Technical Report on the Gelman Sciences Site Remediation

Scio Township, Washtenaw County, Michigan

Prepared for the Washtenaw County Circuit Court

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EXECUTIVE SUMMARY

The Gelman Sciences Remediation Site (Site or Gelman Site) is in Scio Township, Washtenaw County, Michigan. Gelman used the solvent 1,4-dioxane in a portion of its manufacturing operations from approximately 1966 to 1986. Some of this 1,4-dioxane entered the subsurface and formed groundwater plumes. For over three decades, this Site has been the focus of extensive remedial activities to address the release of 1,4-dioxane. Gelman's efforts have resulted in the removal of nearly 110,000 pounds of 1,4-dioxane, the treatment of over 8.9 billion gallons of contaminated groundwater, and a remedy that has been protective of human health and the environment. By any standard, the Gelman Site would be considered a mature remediation site.

In a proposed 4th Amendment to the Consent Judgement (CJ), Gelman offered to enhance the capabilities of the remediation program. Gelman, working with its team of technical experts, Michigan Department of Environment, Great Lakes, and Energy (EGLE) experts, and their associated legal teams, identified multiple enhancements to the remedial program to ensure human health and the environment would continue to be protected. When the Intervenors were permitted to enter into the CJ negotiations, Gelman offered additional remedial action items that went beyond what was necessary to comply with Part 201. After years of negotiations, Gelman's offers were agreed to by negotiators for the Intervenors. Ultimately, however, when the proposed amendments to the CJ were presented to the Intervenors' local units of government, they were rejected. This process took over four years and valuable time has been lost.

In 2017, before the Interventions were granted, Gelman and EGLE agreed to a series of amendments to the 3rd Amendment to the Consent Judgement (3rd CJ). Gelman is now proposing offering further additional amendments reflecting the additional response activities it remains willing to perform despite the Intervenors' rejection of the settlement. The key elements of the 4th Amended CJ now being proposed by Gelman include, but are not limited to:

Changing the definition of 1,4-dioxane groundwater contamination to reflect the new, lower drinking water cleanup standard (85 ppb to 7.2 ppb). 4th CJ p 5, § III J, K.

Expanding the Prohibition Zone (PZ) to cover additional area to account for the reduction in the drinking water cleanup standard. 4th CJ § V.A.2.

Removing the objective to prevent concentrations of 1,4-dioxane above 2,800 ppb (the old groundwater-surface water interface (GSI) criterion) from migrating east of Maple Road, while adding that Gelman must prevent venting of 1,4-dioxane to surface waters in the Eastern Area above the new, lower GSI criterion (280 ppb), except in compliance with state law. 4th CJ § V.A.2.b.

Installing three monitoring well clusters on the northern PZ boundary (called Sentinel Wells) and two clusters at the PZ boundary (PZ Boundary Wells) in order to detect and prevent potential breaches of the PZ boundary before they occur. 4th CJ § V.A.3.a.

Establishing trigger levels which impose additional obligations on Gelman if exceeded (e.g., increased sampling, installation of additional monitoring wells, and provision of municipal water to potentially impacted drinking water wells). 4th CJ § V.A.4 -5.

Establishing a new extraction system in the Evergreen Subdivision (Rose Remediation Area). 4th CJ § V.A.3.e.

Installing three additional monitoring wells/clusters to further delineate the extent of 1,4-dioxane downgradient of Maple Road. 4th CJ § V.A.5.f.

Preventing venting of 1,4-dioxane to surface waters in Western Area above the new, lower GSI criterion (280 ppb), except in compliance with state law. 4th CJ § V.B.2.

Installing six additional monitoring wells/clusters to delineate with greater specificity the presence of 1,4-dioxane in the Western Area. 4th CJ § V.B.3.b.

Removing the requirement to prevent expansion of the horizontal extent of groundwater contamination in the Little Lake Area System, and instead including this System within the Western Area for purposes of the Western Area Objectives, creating a more robust Western Area compliance well verification process to ensure that Western Area objectives are met. 4th CJ § V.B.4.

Gelman has been working on the remediation of this Site for 35 years and it is anticipated that remediation efforts will go on for decades to come. As outlined in this report, Gelman's proposed 4th Amended Consent Judgment represents a sustainable remediation program that will remain protective of human health and the environment. This framework is the result of a combination of technical insight gained at the site and nationally at other sites, the guidance and application of Part 201, court orders, and working with a solid team of regulators for 35 years.

INTRODUCTION

The Washtenaw County Trial Court has ordered the submittal of expert/technical reports regarding Case No. 88-034734, Kelly, Frank J vs Gelman Sciences, Inc. This technical report on the Gelman remediation has been prepared by Fleis & VandenBrink Engineering, Inc. (F&V) on behalf of Gelman.

