Imagine the result

RACER Trust

Pilot ISCO Treatment Work Plan

Former GM Delco Plant 5

USEPA ID IND000806844

August 2013

Matthew Griles, LPG
Project Geologist

Ed Buc, PE
Senior Engineer

Sarah Fisher, CHMM
Senior Scientist

Pilot ISCO Treatment Work Plan

Former GM Delco Plant 5
1723 North Washington Street
Kokomo, Indiana

Prepared for:
RACER Trust

Prepared by:
ARCADIS U.S., Inc.
132 E. Washington Street
Suite 600
Indianapolis
Indiana 46204
Tel 317 231 6500
Fax 317 231 6514

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1. Introduction 1

1.1 Selected Groundwater Remedy 1

1.2 Objective 1

2. Site Conditions 2

2.1 Geology and Hydrogeology 2

2.2 Constituent Distribution 2

3. Pilot Test Details 2

3.1 Well Network 3

3.1.1 Injection Well 3

3.1.2 Dose Response Wells 3

3.1.3 Performance Monitoring Wells 3

3.2 Utility Clearance 4

3.3 Well Installation, Construction, and Development 4

3.3.1 Decontamination 5

3.3.2 Investigation Derived Waste Disposal 5

3.4 Well Surveying 5

4. Baseline Sampling 5

5. ISCO Injection 6

5.1 Health and Safety 6

5.2 Injection Design 6

5.3 Injection Set Up 7

5.4 Injection Procedures 7

5.5 Injection Monitoring 8

6. Post-Injection Monitoring 8

7. Future Injections 9

8. Schedule 9

9. References 10

Figures

Figure 1 Site Location Map

Figure 2 Proposed IW and DR locations with TCE Groundwater Concentration Contours – Unit S1 (April 2, 2013)

Figure 3 Cross-section Reference

Figure 4 A-A' East to West Cross-section

Figure 5 B-B' North to South Cross-section

Figure 6 Potentiometric Surface – Unit S1 (March 12, 2013)

Acronyms

PCE	tetrachloroethene
ISCO	in situ chemical oxidation
ft bgs	feet below ground surface
amsl	above mean sea level
TCE	trichloroethene
KMnO4	potassium permanganate
NaMnO4	sodium permanganate
ROI	radius of influence
SOP	standard operating procedure
PVC	poly vinyl chloride
IDW	investigation derived waste
g/L	grams per liter
PPE	personal protective equipment
MSDS	material safety data sheet
JSA	job safety analysis
EPA	United States Environmental Protection Agency

TOC	total organic carbon
VOC	volatile organic compound

1. Introduction

ARCADIS U.S., Inc. (ARCADIS) has prepared this Pilot ISCO Treatment Work Plan (Work Plan) on behalf of RACER Trust for the Former GM Delco Plant 5 (Site) to use sodium permanganate injections to treat dissolved phase chlorinated volatile organic compounds (cVOCs), including trichloroethene (TCE) and associated daughter products (1,1-dichloroethene [1,1-DCE]; cis-1,2-DCE; trans-1,2-DCE; vinyl chloride). The Site is located at 1723 North Washington Street within the city of Kokomo in Howard County, Indiana. A Site location map is included as Figure 1.

1.1 Selected Groundwater Remedy

A Corrective Measures Proposal (CMP) was completed to evaluate potential options to reduce concentrations of TCE in groundwater at the Site. Remedial options included groundwater extraction, in situ chemical oxidation (ISCO), enhanced reductive dechlorination (ERD), and bentonite cutoff wall. ISCO was the selected remedy based on its short timeframe to reduce residual cVOC mass and the limited infrastructure needed to implement the remedy.

The permanganate anion has a relatively long half-life in groundwater and is frequently used for the treatment of cVOCs. The permanganate anion works via direct chemical oxidation without the need for activation.

Permanganate is injected into the target aquifer in an aqueous solution, usually sourced from potassium permanganate ($KMnO_4$) or sodium permanganate ($NaMnO_4$) salts. Sodium permanganate will be utilized at this Site because of its higher solubility at aquifer temperatures.

1.2 Objective

The objective of the Pilot ISCO treatment is to:

- Demonstrate the effectiveness of sodium permanganate to treat elevated concentrations of TCE and its daughter products present in Site groundwater.
- Evaluate potential rebound of dissolved phase cVOCs.
- Determine the necessary design parameters for full scale system design and implementation of ISCO based on measured injection flow rates, injection pressures, and water levels during the injection test.
- Evaluate the feasibility of implementing a full scale ISCO treatment to address groundwater contamination at or above a threshold treatment concentration of 4,000 µg/L of TCE.

2. Site Conditions

2.1 Geology and Hydrogeology

Consistent with the regional geology, the unconsolidated sediments encountered during historical subsurface investigations have been comprised of three sand and gravel units separated by clay layers. These sand and gravel units have been designated units S1 through S3, with unit S1 being the shallowest and unit S3 being the deepest. Geologic cross-sections and a cross-section reference drawing are presented as Figures 3 through 5.

For the purposes of this work plan the S1 unit is the only pertinent unit as this is the aquifer that is targeted for ISCO. Sand unit S1 is the uppermost continuous water-bearing unit, and consists primarily of sand and gravel. Groundwater within the S1 unit is under confined conditions. The S1 unit is generally encountered between approximately 10 ft to 25 ft below ground surface (bgs) (816 to 801 ft AMSL), and ranges in thickness from 1 ft near the southeastern margins of the investigated area to 35 ft near the center of the former operations area. Underlying the S1 unit is a hard clay (till), which has an approximate range in thickness of 10 to 40 ft.

The potentiometric surface of the S1 unit on-Site ranges from 814.92 to 814.27ft AMSL as illustrated in Figure 6. The potentiometric surface map suggests that groundwater within the S1 unit flows to the southeast toward Wildcat Creek.

