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APPROVED

Supplemental Investigation Work Plan for the Former Refinery at Neodesha, Kansas

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Table of Contents

Executive Summary **1**
1 Introduction **1-1**

1.1 Rationale 1-1
1.2 Scope of Work 1-1

2 Investigation Methods **2-1**

2.1 Health and Safety 2-1
2.2 Property Ownership and Access 2-1
2.3 Mobilization 2-2
2.4 Underground Utility Locate 2-2
2.5 Advancing Laser Induced Fluorescence (LIF) Borings 2-2
2.6 Monitoring Well Installation 2-3
2.7 Well Development 2-3
2.8 Well Abandonment 2-3
2.9 Analytical Sampling 2-4

2.9.1 Soil Sampling 2-4
2.9.2 NAPL and Groundwater Sampling 2-4

2.10 Quality assurance/quality control 2-4
2.11 Equipment Decontamination 2-5
2.12 Investigation-Derived Waste Management 2-5
2.13 Surveying 2-5

3 Soil Investigation **3-1**

3.1 LIF Boring Locations 3-1
3.2 Monitoring Well Locations 3-1

3.2.1 Former Process Areas 3-1
3.2.2 Former Product Storage Areas 3-1
3.2.3 Former Crude Storage Areas 3-1
3.2.4 Former Water Treatment Areas 3-2
3.2.5 Former Cooling Tower Areas 3-2
3.2.6 Former Maintenance Facilities 3-2
3.2.7 Former Material Storage Areas 3-2
3.2.8 Former Non-Operational Areas 3-2
3.2.9 Former Separator Pond Area 3-2
3.2.10 Former South Settling Basins 3-3
3.2.11 Off-site Areas 3-3

4 Schedule **4-1**
5 Data Evaluation and Reporting **5-1**
6 References **6-1**

List of Tables

Table 1 Soil Analytical Parameters

List of Figures

Figure 1 Site Map
Figure 2 Proposed LIF Boring Locations
Figure 3 Proposed Monitoring Well Locations
Figure 4 Proposed Monitoring Well Locations for South Settling Basins
Figure 5 Proposed LIF Borings and Monitoring Well Locations with Historic Aerial Photo
Figure 6 Proposed LIF Borings and Monitoring Well Location with Former Production Areas
Figure 7 Proposed LIF Borings and Monitoring Well Location with Property Ownership

List of Appendices

Appendix A Standard Operation Procedure: Direct-Push/Direct Sensing Investigations

List of Acronyms

ASTM	American Society for Testing and Materials
BP	BP Products North America, Inc.
BTEX	benzene, ethylbenzene, toluene, and xylenes
CAS	Corrective Action Study
COW	Control of Work
CPT	cone petrometer tool
DPT	direct-push technology
DRO	diesel range organics
ETBE	ethyl *tert*-butyl ether
GC	gas chromatography
GRO	gasoline range organics
HASP	Health and Safety Plan
HSSE	health, safety, security, and environment
KDHE	Kansas Department of Health and Environment
LNAPL	light non-aqueous phase liquid
LIF	laser induced fluorescence
MOC	Management of Change
MTBE	methyl *tert*-butyl ether
NAPL	non-aqueous phase liquid
OSHA	Occupational Safety and Health Administration
PAH	polyaromatic hydrocarbons
PID	photoionization detector
PPE	personal protective equipment
PQLs	practical quantitation limits
PVC	Polyvinyl chloride
QAPP	Quality Assurance Project Plan
QA/QC	quality assurance/quality control
RCRA	Resource Concervation and Recovery Act
SIMOPS	simutanous operations
SOP	Standard Operating Procedure
STP	Standard Technical Practice
TAME	*tert*-amyl methyl ether
TBA	*tert*-amyl methyl ether
TSEA	Task Safety and Environmental Analysis
TPH	total petroleum hydrocarbons
USEPA	United States Environmental Protection Agency
UV	ultraviolet
VOCs	volatile organic compounds
WRAT	Work Risk Assemsent Tool

Executive Summary

This report describes the proposed supplemental soil investigation that AECOM, on behalf of BP Products North America, Inc. (BP), will be implementing in 2013. Previously, BP has completed environmental assessments of soil and groundwater conditions associated with the Former Amoco Refinery (Site), located in Neodesha, Kansas (Figure 1, Site Map). These assessments document groundwater contamination caused by oil byproducts beneath the Site, as well as in an off-site area east of the former refinery property, and potential remedies to address the contamination through a Corrective Action Study (CAS) (BP, 2005). The environmental assessments conducted to date have provided information on soil, groundwater, surface water, sediment and air quality; however, BP and Kansas Department of Health and Environment (KDHE) (2008) have agreed that additional sampling is required to fill data gaps to complete the CAS. This work plan focuses on filling data gaps for subsurface soil, Light Non-Aqueous Phase Liquid (LNAPL), and groundwater within the former refinery property and off-site.

The Site is located in Neodesha, Kansas. Neodesha is approximately 20 miles north of Independence, Kansas and approximately 100 miles north of Tulsa, Oklahoma. The site is located in Wilson County, Kansas in portions of the SE ¼ of Section 18, NE ¼ of Section 19, and NE ¼ of Section 30, Township 30 South, Range 16 East. The location of the former refinery in relation to the city of Neodesha is shown on Figure 1.

1 Introduction

1.1 Rationale

Proposed sample locations were selected from areas corresponding to specific facilities and process areas of the former refinery. The number and location of soil borings were selected to evaluate the extent and magnitude of refinery-related impacts. The evaluation and selection of sampling locations included:

- Review of former refinery records to identify process locations and constituents of concern;
- Examination of historic aerial photographs to identify potential surface soil staining;
- Examination of land ownership, building locations, and site access;
- Determination of current zoning;
- Examination of current land use and existing facilities; and
- Review of previous soil boring and well log information to identify potential data gaps.

1.2 Scope of Work

To meet the objectives efficiently, the subsurface soil investigation will be conducted in two parts. First, a preliminary investigation will be conducted where laser induced fluorescence (LIF) methods will be utilized for evaluating the presence of LNAPL and its potential migration pathways in the subsurface. LIF borings are planned for the area of, and east of, the Former Tank Site, the area south of the Former Tank Site and north of the rail yard, and in a portion of the residential area (Figure 2). The data obtained during the LIF portion of the investigation may result in the relocation or addition of proposed monitoring well locations. The LIF borings will be logged via an inline cone petrometer tool (CPT), if available, and no soil samples will be collected for analysis. The LIF investigation is further described in Section 2.4.

Once the findings of the preliminary investigation are reviewed, a hollow-stem auger will be utilized for the installation of 30 monitoring wells. The monitoring wells will be located in historical refinery storage and operations areas, areas where data gaps have been identified, and areas identified in the 2006 plaintiff subsurface investigation that require further assessment. Soil samples will be collected from each monitoring well boring during drilling operations and submitted for analysis. The monitoring wells will be developed via surge block and submersible pump. Groundwater samples will be collected from the new monitoring wells during the following semiannual groundwater sampling event. LNAPL, if present, will be collected from the monitoring wells and submitted for analysis.

In addition to the installation and construction of the new monitoring wells, monitoring well MW-40, located in the southern portion of the industrial park, will be abandoned. MW-40 is screened within the bedrock; however, the filter pack extends two feet into the overburden allowing water from the overburden to come into contact with that from the bedrock. Therefore, MW-40 cannot exclusively monitor the groundwater in either bedrock or the overburden.
All work will be performed in accordance with AECOM Standard Operating Procedures (SOPs) located in the Quality Assurance Project Plan (QAPP) (ENSR 2008).

2 Investigation Methods

This section presents the field sampling and laboratory analytical methods. It includes descriptions of all relevant field tasks including sampling equipment and procedures, laboratory analytical methods, quality assurance and quality control, equipment decontamination, and surveying.

2.1 Health and Safety

AECOM will manage the work so that BP's expectations that there be '**no accidents, no harm to people and no damage to the environment**' throughout the execution of the Project. To achieve this, the Site will be required to operate in accordance with the elements of BP's Health, Safety, Security, and Environment (HSSE) Management System Framework, and in accordance with the AECOM HSSE Management System. At a minimum, the work crews will:

- ensure a Site-specific Health, Safety, Security and Environmental Plan (HASP), and associated Work Risk Assessment (WRA) is prepared in compliance with RM's Health and Safety Plan (HASP) Defined Practice and Work Risk Assessment Defined Practice;
- ensure that BP's Control of Work (COW) processes are implemented and that identified persons on Site are held accountable for delivery;
- undertake regular Site safety meetings and participate in pre and post daily toolbox meetings;
- ensure all workers on Site are inducted and all relevant safety compliance obligations are satisfied;
- ensure that workers are properly trained to conduct the proposed activities, and will have, at a minimum Occupational Safety and Health Administration (OSHA) 40-hour training certificate and/or OSHA 8-hour refresher training certificate.

In general, HSSE-COW practices and Standard Technical Practices (STPs) to be followed during the Execute Stage of this project include, but may not be limited to: Work Risk Assessment (Work Risk Assessment Tool (WRAT) & Task Safety Environmental Analysis (TSEA)), HASP and Emergency Response Plan, Permit to Work, Management of Change (MOC), Daily Toolbox Meeting, Driving Safety, simultaneous operations (SIMOPS), personal protection equipment (PPE), and Stop Work Authority.

Currently, no special site security needs have been identified, but will be evaluated and revised during the task assessment portion of the remediation work plan and prior to the commencement of field activities.

Additional health and safety issues related to investigative activities at the site include, but may not be limited to the following:

- Appropriate material handling procedures for boring and well installation and development;
- Safety procedures for conducting field activities in high traffic areas where wells may be placed in city right-of-way;
- Safety procedures related to specific protocols developed for well installation, development, and sampling.

2.2 Property Ownership and Access

Prior to mobilization, private landowners will be contacted to request permission for access to their property. Written access agreements will be executed prior to sampling. If permission for access cannot be obtained, the field investigation leader may modify sampling locations. If a significant change in location is required, BP will consult with

KDHE. Current landowners of the property which housed the former refinery include the City of Neodesha, Watco (formerly Millennium Rail), Williams Pipeline, John Floyd, Chris Tinsley, Robert Rohde, Airosol, Cobalt Boats, Neodesha Plastics, Sands Tool & Level, and New Beginnings.

2.3 Mobilization

The mobilization point and field operations base for the soil investigation is the BP remediation building located at 1100 North 12th Street in Neodesha, Kansas. A decontamination zone for vehicles and equipment, and a staging area for containerized investigation residuals (e.g., trash, drill cuttings, decontamination fluids) will be established in the area west of the remediation building.

