BASF Corporation

# Biostimulation Treatability Study Work Plan

**Point Hennepin**
**Wayne County, Michigan**

September 12, 2025

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# Acronyms and Abbreviations

| | |
|---|---|
| BASF | BASF Corporation |
| bgs | below ground surface |
| COC | contaminant of concern |
| DBO | distiller blowoff |
| Eurofins | Eurofins in Barberton, Ohio |
| EGLE | Depart of Environment, Great Lakes, and Energy |
| EVO | emulsified vegetable oil |
| FAV | final acute value |
| GSI | groundwater to surface water interface |
| GSI Phase 1 Work Plan | Groundwater to Surface Water Interface Assessment Work Plan |
| kg | kilogram |
| L | liter |
| NREPA | Natural Resources and Environmental Protection Act |
| select metal COCs | barium, mercury, manganese, and selenium |
| Site | Point Hennepin, located in Wayne County, Michigan |
| TDS | total dissolved solids |
| Treatability Laboratory | Arcadis Treatability Laboratory in Durham, North Carolina |
| Work Plan | Biostimulation Treatability Study Work Plan |

# 1 Introduction

This Biostimulation Treatability Study Work Plan (Work Plan) provides a description for the bench-scale treatability study to evaluate the efficacy of in-situ biostimulation of microbes capable of decreasing concentrations of ammonia and select metal contaminants of concern (COCs) in groundwater at Point Hennepin, located in Wayne County, Michigan (Site). The potential microbial generation of field observed ammonia concentrations will also be evaluated. The testing proposed herein will be conducted at the Arcadis Treatability Laboratory in Durham, North Carolina (Treatability Laboratory). Samples collected during testing will be shipped to Eurofins in Barberton, Ohio (Eurofins) for analyses.

Groundwater samples collected under the Groundwater to Surface Water Interface (GSI) Assessment Work Plan (GSI Phase 1 Work Plan; Arcadis 2024) between July 2024 and June 2025 indicate that un-ionized ammonia and select metal COCs (barium, mercury, manganese, and selenium) have exceeded final acute values (FAVs) at select monitoring wells located at the perimeter of the Site, including co-located shallow and deep zone piezometers PZ-08S and PZ-08D, respectively, on the eastern edge of the island. Chloride has also been identified as a Site COC with concentrations exceeding FAVs during July 2024 through June 2025 sampling. Chloride is a conservative ion, and as such it is not expected to respond to the testing proposed in this Work Plan. These samples were collected at wells at the perimeter of the island, not where groundwater may be discharging to the river. Therefore, the exceedances of GSI criteria at the perimeter do not indicate a GSI compliance concern at this point but rather inform the development of the GSI compliance approach and next steps for data collection.

This work scope is the first step in evaluating in-situ biostimulation as a potential GSI compliance approach. As such, this bench-scale treatability study intends to test multiple conditions with multiple potential amendments which could be used for in-situ biostimulation. Analysis of the microcosms over time will establish the merit of the potential amendments for enhancing in-situ removal of ammonia and treatment of select metal COCs. The amendments selected for testing are expected to enrich the conditions for microbes with metabolic capabilities in targeted categories. All GSI Phase 1 results will be reported in the forthcoming GSI Phase 1 Report (Arcadis 2025).

## 1.1 Applicable Regulatory Framework

This Work Plan was developed to support Site closure via Part 201 of Michigan's Natural Resources and Environmental Protection Act (NREPA) with a focus on GSI compliance. Groundwater/Surface Water Interface compliance approaches are summarized in the State of Michigan Department of Environment, Great Lakes, and Energy (EGLE) (2018). This investigation supports GSI compliance through evaluation of in-situ biostimulation as a potential active-remediation approach for Site locations where treatment is required to reduce concentrations of un-ionized ammonia and select metal COCs to below applicable criteria prior to groundwater venting to surface water.

It should be noted that while Site groundwater samples are analyzed in the laboratory for total ammonia as nitrogen by USEPA 350.1 per the GSI Phase 1 Work Plan, the resulting total ammonia as nitrogen concentration is then multiplied by a factor based on the pH and temperature of the receiving surface water body to determine the percent of the total ammonia as nitrogen concentration in the groundwater that will become "un-ionized ammonia" (i.e. $NH_3$) in the receiving surface water body. The un-ionized ammonia is then compared to the Site GSI criteria (i.e. the FAV) to determine the presence or absence of GSI criteria exceedances at the Site. Similarly, the ionized form of ammonia (i.e. ammonium as $NH_4$) is determined from the same laboratory-measured total ammonia as nitrogen result based on the pH of the sample at the time of processing. The term “ammonia” used in this Work Plan refers to both ionized and un-ionized ammonia.