2.2 Constituent Distribution

ARCADIS performed a RCRA Facility Investigation (RFI) at the Site which delineated the horizontal and vertical distribution of cVOCs at the Site. Results of the investigation are summarized in the RFI Report that was submitted to the United States Environmental Protection Agency (USEPA) in 2009. The data from this investigation showed the highest cVOC concentrations on-Site were contained in the S1 unit in the vicinity of MW-0620-S1-S1 and MW-0101-S1U while off-Site impacts were highest in the vicinity of MW-0612-S1 and MW-0606-S1. Dissolved TCE concentrations across the Site have been observed to be highest towards the top of the groundwater table, and generally decrease with increasing depth.

3. Pilot Test Details

The pilot test will be implemented in the vicinity of monitoring wells MW-0620-S1 and MW-0622-S1. Figure 2 illustrates the proposed location of the injection well, dose response wells, and downgradient monitoring wells.

3.1 Well Network

3.1.1 Injection Well

One injection well will be installed at the Site, approximately ten feet hydraulically upgradient of MW-0620-S1. The exact locations may be adjusted in the field to accommodate for utilities and Site features. The location of this injection well is designed to target the elevated TCE concentrations detected in the vicinity of monitoring well MW-0620-S1. Injection well construction details are included in Section 3.3.

3.1.2 Dose Response Wells

The target radius of influence (ROI) for each injection well is 10 feet. Two wells will be utilized for dose response inside this ROI. Existing monitoring well MW-0620-S1 will be used as a dose response well 10 feet downgradient of the injection well location. Additionally, a second dose response well will be installed approximately 5 feet in the side gradient direction from the injection well. These dose response wells will be utilized to monitor the relationship between injection volume and ROI during the injection event. Both dose response wells will be used during the pilot test to determine the mobile porosity of the subsurface. This information will be used to optimize the injection volume and oxidant strength utilized during full scale implementation.

3.1.3 Performance Monitoring Wells

The proposed performance monitoring wells will be located such that the movement of the oxidant, both vertically and horizontally, can be closely tracked. Three monitoring wells will be used to characterize the downgradient oxidant performance. Using an estimated groundwater velocity of one foot per day, a nested set of two monitoring wells will be installed approximately 40 ft downgradient (40-day travel time) from the injection point (Figure 2) in the upper and lower portions of the S1 unit. The installation of these two wells will allow for adequate vertical profiling of the reagent distribution and observation of the lower portion of the aquifer in the event that density driven flow is observed and the reagent dives to the bottom of the S1 unit. In addition to these two monitoring wells, performance monitoring samples will be collected from MW-0620-S1 to observe the decrease in reagent concentration as upgradient groundwater flows through the injected area. Additionally, the performance monitoring samples help to characterize the oxidant dilution at the leading margin of the oxidant reagent. These data will also provide important information about the longevity of the injected solution and assist in determining injection frequency.

3.2 Utility Clearance

Proposed well locations are dependent on proper utility clearance, and may be adjusted in order to avoid underground or overhead utilities. At a minimum, ARCADIS will clear subsurface utilities by completing the following:

- Contacting the One Call service no more than seven days and at least 48 hours prior to beginning field activities to provide markings for public utilities,
- Hiring a private utility locator to locate all private utilities on Site prior to subsurface work, and
- Hand auguring to a depth of five feet at each well location.

3.3 Well Installation, Construction, and Development

After hand auguring through the top five feet of soil, dose response and performance monitoring wells will be installed by a well driller licensed in the State of Indiana using a hollow stem auger or sonic drill rig. Soil samples will be collected from well screen intervals and submitted for sieve analysis to refine the well design for sand pack and screen slot size for the full scale implementation. The dose response well screen will be installed in the upper 10 feet of the S1 aquifer. As stated above, two monitoring wells will be installed at a downgradient location order to monitor the performance of the oxidant in both the upper and lower portions of the S1 unit. The installation of these nested wells will allow for adequate vertical profiling of the reagent distribution and observation of the lower portion of the aquifer in the event that density driven flow is observed and the reagent dives to the bottom of the S1 unit. The upper performance monitoring well will be constructed as an injection well as detailed below. This will allow the upper S1 unit performance monitoring point to be utilized during the full-scale implementation as an injection point. The upper performance monitoring well will be installed with a 10 foot screen to monitor the upper ten feet of the S1 unit and the lower performance monitoring well will be installed with a15 foot screen to monitor the underlying 10 through 25 foot interval of the S1 unit. The lower performance monitoring well and the dose response well will be installed using PVC well materials and according to the Field Method Guideline presented in the RFI Work Plan (ARCADIS, December 15, 2005).

To prevent short-circuiting or “daylighting” of injected solution, injection wells will be constructed using the ARCADIS Standard Operating Procedure (SOP) for injection well installation found in Appendix A. The injection wells will have a two-inch diameter and 10 foot long stainless steel, vee-wire wrapped screen with a PVC casing running to the surface. Vee-wire screens will be used because they possess more open surface area than standard slotted screens, facilitating faster injection rates, better distribution, and lower injection velocities. Stainless steel well screen material is also required to ensure material compatibility with the chemical oxidant. A coarse sand pack will be installed from the bottom of the well to one foot above the top of the screen. Two feet of fine choker sand will be placed above the coarse sand pack to separate the sand

pack from the well seal. The remainder of the well annulus will be sealed with cement grout (no bentonite). New wells will be developed after at least 24 hours of installation to allow the grout to adequately cure.

3.3.1 Decontamination

All down-hole equipment will be decontaminated after use. All drilling and sampling materials that come into contact with subsurface soil and groundwater will be washed after each well is installed using a high-pressure washer and a wiper. Potable water will used for decontamination will come from an onsite potable water source free of contamination (e.g. city fire hydrant).

3.3.2 Investigation Derived Waste Disposal

ARCADIS will containerize and profile all investigation derived waste (IDW). Containerized IDW will be stored on site in sealed drums until proper disposal. Waste disposal will follow applicable regulations.

3.4 Well Surveying

An Indiana-licensed surveyor will survey the horizontal location to Indiana State Plane coordinates and vertical elevation for each well location. Ground elevations will be surveyed to an accuracy of +/- 0.01 foot.