2.4 Underground Utility Locate

Prior to beginning any intrusive soil sampling activities, buried utilities will be located and marked in the area being investigated with assistance from the Kansas One-Call System and a third-party utility locate service. City of Neodesha personnel and/or private landowners familiar with the site may also be interviewed regarding the presence of buried utilities. Available historic and current site maps will also be reviewed to locate known utilities.

2.5 Advancing Laser Induced Fluorescence (LIF) Borings

LIF uses pulsed ultraviolet (UV) light from a laser to excite the fluorescence of aromatic hydrocarbons found in LNAPL. Aromatic hydrocarbons fluoresce at characteristic wavelengths. Low molecular weight aromatic hydrocarbons such as benzene fluoresce at shorter wavelengths whereas high molecular weight aromatic hydrocarbons fluoresce at longer wavelengths. Consequently, the composition of the LNAPL can be estimated by measuring the wavelengths over which it fluoresces. LIF measures the wavelengths and relative intensity of the LNAPL fluorescence in soil, making it possible to identify LNAPL type (e.g., gasoline, diesel fuel, crude oil, coal tar). Since the fluorescence intensity of LNAPL measured by LIF is proportional to the LNAPL concentration in soil, it is also possible to calibrate LIF fluorescence measurements to in-situ LNAPL soil saturations.

In addition to the fluorescence intensity log generated by LIF, Cone Penetrometer Tool (CPT) data may also be collected during the investigation if the CPT tool is available in series with the LIF probe. The CPT provides a continuous log of subsurface soil lithology as well as pore water pressure and electrical conductivity of the soil. Several algorithms can be used to evaluate the sleeve friction and tip resistance data that are the basis of the lithologic interpretation.

During the investigation, 55 primary LIF borings will be advanced to depths averaging 25 feet below ground surface (bgs). Additional secondary borings may be used as step-out locations to delineate the lateral extent of the LNAPL based on field observations and evaluation of real time data. Some of these proposed locations may change based on the real-time data obtained in the field. The progression of LIF investigations will be driven by observations and data interpretation as the field work progresses. Therefore, close and frequent communication between the field staff and the technical and management team will be conducted. Specific termination depths will be selected in the field based on factors such as real-time LIF response, site geology, and groundwater elevations. As a general rule, all borings should be completed to a minimum of 5 feet below LNAPL LIF intensities, or to refusal.

A map of preliminary LIF boring locations is attached as Figure 2. These locations are based on historical data including an area's historical use, soil boring logs, and the detection of LNAPL in monitoring wells. The following criteria were used to select the initial locations:

1. Include locations over a sufficient area to verify the lateral extent of LNAPL distribution, if detected.

2. Where possible, approximate an x-y grid pattern on as small a spacing as practical to provide improved resolution of the likely heterogeneous LNAPL distribution.

3. Include LIF locations immediately adjacent to representative existing monitoring wells with measurable LNAPL thickness. These borings will be located as close to the existing monitoring wells as possible

(normally less than 8 feet) without compromising or damaging the monitoring well. The data from these LIF borings are used in calibrating the fluorescence intensity to the LNAPL saturation.

4. Include clean locations to demonstrate complete lateral delineation and to evaluate background fluorescence effects. If possible, provide a clean soil/clean groundwater and clean soil/impacted groundwater location to help differentiate the fluorescence response to dissolved-phase constituents.

5. Include locations in potential migration pathways.

To correlate soil types descriptions from visual logs to the data produced by the CPT and to qualitatively correlate the variability and distribution of the total petroleum hydrocarbon (TPH) saturation with the distribution produced by the LIF tool, traditional soil boring will be installed adjacent to (within 10 feet) 10 percent of the proposed primary LIF borings. In addition, two undisturbed soil cores will be collected adjacent to LIF locations to compare the visual distribution of LNAPL as well as measure the capillary properties over which the LNAPL is distributed. The locations of the traditional soil borings and undisturbed soil cores will be determined during the LIF investigation and may be advanced as part of the monitoring well installation activities.

The LIF borings will be abandoned in accordance with the Kansas Department of Health and Environment's (KDHE) boring abandonment requirements by plugging them with hydrated bentonite chips from the bottom of the boring to three feet bgs. The boreholes will be completed with a similar material of the area directly adjacent to the borehole (i.e. asphalt, concrete, clean soil). Hydrocarbon impacted soil will not be utilized in the abandonment of the boreholes.

2.6 Monitoring Well Installation

AECOM plans on advancing 30 monitoring well borings to bedrock by utilizing a hollow-stem auger drill rig. The location of the proposed monitoring wells is discussed in Section 4.2 of this report. Field personnel will log the soil profile and collect headspace measurements with a photo ionization detector with a 10.7 mV lamp. . All wells will be installed to meet the specifications of the KDHE Article 30, "Water Well Contractor's License; Water Well Construction," effective September 28, 1993.

The 30 monitoring wells will be constructed of 2-inch diameter PVC with 5 to 15 feet of 0.02-inch slot screen. All wells will be constructed so that their screen is completed across the historic high and low groundwater elevation to allow for the detection of non-aqueous phase liquid (NAPL), if present. A filter pack consisting of 10/20 silica sand will be placed for the bottom of the boring to two feet above the screen. Three feet of hydrated bentonite chips will be placed over the sand pack to act as a seal. The remaining annulus will be filled with hydrated bentonite chips or bentonite grout. The monitoring wells will be completed as either a flush mount or above grade, depending on the surrounding area of each well. A well waiver will be obtained from KDHE for any flush mounted wells installed.

2.7 Well Development

Following installation, the monitoring wells will be developed with a surge block and submersible pump, in accordance with ASTM D 5521–94, "Standard Guide for Development of Ground-Water Monitoring Wells in Granular Aquifers." Water will be recovered from each well until the discharge water is free of sediment. The recovered groundwater will be processed at the wastewater treatment facility operated by BP as part of the ongoing groundwater remediation activities.

2.8 Well Abandonment

In addition to the installation and construction of the new monitoring wells, AECOM proposes to abandon monitoring well MW-40, located in the southern portion of the industrial park, and identified on Figure 3. MW-40 was constructed to monitor the groundwater in bedrock and, while the well is screened within the bedrock, the filter pack extends 2 feet into the overburden allowing water from the overburden to come into contact with that from the bedrock. Therefore, MW-40 cannot exclusively monitor the groundwater in either bedrock or the overburden. MW-40 will be abandoned by either pulling the PVC casing out of the boring or cutting off and removing the top three feet of the PVC casing. The

well will then be grouted via tremie pipe or hydrated bentonite chips. The boring will be completed with a similar material of the area directly adjacent to the borehole (i.e. asphalt, concrete, clean soil). Hydrocarbon impacted soil will not be utilized in the abandonment of the well.

2.9 Analytical Sampling

2.9.1 Soil Sampling

Soil borings advanced during the LIF portion of the investigation will be logged via an inline CPT, if available. No soil samples will be submitted for laboratory analysis during this effort.

Headspace measurements will be collected at all monitoring well boring locations via a PID with a 10.7 mV lamp once the bagged samples has had enough time to volatilize. Analytical laboratory soil samples will be collected from the surface (0 to 6 inches) and subsurface (5 to 10 feet) at five monitoring well boring locations (Figure 3). Analyses of soil samples will include the following constituents and methods:

- Volatile organic compounds including benzene, toluene, ethylbenzene, and xylenes (BTEX), hydrocarbons, solvents and oxygenates by EPA Method 8260, collected via SW-846 Method 5035 (USEPA, 1996).
- Semivolatile organics and polyaromatic hydrocarbons (PAH) by EPA Method 8270
- TPH by EPA Method 8015M OA-1 and OA-2
- Skinner's List metals by EPA Method 6010
- pH by Method 150.1

Table 1 presents a complete list of soil analytical parameters and their respective practical quantitation limits (PQLs). Soil samples will be submitted for analysis to Pace Analytical in Lenexa, Kansas. Quality assurance/ quality control (QA/ QC) samples are discussed in Section 2.10.

2.9.2 NAPL and Groundwater Sampling

Following the completion of well installation activities, the wells will be gauged for groundwater elevations and the presence of LNAPL. If LNAPL is observed in a new monitoring well, the material will be sampled and sent to Torkelson Laboratory in Tulsa, Oklahoma for gas chromatography (GC) fingerprinting. After gauging, and if LNAPL is not observed in the well, groundwater samples will be collected at each new well for dissolved-phase constituents. Due to the estimated timing of the subject well installation effort, it is estimated that the sampling of the new wells will be part of the planned routine semiannual groundwater monitoring events. In general, well purging, sample collection, and purge water storage and discharge activities will be conducted according to the procedures typically followed during semiannual groundwater monitoring events. Groundwater quality field parameters including pH, temperature, and conductivity will be collected during well purging activities. The monitoring wells will be purged until the field parameters have stabilized, and a minimum of three well casing volumes have been removed. The groundwater samples collected from the proposed monitoring wells will be submitted for laboratory analysis of the majority of the constituents identified on USEPA Region 5's "Skinner List" (summarized on Table 1), which includes volatile organic compounds (VOCs) including benzene, ethylbenzene, toluene and xylenes (via EPA Method 8260), semivolatile organic compounds (SVOCs) including naphthalene (via EPA Method 8270), and dissolved and total metals. In addition, groundwater samples will be also analyzed for total petroleum hydrocarbons (TPH) gasoline range organics (GRO) and diesel range organics (DRO). Table 1 summarizes the complete list of analytes, their methods, and their practical quantitation limits. All samples will be stored in a cooler with ice for submittal to Pace Analytical in Lenexa, Kansas.

2.10 Quality assurance/quality control

To collect data of sufficient quality for use in characterization and risk assessment, QA/QC procedures are required. All work will be performed in accordance with the site QAPP (ENSR, 2008). All analytical data generated as part of the supplemental soil assessment will be validated. Data validation will be performed in accordance with the methods defined by the National Functional Guidelines for Organic Data Review (USEPA Contract Laboratory

Program, Revised June, 1991) and summarized in the QAPP. In accordance with the QAPP, the following QA/QC samples will be collected at the frequencies detailed below:

- Duplicate Soil Samples- one duplicate for every 20 samples collected;
- Field Blanks- one field blank for every 10 samples collected;
- Equipment blanks- one equipment blank for every 10 samples collected.

2.11 Equipment Decontamination

Decontamination will be performed on all down-hole drilling and sampling equipment between sample locations to eliminate the potential for cross contamination. Drill rods, drill bits, and other down-hole equipment will be decontaminated prior to arrival at the Site, at the site before the first sampling effort, between each borehole or sampling location, and before the equipment leaves the Site. The down-hole equipment used during drilling will be cleaned using potable water and a mild biodegradable detergent (i.e., Alconox).

Since groundwater samples will be collected using disposable/dedicated sampling equipment, decontamination is not required. However, the electronic oil/water interface probe used for fluid level gauging will be decontaminated prior to use at each proposed sample location using distilled water and lab grade isopropyl alcohol.

