Pilot Trench Performance Monitoring Plan

GM GPS – Bedford Facility
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Bedford, Indiana
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GHD | 651 Colby Drive Waterloo Ontario N2V 1C2 Canada

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Acronyms List

AOC	Administrative Order on Consent
CA	Corrective Action
COC	Contaminant of Concern
Cover System	East Plant Area Final Cover System
DNAPL	Dense, Non-Aqueous Phase Liquid
Facility	GM GPS Bedford Facility
GAC	Granular Activated Carbon
GM	General Motors, LLC
GPS	Global Propulsion Systems
GUS	Gravel Underdrain System
GWTP	Groundwater Treatment Plant
HDPE	High Density Polyethylene
HQ	Standard Core Drill Barrel Size
IM	Interim Measure
LCS	Leachate Collection System
LDS	Leak Detection System
NAPL	Non-Aqueous Phase Liquid
PCBs	Polychlorinated Biphenyls
Pilot Trench	Pilot Perimeter Groundwater Trench Collection System
PMP	Performance Monitoring Plan
RCRA	Resource Conservation and Recovery Act
SSC	Site Source Control
U.S. EPA	United States Environmental Protection Agency
WW4	Wet Well 4

1. Introduction

This Pilot Trench Performance Monitoring Plan (PMP) has been prepared by GHD Services Inc. (GHD) to evaluate and monitor the groundwater collection hydraulic performance of the Pilot Perimeter Groundwater Trench Collection System (Pilot Trench) constructed at the General Motors (GM) LLC Global Propulsion Systems (GPS) Bedford Facility (Facility), located in Bedford Indiana. The Pilot Trench was installed as part of the Resource Conservation and Recovery Act (RCRA) Corrective Action (CA) activities being conducted under the Administrative Order on Consent (AOC) (effective date August 4, 2014) between United States Environmental Protection Agency (U.S. EPA) and GM LLC for the Facility (Docket No. RCRA-005-2014-0011).

The Pilot Trench is part of a perimeter groundwater collection trench system to be installed through the karst bedrock and designed to collect the shallow, PCB-impacted groundwater beneath the East Plant Area, thereby intercepting potential shallow groundwater migration from the Facility. The inherent capture and removal of groundwater by the constructed Pilot Trench, located along a portion of the hydraulically downgradient Facility boundary associated with a bedrock valley drainage feature, is intended to accentuate the existing hydraulic gradients to define the hydraulic capture performance of the completed installation. Thus, the Pilot Trench may have a practical horizontal collection zone that exceeds the mere length of the trench by producing an inward flow path upgradient of the trench location.

The Perimeter Groundwater Trench Collection System is intended to be installed in two or more phases of work, with the Pilot Trench segment constructed to demonstrate installation techniques, attainment of trench depth at or below the competent/karstic bedrock interface, and to assess the effectiveness of the horizontal groundwater hydraulic collection zone. Installation and subsequent inspection of the Pilot Trench has validated the appropriateness of the construction techniques and confirmed attainment of the required depth. This PMP is intended to further define and assess prior monitoring information that indicates (1) overall groundwater flow in the northern portion of the East Plant Area is controlled by an east-west trending bedrock valley that conducts groundwater towards the Pilot Trench, and (2) horizontal and vertical hydraulic capture of groundwater above the competent bedrock at the Pilot Trench effectively prevents contaminated groundwater from migrating off-site at levels which would result in unacceptable risk to human health and the environment (See the Problem Statements in Section X).

Monitoring wells located in select areas in the vicinity of the Pilot Trench, and periodically monitored throughout the various seasons, will be used to monitor and measure the hydraulic performance of the capture zone of the Pilot Trench. The proposed installation of additional monitoring locations will be completed to augment the current monitoring network in this area.

Furthermore, dye trace investigations will be implemented immediately upgradient of the trench to assist in the understanding of groundwater flow in the area of the trench and to provide more information on the broader capture potential from areas on the upgradient side of the East Plant Area. Each of these components, along with other geologic, hydrogeologic and chemical data, will be integrated into a lines of evidence approach to evaluate the overall performance of the hydraulic capture of the Pilot Trench operation.

The Pilot Trench PMP is organized into the following sections:

1) Section 2 presents the Conceptual Site Model (CSM), including a generalized description of the local geologic and hydrogeologic conditions, groundwater movement, and contaminant transport

2) Section 3 presents a description of the Pilot Trench construction

3) Section 4 presents the proposed Performance Monitoring Plan, including monitoring well installation and multiple studies (thermal imaging reconnaissance, groundwater sampling, hydraulic monitoring, and dye tracer studies) that will be used to monitor the performance of the Pilot Trench

4) Section 5 describes the reporting of results from the monitoring activities

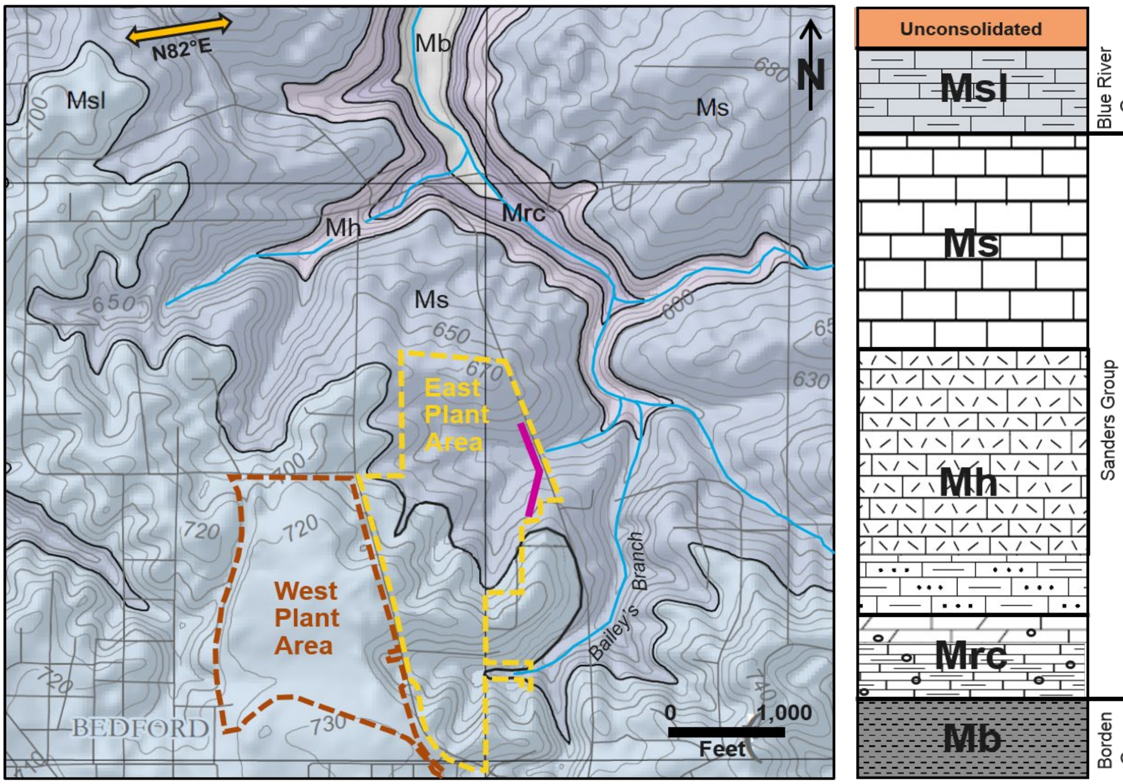
5) Section 6 presents the references referred in completing this work plan

2. Conceptual Site Model – Pilot-Trench Area

2.1 Physical Setting

The Facility is in the Mitchell Plateau physiographic province, a carbonate karst plateau dissected by a few major stream systems. The term karst describes a terrane underlain by soluble rocks, where openings in the rocks are widened through dissolution, creating unique networks of preferential groundwater flow and, frequently, features including caves, sinkholes, and springs. The main Facility structures are situated on a flat hilltop in the West Plant Area (Inset 1). The land surface comprising the East Plant Area generally slopes to the east and is underlain by a veneer of recently placed fill materials situated on limestone bedrock. The bedrock surface is incised by two narrow, roughly east-west trending valleys that convey groundwater eastward to Bailey's Branch creek. The Pilot Trench is constructed across the northernmost of these two bedrock valleys.

Inset 1. **(Left)** Bedrock geology map with topographic contours (after Thompson et al., 2008, with adjustments based on site-specific data); **(Right)** generalized stratigraphic column showing unit relationships. The thickness of the Blue River and Sanders Group Formations shown are relative to the approximate average thickness of formations penetrated at the site. Unit abbreviations explained in text. Yellow arrow denotes strike of regionally dominant joint set (Powell, 1976 [Plate 1]). Pilot trench shown in magenta.



2.2 Geologic Conditions

This section provides an overview of relevant geologic conditions at and around the Facility. Details regarding geologic conditions are contained in the draft RCRA Facility Investigation (RFI) Report (GHD, 2015).

2.2.1 Geologic Materials

The geology of the site and surroundings consists of a thin veneer of unconsolidated clay-rich and finer grained material overlying bedrock comprised of several Mississippian geologic formations (Inset 1). In descending order (youngest to oldest), these are the St. Louis Limestone (Msl) of the Blue River Group, the Salem Limestone (Ms), the Harrodsburg Limestone (Mh), the Ramp Creek Formation (Mrc) of the Sanders Group, and the Edwardsville Formation of the Borden Group (Mb)[1].

[1] The bedrock geologic map prepared by Thompson et al. (2008) does not differentiate between the three formations that comprise the Borden Group. All three are denoted by the symbol "Mb".

Karst can form in all these formations except the Borden, which is not comprised of soluble rock. Figure 2.1 depicts the current surface topography with the underlying top of bedrock surface across the Facility.

Descriptions of the unconsolidated material and bedrock formations beneath the site follow.

Unconsolidated Material

Unconsolidated, native materials overlying the bedrock at the Facility are relatively thin and consist chiefly of loess (silt deposited by wind) underlain by residuum. Residuum is mineral material that accumulated in place as the carbonate bedrock dissolved and disintegrated (chemically weathered). The residuum at the facility is described as predominantly clay with traces of silt and gravel, clayey sand, and silty sand.

Fill materials placed at the Facility consist of gravel with varying amounts of finer-grained material. Debris such as wood, plastic, brick, and metal are occasionally encountered in the fill.

St. Louis Limestone

The St. Louis Limestone in Indiana is divided into two parts based on lithology: the upper St. Louis and the lower St. Louis. Only the lower St. Louis is present at the Facility. The lower St. Louis consists mostly of thin-bedded, generally micritic, limestone with thin beds of calcareous shale and silty dolostone (Carr, 1986). The average matrix (i.e., primary) porosity of samples tested from rock cores collected at the Facility was 8.6%. The St. Louis Limestone thins from the southwest to northeast across the Facility, with an average thickness of approximately 21 feet (GHD, 2015). This formation grades into and conformably overlies the Salem Limestone.

Salem Limestone

The Salem Limestone comprises the youngest unit of the Sanders Group. The most widely known rock type of the Salem Limestone is cross-bedded calcarenite[2] that is medium to coarse grained, porous, and fairly well sorted which occurs in exceptionally thick beds. The individual grains consist of microfossils and fossil fragments cemented with calcite. Other rock types comprising the formation include biocalcirudites[3], very fine grained argillaceous dolostone, and dense argillaceous limestone (Pinsak, 1957).

The average thickness of the Salem Limestone beneath the Facility, where overlain by the St. Louis Limestone, is approximately 61 feet. In the northeast portion of the Facility, where the St. Louis Limestone has been eroded away, the Salem Limestone thins due to weathering. The base of the Salem Limestone grades into and conformably overlies the Harrodsburg Limestone. The average matrix porosity of samples tested from rock cores collected at the Facility was 9%.

Harrodsburg Limestone

The Harrodsburg Limestone has been divided in the literature into an upper and a lower unit. The upper unit at the Facility consists of bioclastic calcarenite and calcirudite with beds of variable

[2] Calcarenite is a type of limestone that is composed predominantly of sand-sized carbonate grains.

[3] Biocalcirudite is a limestone formed predominantly of fossil fragments that are larger than sand (>2 millimeters).

thickness. Occasional shale laminae and small vugs were also present (GHD 2015). The average matrix porosity of samples tested from rock cores of the upper unit collected at the Facility was 5.4%. The thickness of the upper unit beneath the site averaged 51 feet. The lower Harrodsburg Limestone consists predominantly of fine-grained limestone with beds of variable thickness and contains interbedded shale laminae and thicker shale beds. Small vugs occur throughout the lower unit, with small siliceous geodes present near its base. The average thickness of the lower unit is approximately 26 feet. The matrix porosity of the lower unit was not measured.

Ramp Creek Formation

The Ramp Creek Formation beneath the site consists of very fine- to medium-grained, evenly-bedded, dolomitic limestone with occasional shale seams. Vugs and geodes are numerous throughout the formation. The average thickness of the formation beneath the Facility is approximately 20 feet. The matrix porosity of the unit averaged 26%.

Edwardsville Formation

Only a few feet of the Edwardsville Formation were penetrated by borings at the Facility and consisted of relatively soft calcareous shale. The top of this formation was observed to contain a thin layer of glauconitic shale with small crystals of pyrite, which is consistent with information provided by Nicoll and Rexroad (1975). In addition to shale, Stockdale (1931) reports that the Edwardsville Formation also contains beds of siltstone and fine-grained sandstone, and that the formation thickness ranges from 40 to 200 feet in Indiana.

2.2.2 Bedrock Structure

Regionally, all the bedrock formations dip gradually toward the southwest at about 30 to 250 feet per mile (Powell, 1976). Mapping performed as part of the RFI indicates that the dip of the strata locally is on the order of 40 to 100 feet per mile. Local dip angle and direction can vary significantly from the regional trend (Perry and Smith, 1958) due to local folding of strata.

The type, orientation, and frequency of fractures are important factors governing karst development and the movement of groundwater through the bedrock. Fractures represent a form of secondary porosity of the rock. Fractures present in the bedrock are divided into two types: bedding-plane fractures and joints.

As their name implies, bedding-plane fractures occur along bedding planes. Because the bedding-plane fractures are nearly horizontal, they are the type of fractures most-commonly intercepted by vertical borings. While bedding-plane fractures were identified in all the bedrock formations penetrated, their frequency tended to decrease with depth. Also, because bedding planes are less common in the Salem Limestone, bedding-plane fractures in this formation were also less common than in the other limestone formations.

For the purposes of this CSM, joints are defined as rock fractures that are not aligned along bedding. Powell (1976) conducted an extensive study of jointing of Mississippian rocks in southwest Indiana and their implications in terms of karst formation and groundwater movement. He determined that the jointing was common in rocks in the region, including the Blue River and Sanders Groups. The joint system in the area consists of two sets of near-vertical joints, denoted “master” and “cross”. The joints in the master-joint set normally transect more than one bed of rock vertically, are longer than cross joints, and have a preferred orientation that, in the region, is roughly east-west. Cross-joints commonly terminate at master joints, to which they are nearly normal (intercept at right angles) and generally transect only one bed. Powell (1976) notes that the spacing of master joints in the Salem Limestone ranges from 10 to 50 feet.

2.2.3 Karst

Karst refers to geologic terrain that is comprised of and underlain by soluble bedrock. Such terrains often have diagnostic landforms like sinkholes and hydrologic features such as sinking streams and springs. A karst aquifer is comprised of bedrock whose permeability has been enhanced by dissolution processes. A karst aquifer can be present even if there are no karst landforms nearby.

Regionally, karst has been shown to form in all four of the limestone formations that underlie the site (the St. Louis, Salem, Harrodsburg, and Ramp Creek). Although it is calcite-rich, thick-bedded, and possesses the requisite secondary porosity, the Salem Limestone appears less susceptible to karstification than does the St. Louis Limestone (Thornbury 1969).

Karst aquifers represent triple-porosity systems comprised of primary (matrix), secondary (fracture), and tertiary (solution or “conduit”) porosity. Worthington, et al. (2000) examined the storage and movement of groundwater in four well-studied karst aquifers. They found that, in all cases, more than 90% of the groundwater in the aquifers was stored in the matrix porosity and more than 90% of the flow through the aquifers occurred in the conduit porosity, with fractures playing an intermediate role. Hydraulic-head and groundwater-quality data from wells screened across conduit porosity, therefore, are most important in assessing the movement of contaminants dissolved in, or adsorbed to particulates moving with, groundwater in the bedrock.

Solution-widened pathways in karst aquifers enlarge and become integrated over time forming networks of conduits that typically have apertures in the millimeter to centimeter range (Worthington and Ford 2009). These networks converge in the downgradient direction, focusing groundwater flow, and discharging at springs.

2.3 Groundwater Movement

Groundwater in karstic terrain moves, on a macro scale, from areas of relatively higher to lowest pore pressure. On this macro scale water flows principally within regions of the karstic rock where the voids are larger and more densely inter-connected, thus allowing easy communication (i.e., low pressure gradient) between them. On a micro scale, groundwater in the matrix porosity, or in closed or poorly interconnected fractures, drains more slowly towards nearby inter-connected fractures and/or conduits and requires much higher pore pressure gradients to achieve such movement. In practice, groundwater within these interconnected fractures and conduits drains relatively rapidly through the bedrock and discharges to the ground surface or within surface water bodies at seeps and springs.

In the East Plant Area, as described in the RCRA Facility Investigation Report (Section 4.4.2), these interconnected conduits are preferentially located in the upper portion of the karstic rock. This vertical fracture/void density gradient tends to result in a strong shallow horizontal groundwater flow component in the East Plant Area.

In the northern portion of the East Plant Area, where the Pilot Trench is located, potentiometric mapping of groundwater in the shallow bedrock via monitoring wells, along with previous dye tracer testing results, suggests that prior to trench installation groundwater flowed to the east, with little vertical flow, and discharged to springs located along the historical and current Tributary 3. However, the imperfect knowledge of the bedrock permeability structure in such karst aquifers renders validation of these local groundwater flow directions using only potentiometric maps less certain than in non-karst settings. Nevertheless, supported by other available data (e.g., previous dye tracer testing results, observed geology) and professional experience with karst aquifers, it is reasonable to infer that, prior to trench installation, shallow groundwater in the northern portion of the East Plant Area indeed discharged to springs along Tributary 3 and/or Bailey's Branch, but is now be expected to be captured by the Pilot Trench.

To better characterize groundwater movement in karst aquifers, dye tracer studies are often used to supplement hydraulic data collected from monitoring wells and therefore provide better overall confidence in the characterization of groundwater flow. This PMP describes two such post-construction tracer studies to be conducted as part of the performance monitoring program for the Pilot Trench, described later in this document.

The bedrock aquifer is recharged by infiltration of precipitation. Historical water-level data demonstrate that the water levels in some monitoring wells respond rapidly to storm events whereas in other wells they do not. The rapid response suggests that recharge occurs rapidly and is focused along solution-widened fractures. In general, wells that respond rapidly are better-connected hydraulically to the active flow system, while wells with muted responses (or no response) are poorly connected. Samples analyzed from the former represent the quality of groundwater that is in transit through the aquifer whereas samples analyzed from the latter represent the quality of groundwater that is essentially in storage in the aquifer. However, it is noted that rapid responses occur at greater magnitude at this site at wells that are not under the cover system materials. While, those wells that are located under the cover system, do show direct responses at some locations, however those responses are more muted (Figure 4.17 shows a graph of the transducer data that have been collected at the Facility, where these conditions can be observed.

Comparison of groundwater elevation data from wells screened shallow (i.e., in the St. Louis or upper Salem Limestones) with those screened deeper (i.e., in the Harrodsburg Limestone or Ramp Creek Formation) demonstrates that a strong downward gradient exists. If all the limestone formations above the Edwardsville Formation represented one well-integrated karst aquifer, such a large vertical gradient would not exist. This observation is evidence that an interval of more competent rock exists at depth beneath the East Plant Area that retards downward movement of groundwater.

2.4 Contaminant Transport

Prior to the RCRA Corrective Action activities, the East Plant Area was used for the disposal of wastes, including PCB impacted soil and debris. In the northern portion of this area extensive soil sampling was conducted to assess the nature of this fill material and elsewhere in the East Plant Area. The East Plant Area Interim Measure resulted in the removal and on-site containment of PCB material > 50 mg/kg in the landfill vault, and the placement of additional < 50 mg/kg floodplain soil and sediment as grading material prior to installation of a multi-component cover system.

To date, PCBs have not been detected in samples of pilot-trench effluent, indicating that PCBs have not been migrating appreciably in the groundwater collected by the trench. Fill soils in the East Plant Area of the Facility have lower levels of PCBs, typically much less than 50 mg/kg. Such levels typically do not lead to appreciable levels of dissolved PCBs in groundwater because PCBs have low solubility and a high affinity to adhere to soil particles. Groundwater in certain areas upgradient of the pilot trench, including that issuing from select former seeps and springs, has been shown to contain PCBs (GHD, 2015) in either the total or dissolved fraction.

The interpretation of PCB detections in groundwater samples located beyond the installed trench as a primary line of evidence is insufficient in determining Pilot Trench effectiveness because PCBs have low solubility and a high affinity to adhere to soil particles. Positive detections of PCBs downgradient of the Pilot Trench could be remnant artifacts of historic migration that have become entrained on soil particles, which can be inadvertently introduced into the groundwater sample collection process or they may become intermittently mobile in the fracture network of karstic terrain.

Site Source Control (SSC) systems installed in northern portion of the East Plant Area prior to trench installation collect and separately route this groundwater for treatment. As noted in the previous section, springs represent discharge points for conduit networks. These springs result from natural conduit networks that are convergent and drain nearly all the local groundwater moving through the bedrock. Groundwater in the primary porosity and non-weathered fractures moves slowly toward, and discharges into, the conduit networks. The presence of springs upgradient of the Pilot Trench indicates that one-or-more local conduit networks exist in the area and are collecting and transporting impacted groundwater to the SSC systems. There is no evidence that PCB DNAPL is transported by the network(s); specifically, DNAPL has not accumulated in any wells in the area west (upgradient) of the pilot trench, nor has separate-phase oil been identified in the treatment plant that receives the water collected by the SSC systems. Based on this information, it is possible that all impacted groundwater upgradient of the pilot trench is being collected by the SSC systems, which would explain the absence of PCBs in water pumped from the trench.

If a deeper conduit network in the bedrock exists, and impacted groundwater has reached such a network, the impacted groundwater would migrate through the network and would be expected to discharge to one-or-more springs located along Tributary 3 downstream of the pilot trench or along Bailey's Branch.

PCB concentrations in groundwater migrating through fractures toward conduit networks will be significantly attenuated by matrix diffusion, as noted by Dr. Kueper in Appendix J.2 of the draft RFI Report (GHD 2015). Additionally, due to the converging nature of karst conduit networks, contaminant concentrations in groundwater flowing through such networks are commonly reduced with distance downgradient, as tributary conduits containing clean groundwater join the flow system. Seepage of clean groundwater into the network from the rock matrix and unweathered fractures would also play a role in reducing concentrations (i.e., through dilution).

Based on the above discussion, and the length of time since the release of the contaminants, it is likely that the maximum extent of groundwater impacts due to sources in the northern portion of the East Plant Area has been attained, that is, the distribution and migration of contaminants in this area is at quasi-steady state. Under this condition, contaminant concentrations will gradually decline over time. Short term fluctuations in contaminant concentrations detected in samples collected from monitoring wells and springs can be expected. Storm events of a certain magnitude may create ephemeral, turbulent-flow conditions. Such "threshold" storms may temporarily mobilize stored contaminants, potentially including contaminants sorbed to aquifer sediments. If this transport mechanism occurs at the site, it has arguably been occurring periodically since the contaminants were released decades ago and can be characterized by implementing an appropriate storm-event-based sampling program. This condition would be more accentuated for locations outside of the cover system and may not be applicable to those locations under the cover system.

The conceptual model for karst groundwater flow described herein has several implications regarding contaminant characterization and transport:

- With distance downgradient of a source area, impacted groundwater will be increasingly confined to the conduit network. This means that a conventional "plume" of impacted water will not develop; rather, the limits of impacted water will represent the architecture of the conduit network transmitting it.
- Because the architecture of conduit networks cannot be characterized in detail, and individual monitoring wells often do not intercept the networks, more uncertainty exists regarding the details of groundwater flow and quality in the bedrock than in non-karst settings.
- Some storm events likely result in a temporary reversal of the hydraulic gradient in the conduit network. Ewers, et al. (2012) note that in situations where such reversal of flow occurs, and contaminated groundwater is present in a major conduit, impacted groundwater can invade surrounding solution and fracture porosity during storm events. The invading water returns to the conduit when the flood is past; however, contaminants can remain outside the conduit due to various mechanisms. This would result in a "halo" of impacted groundwater and/or sediments in the solution porosity and fractures surrounding the conduit that is transmitting impacted groundwater (or had done so at some time, or many times in the past). Similarly, modeling performed by Smart (1999) implies that during flow-reversal storm events, clastic sediment will be transferred from primary conduits into the aquifer and will remain there rather than being transported back to the conduits when flow reverses after the storm peak passes. If such sediments are contaminated, those transported out of the primary conduits and into surrounding solution and fracture porosity may remain there indefinitely. If a monitoring well happens to tap into a fracture containing such sediments, they may be mobilized during sampling, resulting in a sampling artifact (that is, the detected contaminants were not moving with the groundwater but rather were mobilized by the sampling process).
- Given the extreme heterogeneity of karst aquifers, water-quality data collected from monitoring wells must be interpreted with care and sound judgement. Data from some groundwater samples may represent sample collection artifacts, the quality of groundwater that is stored in (or moving very slowly through) the aquifer or the quality of groundwater moving relatively rapidly through the aquifer. Data collected from still other wells will represent some unique combination of storage and transport components. Chemical concentrations in samples

collected from some wells be affected by antecedent and current weather conditions, whereas samples from other wells will be largely unaffected by such conditions.

- Samples from springs represent the average quality of the water drained by the conduit network feeding them. Such data are useful for assessing potential exposure risks posed by the spring water as well as for detecting potential changes in aquifer conditions and contaminant-transport conditions over time.

2.5 Summary

The Pilot Trench is constructed across the northernmost of two bedrock valleys in the East Plant Area. Both valleys are tributaries to Baily's Branch, which drains northward near the Facility. The geology of the area surrounding the Pilot Trench consists of a relatively thin layer of unconsolidated material overlying bedrock. The unconsolidated material consists chiefly of residuum, the clay-rich, insoluble remnants of limestone bedrock that has been weathered in place, fill material or consolidated creek floodplain soil and sediment from the prior removal action. Bedrock beneath the area consists of four limestone formations deposited atop the Borden Group, a thick sequence of insoluble rocks – predominantly shales, siltstones, and fine-grained sandstones.

In the region, all four limestone formations have been known to develop karst. In this process, certain pathways in the rock are enlarged by dissolution. These pathways converge downgradient, forming an enhanced drainage network in the rock, and discharge at springs. As the bedrock dissolves, crevices are enlarged and cavities are formed. While mitigated as a result of the installation of a cover system, unconsolidated material can move into these openings in the rock and can be intermittently transported through the conduit network. These networks occupy only a small percentage of the rock volume – most of the bedrock is sparsely fractured, particularly at depth, and poorly transmissive. However, because they are such efficient drains, 90 percent or more of the groundwater moving through the rock does so through the conduit network. Hydraulic head data collected from monitoring wells at the site exhibit a strong downward gradient across most of the East Plant Area. These data are evidence that all four limestone formations do not form a single, hydraulically-well-connected aquifer.

Characterizing the movement of groundwater and contaminants in karst aquifers is made challenging by their extreme heterogeneity and anisotropy (i.e., unpredictability). Characterization approaches that work definitively in most other settings do not work as well in karst aquifers. Data collected from monitoring wells, while a necessary part of a characterization effort, must usually be supplemented with other data, including those collected from tracer studies. Such a study is an element of the performance monitoring plan presented in this document.

Groundwater samples collected from those monitoring wells that are poorly connected to the conduit network draining the bedrock represent the quality of groundwater that is essentially stored in the aquifer or moving very slowly toward the network. Groundwater samples collected from monitoring wells that are well connected to the network represent the quality of groundwater moving through the site. With distance downgradient, most of the impacted groundwater is isolated in the conduit network; therefore, a conventional "plume" of impacted water does not develop. A mode of contaminant transport that is important in some karst aquifers is the episodic movement of sediments through the rock in response to storm events. Storm events may also cause a temporary reversal of flow – from the conduits into narrower fractures and other openings in the rock. This process can form a "halo" of contaminants outside the conduits. Because most conduits cannot be remotely sensed and mapped, they cannot be targeted for installation of monitoring wells. This reality means that the extent of contamination in karst aquifers cannot be characterized as precisely as in non-karst aquifers. As such, identifying and mitigating potential risks to receptors is an essential element of groundwater remedial strategies in karst aquifers – arguably more important than in non-karst settings. PCB concentrations in groundwater migrating through fractures will be significantly attenuated by matrix diffusion, and the converging nature of karst conduit networks serves to reduce dissolved PCB concentrations with distance downgradient, as tributary conduits containing clean groundwater join the flow system. Samples from springs represent the average quality of the water drained by the conduit network feeding them. Such data are useful for assessing potential exposure risks posed by the spring water as well as for detecting potential changes in contaminant-transport conditions over time.

Given the nature of the karst aquifer at the site and the length of time since the release of the contaminants, the maximum extent of groundwater impacts due to sources in the northern portion of the East Plant Area is interpreted to have been attained. Under this condition, groundwater contaminant concentrations will gradually decline over time.

Figure 2.2 presents the Conceptual Site Model for the construction Pilot Trench (Section 3). This block diagram attempts to conceptually illustrate some of the groundwater movement and potential contaminant migration mechanisms presented above.

3. Description of Pilot Trench Construction

3.1 Pilot Trench Location and Description

The Pilot Trench is approximately 800 feet in length, and was installed at the northeast corner of the East Plant Area along the downgradient extent of the groundwater table beneath the property. The surface expression of the Pilot Trench alignment is perpendicular to the geomorphic valley feature defined by a drainage channel referred to as Tributary 3. Tributary 3 is the surface expression of a subsurface ravine incised into bedrock.

Groundwater flow in karstic shallow bedrock regimes, such as present beneath the Facility, are typically highly influenced by bedrock topography. Figure 2.1 shows the top of bedrock contours beneath the East Plant Area, with the Pilot Trench shown in the northeast corner. The approximate current and historical bedrock drainage channels are indicated by large arrows directed to the northeast.

The location and alignment of the Pilot Trench was designed to work in conjunction with the local geology/hydrogeology and other East Plant Area Interim Measures (IM) to provide horizontal control of groundwater migration in the northern portion of the East Plant Area. The Pilot Trench exploits the intrinsic control of groundwater flow by the bedrock topography, which includes the northeasterly trending bedrock valley that consolidates the shallow bedrock groundwater flow as well as surface water flow along the topographic and bedrock valley axis. The Pilot Trench transects, and is oriented roughly perpendicular to, this bedrock valley. In addition, the East Plant

Area Final Cover System (Cover System) has reduced overall local groundwater recharge, thereby moderating and/or reducing the flow of groundwater through the karstic rock and into the Pilot Trench. In order to further demonstrate the effectiveness of the installed Pilot Trench, hydraulic monitoring of these wells, combined with a dye trace investigation and chemical testing (described in Section 4), in addition to data collected to date (hydraulic head measurements, observed geology through observation of retrieved bedrock cores, visual and video inspection of the pre-constructed vault area and completed trench walls, packer-pressure testing, etc., will document the hydraulic performance of the Pilot Trench.

3.2 Pilot Trench Components

The Pilot Trench section of the potential Perimeter Groundwater Trench Collection System is being used to evaluate the performance of the overall groundwater collection system. Construction of the Pilot Trench consisted of removal of the overlying overburden soil, excavation of a bedrock trench, installation of collection system components, backfilling of the trench, and re-construction of the engineered cover system. The bottom design elevation of the Pilot Trench was determined based on direct observation of bedrock cores collected during pre-design drilling activities, and further verified by geophysical testing performed after removal of the overburden and prior to excavating the bedrock. The base of the excavated trench was positioned just below the bottom, of identified transmissive fractures (both vertical and horizontal) in the epi or upper karst features in the erosional bedrock surface. These fracture features are the main conduits for shallow bedrock groundwater movement in a karstic environment. The general hydraulic gradient along the Pilot Trench was designed to allow collected groundwater to naturally fall via gravity to a water collection sump, which then would pump the water to the groundwater treatment system, located to the south.

The Pilot Trench (2 feet wide, with variable depth) was cut into bedrock using a Trencor 1660 rock trenching machine, owned by H.L. Chapman Pipeline Construction, Inc. (HL Chapman), a specialty sub-contractor retained by Sevenson Environmental Services Inc, as general contractor. The rock cuttings were removed from the trench to allow for visual inspection of the trench walls and floor, along with obtaining survey data, to determine if an acceptable depth had been achieved.

After the trench depth was confirmed by field survey and cleaned (i.e., rock removed), the collection system was installed.

A physical barrier of vinyl sheet piling was installed on the east (back or downgradient) wall of the trench. The purpose of the vinyl sheet piling was to reduce the potential for groundwater entering the trench from the upgradient area to the west from passing through the downgradient trench wall. A cement-bentonite grout mixture was then poured on the trench floor to a depth of 6 inches up the sheet piling. The grout provided a low permeability seal to prevent water entering the trench from going beneath the bottom of the vinyl sheet piling, as well as to reduce the potential for downward migration.

A 6-inch diameter perforated High Density Polyethylene (HDPE) drain pipe was placed on top of the hardened grout to facilitate conveyance of collected groundwater via gravity drainage towards Wet Well #4 (WW4).

The WW4 chamber was constructed to house two dual vertical 2-foot diameter HDPE sumps at the low point within the Pilot Trench. Each sump was designed to accept a single extraction pump and to permit the free flow of groundwater into WW4 from the 6-inch diameter HDPE drain pipe. Water collected in WW4 is transferred to the on-Site Groundwater Treatment Plant (GWTP) for filtration and granular activated carbon (GAC) treatment prior to discharge at Outfall 004 under the National Pollutant Discharge Elimination System (NPDES) Permit No. IN0064424.

The excavated rock trench was backfilled around the HDPE drain pipe and to the top of the bedrock with clean imported granular material. Piezometers were installed along the east (downgradient) wall within the Pilot Trench, both along the upgradient and downgradient sides of the sheet piling. Above the granular backfill, a geotextile layer was placed to act as a filtration control to separate the granular backfill from the overlying soil. In the area where the trench extends beneath the Cover System, a sand component was added over the geotextile layer to create a vertical extension of the Pilot Trench. This extension creates a downward pathway into the trench for overburden groundwater that has been in contact with the cover system grading soils.

For the portion of the Pilot Trench located within the limits of the East Plant Area Cover System, the area was restored consistent with the previously installed cover system design. In areas outside of the cover system, common fill was used to return the topography to pre-construction elevations.

A full description of the Pilot Trench Construction can be found in the Pilot Trench Construction Certification Report (GHD, May 2, 2018).

3.3 Groundwater Treatment Plant (GWTP)

A GWTP was designed and constructed for treating PCB-impacted groundwater collected from the Pilot Trench, SCC Wet Wells #1, #2, and #3 (WW1, WW2, and WW3), and Vault collection systems [gravel underdrain system (GUS), leak detection system (LDS), and leachate collection system (LCS)], with the treated water being discharged to Bailey's Branch Creek (Creek) via Tributary 3 under a NPDES permit. The treatment processes include an equalization tank, Orival ™ filtration, and GAC. Construction of the GWTP occurred concurrent with the Pilot Trench construction. Since July 2016, the constructed GWTP has treated and discharged approximately 43 million gallons of groundwater in accordance with the requirements of NPDES Permit No. IN0064424.