## 1.2 Objectives

Site-wide indigenous microbial populations have the capacity for the assimilative consumption of ammonia to support growth. The primary objective of this bench-scale treatability study is to evaluate which amendment or combination of amendments (detailed in Section 2) are effective for stimulating ammonia consumption to demonstrate proof-of-concept at the bench scale.

# 2 Background

Point Hennepin is a 225-acre island in the Detroit River located immediately north of Gross Ille and east of Wyandotte, Michigan, upon which distiller blow off (DBO) was placed from the 1920s until 1951. DBO was a by-product of soda ash production at a facility to the west of the island, across the Detroit River in Wyandotte. Additionally, solution mining for salt beneath the Site from 1941 to 1980 led to the formation of three sinkholes, which opened in 1969 and 1970. As the sinkholes formed, clay tills, lacustrine clays, and DBO sank with the bedrock units and initially formed a 100-foot thick plug at the bottom of the holes. The sinkholes were subsequently filled with lacustrine clay, construction debris, and DBO during the 1980s and 1990s. The Site currently sits above the water table and above the level of the Detroit River.

Groundwater samples collected in support of the GSI Phase 1 Work Plan between July 2024 and June 2025, indicate that Site geochemical conditions include (Arcadis 2025):

- Ammonia concentrations ranging from 1.3 mg/L to 39 mg/L
- Salinity conditions ranging from brackish to brine,
- Elevated pH in the shallow zone, generally in the range of 11 to 12 standard units SU
- Neutral pH in the deeper zone, generally in the range of 6 to 7 SU.

The GSI Phase 1 genomic data set indicates microbial populations at the Site in the subsurface environment is complex (Arcadis 2025) and indicate:

- Site-wide indigenous microbial populations have the capacity for the assimilative consumption of ammonia to support growth.
- The capacity for the dissimilative reduction of nitrate to ammonia via the oxidation of ferrous iron is present at all locations.
- The capacity for heterotrophic nitrification (as an energy source) is present at all locations except for shallow-zone monitoring wells PZ-08S and PZ-09S.

Evidence of sulfate-reducing microbes is present at all locations. Bioavailable sulfate provides an energy source for these sulfate-reducing microbes that have the capacity to perform heterotrophic denitrification of ammonia (i.e. perform in-situ treatment of ammonia). Data indicates that in many locations across the Site, sulfate has been consumed to the point that sulfate reduction ceases, limiting the potential for denitrification of ammonia. The proposed treatability study aims to evaluate if the addition of bioavailable sulfate will enhance sulfate reduction and denitrification of ammonia where sulfate is currently limited.

Iron is observed at all locations, in each of the shallow-zone piezometers primarily in the form of ferric iron (i.e. $Fe^{3+}$), in the deep-zone piezometers is primarily in the form of ferrous iron (i.e. $Fe^{2+}$). Augmenting ferric and ferrous iron concentrations potentially could provide a microbial energy source where current concentrations may be limiting native microbial population's capacity to treat ammonia in the shallow and deep zones respectively by supporting the heterotrophic denitrification of ammonia.

Bioavailable carbon serves as a carbon source for heterotrophic microbes that require a carbon source to support growth. After initial biodegradation, carbon dioxide is generated which supports the growth of autotrophic species that require carbon dioxide for growth. Carbon also stimulates the microbial reduction of sulfate and ferric iron as an energy source, thereby creating a source of carbon dioxide for autotrophic microbes.

# 3 Bench Scale Study Basis of Design

The treatability study is designed to stimulate multiple microbial processes that appear to have been or are taking place at the Site. Listed in order of the percentage of genes associated with each process: assimilative ammonia consumption; dissimilatory nitrate ammonification; production of ammonia from native organic materials; heterotrophic ammonia nitrification; archaea; and annamox. In addition, it is anticipated there will be microbial and abiotic effects on select metal COCs. The testing will demonstrate potential activity (or lack thereof) for each of these processes. Chemical concentration data combined with genomic data will further clarify those processes. Further, in addition to defining processes that will consume ammonia, the treatability study may also define current processes that could be generating ammonia site wide. It is anticipated that not all these systems will be stimulated, however the treatability study is designed to assess all potential pathways.