This report is divided into four sections:

Section 1 – Background on the Gelman Sciences Site
Section 2 – Technical Justification for Gelman's Proposed Amendments to the CJ
Section 3 – An Evaluation of Response Activities Added as Part of the Intervenors 4th Amended CJ
Section 4 – Technical Response to Common Misconceptions About the Gelman Site

Gelman is proposing numerous amendments to the existing 3rd CJ. These amendments build on those that were agreed to between Gelman and EGLE. They also incorporate some amendments offered in a draft CJ agreed on by Gelman, EGLE and the Intervenors, prior to the Intervenors' local units of government voting to reject that agreement.

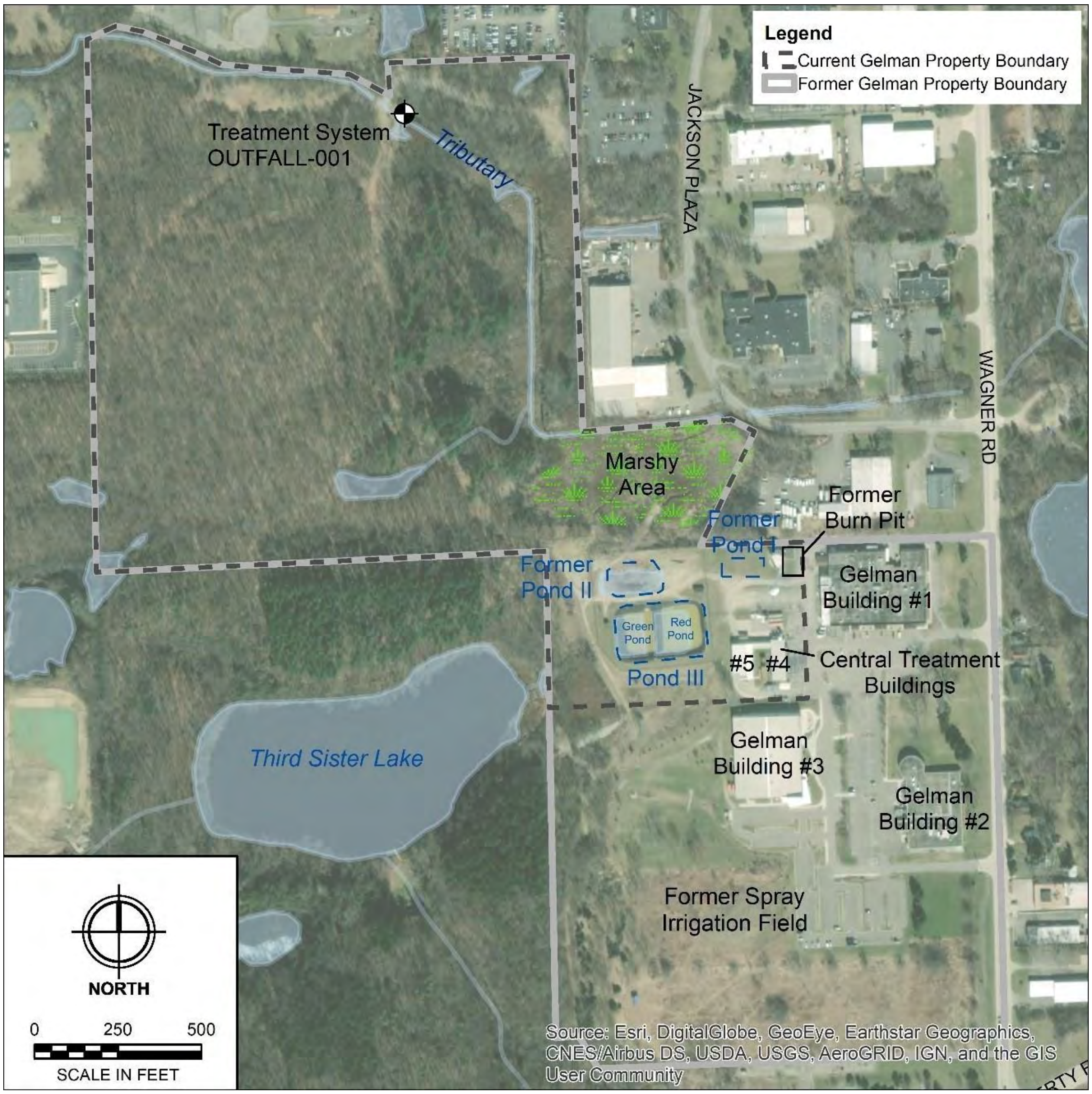
SECTION 1 – BACKGROUND ON THE GELMAN SITE

Site Location

The Gelman Sciences Site (Site) is in the southwest quarter of Section 26 of Scio Township, Washtenaw County, Michigan. More specifically, the Site is located on the west side of Wagner Road between Jackson and Liberty Roads. A map showing the Site is provided as Figure 1, and a photo of the site (circa 1980s) is provided below.