4. Performance Monitoring Plan

4.1 Objectives

The objectives of this PMP are to determine if groundwater above the competent bedrock in the northern portion of the East Plant Area preferentially flows into the northern bedrock drainage valley and to the Pilot Trench, and to present multiple lines of evidence to assess whether the Pilot Trench operates as designed in capturing contaminated groundwater present above competent bedrock, thereby preventing contaminated groundwater from migrating beyond the trench at levels which would result in an unacceptable risk to human health and the environment.

Both of these objectives will be assessed during various seasons of the year. Constructed groundwater contour maps and data analyses will assist in visual depiction and analytical interpretation of the influenced hydraulic gradients, observations of the underlying geology as determined through bedrock coring retrieval, visual observations of the pre-constructed vault area and the completed trench wall, historical and new chemical data as a secondary line of evidence, thermal aerial mapping of the current spring system, and completion of a dye tracer test in this area of the Facility. Well installation logs for the existing monitoring wells can be found in Appendix A.

The proposed Pilot Trench PMP includes completion of a thermal image reconnaissance to identify seeps and springs, installation of new monitoring wells, conduct of two dye tracer tests to assess groundwater flow remote from and close to the trench, recording water levels from monitoring wells, piezometers and surface water staff gauges, further assessment of geological features, and the collection of secondary evidence through the analysis of groundwater, surface water, and spring water samples for PCBs. Details of the monitoring activities are provided in the following sections.

4.2 Groundwater Monitoring Well Installations

Prior to completion of this PMP, GM has installed ten groundwater monitoring wells in the vicinity of the Pilot Trench in order to obtain additional sampling location for monitoring of the performance of the trench (CH-61 through CH-70). These locations are provided on Table 4.1.

Seven new vertical groundwater monitoring locations were installed preceding this plan using a 6-inch diameter outer steel casing set approximately two feet into the top of the bedrock surface in order to obtain a seal from the overburden materials. The steel casing was then grouted into place using a cement-bentonite grout mixture. Once the grout was set, bedrock coring continued below the depth of the outer steel casing using a HQ core barrel. Upon completion of the coring, the corehole remain open so that the length of the cored section of bedrock is open to groundwater, where present. All monitoring wells were completed with a concrete base and a locking cap at the surface. Additional bollards were also installed around the completed monitoring wells. All wells were developed and surveyed for ground and top of casing elevations. Total depths at each location were approximately 10 feet below the bottom elevation of the constructed Pilot Trench. Table 4.1 presents the installed monitoring wells, the rationale and intended use of each of the locations, and the schedule of the proposed monitoring for the activities described herein.

Three additional groundwater monitoring wells were installed at a 30-degree angle (from vertical) to be used as additional monitoring locations to assess the performance of the Pilot Trench. These three locations were completed using an angled installation (approximately 30 degrees from vertical) in order to enhance the possibility of locating the same fractures, or fracture system identified in the videos of the completed Pilot Trench. These angled coreholes were oriented in a north-south direction in an attempt to intersect the east-west trending vertical fracture. One of the paired coreholes was located upgradient and the other one will be located downgradient of the installed Pilot Trench. Figure 4.1 show the completed locations (CH-69 and the paired locations CH-68 and CH-70). Each of these newly proposed monitoring wells were cored via HQ coring techniques and were completed at depth to a similar elevation as the previously installed wells (approximately 580 feet above mean sea level (ft. AMSL).

4.3 Groundwater and Spring Water Monitoring for PCBs

4.3.1 Background

Historical detections of PCBs in groundwater have been detected during the RFI. . Groundwater results in the area of the Pilot Trench have historically detected concentrations of PCBs at locations upgradient of the Pilot Trench location. Detections of estimated PCBs have been detected at 8 groundwater samples from 6 different wells in the shallow groundwater flow system in the area that is included within this study, ranging from estimated concentrations of 0.042J ug/L (MW-X143Y245D-1) to 2.978J u/L (MW-X143Y193CG). In all, there have been 8 detections of total PCBs from 92 samples collected. In addition, detections of PCBs were reported at 510 ug/L and 5.1 ug/L, within the intermediate groundwater flow system at monitoring well MW-X178Y367D-2 and MW-X178Y367D-3, respectively) out of 57 samples collected. However, these detections occurred during a period (May 2006) where the laboratory reported analytical issues related to a previous batch of samples that had been analyzed (non-project related). There were no detections of PCBs from samples collected in the deep groundwater flow system out of 21 collected. Spring water All results and locations are presented in Appendix H and Figures 7.1.1 through 7.1.5 located in the draft RFI Report, GHD, September 30, 2015). Figure 4.2 of this workplan also presents the historical PCB detections in groundwater.

Historical detections of PCBs in seep and spring water have been detected during the RFI. Note that many of these detections were prior to completion of Interim Measures (IM) activities. The seep water is perched groundwater located upgradient and beneath former AOI 4, which was historically discharging to the ground surface near the northern limits of the fill material in the East Plant Area. These seeps and perched groundwater have been captured through implementation of the Site Source Control (SSC) systems in those areas. This groundwater is now all being drained to Wet Well #3 and is treated prior to discharge via a NPDES permit.

There have been 4 estimated detections of the 17 surface water samples collected at the Tributary 3-3 location ranging from 0.067J to 0.13J ug/L, prior to the completion of the SSC systems and prior to the installation of the surface cap and installations of the drainage basins. There have been no detections since May 2014 at the Tributary 3-3 location. Groundwater and surface water results are presented on Figure 4.2.

There have been several springs identified during an aerial infra-red, thermal survey conducted in 2004 and subsequently verified at the ground surface. These seeps and springs were included in the Site Source Control (SSC) Study, where several samples were collected during an approximately 3 year study (note that some springs were sampled prior to the SSC program). Many of these springs have been included in subsequent soil removal and surface water controls as part of Interim Measures implementation. The following provides a brief summary for the samples collected from the seeps and springs located within and near the current Pilot Trench Monitoring Plan (many of these results were from samples collected prior to IMs):

- Four springs were previously sampled out of six identified along the Northern Tributary. Out of the 33 samples collected in total, there were 6 positive (some estimated) results for total and/or dissolved PCBs. The range of detections was from 0.33 to 6.05J ug/L located in the headwaters of the Northern Tributary. This area has since undergone an extensive soil removal IM. One additional detection of PCBs was identified further downstream at an estimated concentration of 0.947J (16 samples were collected from this location with only the one estimated detection collected during the middle of the SSC program).

- From Outfall 002 (former and current), along Bailey's Branch to the confluence of Tributary 3, Eight springs were identified prior to the completion of the water control and soil IMs. Of these 8 springs, 5 were sampled during and prior to the SSC. Detections near the headwaters (Seep 001 at Outfall 002), ranged from 0.14J (2007) to 9.9 ug/L (2004). An SSC collection system was installed during this time period. One other detection was reported from Spring 013 at 0.27 ug/L during 2004.
- There were 6 springs identified from Bailey's Scales Road along Tributary 3 to the confluence with Baily's Branch. All of these spring were located along the southern bank on Parcel 15. Of the 17 total samples collected, there was one estimated detection of PCBs at 0.096J ug/L.
- From the confluence of Tributary 3 and Bailey's Branch to the confluence of Bailey's Branch and the Northern Tributary, and including smaller ephemeral tributaries (exclusive of Spring 018, Spring 018B, and Spring 018C), Sixteen seeps and springs were identified and sampled during the SSC program. In total, 14 locations were sampled with 21 detections out of 111 samples collected along this stretch. Of those, 5 springs were located immediately downgradient of Spring 0018 Area (prior to containment). Of the 21 total detections, 14 exhibited detections ranging from 0.11J to 810 ug/L in 2004. Containment at the Spring 018 Area and remediation of the creek material has occurred subsequent to this time. The other 7 estimated detections were a little further downstream and ranged from 0.038J to 0.12J ug/L.

Figure 4.3 presents the locations and historical databoxes of the previous seeps and springs along with the currently identified thermal anomalies identified during the 2019 unmanned aerial systems (UAS) study. Several of the previous seeps and springs do not currently exist due to IM implementation. However, several current anomalies were determined to be previous seeps and springs that have been sampled for total and dissolved PCBs. All 2019 identified anomalies will be field verified, where access is granted.

4.3.2 Proposed Groundwater Monitoring

Groundwater samples for total and dissolved PCBs will be collected at 42 locations near the vicinity of the Pilot Trench and will be used as a secondary line of evidence to support and evaluate current conditions related to the performance of the Pilot Trench. Eleven of these samples will be collected from groundwater monitoring wells (existing and newly installed) and two will be collected from the two Wet Wells (3 & 4). Of the 42 locations, 7 are included in either the CA750 monitoring program or during the monthly collections at Wet Wells 3 & 4. Table 4.1 presents a list of monitoring wells and Figure 4.2 shows the locations where it is proposed to collect samples under this program.

All groundwater samples will be collected using a zero-purge sampling protocol under low-flow sampling procedures. All samples will be submitted to Test America Laboratories (TAL) for analysis of total and dissolved PCBs under normal chain of custody protocol. Samples that are not part of the CA750 program (or monthly collection) that have positive detections will be considered for inclusion in part under the CA750 program or as a separate program specifically designed for the evaluation of the trench performance. That decision will be discussed with the U.S. EPA prior to any future sampling events.

4.4 Hydraulic Monitoring Locations

The existing wells that are most appropriate for monitoring to assess performance of the Pilot Trench are listed in Table 4.1. Figure 4.1 presents the forty-nine existing locations to be monitored during this activity to assess the overall performance evaluation of the Pilot Trench, including existing monitoring wells and piezometers, the newly installed and newly proposed monitoring well locations, and staff gauge. Table 4.1 also presents the proposed schedule of water elevation collections, method of monitoring, and rationale for each location.

4.5 Piezometer Locations within Pilot Trench

Fifteen, 2-inch diameter piezometers were installed at approximate 50-foot intervals along the Pilot Trench alignment during construction. Of the 15 installed piezometers, 7 were installed to the north of WW4 and 8 were installed south of WW4. Eleven of those piezometers were installed within the Pilot Trench, along the inside groove of the vinyl sheet piling and rested on the grout base. The other four piezometers were installed along the outside groove of the vinyl sheet piling to similar depths. The purpose of installing these trench piezometers is to assist in the evaluation of the Pilot Trench hydraulic performance. Piezometer locations along the trench alignment are shown on Figure 4.1. Table 4.1 presents the frequency, method of hydraulic monitoring, and rationale two of the 15 piezometers.

4.6 Well/Piezometer Monitoring

Hydrostatic water levels will be recorded from monitoring of existing coreholes/wells/piezometers and proposed monitoring wells located downgradient and upgradient of the Pilot Trench. The proposed monitoring wells for pressure-transducer and hand measurements of hydraulic head, and schedule for monitoring are provided in Table 4.1. Water level recordings from both the installed transducers, as well as manual readings, will help to evaluate the Pilot Trench performance. Pressure transducers/data loggers will be set to record head readings every 15 minutes and will be downloaded monthly (the back-up sump at Wet Well 4 will be monitored with a pressure-transducer so that the working pump will not interfere or damage the equipment). Should it be determined that fewer, different or more locations are desirable for pressure transducers, they can be removed, moved, or added to in the future. All locations are presented on Figure 4.1. All hydraulic head measurements will be recorded more frequently during the first month of monitoring, then monthly, then quarterly in order to increase the opportunity to capture rainfall events and variable pumping rates from the operation of the trench.

4.7 Staff Gauge Monitoring

In addition to the existing and proposed monitoring wells and piezometers, one surface water staff gauge will be installed within Tributary 3, downgradient of the Pilot Trench (refer to Figure 4.1). The staff gauge will be mounted on a pipe installed within the bottom of the creek. The staff gauge will be graduated and surveyed to determine the elevation of the reference point for measurement.

Monitoring the surface water elevations will be included in the hydraulic assessment of the trench performance to help assess the groundwater-surface water interaction downgradient of the Pilot Trench. The rate of recording the surface water elevations will be the same as the hand measurement.

4.8 Thermal Imaging Reconnaissance

Prior to the preparation of this plan GM conducted a thermal image reconnaissance study along the upper portions of Bailey's Branch to identify any existing and current springs flowing into those surface waters (areas approximate coverage area is shown on Figure 4.3). The purpose of this study was to identify any new, or previously unknown springs that can be used to monitor for the presence of dye (Section 4.9) and for the collection of sample for analysis of PCBs.

To prevent the administrative burden and timing of securing access agreements and to mitigate the risks associated with a ground-based survey, unmanned aircraft systems (UAS) affixed with visible-light and infrared cameras were determined to be the best solution for identifying groundwater seeps and springs. A remote pilot certified by the Federal Aviation Administration completed operations in public airspace to collect non-identifiable imagery of the creek systems north, east, and northeast of the Facility operations. As a courtesy to neighboring property owners, GM distributed mail-out flyers to the community notifying them of the proposed UAS operations. The survey was conducted during the week of March 18, 2019, in order to capture temperature differences between the warmer groundwater and the cooler ground surface and surface water.

The thermal infrared camera utilized for this application was an uncooled VOx microbolometer with a 13mm lens capable of capturing 640x512 pixel resolution radiometric images. The sensor has a spectral band of (7.5-13.5 μm) and a scenic range -25° to 135°C. At 150 ft. above ground level, the sensor can scan a 200 ft. wide area, measure distinct thermal anomalies greater than/equal to 0.90 ft^2, and detect a temperature difference (ΔT) of 0.05 °C.

Imagery was then compiled into a thermal report, side-by-side video of visible light and identified thermal anomalies, and a visible light mosaic of the area flown.

4.9 Dye Tracer Testing

Standard Operating Procedures for the collection and analyses for the dye tracing studies presented below are described in Appendix B.

4.9.1 Previous Dye Tracer Study Near The Proposed Dye Tracer Study

Overview

On March 22, 2005, a dye trace test was conducted at the GM GPS Bedford Facility consisting of two separate injection of separate dyes near the Pilot Trench Area. The purpose of these traces was to identify groundwater flow-paths at the site. Injections were conducted in monitoring wells (bedrock and overburden). Below is a brief description of the lessons learned and results of the 2005 tests (Figure 4.7).

Lessons Learned

- AOI4 dye trace showed groundwater flow predominantly to the east, in the direction of the Pilot Trench.
- AOI4 dye trace highlighted the complicated nature of injecting dye into wells as no dye was recovered from injections at three wells. The lack of detections was likely due to poor communication with existing conduits through the system at the injection locations, resulting in inconclusive testing results.

AOI4 – Dye Trace Summary

<u>Injection Well 1: TMW-X193Y251.</u>

Formation: Overburden.

Injection Elevation: 659.5 ft to 654.5.35 ft.

Dye Used: Fluorescein

Injection Date: 3/22/05

Detections: 12 locations, See Table 1.

Travel Time Range: 18.6 ft/day (SSC System F) to 1.5 ft/day (SSC System B).

Arrival Time Range: 36 days (SSC System E) to 1 year 7 months (SSC System B).

Travel Direction: Predominantly east, slight northerly component.

<u>Injection Well 2: MW-X145Y245S.</u>

Injection Formation: St Louis Limestone.

Injection Elevation: 681.35 ft to 670.35 ft.

Dye Used: Rhodamine WT

Injection Date: 3/22/05

Detections: None. Inconclusive results.

Travel Time Range: NA.

Travel Direction: NA.

4.9.2 Goals and Objectives for Proposed Dye Tracer Study

In order to assist in assessing project requirements, the following goals and objectives are provided:

1. Enhance the understanding of the karst flow system upgradient of the Pilot Trench
2. Assist in the evaluation of the lateral and vertical extent of capture of Pilot Trench to demonstrate the effectiveness of the Pilot Trench in capturing groundwater and minimizing by-pass

4.9.3 Background Monitoring for Proposed Dye Tracer Study

In order to enhance the data collected during hydraulic head measurements, a dye tracer test will be conducted in the area of the Pilot Trench. This area was previously dye tracer tested in 2005 (HGI, 2006) with fluorescent dyes being injected in the overburden (Fluoroscein), and shallow bedrock (Rhodamine WT). These two dyes are preferred when using two at one time due to the larger wavelength separation in laboratory detection techniques, in case of potential mixing of dye-injected water. Prior to injection of any new dyes, the proposed network will be sampled for background conditions to determine whether any prior dyes remain in the system before new testing at the locations described in Table 4.1 and depicted on Figures 4.5 and 4.6

4.9.4 Dye Injection for Proposed Dye Tracer Study

GM will monitor a large network of monitoring well locations, as well as surface water and spring water locations for the presence of dye, including a thorough dye background monitoring program prior to the final selection of dye types and prior to dye injection. The base set of surface water and spring water sampling locations will be based on the previous locations sampled during the AOI4 dye tracing study, where locations are still available. Additional surface water and spring water locations may be added based on the thermal photographic and visual reconnaissance that was conducted as part of this PMP (Section 4.8).

The overall success of any dye tracing is a direct result of the appropriateness and inter- connection of the dye introduction locations. It is undesirable to introduce dye into a location that is in poor connection to the bedrock drainage network, which could result in inconclusive results. It should be noted that PCBs have been primarily found in the shallow karstic groundwater system, and as such, it is appropriate to inject into that system. GM will not be evaluating injection locations in units where PCBs have not been identified in the past sampling. The following text discusses two general testing locations as they relate to distance from the Pilot Trench (Near Field and Far Field). The Near Field locations were chosen based on existing and proposed locations that can best demonstrate the horizontal performance of the Pilot Trench in capturing any groundwater in the vicinity of the trench. The second test, Far Field, was chosen by virtue of the vault underdrain system to distribute dye into the karst flow system , that it represents a potential PCB-impacted groundwater source and to assist in the understanding of the potential for groundwater in the northern portion of the East Plant Area to be captured by the Pilot Trench.

Two dye tracer tests are being proposed under the PMP. The first test will be to inject dye in three areas immediately upgradient of the Pilot Trench. The initial injection is proposed at CH-20 (mid-section of the trench which extends deeper into the bedrock), with a second injection of the same fluorescent dye at either end of the Pilot Trench, at a minimum of one month after the first, at the proposed angled wells (CH-68 and CH-69) and will include up to six months monitoring at downgradient locations (referred to as the Near Field testing). These injections will be focused on potential pathways in the immediate upgradient area of the trench to gauge the vertical and horizontal effectiveness of the Pilot Trench at collecting groundwater that flows within this northern bedrock valley. Figure 4.5 presents the proposed tracer injection and monitoring locations. The purpose of this testing, along with the results of head measurements, will be to assist in the assessment of the hydraulic capture of the Pilot Trench operation. Table 4.1 presents the proposed locations to be monitored for both of these injections.

At the conclusion of the Near Field test, a second dye trace test, referred to as the Far Field test, will inject a different fluorescent dye within the Vault Gravel Underdrain System (GUS) using the Vault cleanouts and will be monitored at the same locations as the first dye injection. In addition, the monitoring network will be expanded to include other locations south and north of the injected area. Table 4.1 presents the locations to be monitored during this separate dye tracer study.

This second study (Far Field) will be conducted at the GUS to evaluate groundwater flow farther upgradient of the Pilot Trench in an area hydraulically connected to the northern bedrock valley. In addition, the GUS has PCB-impacted groundwater and is hydraulically connected to the shallow groundwater flow system. Figure 4.6 presents the dye injection location and monitoring locations for the GUS dye tracing testing. Monitoring at well locations under this program will also be for a duration of six months. Given that the surface and spring water locations are potentially longer travel times from the injection location, the sampling for dye at surface water and spring water, as identified through completion of the thermal and visual reconnaissance, may be extended for three additional months. While exact travel times are not necessary to assess either general groundwater flow nor the Pilot Trench capture potential, this evaluation (using charcoal packs) will record relative travel times for dyes to reach various sampling locations.

The final PMP monitoring locations for sampling for dissolved and total PCBs at surface water and spring water locations will be dependent on only those locations with positive dye detections. The proposed monitoring sampling network will be sampled regardless of the outcome of the dye tracing study. The monitoring well and final surface water/spring water PCB sampling will help assess the broader understanding of the distribution of PCBs in the area of the trench, as well as potentially assist in the assessment of the performance of the Pilot Trench. Locations noted above may be re-sampled during the subsequent CA750 sampling event if PCB concentrations above the reporting limit are detected. This decision will be discussed with the U.S. EPA prior to future sampling events.

The water that will be injected with dye tracers will likely be captured via Wet Well 3 and Wet Well 4, which will be sent to the groundwater treatment plant for treatment with activated granular carbon. The discharge of the treated water (Outfall 003/004) is then sent to a common discharge location on the Facility property prior to reaching the surface waters of Tributary 3. This location will be monitored for the presence of any dye that may not have been removed through the treatment process. Though unlikely, if dye is detected within the discharged water and allowed to move downstream, any potential future dye detections downstream of the Outfall may be compromised and the analysis/interpretation of those results may be impossible to distinguish between groundwater discharge of dyed water downstream and the discharged water from the treatment process. Surface water within portions of Bailey’s Branch and Tributary 3 are known to recharge the groundwater prior to returning to discharge downstream to the surface water.

4.9.5 Dye Monitoring and Schedule for Proposed Dye Tracer Study

Monitoring for background conditions and for the detection of the injected dyes will be at the locations presented in Figures 4.5 and 4.6. Monitoring will be completed through the collection of groundwater samples at the locations identified by means of pumps installed at the Waterloo well locations and through the placement and retrieval of charcoal packs, as described in Table 4.1. The frequency of sampling will vary by locations. Table 4.1 presents the locations, anticipated method of sample collection, and anticipated schedule and duration for the twenty-three locations to be monitored for the presence of dye after injection. It should be noted that if a dye is not detected within a six month period, then the test will be deemed complete and that the fractures did not connect enough to form a pathway to the trench. In this case, the need for any additional testing will be evaluated and discussed with the U.S. EPA.

4.9.6 Quality Assurance/Quality Control

Field and laboratory standard operational procedures for the collection and analysis of fluorescent dye samples can be located in Appendix B to this PMP.

4.10 GWTP Monitoring

Monitoring activities for the GWTP includes sampling of the treated discharge as required by the NPDES permit. The discharged water is tested monthly for PCBs, Oil and Grease (HEM), and Total Suspended Solids (TSS). The GWTP monitoring will be reviewed as part of the scope of the Pilot Trench monitoring. GWTP operational samples include monthly monitoring of the system influent (including wet wells and vault sumps). All sampling regarding the GWTP will be reported in Quarterly Progress Reports and the CA750 Reports.

4.11 Data Quality and Analyses

4.11.1 Data Quality Objectives

Problem Statements

- Does the groundwater above the competent bedrock in the northern portion of the East Plant Area preferentially flow into the northern bedrock drainage valley and to the Pilot Trench?
- Do lines of evidence support a determination that the Pilot Trench operates as designed in capturing contaminated groundwater present above competent bedrock, thereby preventing contaminated groundwater from migrating beyond the trench at levels which would result in an unacceptable risk to human health and the environment?

Study Goals

The goal of this study is to assess groundwater flow in the northern portion of the East Plant in relation to the groundwater above competent bedrock horizontal capture performance of the installed Pilot Trench with respect to this area. The study will gather relevant data and information, employ various techniques and use a multiple lines of evidence approach (e.g., existing geologic conditions as observed through bedrock corings and trench face evaluation through visual and video observation, ground penetrating radar, packer-pressure testing, groundwater head measurements and evaluation, PCB sampling of groundwater and spring water, dye tracer testing results, etc.), to evaluate the performance of the Pilot Trench relative to the design intent of capturing the horizontal groundwater flow above competent bedrock. Each line of evidence is described below.

Information Inputs

The following types of data input will be evaluated during this study.

Each of these lines of evidence, while individually not adequately define the overall capture performance of the Pilot Trench, can be used to assess trench performance:

- Existing overall geologic conditions as determined through installation of coreholes, visual examination or collected cores, packer-pressure testing for hydraulic conductivity, downhole geophysical data collection and evaluation, the evaluation of the completed trench faces through the design process, and the installation of new vertical and angled coreholes post trench construction.
- Hydraulic head measurements will be collected from a suite of monitoring wells at differing elevations that will provide the direction of groundwater flow, evaluation of hydraulic gradients, and seasonal and weather-related episodic conditions. Data will be collected both manually and with pressure transducers installed in select monitoring wells.
- Sampling of PCBs in groundwater monitoring wells, collected trench water and spring and surface water will also be collected as part of the multiple line of evidence approach. These data will be evaluated as part of the multiple lines of evidence approach.
- Dye tracer studies can provide information on groundwater flow from point A to point B so as to create a general picture of where groundwater may be flowing through the subsurface karstic system. They can also be used, in combination with other supporting lines of evidence, to assess where groundwater may not be readily flowing (within the time constraints of the study). In addition, dye introduced in a source area that subsequently shows at a distal location is not a sole indicator that any contamination would ever have been detected at the distal location, as the dye tracer is more soluble and conservative than a contaminant migrating. Conversely, the absence of dye at a distal location does not necessarily indicate that such a sampling point have never, nor would ever receive any migrating contamination from the point of introduction.

Because there are no other scientific methods available to be able to map the actual subsurface conduits, this study will use each line of evidence together to provide a reasonable review of the Pilot Trench Performance.

Study Boundaries

Vertically, the study is primarily bounded by the shallow groundwater flow system, which is underlain by the top of the competent bedrock. While, there will be checks on monitoring wells in the intermediate and deep flow systems, data to date have shown that the majority of the contamination at the Facility is limited to the upper portions of groundwater flow which is dominated by karstic and significantly fractured rock. Horizontally, the study will include upgradient, side gradient, and downgradient locations within the northern portion of the East Plant Area of the Facility, near the Pilot Trench Area (The attached figure presents the horizontal physical boundaries). Each study, or line of evidence, will have slightly different boundaries specific to that task, as described in the above scope of work

Analytic Approach

- Continuing assessment of the geologic conditions will be augmented through the installation of the new vertical and angled coreholes
- Hydraulic head measurement will be completed through hand measurement and pressure-transducers, in accordance with the existing QAPP for the RFI
- Groundwater, collected trench water, surface water, and spring water will be sampled in accordance with the existing QAPP for the RFI

Dye tracer tested will be completed by fluorescent dye injection, sampling of grab and charcoal packs, and analyses at a fixed facility laboratory, in accordance with Appendix B.

Performance or Acceptance Criteria

The collected analytical data will be evaluated as follows:

- Hydraulic head will be measured to the nearest 0.01'. These data will be plotted on graphs showing head trends at each location along with recorded rainfall. These data will also be selectively presented as potentiometric surface figures in order to illustrate relationships between rainfall and the pumping operations at the Pilot Trench. The pumps within WW#3 and WW#4 may also be temporarily shut down in order to monitor the recovery of the aquifer and then re-started to monitor the response to pumping. GM will also be recording the staff gauge for surface water elevations at the Tributary 3-3 location. These head evaluations will provide, in part, a more complete definition of the general capture zone for the Pilot Trench operations.
- Groundwater, collected trench water, surface water, and spring water sampling will include total and dissolved PCBs. Interpreting sample results can be challenging due to the potential for particulates, which preferentially retain PCBs, being inadvertently introduced into the sample during the collection process. The results of this sampling will provide a current condition for the presence or absence of PCBs at individual locations. Groundwater sampling will continue at twice per year thereafter at the locations included in the EI CA750 program. Additional locations may be added for further evaluation and will be discussed with the U.S. EPA prior to proceeding.
- Dye tracing results will be analyzed from grab and charcoal sample collected at locations presented in Table 4.1. Final spring and seep sample locations, will be agreed upon in consultation with the U.S. EPA, and will be based on current conditions resulting from the completed thermal study, as well as previously collected seep and spring samples. The actual dyes that will be used will be based on a thorough background sampling to identify if any previously used dyes are still present within the groundwater system. The results of the monitoring after dye injection will assist in the evaluation of the performance of the Pilot Trench operations and will provide a better understanding of flow patterns in the area. Specific rates of travel through the karstic rock, though not the goal of, nor needed for, the study, will also be calculated based on distance traveled and sample collection time associated with a positive laboratory result.

4.11.2 Data Analysis

The shallow groundwater potentiometric surface in the area of the Pilot Trench is influenced by the topography of the historical bedrock drainage valley defining Tributary 3 (Figure 2.1). The shallow groundwater potentiometric contouring in the Pilot Trench area shown on Figure 4.8 illustrates this influence prior to the completion of the East Plant Area Cover System. The potentiometric contours shown on Figure 4.8 are based on groundwater conditions in December 2010. Figures 4.9 to 4.12 present the shallow groundwater potentiometric contours from yearly monitoring prior to the Pilot Trench completion and yearly monitoring after the Pilot Trench construction. Figures 4.13 to Figure 4.16 depict the shallow groundwater potentiometric surfaces after operation of the Pilot Trench began in March 2016, Figure 17 depicts a graphical chart of hydraulic heads from selected existing wells in the area prior and subsequent to the Pilot Trench completion. As can be seen in the progression of potentiometric surfaces, the influence of the Pilot Trench has lowered the potentiometric surface near the trench and increased the hydraulic gradients toward the trench at upgradient and side-gradient locations, as well as increased the area of capture of the shallow groundwater. Because the pump operates in a cyclic manner (i.e., activated by a high-float switch), steady-state conditions may never be technically realized. However, it is anticipated that a steady-shape will be clearly demonstrated. Continual monitoring of the proposed network will provide useful data for the evaluation to be completed under the Corrective Measures Proposal (CMP). The data collected from the dye tracing (Section 4.9) and the hydraulic head monitoring will be evaluated in a similar fashion as shown in Figures 4.8 to 4.16. Other analyses may include point-by-point data evaluation between monitored locations, time trends for seasonal pumping fluctuations and precipitation, hydraulic gradients, surface water-groundwater interaction downgradient of the trench, and comparison to previous dye tracing for a more complete evaluation of the performance of the Pilot Trench.

U.S.EPA has requested that GM include PCB sampling as a “secondary line of evidence” to supplement the dye trace testing and hydraulic monitoring. GM has stated its concerns with relying on PCB groundwater results without additional lines of evidence for purposes of assessing the performance of the Pilot Trench collection system. Some of these concerns include:

- There is a possibility for sampling artifacts. It is possible that PCBs migrated beyond the Pilot Trench prior to its installation and came to be adsorbed onto unconsolidated materials lining weathered fracture faces or unconsolidated materials deposited in grikes or other solution-widened elements of the bedrock drainage network. If such features happen to be penetrated by a monitoring well located downgradient of the Pilot Trench, the sampling process could mobilize particulate matter to which PCBs are adsorbed, entraining them in the sample. Thus, the PCBs detected in the sample would not be indicative of PCBs moving with the groundwater, but rather of historical, immobile PCBs sorbed to the aquifer matrix and would have no relation to the operation of the Pilot Trench.
- There is a possibility that some groundwater in more stagnant portions of the bedrock downgradient of the trench (for example, in tight fractures or in the matrix pore water) contains PCBs from historical migration prior to installation of the Pilot Trench. Such “pre-existing” PCBs, which would be moving very slowly toward more active elements of the bedrock flow system, would not be relevant to the performance of the trench.

- There are potential challenges associated with the ability of laboratories to consistently and accurately detect and report very low concentrations of PCBs in groundwater samples and sometimes false detects occur. To minimize this potential GM will rely on one laboratory so that a consistent detection/non-detection and identification of the specific Aroclor patterns will be reported. An additional laboratory may be used if any difficulties are noted at the original lab.
- There are potential challenges associated with potential entrained sediment, or colloidal material, from surface water and/or spring water, after remediation to the cleanup standards (Ewers, et.al., 2012)

If PCBs are detected downgradient of the Pilot Trench, they will be evaluated in light of the above potential issues with the data, which may include additional sampling or other potential additional investigation.

As a result, data analysis of each monitoring activity individually, and in combination, will sufficiently document the hydraulic capture capability of the installed Pilot Trench. Individually, the dye tracer results will show a conservative groundwater flow pathway from the point of injection to points of detection qualitatively. The detailed hydraulic head evaluation through time will show a generalized flow pattern of the Shallow groundwater flow system in this area. PCB sampling will provide a current snapshot of existing concentrations in groundwater and surface water, which may result in additional sampling in the future. All, in combination, will provide demonstration of the overall performance of the Pilot Trench in the capture and treatment of the Shallow groundwater flow system in reducing, or eliminating, potential contaminant migration in this system from moving off-Site.

5. Reporting

Note that not all data collected under the thermal and dye tracer studies, or the PCB sampling may end up being directly related to the performance of the Pilot Trench. However, all data will be provided, summarized, and described as to the relative usefulness in evaluating the performance of the Pilot Trench hydraulic control. All results of the activities described under the PMP will also be evaluated as to any data gaps identified that may be relevant to the Pilot Trench and/or any potential future IMs at the Facility.

GM may also request future modifications to this proposed performance monitoring program based on the performance of the Pilot Trench through evaluation of the data, described herein.