With regards to stimulating reagents, their use in the treatability study is driven by genomic data indicating the capacity for their use and groundwater data showing if that chemical species is present or absent (or below a concentration that can be utilized by the indigenous microbial populations), as summarized below for Site COCs:

Ammonia

- Sulfate – Energy Source – Must be in the 100 mg/L range – Low in PZ-08S and PZ-08D
- Ferric Iron – Energy Source – Low in PZ-08D
- Ferrous – Energy Source (for nitrate ammonification) – Low in PZ-08S
- Carbon Substrate – Low in PZ-08D
  - Energy Source for Heterotrophs and Autotrophs
  - Provides Carbon for Heterotrophic Growth
  - Degradation product ($CO_2$) Provides Carbon for Autotrophic Growth

Metals

- Sulfate – Can Contribute to Metal Removal in Sulfide Systems (after microbial reduction)
- Ferrous Iron – Can Contribute to Metal Removal in Sulfide Systems
- Ferric Iron – Can Contribute to Metal Removal in Sulfide Systems (after microbial reduction)

The bioavailable carbon serves as a carbon source for heterotrophic microbes that require a carbon source to support growth. After initial biodegradation, carbon dioxide is generated which supports the growth of autotrophic species that require carbon dioxide for growth. Carbon also stimulates the microbial reduction of sulfate and ferric iron as an energy source, thereby creating a source of carbon dioxide for autotrophic microbes. This bench scale study has been designed to evaluate four amendments/conditions. These amendments have properties that would allow injection and distribution in the subsurface and include: a carbon source, magnesium sulfate, ferrous chloride, and ferric chloride. The rationale for selection of these amendments in the bench scale study is as follows:

- **Acetate** is a bioavailable carbon source with a relatively short half-life that is ideal for bench-scale testing.

  Emulsified vegetable oil (EVO), or similar, will likely be the preferable carbon amendment for field applications in terms of the duration of its reactive life and production of organic species easily used by microbial populations. EVO is not being used in the initial bench-scale study because of the time frame, as it can take many months for EVO to be processed for full microbial usability. The use of acetate in the initial bench-scale study allows for the definition of key processes in weeks to a couple of months (based on microbial growth dynamics rather than substrate availability).

- **Magnesium sulfate** is an ideal source of sulfate due to its commercial availability and presence of magnesium as the counter cation and has reasonable water solubility. Other common sulfate reagents include iron as the counter cation and thus would confound results, as augmentation of iron is the other variable of interest in this study. In addition, magnesium sulfate will add magnesium to the system, contributing to conditions favorable for the precipitation of the mineral barite ($BaSO_4$), potentially leading to the removal of barium from site groundwater. Barium is another site COC though it should be noted that this objective is secondary to the removal of ammonia at this stage of the investigation.
- **Ferrous chloride and ferric chloride** are commercially available salts containing reduced and oxidized iron, respectively. Augmenting ferrous and ferric iron using chloride as the counter anion will allow for discrete testing of iron augmentation, distinct from sulfate augmentation as the other common iron reagents include ferrous and ferric sulfate, as mentioned above. Augmentation of iron will potentially provide a microbial energy source (via ferrouos iron oxidation of ferric iron reduction) where current concentrations may be limiting native microbial population's capacity to treat ammonia, as discussed in Section 2.

As detailed further in Sections 3, the bench-scale treatability study will evaluate the following systems to evaluate which condition(s) is most effective for in-situ treatment of aqueous phase ammonia in groundwater collected from the Site:

- Site groundwater and aquifer solids with no amendments
- Site groundwater and aquifer solids with a bioavailable carbon amendment only
- Site groundwater and aquifer solids with a bioavailable carbon amendment and sulfate
- Site groundwater and aquifer solids with a bioavailable carbon amendment and ferrous iron
- Site groundwater and aquifer solids with a bioavailable carbon amendment and ferric iron

Overall, PZ-08S and PZ-08D are ideal locations for aquifer solid and groundwater collection to support this investigation because GSI Phase 1 sample results indicate that they contain the greatest un-ionized ammonia concentrations measured at the Site and un-ionized ammonia concentrations are consistently elevated throughout the year while other Site monitoring wells demonstrate seasonal fluctuations. Additionally, PZ-08S and PZ-08D represent the range of pH and salinity conditions observed across the Site with high pH and (relatively) low salinity conditions observed in the shallow zone at PZ-08S and neutral pH and relatively high salinity observed at co-located deep-zone piezometer PZ-08D. As such, if treatment of target analytes is successful at this piezometer pair, it is anticipated to be successful sitewide.