The Site consisted of an approximately 101-acre campus with manufacturing/office, warehouse and utility buildings. Portions of the original campus have been sold to others. Gelman now occupies a small portion of the site where its Wagner Road Treatment System and associated infrastructure is located (see Figure 1). The Site features shown on Figure 1 as Gelman buildings 1, 2 and 3 and the Former Spray Irrigation Field are now owned by others.

Figure 1. Site Map Showing Key Site Features



As will be presented in this report, 1,4-dioxane entered the groundwater at the Site and as a result, plumes of 1,4-dioxane formed and migrated off-site. Over the years, certain geographic areas have become relevant to the Site. To help the reader better understand those areas and other geographic features that are relevant to this report, a map has been prepared (Attachment

1). This map is also being provided in a larger format (24' x 36') with the intent it can accompany the reader during review of this document.

Nature of 1,4-Dioxane

1,4-Dioxane ($C_4H_8O_2$) is a cyclic ether. Its formula and molecular configuration make 1,4-dioxane an ideal solvent, but also impart this compound with environmental characteristics that make it difficult to remediate.

The relevant environmental characteristics of 1,4-dioxane include*:

- Soil Organic Carbon-Water Partition Coefficient (0.588 L/kg): This measure indicates that 1,4-dioxane does not tend to stay bonded with soil, preferring to mix with water.
- Water Solubility (900,000,000 ug/L): This measure indicates that 1,4-dioxane is highly soluble in water.
- Water Diffusivity (0.00001 cm^2/s): 1,4-dioxane has a tendency to diffuse (move from areas of high to low concentrations) in water.
- Henry's Law Constant (HLC) (0.0000049 atm-m^3/mol): A chemical's HLC is a measure of its ability to volatilize out of water and into the gas state. 1,4-dioxane has a low HLC, significantly less than 0.00001 atm-m^3/mol, meaning that once dissolved in water, it does not readily leave water and volatilize into the air.

*Sources: EGLE Part 201 Cleanup Criteria Requirements for Response Activity and
EGLE Proposed Part 201 Rule Changes Document, August 29, 2017.

Because of these characteristics, 1,4-dioxane is a highly mobile contaminant that migrates in groundwater at a rate similar to the water in which it is dissolved. 1,4-Dioxane does not adhere well to soil and it does not degrade readily (either through biological or abiotic means), although there is some indication natural degradation can occur (Jackson, 2019). It also does not readily transfer from water into air. These same characteristics that make it stable and mobile in the subsurface also make it difficult to remove from water when attempting to treat it.

Use/Sources of 1,4-Dioxane at Gelman

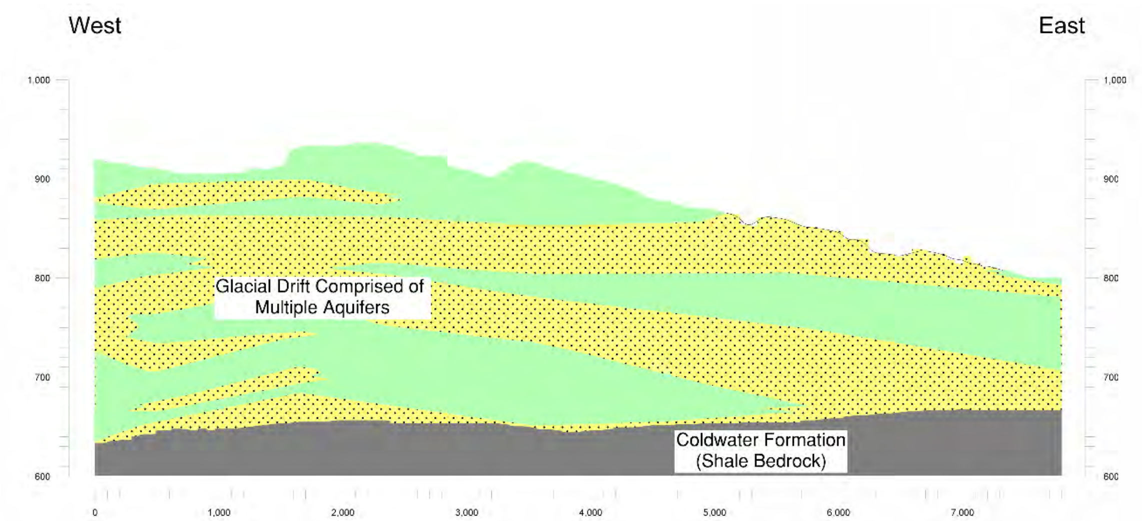
Gelman produced microporous filters, primarily for numerous life sciences applications. Beginning in the mid-1960s, Gelman used 1,4-dioxane as a solvent to manufacture one of its filter products. The manufacturing process created process wastewater that contained 1,4-dioxane. The process wastewater was ultimately disposed of at the Gelman Property via various disposal practices, pursuant to state- and federally issued groundwater discharge permits.