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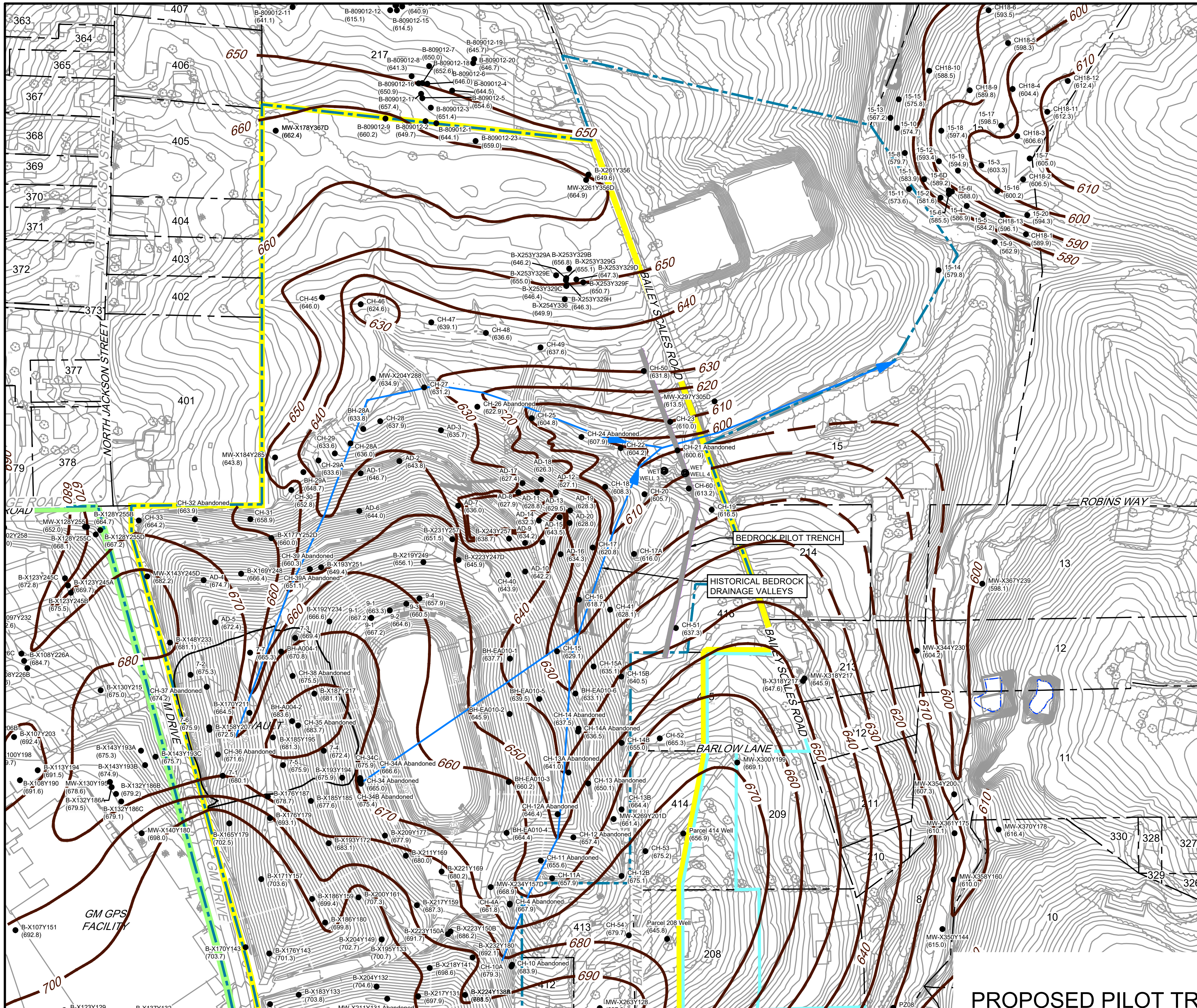

N

0 150 300ft

LEGEND

- EXISTING GROUND SURFACE ELEVATION CONTOURS (feet AMSL)
- EXISTING VEGETATION
- EXISTING BUILDINGS
- FENCE LINE
- RAILROAD TRACKS
- DIRT ROADS
- ROADS / PAVED AREAS
- APPROXIMATE PARCEL PROPERTY
- APPROXIMATE GM PROPERTY BOUNDARY
- APPROXIMATE SURFACE WATER LOCATION
- EAST PLANT COVER SYSTEM LIMIT
- EAST PLANT AREA
- WEST PLANT AREA
- GM LLC OWNED RESIDENTIAL PROPERTIES
- PILOT TRENCH ALIGNMENT
- WET WELL 4 — WET WELL
- EXISTING COREHOLE AND MONITORING WELL LOCATIONS NEAR PROPOSED BEDROCK TRENCH
- 610 — BEDROCK CONTOUR (FT AMSL) DASHED WHERE INFERRED
- DIRECTION OF HISTORICAL SURFACE WATER FLOW

NOTE:
GM PROPERTY BOUNDARY SURVEY BY BLEDSOE RIGGERT GUERRETTAZ RECEIVED OCTOBER 2007. ADJACENT PROPERTY BOUNDARY LOCATIONS APPROXIMATED FROM THE LAWRENCE COUNTY SURVEY PLATS. ADJOINING PROPERTY LINES MAY NOT ACCURATELY REPRESENT THE TRUE PROPERTY BOUNDARIES

SOURCE: BASE MAP COMPLETED BY AIR-LAND SURVEYS, FLINT, MI, APRIL 2001 AND CRA SURVEYS 2002 TO 2013.

GHD

figure 2.1

TOP OF BEDROCK CONTOUR MAP
PROPOSED PILOT TRENCH PERFORMANCE MONITORING PLAN
TRENCH COLLECTION SYSTEM
GM GPS BEDFORD FACILITY
Bedford, Indiana

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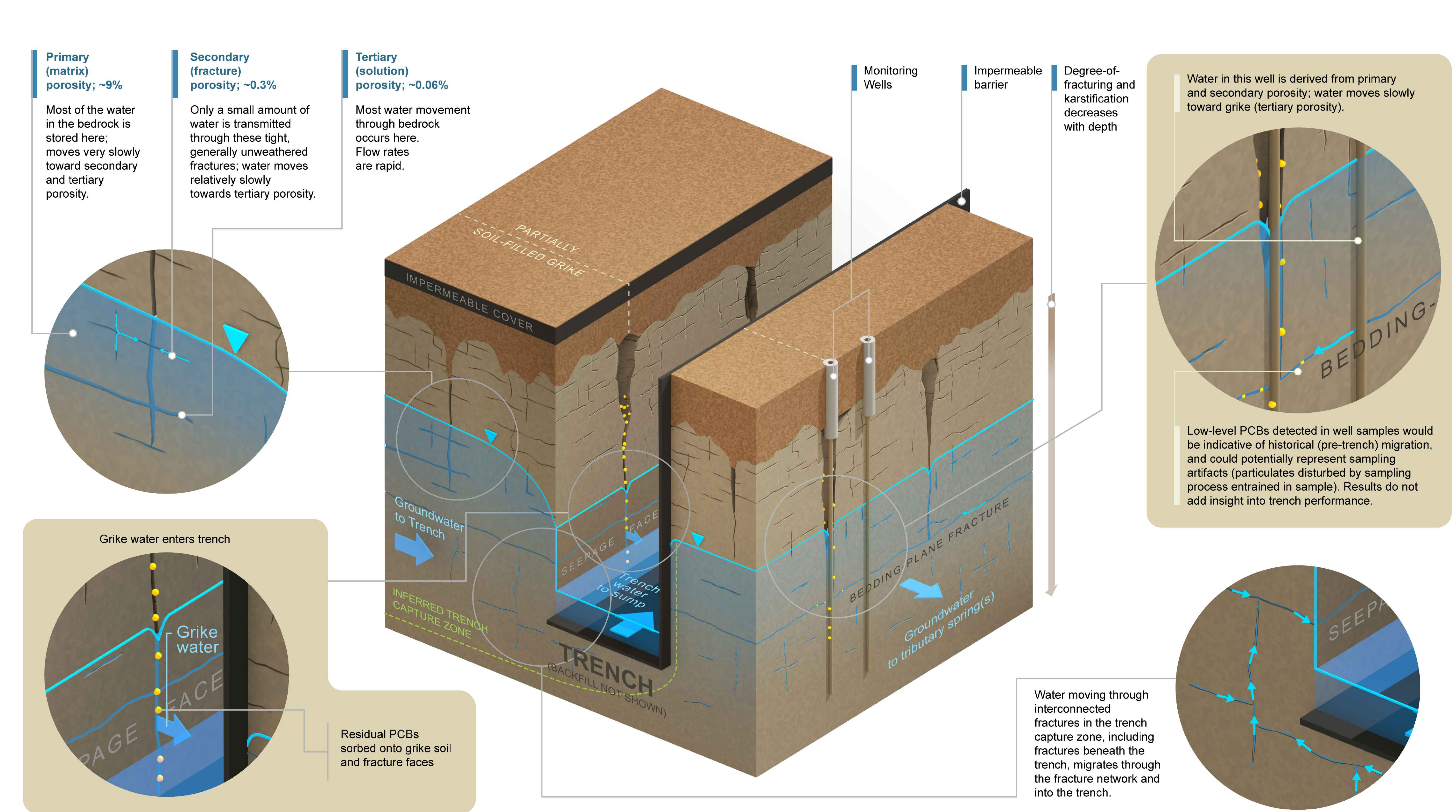


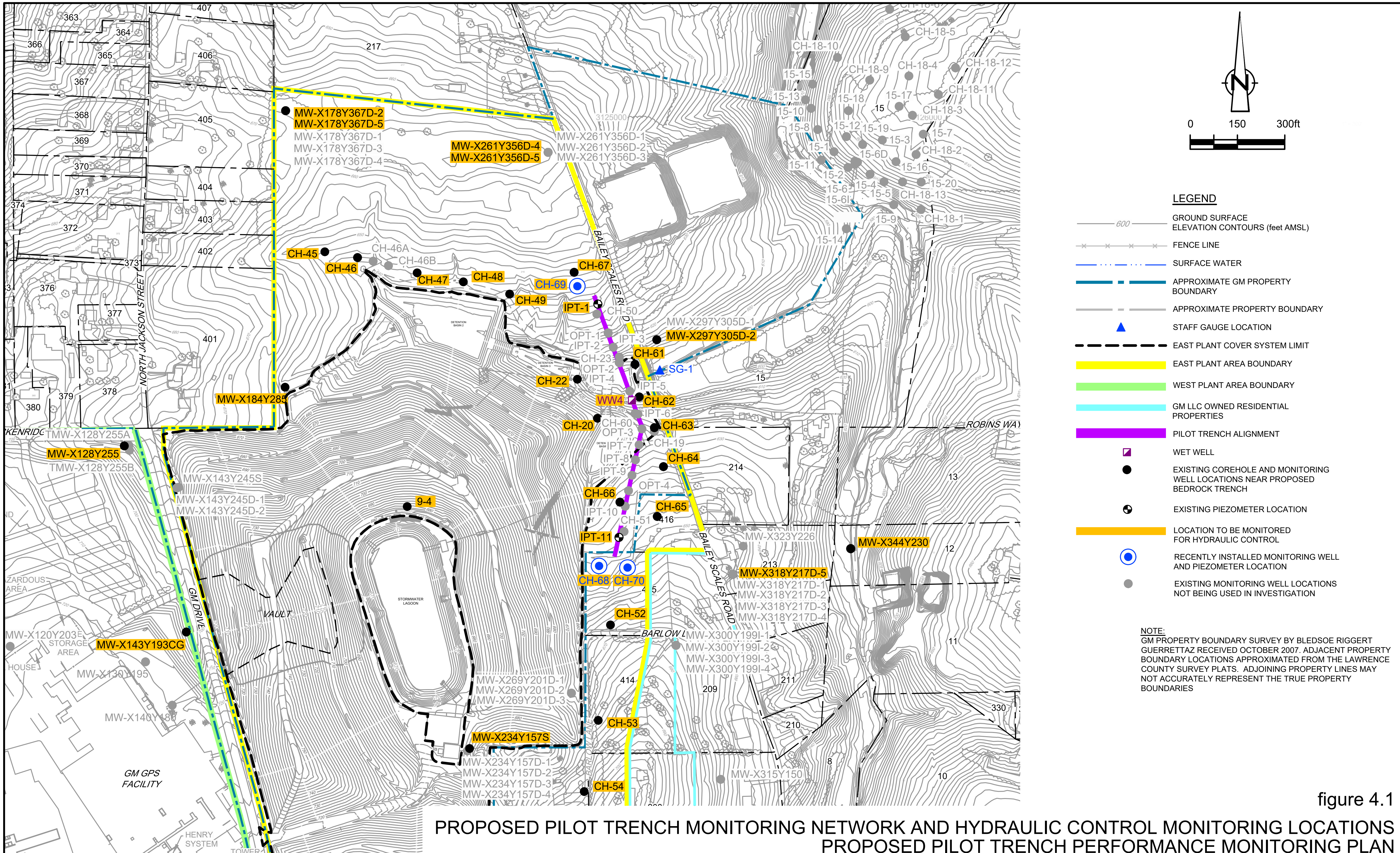
Groundwater flow direction in fracture

NOT TO SCALE

figure 2.2

CONCEPTUAL SITE MODEL OF TRENCH
PROPOSED PILOT TRENCH PERFORMANCE MONITORING PLAN
TRENCH COLLECTION SYSTEM
Bedford, Indiana

N:\US\Chicago\Legacy\DRAWINGS\13000S\13968\13968-REPORTS\13968-00(404)\13968-00(404)GN\13968-00(404)GN-CO021.DWG Plot Date: AUG 15, 2019



NOTE:
GM PROPERTY BOUNDARY SURVEY BY BLEDSOE RIGGERT GUERRETTAZ RECEIVED OCTOBER 2007. ADJACENT PROPERTY BOUNDARY LOCATIONS APPROXIMATED FROM THE LAWRENCE COUNTY SURVEY PLATS. ADJOINING PROPERTY LINES MAY NOT ACCURATELY REPRESENT THE TRUE PROPERTY BOUNDARIES

SOURCE: BASE MAP COMPLETED BY AIR-LAND SURVEYS, FLINT, MI, APRIL 2001 AND CRA SURVEYS 2002 TO 2013.

figure 4.1

PROPOSED PILOT TRENCH MONITORING NETWORK AND HYDRAULIC CONTROL MONITORING LOCATIONS
PROPOSED PILOT TRENCH PERFORMANCE MONITORING PLAN
TRENCH COLLECTION SYSTEM
GM GPS BEDFORD FACILITY
Bedford, Indiana

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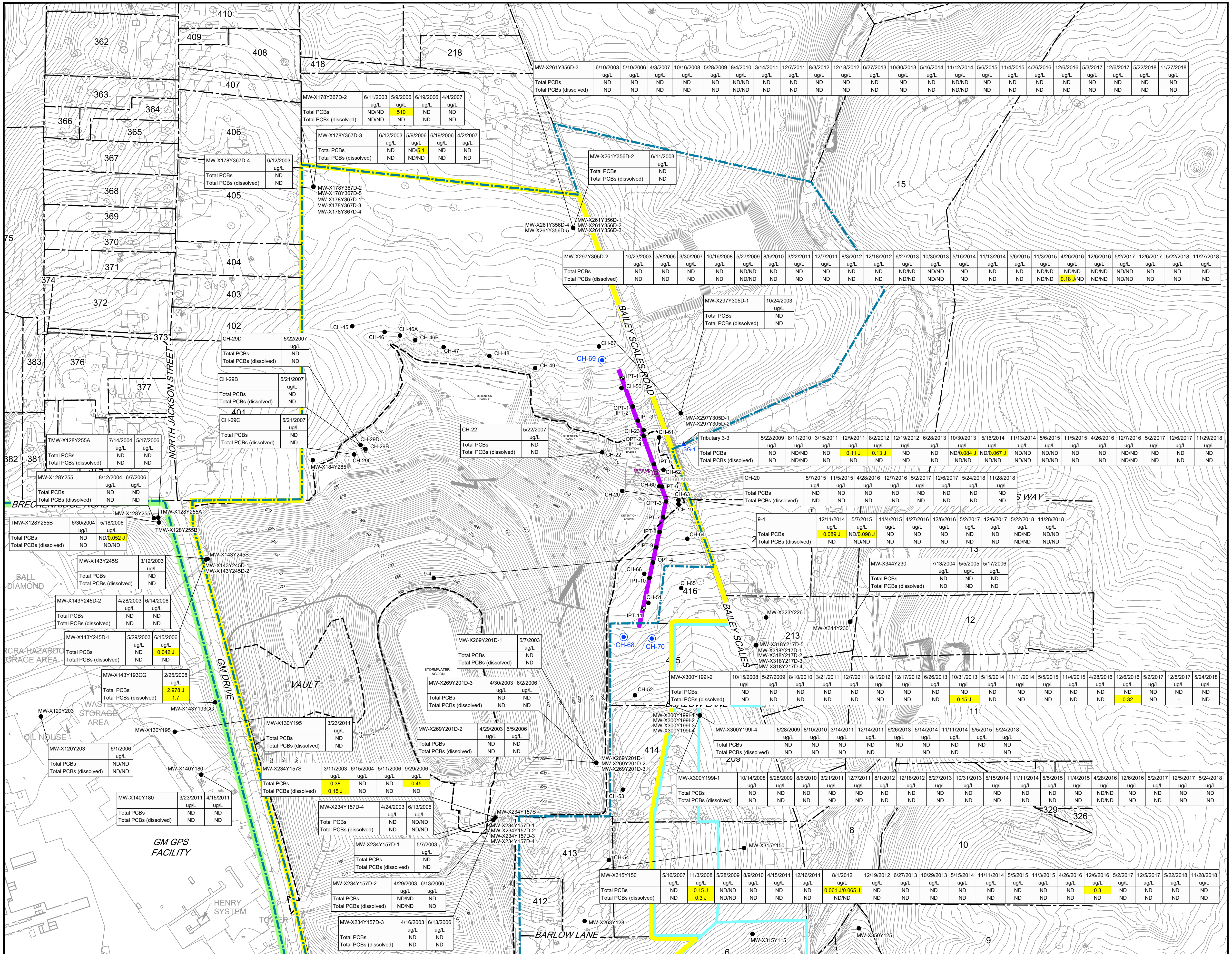

MW-X261Y356D-3	6/10/2003 ug/L	5/10/2006 ug/L	4/3/2007 ug/L	10/16/2008 ug/L	5/28/2009 ug/L	8/4/2010 ug/L	3/14/2011 ug/L	12/7/2011 ug/L	8/3/2012 ug/L	12/18/2012 ug/L	6/27/2013 ug/L	10/30/2013 ug/L	5/16/2014 ug/L	11/12/2014 ug/L	5/6/2015 ug/L	11/4/2015 ug/L	4/26/2016 ug/L	12/6/2016 ug/L	5/3/2017 ug/L	12/6/2017 ug/L	5/22/2018 ug/L	11/27/2018 ug/L
Total PCBs	ND	ND	ND	ND	ND	ND/ND	ND	ND	ND	ND	ND	ND	ND	ND/ND	ND	ND	ND	ND	ND	ND	ND	ND
Total PCBs (dissolved)	ND	ND	ND	ND	ND	ND/ND	ND	ND	ND	ND	ND	ND	ND	ND/ND	ND	ND	ND	ND	ND	ND	ND	ND

MW-X178Y367D-2	6/11/2003 ug/L	5/9/2006 ug/L	6/19/2006 ug/L	4/4/2007 ug/L
Total PCBs	ND/ND	510	ND	ND
Total PCBs (dissolved)	ND/ND	ND	ND	ND

MW-X178Y367D-3	6/12/2003 ug/L	5/9/2006 ug/L	6/19/2006 ug/L	4/2/2007 ug/L
Total PCBs	ND	ND/5.1	ND	ND
Total PCBs (dissolved)	ND	ND/ND	ND	ND

MW-X178Y367D-4	6/12/2003 ug/L
Total PCBs	ND
Total PCBs (dissolved)	ND

MW-X261Y356D-2	6/11/2003 ug/L
Total PCBs	ND
Total PCBs (dissolved)	ND

MW-X297Y305D-2	10/23/2003 ug/L	5/8/2006 ug/L	3/30/2007 ug/L	10/16/2008 ug/L	5/27/2009 ug/L	8/5/2010 ug/L	3/22/2011 ug/L	12/7/2011 ug/L	8/3/2012 ug/L	12/18/2012 ug/L	6/27/2013 ug/L	10/30/2013 ug/L	5/16/2014 ug/L	11/13/2014 ug/L	5/6/2015 ug/L	11/3/2015 ug/L	4/26/2016 ug/L	12/6/2016 ug/L	5/2/2017 ug/L	12/6/2017 ug/L	5/22/2018 ug/L	11/27/2018 ug/L
Total PCBs	ND	ND	ND	ND	ND/ND	ND	ND	ND	ND	ND	ND/ND	ND/ND	ND	ND	ND	ND/ND	ND/ND	ND/ND	ND/ND	ND	ND	ND
Total PCBs (dissolved)	ND	ND	ND	ND	ND/ND	ND	ND	ND	ND	ND	ND/ND	ND/ND	ND	ND	ND	ND/ND	0.18 J/ND	ND/ND	ND/ND	ND	ND	ND

MW-X297Y305D-1	10/24/2003 ug/L
Total PCBs	ND
Total PCBs (dissolved)	ND

CH-29D	5/22/2007 ug/L
Total PCBs	ND
Total PCBs (dissolved)	ND

CH-29B	5/21/2007 ug/L
Total PCBs	ND
Total PCBs (dissolved)	ND

CH-29C	5/21/2007 ug/L
Total PCBs	ND
Total PCBs (dissolved)	ND

CH-22	5/22/2007 ug/L
Total PCBs	ND
Total PCBs (dissolved)	ND

TMW-X128Y255A	7/14/2004 ug/L	5/17/2006 ug/L
Total PCBs	ND	ND
Total PCBs (dissolved)	ND	ND

MW-X128Y255	8/12/2004 ug/L	6/7/2006 ug/L
Total PCBs	ND	ND
Total PCBs (dissolved)	ND	ND

TMW-X128Y255B	6/30/2004 ug/L	5/18/2006 ug/L
Total PCBs	ND	ND/0.052 J
Total PCBs (dissolved)	ND	ND/ND

Tributary 3-3	5/22/2009 ug/L	8/11/2010 ug/L	3/15/2011 ug/L	12/9/2011 ug/L	8/2/2012 ug/L	12/19/2012 ug/L	6/28/2013 ug/L	10/30/2013 ug/L	5/16/2014 ug/L	11/13/2014 ug/L	5/6/2015 ug/L	11/5/2015 ug/L	4/26/2016 ug/L	12/7/2016 ug/L	5/2/2017 ug/L	12/6/2017 ug/L	11/29/2018 ug/L
Total PCBs	ND	ND/ND	ND	0.11 J	0.13 J	ND	ND	ND/0.084 J	ND/0.067 J	ND/ND	ND/ND	ND	ND	ND/ND	ND	ND	ND
Total PCBs (dissolved)	ND	ND/ND	ND	ND	ND	ND	ND	ND/ND	ND/ND	ND/ND	ND/ND	ND	ND	ND/ND	ND	ND	ND

CH-20	5/7/2015 ug/L	11/5/2015 ug/L	4/28/2016 ug/L	12/7/2016 ug/L	5/2/2017 ug/L	12/6/2017 ug/L	5/24/2018 ug/L	11/28/2018 ug/L
Total PCBs	ND	ND	ND	ND	ND	ND	ND	ND
Total PCBs (dissolved)	ND	ND	ND	ND	ND	ND	ND	ND

9-4	12/11/2014 ug/L	5/7/2015 ug/L	11/4/2015 ug/L	4/27/2016 ug/L	12/6/2016 ug/L	5/2/2017 ug/L	12/6/2017 ug/L	5/22/2018 ug/L	11/28/2018 ug/L
Total PCBs	0.089 J	ND/0.098 J	ND	ND	ND	ND	ND	ND/ND	ND/ND
Total PCBs (dissolved)	ND	ND/ND	ND	ND	ND	ND	ND	ND/ND	ND/ND

MW-X344Y230	7/13/2004 ug/L	5/5/2005 ug/L	5/17/2006 ug/L
Total PCBs	ND	ND	ND
Total PCBs (dissolved)	ND	ND	ND

MW-X143Y245S	3/12/2003 ug/L
Total PCBs	ND
Total PCBs (dissolved)	ND

MW-X143Y245D-2	4/28/2003 ug/L	6/14/2006 ug/L
Total PCBs	ND	ND
Total PCBs (dissolved)	ND	ND

MW-X143Y245D-1	5/29/2003 ug/L	6/15/2006 ug/L
Total PCBs	ND	0.042 J
Total PCBs (dissolved)	ND	ND

MW-X143Y193CG	2/25/2008 ug/L
Total PCBs	2.978 J
Total PCBs (dissolved)	1.7

MW-X269Y201D-1	5/7/2003 ug/L
Total PCBs	ND
Total PCBs (dissolved)	ND

MW-X269Y201D-3	4/30/2003 ug/L	6/2/2006 ug/L
Total PCBs	ND	ND
Total PCBs (dissolved)	ND	ND

MW-X130Y195	3/23/2011 ug/L
Total PCBs	ND
Total PCBs (dissolved)	ND

MW-X269Y201D-2	4/29/2003 ug/L	6/5/2006 ug/L
Total PCBs	ND	ND
Total PCBs (dissolved)	ND	ND

MW-X120Y203	6/1/2006 ug/L
Total PCBs	ND/ND
Total PCBs (dissolved)	ND/ND

MW-X234Y157S	3/11/2003 ug/L	6/15/2004 ug/L	5/11/2006 ug/L	9/29/2006 ug/L
Total PCBs	0.38	ND	ND	0.45
Total PCBs (dissolved)	0.15 J	ND	ND	ND

MW-X140Y180	3/23/2011 ug/L	4/15/2011 ug/L
Total PCBs	ND	ND
Total PCBs (dissolved)	ND	ND

MW-X234Y157D-4	4/24/2003 ug/L	6/13/2006 ug/L
Total PCBs	ND	ND/ND
Total PCBs (dissolved)	ND	ND/ND

MW-X234Y157D-1	5/7/2003 ug/L
Total PCBs	ND
Total PCBs (dissolved)	ND

MW-X234Y157D-2	4/29/2003 ug/L	6/13/2006 ug/L
Total PCBs	ND/ND	ND
Total PCBs (dissolved)	ND/ND	ND

MW-X234Y157D-3	4/16/2003 ug/L	6/13/2006 ug/L
Total PCBs	ND	ND
Total PCBs (dissolved)	ND	ND

MW-X300Y199I-2	10/15/2008 ug/L	5/27/2009 ug/L	8/10/2010 ug/L	3/21/2011 ug/L	12/7/2011 ug/L	8/1/2012 ug/L	12/17/2012 ug/L	6/26/2013 ug/L	10/31/2013 ug/L	5/15/2014 ug/L	11/11/2014 ug/L	5/5/2015 ug/L	11/4/2015 ug/L	4/28/2016 ug/L	12/6/2016 ug/L	5/2/2017 ug/L	12/5/2017 ug/L	5/24/2018 ug/L
Total PCBs	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total PCBs (dissolved)	ND	ND	ND	ND	ND	ND	ND	ND	0.15 J	ND	ND	ND	ND	ND	0.32	ND	-	ND

MW-X300Y199I-4	5/28/2009 ug/L	8/10/2010 ug/L	3/14/2011 ug/L	12/14/2011 ug/L	6/26/2013 ug/L	5/14/2014 ug/L	11/11/2014 ug/L	5/5/2015 ug/L	5/24/2018 ug/L
Total PCBs	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total PCBs (dissolved)	ND	ND	ND	ND	-	ND	ND	-	ND

MW-X300Y199I-1	10/14/2008 ug/L	5/28/2009 ug/L	8/6/2010 ug/L	3/21/2011 ug/L	12/7/2011 ug/L	8/1/2012 ug/L	12/18/2012 ug/L	6/27/2013 ug/L	10/31/2013 ug/L	5/15/2014 ug/L	11/11/2014 ug/L	5/5/2015 ug/L	11/4/2015 ug/L	4/28/2016 ug/L	12/6/2016 ug/L	5/2/2017 ug/L	12/5/2017 ug/L	5/24/2018 ug/L
Total PCBs	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND/ND	ND	ND	ND	ND
Total PCBs (dissolved)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND/ND	ND	ND	ND	ND

MW-X315Y150	5/16/2007 ug/L	11/3/2008 ug/L	5/28/2009 ug/L	8/9/2010 ug/L	4/15/2011 ug/L	12/16/2011 ug/L	8/1/2012 ug/L	12/19/2012 ug/L	6/27/2013 ug/L	10/29/2013 ug/L	5/15/2014 ug/L	11/11/2014 ug/L	5/5/2015 ug/L	11/3/2015 ug/L	4/26/2016 ug/L	12/6/2016 ug/L	5/2/2017 ug/L	12/5/2017 ug/L	5/22/2018 ug/L	11/28/2018 ug/L
Total PCBs	ND	0.15 J	ND/ND	ND	ND	ND	0.061 J/0.065 J	ND	ND	ND	ND	ND	ND	ND	ND	0.3	ND	ND	ND	ND
Total PCBs (dissolved)	ND	0.3 J	ND/ND	ND	ND	ND	ND/ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Nº	Revision	Date	Initial

0 75 150ft

LEGEND
- GROUND SURFACE ELEVATION CONTOURS (feet AMSL)
- FENCE LINE
- SURFACE WATER
- APPROXIMATE GM PROPERTY BOUNDARY
- APPROXIMATE PROPERTY BOUNDARY
- PROPOSED STAFF GAUGE
- EAST PLANT COVER SYSTEM LIMIT
- EAST PLANT AREA BOUNDARY
- WEST PLANT AREA BOUNDARY
- GM LLC OWNED RESIDENTIAL PROPERTIES
- PILOT TRENCH ALIGNMENT
- WET WELL
- MONITORING WELL LOCATION
- EXISTING PIEZOMETER LOCATION
- RECENTLY INSTALLED MONITORING WELL AND PIEZOMETER LOCATION
- DETECTION

NOTE:
GM PROPERTY BOUNDARY SURVEY BY BLEDSOE RIGGERT GUERRETTAZ RECEIVED OCTOBER 2007. ADJACENT PROPERTY BOUNDARY LOCATIONS APPROXIMATED FROM THE LAWRENCE COUNTY SURVEY PLATS. ADJOINING PROPERTY LINES MAY NOT ACCURATELY REPRESENT THE TRUE PROPERTY BOUNDARIES

SCALE VERIFICATION

THIS BAR MEASURES 1" ON ORIGINAL. ADJUST SCALE ACCORDINGLY.

Approved

DRAWING STATUS

Status	Date	Initial

GM GPS BEDFORD FACILITY
BEDFORD, INDIANA

PROPOSED PILOT TRENCH PERFORMANCE MONITORING PLAN
TRENCH COLLECTION SYSTEM

GROUNDWATER ANALYTICAL RESULTS

GHD

Source Reference:

Project Manager: K. Kamm	Reviewed By: J. Luzwick	Date: August 2019	
Scale: as shown	Project Nº: 13968-00	Report Nº: 404	Drawing Nº: figure 4.2

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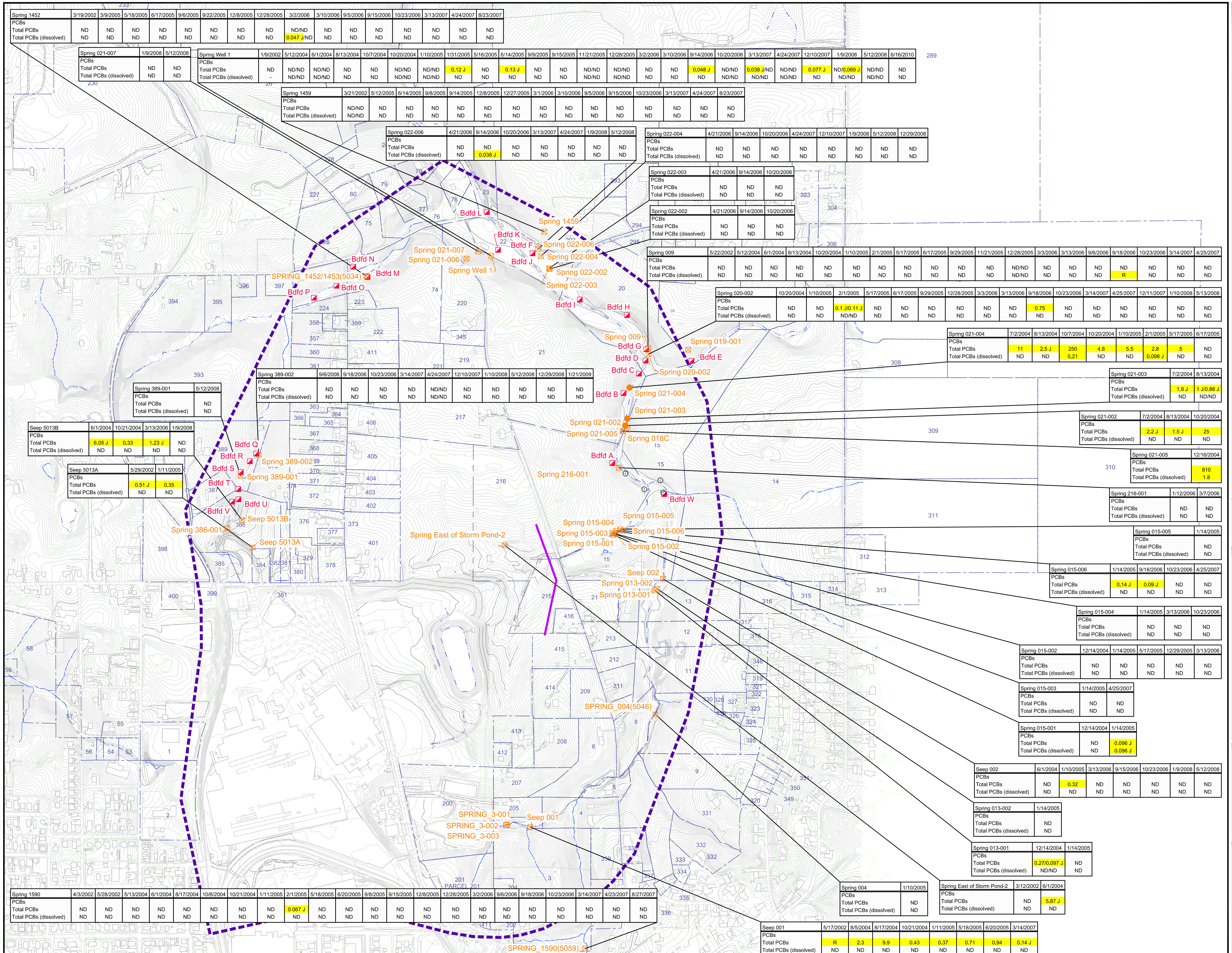


Spring 1452	3/19/2002	3/9/2005	5/18/2005	6/17/2005	9/6/2005	9/22/2005	12/8/2005	12/28/2005	3/2/2006	3/10/2006	9/5/2006	9/15/2006	10/23/2006	3/13/2007	4/24/2007	8/23/2007
PCBs																
Total PCBs	ND	ND	ND	ND	ND	ND	ND	ND	ND/ND	ND	ND	ND	ND	ND	ND	ND
Total PCBs (dissolved)	ND	ND	ND	ND	ND	ND	ND	ND	0.047 J/ND	ND	ND	ND	ND	ND	ND	ND

Spring 021-007	1/9/2008	5/12/2008
PCBs		
Total PCBs	ND	ND
Total PCBs (dissolved)	ND	ND

Spring Well 1	1/9/2002	5/12/2004	6/1/2004	8/13/2004	10/7/2004	10/20/2004	1/10/2005	1/31/2005	5/16/2005	6/14/2005	9/9/2005	9/15/2005	11/21/2005	12/28/2005	3/2/2006	3/10/2006	9/14/2006	10/20/2006	3/13/2007	4/24/2007	12/10/2007	1/9/2008	5/12/2008	6/16/2010
PCBs																								
Total PCBs	ND	ND/ND	ND/ND	ND	ND	ND/ND	ND/ND	0.12 J	ND	0.13 J	ND	ND	ND/ND	ND/ND	ND	ND	0.048 J	ND/ND	0.038 J/ND	ND/ND	0.077 J	ND/0.069 J	ND/ND	ND
Total PCBs (dissolved)	-	ND/ND	ND/ND	ND	ND	ND/ND	ND/ND	ND	ND	ND	ND	ND	ND/ND	ND/ND	ND	ND	ND	ND/ND	ND/ND	ND/ND	ND	ND/ND	ND/ND	ND

Spring 1459	3/21/2002	5/12/2005	6/14/2005	9/8/2005	9/14/2005	12/8/2005	12/27/2005	3/1/2006	3/10/2006	9/5/2006	9/15/2006	10/23/2006	3/13/2007	4/24/2007	8/23/2007
PCBs															
Total PCBs	ND/ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total PCBs (dissolved)	ND/ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Spring 022-006	4/21/2006	9/14/2006	10/20/2006	3/13/2007	4/24/2007	1/9/2008	5/12/2008
PCBs							
Total PCBs	ND	ND	ND	ND	ND	ND	ND
Total PCBs (dissolved)	ND	0.038 J	ND	ND	ND	ND	ND

Spring 022-004	4/21/2006	9/14/2006	10/20/2006	4/24/2007	12/10/2007	1/9/2008	5/12/2008	12/29/2008
PCBs								
Total PCBs	ND	ND	ND	ND	ND	ND	ND	ND
Total PCBs (dissolved)	ND	ND	ND	ND	ND	ND	ND	ND

Spring 022-003	4/21/2006	9/14/2006	10/20/2006
PCBs			
Total PCBs	ND	ND	ND
Total PCBs (dissolved)	ND	ND	ND

Spring 022-002	4/21/2006	9/14/2006	10/20/2006
PCBs			
Total PCBs	ND	ND	ND
Total PCBs (dissolved)	ND	ND	ND