# 4 Field Collection of Soil and Groundwater

To complete this scope of work the following materials will be collected from locations shown on Figure 1 and used:

- Approximately 4 gallons (15 liters) of groundwater from both PZ-08S and PZ-08D (8 gallons [30 liters] total)
- A minimum of 4 kilograms (kg) of aquifer solids from each hydrostratigraphic zone (i.e. shallow and deep, analogous to PZ-08S and PZ-08D, respectively) will be collected from boreholes advanced adjacent to PZ-08S/D as shown on Figure 1.

The soil and groundwater will be collected using methods that will preserve the representative in-situ bio/geochemical conditions at the sampled locations as described below.

## 4.1 Collection of Groundwater

Approximately 4 gallons (15 liters) of groundwater will be collected from both PZ-08S and PZ-08D (8 gallons [30 liters] total), where un-ionized ammonia exceeds FAVs. Groundwater will be collected via low-flow sampling procedures into 2.5- or 4-liter (depending on availability at the time of groundwater collection) amber glass sample bottles. The bottles will be argon purged at the Treatability Laboratory and supplied to the field team prior to the field event to preserve representative in-situ bio/geochemical conditions. Once collected and packed on ice, the groundwater samples will be shipped to the Treatability Laboratory. Upon receipt, the Treatability Laboratory will subsample PZ-08S and PZ-08D groundwater from the argon-purged bottles and ship to Eurofins for analysis of baseline conditions. Subsampling at the Treatability Lab will allow laboratory staff to homogenize the multiple argon-purged amber glass bottles for each hydrostratigraphic zone in the glove box, while maintaining anaerobic conditions, to ensure identical water composition is applied to all microcosms and that a representative subsample is collected to characterise baseline conditions. The baseline groundwater samples will be collected and shipped to the analytical laboratory for the analyses summarized in Table 2.

## 4.2 Collection of Soil

A minimum of 4 kilograms (kg) of aquifer solids will be collected from each hydrostratigraphic zone (i.e. shallow and deep, analogous to PZ-08S and PZ-08D, respectively) from boreholes advanced adjacent to PZ-08S/D as shown on Figure 1. Boreholes for soil sample collection will be advanced to approximately 29.5 feet below ground surface (bgs) (i.e. bottom of the screened interval at PZ-08D) using direct push technology (DPT) drilling methods. Soil collection will target and 24.5 to 29.5 feet bgs, equivalent to the screened intervals at PZ-08S and PZ-08D, respectively. The soil from the boring will not be continuously logged in order to preserve in-situ conditions and prevent the introduction of additional oxygen to the core. Instead, the boring logs and associated soil descriptions from PZ-08S and PZ-08D will be used to target the desired sampling depth and materials.

To collect 4 kg of aquifer solids from each hydrostratigraphic zone, a MC5 sampler (5-feet long x 1.75-inch inner diameter) will be advanced to the targeted depths as close to PZ-08S/D as possible. Two borings are needed to collect sufficient quantities of aquifer solids (4 kg from each zone) with the MC5 sampler to support the Treatability Study. In the first borehole, the sampler will be advanced to the shallower target zone (8 to 15 feet bgs) to collect the shallow-zone sample, then the sampler will advance to the deeper hydrostratigraphic zone (24.5 to 29.5 feet bgs) for deep-zone sample collection. This process will be repeated in the second borehole, located a few inches from the first borehole. This will result in two MC5 sample liners from the 8 to 15 feet bgs hydrostratigraphic zone and two MC5 sample liners from the 24.5 to 29.5 feet bgs hydrostratigraphic zone, which is anticipated to yield greater than 4 kg of aquifer solids per zone. Upon reaching the desired depths, liners will be removed from the DPT tooling, capped, wrapped with vinyl tape to limit exposure to oxygen, and immediately shipped to the Treatability Laboratory. The liners containing the soil cores will remain sealed until being introduced to the anoxic glove box at the Treatability Laboratory to preserve anaerobic conditions to the maximum extent practical Upon sample receipt at the Treatability Laboratory, 1 inch from each end of the cores will be discarded and not used in the bench scale Treatability Study to ensure the soil used in the microcosms is representative of in-situ conditions and hasn't been exposed to additional oxygen through the caps on either end of the MC5 sampler. The direct push boreholes will be backfilled with hydrated granular bentonite.