Working with a team of engineers and State of Michigan regulators, Gelman developed state-of-the-art treatment systems that used aerobic methods to treat the process wastewater before it was discharged to the environment. Unbeknownst to Gelman, its wastewater treatment systems did not fully treat 1,4-dioxane because of the chemical's unknown and unexpected resistance to biodegradation and the treatment processes Gelman utilized. As such, when the treated water infiltrated into the groundwater as authorized by Gelman's groundwater discharge permits, 1,4-dioxane remained and was released into the environment.

Nature and Extent of 1,4-Dioxane at the Gelman Site

The subsurface geology in the Gelman Site area consists of glacial deposits (drift) overlying bedrock of the Michigan Basin. The glacial drift ranges in thickness from approximately 200 to 300 feet. Underlying the glacial drift is the Coldwater Shale of the Mississippian-aged Michigan Formation. A generalized/conceptual cross-section of the subsurface in the Gelman Site area is provided below as Figure 2.

Figure 2. Generalized Cross Section

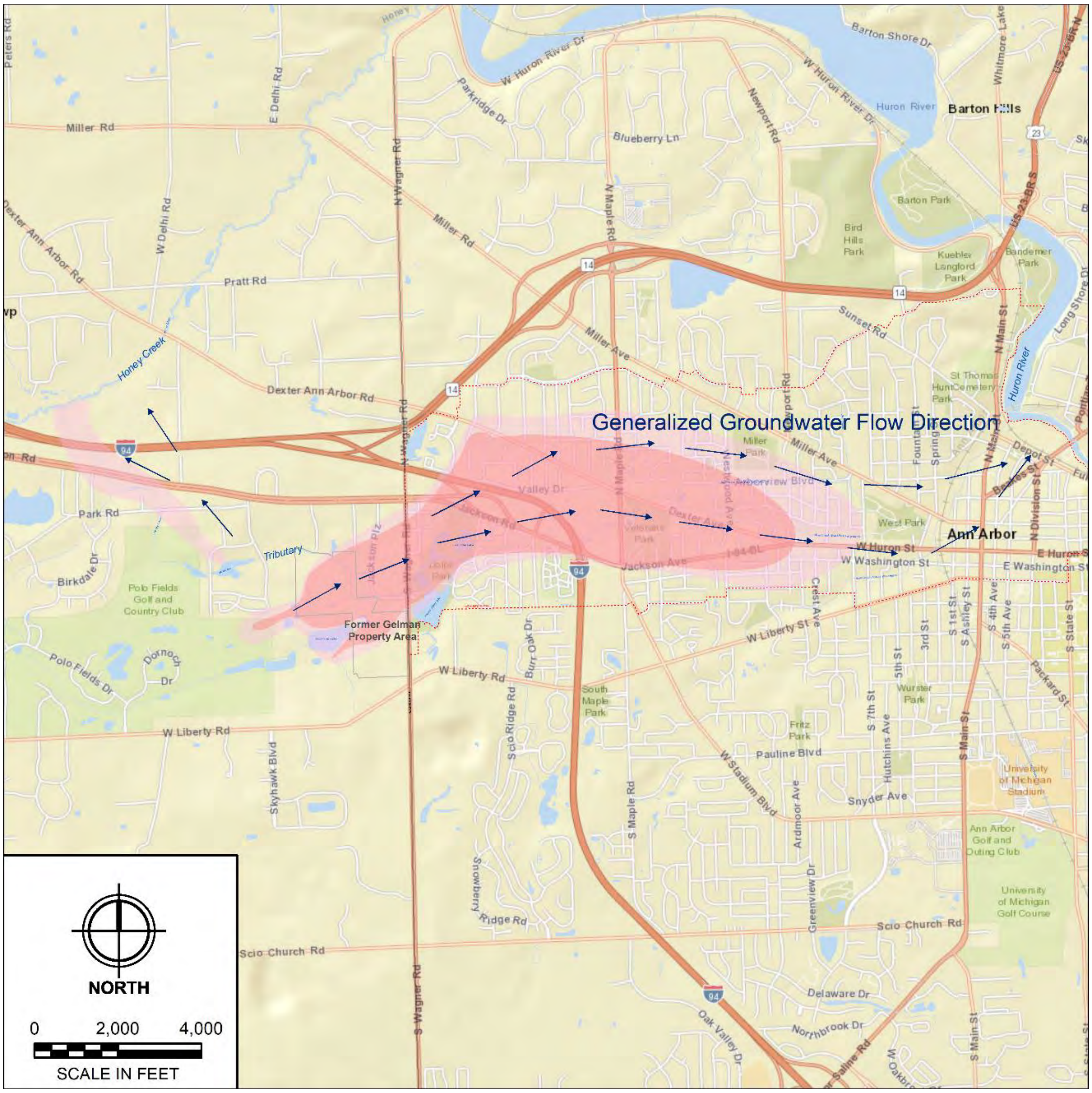


The glacial drift is comprised of a mixture of materials. Sands and gravels form groundwater aquifers (yellow dotted pattern in Figure 2 above) and clays and silts form aquitards and aquicludes (green) that separate the water-bearing zones. Multiple aquifers are present in the Gelman Site area. The underlying Coldwater Shale is not considered to be a usable source of groundwater because of its physical characteristics and the poor water quality of the water it contains.

Attachment 1 shows the extent of 1,4-dioxane related to the Gelman Site. It is important to remember that this map does not differentiate the plumes vertically. Gelman maps the plumes by different aquifer systems on a semi-annual basis. These maps are provided to EGLE and are available at the following link (https://www.michigan.gov/egle/0,9429,7-135-3311_4109_9846_30022-72394--,00.html).

Two primary surface waters control the flow of groundwater from the Gelman Site: The Honey Creek and its tributaries; and the Huron River (including ancestral drainage ways located east of the Gelman Site). Regional groundwater flow is generally from the Gelman Site toward these surface waters. This is shown on Figure 3 below. Detailed groundwater flow mapping is routinely done by Gelman, and maps are submitted to EGLE on a semi-annual basis.

Figure 3. Generalized Flow Pathways Toward Regional Discharge Areas



The vast majority of 1,4-dioxane released from the Gelman Site has migrated east due to the regional direction of groundwater flow toward the Huron River. The eastward migration is a result of the natural groundwater flow direction and the characteristics of the aquifer systems. The plumes of 1,4-dioxane migrate to the east at multiple levels vertically. That said, shallower water-bearing zones do not control the flow of 1,4-dioxane in the Eastern Area until the plume gets closer to the Huron River. As such, the plumes do not interact with either First or Second Sister Lake (the plumes are hydraulically lower than the lakes). The eastern plumes have migrated toward and into the Evergreen Subdivision area and toward Maple Road/Veteran's Memorial Park and West Park/Huron River.