Spring 009	5/22/2002	5/12/2004	6/1/2004	8/13/2004	10/20/2004	1/10/2005	2/1/2005	5/17/2005	6/17/2005	9/29/2005	11/21/2005	12/28/2005	3/3/2006	3/13/2006	9/6/2006	9/18/2006	10/23/2006	3/14/2007	4/25/2007
PCBs																			
Total PCBs	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND/ND	ND	ND	ND	ND	ND	ND	ND
Total PCBs (dissolved)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND/ND	ND	ND	ND	R	ND	ND	ND

Spring 020-002	10/20/2004	1/10/2005	2/1/2005	5/17/2005	6/17/2005	9/29/2005	12/28/2005	3/3/2006	3/13/2006	9/18/2006	10/23/2006	3/14/2007	4/25/2007	12/11/2007	1/10/2008	5/13/2008
PCBs																
Total PCBs	ND	ND	0.1 J/0.11 J	ND	ND	ND	ND	ND	ND	0.75	ND	ND	ND	ND	ND	ND
Total PCBs (dissolved)	ND	ND	ND/ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Spring 021-004	7/2/2004	8/13/2004	10/7/2004	10/20/2004	1/10/2005	2/1/2005	5/17/2005	6/17/2005
PCBs								
Total PCBs	11	2.5 J	250	4.8	5.5	2.8	5	ND
Total PCBs (dissolved)	ND	ND	0.21	ND	ND	0.098 J	ND	ND

Spring 021-003	7/2/2004	8/13/2004
PCBs		
Total PCBs	1.9 J	1 J/0.88 J
Total PCBs (dissolved)	ND	ND/ND

Spring 389-001	5/12/2008
PCBs	
Total PCBs	ND
Total PCBs (dissolved)	ND

Spring 389-002	9/6/2006	9/18/2006	10/23/2006	3/14/2007	4/24/2007	12/10/2007	1/10/2008	5/12/2008	12/29/2008	1/21/2009
PCBs										
Total PCBs	ND	ND	ND	ND	ND/ND	ND	ND	ND	ND	ND
Total PCBs (dissolved)	ND	ND	ND	ND	ND/ND	ND	ND	ND	ND	ND

Spring 021-002	7/2/2004	8/13/2004	10/20/2004
PCBs			
Total PCBs	2.2 J	1.5 J	25
Total PCBs (dissolved)	ND	ND	ND

Seep 5013B	6/1/2004	10/21/2004	3/13/2006	1/9/2008
PCBs				
Total PCBs	6.05 J	0.33	1.23 J	ND
Total PCBs (dissolved)	ND	ND	ND	ND

Spring 021-005	12/16/2004
PCBs	
Total PCBs	810
Total PCBs (dissolved)	1.8

Seep 5013A	5/29/2002	1/11/2005
PCBs		
Total PCBs	0.51 J	0.35
Total PCBs (dissolved)	ND	ND

Spring 216-001	1/12/2006	3/7/2006
PCBs		
Total PCBs	ND	ND
Total PCBs (dissolved)	ND	ND

Spring 015-005	1/14/2005
PCBs	
Total PCBs	ND
Total PCBs (dissolved)	ND

Spring 015-006	1/14/2005	9/18/2006	10/23/2006	4/25/2007
PCBs				
Total PCBs	0.14 J	0.09 J	ND	ND
Total PCBs (dissolved)	ND	ND	ND	ND

Spring 015-004	1/14/2005	3/13/2006	10/23/2006
PCBs			
Total PCBs	ND	ND	ND
Total PCBs (dissolved)	ND	ND	ND

Spring 015-002	12/14/2004	1/14/2005	5/17/2005	12/29/2005	3/13/2006
PCBs					
Total PCBs	ND	ND	ND	ND	ND
Total PCBs (dissolved)	ND	ND	ND	ND	ND

Spring 015-003	1/14/2005	4/25/2007
PCBs		
Total PCBs	ND	ND
Total PCBs (dissolved)	ND	ND

Spring 015-001	12/14/2004	1/14/2005
PCBs		
Total PCBs	ND	0.096 J
Total PCBs (dissolved)	ND	0.096 J

Seep 002	6/1/2004	1/10/2005	3/13/2006	9/15/2006	10/23/2006	1/9/2008	5/12/2008
PCBs							
Total PCBs	ND	0.32	ND	ND	ND	ND	ND
Total PCBs (dissolved)	ND	ND	ND	ND	ND	ND	ND

Spring 013-002	1/14/2005
PCBs	
Total PCBs	ND
Total PCBs (dissolved)	ND

Spring 013-001	12/14/2004	1/14/2005
PCBs		
Total PCBs	0.27/0.097 J	ND
Total PCBs (dissolved)	ND/ND	ND

Spring 1590	4/3/2002	5/28/2002	5/13/2004	6/1/2004	8/17/2004	10/8/2004	10/21/2004	1/11/2005	2/1/2005	5/18/2005	6/20/2005	9/8/2005	9/15/2005	12/8/2005	12/28/2005	3/2/2006	9/6/2006	9/18/2006	10/23/2006	3/14/2007	4/23/2007	8/27/2007
PCBs																						
Total PCBs	ND	ND	ND	ND	ND	ND	ND	ND	0.067 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total PCBs (dissolved)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Spring 004	1/10/2005
PCBs	
Total PCBs	ND
Total PCBs (dissolved)	ND

Spring East of Storm Pond-2	3/12/2002	6/1/2004
PCBs		
Total PCBs	ND	5.87 J
Total PCBs (dissolved)	ND	ND

Seep 001	5/17/2002	8/5/2004	8/17/2004	10/21/2004	1/11/2005	5/18/2005	6/20/2005	3/14/2007
PCBs								
Total PCBs	R	2.3	9.9	0.43	0.37	0.71	0.94	0.14 J
Total PCBs (dissolved)	ND	ND	ND	ND	ND	ND	ND	ND

Nº	Revision	Date	Initial

0 175 350ft

LEGEND

- EXISTING GROUND SURFACE ELEVATION CONTOURS (feet AMSL)
- EXISTING BUILDINGS
- FENCE LINE
- APPROXIMATE SURFACE WATER LOCATION
- LIMITS OF 2019 THERMAL STUDY
- RAILROAD TRACKS
- DIRT ROADS
- ROADS / PAVED AREAS
- THERMAL ANOMALIES IDENTIFIED VIA UAV
- PREVIOUSLY IDENTIFIED SPRING/SEEPS
- 1 J/0.88 J — PARENT/DUPLICATE RESULT
- J — ESTIMATED
- ND — NOT DETECTED ABOVE LIMIT
- DETECTION

Spring 021-005	12/16/2004	
PCBs		
Total PCBs	810	
Total PCBs (dissolved)	1.8	

SAMPLE IDENTIFICATION — SAMPLE DATE — RESULT µg/L — PARAMETER

SCALE VERIFICATION

THIS BAR MEASURES 1" ON ORIGINAL. ADJUST SCALE ACCORDINGLY.

Approved

DRAWING STATUS

Status	Date	Initial

GM GPS BEDFORD FACILITY BEDFORD, INDIANA

PROPOSED PILOT TRENCH PERFORMANCE MONITORING PLAN
TRENCH COLLECTION SYSTEM

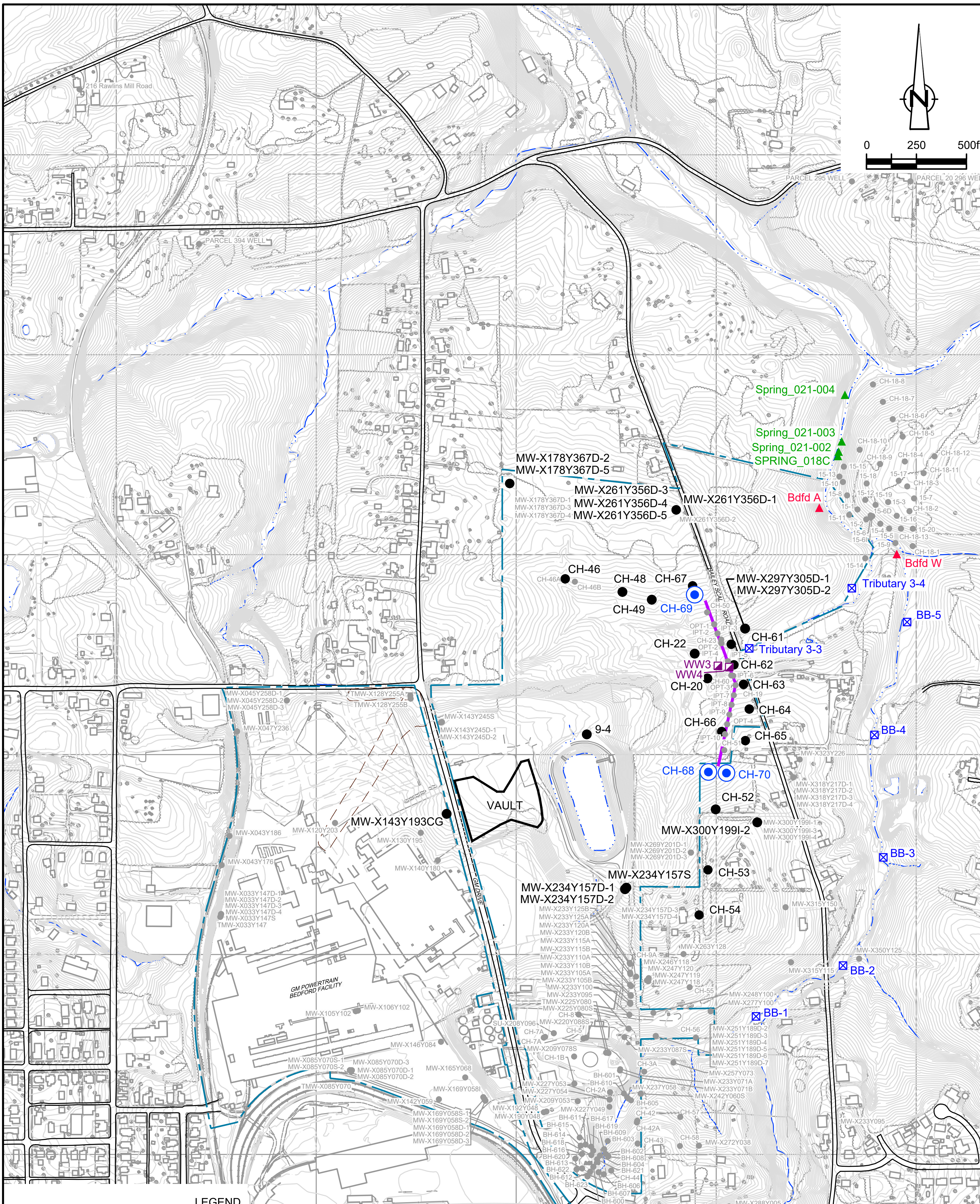
SEEPS AND SPRINGS ANALYTICAL RESULTS

GHD

Source Reference: BASE MAP COMPLETED BY AIR-LAND SURVEYS, FLINT, MI, APRIL 2001 AND CRA SURVEYS 2002 TO 2013.

Project Manager: B. STEINMANN	Reviewed By: J. LUZWICK	Date: September 2019	
Scale: AS SHOWN	Project Nº: 13968-00	Report Nº: 404	Drawing Nº: figure 4.3

N:\US\Chicago\Legacy\DRAWINGS\13000S\13968\13968-REPORTS\13968-00(404)\13968-00(404)GN\13968-00(404)GN-CO020.DWG Plot Date: SEP 23, 2019



LEGEND

- GROUND SURFACE ELEVATION CONTOURS (feet AMSL) (600)
- FENCE LINE
- SURFACE WATER
- APPROXIMATE GM PROPERTY BOUNDARY
- TENTATIVE SPRING WATER LOCATION (PENDING RESULTS OF CREEK RECONNAISSANCE)
- TENTATIVE SPRING SAMPLE LOCATION (LOCATION HAS BEEN DEMONSTRATED TO BE CONNECTED TO THE SURFACE WATER VIA SWALLETS. DETECTIONS MAY BE THE RESULT OF SURFACE WATER CONVEYANCE)
- EAST PLANT COVER SYSTEM LIMIT
- EAST PLANT AREA BOUNDARY
- WEST PLANT AREA BOUNDARY
- GM LLC OWNED RESIDENTIAL PROPERTIES
- PILOT TRENCH ALIGNMENT (2016)
- SURFACE WATER MONITORING LOCATION
- WET WELL
- EXISTING COREHOLE AND MONITORING WELL LOCATIONS NEAR PROPOSED BEDROCK TRENCH
- EXISTING MONITORING WELL LOCATIONS NOT BEING USED IN INVESTIGATION
- RECENTLY INSTALLED MONITORING WELL AND PIEZOMETER LOCATION

NOTES:

- ALL SPRING SAMPLE LOCATIONS AND SURFACE WATER LOCATIONS ALONG BAILEY'S BRANCH ARE DEPENDANT UPON ACCESSIBILITY.
- SPRING AND SURFACE WATER SAMPLE LOCATIONS WILL BE SAMPLED FOR PCBs ONLY IF DYE IS DETECTED.
- GM PROPERTY BOUNDARY SURVEY BY BLEDSOE RIGGERT GUERRETTAZ RECEIVED OCTOBER 2007. ADJACENT PROPERTY BOUNDARY LOCATIONS APPROXIMATED FROM THE LAWRENCE COUNTY SURVEY PLATS. ADJOINING PROPERTY LINES MAY NOT ACCURATELY REPRESENT THE TRUE PROPERTY BOUNDARIES.

figure 4.4

PROPOSED LOCATIONS FOR PCB SAMPLING
PROPOSED PILOT TRENCH PERFORMANCE MONITORING PLAN
TRENCH COLLECTION SYSTEM
GM GPS BEDFORD FACILITY
Bedford, Indiana

GHD

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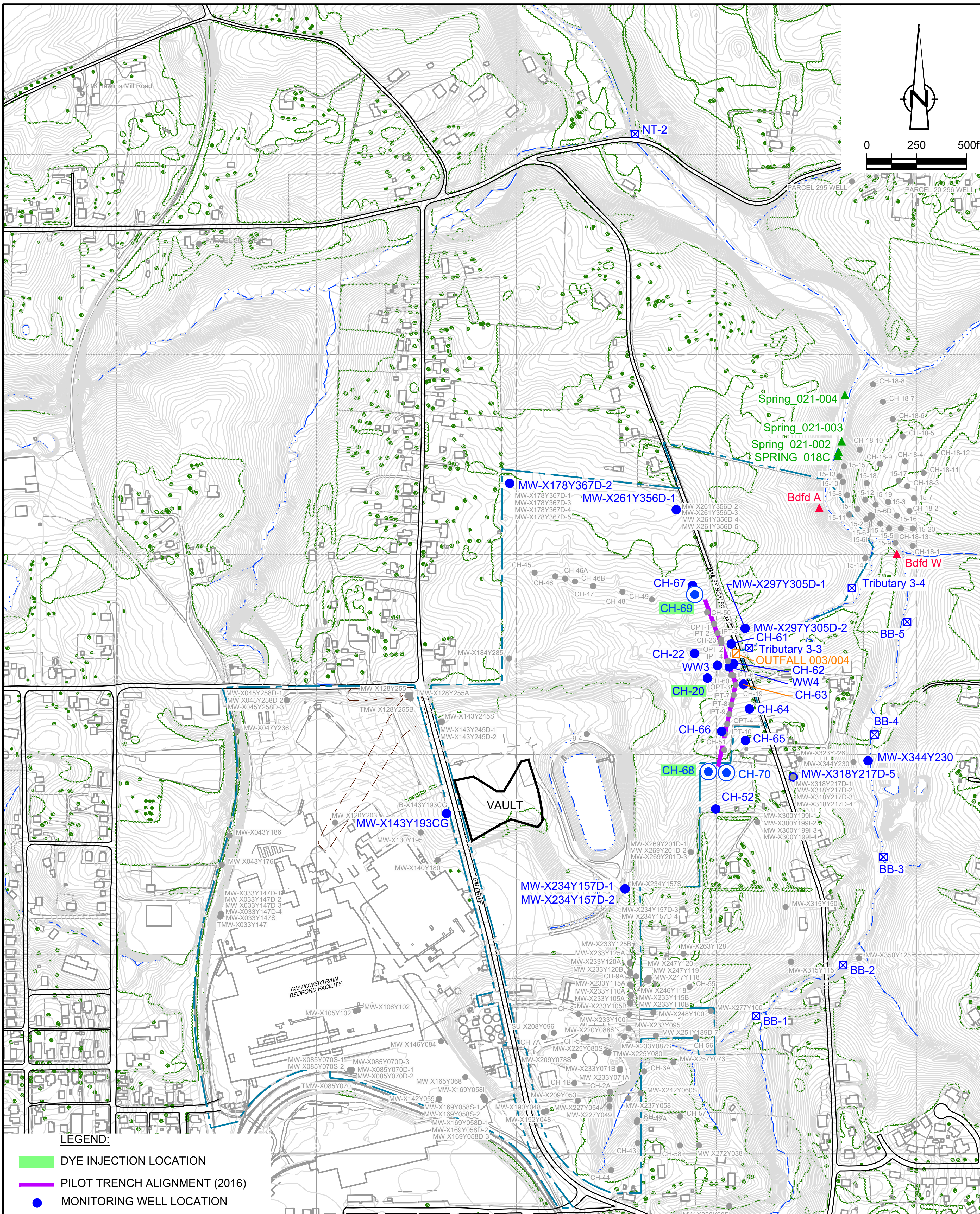

LEGEND:

- DYE INJECTION LOCATION
- PILOT TRENCH ALIGNMENT (2016)
- MONITORING WELL LOCATION
- SURFACE WATER MONITORING LOCATION
- RECENTLY INSTALLED MONITORING WELL AND PIEZOMETER LOCATION
- TENTATIVE SPRING WATER LOCATION (PENDING RESULTS OF CREEK RECONNAISSANCE)
- TENTATIVE SPRING SAMPLE LOCATION (LOCATION HAS BEEN DEMONSTRATED TO BE CONNECTED TO THE SURFACE WATER VIA SWALLETS. DETECTIONS MAY BE THE RESULT OF SURFACE WATER CONVEYANCE)
- EXISTING MONITORING WELL LOCATIONS NOT BEING USED IN THIS PHASE OF INVESTIGATION
- OUTFALL LOCATION

NOTE:

- ALL SPRING SAMPLE LOCATIONS AND SURFACE WATER LOCATIONS ALONG BAILEY'S BRANCH ARE DEPENDANT UPON ACCESSIBILITY.

figure 4.5

PROPOSED PILOT TRENCH MONITORING LOCATIONS FOR DYE TRACER MONITORING (NEAR FIELD)
PROPOSED PILOT TRENCH PERFORMANCE MONITORING PLAN
TRENCH COLLECTION SYSTEM
GM GPS BEDFORD FACILITY
Bedford, Indiana

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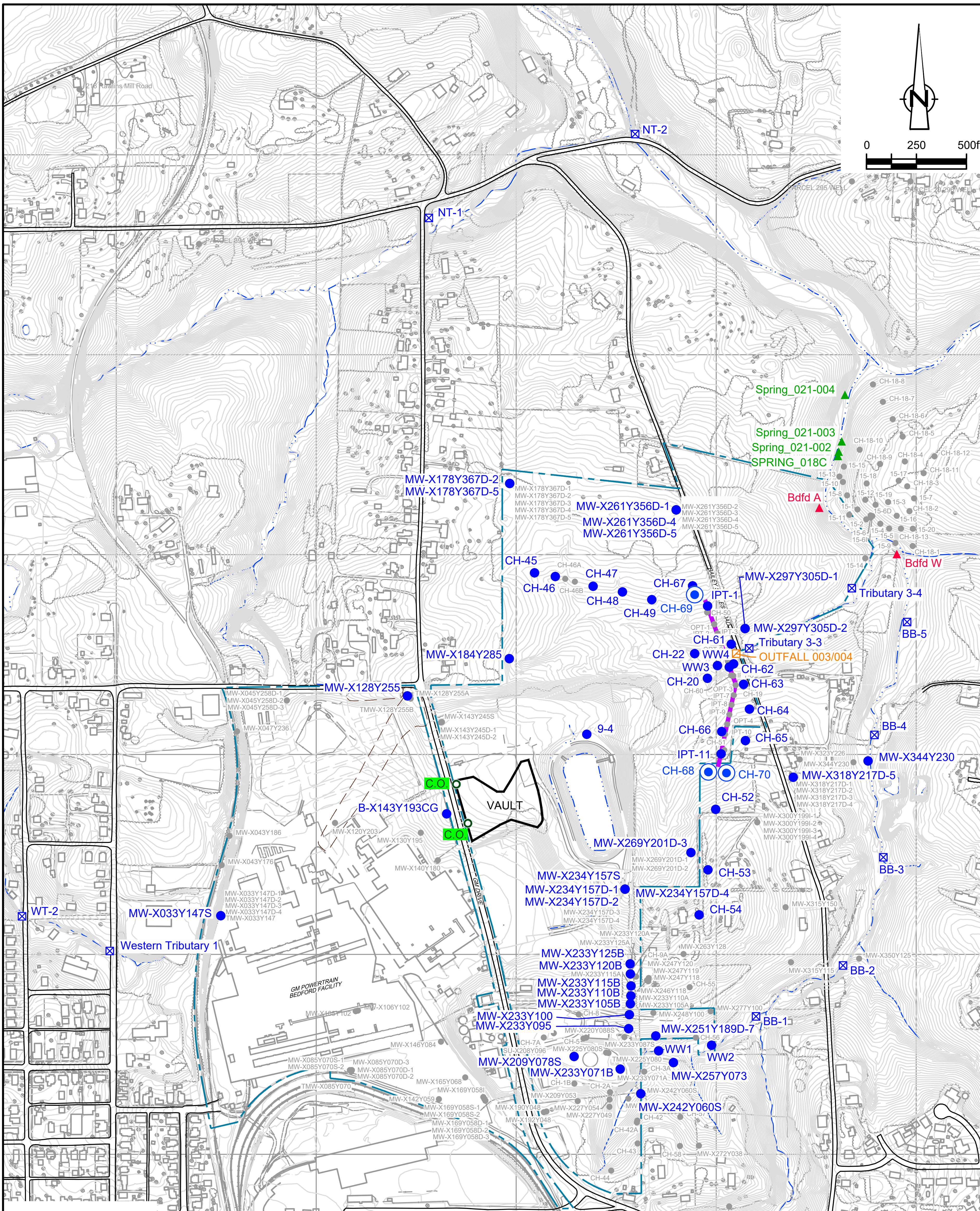

LEGEND:

DYE INJECTION LOCATION

PILOT TRENCH ALIGNMENT (2016)

MONITORING WELL LOCATION

TENTATIVE SPRING WATER LOCATION
(PENDING RESULTS OF CREEK RECONNAISSANCE)

TENTATIVE SPRING SAMPLE LOCATION
(LOCATION HAS BEEN DEMONSTRATED TO BE CONNECTED TO THE SURFACE WATER VIA SWALLETS. DETECTIONS MAY BE THE RESULT OF SURFACE WATER CONVEYANCE)

SURFACE WATER MONITORING LOCATION

OUTFALL LOCATION

CLEAN OUT DYE INJECTION LOCATION

RECENTLY INSTALLED MONITORING WELL AND PIEZOMETER LOCATION

EXISTING MONITORING WELL LOCATIONS NOT BEING USED IN THIS PHASE OF INVESTIGATION

NOTES:

- ALL SPRING SAMPLE LOCATIONS AND SURFACE WATER LOCATIONS ALONG BAILEY'S BRANCH ARE DEPENDANT UPON ACCESSIBILITY.
- LOCATIONS ARE DEPENDENT UPON COMPLETION OF THE THERMAL STUDY AND ACTUAL FLOW.

figure 4.6

PROPOSED PILOT TRENCH MONITORING LOCATIONS
FOR DYE TRACER MONITORING (FAR FIELD)
PROPOSED PILOT TRENCH PERFORMANCE MONITORING PLAN
TRENCH COLLECTION SYSTEM
GM GPS BEDFORD FACILITY
Bedford, Indiana

GHD

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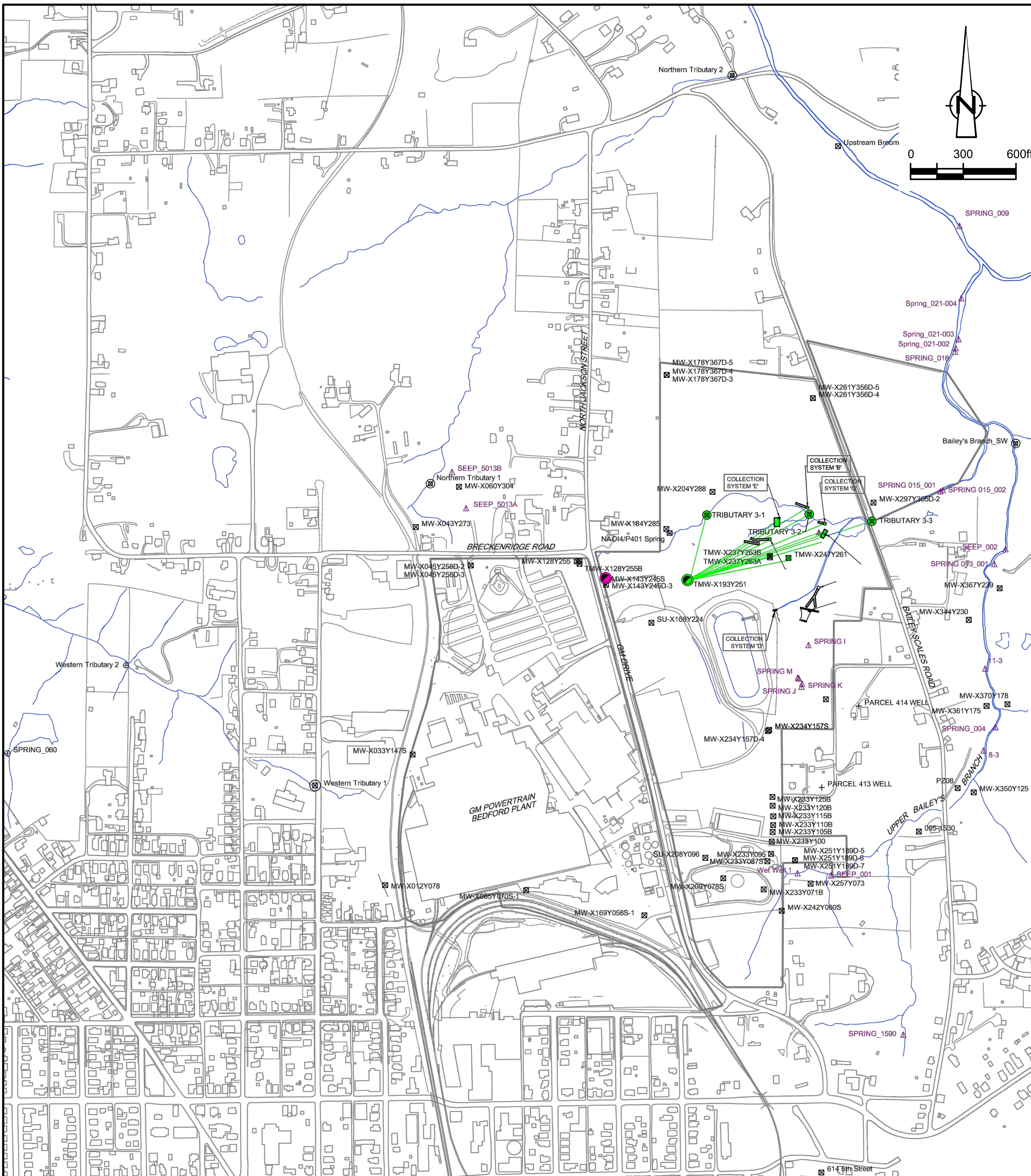

LEGEND

- EXISTING BUILDINGS
- RAILROAD TRACKS
- DIRT ROADS
- ROADS / PAVED AREAS
- APPROXIMATE SURFACE WATER LOCATION
- APPROXIMATE PROPERTY BOUNDARY
- SSC COLLECTION/EXTRACTION TRENCH
- SSC SUMP STRUCTURE
- SPRING SAMPLE LOCATION, DYE NON-DETECT
- SPRING SAMPLE LOCATION, FLUORESCEIN DETECTION
- GRAB AND PORT SAMPLE LOCATION, DYE NON-DETECT
- GRAB AND PORT SAMPLE LOCATION, DYE DETECTION
- SURFACE WATER SAMPLE LOCATION, DYE NON-DETECT
- RHODAMINE WT INJECTION WELL
- FLUORESCEIN INJECTION WELL
- ILLUSTRATIVE DYE TRAVEL PATH
- ABANDONED COREHOLE LOCATION
- COREHOLE LOCATION

NOTE:

(1) PROPERTY BOUNDARY LOCATIONS APPROXIMATED FROM THE LAWRENCE COUNTY SURVEY PLATS. LOCATIONS MAY NOT ACCURATELY REPRESENT THE TRUE BOUNDARIES.

figure 4.7

PREVIOUS DYE TRACING RESULTS AT AO14
PROPOSED PILOT TRENCH PERFORMANCE MONITORING PLAN
TRENCH COLLECTION SYSTEM
GM GPS BEDFORD FACILITY
Bedford, Indiana

GHD

BASE SOURCE: HYDROGEOLOGY INC.

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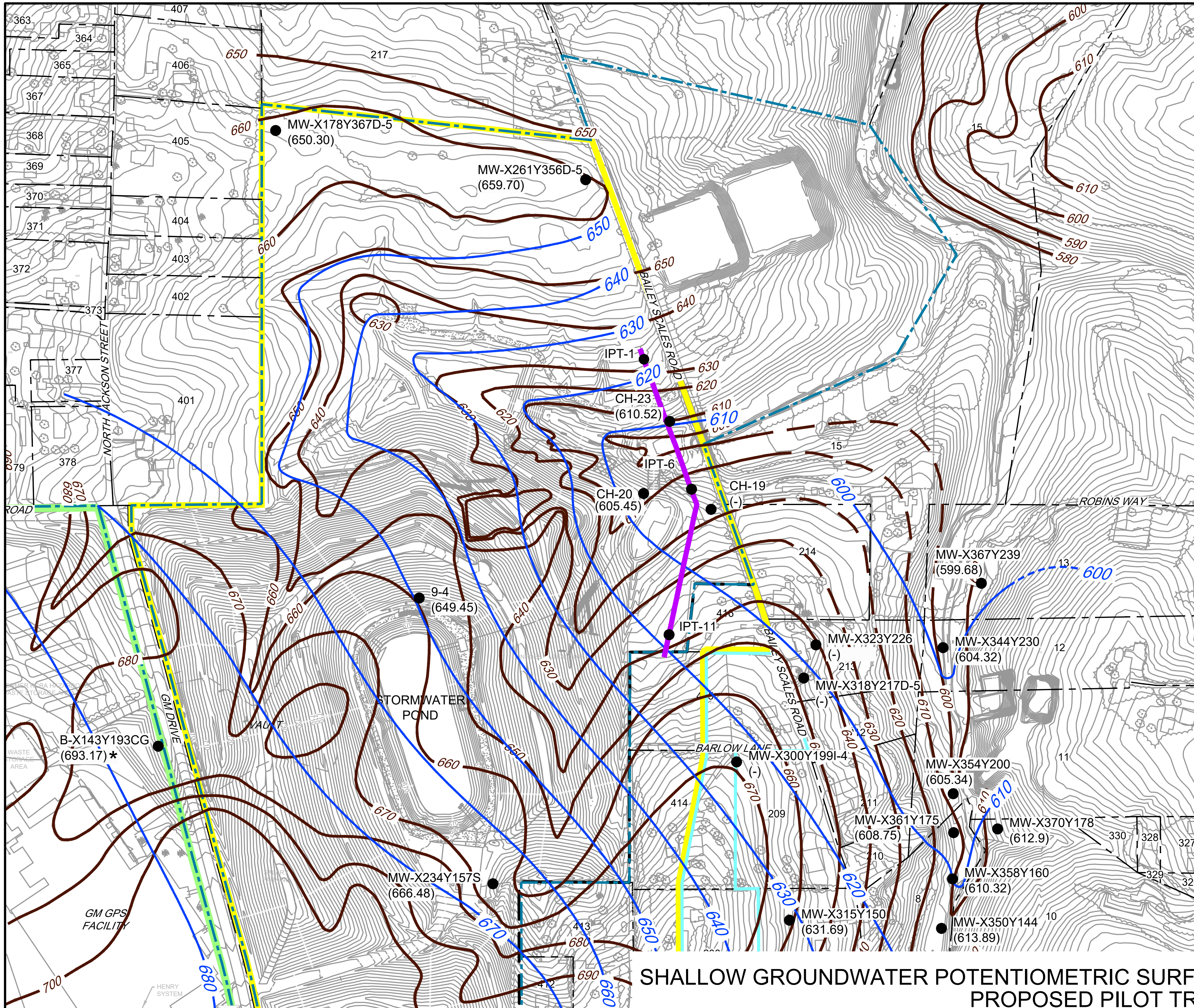

0 100 300ft

LEGEND

EXISTING GROUND SURFACE ELEVATION CONTOURS (feet AMSL)

EXISTING VEGETATION

EXISTING BUILDINGS

FENCE LINE

RAILROAD TRACKS

DIRT ROADS

ROADS / PAVED AREAS

APPROXIMATE PARCEL PROPERTY

APPROXIMATE GM PROPERTY BOUNDARY

APPROXIMATE SURFACE WATER LOCATION

EAST PLANT COVER SYSTEM LIMIT

EAST PLANT AREA

WEST PLANT AREA

GM LLC OWNED RESIDENTIAL PROPERTIES

PILOT TRENCH ALIGNMENT (2016)

MONITORING WELL SAMPLE LOCATION

(654.24) GROUNDWATER ELEVATION (ft AMSL) (NOV 29 TO DEC 1, 2010)

(-) GROUNDWATER ELEVATION NOT MEASURED

* GROUNDWATER ELEVATION REPRESENTS PERCHED WATER TABLE NOT USED IN CONTOURING

680 GROUNDWATER FLOW CONTOUR (ft AMSL)

610 BEDROCK CONTOUR (FT AMSL) DASHED WHERE INFERRED

NOTE: CONTOURS FOR THE EAST PLANT AREA VAULT REPRESENT AS-BUILT CONTOURS FOR THE BOTTOM OF THE LEAK DETECTION LINER (ie. THE SECONDARY LINER)

GROUNDWATER CONTOURS PRESENTED HERE ARE A PORTION OF THE OVERALL FACILITY CONTOURS

GM PROPERTY BOUNDARY SURVEY BY BLEDSOE RIGGERT GUERRETTAZ RECEIVED OCTOBER 2007. ADJACENT PROPERTY BOUNDARY LOCATIONS APPROXIMATED FROM THE LAWRENCE COUNTY SURVEY PLATS. ADJOINING PROPERTY LINES MAY NOT ACCURATELY REPRESENT THE TRUE PROPERTY BOUNDARIES

figure 4.8

SHALLOW GROUNDWATER POTENTIOMETRIC SURFACE NOVEMBER 29 TO DECEMBER 1, 2010
PROPOSED PILOT TRENCH PERFORMANCE MONITORING PLAN
TRENCH COLLECTION SYSTEM
GM GPS BEDFORD FACILITY
Bedford, Indiana

SOURCE: BASE MAP COMPLETED BY AIR-LAND SURVEYS, FLINT, MI, APRIL 2001 AND CRA SURVEYS 2002 TO 2013.