## 4.3 Injection Well Installation

Two injection wells will be installed during this drilling mobilization to facilitate a field pilot test quickly following the bench scale test, if the bench scale test is successful. The two pilot injections wells (IW-08S and IW-08D) will be installed approximately 5-feet from PZ-08S and PZ-08D, respectively. A work plan for the field implementation pilot test will be developed after the completion of this Work Plan (Phase A) and Phase B, if necessary. The pilot injection wells will be 4-inch diameter and constructed with 5 feet of 0.010-inch slot stainless steel wire wrapped screen with a schedule 40 PVC riser pipe. Injection well IW-08S will target the 8 to 15 feet bgs interval consistent with PZ-08S, while IW-08D, will target the 24.5 to 29.5 feet bgs screened interval consistent with PZ-08D. The primary filter pack around the screen will consist of 20/40 clean quartz sand will be placed from the bottom of the well screen to approximately 2 feet above the top of the screen. Additionally, 1 foot of finer grained secondary filter pack (choker sand) seal will be placed on top of the primary filter pack followed by a two-foot thick bentonite seal on top of choker sand. The remainder of the annular space above the bentonite seal will be backfilled with cement bentonite grout to ground surface using a tremie pipe. Each well will be completed with a protective stick-up steel casing set in a concrete collar. Since these wells are pilot injection wells and are being installed in interbedded lithology that includes clay, care will be taken for thorough well development including the use of a clay dispersant to remove fine grained material that may have accumulated on the well screen and/or the smeared on the borehole during installation. A work plan for the field implementation pilot test will be developed after the completion of the bench scale study, as appropriate.

# 5 Bench-Scale Microcosm Testing for In-situ Biostimulation of Ammonia

Microcosms with aquifer solids from the Site, groundwater, and amendments will be prepared according to the experimental matrix in Table 1. As stated in Section 2, PZ-08S and PZ-08D have been determined to have the ideal conditions for bench scale testing because the un-ionized ammonia concentrations are among the highest at the Site with pH and salinity conditions that reflect the general conditions Site wide. As such, five microcosms will be constructed for each hydrostratigraphic zone (represented by PZ-08S and PZ-08D) in triplicate (30 microcosms total). Upon receipt of the soil and groundwater at the Treatability Laboratory, the microcosms will be constructed in 1 liter (L) autoclaved media bottles in the anoxic glove box. Note that one inch from each end of the soil cores will be discarded and not used in the bench scale Treatability Study to ensure the soil used in the microcosms is representative of in-situ conditions and has not been exposed to oxygen during the sample collection and capping process.

Microcosms will be constructed in triplicate to allow for sacrificial sampling at 3-time intervals to evaluate reaction kinetics. The first sample interval will occur at 2 weeks. The second and third sample intervals may occur 1 month and 3 months, respectively, but are subject to change based on the first sample interval results. After preparation within an anaerobic glove box, the microcosms will be incubated in the glove box for a time period dependent on microcosm number (e.g. the unamended controls for PZ-08S, microcosms 1-1, 1-2, and 1-3, will be sacrificially sampled first, second, and third, respectively). Following the incubation period, groundwater samples will be collected and shipped to the analytical laboratory for the analyses summarized in Table 2. All microcosms will be sacrificially sampled on the bench rather than within the anoxic glove box for ease of processing. Maintaining anoxic conditions in the glove box is necessary to maintain the in-situ microbial ecology during preparation and incubation of microcosms. However, following the incubation period when a microcosm is ready for sampling, the data quality no longer relies on preservation of in-situ microbial ecology, so destructive sampling is appropriate. Additionally, sampling microcosms in the glove box is not as efficient as sampling on the bench. Therefore, sampling on the bench is more efficient and does not threaten data quality.

