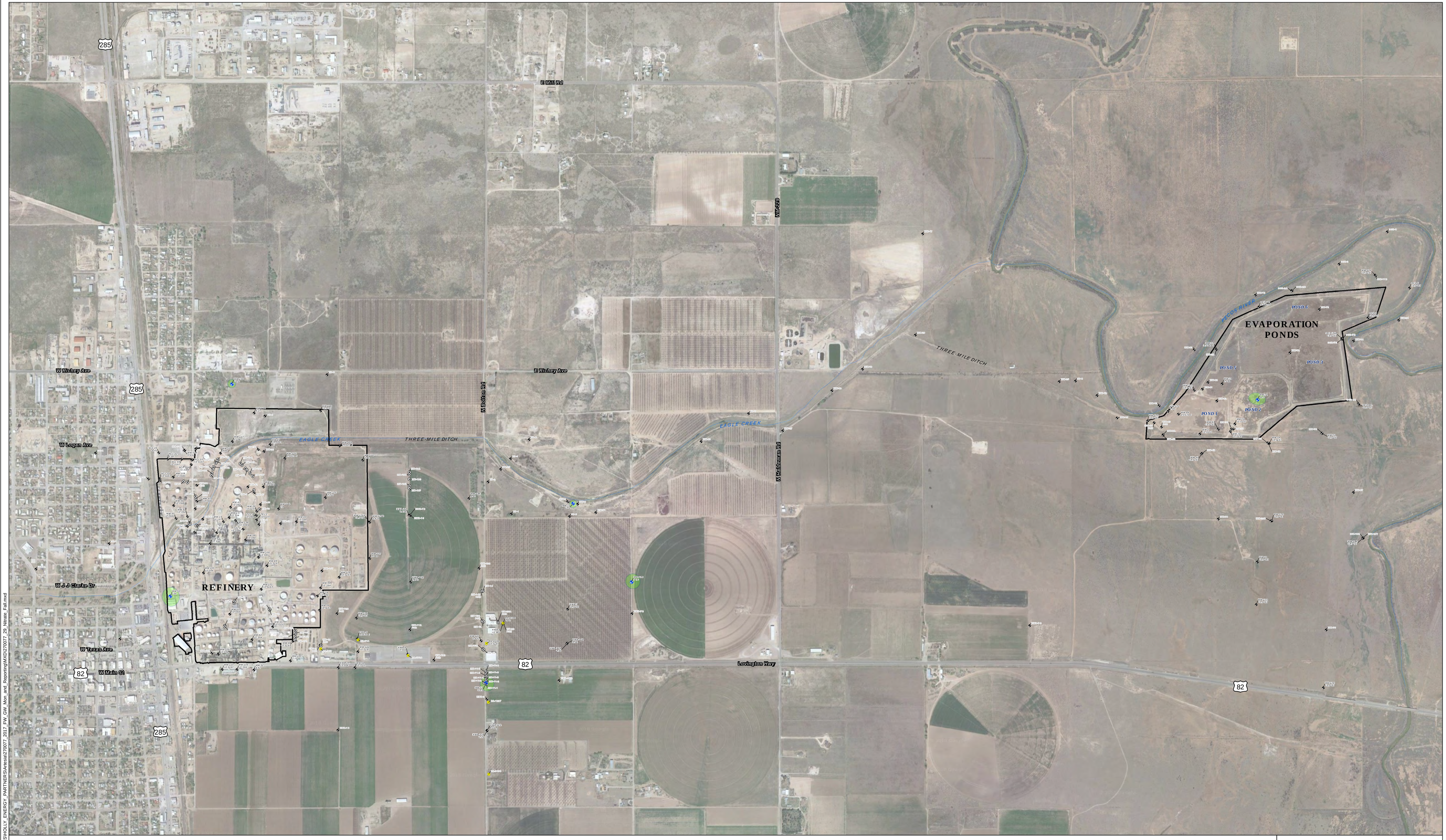
FIGURE 28



LEGEND

- MONITORING WELL EXCEEDS SCREENING LEVELS
- MONITORING WELL
- IRRIGATION WELL
- RECOVERY WELL

- 44.7 NITRATE/NITRITE CONCENTRATION
- < 0.394 NITRATE/NITRITE NOT DETECTED ABOVE METHOD DETECTION LIMIT
- MW-69 WELL NOT SAMPLED
- PSH PHASE-SEPARATED HYDROCARBON PRESENT IN WELL (> 0.03 FEET THICK)
- NITRATE/NITRITE CRITICAL GROUNDWATER SCREENING LEVEL EXCEEDANCE AREA (CONCENTRATION > 10 mg/L)
- FENCELINE

NOTES:

1. ALL CONCENTRATIONS ARE IN MILLIGRAMS PER LITER (mg/L).
2. J = CONCENTRATION QUALIFIED AS AN ESTIMATED VALUE.

N W E S

0 750 1,500
Feet

1 IN = 750 FT

NEW MEXICO

NITRATE/NITRITE CRITICAL GROUNDWATER SCREENING LEVEL EXCEEDANCE MAP 2017 SECOND SEMIANNUAL EVENT

2017 ANNUAL GROUNDWATER REPORT
HOLLYFRONTIER NAVAJO REFINING LLC
ARTESIA REFINERY, EDDY COUNTY, NEW MEXICO

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FIGURE 29

AERIAL IMAGERY SOURCE: GOOGLE AND THEIR DATA PARTNERS 2017

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