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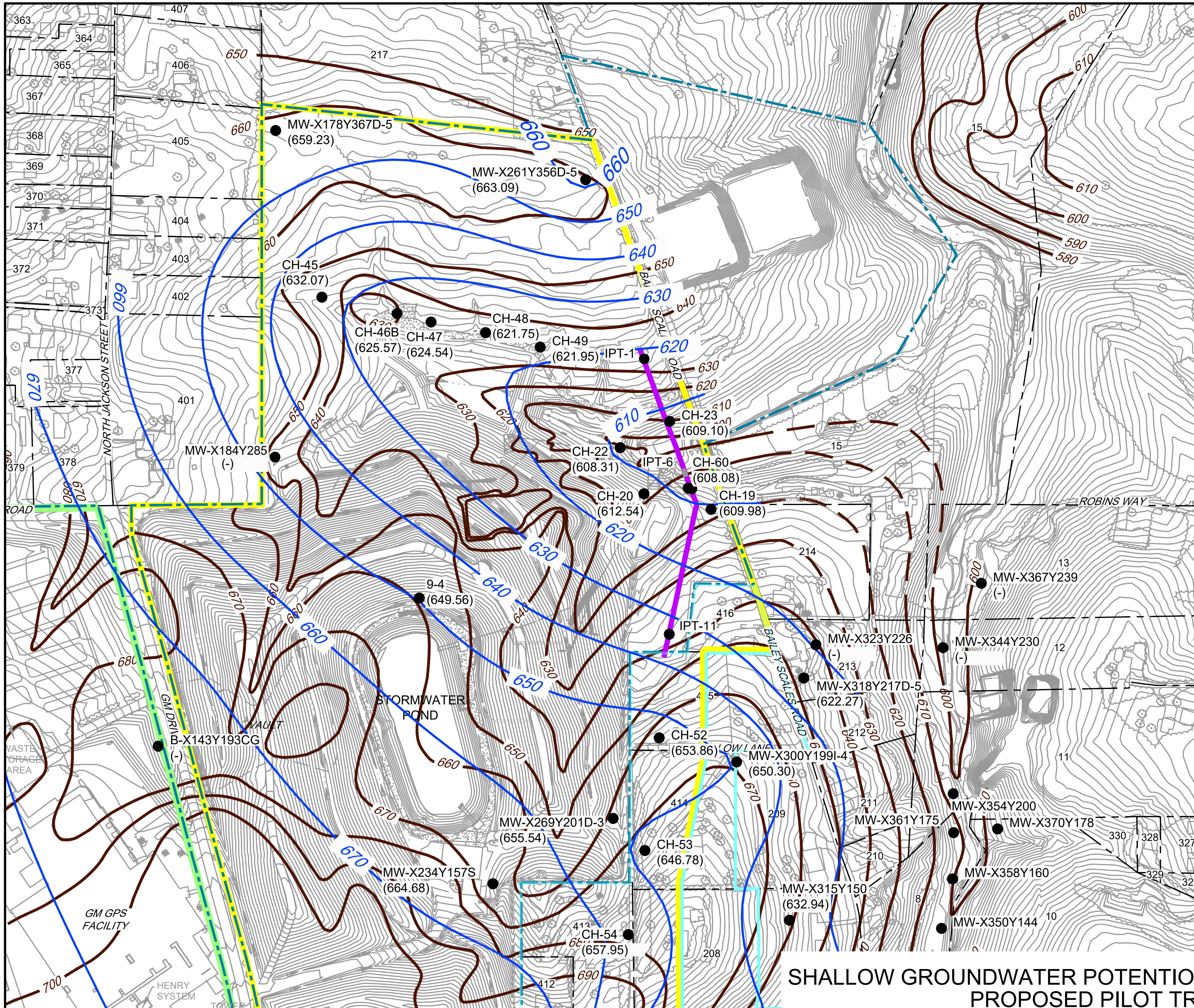

LEGEND

- EXISTING GROUND SURFACE ELEVATION CONTOURS (feet AMSL)
- EXISTING VEGETATION
- EXISTING BUILDINGS
- FENCE LINE
- RAILROAD TRACKS
- DIRT ROADS
- ROADS / PAVED AREAS
- APPROXIMATE PARCEL PROPERTY
- APPROXIMATE GM PROPERTY BOUNDARY
- APPROXIMATE SURFACE WATER LOCATION
- EAST PLANT COVER SYSTEM LIMIT
- EAST PLANT AREA
- WEST PLANT AREA
- GM LLC OWNED RESIDENTIAL PROPERTIES
- PILOT TRENCH ALIGNMENT (2016)
- MONITORING WELL SAMPLE LOCATION
- (654.24) GROUNDWATER ELEVATION (ft AMSL) (DECEMBER, 2017)
- (-) GROUNDWATER ELEVATION NOT MEASURED
- * GROUNDWATER ELEVATION REPRESENTS PERCHED WATER TABLE NOT USED IN CONTOURING
- 680 GROUNDWATER FLOW CONTOUR (ft AMSL)
- 610 BEDROCK CONTOUR (FT AMSL) DASHED WHERE INFERRED

NOTE: CONTOURS FOR THE EAST PLANT AREA VAULT REPRESENT AS-BUILT CONTOURS FOR THE BOTTOM OF THE LEAK DETECTION LINER (ie. THE SECONDARY LINER)

GROUNDWATER CONTOURS PRESENTED HERE ARE A PORTION OF THE OVERALL FACILITY CONTOURS

GM PROPERTY BOUNDARY SURVEY BY BLEDSOE RIGGERT GUERRETTAZ RECEIVED OCTOBER 2007. ADJACENT PROPERTY BOUNDARY LOCATIONS APPROXIMATED FROM THE LAWRENCE COUNTY SURVEY PLATS. ADJOINING PROPERTY LINES MAY NOT ACCURATELY REPRESENT THE TRUE PROPERTY BOUNDARIES

figure 4.9

SHALLOW GROUNDWATER POTENTIOMETRIC SURFACE FEBRUARY 5 TO 6, 2015
PROPOSED PILOT TRENCH PERFORMANCE MONITORING PLAN
TRENCH COLLECTION SYSTEM
GM GPS BEDFORD FACILITY
Bedford, Indiana

GHD

SOURCE: BASE MAP COMPLETED BY AIR-LAND SURVEYS, FLINT, MI, APRIL 2001 AND CRA SURVEYS 2002 TO 2013.

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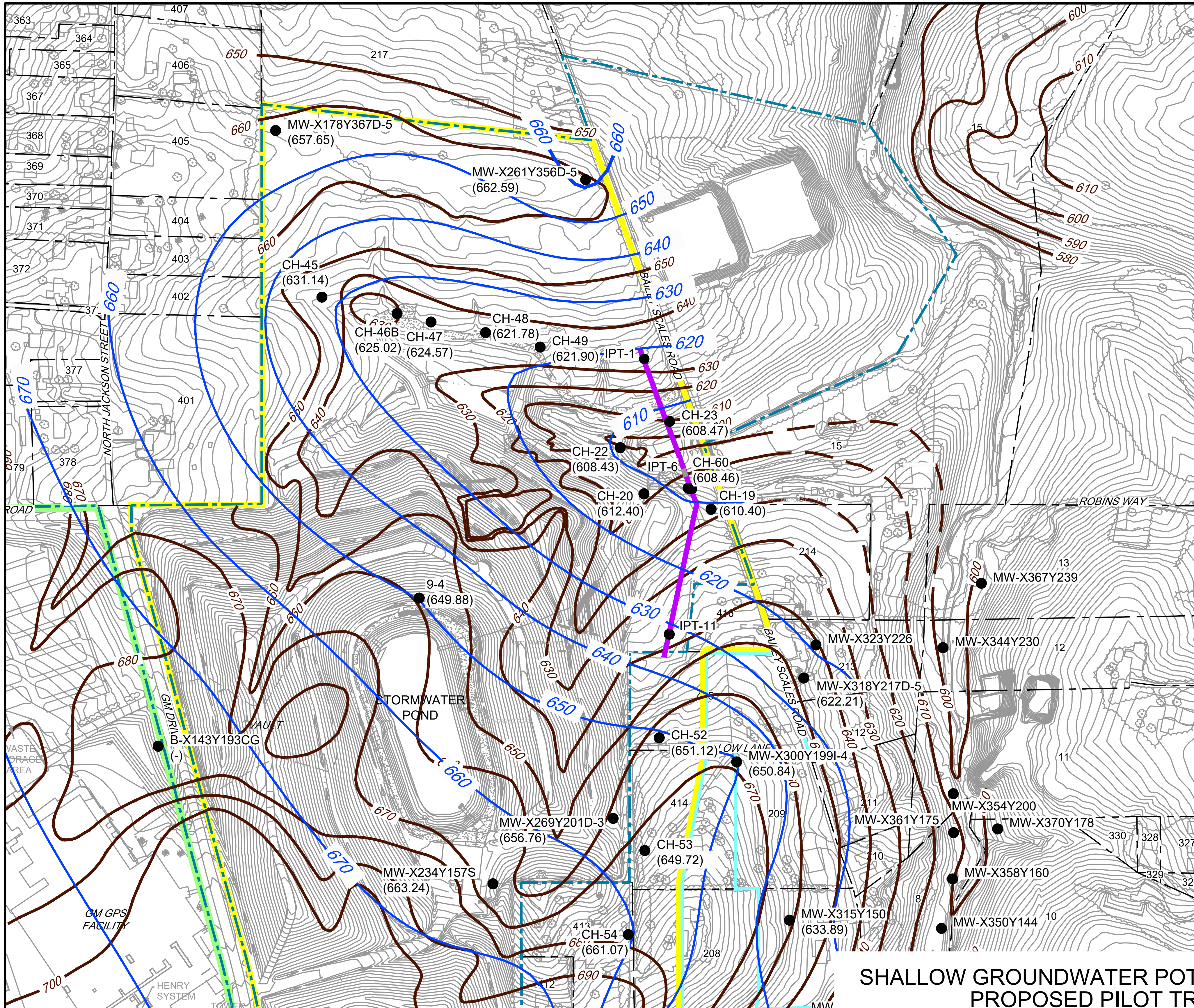

LEGEND

- EXISTING GROUND SURFACE ELEVATION CONTOURS (feet AMSL)
- EXISTING VEGETATION
- EXISTING BUILDINGS
- FENCE LINE
- RAILROAD TRACKS
- DIRT ROADS
- ROADS / PAVED AREAS
- APPROXIMATE PARCEL PROPERTY
- APPROXIMATE GM PROPERTY BOUNDARY
- APPROXIMATE SURFACE WATER LOCATION
- EAST PLANT AREA
- WEST PLANT AREA
- PILOT TRENCH ALIGNMENT (2016)
- MONITORING WELL SAMPLE LOCATION
- (654.24) GROUNDWATER ELEVATION (ft AMSL) (DECEMBER, 2017)
- (-) GROUNDWATER ELEVATION NOT MEASURED
- * GROUNDWATER ELEVATION REPRESENTS PERCHED WATER TABLE NOT USED IN CONTOURING
- 680 GROUNDWATER FLOW CONTOUR (ft AMSL)
- 610 BEDROCK CONTOUR (FT AMSL) DASHED WHERE INFERRED

NOTE: CONTOURS FOR THE EAST PLANT AREA VAULT REPRESENT AS-BUILT CONTOURS FOR THE BOTTOM OF THE LEAK DETECTION LINER (IE. THE SECONDARY LINER)

GROUNDWATER CONTOURS PRESENTED HERE ARE A PORTION OF THE OVERALL FACILITY CONTOURS

GM PROPERTY BOUNDARY SURVEY BY BLEDSOE RIGGERT GUERRETTAZ RECEIVED OCTOBER 2007. ADJACENT PROPERTY BOUNDARY LOCATIONS APPROXIMATED FROM THE LAWRENCE COUNTY SURVEY PLATS. ADJOINING PROPERTY LINES MAY NOT ACCURATELY REPRESENT THE TRUE PROPERTY BOUNDARIES

figure 4.10

SHALLOW GROUNDWATER POTENTIOMETRIC SURFACE MAY 4 TO 5, 2015
PROPOSED PILOT TRENCH PERFORMANCE MONITORING PLAN
TRENCH COLLECTION SYSTEM
GM GPS BEDFORD FACILITY
Bedford, Indiana

SOURCE: BASE MAP COMPLETED BY AIR-LAND SURVEYS, FLINT, MI, APRIL 2001 AND CRA SURVEYS 2002 TO 2013.

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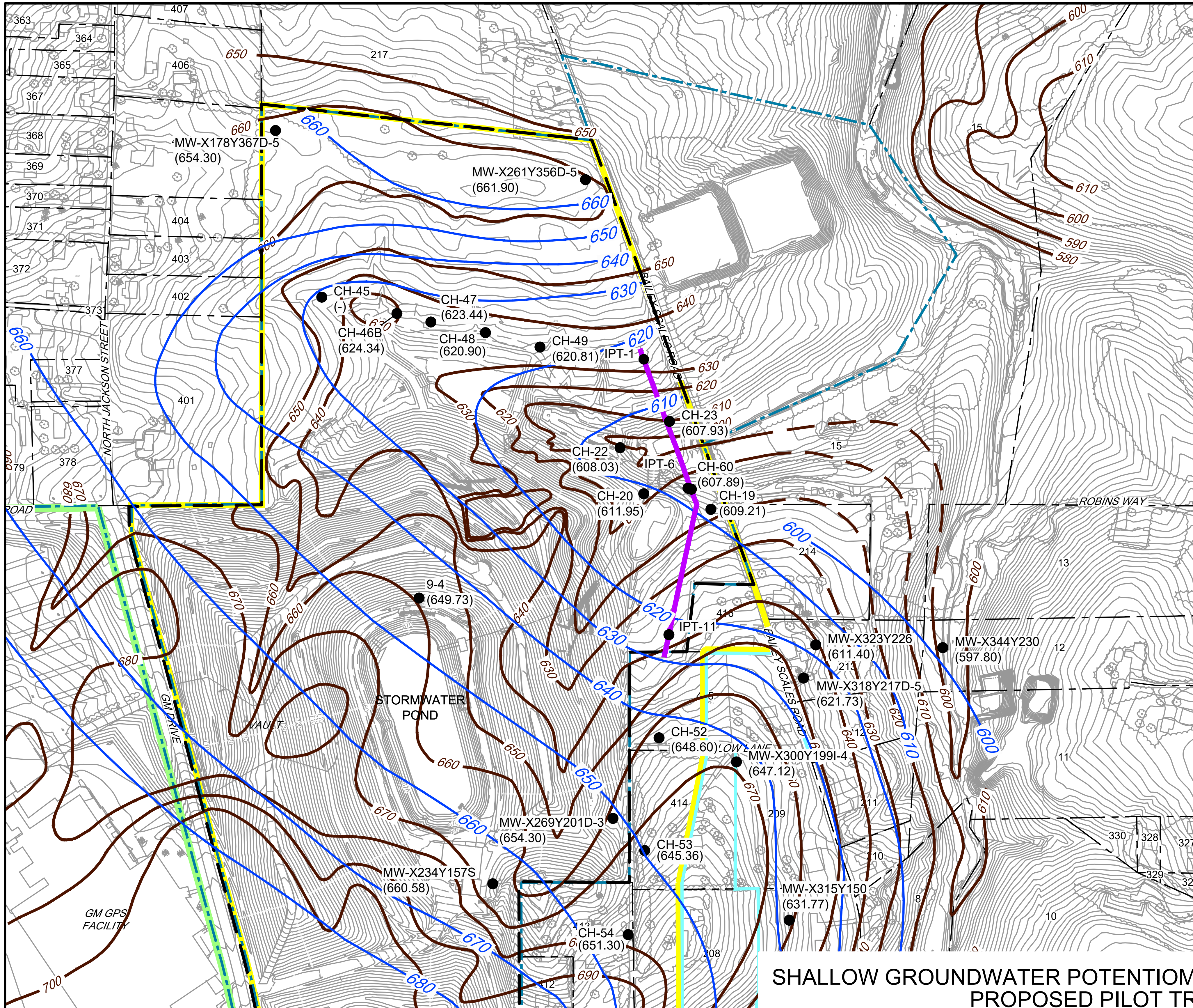


0 100 300ft

LEGEND

EXISTING GROUND SURFACE ELEVATION CONTOURS (feet AMSL)
EXISTING VEGETATION
EXISTING BUILDINGS
FENCE LINE
RAILROAD TRACKS
DIRT ROADS
ROADS / PAVED AREAS
APPROXIMATE PARCEL PROPERTY
APPROXIMATE GM PROPERTY BOUNDARY
APPROXIMATE SURFACE WATER LOCATION
EAST PLANT AREA
WEST PLANT AREA
PILOT TRENCH ALIGNMENT (2016)
MONITORING WELL SAMPLE LOCATION
(654.24) GROUNDWATER ELEVATION (ft AMSL) (SEPTEMBER 2 TO 3, 2015)
(-) GROUNDWATER ELEVATION NOT MEASURED
* GROUNDWATER ELEVATION REPRESENTS PERCHED WATER TABLE NOT USED IN CONTOURING
680 GROUNDWATER FLOW CONTOUR (ft AMSL)
610 BEDROCK CONTOUR (FT AMSL) DASHED WHERE INFERRED

NOTE: CONTOURS FOR THE EAST PLANT AREA VAULT REPRESENT AS-BUILT CONTOURS FOR THE BOTTOM OF THE LEAK DETECTION LINER (ie. THE SECONDARY LINER)

GROUNDWATER CONTOURS PRESENTED HERE ARE A PORTION OF THE OVERALL FACILITY CONTOURS

GM PROPERTY BOUNDARY SURVEY BY BLEDSOE RIGGERT GUERRETTAZ RECEIVED OCTOBER 2007. ADJACENT PROPERTY BOUNDARY LOCATIONS APPROXIMATED FROM THE LAWRENCE COUNTY SURVEY PLATS. ADJOINING PROPERTY LINES MAY NOT ACCURATELY REPRESENT THE TRUE PROPERTY BOUNDARIES

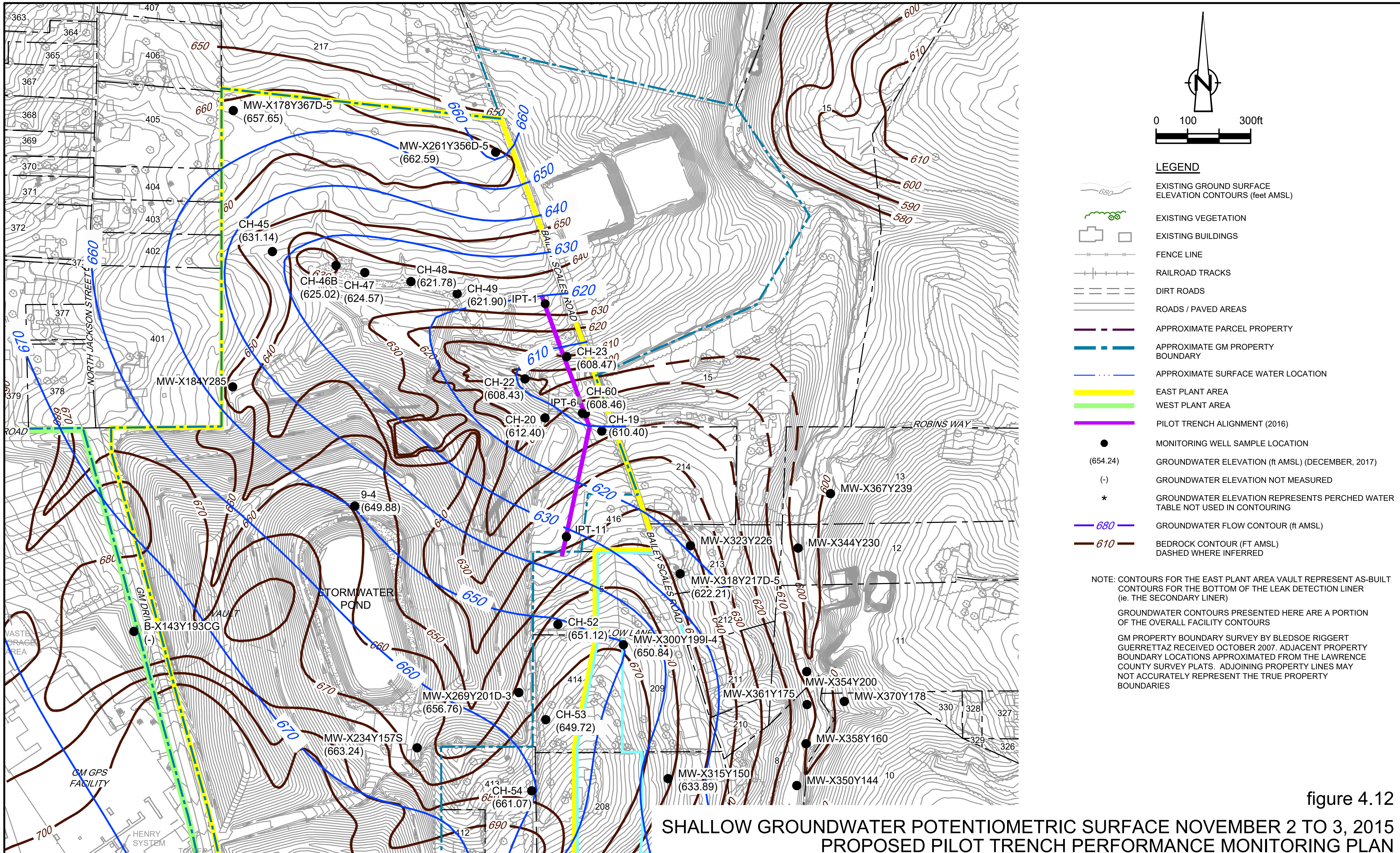
SOURCE: BASE MAP COMPLETED BY AIR-LAND SURVEYS, FLINT, MI, APRIL 2001 AND CRA SURVEYS 2002 TO 2013.

GHD

figure 4.11

SHALLOW GROUNDWATER POTENTIOMETRIC SURFACE SEPTEMBER 2 TO 3, 2015
PROPOSED PILOT TRENCH PERFORMANCE MONITORING PLAN
TRENCH COLLECTION SYSTEM
GM GPS BEDFORD FACILITY
Bedford, Indiana

N:\US\Chicago\Legacy\DRAWINGS\13000S\13968\13968-REPORTS\13968-00(404)\13968-00(404)GN\13968-00(404)GN-CO010.dwg Plot Date: AUG 15, 2019



NOTE: CONTOURS FOR THE EAST PLANT AREA VAULT REPRESENT AS-BUILT CONTOURS FOR THE BOTTOM OF THE LEAK DETECTION LINER (ie. THE SECONDARY LINER)

GROUNDWATER CONTOURS PRESENTED HERE ARE A PORTION OF THE OVERALL FACILITY CONTOURS

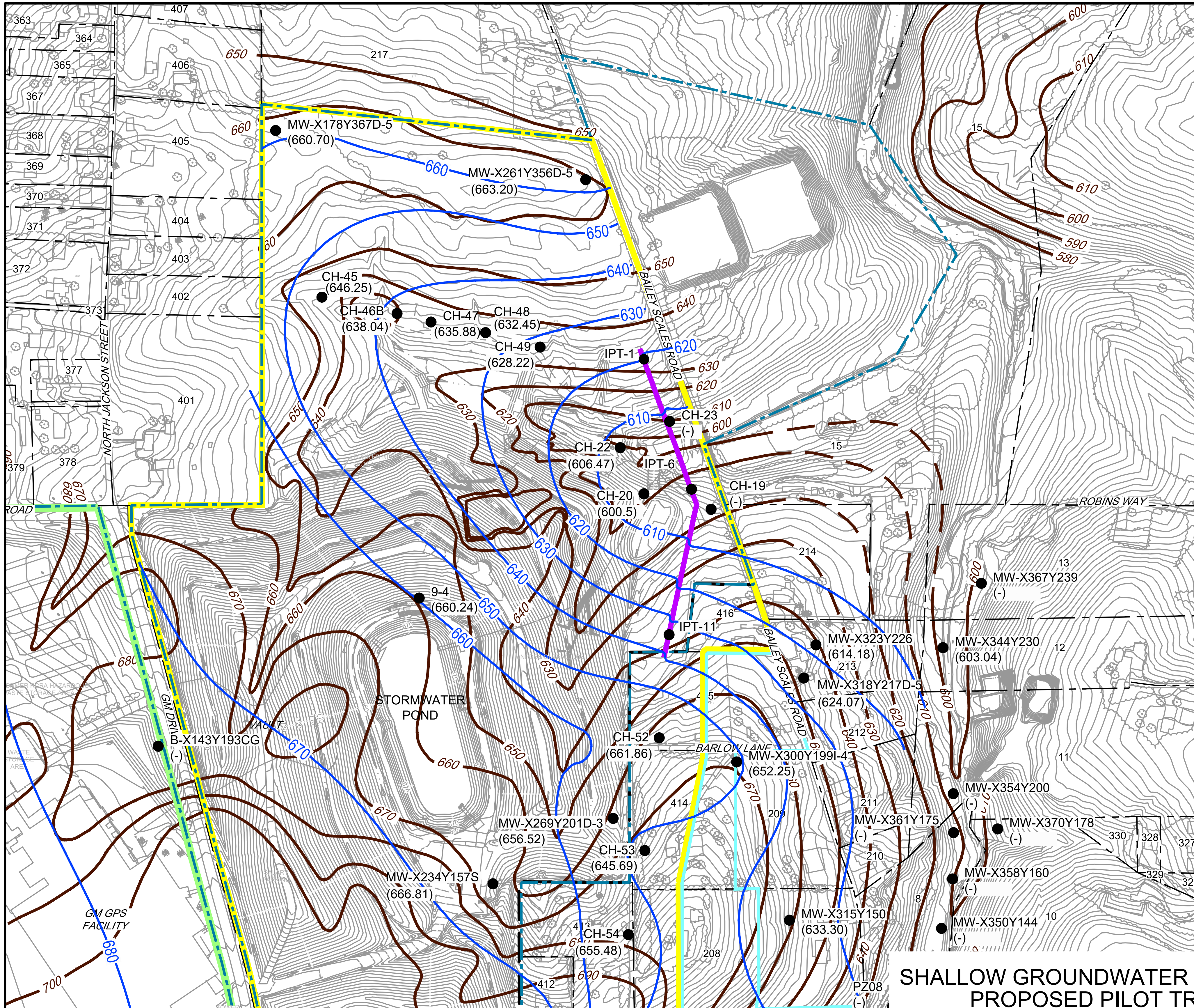
GM PROPERTY BOUNDARY SURVEY BY BLEDSOE RIGGERT GUERRETTAZ RECEIVED OCTOBER 2007. ADJACENT PROPERTY BOUNDARY LOCATIONS APPROXIMATED FROM THE LAWRENCE COUNTY SURVEY PLATS. ADJOINING PROPERTY LINES MAY NOT ACCURATELY REPRESENT THE TRUE PROPERTY BOUNDARIES

SOURCE: BASE MAP COMPLETED BY AIR-LAND SURVEYS, FLINT, MI, APRIL 2001 AND CRA SURVEYS 2002 TO 2013.

figure 4.12

SHALLOW GROUNDWATER POTENTIOMETRIC SURFACE NOVEMBER 2 TO 3, 2015
PROPOSED PILOT TRENCH PERFORMANCE MONITORING PLAN
TRENCH COLLECTION SYSTEM
GM GPS BEDFORD FACILITY
Bedford, Indiana

N:\US\Chicago\Legacy\DRAWINGS\13000S\13968\13968-REPORTS\13968-00(404)\13968-00(404)GN\13968-00(404)GN-CO011.dwg Plot Date: AUG 15, 2019



0 100 300ft

LEGEND

EXISTING GROUND SURFACE ELEVATION CONTOURS (feet AMSL)

EXISTING VEGETATION

EXISTING BUILDINGS

FENCE LINE

RAILROAD TRACKS

DIRT ROADS

ROADS / PAVED AREAS

APPROXIMATE PARCEL PROPERTY

APPROXIMATE GM PROPERTY BOUNDARY

APPROXIMATE SURFACE WATER LOCATION

EAST PLANT AREA

WEST PLANT AREA

PILOT TRENCH ALIGNMENT (2016)

MONITORING WELL SAMPLE LOCATION

(654.24) GROUNDWATER ELEVATION (ft AMSL) (MARCH, 2017)

(-) GROUNDWATER ELEVATION NOT MEASURED

* GROUNDWATER ELEVATION REPRESENTS PERCHED WATER TABLE NOT USED IN CONTOURING

680 GROUNDWATER FLOW CONTOUR (ft AMSL)

610 BEDROCK CONTOUR (FT AMSL) DASHED WHERE INFERRED

NOTE: CONTOURS FOR THE EAST PLANT AREA VAULT REPRESENT AS-BUILT CONTOURS FOR THE BOTTOM OF THE LEAK DETECTION LINER (ie. THE SECONDARY LINER)

GROUNDWATER CONTOURS PRESENTED HERE ARE A PORTION OF THE OVERALL FACILITY CONTOURS

GM PROPERTY BOUNDARY SURVEY BY BLEDSOE RIGGERT GUERRETTAZ RECEIVED OCTOBER 2007. ADJACENT PROPERTY BOUNDARY LOCATIONS APPROXIMATED FROM THE LAWRENCE COUNTY SURVEY PLATS. ADJOINING PROPERTY LINES MAY NOT ACCURATELY REPRESENT THE TRUE PROPERTY BOUNDARIES

figure 4.13

SHALLOW GROUNDWATER POTENTIOMETRIC SURFACE MARCH, 2017
PROPOSED PILOT TRENCH PERFORMANCE MONITORING PLAN
TRENCH COLLECTION SYSTEM
GM GPS BEDFORD FACILITY
Bedford, Indiana

SOURCE: BASE MAP COMPLETED BY AIR-LAND SURVEYS, FLINT, MI, APRIL 2001 AND CRA SURVEYS 2002 TO 2013.

GHD

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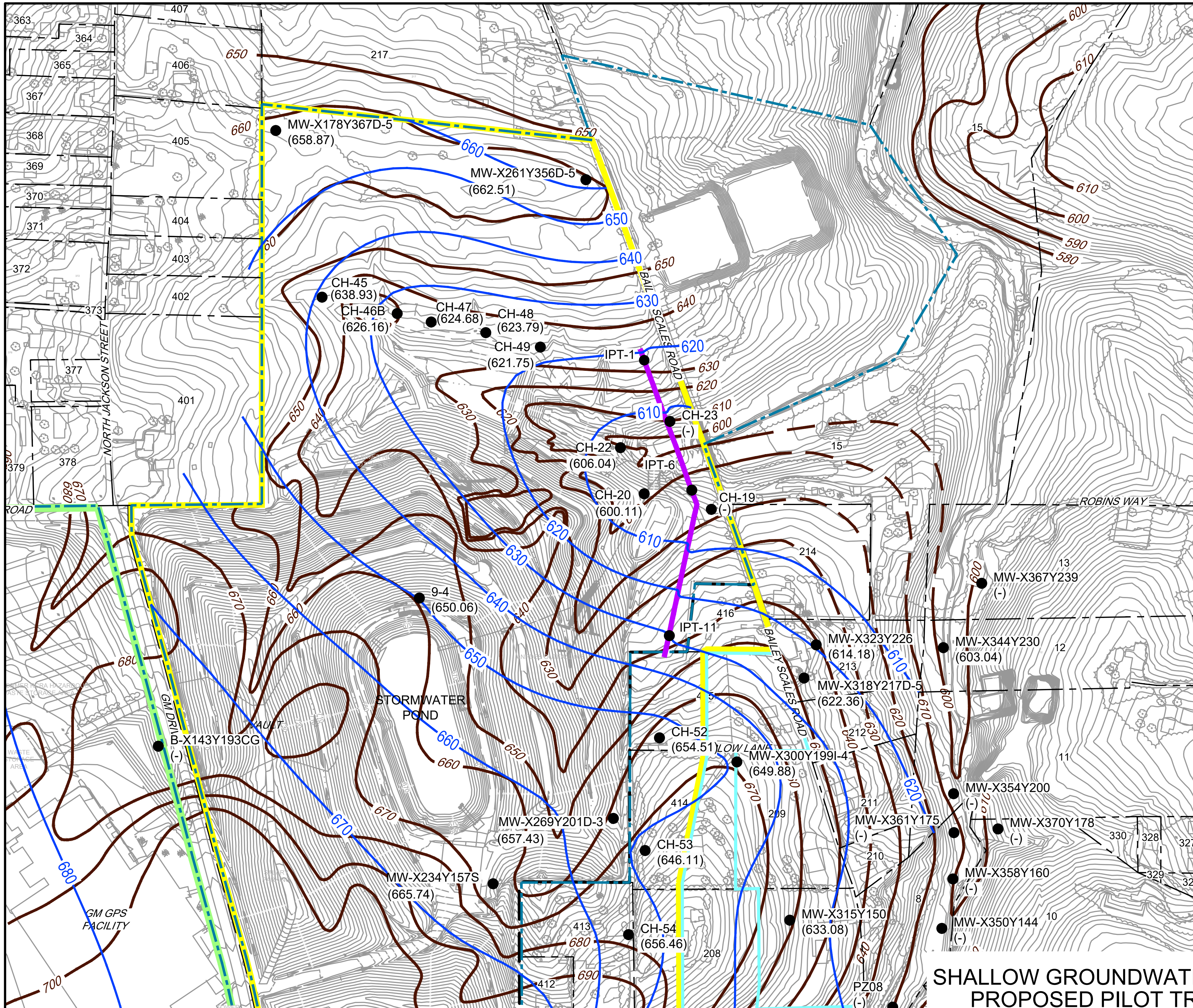

0 100 300ft

LEGEND

- EXISTING GROUND SURFACE ELEVATION CONTOURS (feet AMSL)
- EXISTING VEGETATION
- EXISTING BUILDINGS
- FENCE LINE
- RAILROAD TRACKS
- DIRT ROADS
- ROADS / PAVED AREAS
- APPROXIMATE PARCEL PROPERTY
- APPROXIMATE GM PROPERTY BOUNDARY
- APPROXIMATE SURFACE WATER LOCATION
- EAST PLANT AREA
- WEST PLANT AREA
- PILOT TRENCH ALIGNMENT (2016)
- ● MONITORING WELL SAMPLE LOCATION
- (654.24) GROUNDWATER ELEVATION (ft AMSL) (MAY, 2017)
- (-) GROUNDWATER ELEVATION NOT MEASURED
- * GROUNDWATER ELEVATION REPRESENTS PERCHED WATER TABLE NOT USED IN CONTOURING
- 680 GROUNDWATER FLOW CONTOUR (ft AMSL)
- 610 BEDROCK CONTOUR (FT AMSL) DASHED WHERE INFERRED

NOTE: CONTOURS FOR THE EAST PLANT AREA VAULT REPRESENT AS-BUILT CONTOURS FOR THE BOTTOM OF THE LEAK DETECTION LINER (ie. THE SECONDARY LINER)

GROUNDWATER CONTOURS PRESENTED HERE ARE A PORTION OF THE OVERALL FACILITY CONTOURS

GM PROPERTY BOUNDARY SURVEY BY BLEDSOE RIGGERT GUERRETTAZ RECEIVED OCTOBER 2007. ADJACENT PROPERTY BOUNDARY LOCATIONS APPROXIMATED FROM THE LAWRENCE COUNTY SURVEY PLATS. ADJOINING PROPERTY LINES MAY NOT ACCURATELY REPRESENT THE TRUE PROPERTY BOUNDARIES

figure 4.14

SHALLOW GROUNDWATER POTENTIOMETRIC SURFACE MAY, 2017 PROPOSED PILOT TRENCH PERFORMANCE MONITORING PLAN TRENCH COLLECTION SYSTEM GM GPS BEDFORD FACILITY

Bedford, Indiana

SOURCE: BASE MAP COMPLETED BY AIR-LAND SURVEYS, FLINT, MI, APRIL 2001 AND CRA SURVEYS 2002 TO 2013.