*Table 1. Summary of microcosms and experimental matrix.*

| Microcosm Number | Groundwater[1] | Soil[2] | Amendments[3] | Description |
|---|---|---|---|---|
| 1-1, 1-2, and 1-3 | **PZ-8S** | Shallow | None (control) | Unamended Control – PZ-8S groundwater and shallow zone solids with no amendments |
| 2-1, 2-2, and 2-3 | **PZ-8S** | Shallow | Acetate | PZ-8S groundwater and shallow zone solids with bioavailable carbon amendment only |
| 3-1, 3-2, and 3-3 | **PZ-8S** | Shallow | Magnesium sulfate + acetate | Sulfate – with bioavailable carbon |
| 4-1, 4-2, and 4-3 | **PZ-8S** | Shallow | Ferrous chloride + acetate | Ferrous iron - with bioavailable carbon |
| 5-1, 5-2, and 5-3 | **PZ-8S** | Shallow | Ferric chloride + acetate | Ferric iron – with bioavailable carbon |
| 6-1, 6-2, and 6-3 | **PZ-8D** | Deep | None (control) | Unamended Control – PZ-8D groundwater and deep zone solids with no amendments |
| 7-1, 7-2, and 7-3 | **PZ-8D** | Deep | Acetate | PZ-8D groundwater and deep zone solids with bioavailable carbon amendment only |

| Microcosm Number | Groundwater[1] | Soil[2] | Amendments[3] | Description |
|---|---|---|---|---|
| 8-1, 8-2, and 8-3 | **PZ-8D** | Deep | Magnesium sulfate + acetate | Sulfate – with bioavailable carbon |
| 9-1, 9-2, and 9-3 | **PZ-8D** | Deep | Ferrous chloride + acetate | Ferrous iron - with bioavailable carbon |
| 10-1, 10-2, and 10-3 | **PZ-8D** | Deep | Ferric chloride + acetate | Ferric iron – with bioavailable carbon |

**Notes:**

1. 1L of groundwater collected from PZ-08S or PZ-08D.
2. 0.2 kg of soil collected from the sample-collection borehole shown on Figure 1.
3. Amendment doses below are tentative and subject to change upon receipt of baseline constituent concentrations determined from baseline samples:
    a. Iron and sulfate salts: 500 milligrams per liter
    b. Acetate: 1 gram per liter

*Table 2 Summary of analyses.*

| Parameter | Method | Lab Performing | Rationale |
|---|---|---|---|
| Ammonia | USEPA 350.1 | Eurofins | • Primary Site COC |
| Calcium, magnesium, sodium, potassium, manganese, selenium, iron, and barium | USEPA 6010 | Eurofins | • Metals list to include barium, a Site COC<br>• Iron and manganese can support microbial activity driven by any biologically available carbon, including interactions with sulfate and trivalent nitrogen.<br>• Major cations contribute to the ion balance in the sample, which is useful in evaluating the accuracy of the analysis. |
| Mercury | USEPA 7470 | Eurofins | • Mercury is a Site COC<br>• The presence of mercury can inhibit microbial nitrification of ammonia. |
| Chloride, nitrate, nitrite, sulfate | USEPA 300 | Eurofins | • Chloride is a Site COC and is a major ion that contributes to the ion balance along with sulfate and alkalinity<br>• Sulfate participates in microbial sulfate reduction, which impacts iron chemistry and can affect trivalent nitrogen. |

| Parameter | Method | Lab Performing | Rationale |
|---|---|---|---|
| | | | • Nitrate and nitrite are products of ammonia nitrification<br>• Nitrite is critical for the anerobic Anammox process that converts ammonia to nitrogen gas. |
| Total and Dissolved Organic Carbon | USEPA 9060 | Eurofins | • Provides assessment of carbon that may be available for microbial processing in the groundwater system |
| Alkalinity | SM2320B | Eurofins | • Potential indicator of microbial activity and autotrophic microbial population require $CO_2$ for growth, which alkalinity can provide.<br>• Major anion to allow assessment of the ion balance. |
| Reactive sulfide | SW 9084 | Eurofins | • Product of sulfate reduction |
| Gene scan[1] | Metagenomic Sequencing | Microbac | • Identify specific microbial populations |
| Total organic carbon, biochemical oxygen demand, chemical oxygen demand | EPA 415.1/SM 5310, SM5210B, E410.4 | ALS | • Indicators of microbial activity |
| Methane and $CO_2$ | RSK-175 | Eurofins | • Indicators of microbial activity |
| pH, oxidation-reduction potential, dissolved oxygen | Probe | Treatability Laboratory | • To document representative geochemical conditions and support data analysis |

**Notes:**

1. Gene scan analysis will be performed on the baseline sample and microcosm samples collected from the third sample interval, rather than on all three microcosm-sample intervals.