4. Baseline Sampling

Baseline (pre-injection) samples will be collected from the injection well, dose response wells, and performance monitoring wells to understand the subsurface conditions present at the Site prior to the pilot injection. Groundwater samples will be collected using a low flow/low stress sampling method and submitted for analysis to Pace Analytical Services, Inc. in Indianapolis, Indiana for the following parameters:

- VOCs – USEPA SW-8260
- Alkalinity – SM 2320B
- Total Metals (Na, Mn) – USEPA SW-6010
- Dissolved Metals (Na, Mn) – USEPA SW-6010

Field parameters (pH, dissolved oxygen, oxidation-reduction potential, specific conductivity, temperature, and color) and groundwater elevations will also be collected during the baseline sampling event.

5. ISCO Injection

5.1 Health and Safety

The Site-specific Health and Safety Plan will be updated to include hazards and controls associated with handling and injecting sodium permanganate into the subsurface.

5.2 Injection Design

The injection volume required to distribute the oxidant solution to the full design ROI is calculated based upon the aquifer mobile porosity and treated aquifer thickness, using the following equation:

$$V = \pi * r2 * h * \theta m * 7.48$$

Where:

r, targeted ROI = 10-20 feet;

θm , estimated mobile porosity = 15%; and

h, injection well screen interval = 10 feet

Using this equation, the estimated target injection volume for the injection event is 3,500 gallons with a ROI of 10 feet . The actual volume required to reach the target ROI, however, can vary significantly due to the variability of site-specific mobile porosity and thickness of the S1 unit, therefore the actual required injected volume will be verified during the injection event using the dose response wells, and modified as necessary.

The permanganate oxidant concentration in the injection solution has been selected to provide thorough treatment of the cVOCs in the target area. Typical injection concentrations for sodium permanganate range from 2% to 10%. Based on the high concentrations of cVOCs in groundwater and the limited potential for density driven flow (i.e., denser than water oxidant solution to sink below the target treatment interval), a 10% solution will be utilized for the pilot injection.

Injection and post-injection monitoring will evaluate the vertical and horizontal migration of the injection solution as well as the treatment within the injection well ROI and downgradient. It is expected that the oxidant will persist at a high enough concentration to provide treatment 10-20 feet horizontally and downgradient from the injection well. Information gathered regarding oxidant solution migration, oxidant persistence, and oxidant solution effectiveness at degrading Site impacts will all be used to further optimize the solution strength during full scale implementation.

5.3 Injection Set Up

Prior to the injection event, applicable health and safety measures will be in place, including appropriate personal protective equipment (PPE) and secondary containment. PPE for sodium permanganate injection activities will include a Tychem® suit (or equivalent), inner nitrile gloves, outer rubber gloves, chemical resistant boots, full-face shield, and chemical apron. An eye wash station, safety shower (or equivalent) will be located onsite during field activities. Proper functioning of the equipment will be confirmed each day prior to commencement of field activities. In addition, spill kits, a potable water supply for diluting or washing down a small release, and a neutralizing solution will be available in spray bottles during injections in the event of a small spill or dermal contact. Field staff will review the Site specific health and safety plan, including the material safety data sheet (MSDS) for sodium permanganate and job safety analyses (JSAs) for ISCO and tracer injections (Appendix A). These documents will be discussed as a part of daily tailgate safety meetings.

Clean water will be run through the injection system to ensure that it is free of leaks prior to injection of the sodium permanganate. Injection activities will commence after it is confirmed that the system is leak-free.

5.4 Injection Procedures

Injection activities will begin with the mixing and injection of a sodium permanganate solution into the injection well. Sodium permanganate at a concentration of 40% will be used as the stock solution. The stock solution will be diluted with potable water to a concentration of approximately 10%. Injection into the injection well will continue until injection solution arrival is confirmed (as indicated by purple color and/or increase in conductivity) at dose response well MW-0620-S1. The volume injected will be based on the volume required to reach a 10 foot ROI for the injection well, and confirmed at the dose response well MW-0620-S1. In the event that the target injection volume is taking significantly longer than anticipated to reach the 10 foot ROI, the dose response well 5 feet side-gradient from the injection point will be used and the injection will be terminated once the 5 foot ROI is reached.

The injection well will be fitted with a bleed valve and pressure gauge to ensure that minimal wellhead pressure is applied. Over-pressurization of the well could result in failure of the well and/or fracture of the subsurface formation, which could create preferential pathways away from the target treatment interval or cause surfacing of the injection solution. If the injection rate is too fast, injection solution will discharge out of the bleed valve providing a visual indication that the pumping rate should be reduced. A 5-gallon bucket (or equivalent) will be placed at the injection well to contain any discharges from the bleed valve.

If possible, injections will be completed under gravity feed, although an injection pump may be added to offset frictional losses in the injection lines and manifolds and to increase flow to the well. The anticipated

injection flow rate is approximately 1 gallon per minute. The injection manifold will be equipped with a flow meter, pressure gauge, and flow control valve to monitor and control the injection flow to the well.

5.5 Injection Monitoring

Immediately prior to starting injection activities, field parameter readings (specific conductance ,pH and temperature) readings and water levels will be collected from the injection well, dose response well, MW-0620-S1 and the two nested performance monitoring wells. Additionally, the injection batch solutions will be periodically monitored for specific conductance, pH, and temperature. Dose-response monitoring will be conducted during the injection activities. The dose response well and MW-0620-S1 will be monitored for specific conductance, temperature, and water level using a dedicated water quality data logger placed at mid-screen and set to record measurements on a 1-minute frequency. A minimum of 30 minutes of background data will be collected prior to the start of the injection. Approximately once per hour, vertical profiling will be conducted during the injection to check for preferential flow paths and a bailer grab sample will be collected from the groundwater in the well column. The water quality data logger will be raised or lowered in one-foot increments across the screened interval of the dose response well. The data logger will be positioned in the interval of highest conductivity after vertical profiling is completed. When the conductivity increases or when a purple color is noted in the dose response well, a field test for measurement of sodium permanganate will be used to confirm arrival of the injected solution. Field measurement of the sodium permanganate concentration will be conducted using the HACH DR/890 kit by Method 8034, Manganese High Range. If the sample concentration is out of range for the kit, the sample will be diluted with distilled water and reanalyzed. Manual water levels at the dose response well and MW-0620 will be checked approximately once per hour to ensure that there are no substantial changes in the water table elevation during the injection.