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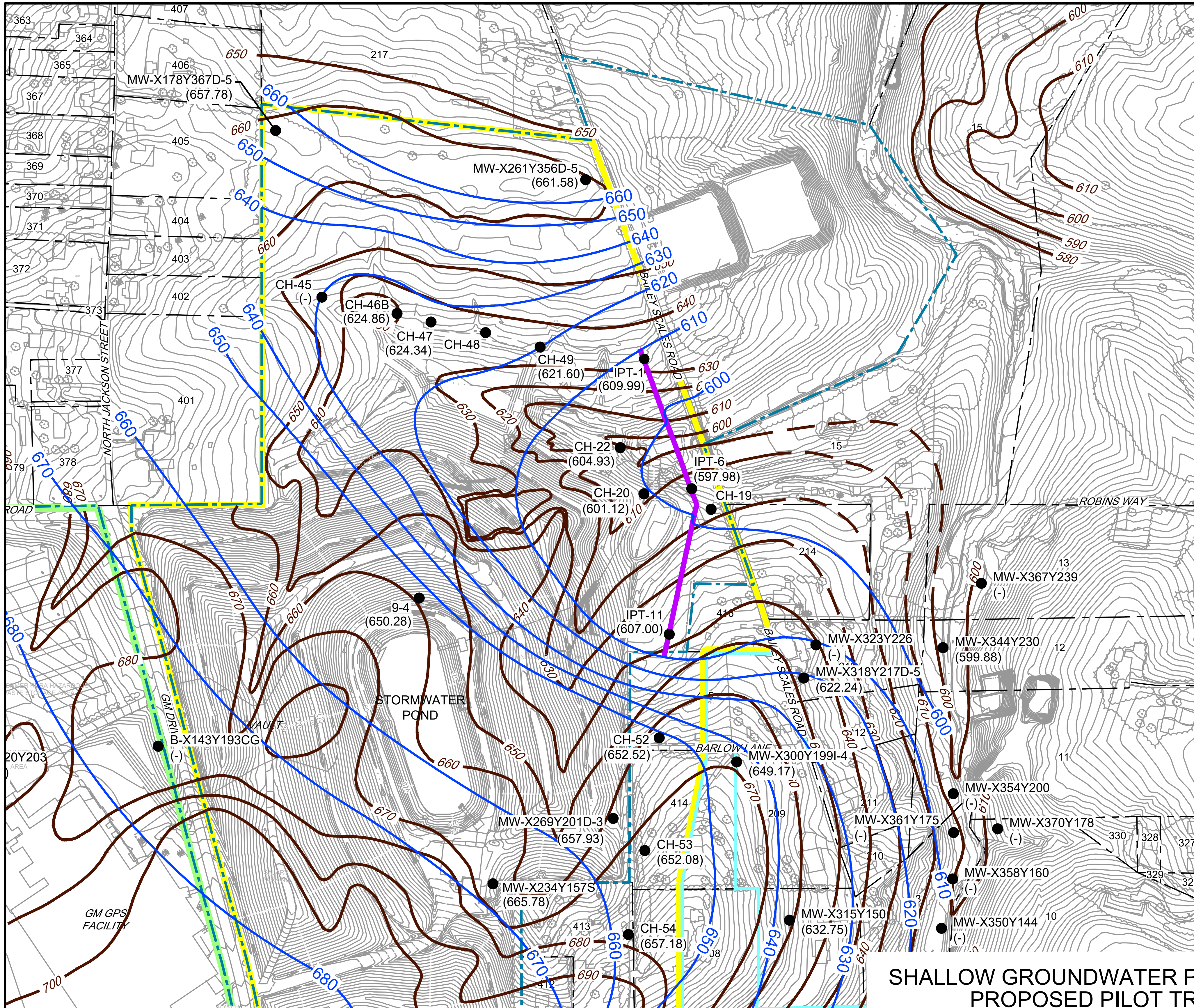


0 100 300ft

LEGEND

EXISTING GROUND SURFACE ELEVATION CONTOURS (feet AMSL)

EXISTING VEGETATION

EXISTING BUILDINGS

FENCE LINE

RAILROAD TRACKS

DIRT ROADS

ROADS / PAVED AREAS

APPROXIMATE PARCEL PROPERTY

APPROXIMATE GM PROPERTY BOUNDARY

APPROXIMATE SURFACE WATER LOCATION

EAST PLANT AREA

WEST PLANT AREA

PILOT TRENCH ALIGNMENT (2016)

MONITORING WELL SAMPLE LOCATION

(654.24) GROUNDWATER ELEVATION (ft AMSL) (AUGUST, 2017)

(-) GROUNDWATER ELEVATION NOT MEASURED

* GROUNDWATER ELEVATION REPRESENTS PERCHED WATER TABLE NOT USED IN CONTOURING

680 GROUNDWATER FLOW CONTOUR (ft AMSL)

610 BEDROCK CONTOUR (FT AMSL) DASHED WHERE INFERRED

NOTE: CONTOURS FOR THE EAST PLANT AREA VAULT REPRESENT AS-BUILT CONTOURS FOR THE BOTTOM OF THE LEAK DETECTION LINER (ie. THE SECONDARY LINER)

GROUNDWATER CONTOURS PRESENTED HERE ARE A PORTION OF THE OVERALL FACILITY CONTOURS

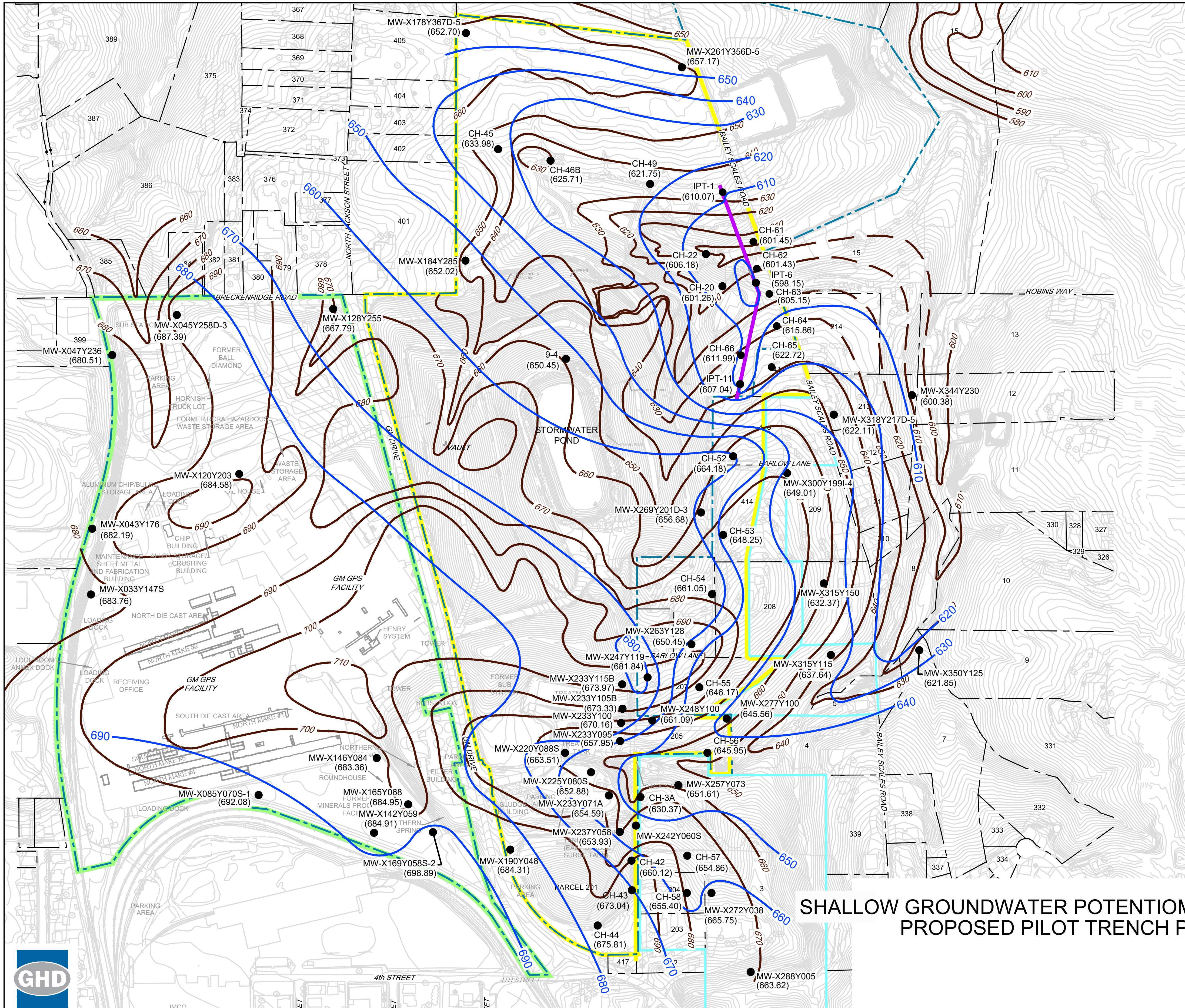
GM PROPERTY BOUNDARY SURVEY BY BLEDSOE RIGGERT GUERRETTAZ RECEIVED OCTOBER 2007. ADJACENT PROPERTY BOUNDARY LOCATIONS APPROXIMATED FROM THE LAWRENCE COUNTY SURVEY PLATS. ADJOINING PROPERTY LINES MAY NOT ACCURATELY REPRESENT THE TRUE PROPERTY BOUNDARIES

SOURCE: BASE MAP COMPLETED BY AIR-LAND SURVEYS, FLINT, MI, APRIL 2001 AND CRA SURVEYS 2002 TO 2013.

figure 4.15

SHALLOW GROUNDWATER POTENTIOMETRIC SURFACE AUGUST, 2017
PROPOSED PILOT TRENCH PERFORMANCE MONITORING PLAN
TRENCH COLLECTION SYSTEM
GM GPS BEDFORD FACILITY
Bedford, Indiana

N:\US\Chicago\Legacy\DRAWINGS\13000S\13968\13968-REPORTS\13968-00(404)\13968-00(404)GN\13968-00(404)GN-CO014.dwg Plot Date: AUG 15, 2019



N
0 200 400ft

LEGEND

EXISTING GROUND SURFACE ELEVATION CONTOURS (feet AMSL)
EXISTING VEGETATION
EXISTING BUILDINGS
FENCE LINE
DIRT ROADS
ROADS / PAVED AREAS
APPROXIMATE PARCEL PROPERTY
APPROXIMATE GM PROPERTY BOUNDARY
APPROXIMATE SURFACE WATER LOCATION
EAST PLANT AREA
WEST PLANT AREA
PILOT TRENCH ALIGNMENT (2016)
MONITORING WELL SAMPLE LOCATION
(653.98) GROUNDWATER ELEVATION (ft AMSL) (DECEMBER, 2017)
680 GROUNDWATER FLOW CONTOUR (ft AMSL)
610 BEDROCK CONTOUR (FT AMSL) DASHED WHERE INFERRED

SOURCE: BASE MAP COMPLETED BY AIR-LAND SURVEYS, FLINT, MI, APRIL 2001 AND CRA SURVEYS 2002 TO 2013.

figure 4.16

SHALLOW GROUNDWATER POTENTIOMETRIC SURFACE DECEMBER 2018
PROPOSED PILOT TRENCH PERFORMANCE MONITORING PLAN
TRENCH COLLECTION SYSTEM
GM GPS BEDFORD FACILITY
Bedford, Indiana

GHD

N:\US\Chicago\Legacy\DRAWINGS\13000S\13968\13968-REPORTS\13968-00(404)\13968-00(404)GN\13968-00(404)GN-CO019.DWG Plot Date: AUG 15, 2019

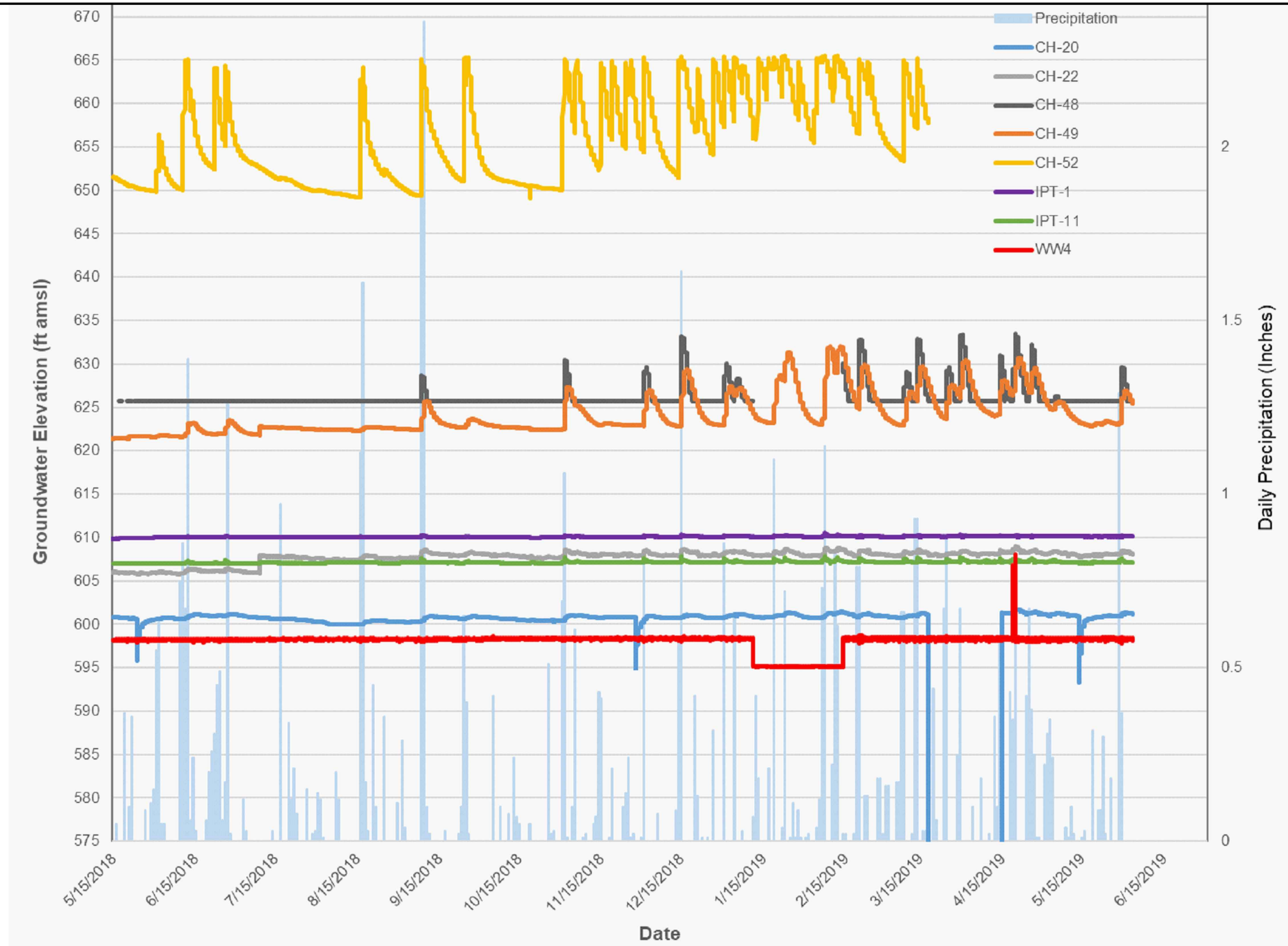


figure 4.17

SHALLOW GROUNDWATER TRANSDUCER DATA INSTALLED IN 2019
PROPOSED PILOT TRENCH PERFORMANCE MONITORING PLAN
TRENCH COLLECTION SYSTEM
GM GPS BEDFORD FACILITY
Bedford, Indiana

GHD

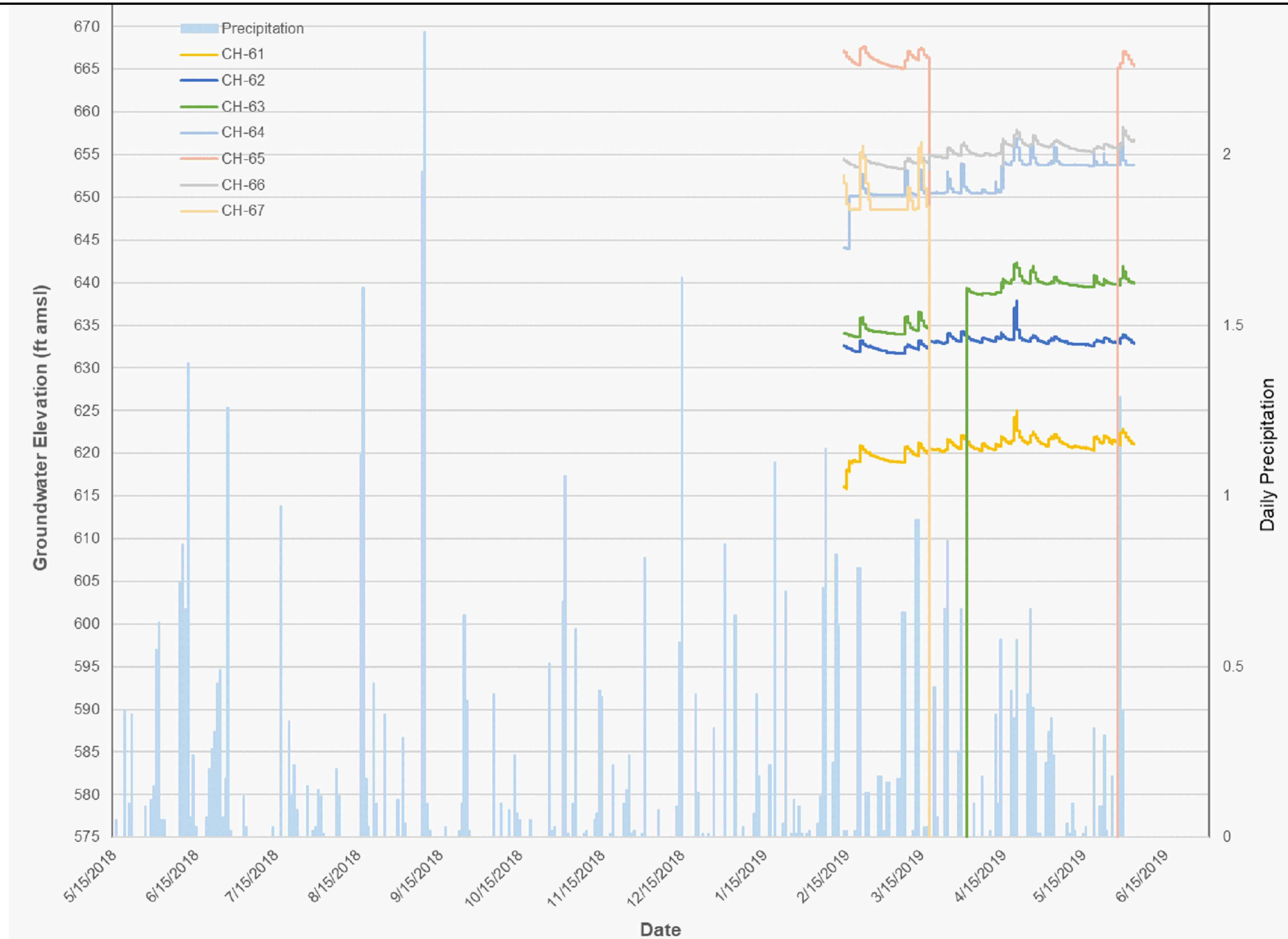


figure 4.18

SHALLOW GROUNDWATER TRANSDUCER DATA INSTALLED IN 2019
PROPOSED PILOT TRENCH PERFORMANCE MONITORING PLAN
TRENCH COLLECTION SYSTEM
GM GPS BEDFORD FACILITY
Bedford, Indiana

N:\US\Chicago\Legacy\DRAWINGS\13000S\13968\13968-REPORTS\13968-00(404)\13968-00(404)GN\13968-00(404)GN-CO022.DWG Plot Date: AUG 15, 2019

Table 4.1

Monitoring Locations and Rationale

	Location ID	Location Type	Measurement Type	Frequency	Qualifier	Rationale[1]
Hydraulic Monitoring (Figure 4.2)	IPT-1	Trench Piezometer	Pressure Transducer	15 Minutes/Monthly Download		Provide control point for pumping level in the northern portion of the pilot trench
	IPT-11	Trench Piezometer	Pressure Transducer	15 Minutes/Monthly Download		Provide control point for pumping level in the southern portion of the pilot trench
	9-4	Monitoring Well	Hand Measurement	Weekly for 1 month, then monthly for 5 months		Data will allow for the collection of head measurements to evaluate the upgradient extent of pumping influence of the Pilot Trench
	CH-20	Monitoring Well	Pressure Transducer	15 Minutes/Monthly Download		Data will allow for the collection of head measurements to evaluate the upgradient extent of pumping influence of the Pilot Trench
	CH-22	Monitoring Well	Pressure Transducer	15 Minutes/Monthly Download		Data will allow for the collection of head measurements to evaluate the upgradient extent of pumping influence of the Pilot Trench
	CH-45	Monitoring Well	Hand Measurement	Weekly for 1 month, then monthly for 5 months		Data will allow for the collection of head measurements to evaluate the upgradient extent of pumping influence to the northwest of the Pilot Trench
	CH-46	Monitoring Well	Hand Measurement	Weekly for 1 month, then monthly for 5 months		Data will allow for the collection of head measurements to evaluate the upgradient extent of pumping influence to the northwest of the Pilot Trench
	CH-47	Monitoring Well	Hand Measurement	Weekly for 1 month, then monthly for 5 months		Data will allow for the collection of head measurements to evaluate the upgradient extent of pumping influence to the northwest of the Pilot Trench
	CH-48	Monitoring Well	Pressure Transducer	15 Minutes/Monthly Download	Obstruction may prevent location	Data will allow for the collection of head measurements to evaluate the upgradient extent of pumping influence to the northwest of the Pilot Trench
	CH-49	Monitoring Well	Pressure Transducer	15 Minutes/Monthly Download		Data will allow for the collection of head measurements to evaluate the upgradient extent of pumping influence to the northwest of the Pilot Trench
	CH-52	Monitoring Well	Pressure Transducer	15 Minutes/Monthly Download		Data will allow for the collection of head measurements to evaluate the upgradient extent of pumping influence to the south of the Pilot Trench
	CH-53	Monitoring Well	Hand Measurement	Weekly for 1 month, then monthly for 5 months		Data will allow for the collection of head measurements to evaluate the upgradient extent of pumping influence to the south of the Pilot Trench
	CH-54	Monitoring Well	Hand Measurement	Weekly for 1 month, then monthly for 5 months		Data will allow for the collection of head measurements to evaluate the upgradient extent of pumping influence to the south of the Pilot Trench
	CH-61	Monitoring Well	Pressure Transducer	15 Minutes/Monthly Download		Data will allow for the collection of head measurements to evaluate the downgradient influence, if any, of pumping at the Pilot Trench
	CH-62	Monitoring Well	Pressure Transducer	15 Minutes/Monthly Download		Data will allow for the collection of head measurements to evaluate the downgradient influence, if any, of pumping at the Pilot Trench
	CH-63	Monitoring Well	Pressure Transducer	15 Minutes/Monthly Download		Data will allow for the collection of head measurements to evaluate the downgradient influence, if any, of pumping at the Pilot Trench
	CH-64	Monitoring Well	Pressure Transducer	15 Minutes/Monthly Download		Data will allow for the collection of head measurements to evaluate the downgradient influence, if any, of pumping at the Pilot Trench
	CH-65	Monitoring Well	Pressure Transducer	15 Minutes/Monthly Download		Data will allow for the collection of head measurements to evaluate the downgradient influence, if any, of pumping at the Pilot Trench
	CH-66	Monitoring Well	Pressure Transducer	15 Minutes/Monthly Download		Data will allow for the collection of head measurements to evaluate the downgradient influence, if any, of pumping at the Pilot Trench
	CH-67	Monitoring Well	Pressure Transducer	15 Minutes/Monthly Download	Obstruction may prevent location	Data will allow for the collection of head measurements to evaluate the upgradient extent pf pumping influence to the north of the Pilot Trench
	CH-68	Monitoring Well	Hand Measurement	Weekly up to the time of dye injection		Data will allow for the collection of head measurements to evaluate the upgradient extent pf pumping influence of the Pilot Trench
	CH-69	Monitoring Well	Hand Measurement	Weekly up to the time of dye injection		Data will allow for the collection of head measurements to evaluate the upgradient extent pf pumping influence of the Pilot Trench
	CH-70	Monitoring Well	Hand Measurement	Weekly for 1 month, then monthly for 5 months		Data will allow for the collection of head measurements to evaluate the downgradient influence, if any, of pumping at the Pilot Trench
	MW-X128Y255	Monitoring Well	Hand Measurement	Weekly for 1 month, then monthly for 5 months		Data will allow for the collection of head measurements to evaluate the upgradient extent pf pumping influence to the west of the Pilot Trench
	MW-X143Y193CG	Monitoring Well	Hand Measurement	Weekly for 1 month, then monthly for 5 months		Data will allow for the collection of head measurements to evaluate the upgradient extent pf pumping influence to the west of the Pilot Trench
	MW-X184Y285	Monitoring Well	Hand Measurement	Weekly for 1 month, then monthly for 5 months		Data will allow for the collection of head measurements to evaluate the upgradient extent pf pumping influence to the northwest of the Pilot Trench
	MW-X297Y305D-2	Waterloo	Hand Measurement	Weekly for 1 month, then monthly for 5 months		Data will allow for the collection of head measurements to evaluate the downgradient influence, if any, of pumping at the Pilot Trench
	MW-X178Y367D-2	Waterloo	Hand Measurement	Weekly for 1 month, then monthly for 5 months		Data will allow for the collection of head measurements to evaluate the upgradient extent of pumping influence in the Intermediate Flow System to the north of the Pilot Trench
	MW-X178Y367D-5	Waterloo	Hand Measurement	Weekly for 1 month, then monthly for 5 months		Data will allow for the collection of head measurements to evaluate the upgradient extent of pumping influence to the northwest of the Pilot Trench
	MW-X234Y157S	Monitoring Well	Hand Measurement	Weekly for 1 month, then monthly for 5 months		Data will allow for the collection of head measurements to evaluate the upgradient extent of pumping influence to the southwest of the Pilot Trench
	MW-X261Y356D-4	Waterloo	Hand Measurement	Weekly for 1 month, then monthly for 5 months		Data will allow for the collection of head measurements to evaluate the upgradient extent of pumping influence to the north of the Pilot Trench
	MW-X261Y356D-5	Waterloo	Hand Measurement	Weekly for 1 month, then monthly for 5 months		Data will allow for the collection of head measurements to evaluate the upgradient extent of pumping influence to the north of the Pilot Trench
	MW-X318Y217D-5	Waterloo	Hand Measurement	Weekly for 1 month, then monthly for 5 months		Data will allow for the collection of head measurements to evaluate the downgradient influence, if any, of pumping at the Pilot Trench
	MW-X344Y230	Monitoring Well	Hand Measurement	Weekly for 1 month, then monthly for 5 months		Data will allow for the collection of head measurements to evaluate the downgradient influence, if any, of pumping at the Pilot Trench
	SG-1	Staff Gauge	Hand Measurement	Weekly for 1 month, then monthly for 5 months		Data will allow for the collection of head measurements to evaluate the downgradient influence, if any, of pumping at the Pilot Trench
	WW-4	Collection Sump	Pressure Transducer	15 Minutes/Monthly Download		Evaluate pumping level at pumping location
Dye Tracing Injection and Monitoring (NEAR FIELD)						
Pilot Trench (Figure 4.5)[3]						
First Injection						
	CH-20	Injection	NA	NA		For the near injection of a a dye tracer into the shallow groundwater flow system upgradient and near the middle portion of the Pilot Trench.
	CH-22	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to help assess tracer movement.
	CH-46	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to help assess tracer movement.
	CH-48	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to help assess tracer movement.
	CH-49	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to help assess tracer movement.
	CH-52	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to help assess potential tracer movement south of the Pilot Trench.
	CH-61	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to travel beneath the-Pilot Trench at this location.
	CH-62	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to travel beneath the-Pilot Trench at this location.
	CH-63	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to travel beneath the-Pilot Trench at this location.
	CH-64	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to travel beneath the-Pilot Trench at this location.
	CH-65	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to travel beneath the-Pilot Trench at this location.
	CH-66	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to help assess tracer movement.
	CH-67	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months	Obstruction may prevent location	Data will be used to help assess potential tracer movement north of the Pilot Trench.
	CH-68	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to help assess potential tracer movement north of the Pilot Trench.
	CH-69	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to help assess potential tracer movement north of the Pilot Trench.
	CH-70	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to travel beneath the Pilot Trench at this location.
	MW-X178Y367D-2	Waterloo	Hand Collection	Weekly for 8 weeks, monthly for 4 months		Data will be used to help identify the potential for other, upgradient dye in the area and within the intermediate flow system.
	MW-X234Y157D-1	Waterloo	Hand Collection	Weekly for 8 weeks, monthly for 4 months		Data will be used to help identify the potential for other, upgradient dye in the area and within the deep flow system.
	MW-X234Y157D-2	Waterloo	Hand Collection	Weekly for 8 weeks, monthly for 4 months		Data will be used to help identify the potential for other, upgradient dye in the area and within the intermediate flow system.
	MW-X261Y356D-1	Waterloo	Hand Collection	Weekly for 8 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to travel beneath the Pilot Trench at this location in the Deep Flow System.
	MW-X297Y305D-1	Waterloo	Hand Collection	Weekly for 8 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to travel beneath the Pilot Trench at this location in the Deep Flow System.
	MW-X297Y305D-2	Waterloo	Hand Collection	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to travel beneath the Pilot Trench at this location.
	MW-X318Y217D-5	Waterloo	Hand Collection	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to travel beneath the Pilot Trench at this location.
	MW-X344Y230	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye travel beyond the trench to Bailey's Branch
	BB-1	Surface Water	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to monitor the background fluorescence of water in the head waters of Bailey's Branch throughout the tracer study for inputs of non-site-related dye into the study area.
	BB-2	Surface Water	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to discharge to Bailey's Branch between location BB-1 and this location.
	BB-3	Surface Water	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to discharge to Bailey's Branch between location BB-2 and this location.
	BB-4	Surface Water	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to discharge to Bailey's Branch between location BB-3 and this location.
	BB-5	Surface Water	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to discharge to Bailey's Branch between location BB-4 and this location.
	Tributary 3-3	Surface Water	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Dye positive location for AOI4 Dye Trace. Data will be used to evaluate the potential for dye to discharge to-Tributary 3 upstream of this location.
	Tributary 3-4	Surface Water	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to discharge toTributary 3 upstream of this location and prior to joining Bailey's Branch.
	WW-3	Collection Sump	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye travel to the existing collections systems located upgradient of the Pilot Trench
	WW-4	Collection Sump	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		These data will be used to evaluate recovery of dye in water pumped from the trench.
	Outfall 003/004[4]	NPDES Outfall	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		These data will be used to assess the viability of downstream dye detections.
	NT-2	Surface Water	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Monitor for northward movement of dye. Potential access issues exist for any remaning springs. Location is primarily intended to bound the observed flow direction
	Spring 021-004	Spring Water	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months	Pending Access and Thermal Reconnaisance	Data will be used to evaluate the potential for dye to travel beyond the Pilot Trench, and if so, document where dyed water discharges to the surface.
	Spring 021-003	Spring Water	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months	Pending Access and Thermal Reconnaisance	Data will be used to evaluate the potential for dye to travel beyond the Pilot Trench, and if so, document where dyed water discharges to the surface.
	Spring 021-002	Spring Water	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months	Pending Access and Thermal Reconnaisance	Data will be used to evaluate the potential for dye to travel beyond the Pilot Trench, and if so, document where dyed water discharges to the surface.
	Spring 018C	Spring Water	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to travel beyond the Pilot Trench, and if so, document where dyed water discharges to the surface.
Second Injection						
	CH-68	Injection	NA	NA		For the near injection of a a dye tracer into the shallow groundwater flow system upgradient and near the southern extent of the Pilot Trench operations
	CH-69	Injection	NA	NA		For the near injection of a a dye tracer into the shallow groundwater flow system upgradient and near the northern extent of the Pilot Trench operations
	CH-22	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to help assess tracer movement and, if dye is detected, estimate straight-line groundwater velocity.
	CH-52	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to help assess potential tracer movement south of the Pilot Trench.
	CH-61	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to travel beneath the-Pilot Trench at this location.
	CH-62	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to travel beneath the-Pilot Trench at this location.
	CH-63	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to travel beneath the-Pilot Trench at this location.
	CH-64	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to travel beneath the-Pilot Trench at this location.