# 6 Data Analysis and Reporting

Data generated under this Work Plan will fall into two categories:

1. Concentration changes of COCs and the added reagents. Both will be dominantly due to microbial processing, with some secondary consequences of abiotic reactions involving microbial processed daughter products.
2. The second important data category will be changes in the microbial populations seen in microbial genetic scans that will be done prior to and after the study. These data will be matched to the concentration data

above to determine the specifics of the dynamic processes and the means of stimulating those processes in field applications.

Information and understandings developed during this bench scale study will inform the path forward. Potential next steps could include:

- Design of a field pilot test:
  - It is anticipated that the initial bench scale study will demonstrate the means for controlling ammonia concentrations at the site. Additional results that would support moving directly to a field pilot test would be the demonstration of successful control of metal concentrations in the bench scale test. If metal control is not demonstrated in the Phase A treatability study, an additional Phase B bench scale treatability study may be needed.
  - The specific dynamics for the field use of EVO is largely focused on the kinetics of activating indigenous microbial populations and life expectancy in use. Arcadis has deep experience in the field application of EVO at other sites that could support direct mobilization to the field pilot study. If control of ammonia and metals are demonstrated in the Phase A treatability study, it would be reasonable to move directly to the field scale pilot study.
- Design of an additional Phase B bench scale testing:
  - Additional reagents may be evaluated for the removal of ammonia and/or treatment of recalcitrant metal COCs that did not respond during initial bench testing
  - Refinement of concentrations of amendments to optimize field treatment and limit byproducts (i.e. can treatment be achieved with less amendments?)
- Change of GSI compliance approach
  - If the bench scale study results indicate biostimulation is not a viable alternative to reduce un-ionized ammonia to below relevant GSI criteria, alternative GSI compliance approaches will be considered.

# 7 Implementation Schedule

The following provides a tentative schedule for implementation of the scope laid out in this Work Plan:

- Fourth Quarter 2025: EGLE review of this Work Plan and associated meetings
- First Quarter 2026: Following EGLE acceptance of this Work Plan, aquifer solid and groundwater collection activities to be conducted at the Site
- Second and Third Quarters 2026: conduct microcosm testing presented in Phase A of this Work Plan
- Fourth Quarter 2026: pending results of Phase A microcosm testing, Phase B will be conducted, or a field-pilot study will be conducted.
- Final investigation results report will be submitted following completion of Phase A and Phase B (if necessary)