All decontamination water will be contained in 55-gallon drums for subsequent transport for processing at the wastewater treatment facility operated by BP as part of the ongoing groundwater remediation activities.

2.12 Investigation-Derived Waste Management

Investigation-derived waste includes soil cuttings generated during drilling activities; water generated during equipment decontamination activities, monitoring well development, and monitoring well purging activities; and personal protective equipment (PPE). Investigation-derived soil will be contained in 55-gallon drums. These drums will be transported to the treatment building for staging prior to transport to an off-site permitted waste disposal facility, pending approval and authorization. Investigation-derived water will be contained in 55-gallon drums and transported to the BP's wastewater treatment facility for staging until removed for disposal. Investigation-derived PPE will be contained in garbage bags and stored at the treatment building property for transport to the municipal landfill.

2.13 Surveying

After all field activities have been completed, the locations of soil borings new monitoring wells will be surveyed. The survey information will be used for generating maps and graphics during data evaluation and reporting.

3 Soil Investigation

This section presents the specific soil investigation plan. Figure 2 depicts the LIF boring locations and Figure 3 depicts the proposed monitoring well locations. Figure 4 has locations of the proposed monitoring wells overlaid on a historical aerial photograph of the south settling basins. Figure 5 has locations of the proposed LIF borings and monitoring wells, as well as former soil borings, overlaid on a historical aerial photograph of the operating refinery. Figure 6 has the proposed LIF borings and monitoring wells locations overlaid on former refinery use areas as well as the current buildings, roads, and railways. Figure 7 has the locations of the proposed LIF borings and monitoring wells overlaid on areas with property ownership identified. The final placement of these sampling points will be contingent on site access and other constraints that may arise in the field. The field personnel may move sample locations to resolve access and utility clearance issues, if they arise and pending confirmation from the Project Manager.

3.1 LIF Boring Locations

LIF borings are planned for the area of, and east of, the Former Tank Site, the area south of the Former Tank Site to the north of the rail yard, and a portion of the residential area (Figure 1). These LIF borings will evaluate the presence of LNAPL in an area and possible migration pathways. LIF borings locations may be moved due to field conditions. The data obtained during the LIF portion of the investigation may result in the relocation or addition of proposed monitoring well locations.

3.2 Monitoring Well Locations

In addition to the LIF investigation, AECOM plans to install 30 monitoring wells. Of the proposed monitoring wells, 15 will be located onsite and 15 will be located offsite. The number and locations of the proposed monitoring wells is subject to change due to the findings of the LIF investigation and field conditions. The onsite wells will be installed in the following areas as depicted in Figures 3 and 6.

3.2.1 Former Process Areas

The process areas for the former refinery were located in the central portion of the current industrial park as well as along the eastern boundary. Crude stills, a fluid catalytic cracking unit, an alkylation unit, an ultraformer unit, gas absorption plant, boiler and power house, loading racks and a mercapfiner unit were all located in this area. The industrial park is the current land use for this area. Sample collection will be conducted to identify potential impact from crude oil and refined products.

Previously, there were 18 soil samples and 6 monitoring wells in this area. To supplement this area and fill data gaps, four wells are proposed.

3.2.2 Former Product Storage Areas

Product was stored at the former refinery in many areas, including the southwest corner of the North Site, the former Tank Farm, the north central area of the industrial park, and the south central area of the industrial park. The product storage tanks held a variety of products including gas oil, fuel oil, cresol, naphtha, diesel, regular and premium gasoline, alkylate, and ultraformate. The current land usage of these areas is a combination of industrial, recreational, and undeveloped land.

Previously, there were 40 soil samples and 68 monitoring wells in this area. To supplement this area and fill data gaps, three wells are proposed in this area.

3.2.3 Former Crude Storage Areas

The crude oil storage area for the former refinery was located along the western portion of the tank farm area, near the current softball field. Three above ground crude oil storage tanks were located in this area. The current land usage in this area is recreational and undeveloped. The current land zoning is industrial.

Previously, there were 8 soil samples and 3 monitoring wells in this area. No monitoring wells will be installed in the crude storage area. There are no wells proposed in this area.

3.2.4 Former Water Treatment Areas

The water treatment areas of the former refinery included a water treatment facility, water storage tanks, and oil/water separator boxes. These facilities were located at various areas in the southern half of what is now the industrial park.

Previously, there were 6 soil samples and 2 monitoring wells in this area. To supplement this area and fill data gaps, one monitoring well will be installed in the water management area.

3.2.5 Former Cooling Tower Areas

The cooling towers of the former refinery were located near the center of the current industrial park. These towers cooled process water. Metal compounds including chromate solutions, were often used as scaling and microbial inhibitors in process water.

Previously, there were 6 soil samples and 1 monitoring well in this area. No monitoring wells will be installed in the cooling tower area.

3.2.6 Former Maintenance Facilities

Maintenance facilities including boiler, machine, and car shops were located along the southeastern edge of the former refinery. In addition, a sheet metal house was located in the south central portion. The current land use for all of these former facilities is classified as industrial. Maintenance facilities typically use common machine shop compounds such as solvents for cleaning parts, petroleum based machine fuels and lubricants, and metals from equipment fabrication and repair.

Previously, there were 6 soil samples and 1 monitoring well in this area. No monitoring wells are proposed in the maintenance facility area.

3.2.7 Former Material Storage Areas

Material storage was located in four areas in the southern half of the former refinery. These storage areas housed acid, pipe, and other materials used in refinery operation. All former material storage areas are located within the current industrial park.

Previously, there were 6 soil samples and 1 monitoring well in this area. No monitoring wells are proposed in the former material storage areas

3.2.8 Former Non-Operational Areas

The non-operational areas of the former refinery are scattered throughout the site. The northern half of the North Site, as well as the northern, western, and southern edges of the refinery property, are areas that contained non-operational land. The current land usage of these areas is classified as industrial and undeveloped.

Previously, there were 6 soil samples and 14 monitoring wells in this area. To supplement this area and fill data gaps, three monitoring wells are proposed.

3.2.9 Former Separator Pond Area

The separator pond area for the former refinery was located to west of the current industrial park. The pond was downstream of an oil/water separator box and acted as a secondary oil/water separator basin. The area is currently undeveloped and is overgrown with vegetation. Storm water may flow through the former pond into a small meandering drainage ditch which discharges to the Fall River.

Previously, there were 6 soil samples and 3 monitoring wells in this area. No monitoring wells will be installed in the material storage area.

3.2.10 Former South Settling Basins

The settling basins for the former refinery were located to the south of the current industrial park. There are currently no monitoring wells in this area. Four monitoring wells will be installed in the vicinity of the settling basins.

3.2.11 Off-site Areas

The off-site areas represent locations that were not on refinery property and were not owned by the refinery. Previously, there were 14 soil samples and 59 monitoring wells throughout off-site areas. Note that 16 new monitoring wells will be installed in off-site areas in addition to any wells installed as a result of the LIF investigation.

- Two monitoring wells will be installed down-gradient of the Phase 2 Trench, up-gradient of wells MW-81 and MW-62.
- Three monitoring wells will be installed north of the benzene plume near Granby and 10th St. to delineate the northern extent of contamination identified in the fall 2006 sampling of temporary probes.
- Two monitoring wells will be installed to the west of the southern portion of the industrial park and southwest of the railroad tracks to delineate the western extent of the southern plume
- Six monitoring wells will be installed east of the industrial park in the area within and south of the groundwater plume associated with the Airosol facility, as estimated by KDHE.
- One well will be installed near the southern extent of the off-site benzene plume near temporary well G-35.
- One monitoring well will be installed in the area west of the Former Tank Site.
- One monitoring well will be installed in the area south of the North Cap Site.

All proposed boring and well locations are dependent upon site access, clearance of utilities, and surface obstructions (e.g., buildings, equipment laydown areas, and railroad tracks).

4 Schedule

A schedule to implement the Soil Investigation Work Plan has been developed and is as follows:

- Fieldwork is planned to start within four weeks following KDHE review and approval of this work plan, subject to access being obtained from property owners. BP will notify the KDHE of access denials.
- The Supplemental Investigation Report is planned to be generated within three months following receipt of analytical data, and it will combine results of the LIF investigation and the monitoring well installation. Groundwater results of the new monitoring wells will be discussed as part of the semiannual groundwater report.

Groundwater sampling of the proposed monitoring wells will be conducted during the next semiannual groundwater monitoring event following their installation. The results of the sampling will be discussed in the following Semiannual Groundwater Monitoring Report. If there is any schedule change, BP will coordinate with KDHE on the revised sampling schedule.

5 Data Evaluation and Reporting

Data generated during the Supplemental Soil Investigation will be evaluated and included in a Supplemental Soil Investigation Report. Data evaluation activities include tabulation and evaluation of semi-quantitative field data and quantitative analytical data. The Supplemental Soil Investigation Report will include:

- Summary of all field investigation activities;
- Summary of any deviations from the Work Plan;
- Maps of soil sample surveyed locations;
- Figures and Tables presenting characterization data;
- Raw analytical data, QA/QC summary, and validation information;
- Copies of all field notes and forms; and
- Evaluation of soil data.

Following completion of the Supplemental Investigation Report, the report will be submitted to the KDHE.

6 References

BP, 2005. *Corrective Action Study*, Revision 1. Former Amoco Refinery, Neodesha, Kansas. February 7, 2005.