Table 4.1

Monitoring Locations and Rationale

Location ID	Location Type	Measurement Type	Frequency	Qualifier	Rationale[1]
CH-65	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to travel beneath the-Pilot Trench at this location.
CH-66	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to help assess tracer movement.
CH-67	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months	Obstruction may prevent location	Data will be used to help assess potential tracer movement north of the Pilot Trench.
CH-70	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to travel beneath the Pilot Trench at this location.
MW-X178Y367D-2	Waterloo	Hand Collection	Weekly for 8 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to travel beneath the Pilot Trench at this location in the Intermediate Flow System.
MW-X234Y157D-1	Waterloo	Hand Collection	Weekly for 8 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to travel beneath the Pilot Trench at this location in the Deep Flow System.
MW-X234Y157D-2	Waterloo	Hand Collection	Weekly for 8 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to travel beneath the Pilot Trench at this location in the Intermediate Flow System.
MW-X261Y356D-1	Waterloo	Hand Collection	Weekly for 8 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to travel beneath the Pilot Trench at this location in the Deep Flow System.
MW-X297Y305D-1	Waterloo	Hand Collection	Weekly for 8 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to travel beneath the Pilot Trench at this location in the Deep Flow System.
MW-X297Y305D-2	Waterloo	Hand Collection	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to travel beneath the Pilot Trench at this location.
MW-X318Y217D-5	Waterloo	Hand Collection	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to travel beneath the Pilot Trench at this location.
MW-X344Y230	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye travel beyond the trench to Bailey's Branch
BB-1	Surface Water	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to monitor the background fluorescence of water in the head waters of Bailey's Branch throughout the tracer study for inputs of non-site-related dye into the study area.
BB-2	Surface Water	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to discharge to Bailey's Branch between location BB-1 and this location.
BB-3	Surface Water	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to discharge to Bailey's Branch between location BB-2 and this location.
BB-4	Surface Water	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to discharge to Bailey's Branch between location BB-3 and this location.
BB-5	Surface Water	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to discharge to Bailey's Branch between location BB-4 and this location.
Tributary 3-3	Surface Water	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Dye positive location for AOI4 Dye Trace. Data will be used to evaluate the potential for dye to discharge to-Tributary 3 upstream of this location.
Tributary 3-4	Surface Water	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to discharge toTributary 3 upstream of this location and prior to joining Bailey's Branch.
WW-3	Collection Sump	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye travel to the existing collections systems located upgradient of the Pilot Trench
WW-4	Collection Sump	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		These data will be used to evaluate recovery of dye in water pumped from the trench.
Outfall 003/004[4]	NPDES Outfall	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		These data will be used to assess the viability of downstream dye detections.
NT-2	Surface Water	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Monitor for northward movement of dye. Potential access issues exist for any remaning springs. Location is primarily intended to bound the observed flow direction
Spring 021-004	Spring Water	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months	Pending Access and Thermal Reconnaisance	Data will be used to evaluate the potential for dye to travel beyond the Pilot Trench, and if so, document where dyed water discharges to the surface.
Spring 021-003	Spring Water	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months	Pending Access and Thermal Reconnaisance	Data will be used to evaluate the potential for dye to travel beyond the Pilot Trench, and if so, document where dyed water discharges to the surface.
Spring 021-002	Spring Water	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months	Pending Access and Thermal Reconnaisance	Data will be used to evaluate the potential for dye to travel beyond the Pilot Trench, and if so, document where dyed water discharges to the surface.
Spring 018C	Spring Water	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to travel beyond the Pilot Trench, and if so, document where dyed water discharges to the surface.
GUS (Figure 4.6)[3] (FAR FIELD)					
Vault CO1	Injection	NA	NA		To distribute dye into the shallow bedrock groundwater flow system within the north-eastern portion of the Facility
Vault CO2	Injection	NA	NA		To distribute dye into the shallow bedrock groundwater flow system within the north-eastern portion of the Facility
9-4	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Dye presence at this location will serve to confirm the successful introduction of dye to the shallow bedrock flow system. Dye absence would indicate that the well is poorly connected to the flow system.
CH-20	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Dye presence at this location will serve to confirm the successful introduction of dye to the shallow bedrock flow system. Dye absence would indicate that the well is poorly connected to the flow system.
CH-22	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Dye presence at this location will serve to confirm the successful introduction of dye to the shallow bedrock flow system. Dye absence would indicate that the well is poorly connected to the flow system.
CH-45	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Postive dye detections at this location would indicate that a portion of the northeastern area of the Facility includes a northerly component
CH-46	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Postive dye detections at this location would indicate that a portion of the northeastern area of the Facility includes a northerly component
CH-47	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Postive dye detections at this location would indicate that a portion of the northeastern area of the Facility includes a northerly component
CH-48	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months	Obstruction may prevent location	Postive dye detections at this location would indicate that a portion of the northeastern area of the Facility includes a northerly component
CH-49	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Postive dye detections at this location would indicate that a portion of the northeastern area of the Facility includes a north-easterly component
CH-52	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Postive dye detections at this location would indicate that a portion of the northeastern area of the Facility includes a south-easterly component
CH-53	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Postive dye detections at this location would indicate that a portion of the northeastern area of the Facility includes a south-easterly component
CH-54	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Postive dye detections at this location would indicate that a portion of the northeastern area of the Facility includes a south-easterly component
CH-61	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to travel beneath the Pilot Trench at this location.
CH-62	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to travel beneath the Pilot Trench at this location.
CH-63	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to travel beneath the Pilot Trench at this location.
CH-64	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to travel beneath the Pilot Trench at this location.
CH-65	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to travel beneath the Pilot Trench at this location.
CH-66	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to travel beneath the Pilot Trench at this location.
CH-67	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months	Obstruction may prevent location	Data will be used to evaluate the potential for dye travel from the injection location around to the north-northeast of the Pilot Trench
CH-68	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Dye presence at this location will serve to confirm the successful introduction of dye to the shallow bedrock flow system. Dye absence would indicate that the well is poorly connected to the flow system.
CH-69	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Dye presence at this location will serve to confirm the successful introduction of dye to the shallow bedrock flow system. Dye absence would indicate that the well is poorly connected to the flow system.
CH-70	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye travel from the injection location around to the north-northeast of the Pilot Trench
MW-X033Y147S	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Monitor for westward movement of dye. Location is primarily intended to bound the observed flow direction
MW-X128Y255	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Monitor for northwestward movement of dye. Location is primarily intended to bound the observed flow direction
MW-X143Y193CG	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Monitor for westward movement of dye. Location is primarily intended to bound the observed flow direction
MW-X184Y285	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Monitor for northward movement of dye. Location is primarily intended to bound the observed flow direction
MW-X209Y078S	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Monitor for southward movement of dye. Location is primarily intended to bound the observed flow direction
MW-X233Y071B	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Dye positive location for AOI6 Dye Trace. Monitor for southward movement of dye. Location is primarily intended to bound the observed flow direction
MW-X233Y095	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Monitor for southeastward movement of dye. Location is primarily intended to bound the observed flow direction
MW-X233Y100	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Monitor for southeastward movement of dye. Location is primarily intended to bound the observed flow direction
MW-X233Y110B	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Monitor for southeastward movement of dye. Location is primarily intended to bound the observed flow direction
MW-X233Y115B	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Monitor for southeastward movement of dye. Location is primarily intended to bound the observed flow direction
MW-X233Y120B	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Monitor for southeastward movement of dye. Location is primarily intended to bound the observed flow direction
MW-X233Y125B	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Monitor for southeastward movement of dye. Location is primarily intended to bound the observed flow direction
MW-234Y157S	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Dye positive location for AOI4 Dye Trace. Monitor for southeastward movement of dye. Location is primarily intended to bound the observed flow direction
MW-X234Y157D-1	Waterloo	Hand Collection	Weekly for 8 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to travel beneath the Pilot Trench at this location in the Deep Flow System.
MW-X234Y157D-2	Waterloo	Hand Collection	Weekly for 8 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to travel beneath the Pilot Trench at this location in the Intermediate Flow System.
MW-234Y157D-4	Waterloo	Hand Collect	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Dye positive location for AOI4 Dye Trace. Monitor for southeastward movement of dye. Location is primarily intended to bound the observed flow direction
MW-X242Y060S	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Monitor for southeastward movement of dye. Location is primarily intended to bound the observed flow direction
MW-X251Y189D-7	Waterloo	Hand Collect	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Monitor for southeastward movement of dye. Location is primarily intended to bound the observed flow direction
MW-X257Y073	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Monitor for southeastward movement of dye. Location is primarily intended to bound the observed flow direction
MW-X269Y201D-3	Waterloo	Hand Collect	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Monitor for southeastward movement of dye. Location is primarily intended to bound the observed flow direction
MW-X297Y305D-1	Waterloo	Hand Collection	Weekly for 8 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to travel beneath the Pilot Trench at this location in the Deep Flow System.
MW-X297Y305D-2	Waterloo	Hand Collection	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to travel beneath the Pilot Trench at this location.
MW-X178Y367D-2	Waterloo	Hand Collection	Weekly for 8 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to travel beneath the Pilot Trench at this location in the Intermediate Flow System.
MW-X178Y367D-5	Waterloo	Hand Collection	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Monitor for northward movement of dye. Location is primarily intended to bound the observed flow direction
MW-X261Y356D-1	Waterloo	Hand Collection	Weekly for 8 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to travel beneath the Pilot Trench at this location in the Deep Flow System.
MW-X261Y356D-4	Waterloo	Hand Collection	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Monitor for northward movement of dye. Location is primarily intended to bound the observed flow direction
MW-X261Y356D-5	Waterloo	Hand Collection	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Monitor for northward movement of dye. Location is primarily intended to bound the observed flow direction
MW-X318Y217D-5	Waterloo	Hand Collection	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Monitor for southeastward movement of dye. Location is primarily intended to bound the observed flow direction
MW-X344Y230	Monitoring Well	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye travel beyond the trench to Bailey's Branch
BB-1	Surface Water	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months	Pending Access	Data will be used to monitor the background fluorescence of water in the head waters of Bailey's Branch throughout the tracer study for inputs of non-site-related dye into the study area.
BB-2	Surface Water	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months	Pending Access	Data will be used to evaluate the potential for dye to discharge to Bailey's Branch between location BB-1 and this location.
BB-3	Surface Water	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months	Pending Access	Data will be used to evaluate the potential for dye to discharge to Bailey's Branch between location BB-2 and this location.
BB-4	Surface Water	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months	Pending Access	Data will be used to evaluate the potential for dye to discharge to Bailey's Branch between location BB-3 and this location.
BB-5	Surface Water	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months	Pending Access	Data will be used to evaluate the potential for dye to discharge to Bailey's Branch between location BB-4 and this location.
Tributary 3-3	Surface Water	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Dye positive location for AOI4 Dye Trace. Data will be used to evaluate the potential for dye travel to the existing collections systems located upgradient of the Pilot Trench
Tributary 3-4	Surface Water	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		These data will be used to evaluate recovery of dye in water pumped from the trench.
NT-1	Surface Water	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Monitor for northward movement of dye. Potential access issues exist for any remaning springs. Location is primarily intended to bound the observed flow direction
NT-2	Surface Water	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Monitor for northward movement of dye. Potential access issues exist for any remaning springs. Location is primarily intended to bound the observed flow direction
Western Tributary 1	Surface Water	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Monitor for westward movement of dye. Potential access issues exist for any remaning springs. Location is primarily intended to bound the observed flow direction
WT-2	Surface Water	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Monitor for westward movement of dye. Potential access issues exist for any remaning springs. Location is primarily intended to bound the observed flow direction
WW-1	Collection Sump	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Dye positive location for Outfall 002 Dye Trace. Monitor for southeastward movement of dye. Location is primarily intended to bound the observed flow direction
WW-2	Collection Sump	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Monitor for southeastward movement of dye. Location is primarily intended to bound the observed flow direction
WW-3	Collection Sump	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye travel to the existing collections systems located upgradient of the Pilot Trench

Table 4.1

Monitoring Locations and Rationale

	Location ID	Location Type	Measurement Type	Frequency	Qualifier	Rationale[1]
	WW-4	Collection Sump	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		These data will be used to evaluate recovery of dye in water pumped from the trench.
	Outfall 003/004[4]	NPDES Outfall	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		These data will be used to assess the viability of downstream dye detections.
	Spring 021-004	Spring Water	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months	Pending Access and Thermal Reconnaisance	Dye positive location for Swallet 1, 2 and 5 dye traces. Data will be used to evaluate the potential for dye to travel beyond the Pilot Trench, and if so, document where dyed water discharges to the surface.
	Spring 021-003	Spring Water	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months	Pending Access and Thermal Reconnaisance	Dye positive location for Swallet 1, 2 and 5 dye traces. Data will be used to evaluate the potential for dye to travel beyond the Pilot Trench, and if so, document where dyed water discharges to the surface.
	Spring 021-002	Spring Water	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months	Pending Access and Thermal Reconnaisance	Dye positive location for Swallet 1, 2 and 5 dye traces. Data will be used to evaluate the potential for dye to travel beyond the Pilot Trench, and if so, document where dyed water discharges to the surface.
	Spring 018C	Spring Water	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Dye positive location for Swallet 1, 2 and 5 dye traces. Data will be used to evaluate the potential for dye to travel beyond the Pilot Trench, and if so, document where dyed water discharges to the surface.
	Bdfd A	Spring Water	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months		Data will be used to evaluate the potential for dye to travel beyond the Pilot Trench, and if so, document where dyed water discharges to the surface.
	Bdfd W	Spring Water	Charcoal	Daily for 2 weeks, weekly for 6 weeks, monthly for 4 months	Pending Access and Thermal Reconnaisance	Data will be used to evaluate the potential for dye to travel beyond the Pilot Trench, and if so, document where dyed water discharges to the surface.
PCB Sampling[3] (Figure 4.4)	9-4	Monitoring Well	Zero Purge/Low Flow	CA750 (bi-annually)[2]		Upgradient of Pilot Trench. To assist in the evaluation of the existing overall shallow groundwater conditions in the northeast portion of the Facility. This well is also included as part of the CA750 sampling program.
	CH-20	Monitoring Well	Zero Purge/Low Flow	CA750 (bi-annually)[2]		Upgradient of Pilot Trench. To assist in the evaluation of the existing overall shallow groundwater conditions in the northeast portion of the Facility. This well is also included as part of the CA750 sampling program.
	CH-22	Monitoring Well	Zero Purge/Low Flow	Baseline		Upgradient of Pilot Trench. To assist in the evaluation of the curent overall shallow groundwater conditions in the northeast portion of the Facility.
	CH-46	Monitoring Well	Zero Purge/Low Flow	Baseline		Upgradient of Pilot Trench. To assist in the evaluation of the existing overall shallow groundwater conditions in the northeast portion of the Facility.
	CH-48	Monitoring Well	Zero Purge/Low Flow	Baseline	Obstruction may prevent location	Upgradient of Pilot Trench. To assist in the evaluation of the existing overall shallow groundwater conditions in the northeast portion of the Facility.
	CH-49	Monitoring Well	Zero Purge/Low Flow	Baseline		Upgradient of Pilot Trench. To assist in the evaluation of the existing overall shallow groundwater conditions in the northeast portion of the Facility.
	CH-52	Monitoring Well	Zero Purge/Low Flow	Baseline		Upgradient of Pilot Trench. To assist in the evaluation of the existing overall shallow groundwater conditions in the northeast portion of the Facility.
	CH-53	Monitoring Well	Zero Purge/Low Flow	Baseline		Upgradient of Pilot Trench. To assist in the evaluation of the existing overall shallow groundwater conditions in the northeast portion of the Facility.
	CH-54	Monitoring Well	Zero Purge/Low Flow	Baseline		Upgradient of Pilot Trench. To assist in the evaluation of the existing overall shallow groundwater conditions in the northeast portion of the Facility.
	CH-61	Monitoring Well	Zero Purge/Low Flow	Baseline, if PCB detections, then resample during CA750		Downgradient of Pilot Trench. To assist in the evaluation of the existing overall shallow groundwater conditions in the northeast portion of the Facility. New installation
	CH-62	Monitoring Well	Zero Purge/Low Flow	Baseline, if PCB detections, then resample during CA750		Downgradient of Pilot Trench. To assist in the evaluation of the existing overall shallow groundwater conditions in the northeast portion of the Facility. New installation
	CH-63	Monitoring Well	Zero Purge/Low Flow	Baseline, if PCB detections, then resample during CA750		Downgradient of Pilot Trench. To assist in the evaluation of the existing overall shallow groundwater conditions in the northeast portion of the Facility. New installation
	CH-64	Monitoring Well	Zero Purge/Low Flow	Baseline, if PCB detections, then resample during CA750		Downgradient of Pilot Trench. To assist in the evaluation of the existing overall shallow groundwater conditions in the northeast portion of the Facility. New installation
	CH-65	Monitoring Well	Zero Purge/Low Flow	Baseline, if PCB detections, then resample during CA750		Downgradient of Pilot Trench. To assist in the evaluation of the existing overall shallow groundwater conditions in the northeast portion of the Facility. New installation
	CH-66	Monitoring Well	Zero Purge/Low Flow	Baseline, if PCB detections, then resample during CA750		Downgradient of Pilot Trench. To assist in the evaluation of the existing overall shallow groundwater conditions in the northeast portion of the Facility. New installation
	CH-67	Monitoring Well	Zero Purge/Low Flow	Baseline	Obstruction may prevent location	Downgradient of Pilot Trench. To assist in the evaluation of the existing overall shallow groundwater conditions in the northeast portion of the Facility. New installation
	CH-68	Monitoring Well	Zero Purge/Low Flow	Baseline		Downgradient of Pilot Trench. To assist in the evaluation of the existing overall shallow groundwater conditions in the northeast portion of the Facility. New installation
	CH-69	Monitoring Well	Zero Purge/Low Flow	Baseline		Downgradient of Pilot Trench. To assist in the evaluation of the existing overall shallow groundwater conditions in the northeast portion of the Facility. New installation
	CH-70	Monitoring Well	Zero Purge/Low Flow	Baseline		Downgradient of Pilot Trench. To assist in the evaluation of the existing overall shallow groundwater conditions in the northeast portion of the Facility. New installation
	MW-X143Y193CG	Monitoring Well	Zero Purge/Low Flow	Baseline		Upgradient of Pilot Trench. To assist in the evaluation of the existing overall shallow groundwater conditions in the immediately west of the Vault.
	MW-X234Y157S	Monitoring Well	Zero Purge/Low Flow	Baseline		Upgradient of Pilot Trench. To assist in the evaluation of the existing overall shallow groundwater conditions in the northeast portion of the Facility. Static groundwater elevations indicate response to rainfall events.
	MW-X178Y367D-2	Waterloo	Zero Purge/Low Flow	Baseline		Data will be used to evaluate the potential for dye to travel beneath the Pilot Trench at this location in the Intermediate Flow System.
	MW-X178Y367D-5	Waterloo	Zero Purge/Low Flow	Baseline		Upgradient of Pilot Trench. To assist in the evaluation of the existing overall shallow groundwater conditions in the northeast portion of the Facility.
	MW-X234Y157D-1	Waterloo	Zero Purge/Low Flow	One Time		Data will be used to evaluate the potential for dye to travel beneath the Pilot Trench at this location in the Deep Flow System.
	MW-X234Y157D-2	Waterloo	Zero Purge/Low Flow	One Time		Data will be used to evaluate the potential for dye to travel beneath the Pilot Trench at this location in the Intermediate Flow System.
	MW-X261Y356D-1	Waterloo	Zero Purge/Low Flow	One Time		Data will be used to evaluate the potential for dye to travel beneath the Pilot Trench at this location in the Deep Flow System.
	MW-X261Y356D-3	Waterloo	Zero Purge/Low Flow	CA750 (bi-annually)[2]		Upgradient of Pilot Trench. To assist in the evaluation of the existing overall groundwater conditions within the intermediate flow system in the northeast portion of the Facility.
	MW-X261Y356D-4	Waterloo	Zero Purge/Low Flow	Baseline		Upgradient of Pilot Trench. To assist in the evaluation of the existing overall shallow groundwater conditions in the northeast portion of the Facility.
	MW-X261Y356D-5	Waterloo	Zero Purge/Low Flow	Baseline		Upgradient of Pilot Trench. To assist in the evaluation of the existing overall shallow groundwater conditions in the northeast portion of the Facility.
	MW-X297Y305D-1	Waterloo	Zero Purge/Low Flow	One Time		Data will be used to evaluate the potential for dye to travel beneath the Pilot Trench at this location in the Deep Flow System.
	MW-X297Y305D-2	Waterloo	Zero Purge/Low Flow	CA750 (bi-annually)[2]		Data will be used to evaluate the potential for dye travel from the injection location beneath the bottom of the Pilot Trench
	MW-X300Y199D-2	Waterloo	Zero Purge/Low Flow	CA750 (bi-annually)[2]		Downgradient of Pilot Trench. To assist in the evaluation of the existing overall groundwater conditions within the intermediate flow system in the northeast portion of the Facility.
	Spring 021-004	Spring Water	Grab	Baseline	Pending Access and Thermal Reconnaisance	Provide a current "snapshot" of the concentration of PCBs in groundwater discharging from this spring under base-flow conditions, if tested positive for dye. If PCBs are detected, a second, confirmatory sample will be collected and analyzed.
	Spring 021-003	Spring Water	Grab	Baseline	Pending Access and Thermal Reconnaisance	Provide a current "snapshot" of the concentration of PCBs in groundwater discharging from this spring under base-flow conditions, if tested positive for dye. If PCBs are detected, a second, confirmatory sample will be collected and analyzed.
	Spring 021-002	Spring Water	Grab	Baseline	Pending Access and Thermal Reconnaisance	Provide a current "snapshot" of the concentration of PCBs in groundwater discharging from this spring under base-flow conditions, if tested positive for dye. If PCBs are detected, a second, confirmatory sample will be collected and analyzed.
	Spring 018C	Spring Water	Grab	Baseline		Provide a current "snapshot" of the concentration of PCBs in groundwater discharging from this spring under base-flow conditions, if tested positive for dye. If PCBs are detected, a second, confirmatory sample will be collected and analyzed.
	BB-1	Surface Water	Grab	Baseline	Pending Access and Thermal Reconnaisance	Provide a current "snapshot" of the concentration of PCBs in groundwater discharging from this spring under base-flow conditions, if tested positive for dye. If PCBs are detected, a second, confirmatory sample will be collected and analyzed.
	BB-2	Surface Water	Grab	Baseline	Pending Access and Thermal Reconnaisance	Provide a current "snapshot" of the concentration of PCBs in groundwater discharging from this spring under base-flow conditions, if tested positive for dye. If PCBs are detected, a second, confirmatory sample will be collected and analyzed.
	BB-3	Surface Water	Grab	Baseline	Pending Access and Thermal Reconnaisance	Provide a current "snapshot" of the concentration of PCBs in groundwater discharging from this spring under base-flow conditions, if tested positive for dye. If PCBs are detected, a second, confirmatory sample will be collected and analyzed.
	BB-4	Surface Water	Grab	Baseline	Pending Access and Thermal Reconnaisance	Provide a current "snapshot" of the concentration of PCBs in groundwater discharging from this spring under base-flow conditions, if tested positive for dye. If PCBs are detected, a second, confirmatory sample will be collected and analyzed.
	BB-5	Surface Water	Grab	Baseline	Pending Access and Thermal Reconnaisance	Provide a current "snapshot" of the concentration of PCBs in groundwater discharging from this spring under base-flow conditions, if tested positive for dye. If PCBs are detected, a second, confirmatory sample will be collected and analyzed.
	Trib 3-3	Surface Water	Grab	Baseline		Provide a current "snapshot" of the concentration of PCBs in groundwater discharging from this spring under base-flow conditions, if tested positive for dye. If PCBs are detected, a second, confirmatory sample will be collected and analyzed.
	Trib 3-4	Surface Water	Grab	Baseline		Provide a current "snapshot" of the concentration of PCBs in groundwater discharging from this spring under base-flow conditions, if tested positive for dye. If PCBs are detected, a second, confirmatory sample will be collected and analyzed.
	WW-3	Wet Well	Spigot	Baseline		Provide a current "snapshot" of the concentration of PCBs in groundwater discharging from this spring under base-flow conditions, if tested positive for dye. If PCBs are detected, a second, confirmatory sample will be collected and analyzed.
	WW-4	Wet Well	Spigot	Baseline		Provide a current "snapshot" of the concentration of PCBs in groundwater discharging from this spring under base-flow conditions, if tested positive for dye. If PCBs are detected, a second, confirmatory sample will be collected and analyzed.

NOTES:

1: The rationale are representative of GM's current understanding of the data and the potential use of such in each category. However, actual use of the data will be in conjunction with, and in context with, other collected information and will be part of a multiple lines of evidence approach.
2: Currently collected bi-annually as part of the CA750 program
3: At any monitoring location where dye is positively detected, a straight-line groundwater velocity will be estimated.
4: Outfall 003/004 is the location where treated groundwater discharges to Tributary 3. Any dye detections after the groundwater is treated will nullify, or complicate, interpretations of any dye presence within Tributary 3 and downstream thereof (See Section 4.9.3).
5: Currently collected monthly

Appendices

Appendix A
Existing Monitoring Well Logs

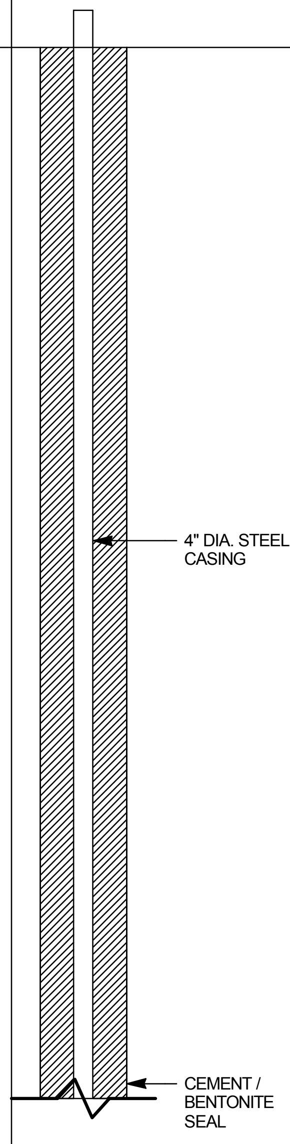
STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: GM BEDFORD RFI
PROJECT NUMBER: 013968
CLIENT: GENERAL MOTORS CORPORATION
LOCATION: BEDFORD, INDIANA

HOLE DESIGNATION: 9-4
DATE COMPLETED: July 19, 2005
DRILLING METHOD: 6 1/4" HSA & HQ CORE
FIELD PERSONNEL: D. DEITNER

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	SAMPLE NUMBER	INTERVAL	REC (ft)	'N' VALUE	PID (ppm)
	TOP OF CASING	681.8					
	GROUND SURFACE	679.2					
	ML-SILT (FILL), with fine grained sand, with clay, trace fine round gravel, loose, light brown, dry						
2			1	P/S	2.4		0.0
	CL-CLAY (FILL), with silt, soft, low plasticity, black, moist	676.2					
4	- 2-inches of concrete at 4.2ft BGS - trace silty clay sand at 4.4ft BGS						
6			2	P/S	2.4		0.0
	SP-SAND (FILL), compact, fine grained, poorly graded, black, moist - 2.5-inches of silty clay at 6.6ft BGS	673.0					
8	- trace fine round gravel, dark gray at 7.7ft BGS - 1/2-inch light gray lens at 8.6ft BGS - odor present at 8.7ft BGS - 1/2-inch light gray at 9.2ft BGS						
10			3	P/S	2.5		0.0
12	- 2.5-inches of wood debris at 11.6ft BGS						
14	- 7.3 feet of metal, plastic and wood debris observed in soil cuttings during drilling at 14.0ft BGS - 1/2-inch yellow staining lens at 15.1ft BGS		4	P/S	1.8		0.0
16	- 1/2-inch yellow staining at 15.3ft BGS						
18	- strong odor at 18.0ft BGS		5	P/S	2.2		0.0
	CL-CLAY (FILL), with silt, trace fine grained sand, soft, low plasticity, black, moist, moderate odor	660.7					
20	CL-CLAY, with silt, stiff, low plasticity, brown, moist	660.2	6	P/S	1.3		0.0
	END OF OVERBURDEN HOLE @ 21.3ft BGS						
22							
24							
26							

COREHOLE



NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG (BEDROCK)

PROJECT NAME: GM BEDFORD RFI
PROJECT NUMBER: 013968
CLIENT: GENERAL MOTORS CORPORATION
LOCATION: BEDFORD, INDIANA

HOLE DESIGNATION: 9-4
DATE COMPLETED: July 19, 2005
DRILLING METHOD: 6 1/4" HSA & HQ CORE
FIELD PERSONNEL: D. DEITNER

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL
21.3	LIMESTONE (SALEM FORMATION), weathered and fractured, thin bedded, gray, medium grained	657.9
	- no longer fractured rock at 21.9ft BGS	
	- set 4" steel casing at 24.0ft BGS	
	- horizontal fracture at 26.1ft BGS	
	- horizontal fracture at 32.2ft BGS	
	- horizontal fracture at 35.0ft BGS	
	- open stylolite at 35.4ft BGS	
	- open stylolite at 36.2ft BGS	
	- stylolite at 36.7ft BGS	
	- stylolite at 37.0ft BGS	
	- medium grained, gray, calcite content at 37.6ft BGS	
	- open stylolite at 38.2ft BGS	
	- 5-feet of porous section at 39.0ft BGS	
	- stylolite at 39.2ft BGS	
	- stylolite at 42.7ft BGS	
	- stylolite at 43.1ft BGS	
	- stylolite at 44.9ft BGS	
	- stylolite at 45.7ft BGS	
	- open stylolite at 45.9ft BGS	

COREHOLE: CEMENT / BENTONITE SEAL; 4" DIA. COREHOLE

RUN NUMBER	CORE RECOVERY %	RQD %
1	100	100
2	100	100

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG (BEDROCK)

PROJECT NAME: GM BEDFORD RFI
PROJECT NUMBER: 013968
CLIENT: GENERAL MOTORS CORPORATION
LOCATION: BEDFORD, INDIANA

HOLE DESIGNATION: 9-4
DATE COMPLETED: July 19, 2005
DRILLING METHOD: 6 1/4" HSA & HQ CORE
FIELD PERSONNEL: D. DEITNER

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	COREHOLE	RUN NUMBER	CORE RECOVERY %	RQD %
	- open stylolite at 49.3ft BGS		4" DIA. COREHOLE	3	100	98
54	END OF BOREHOLE @ 54.1ft BGS	625.1				

Depth scale: 50, 52, 54, 56, 58, 60, 62, 64, 66, 68, 70, 72, 74

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

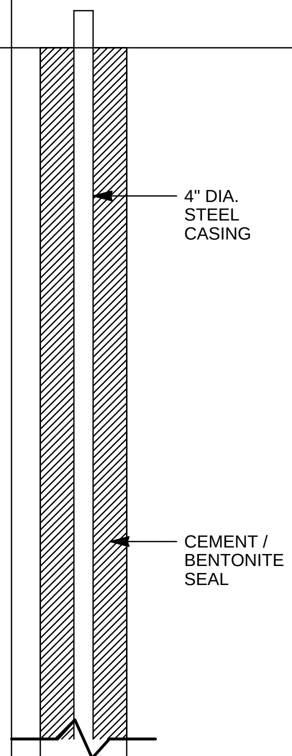
STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

PROJECT NAME: GM BEDFORD RFI
PROJECT NUMBER: 013968
CLIENT: GENERAL MOTORS CORPORATION
LOCATION: BEDFORD, INDIANA

HOLE DESIGNATION: CH-20
DATE COMPLETED: June 7, 2005
DRILLING METHOD: 6 1/4" HSA & HQ CORE
FIELD PERSONNEL: K. VANDER MEULEN

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	SAMPLE NUMBER	SAMPLE INTERVAL	REC (ft)	'N' VALUE	PID (ppm)
	TOP OF CASING	621.8					
	GROUND SURFACE	619.2					
	CL-CLAY (FILL), with silt, gravel, firm, low plasticity, brown, moist						
2	ML-SILT (FILL), little clay, compact, beige, wet, dilatant	617.2	1	P/S	3.0		0.0
6	CL-CLAY (FILL), little silt, soft, medium plasticity, dark gray, very moist to wet	613.2	2	P/S	4.0		0.0
10			3	P/S	3.0		0.0
			4	P/S	2.0		0.0
	Rock fragments	605.7					
14	END OF OVERBURDEN HOLE @ 14.0ft BGS						

COREHOLE



NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

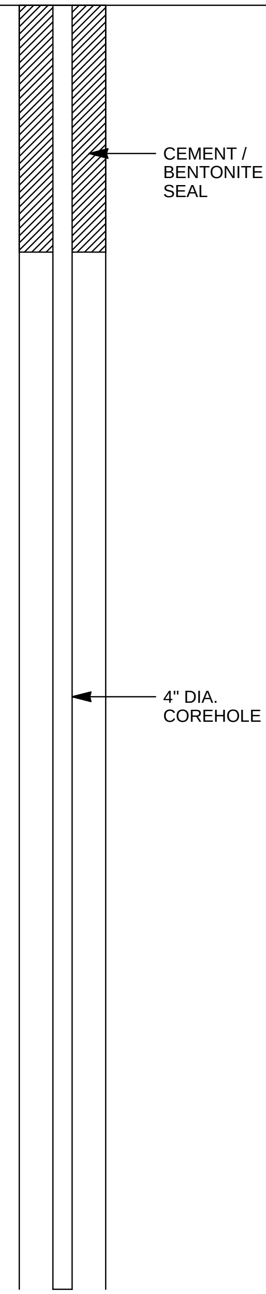
STRATIGRAPHIC AND INSTRUMENTATION LOG (BEDROCK)

PROJECT NAME: GM BEDFORD RFI
PROJECT NUMBER: 013968
CLIENT: GENERAL MOTORS CORPORATION
LOCATION: BEDFORD, INDIANA

HOLE DESIGNATION: CH-20
DATE COMPLETED: June 7, 2005
DRILLING METHOD: 6 1/4" HSA & HQ CORE
FIELD PERSONNEL: K. VANDER MEULEN

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	RUN NUMBER	CORE RECOVERY %	RQD %
13.5	Rock fragments	605.7			
14.0	LIMESTONE (SALEM FORMATION), medium grained, gray with brown in color - set 4-inch steel casing at 17.0ft BGS - stylolite at 17.6ft BGS	605.2			
18.0	LIMESTONE (UPPER HARRODSBURG FORMATION), medium to coarse grained, gray/tan - horizontal fracture at 20.8ft BGS - horizontal fracture at 22.7ft BGS - shale parting at 23.4ft BGS - shale parting at 23.8ft BGS - shale parting at 24.4ft BGS - 1/2-inch vug at 25.4ft BGS - open stylolite at 26.0ft BGS - stylolite at 27.5ft BGS - fossils present at 27.9ft BGS - 8-inch slightly porous section at 28.6ft BGS - stylolite at 30.4ft BGS - stylolite at 30.9ft BGS - stylolite at 31.5ft BGS - open stylolite at 32.1ft BGS - 10-inch slightly porous section at 33.3ft BGS - horizontal fracture at 33.7ft BGS - stylolite at 35.1ft BGS - horizontal fracture at 37.1ft BGS	601.2	1 (17.5–28.0) 2 (28.0–38.0)	100 100	100 100
38.0	END OF BOREHOLE @ 38.0ft BGS	581.2			

COREHOLE



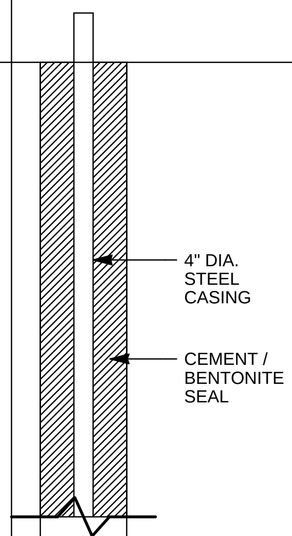
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: GM BEDFORD RFI
PROJECT NUMBER: 013968
CLIENT: GENERAL MOTORS CORPORATION
LOCATION: BEDFORD, INDIANA

HOLE DESIGNATION: CH-22
DATE COMPLETED: June 1, 2005
DRILLING METHOD: 6 1/4" HSA & HQ CORE
FIELD PERSONNEL: K. VANDER MEULEN

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	COREHOLE	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE REC (ft)	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	TOP OF CASING	615.9						
	GROUND SURFACE	613.4						
0–9.2	CL-CLAY (FILL), some silt, trace gravel, firm, low to medium plasticity, strong brown, moist							
2				1	P/S	3.0		0.0
6				2	P/S	3.0		0.0
8.6				3	P/S	1.0		0.0
9.2	END OF OVERBURDEN HOLE @ 9.2ft BGS							



Depth scale: 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG (BEDROCK)

PROJECT NAME: GM BEDFORD RFI
PROJECT NUMBER: 013968
CLIENT: GENERAL MOTORS CORPORATION
LOCATION: BEDFORD, INDIANA

HOLE DESIGNATION: CH-22
DATE COMPLETED: June 1, 2005
DRILLING METHOD: 6 1/4" HSA & HQ CORE
FIELD PERSONNEL: K. VANDER MEULEN

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	COREHOLE	RUN NUMBER	CORE RECOVERY %	RQD %
10	LIMESTONE (SALEM FORMATION), fine to medium grained, occasional calcite content, thin bedded, gray	604.2	CEMENT / BENTONITE SEAL			
12	- set 4-inch steel casing at 12.0ft BGS					
14	LIMESTONE (UPPER HARRODSBURG FORMATION), fine to medium grained, occasional calcite content, thin bedded, gray - stylolite at 13.9ft BGS - stylolite at 14.1ft BGS - open stylolite at 14.5ft BGS - stylolite at 15.0ft BGS - vertical fracture at 15.5ft BGS - open stylolite at 16.3ft BGS - 1.4 feet of porous section at 17.5ft BGS - stylolite at 18.8ft BGS - stylolite at 19.7ft BGS - stylolite at 19.8ft BGS - open stylolite at 20.7ft BGS	599.9	4" DIA. HQ COREHOLE	1	100	100
22–32	- open stylolite at 23.4ft BGS - stylolite at 24.0ft BGS - 3 feet of porous section at 24.9ft BGS - stylolite at 27.1ft BGS - stylolite at 27.5ft BGS - open stylolite at 28.2ft BGS - 4 feet porous section at 28.8ft BGS - horizontal fracture at 30.5ft BGS - horizontal fracture at 31.6ft BGS - horizontal fracture at 31.8ft BGS - horizontal fracture at 32.1ft BGS			2	100	100
32.6	END OF BOREHOLE @ 32.6ft BGS	580.8				
34						