To monitor the progress of the injection, the following parameters will be recorded approximately once per hour during the entire duration of the injection event:

- Flow totalizer readings,
- Injection flow rate at the well, and
- Wellhead pressure.

Parameters will be recorded in dedicated field logs. A field book will also be maintained to record the time on site for field personnel and any notable events that occur during injection activities.

6. Post-Injection Monitoring

The permanganate ion will react with a variety of organic and inorganic constituents in the aquifer as it travels through the subsurface. As the oxidant continues to react, its concentration and capacity to degrade

the target constituents will gradually decline. Groundwater samples will be collected following completion of the injection activities to track the movement of the sodium permanganate through the aquifer during the pilot test. Groundwater samples will be collected from MW-0620-S1, MW-0605-S1 and the performance monitoring well after one well volume has been purged from the monitoring well with a dedicated bailer. Groundwater samples will also be inspected visually for a purple color that is indicative of the presence or absence of the oxidant. Groundwater samples will be analyzed for alkalinity, total and dissolved sodium and manganese, and VOCs. Post-injection sampling will commence only after the oxidant concentration has decreased to a level that will not effectively degrade the target constituents further (i.e., baseline conditions). The initial post-injection sampling event will be timed as soon as possible after a return to baseline conditions to ensure that the full effectiveness of the pilot test was quantified. The timing of the post-injection sampling may vary for the selected wells depending on the persistence of the oxidant in different areas of the Site. It will be dependent on field observations of oxidant migration and laboratory analysis. Additional VOC sampling will follow approximately one month and two months after the initial post-injection sampling to monitor for constituent rebound in the target treatment area. If the actual groundwater flow velocity varies significantly from the expected velocity, the performance monitoring event frequency will be increased or decreased to adjust for the movement of sodium permanganate through the aquifer.

Performance monitoring data will be used to determine the effectiveness of the initial injection event and to gauge the extent of constituent rebound that follows after the oxidant has dissipated in the subsurface. The data will be used in the full scale design to maximize both treatment of the Site constituents and the distribution of the oxidant solution in the subsurface. Although permanganate has proven to be effective at treating the chlorinated VOCs that are present at the Site, based on the groundwater concentrations constituent rebound is likely, requiring additional application of oxidant. Rebound results from the diffusion of dissolved phase contaminants present within the immobile pore space into the mobile pore space. The magnitude of the rebound will be dependent on the oxidant distribution and its persistence in the treatment area/interval.

7. Future Injections

The design parameters of a second injection event, including oxidant concentration and the injection solution volume, may vary from the initial design depending upon the information that is available from the first injection event.

8. Schedule

Field activities will commence within 45 days of USEPA approval of the Work Plan. The injection event is estimated to take three days. A report summarizing the injection event and performance monitoring results will be submitted within 45 days of completion of the field activities. Based on the results of the pilot test, recommendations for full scale treatment activities will be submitted under separate cover.

9. References

Scott, Robert A., July 2008. Unconsolidated Aquifer Systems of Howard County, Indiana. Division of Water, Resource Assessment Section.

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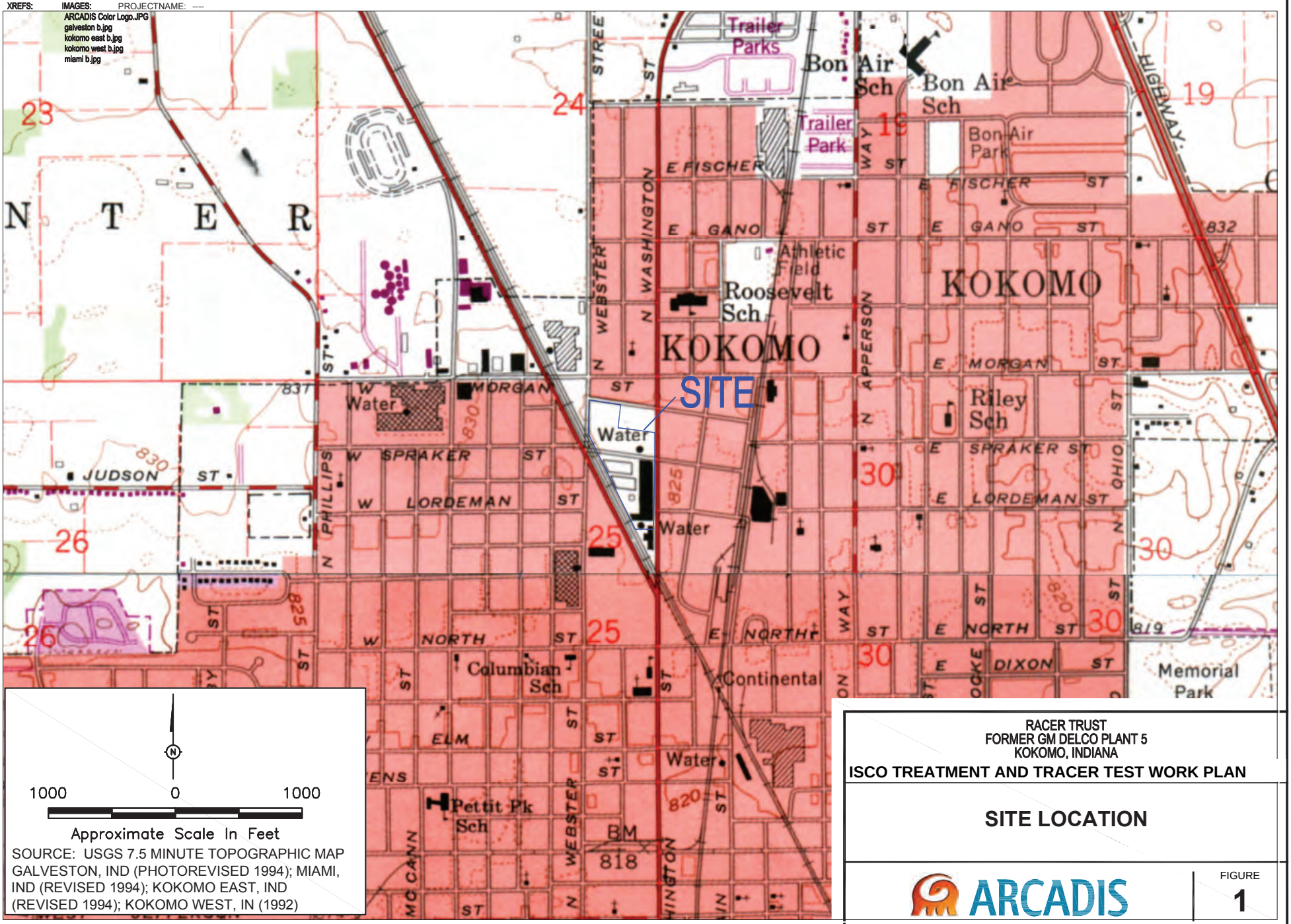