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Tables

Table 1
Soil Analytical Parameters

Analyte Group	Constituents and Analytical Method	Method	Reporting Limit For Soil Samples (ug/kg)
BTEX	Benzene	8260B	5
	Toluene	8260B	5
	Ethylbenzene	8260B	5
	Xylenes (total)	8260B	5
Solvents	1,1,1-Trichloroethane	8260B	5
	1,1,2,2-Tetrachloroethane	8260B	5
	1,1-Dichloroethane	8260B	5
	1,1-Dichloroethene	8260B	5
	1,2-Dibromoethane	8260B	5
	1,2-Dichloroethane	8260B	5
	1,2-Dichloroethene (total)	8260B	5
	1,2-Dichloropropane	8260B	5
	1,2,4-Trimethylbenzene	8260B	5
	1,3,5-Trimethylbenzene	8260B	5
	1,4-Dioxane	8260B	500
	2-Hexanone	8260B	20
	4-Isopropyltoluene	8260B	5
	Acetone	8260B	20
	Acrylonitrile	8260B	100
	Benzene	8260B	5
	Bromodichloromethane	8260B	5
	Carbon disulfide	8260B	5
	Chlorobenzene	8260B	5
	Chloroethane	8260B	10
	Chloroform	8260B	10
	Chloromethane	8260B	10
	Dibromochloromethane	8260B	5
	Dibromomethane	8260B	5
	Ethanol	8260B	500
	Ethylbenzene	8260B	5
	Isopropanol	8260B	TIC
	Isopropylbenzene	8260B	5
	Methyl ethyl ketone; MEK; 2-Butanone	8260B	20
	4-Methyl-2-pentanone	8260B	20
	Methylene chloride	8260B	5
	Methyl-tertiary-butyl-ether; MTBE	8260B	20
	n-Butylbenzene	8260B	5
	n-Propylbenzene	8260B	5
	sec-Butylbenzene	8260B	5
	Styrene	8260B	5
	Tetrachloroethene	8260B	5
	Toluene	8260B	5
	trans-1,4-Dichloro-2-butene	8260B	5
	Trichloroethene	8260B	5
	Trichlorofluoromethane	8260B	10
	Vinyl acetate	8260B	10
	Vinyl chloride	8260B	10
	Xylenes (total)	8260B	5

Table 1
Soil Analytical Parameters

Analyte Group	Constituents and Analytical Method	Method	Reporting Limit For Soil Samples (ug/kg)
Oxygenates	methyl *tert* -butyl ether (MTBE)	8260B	5
	ethyl *tert* -butyl ether (ETBE)	8260B	5
	tert-amyl methyl ether (TAME)	8260B	5
	diisopropyl ether (DIPE)	8260B	5
	tert-butyl alcohol (TBA)	8260B	25
Semivolatile Organics	Bis(2-ethylhexyl) phthalate	8270	330
	o-Cresol	8270	330
	m-Cresol	8270	330
	p-Cresol	8270	330
	Di-n-butyl phthalate	8270	330
	1,2-Dichlorobenzene*	8270	330
	1,3-Dichlorobenzene*	8270	330
	1,4-Dichlorobenzene*	8270	330
	Diethyl phthalate	8270	660
	2,4 Dimethylphenol	8270	330
	Dimethyl phthalate	8270	330
	2,4 Dinitrophenol	8270	1600
	4-Nitrophenol	8270	1600
	Phenol	8270	330
	Pyridine	8270	660
	Quinoline	8270	1600
Polyaromatic Hydrocarbons (PAH)	1-Methylnaphthalene	8270	330
	2-Methylnaphthalene	8270	330
	Acenaphthene	8270	330
	Acenaphthylene	8270	330
	Anthracene	8270	330
	Benzo(a)anthracene	8270	330
	Benzo(a)pyrene	8270	330
	Benzo(b)fluoranthene	8270	330
	Benzo(g,h,i)perylene	8270	330
	Benzo(k)fluoranthene	8270	330
	Chrysene	8270	330
	Dibenz(a,h)anthracene	8270	330
	Fluoranthene	8270	330
	Fluorene	8270	330
	Indeno(1,2,3-cd)pyrene	8270	330
	Naphthalene	8270	330
	Phenanthrene	8270	330
	Pyrene	8270	330
RCRA Metals	**Metals (6010B/6020)**		
	Arsenic	6010	1000
	Barium	6010	1000
	Cadmium	6010	500
	Chromium (Total)	6010	1000
	Lead	6010	300
	Mercury (method 7471A/7470A)	6010	33
	Selenium	6010	500
	Silver	6010	1000

Table 1
Soil Analytical Parameters

Analyte Group	Constituents and Analytical Method	Method	Reporting Limit For Soil Samples (ug/kg)
General Chemistry	pH	150.1	0.1
TPH	TPH (as Diesel)	OA2	16 mg/kg
	TPH (as Fuel oil no.6)	OA2	110 mg/kg
	TPH (as Gasoline)	OA1	0.025 mg/kg
	TPH (as Jet fuels)	OA2	16 mg/kg
	TPH (as Kerosene)	OA2	16 mg/kg
	TPH (as Miscellaneous)	OA2	16 mg/kg
	TPH (as Naphtha)	OA2	16 mg/kg

Notes:

1. ug/kg = micrograms per kilogram
2. TIC - Tentatively Identified Compound

Figures

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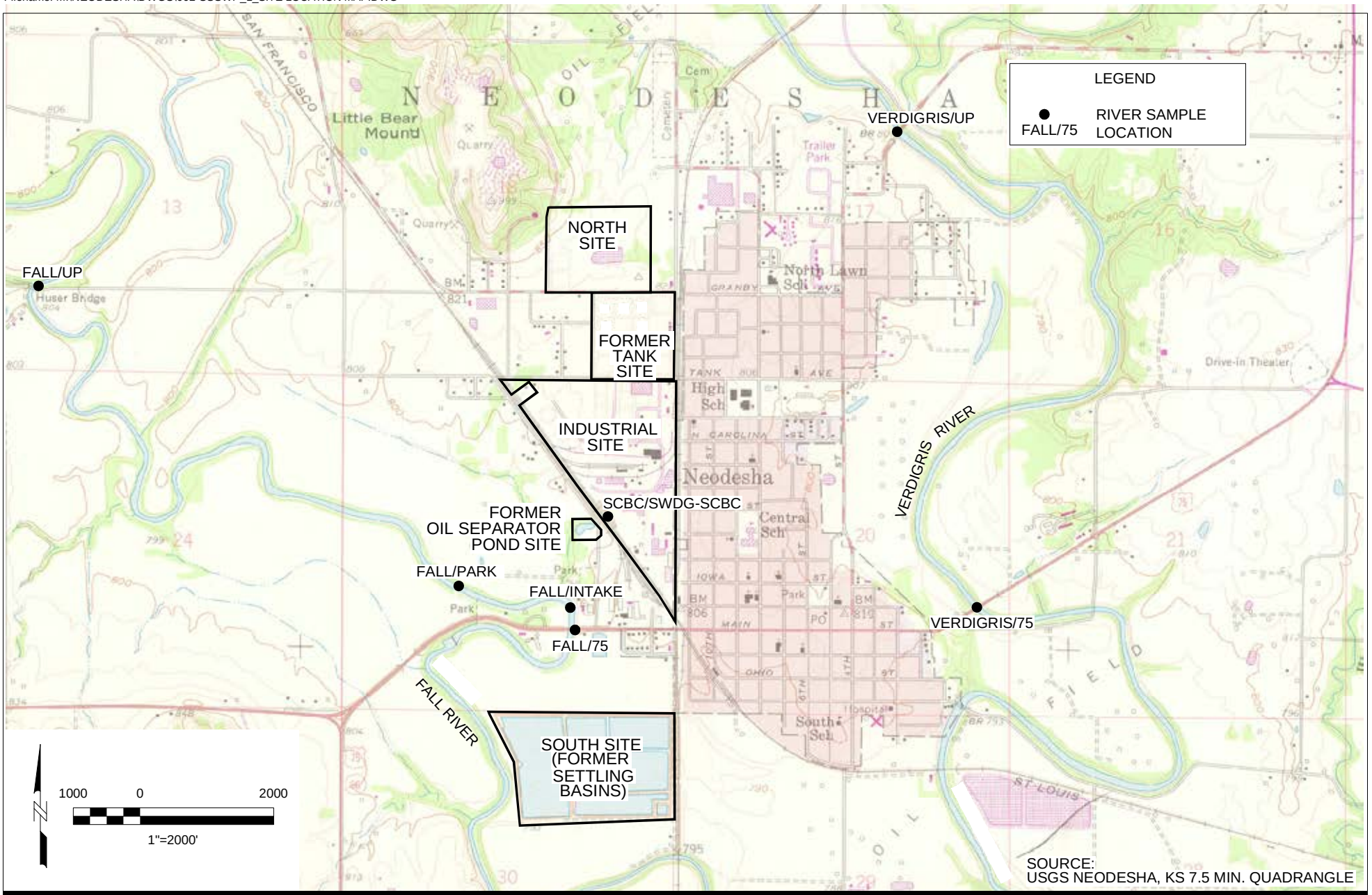


Supplemental Soil Sampling Work Plan
Former Amoco Refinery, Neodesha, KS
BP Products North America, Inc.
Project No.: 60239455 Date: 12/05/12

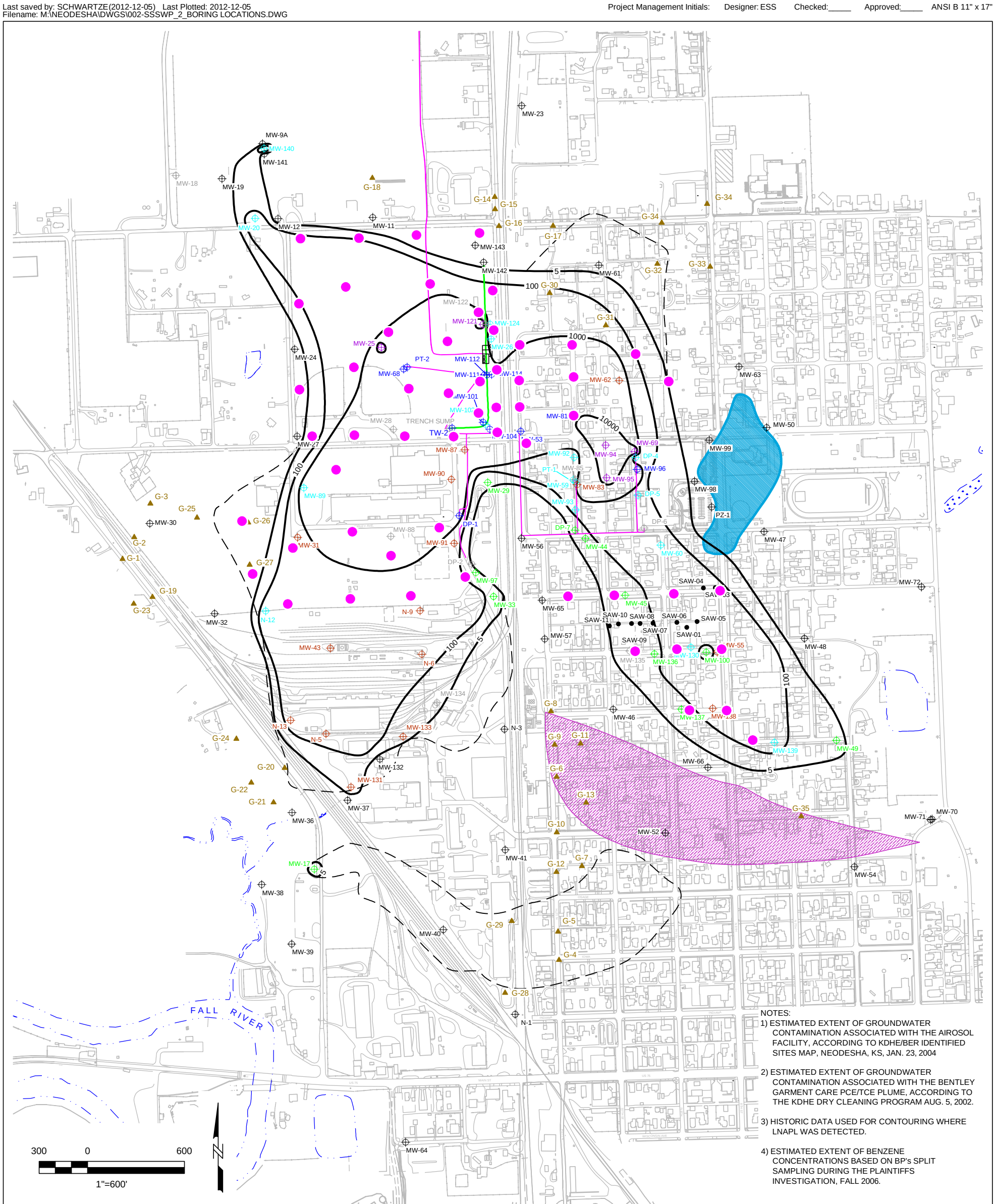
SITE LOCAITON MAP

AECOM

Figure: 1

Last saved by: SCHWARTZE(2012-12-05) Last Plotted: 2012-12-05
Filename: M:\NEODESHA\DWGS\002-SSSWP_2_BORING LOCATIONS.DWG