1,4-Dioxane that has migrated to the west of the Gelman Site (the Little Lake/Park Road Area) is believed to be related to interaction between an unnamed tributary and the groundwater west of the Gelman Site. Water in the tributary that once contained elevated concentrations of 1,4-dioxane is believed to have recharged the groundwater and an ensuing plume developed. This plume has migrated to the northwest toward the Honey Creek where it is interpreted to slowly vent to the creek at concentrations well below the applicable Groundwater Surface Water Interface (GSI) cleanup criterion. The data demonstrate that there is no continuing source of 1,4-dioxane for the Little Lake/Park Road portion of the plume because there are no known physical connections to the source areas on the Gelman Property. This plume has been monitored for nearly 35 years and its core concentrations have steadily decayed/decreased, consistent with the lack of any continuing source of 1,4-dioxane (Pall Life Sciences, 2014 and 2015).

Investigations of the Gelman Site

The Gelman Site is likely among the most investigated 1,4-dioxane contamination sites in the United States, and certainly within the state of Michigan. Upon the discovery of 1,4-dioxane in the subsurface at its Wagner Road facility, Gelman began investigating the contaminant's toxicology, treatability, chemistry, and behavior in the subsurface. Gelman pioneered much of the work into this compound. In his landmark book on 1,4-dioxane titled *1,4-Dioxane and Other Solvent Stabilizers*, author Tom Mohr wrote,

> *"The engineers at [Gelman], and the regulators with the State of Michigan and Washtenaw County, together with scientists at the University of Michigan, were pioneers who developed the earliest 1,4-dioxane analysis, treatment technologies, toxicological profiles, and regulatory solutions to a massive 1,4-dioxane contamination problem. The [Gelman] site is the oldest and largest single 1,4-dioxane contamination case in the United States."*

Gelman's investigations of the subsurface conditions represent one of the most extensive investigations of any site of contamination in the State of Michigan, as demonstrated by the following statistics:

> Years of investigation: 35
>
> Number of Monitoring Wells: Approximately 250, plus many additional test borings (nearly 400 total wells/borings).
>
> Number of Groundwater Samples: Approximately 800 annually to track the changes in the plumes.
>
> Water-level measurements: Thousands

Estimated feet of core drilled: 44,000 feet of core (8.3 miles of drilling core laid end to end).

Extended pumping aquifer tests: eight plus tests to determine physical properties of the aquifers.

In situ hydraulic (slug) tests on numerous well sites to determine physical properties of the aquifers.