SOURCE: USGS 7.5 MINUTE TOPOGRAPHIC MAP GALVESTON, IND (PHOTOREVISED 1994); MIAMI, IND (REVISED 1994); KOKOMO EAST, IND (REVISED 1994); KOKOMO WEST, IN (1992)

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ISCO TREATMENT AND TRACER TEST WORK PLAN

SITE LOCATION

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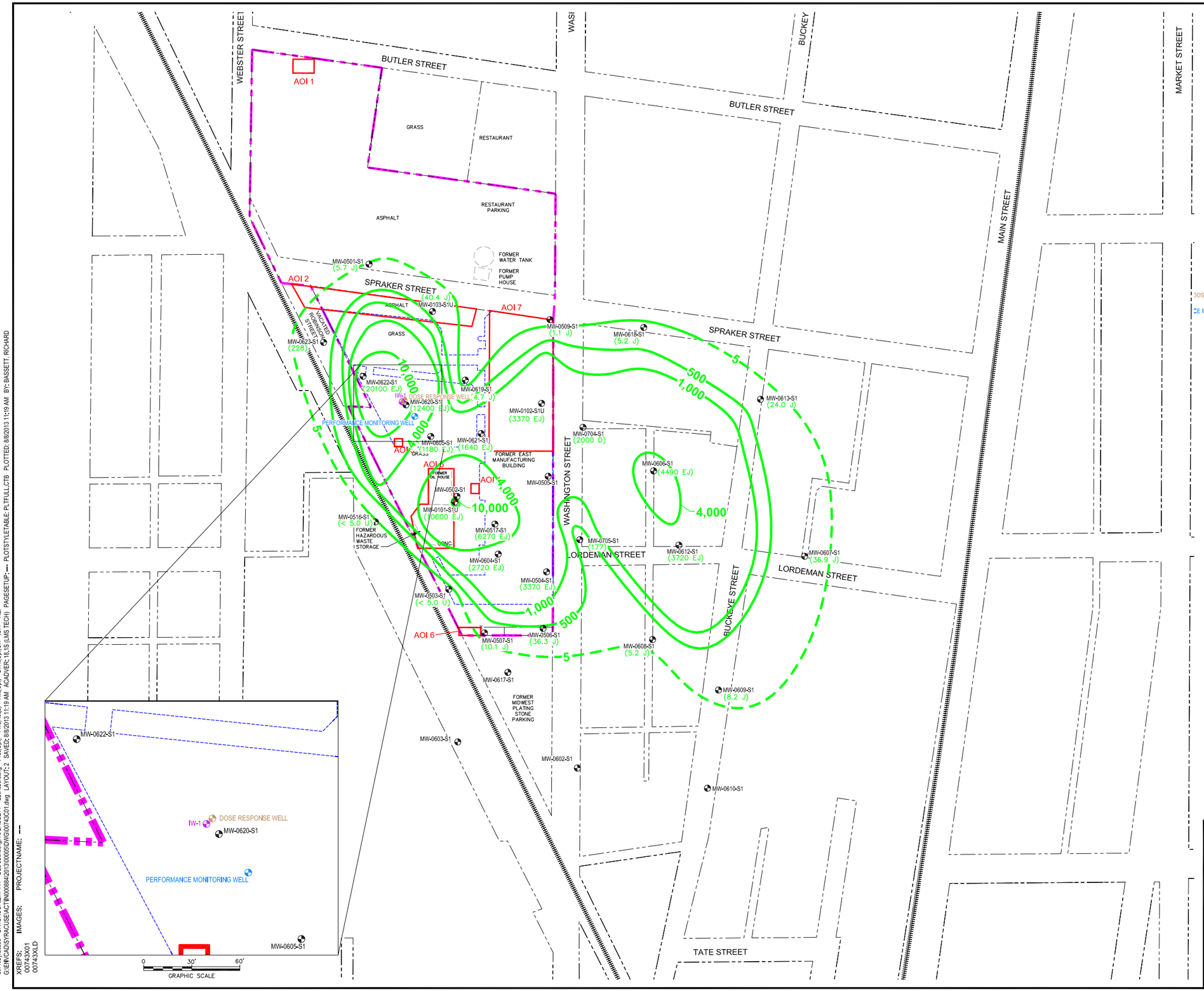
FIGURE
1



LEGEND

MW-0603-S1	MONITORING WELL SCREENED IN UNIT S1
INJECTION WELL	INJECTION WELL
DOSE RESPONSE WELL	DOSE RESPONSE WELL
PERFORMANCE MONITORING WELL	PERFORMANCE MONITORING WELL
	AOI
	PROPERTY LINE
103	TCE CONCENTRATION IN µg/L
5	ISOCONCENTRATION CONTOUR IN µg/L
E	THE COMPOUND WAS QUANTIFIED ABOVE THE CALIBRATION RANGE
J	COMPOUND POSITIVELY IDENTIFIED; HOWEVER THE ASSOCIATED NUMERICAL VALUE IS AN ESTIMATED CONCENTRATION

NOTE:

ALL SAMPLES COLLECTED VIA PASSIVE DIFFUSION BAGS

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TCE GROUNDWATER CONCENTRATION CONTOURS AND PROPOSED WELL LOCATIONS

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DRAWING
2

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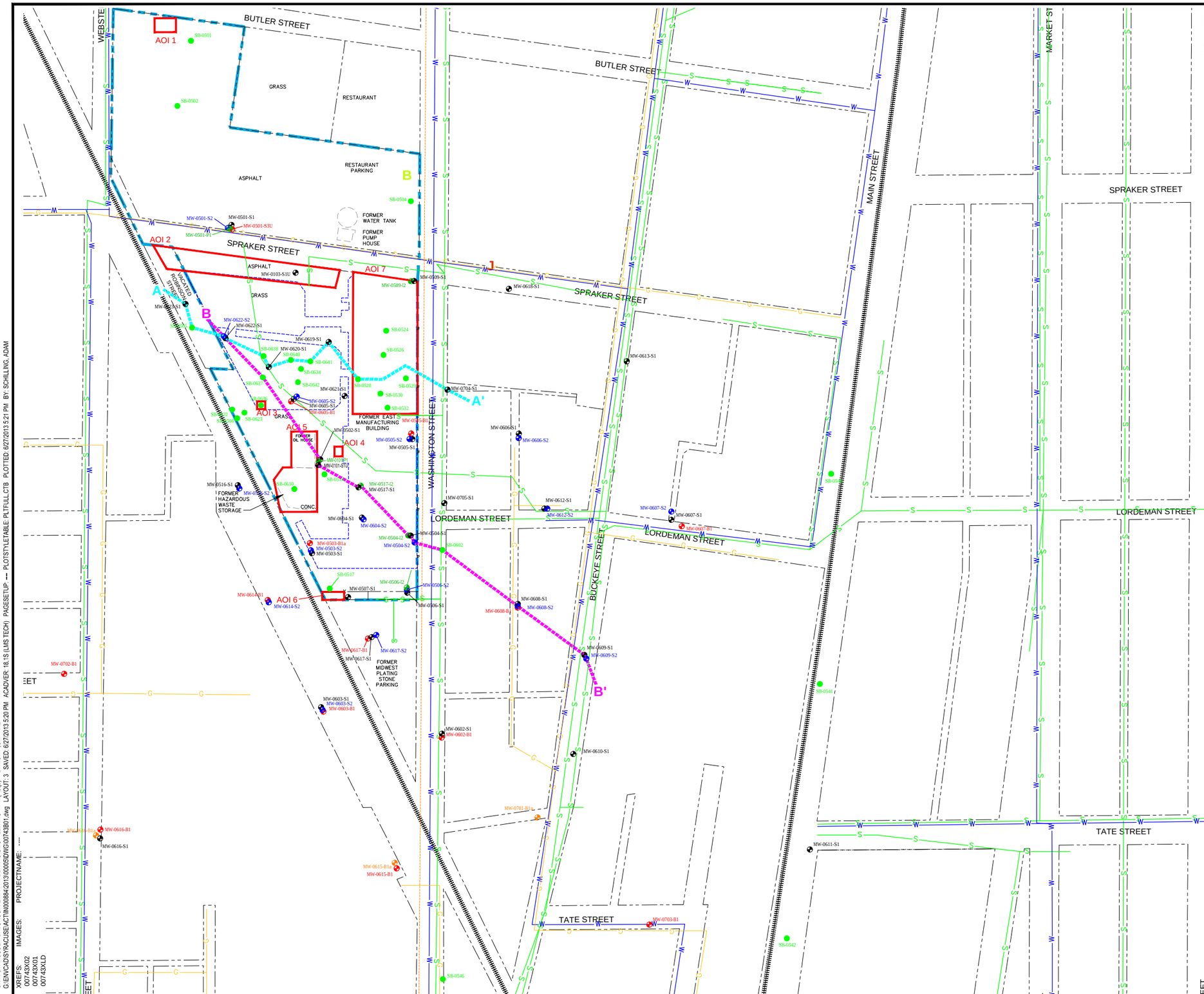

LEGEND

- MW-0501-P1 — MONITORING WELL SCREENED IN DISCONTINUOUS UNIT P1 DENOTES SCREENED INTERVAL IS IN A PERCHED ZONE ABOVE UNIT S1 I2 DENOTES SCREENED INTERVAL IS A SAND UNIT BETWEEN UNITS S1 AND S2
- MW-0603-S1 — MONITORING WELL S2 SCREENED IN UNIT S1
- MW-0603-S2 — MONITORING WELL SCREENED IN UNIT S2
- MW-0603-B1 — MONITORING WELL SCREENED IN UNIT B1. UNIT B1 REFERS TO THE UPPER-MOST TRANSMISSIVE ZONE WITHIN THE LIMESTONE BEDROCK UNIT.
- MW-0615-B1a — MONITORING WELL (B1A LOCATIONS ARE OPEN BEDROCK BOREHOLES TO A DEPTH OF APPROXIMATELY 150 FT BG CURRENTLY SEALED WITH FLUTE LINERS)
- PRE-RFI SOIL BORING LOCATIONS
- RFI SOIL BORING LOCATIONS
- S — SEWER UTILITY
- W — WATER UTILITY
- G — GAS UTILITY
- FIBER OPTIC UTILITY
- A — A' CROSS SECTION LOCATION (SECTION LINES AND TEXT COLORED AND DASHED FOR CLAIRITY)

NOTE:

UTILITY LOCATIONS ARE APPROXIMATE BASED ON REVIEW OF AVAILABLE PRINTS FROM EACH UTILITY.