Project Management Initials: Designer: ESS Checked:_____ Approved:_____ ANSI B 11" x 17"



NOTES:

1) ESTIMATED EXTENT OF GROUNDWATER CONTAMINATION ASSOCIATED WITH THE AIROSOL FACILITY, ACCORDING TO KDHE/BER IDENTIFIED SITES MAP, NEODESHA, KS, JAN. 23, 2004

2) ESTIMATED EXTENT OF GROUNDWATER CONTAMINATION ASSOCIATED WITH THE BENTLEY GARMENT CARE PCE/TCE PLUME, ACCORDING TO THE KDHE DRY CLEANING PROGRAM AUG. 5, 2002.

3) HISTORIC DATA USED FOR CONTOURING WHERE LNAPL WAS DETECTED.

4) ESTIMATED EXTENT OF BENZENE CONCENTRATIONS BASED ON BP's SPLIT SAMPLING DURING THE PLAINTIFFS INVESTIGATION, FALL 2006.

LEGEND

MW-23 MONITORING WELL WITH NO BENZENE DETECTED

G-34 TEMPORARY MONITORING WELL (FEB. 2007) (NOT CONTOURED)

MW-62 MONITORING WELL NOT SAMPLED DUE TO MEASURABLE LNAPL IN WELL (October 2011)

SAW-03 SULFATE ADDITION WELL

PROPOSED LIF BORING

MONITORING WELL WITH DISSOLVED BENZENE DETECTED IN GROUNDWATER (DISSOLVED BENZENE CONCENTRATION (µg/l))(October 2011)

MW-143 <5 (µg/l)

MW-44 5-100 (µg/l)

MW-95 1000-10000 (µg/l)

MW-60 100-1000 (µg/l)

MW-69 > 10000 (µg/l)

5 BENZENE CONCENTRATION CONTOUR (µg/l) (October 2011)

BENZENE ISOCONCENTRATIONS (TEMPORARY MONITORING WELLS) (SEE NOTE 4)

SEE NOTE 1

SEE NOTE 2

TRENCH

NOTE: PROPOSED WELL LOCATIONS DEPENDENT UPON ACCESS, UNDERGROUND/SUBSURFACE UTILITY LOCATIONS AND SURFACE STRUCTURES.

Supplemental Soil Sampling Work Plan
Former Amoco Refinery, Neodesha, KS
BP Products North America, Inc.
Project No.: 60239455 Date: 12/05/12

PROPOSED LIF BORING LOCATIONS

AECOM

Figure: 2

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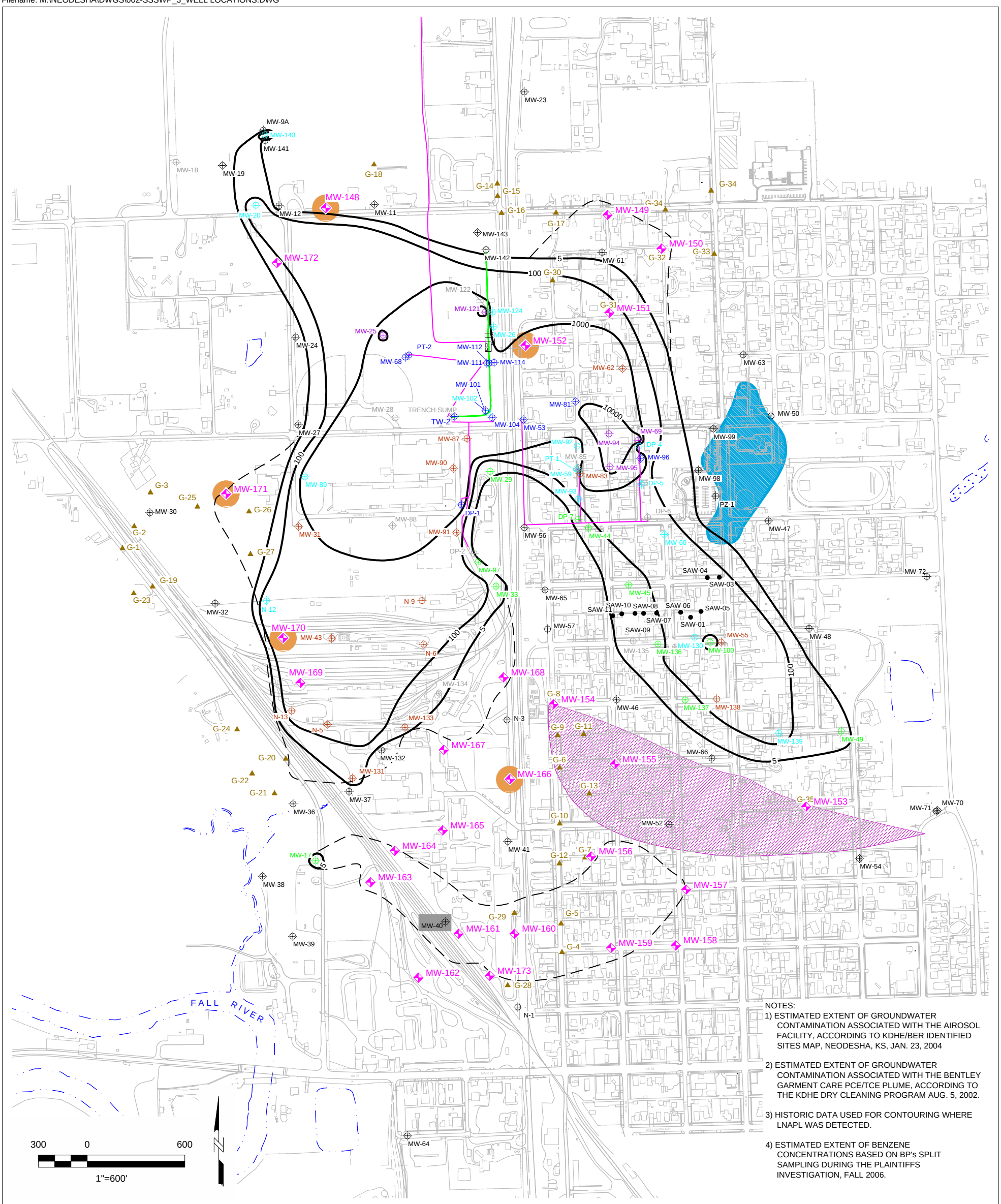

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1) ESTIMATED EXTENT OF GROUNDWATER CONTAMINATION ASSOCIATED WITH THE AIROSOL FACILITY, ACCORDING TO KDHE/BER IDENTIFIED SITES MAP, NEODESHA, KS, JAN. 23, 2004

2) ESTIMATED EXTENT OF GROUNDWATER CONTAMINATION ASSOCIATED WITH THE BENTLEY GARMENT CARE PCE/TCE PLUME, ACCORDING TO THE KDHE DRY CLEANING PROGRAM AUG. 5, 2002.

3) HISTORIC DATA USED FOR CONTOURING WHERE LNAPL WAS DETECTED.

4) ESTIMATED EXTENT OF BENZENE CONCENTRATIONS BASED ON BP's SPLIT SAMPLING DURING THE PLAINTIFFS INVESTIGATION, FALL 2006.

LEGEND

MW-23 MONITORING WELL WITH NO BENZENE DETECTED

G-34 TEMPORARY MONITORING WELL (FEB. 2007) (NOT CONTOURED)

MW-62 MONITORING WELL NOT SAMPLED DUE TO MEASURABLE LNAPL IN WELL (October 2011)

SAW-03 SULFATE ADDITION WELL

PROPOSED MONITORING WELL

PROPOSED SOIL SAMPLING LOCATION

MW-40 EXISTING MONITORING WELL TO BE ABANDONED

MONITORING WELL WITH DISSOLVED BENZENE DETECTED IN GROUNDWATER (DISSOLVED BENZENE CONCENTRATION (µg/l))(October 2011)

MW-143 <5 (µg/l)

MW-44 5-100 (µg/l)

MW-95 1000-10000 (µg/l)

MW-60 100-1000 (µg/l)

MW-69 > 10000 (µg/l)

5 BENZENE CONCENTRATION CONTOUR (µg/l) (October 2011)

BENZENE ISOCONCENTRATIONS (TEMPORARY MONITORING WELLS) (SEE NOTE 4)

SEE NOTE 1

SEE NOTE 2

TRENCH

NOTE: PROPOSED WELL LOCATIONS DEPENDENT UPON ACCESS, UNDERGROUND/SUBSURFACE UTILITY LOCATIONS AND SURFACE STRUCTURES.