Extensive natural gamma logging of boreholes (100+) locations to help develop a conceptual understanding of the geology.

Extensive vertical aquifer sampling through the entire drift sequence to determine the distribution of 1,4-dioxane.

Extensive on-site soil sampling

Full water quality characterizations from multiple wells/aquifers to understanding how natural water characteristics vary in the aquifers.

Extensive biological testing of the unnamed tributary/Honey Creek.

Surface water flow monitoring of the unnamed tributary and Honey Creek to determine if potential exposures exist, evaluate GSI potential and trend data over time.

Surface water monitoring in First, Second, and Third Sister Lakes and other water bodies.

Plant identification study of the Marshy Area.

Numerous Analytical/Numerical flow and transport models to better predict the migration of 1,4-dioxane and the capture of extraction wells.

Findings from these investigations have been described in over a hundred reports prepared by Gelman and others that date back to 1986.

Many well-known and respected groundwater scientists have reviewed or been a part of investigations of this site. The Site has been the subject of at least six master theses and one doctoral dissertation, was used as a case study in a USEPA publication on treatment technologies for 1,4-dioxane (USEPA, 2006), and has been the subject of several articles in professional publications, as well as presentations and poster sessions presented to numerous to professional organizations. In addition, investigations of the Gelman Site have been cited multiple times in peer-reviewed publications and have been the subject in the chapter of a book on 1,4-dioxane (Mohr, 2010).

This body of work is testament to the considerable investigations of and interest in the work at the Gelman Site. The knowledge gained from the Site has contributed to the general knowledge of the management of 1,4-dioxane contaminated sites.

The Extent of 1,4-Dioxane

Since 1985, extensive efforts have gone into mapping and delineating the extent of 1,4-dioxane. Professional hydrogeologists have used data from a network of monitoring wells and borings in concert with conceptual models of regional recharge and discharge areas to map the flow of groundwater in the complete glacial drift sequence. Gelman routinely collects groundwater from a large network of wells. The groundwater data are analyzed by professionals and used to prepare a series of maps on a semi-annual basis that depict the extent of 1,4-dioxane in the groundwater. These maps are made available to the general public on EGLE's Gelman Website (https://www.michigan.gov/egle/0,9429,7-135-3311_4109_9846_9847-71595--,00.html).

Overview of Gelman's Current Remediation Operations

Gelman operates one of the largest 1,4-dioxane remediation systems in the world. Groundwater from multiple strategically located wells (see Attachment 1) is extracted/pumped from the ground and transferred to Gelman's Wagner Road facility for treatment. The operation runs 24 hours per day, 7 days per week, 365 days per year. There are two full-time licensed operators at the facility, two full time chemists that operate a state-of-the art laboratory, and one full-time groundwater sampler. The treatment facility is depicted below:

Photo 1. Gelman Ozone/Hydrogen Peroxide Treatment System

Photo 2. Gelman Red Pond (where untreated water is stored before treatment)

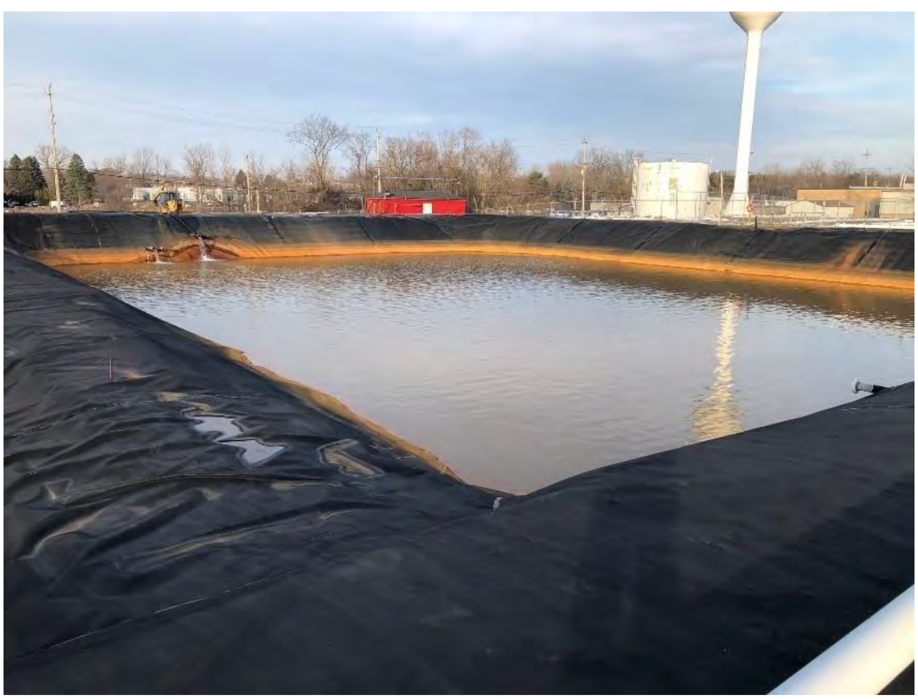


Photo 3. Gelman Water Quality Laboratory

Gelman relies on groundwater pumping and the above ground or “ex situ” treatment of 1,4-dioxane. This process is generally referred to as “pump and treat.”