0 100' 200'
GRAPHIC SCALE

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ISCO TREATMENT AND TRACER TEST WORK PLAN

CROSS SECTION REFERENCE

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DRAWING
3

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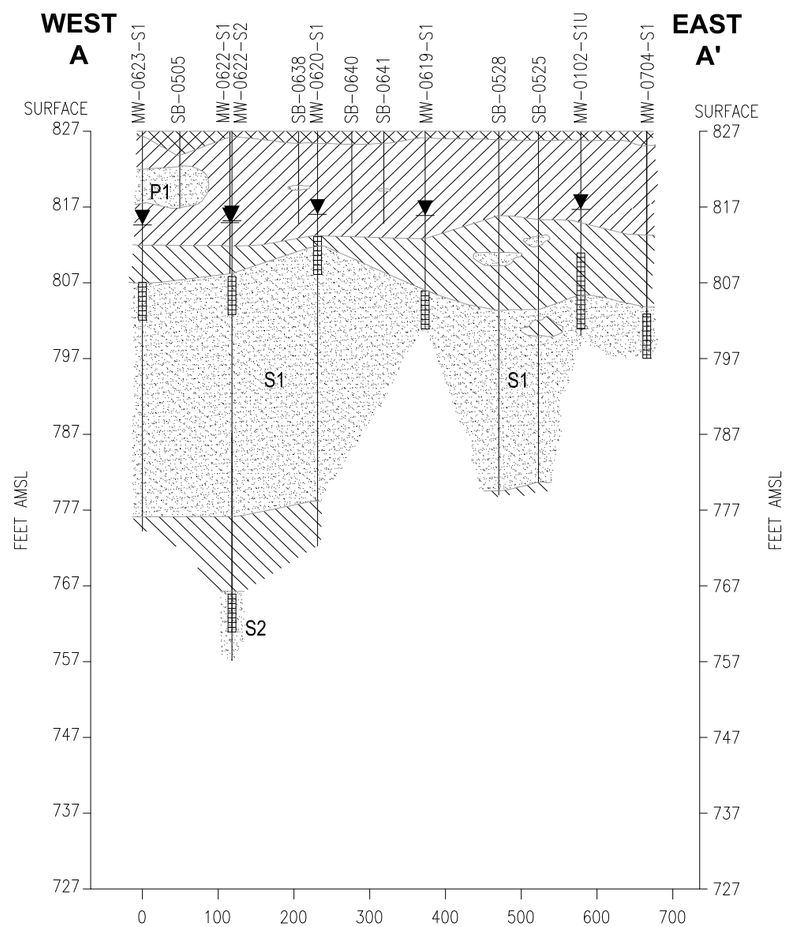

LEGEND:

- FILL/TOPSOIL/GRAVEL/ASPHALT
- PLASTIC CLAY
- SAND
- TILL
- WEATHERED BEDROCK (LIME MUD W/ LIMESTONE FRAGMENTS)
- BEDROCK (LIMESTONE)
- MONITORING WELL SCREENED INTERVAL
- S1/S2/B1 — SATURATED UNIT ID
- P1 — INDICATES DISCONTINUOUS SATURATED SAND UNIT ABOVE UNIT S1
- I2 — INDICATES DISCONTINUOUS SATURATED SAND UNIT BETWEEN UNITS S1 AND S2
- DEPTH TO WATER DATA (10/2007)

CROSS-SECTION LOCATIONS

NOT TO SCALE

0 10' 20'
VERTICAL SCALE

0 100' 200'
HORIZONTAL SCALE

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CROSS SECTION A - A'

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DRAWING
4

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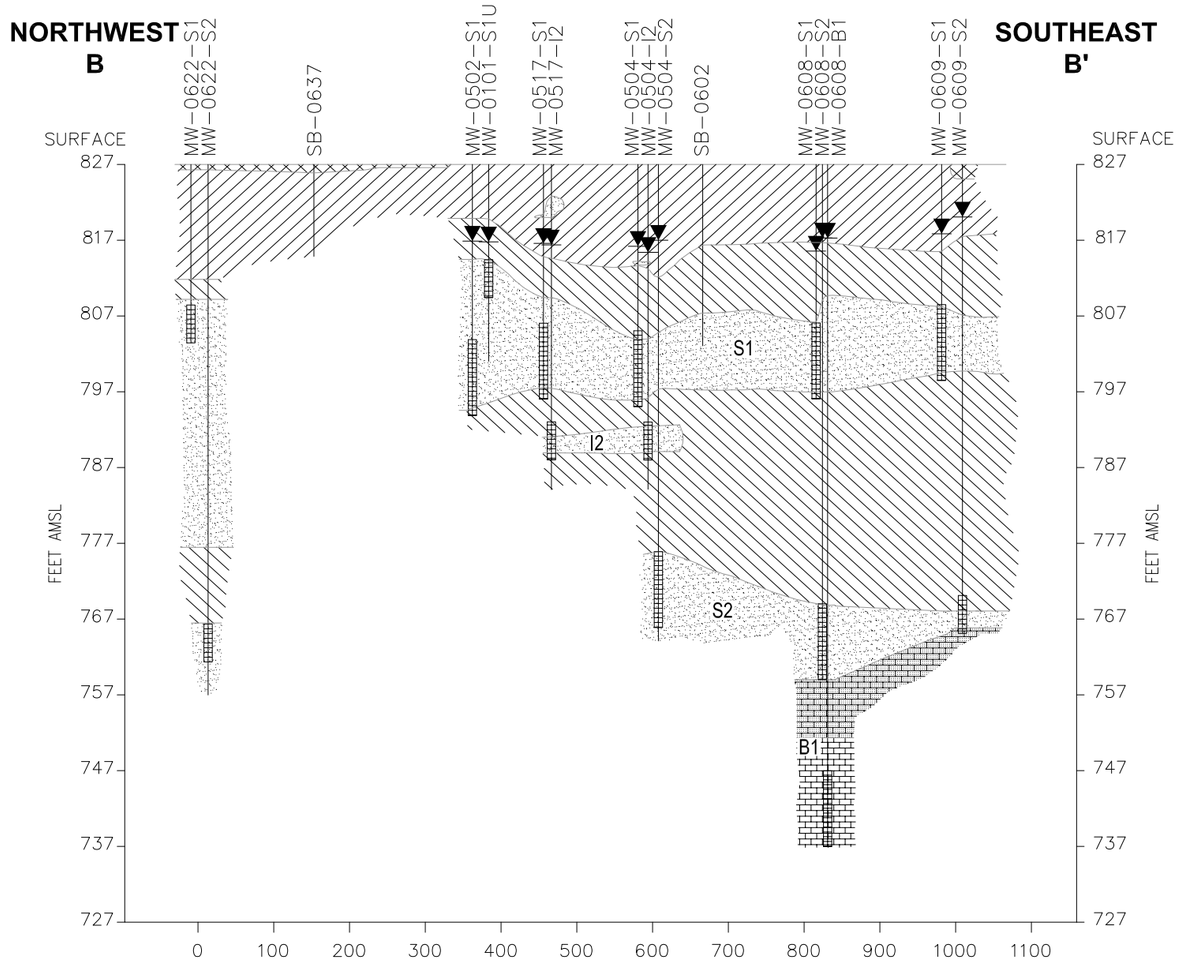