Supplemental Soil Sampling Work Plan
Former Amoco Refinery, Neodesha, KS
BP Products North America, Inc.
Project No.: 60239455 Date: 02/22/13

PROPOSED MONITORING WELL LOCATIONS

AECOM

Figure: 3

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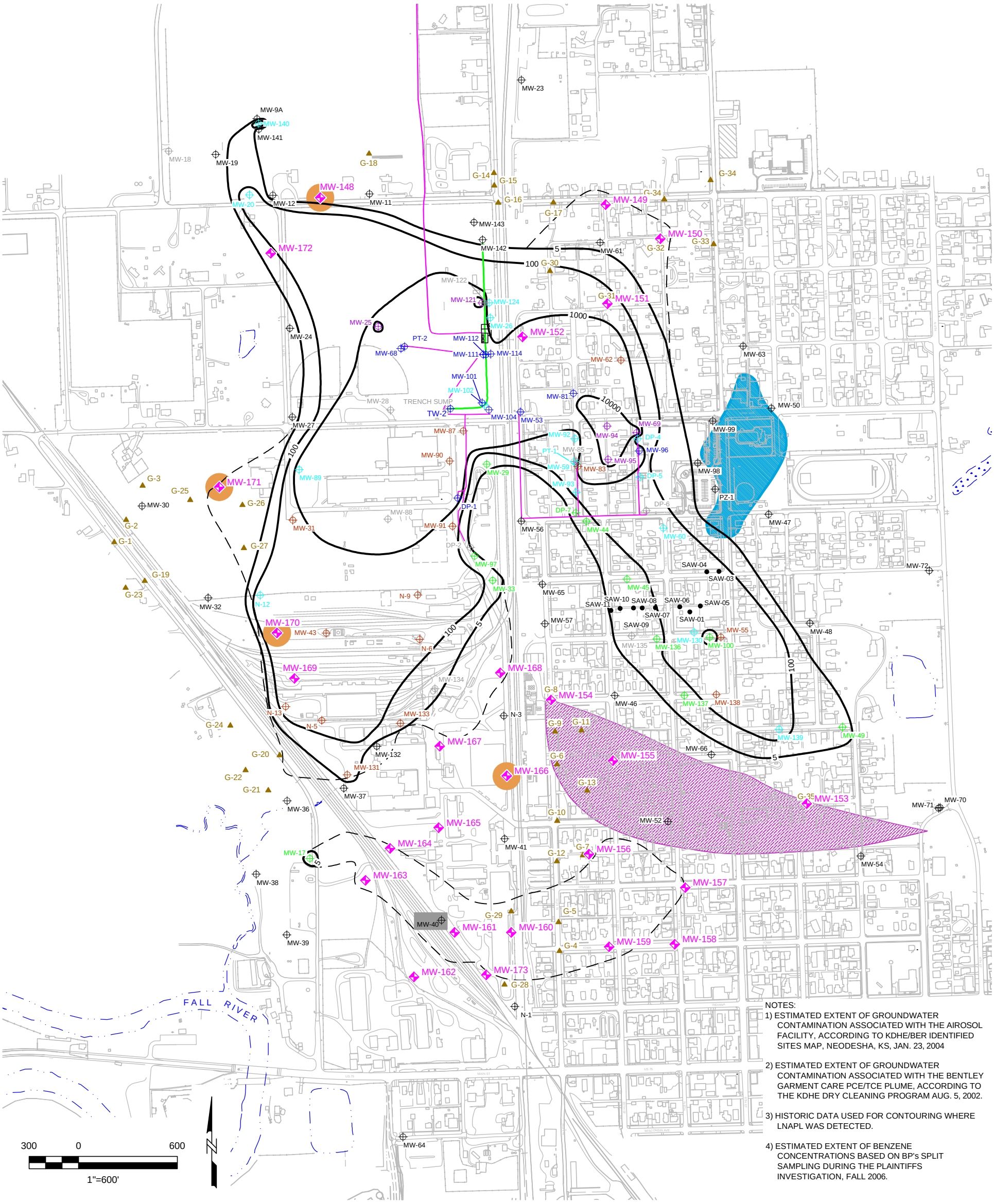

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1) ESTIMATED EXTENT OF GROUNDWATER CONTAMINATION ASSOCIATED WITH THE AIROSOL FACILITY, ACCORDING TO KDHE/BER IDENTIFIED SITES MAP, NEODESHA, KS, JAN. 23, 2004

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3) HISTORIC DATA USED FOR CONTOURING WHERE LNAPL WAS DETECTED.

4) ESTIMATED EXTENT OF BENZENE CONCENTRATIONS BASED ON BP's SPLIT SAMPLING DURING THE PLAINTIFFS INVESTIGATION, FALL 2006.

LEGEND

MW-23 MONITORING WELL WITH NO BENZENE DETECTED

G-34 TEMPORARY MONITORING WELL (FEB. 2007) (NOT CONTOURED)

MW-62 MONITORING WELL NOT SAMPLED DUE TO MEASURABLE LNAPL IN WELL (October 2011)

SAW-03 SULFATE ADDITION WELL

PROPOSED MONITORING WELL

PROPOSED SOIL SAMPLING LOCATION

MW-40 EXISTING MONITORING WELL TO BE ABANDONED

MONITORING WELL WITH DISSOLVED BENZENE DETECTED IN GROUNDWATER (DISSOLVED BENZENE CONCENTRATION (µg/l))(October 2011)

MW-143 <5 (µg/l)

MW-44 5-100 (µg/l)

MW-95 1000-10000 (µg/l)

MW-60 100-1000 (µg/l)

MW-69 > 10000 (µg/l)

5 BENZENE CONCENTRATION CONTOUR (µg/l) (October 2011)

BENZENE ISOCONCENTRATIONS (TEMPORARY MONITORING WELLS) (SEE NOTE 4)

SEE NOTE 1

SEE NOTE 2

TRENCH

NOTE: PROPOSED WELL LOCATIONS DEPENDENT UPON ACCESS, UNDERGROUND/SUBSURFACE UTILITY LOCATIONS AND SURFACE STRUCTURES.

Supplemental Soil Sampling Work Plan
Former Amoco Refinery, Neodesha, KS
BP Products North America, Inc.
Project No.: 60239455 Date: 12/05/12

PROPOSED MONITORING WELL LOCATIONS

AECOM

Figure: 3

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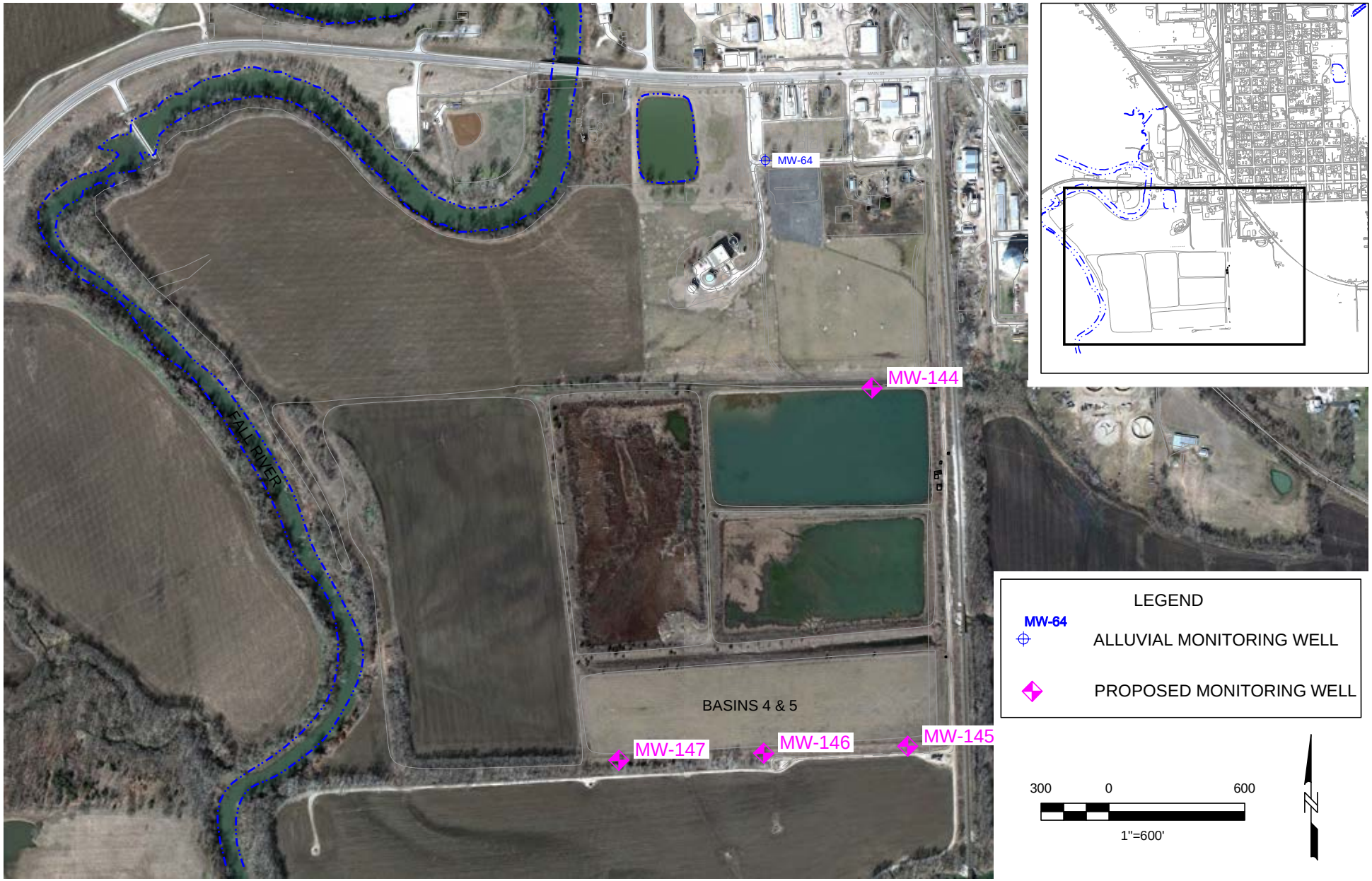

Supplemental Soil Sampling Work Plan
Former Amoco Refinery, Neodesha, KS
BP Products North America, Inc.
Project No.: 60239455 Date: 12/05/12

PROPOSED MONITORING WELLS
FOR SOUTH SETTLING BASINS
(MAY, 2012 AERIAL IMAGE)