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

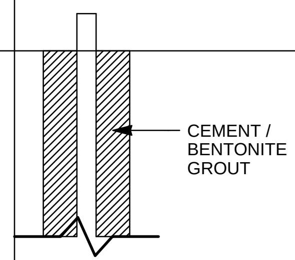
STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

PROJECT NAME: INVESTIGATORY BEDROCK COREHOLES
PROJECT NUMBER: 013968
CLIENT: GENERAL MOTORS CORPORATION
LOCATION: BEDFORD, INDIANA

HOLE DESIGNATION: CH-49
DATE COMPLETED: August 23, 2012
DRILLING METHOD: HSA / HQ CORE
FIELD PERSONNEL: K. VANDER MEULEN

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	COREHOLE	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE REC (ft)	SAMPLE 'N' VALUE
	TOP OF CASING	643.8					
	GROUND SURFACE	641.1					
0–3.5	CL-SILTY CLAY, little silt, firm, medium plasticity, strong brown, moist		CEMENT / BENTONITE GROUT				
3.5	END OF OVERBURDEN HOLE @ 3.5ft BGS						

Depth scale: 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24



NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG (BEDROCK)

PROJECT NAME: INVESTIGATORY BEDROCK COREHOLES
PROJECT NUMBER: 013968
CLIENT: GENERAL MOTORS CORPORATION
LOCATION: BEDFORD, INDIANA

HOLE DESIGNATION: CH-49
DATE COMPLETED: August 23, 2012
DRILLING METHOD: HSA / HQ CORE
FIELD PERSONNEL: K. VANDER MEULEN

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	COREHOLE	RUN NUMBER	CORE RECOVERY %	RQD %
3	LIMESTONE (SALEM FORMATION), fine grained, thin bedded, calcite content, light grey	637.6				
6.5	- set 4-inch steel casing at 6.5ft BGS		4" DIA. STEEL CASING			
7.3	- stylolite at 7.3ft BGS					
8.1	- horizontal fracture at 8.1ft BGS					
9.8	- stylolite at 9.8ft BGS					
10.2	- horizontal fracture at 10.2ft BGS			1	98	98
12.3	- open stylolite at 12.3ft BGS					
13.1	- horizontal fracture at 13.1ft BGS					
14.3	- horizontal fracture at 14.3ft BGS					
15.9	- stylolite at 15.9ft BGS					
16.3	- horizontal fracture at 16.3ft BGS					
18			4" DIA. HQ COREHOLE			
19.8	- 7-inch vertical fracture at 19.8ft BGS			2	100	100
20.9	- horizontal fracture at 20.9ft BGS					
23.2	- horizontal fracture at 23.2ft BGS					
24.7	- stylolite at 24.7ft BGS					
27.1	- open stylolite at 27.1ft BGS					

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG (BEDROCK)

PROJECT NAME: INVESTIGATORY BEDROCK COREHOLES
PROJECT NUMBER: 013968
CLIENT: GENERAL MOTORS CORPORATION
LOCATION: BEDFORD, INDIANA

HOLE DESIGNATION: CH-49
DATE COMPLETED: August 23, 2012
DRILLING METHOD: HSA / HQ CORE
FIELD PERSONNEL: K. VANDER MEULEN

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	COREHOLE	RUN NUMBER	CORE RECOVERY %	RQD %
	- stylolite at 28.6ft BGS - 6-inch medium grained section at 29.6ft BGS - fine grained at 30.0ft BGS - open stylolite at 30.9ft BGS - trace small fosil content at 31.0ft BGS		4" DIA. HQ COREHOLE	3	100	100
34.2	END OF BOREHOLE @ 34.2ft BGS	606.9				

Depth scale: 30, 32, 34, 36, 38, 40, 42, 44, 46, 48, 50, 52

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

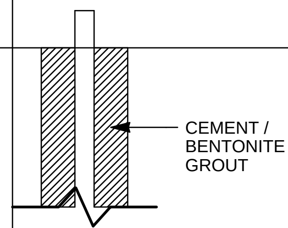
STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

PROJECT NAME: INVESTIGATORY BEDROCK COREHOLES
PROJECT NUMBER: 013968
CLIENT: GENERAL MOTORS CORPORATION
LOCATION: BEDFORD, INDIANA

HOLE DESIGNATION: CH-52
DATE COMPLETED: August 28, 2012
DRILLING METHOD: HSA / HQ CORE
FIELD PERSONNEL: K. VANDER MEULEN

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	COREHOLE	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE REC (ft)	SAMPLE 'N' VALUE
	TOP OF CASING	671.0					
	GROUND SURFACE	668.3					
0–3.0	CL-SILTY CLAY, little silt, firm, low plasticity, strong brown, moist		CEMENT / BENTONITE GROUT				
3.0	END OF OVERBURDEN HOLE @ 3.0ft BGS						

Depth scale: 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24



NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG
(BEDROCK)

PROJECT NAME: INVESTIGATORY BEDROCK COREHOLES

PROJECT NUMBER: 013968

CLIENT: GENERAL MOTORS CORPORATION

LOCATION: BEDFORD, INDIANA

HOLE DESIGNATION: CH-52

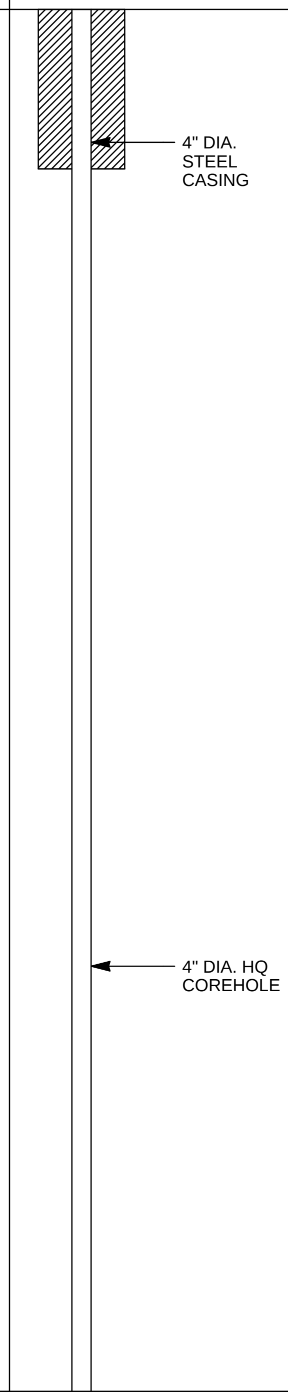
DATE COMPLETED: August 28, 2012

DRILLING METHOD: HSA / HQ CORE

FIELD PERSONNEL: K. VANDER MEULEN

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL
	LIMESTONE (SALEM FORMATION), fine grained, thin bedded, light grey, trace calcite	665.3
4		
	- set 4-inch steel casing at 5.0ft BGS	
	- 1-feet broken rock at 5.5ft BGS	
6		
8		
	- horizontal fracture with clay infill at 8.5ft BGS	
10		
	- horizontal fracture at 10.4ft BGS	
12	- open stylolite at 11.9ft BGS	
14	- open stylolite at 13.8ft BGS	
16	- oxidized horizontal fracture at 16.0ft BGS	
18	- horizontal fracture at 17.8ft BGS	
20		
	- horizontal fracture with half-inch clay fill at 20.3ft BGS	
22		
	- horizontal fracture at 23.0ft BGS	
24		
26		
	- horizontal fracture at 27.8ft BGS	

COREHOLE



RUN NUMBER	CORE RECOVERY %	RQD %
1	89	89
2	100	100

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG (BEDROCK)

PROJECT NAME: INVESTIGATORY BEDROCK COREHOLES
PROJECT NUMBER: 013968
CLIENT: GENERAL MOTORS CORPORATION
LOCATION: BEDFORD, INDIANA

HOLE DESIGNATION: CH-52
DATE COMPLETED: August 28, 2012
DRILLING METHOD: HSA / HQ CORE
FIELD PERSONNEL: K. VANDER MEULEN

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	COREHOLE	RUN NUMBER	CORE RECOVERY %	RQD %
	- horizontal fracture at 28.4ft BGS - open stylolite at 28.9ft BGS - medium grained at 29.4ft BGS					
30				3	100	100
32	- stylolite at 32.1ft BGS - open stylolite at 33.0ft BGS					
34	- stylolite at 34.0ft BGS - medium grained, high calcite content, gray at 35.0ft BGS					
36	- stylolite at 35.6ft BGS - horizontal fracture at 36.5ft BGS					
38	- stylolite at 38.4ft BGS - horizontal fracture at 39.2ft BGS					
40	- horizontal fracture at 40.4ft BGS - half-inch open stylolite at 40.9ft BGS - fine grained at 41.0ft BGS		4" DIA. HQ COREHOLE	4	100	99
42	- stylolite at 43.3ft BGS					
44	- horizontal fracture at 44.0ft BGS - stylolite at 45.0ft BGS					
46						
48	- horizontal fracture at 47.9ft BGS - stylolite at 48.0ft BGS - horizontal fracture at 48.8ft BGS					
50	- stylolite at 50.3ft BGS - horizontal fracture at 51.3ft BGS - horizontal fracture at 51.8ft BGS			5	100	100
52	- horizontal fracture at 52.9ft BGS - brown in color at 53.0ft BGS					

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG (BEDROCK)

PROJECT NAME: INVESTIGATORY BEDROCK COREHOLES

HOLE DESIGNATION: CH-52

PROJECT NUMBER: 013968

DATE COMPLETED: August 28, 2012

CLIENT: GENERAL MOTORS CORPORATION

DRILLING METHOD: HSA / HQ CORE

LOCATION: BEDFORD, INDIANA

FIELD PERSONNEL: K. VANDER MEULEN

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	COREHOLE	RUN NUMBER	CORE RECOVERY %	RQD %
	- stylolite at 54.0ft BGS - horizontal fracture at 54.7ft BGS					
	END OF BOREHOLE @ 55.0ft BGS	613.3				

Depth scale: 56, 58, 60, 62, 64, 66, 68, 70, 72, 74, 76, 78

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

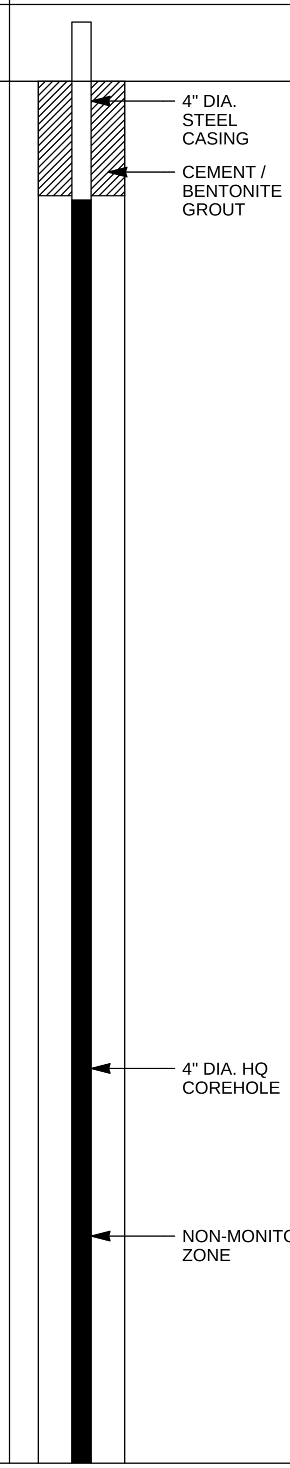
STRATIGRAPHIC AND INSTRUMENTATION LOG (BEDROCK)

PROJECT NAME: GM BEDFORD RFI
PROJECT NUMBER: 013968
CLIENT: GENERAL MOTORS CORPORATION
LOCATION: BEDFORD, INDIANA
DRILLING CONTRACTOR: RDNP

HOLE DESIGNATION: MW-X297Y305D
DATE COMPLETED: June 23, 2003
DRILLING METHOD: 6 1/4-INCH HSA
FIELD PERSONNEL: J. MC COMBS & K. VANDER MEULEN

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL
	TOP OF RISER	616.0
	GROUND SURFACE	614.5
	TOPSOIL	614.2
	LIMESTONE (SALEM FORMATION), medium to coarse grained fossiliferous, granular, calcite, thick bedding, gray to dark gray	
2	- pair of horizontal fractures, unweathered at 2.9ft BGS	
4		
	- horizontal fracture, slightly weathered at 5.3ft BGS	
6	- open stylolite, brown, weathered at 5.6ft BGS	
	- horizontal fracture at 7.3ft BGS	
8	- horizontal fracture at 8.5ft BGS	
10	- horizontal fracture, unweathered at 10.4ft BGS	
	- stylolite at 11.6ft BGS	
12	- stylolite, brown and parted at 12.7ft BGS	602.0
	LIMESTONE (UPPER HARRODSBURG FORMATION), well cemented bioclastic calcarenite and calcirudite, stylolite, brown and parted	
14	- stylolite, gray at 13.0ft BGS	
16	- 2-inch near vertical clean non-continuous opening at 14.8ft BGS	
	- stylolite, gray at 15.6ft BGS	
18	- 1.2-feet near vertical fracture, stylolites at 19.0ft BGS	
20	- 2 thin stylolites at 19.8ft BGS	
	- horizontal fracture, dissolved at 21.5ft BGS	
22	- 2 centimeter thick stylolite at 22.6ft BGS	
	- slightly dissolved horizontal fracture at 23.4ft BGS	
24	- stylolite, dark gray at 24.1ft BGS	
	- 1 to 4 centimeter dissolution vugs at 25.4ft BGS	
26	- stylolite, parted, dark gray at 26.7ft BGS	
	- stylolite, dark gray at 27.0ft BGS	
28	- 2 stylolites, parted, dark gray at 28.7ft BGS	
	- stylolite, parted, slightly weathered and oxidized at 28.8ft BGS	
30	- horizontal fracture, stylolite, slightly oxidized at 29.4ft BGS	
32	- 3.5-inch near vertical non-continuous opening at 30.7ft BGS	
	- near vertical fracture, parted, 0.8-feet section of darker limestone with fossil hash at 31.3ft BGS	
34	- stylolite at 32.1ft BGS	

MONITORING WELL



RUN NUMBER	CORE RECOVERY %	RQD %
1	95	85
2	96	97
3	103	99
4	100	100

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG (BEDROCK)

PROJECT NAME: GM BEDFORD RFI
HOLE DESIGNATION: MW-X297Y305D
PROJECT NUMBER: 013968
DATE COMPLETED: June 23, 2003
CLIENT: GENERAL MOTORS CORPORATION
DRILLING METHOD: 6 1/4-INCH HSA
LOCATION: BEDFORD, INDIANA
FIELD PERSONNEL: J. MC COMBS & K. VANDER MEULEN
DRILLING CONTRACTOR: RDNP

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	MONITORING WELL	RUN NUMBER	CORE RECOVERY %	RQD %
36	- horizontal fracture at 32.6ft BGS - stylolite, parted, dark gray at 34.0ft BGS - stylolite, parted, weathered at 35.3ft BGS - thin shale seam, dark gray at 35.5ft BGS					
38						
40	- stylolite, dark gray at 39.8ft BGS - stylolite, dark gray at 40.7ft BGS					
42	- horizontal fracture, shale parting at 42.0ft BGS - stylolite, dark gray at 42.6ft BGS					
44	- stylolite, dark gray at 43.7ft BGS			5	100	99
46	- near vertical horizontal fracture, slightly weathered, some fossils, thin mineralized fracture at 45.8ft BGS					
48	- stylolite, 2 centimeter mineralized vug at 47.1ft BGS - open stylolite, dark gray at 48.3ft BGS - pair stylolite, dark gray at 49.3ft BGS		4" DIA. HQ COREHOLE			
50	- stylolite, dark gray at 50.5ft BGS			6	100	99
52	- 3-inch of unconsolidated limestone, mud wash at 50.7ft BGS - horizontal shale parting, weathered at 51.1ft BGS					
54	- horizontal shale parting, weathered at 52.0ft BGS - horizontal fracture, slightly weathered at 52.3ft BGS			7	100	90
56	- stylolite, dark gray at 52.7ft BGS - stylolite, parted/fractured, weathered / washed at 54.1ft BGS		DOW PACKER			
58	- horizontal fracture, weathered at 54.6ft BGS - horizontal shale parting, 1-feet thin vertical fracture at 55.0ft BGS					
60	- stylolite at 56.8ft BGS - stylolite at 57.7ft BGS - stylolite, parted, slightly weathered at 58.5ft BGS					
62	- stylolite, white at 60.8ft BGS - stylolite, white at 61.4ft BGS					
64	- stylolite, white at 61.8ft BGS - stylolite, white at 62.6ft BGS LIMESTONE (LOWER HARRODSBURG FORMATION), horizontal fracture, interbedded thin layers of shale	551.3		8	102	99
66	- horizontal fracture at 64.2ft BGS - 1-inch shale seam at 64.5ft BGS					
68	- 1-inch shale seam at 65.6ft BGS - horizontal fracture at 66.1ft BGS - horizontal fracture at 66.4ft BGS		SAMPLE ZONE 2			

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG (BEDROCK)

PROJECT NAME: GM BEDFORD RFI
PROJECT NUMBER: 013968
CLIENT: GENERAL MOTORS CORPORATION
LOCATION: BEDFORD, INDIANA
DRILLING CONTRACTOR: RDNP

HOLE DESIGNATION: MW-X297Y305D
DATE COMPLETED: June 23, 2003
DRILLING METHOD: 6 1/4-INCH HSA
FIELD PERSONNEL: J. MC COMBS & K. VANDER MEULEN

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	MONITORING WELL
72–92	- shale seam at 66.5ft BGS - 7-inch section of shale at 66.7ft BGS - horizontal fracture at shale at 67.7ft BGS - stylolite at 68.0ft BGS - stylolite at 69.0ft BGS - stylolites, dark gray at 69.8ft BGS - stylolites, dark gray at 70.0ft BGS - stylolites, dark gray at 70.1ft BGS - 1 centimeter thick stylolite, dark gray and parted at 70.6ft BGS - horizontal fracture at 71.7ft BGS - thin shale seam at 72.6ft BGS - 0.1-feet thick shale seam at 73.6ft BGS - 1 centimeter thick stylolite, dark gray and parted at 74.7ft BGS - shale seam, parted at 75.7ft BGS - 0.1-feet thick shale seam, dark gray at 76.0ft BGS - 0.2-feet thick shale seam at 76.7ft BGS - horizontal fracture along shale parting, dark gray at 78.2ft BGS - horizontal fracture, interbedded thin layers of shale at 79.6ft BGS - 1-centimeter thick shale stringer at 80.0ft BGS - 1-centimeter thick shale stringer at 81.6ft BGS - 0.3-feet thick zone of shale stringers, dark gray with pyrite crystals at 83.4ft BGS - stylolite, wash out at 84.8ft BGS - 0.4-feet thick geode within shale zone, bottom of zone contains near vertical shale partings at 86.2ft BGS - horizontal fracture, slightly oxidized at 87.7ft BGS - horizontal fracture, shaley, 1-feet long vertical non-continuous opening at 88.0ft BGS - shale parting at 89.0ft BGS - stylolite, dark gray at 89.4ft BGS - 1-feet thick shale seam at 89.6ft BGS - horizontal fracture, slightly weathered at 92.3ft BGS		DOW PACKER NON-MONITORING ZONE DOW PACKER
92.5–104	LIMESTONE (RAMP CREEK FORMATION), very fine grained, even bedded, shaley with geodes - 1-feet thick section of geodes, white, quartz at 94.8ft BGS - 0.1-feet thick geode, tabular parted, white with calcite / quartz and pyrite minerals, slightly dissolved at 97.0ft BGS - 0.1-feet thick vug slightly mineralized at 99.1ft BGS - 3.4-feet thick section of shaley limestone with quartz geodes at 100.1ft BGS - horizontal fractures, shale partings at 103.1ft BGS - 0.8-feet light gray limestone with shale	522.0	4" DIA. HQ COREHOLE

RUN NUMBER	CORE RECOVERY %	RQD %
9	99	98
10	100	99
11	100	100

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG (BEDROCK)

PROJECT NAME: GM BEDFORD RFI
HOLE DESIGNATION: MW-X297Y305D
PROJECT NUMBER: 013968
DATE COMPLETED: June 23, 2003
CLIENT: GENERAL MOTORS CORPORATION
DRILLING METHOD: 6 1/4-INCH HSA
LOCATION: BEDFORD, INDIANA
FIELD PERSONNEL: J. MC COMBS & K. VANDER MEULEN
DRILLING CONTRACTOR: RDNP

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	MONITORING WELL	RUN NUMBER	CORE RECOVERY %	RQD %
106	stringers, fossiliferous at 103.5ft BGS - horizontal fracture at 105.1ft BGS - horizontal fracture at 106.5ft BGS		SAMPLE ZONE 1	12	99	100
108	- horizontal fracture along shale stringer at 108.5ft BGS - 0.4-feet thick section of fossiliferous limestone, shale stringers, light gray at 109.6ft BGS					
110	SHALE (EDWARDSVILLE FORMATION), moderately dense, pyrite, dark gray / blue, soft, slightly fissile	504.5	4" DIA. HQ COREHOLE	13	99	100
114	END OF BOREHOLE @ 114.8ft BGS	499.7				

Depth scale: 106, 108, 110, 112, 114, 116, 118, 120, 122, 124, 126, 128, 130, 132, 134, 136, 138

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

Appendix B
Hydrogeology, Inc. SOP for Dye Tracer Analysis

hydrogeology inc.
1211 S Walnut St
Bloomington, IN 47401

FIELD AND LABORATORY PROCEDURES FOR ANALYSIS OF FLUORESCENT DYES IN CHARCOAL AND WATER SAMPLES

January 28, 2019

Jason N. Krothe
President
Hydrogeology Inc.

1. Introduction

This document describes the standard field and laboratory operating procedures used by Hydrogeology Inc. (HGI) for the analysis of charcoal and water samples for the presence of fluorescent dyes. In some situations, these procedures are altered, and are noted as such in the laboratory report.

2. Fluorescent Dyes

The following dyes are typically used for tracing studies. These dyes have been used successfully and safely for groundwater tracing for the past 40 years.

Common Name: Pyranine
Color Index Number: 59040
Color Index Name: Solvent Green 7

Common Name: Fluorescein
Color Index Number: 45350
Color Index Name: Acid Yellow 73

Common Name: Eosine
Color Index: 45830
Chemical Name: Acid Red 87

Common Name: Phloxine B
Color Index Number: 45410
Color Index Name: Acid Red 92

Common Name: Rhodamine WT
Chemical Name: Acid Red 388

Common Name: Sulforhodamine B
Color Index Number: 45100
Color Index Name: Acid Red 52

3. Field Procedures

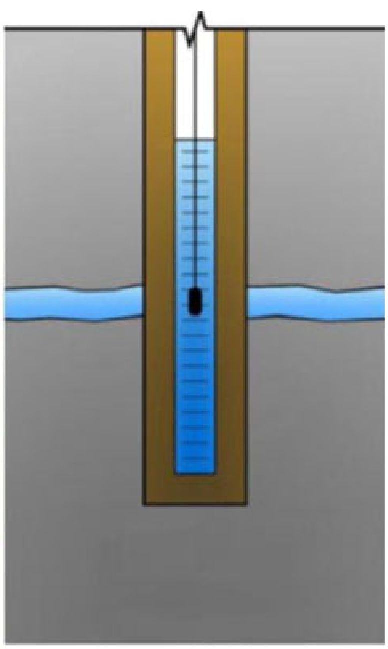
3.1 Activated Charcoal Sample Preparation

Activate Charcoal Sample (ACS) packets are constructed using fiberglass screen. The screen is formed into approximately 2-inch by 2-inch pouches for spring and surface water locations and 3-inch by 0.5-inch cylindrical pouches for wells. The pouches are filled with 10 grams of Calgon 207C coconut shell carbon. Prior to being placed in the field, all ACS packets are washed with de-ionized water, until there are no carbon particulates visible in the water. This process typically requires three rinses. After rinsing, ACS packets are placed in plastic containers or plastic bags for transport.

Example of well ACS packet.

3.2 Well ACS Installation

In the case of monitoring well sampling, ACS packets are typically deployed to the mid-point of the targeted screen interval at each monitoring well using a non-colored nylon string and stainless-steel bolts as weights. However, each well will be evaluated on an individual basis to determine areas of high flow, with the possibility of multiple ACS packets being installed in a single well. Wells with no obvious high flow zones will have one ACS packet deployed for every 15 feet of well screen



Example of ACS installation.

3.3 Surface Water ACS Installation

ACS packets deployed at surface water locations including springs and streams are connected to an anchored wire and submerged in the location with the highest estimated flow.

3.4 ACS Sample Collection

HGI staff will be responsible for all ACS sample collection. All collected samples will be logged on a form with notes documenting any irregularities with the sample collection. ACS packets are collected in 250 milliliter opaque HDPE bottles. One out of every 100 sample bottles are analyzed for fluorescence. The ACS packet is removed from the nylon line with gloved hands and placed in the bottle. All ACS samples will be stored in a cooler after collection and delivered same day to the HGI laboratory and refrigerated until analysis.

3.5 Water Sample Collection

HGI staff will be responsible for all water sample collection. All collected samples will be logged on a form with notes documenting any irregularities with the sample collection Surface water samples obtained from springs and streams are collected by direct dip with the sampling bottle, a method that is in general accordance with U.S. EPA operating procedures (specifically SESDPROC-201-R4).

Subsurface groundwater sampling from monitoring well locations is typically conducted using the "Standard/Well-Volume" method. If there is either a physical or chemical reason to reduce the rate of discharge or purge volume, "Low-Stress (low-flow)" sampling methods are employed during sampling. Both "Standard/Well-Volume" and "Low-Stress (low-flow)" methods are conducted in general accordance with U.S. EPA operating procedures (*Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers - EPA 542-S-02-001, May 2002*).

All water samples are collected in Cincinnati Container brand 2-ounce amber round bottles and stored in a cooler. One out of every 100 sample bottles are analyzed for fluorescence. Amber bottles are used to decrease potential UV exposure. All waters samples will be delivered same day to the HGI laboratory and refrigerated until analysis.

For reference, excerpts of the referenced EPA guidance regarding water sample collection methods is included as Attachment 1.

4. Laboratory Procedures

4.1 ACS Laboratory Preparation

During preparation in the laboratory, ACS packets are rinsed with de-ionized water to remove all excess sediment and particulates that can interfere with analysis. All wash water used to clean ACS packets is processed through a de-ionizing system to remove chlorine. The water is analyzed for fluorescence prior to rinsing any ACS packets. Once the ACS is properly rinsed the packet is manually opened (with a gloved hand) and the contents are poured back into the original HDPE sampling container. The ACS container is then filled with 10 mL of eluting solution which is composed of 5 parts alcohol, 3 parts de-ionized water, and 2 parts aqueous ammonia. The eluting solution is analyzed for fluorescence prior to being applied to the sample. The loose charcoal sits in this solution for one hour and then 4 mL is poured into a cuvette for analysis. The remaining solution is reserved in the event it is needed for a secondary analysis.

After one hour of eluting, approximately 4 milliliters (mL) of the elutant is poured into a disposable polyethylene cuvette. These cuvettes are designed for fluorometric analysis and are clear on all four sides. The cuvettes have a spectral range of 340 to 800 nanometer. The cuvette is then placed in the Shimadzu RF-5301PC and analyzed as noted Section 4.3.

All cuvettes with elutant are placed in a constant temperature cell designed to maintain a temperature of 4º Celsius prior to analysis. The constant temperature cells are placed in an ice-bath with one temperature blank sample. A digital thermometer is placed in the temperature blank to ensure the samples maintain a constant temperature of 4º Celsius.

4.2 Water Sample Laboratory Preparation

Approximately 4 ml of the water sample is poured into a disposable polyethylene cuvette. These cuvettes are designed for fluorometric analysis. The cuvettes have a spectral range of 340 to 800mm. The cuvette is then placed in the Shimadzu RF-5301PC and analyzed as noted below.

All water sample cuvettes are placed in a constant temperature cell designed to maintain a temperature of 4º Celsius prior to analysis on the RF-5301PC. The constant temperature cells are placed in an ice-bath with one temperature blank sample. A digital thermometer is placed in the temperature blank to ensure the samples maintain a constant temperature of 4º Celsius. The fluorescence intensity of fluorescein, eosine and pyranine is pH dependent. Water samples for those dyes are adjusted to pH 9.5 or higher prior to analysis. The water samples are placed in a high ammonia atmosphere for up to two (2) hours to achieve a pH of 9.5.

4.3 Analysis on the Shimadzu RF-5301PCPC

The Shimadzu RF-5301PC spectrofluorophotometer (RF-5301PC) is used for all sample analysis. This is a synchronous scanning model and is controlled by LabSolutions RF software. The Shimadzu RF-5301PCPC is operated and maintained in accordance with the manufacturer's recommendations. Shimadzu Scientific Instrument technicians provided the initial installation and training of all HGI staff that operate the RF-5301PC.

The standard excitation and emission slit widths used for the RF-5301PC can be seen in Table 1. Synchronous scanning of the excitation and emission wavelength is standard with a 17 nanometer (nm) separation between excitation and emission wavelengths. The following are the standard parameters used for analysis with the RF-5301PC:

Scanning Speed = Fast
Scanning Interval = 0.2 nanometers
Sensitivity = High

The fluorogram produced for each sample plots the emission wavelength (nanometer) versus the intensity (unitless). The fluorogram is inspected by the lab technician who identifies any fluorescence peaks indicative of the dyes used for the trace. For a sample to have been considered a potential dye positive a peak in the appropriate range must be identified in the LabSolutions RF interface.

Table 1: Typical excitation and emission slit widths for dye analysis

Matrix	Excitation Slit Width (EX)	Emission Slit Width (EM)
Water	5	5
Elutant	3	5

4.4 PeakFit Analysis

All samples with a potential dye peak are imported into PeakFit for additional analysis. PeakFit is a non-linear curve matching program designed for spectroscopy. PeakFit allows for the separation of potential peaks from background noise. The peak wavelength, peak height and peak area are recorded for all samples analyzed with PeakFit. To quantify dye concentration, the peak area is calculated and compared to the appropriate dye calibration curve.

4.5 Dilution

Dilution of water and elutant samples is often required. Any sample with an intensity peak above the recordable range will be diluted prior to analysis on the RF-5301PC. Diluted samples will be identified in the laboratory report.

4.6 Sample Retention

After analysis, the cuvettes with elutant are stored in a freezer located at HGI's office for possible re-analysis.

5. Quality Assurance / Quality Control

5. 1 Trip Blanks

ACS and water trip blanks will be collected for each sampling event. ACS trip blanks consist of one ACS packet placed in a 250 ml HDPE bottle, which is then placed in the sample storage cooler. The ACS blank will remain in the cooler for the duration of the sampling event. Water trip blanks consist of 2-ounce amber round bottle filled with laboratory de-ionized water. The water trip blank is kept in the sample storage cooler for the duration of the sampling event.

Blank ACS packets exhibit a unique signal when analyzed on the RF-5301PC, with two fluorescence peaks that fall within the accepted emission wavelengths for Fluorescein and Rhodamine WT. The peaks are taken into consideration for potential detections of Fluorescein and Rhodamine WT.

5.2 Laboratory Blanks

Elutant and water blanks are analyzed for fluorescence prior to all lab sessions. De-ionized water used for rinsing ACS packets and elutant applied to ACS packets are also analyzed for fluorescence prior to use.

5.3 Dye Standards

Dye standards are run prior to and after all analysis on the RF-5301PC. Dye standards are also run every 100 samples. The typical elutant standards used are as follows:

I. Pyranine in elutant at concentrations of 1 & 10 ppb
II. Fluorescein in elutant at concentrations of 0.1 & 1 ppb
III. Eosine, Phloxine B, Rhodamine WT and Sulphorhodamine B in elutant at concentrations of 1 & 10 ppb

Laboratory standards are prepared on a quarterly basis. Standards are kept refrigerated and in amber bottles to prevent photodegradation. The following procedures are followed in the event that a dye standard shows +/- 5 nanometer deviation from the accepted excitation wavelength range and/or a +/- 2% deviation in the accepted emission intensity for a given standard:

1. Re-analyze standard.
2. Shutdown Lab Solutions RF Software, then re-analyze standard.
3. Adjust Xenon Lamp per RF-5301PC manual, then re-analyze standard.
4. Contact manufacturer.

6.0 Determination of Positive Dye Recovery for Water and Elutant

The fluorescent emission wavelength ranges for all the dyes used have been established and are listed in Table 2. The following criteria are used to determine a dye positive in water and elutant samples:

1. Fluorescence peak within +/- 5 nanometers of accepted emission range for the dye in question.

2. Fluorescence peak must have typical sharp symmetrical peak exhibited by fluorescent dyes.

3. The fluorescence peak must be ten times greater than the detection limit for the sample for that location.

4. The fluorescence peak must be ten times greater than any fluorescent peak within the typical range observed in the background samples for that location.

5. It must be reasonable that the dye detection came from the dye injection and no other source. Factors such as local hydrogeology are considered as part of this step.

All fluorescence peaks that meet the above criteria are reported as dye positives. However, the following secondary set of qualifying terms are also applied to dye positives:

1. High Confidence Result – Any location with two or more dye positives for the same dye and/or a concentration at least double the quantitation limit.

2. Low Confidence Result – Any location with a single result, a concentration less than double the quantitation limit, or any other factor that calls the result into question.

Quantification

The magnitudes of fluorescent peaks for all dyes used are determined using a series of dye standards. Dye concentrations are calculated based on the area of the fluorescence peak. The accepted emission wavelengths for each dye can be seen in Table 2 and the Limit of Detection (LOD) and Limit of Quantitation (LOQ) for each dye can be seen in Table 3. Please note the LOQ is ten times the LOD.

Table 2: Elutant Emission Wavelength Ranges

Dye	Emission Wavelength Range (nm)
Pyranine	485.6 to 495.6
Fluorescein	508.6 to 518.6
Eosine	535.1 to 545.1
Phloxine B	557.2 to 567.7
Rhodamine WT	564.3 to 574.3
Sulforhodamine B	573.0 to 583.0

Table 3: LOD/LOQ

Dye Name	Matrix	Limit Of Detection (ppb)	Limit Of Quantitation (ppb)
Pyranine	Elutant	0.55	5.5
Fluorescein	Elutant	0.007	0.07
Eosine	Elutant	0.029	0.29
Phloxine B	Elutant	0.016	0.16
Rhodamine WT	Elutant	0.014	0.14
Sulforhodamine B	Elutant	0.026	0.26

7.0 Flagged Results

Samples often meet some of the positive dye criteria but not all. Those samples are reported as flagged non-detects. The flagged results are described below.

7.1 ND^J

The ND^J designation indicates the analyte (in this case dye) is greater than any background level but the result is less than the quantitation limit. The ND^J designation is common in analytical chemistry. Locations with this designation would be considered to have weak evidence of dye present.

7.2 ND^P

Samples can have fluorescence peaks near, but outside the typical range for the dye used for the trace. Samples that display peaks near, but outside the typical range are given the ND^P designation.