To facilitate this pump and treat remediation, Gelman operates a network of extraction wells. There are a total of 36 wells in the Gelman extraction well network (active plus non-active extraction wells), 10 of which are regularly in operation. The active and inactive wells are shown on Attachment 1. By pumping contaminated groundwater, it can be extracted from strategic locations/areas and made available to the treatment process. Pump and treat is a proven remedial strategy for 1,4-dioxane as the molecule does not readily adhere well to the skeletal material of the aquifers, a constraint that makes pump and treat systems ineffective for many other chemicals.

After extraction, the groundwater is treated using an advanced oxidation system (designed by Gelman) that uses ozone and hydrogen peroxide (O_3 and H_2O_2) to break down the 1,4-dioxane molecule. (DiGuiseppi, 2016). The treated water is discharged from the treatment system to a nearby tributary to the Honey Creek (see Figure 1). Gelman has a National Discharge Pollution Elimination System (NPDES) permit for this discharge.

From 2000 to 2011, Gelman aggressively pumped the aquifer systems in an attempt to remediate the aquifers to 85 ug/L. Numerous wells were installed to recover mass from highly concentrated areas. Ultimately, with the discovery of the Unit E plume and other indications that this goal was not achievable, Gelman worked with EGLE to develop an alternative solution to the remediation that met Part 201 and was more practical over time. Ultimately, this resulted in the establishment of a non-expansion objective for the Western Area and the establishment of the PZ in the Eastern Area. With these more sustainable approaches, aggressive pumping was no longer needed to be protective of human health and the environment. Gelman now extracts, treats, and discharges approximately 500 gpm in order to meet its cleanup objectives. At this rate, Gelman pumps and treats more water than a vast majority of remedial systems in the State.

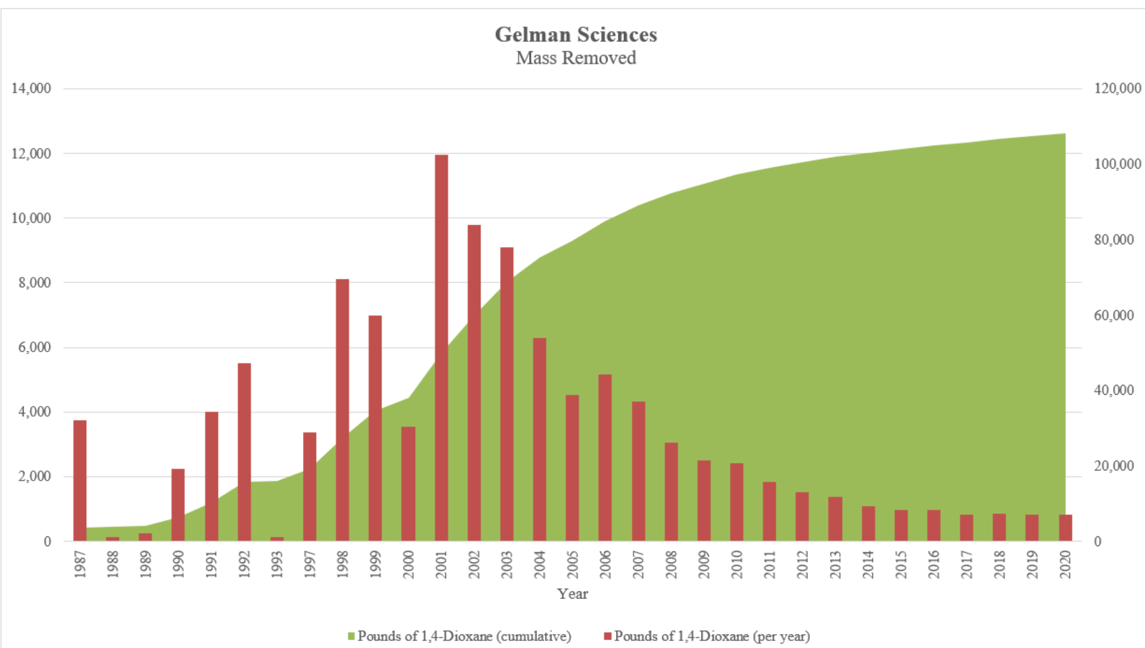
The Effectiveness of Gelman's Remedial Efforts to Date

Gelman's remedial efforts have resulted in substantial mass reduction and reductions in plume 1,4-dioxane concentrations to date and have supported Gelman's ability to maintain compliance with its regulatory and Consent Judgment obligations.