AECOM

Figure: 4

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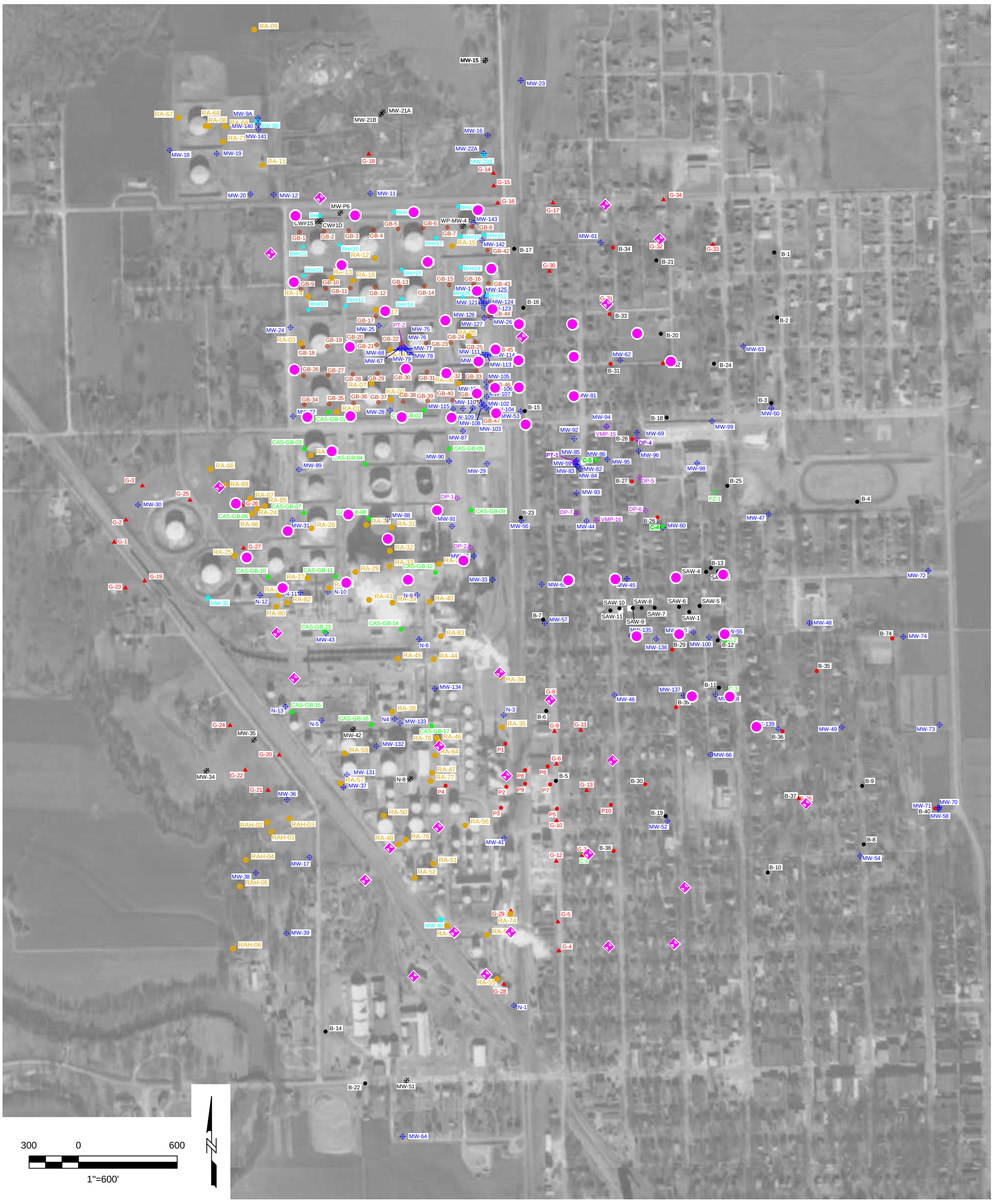

LEGEND

MW-23	ALLUVIAL MONITORING WELL	BH#13	WILLIAMS PIPELINE PHASE II INVESTIGATION (1993)		PROPOSED LIF BORING
MW-22B	BEDROCK MONITORING WELL (MW-9B, MW-22B, MW-32, AND MW40)	B-1	PHASE III REMEDIAL INVESTIGATION (1999)		PROPOSED MONITORING WELL
PT-2	PHASE 2 SYSTEM AND PIPING	CAS-GB-01	CAS SUPPLEMENTAL DATA COLLECTION (2001)		
PZ-1	PIEZOMETER	SAW-5	SULFATE SYSTEM PROTOTYPE (2004)		
	TRENCH	G-34	SUPPLEMENTAL SOIL BORINGS (2006)		
P2	KDHE INVESTIGATION (2001)	MW-51	ABANDONED WELL		
GB-28	PHASE 1 IRM INVESTIGATION (2000)	C-4	SOIL CORE SAMPLE		
			SOIL SAMPLE		

Supplemental Soil Sampling Work Plan
Former Amoco Refinery, Neodesha, KS
BP Products North America, Inc.
Project No.: 60239455 Date: 12/05/12

PROPOSED SOIL BORINGS AND MONITORING WELL LOCATIONS WITH 1962 AERIAL IMAGE

AECOM

Figure: 5

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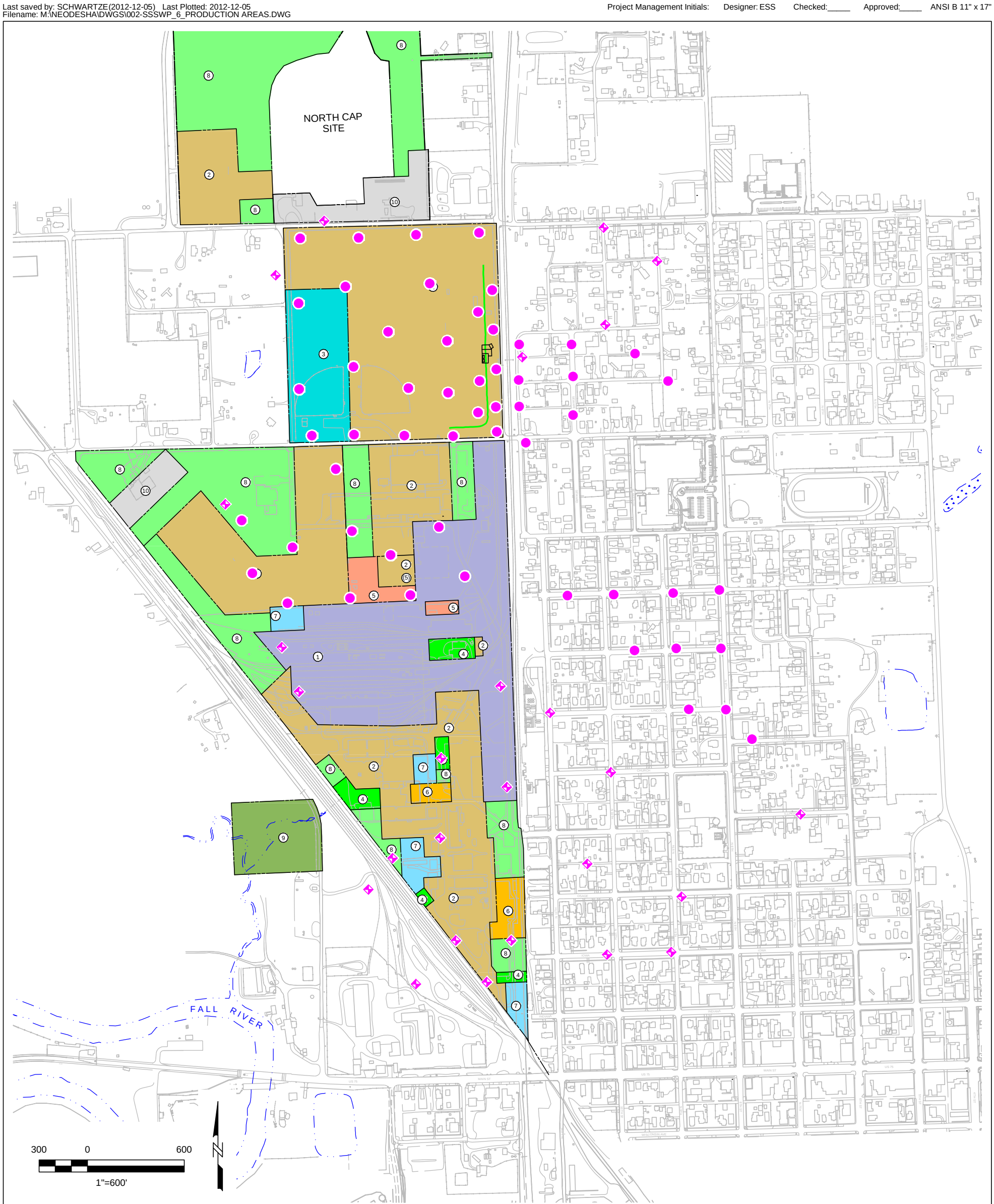

LEGEND

- PROPOSED LIF BORING
- PROPOSED MONITORING WELL

1	PROCESS AREAS
2	PRODUCT STORAGE AREA
3	CRUDE STORAGE AREA
4	WATER TREATMENT AREA
5	COOLING TOWER AREA
6	MAINTENANCE FACILITIES
7	MATERIAL STORAGE
8	NON-OPERATIONAL AREA
9	SEPARATOR POND AREA
10	NOT PART OF REFINERY

Supplemental Soil Sampling Work Plan
Former Amoco Refinery, Neodesha, KS
BP Products North America, Inc.
Project No.: 60239455 Date: 12/05/12

PROPOSED SOIL BORINGS AND MONITORING WELL LOCATIONS WITH FORMER PRODUCTION AREAS

AECOM

Figure: 6

Last saved by: SCHWARTZE(2012-12-05) Last Plotted: 2012-12-05
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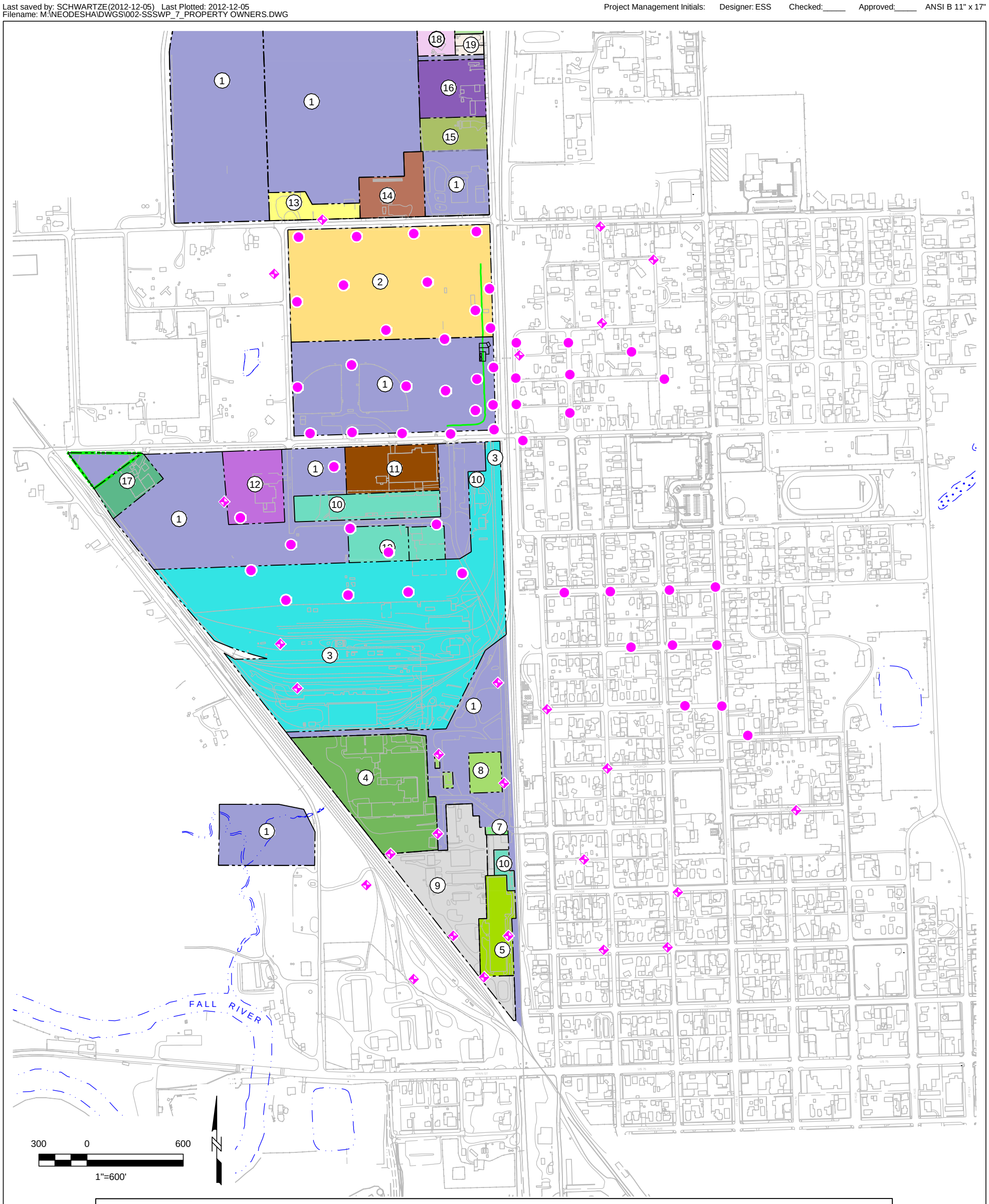