LEGEND:

- FILL/TOPSOIL/GRAVEL/ASPHALT
- PLASTIC CLAY
- SAND
- TILL
- WEATHERED BEDROCK (LIME MUD W/ LIMESTONE FRAGMENTS)
- BEDROCK (LIMESTONE)
- MONITORING WELL SCREENED INTERVAL
- S1/S2/B1 — SATURATED UNIT ID
- P1 — INDICATES DISCONTINUOUS SATURATED SAND UNIT ABOVE UNIT S1
- I2 — INDICATES DISCONTINUOUS SATURATED SAND UNIT BETWEEN UNITS S1 AND S2
- DEPTH TO WATER DATA (10/2007)

CROSS-SECTION LOCATIONS

NOT TO SCALE

0 10' 20'
VERTICAL SCALE

0 100' 200'
HORIZONTAL SCALE

RACER TRUST
FORMER GM DELCO PLANT 5
KOKOMO, INDIANA
ISCO TREATMENT AND TRACER TEST WORK PLAN

CROSS SECTION B - B'

ARCADIS

DRAWING
5

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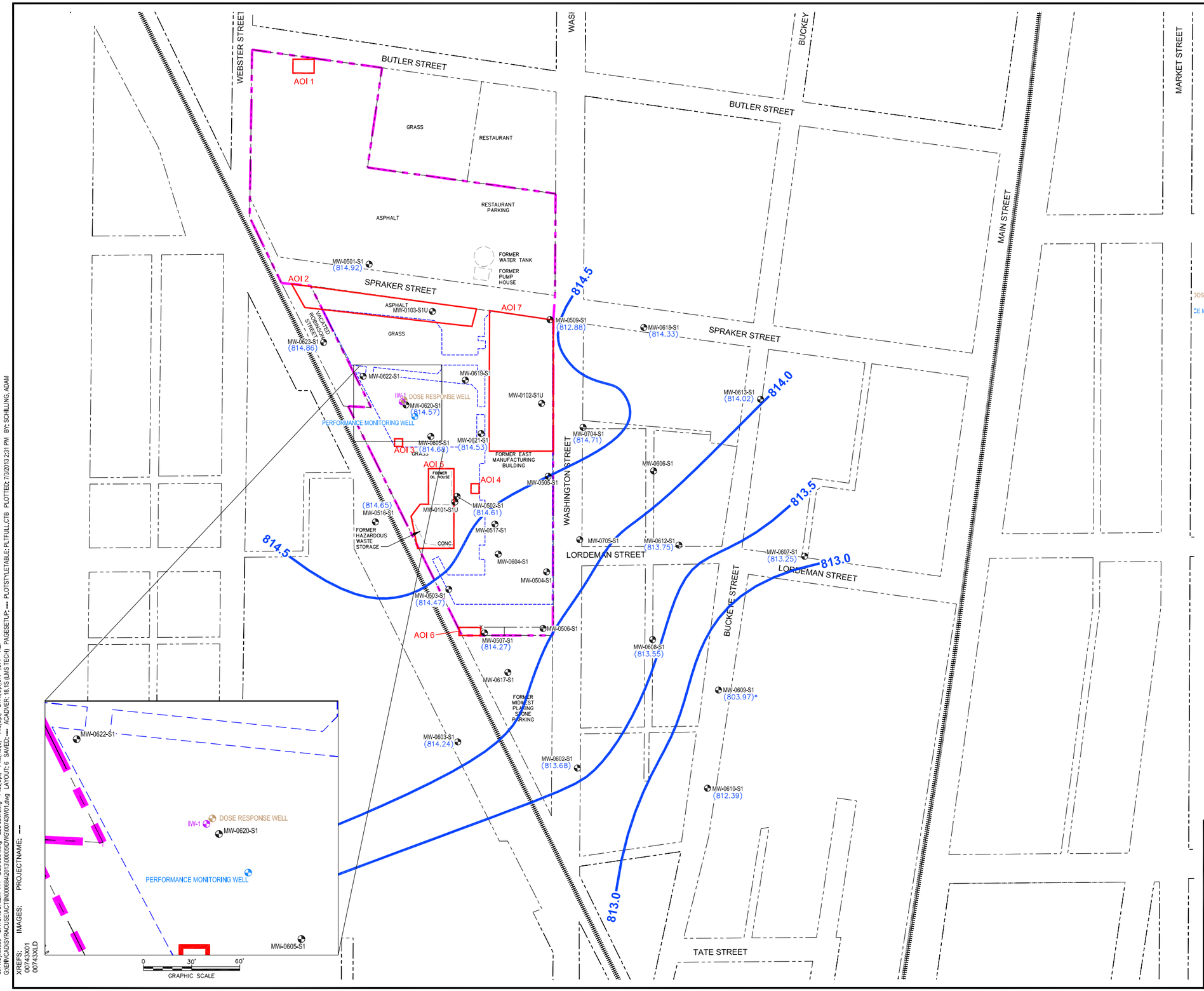

RACER TRUST
FORMER GM DELCO PLANT 5
KOKOMO, INDIANA

ISCO TREATMENT AND TRACER TEST WORK PLAN

POTENTIOMETRIC SURFACE - UNIT S1 (MARCH 12, 2013)

ARCADIS

DRAWING **6**

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