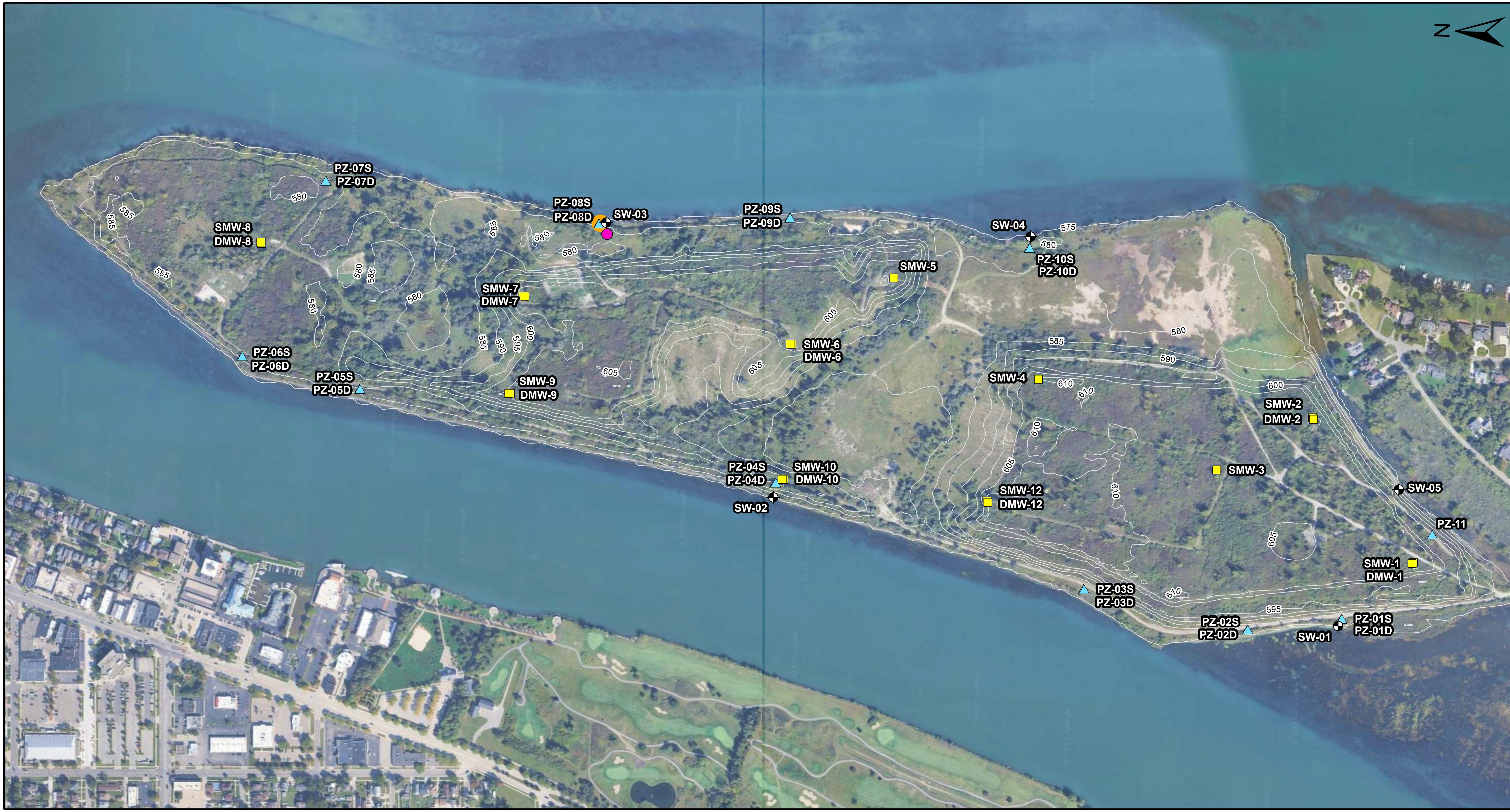
# 8 References

Arcadis. 2024. Groundwater/Surface Water Interface Work Plan. Point Hennepin, Wyandotte, Michigan. May 17.

Arcadis. 2025. Groundwater/Surface Water Interface Phase I Report. Point Hennepin, Wyandotte, Michigan. *In progress.*

EGLE. 2018. Groundwater-Surface Water Pathway Compliance Options. Remediation and Redevelopment Division Resource Materials. April 23.

# Figure




**LEGEND**

- EXISTING MONITORING WELL
- PIEZOMETER
- STILLING WELL
- APPROXIMATE LOCATION OF PROPOSED SOIL BORING AND SOIL COLLECTION
- TREATABILITY STUDY GROUNDWATER COLLECTION LOCATION
- TOPOGRAPHIC CONTOURS (FEET NAVD88)

**NOTES:**

1. Projection: NAD 1983 UTM Zone 17N
2. Basemap source: Google Satellite, accessed 7/23/2025

**ABBREVIATIONS:**

NAVD 88 = North American Vertical Datum of 1988

0 500 1,000

GRAPHIC SCALE IN FEET

BASF CORPORATION
POINT HENNEPIN, WAYNE COUNTY, MICHIGAN
**BIOSTIMULATION TREATABILITY STUDY WORK PLAN**

**PROPOSED GROUNDWATER AND SOIL COLLECTION LOCATIONS**

ARCADIS

FIGURE
**1**

Path: T:_ENV\Pt_Hennepin\Pt_Hennepin_2025\Pt_Hennepin_2025.aprx\Fig1_Proposed_GW_Soil_Locations Last Saved By: ldrum 7/23/2025

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