LEGEND

PROPOSED LIF BORING

PROPOSED MONITORING WELL

PROPERTY LINES

PROPERTIES WITH DEED RESTRICTIONS

1 CITY OF NEODESHA
2 WILLIAMS PIPELINE
3 WATCO (MILLENNIUM RAIL)
4 FIBERGLASS ENGINEERING (COBALT BOATS)

PROPERTIES WITH NO RESTRICTIONS

5 JOHN FLOYD (QUALITY MACHINING)
7 STEVE AESCHLIMAN
8 AIROSOL
9 FIBERGLASS ENGINEERING (COBALT BOATS)

PROPERTIES WITH NO RESTRICTIONS

10 NEODESHA PLASTICS
11 HARMON INC.
12 NEW BEGINNINGS
13 ART HOOPER & FRED ROHLING
14 LANNY & RHONDA FORSYTHE
15 DAVID GREEN & DANNY WILLIAMS
16 RODNEY & DARLENE SCHLEGEL
17 SOMMER
18 LINDA & THOMAS SMITH
19 DAVID & LORRAINE MCROBERTS
20 WILLIAM & LINDA FULLER

Supplemental Soil Sampling Work Plan
Former Amoco Refinery, Neodesha, KS
BP Products North America, Inc.
Project No.: 60239455 Date: 12/05/12

PROPOSED SOIL BORINGS AND MONITORING WELL LOCATIONS WITH AREA PROPERTY OWNERSHIP

AECOM

Figure: 7

Appendix A

TG: 106 **SUBJECT:** DIRECT-PUSH DIRECT SENSING INVESTIGATIONS (MIP/LIF/UVOST/TARGOST/ROST/EC/CPT/HPT)

SUMMARY:

Direct sensing boring investigations are conducted to delineate or screen contaminants and soil types at high resolution, with minimal generation of waste, in a more rapid fashion than traditional soil borings. Direct sensing tools for delineating or screening contaminants include but are not limited to Membrane Interface Probe (MIP), Laser Induced Fluorescence (LIF) including Ultraviolet Optical Screening Tool (UVOST), Tar Green Optical Screening Tool (TarGOST), Rapid Optical Screening Tool (ROST). Direct sensing tools for identifying soil types include Electrical Conductivity Probe (EC), Cone Penetrometer Tool (CPT), and Hydrualic Profiling Tool (HPT). Many of the same practices used to conduct traditional direct push borings are used to conduct direct sensing borings, the procedures of which are covered in TG 101. Direct-sensing methods are limited to soils and unconsolidated materials that can be penetrated with specified equipment. In general, sampling is performed by advancing a rods carrying direct sensing tooling into soil by means of a 'direct-push' method. The ability to penetrate a soil and attain a specific depth is contingent upon several factors, including hammer energy, carrying rigs weight, compactness and density of soil, consistency of soil, and tooling. In general, direct-push methods are **not** effective for 1) solid rock, 2) weathered rock, 3) dense, cemented or coarse soils, and 4) certain cohesive soils (water can impart friction on tooling which can also lead to refusal).

Insertion methods are varied with direct-push rigs and include static hydraulic push, impact, percussion and combination/hybrid rigs.

Tooling typically consists of hollow rods which carry data lines to a direct sensing interface near the base of the drill tooling. Familiarity with the rig specifications and tooling and site setting is essential prior to safely and effectively implementing direct-push investigations.

This TG addresses the oversight and direction of direct sensing direct-push rigs for evaluating contaminants and soil types.

1.0 REQUIRED EQUIPMENT

- HASP/Environmental Health & Safety SOPs Manual
- Level D equipment or PPE upgrades as dictated by site conditions and HASP.
- Procurement Documentation/SOW/Cost Breakdown
- Kansas One-Call or Utility Clearance Number
- Signed Access Agreement (if applicable or off-site work is performed)
- Field Notebook, Pen

2.0 PROCEDURES

- In many instances site conditions will require deviation of scope of work or work plan. It is important that field staff and PMs communicate regarding unique site conditions (e.g. stratigraphy, presence of water, presence of contaminants and so forth) that could potentially affect drilling scope of work. Document communication in field log book.
- Prior to performing direct-push rig oversight, review equipment and tooling specifications, scope of work, project work plan and HASP with the Project Manager or Technical Leader, On-Site Personnel and Sub-Contractors (if present). Confirm that utilities are identified and clearly demarcated in the field. Confirm that property access is approved and signed by property owner.
- Document utility clearance in field book.
- Direct-push rigs are potentially dangerous due to stored energy (e.g. hydraulic cylinders and overhead masts) and rotating/mechanized parts. Ask the driller where the emergency power shot-off “kill-switches” are located. Do not proceed further if the drill rig is not equipped with an emergency shut-off device. Proceed with drill rig inspection. Proceed with tail-gate safety meeting and HASP overview, with all site personnel reading and signing HASP.
- Document site activity and soil descriptions in a hard-bound survey-grade field note book dedicated to the project. Tablet PCs or other portable electronic devices may be used to store lithological data/observations.
- Proceed with drilling and soil collection.
- Take and document photographs if required for project.
- Document/Log the following:
    - Personnel Present
    - Dates, Time, Weather Conditions
    - Drill Contractor and Drillers’ names.
    - Drill Rig Make and Model
    - Drill Tooling (e.g. rods, augers, dimensions, Hammer weights and so forth)
    - Downtime
    - Boring ID, Start and Stop Times
    - Linear Footage Driller. Note Sampling Method.
    - Any comments from driller regarding penetration resistance.
    - Any damage to landscaping, pavement or other site features.

3.0 Selection of Boring Locations

Direct sensing tools are unique in their real time response and reporting of subsurface conditions. This offers the ability to implement a dynamic scope of work in which boring locations can be shifted, added, removed, and lengthened. There are many implications of this, the first of which is utility clearance and access. Prior to entering the field the most up to date version of the conceptual site model should be reviewed and any area of suspected contamination to be investigated should be cleared for utilities as well as some margin around that area to allow for step out borings. In some cases access restrictions and preclearance requirements do not allow for this.

Generally investigations should be performed on a grid spaced coarsely across the investigation area. Unlike traditional soil borings there is little benefit from starting in the cleanest zones and moving into the most heavily contaminated zones, except in the case of the MIP where high levels of contamination may cause longer periods of cool down time between borings. Based off the observations from the borings performed on the coarse grid additional borings can be focused to meet project goals. Generally the following is a list of considerations that should be made when performing direct sensing investigations:

1. Include locations over a sufficient area to verify the lateral extent of LNAPL distribution, if detected.

2. Where possible, approximate an x-y grid pattern on as small a spacing as practical to provide improved resolution of the likely heterogeneous LNAPL distribution.

3. Include locations immediately adjacent to representative existing monitoring wells and borings with varying degrees of observed impacts (e.g., wells with LNAPL, wells with high and low LNAPL transmissivity, wells with high dissolved phase concentration, wells with low dissolved phase concentration, wells with no observed impacts). These borings should be located as close to the existing monitoring wells as possible (normally less than 8 feet) without compromising or damaging the monitoring well. The data from these direct sensing borings are used in calibrating the direct sensing data to historical boring data collected.

4. Include clean locations to demonstrate complete lateral delineation and to evaluate background effects. If possible, provide a clean soil/clean groundwater and clean soil/impacted groundwater location to help differentiate the direct sensing response to dissolved-phase constituents.

5. Include locations in potential migration pathways

6. Collect data from borings adjacent to each other (note that it is impossible to take the same boring twice (i.e., duplicates)) however it is useful to qualitatively compare the variability in the surface the response of direct sensing tools to it. This includes completing direct sensing borings adjacent to each other to confirm variability in contaminant response and/or soil type.

An additional recommended option is to have technical staff interpreting data in near real time (e.g., at the end of each day) by incorporating it into the existing conceptual model. This can be done on markups of aerial and cross section figures or through integrated 3D conceptual modeling visualizations. Based on these interpretations technical staff can recommend changes to the dynamic work plan in terms of boring placement, priority, and depth during the same mobilization. This typically results in the acquisition of a complete picture of the conceptual site model minimizing future mobilizations.

4.0 RESPONSIBILITY

- Staff geologists and geological engineers are required to review and become familiar with this TG.

- Field staff are responsible for collecting appropriate field notes and placing them in file. Typically electronic boring logs are generated from direct sensing tools. Hard copies of these logs should be kept and raw data should be forwarded along to the technical team in a timely manner (e.g., at least at the end of every day).
- Field staff are responsible for noting all deviations from the original scope and stopping work if deviations and especially safety conditions are not appropriate.
- PMs and Technical Leaders are responsible for distributing or enforcing the use of this TG
- PMs and Technical Leaders are responsible for implementing use of this TG.

5.0 RELEVANT FORMS AND ATTACHMENTS

- Health and Safety Procedures No. 35 (Well Drilling) and No. 38 (Subsurface Drilling).
- TG_001

6.0 REFERENCES

D6282-98 Standard Guide for Direct Push Soil Sampling for Environmental Site Characterizations.

Technology specific information can be found with direct sensing equipment manufactures and operators.

7.0 DOCUMENT APPROVAL AND HISTORY

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