Mass and Concentration Reduction

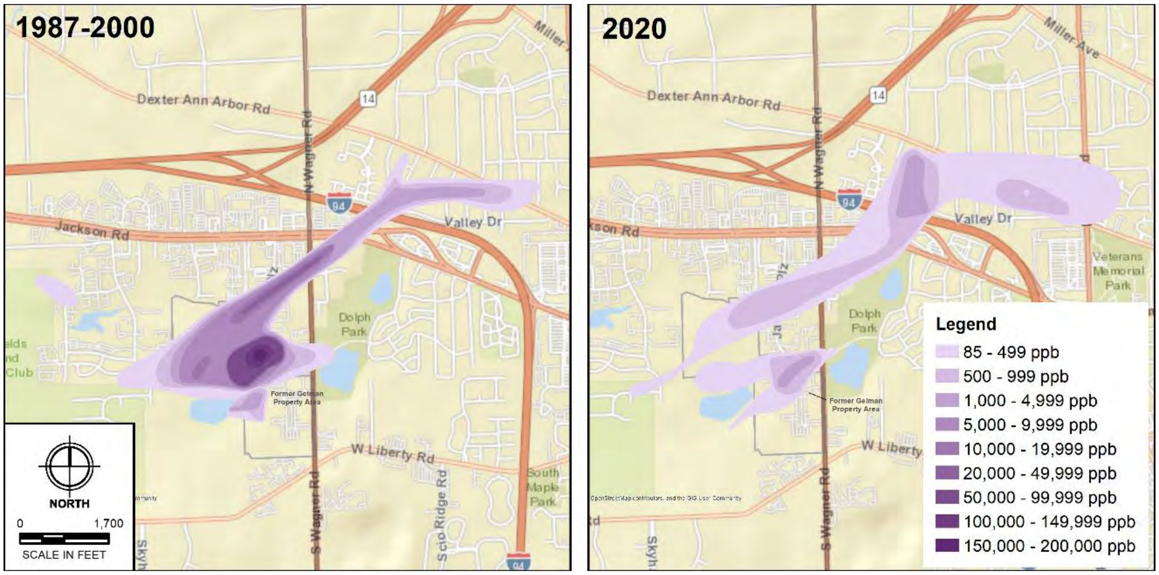
Gelman tracks the amount of mass extracted from each of its extraction wells so that mass reduction can be calculated for various plume areas. Gelman has removed approximately 110,000 pounds of 1,4-dioxane from contaminated aquifers and treated 8.9 billion gallons of water. A graph showing this mass reduction is provided in Figure 4.

Figure 4. 1,4-Dioxane Mass Reduction



As a result of the mass reduction efforts, 1,4-dioxane concentrations in the areas around the Site have been dramatically reduced from a peak value of over 200,000 ug/L to approximately 1,000 ug/L in all but small, discrete areas of the Site. Figure 5 shows the dramatic changes in 1,4-dioxane concentrations in the on-site and northeast plume (commonly referred to as the D2 plume).

Figure 5. 1,4-Dioxane Concentration Changes in On-Site and Northeast Plume



The effectiveness of Gelman's remedial effort is also reflected in the declining concentrations of 1,4-dioxane in the influent to the treatment system over time. The influent consists of the combined groundwater extracted from all of Gelman's extraction wells. Figure 6 below shows the treatment system flow rates and the decline in 1,4-dioxane concentrations in the influent to the system over time.

Figure 6. Treatment System Influent Concentrations (Purple) and Flow Rates (Orange)

When the Gelman treatment system began operation in 1996, combined extraction system 1,4-dioxane influent concentrations were more than 27,000 ug/L. Since 2009, the influent concentrations have become asymptotic in the 300 to 700 ug/L range. This is a strong indicator that much of the available areas of higher contaminant concentrations have been addressed. There have been repeated demands for source control, but these data sources confirm that the significant mass already removed from the aquifers was the largest and most concentrated source of 1,4-dioxane. Further mass reduction in the groundwater is no longer source control as traditionally understood, but rather the management of residual/remnant pockets of mass that remain after extensive remedial efforts. Such pockets commonly develop at mature sites, especially those with complex subsurface conditions like the Gelman Site.

Award-Winning Program

Although it has been subject to criticism locally, the largest groundwater organization in the United States, the National Groundwater Association (NGWA), has twice recognized the excellence of Gelman's remedial program. In 1999 Gelman (Pall) received the prestigious NGWA Remedial Project Award for the design and construction of the Horizontal Well/Transmission pipeline. And again in 2010, the NGWA awarded Gelman (Pall) the equally prestigious Outstanding Ground Water Award in recognition of its "Innovations and Advancements in the Remediation Groundwater Contaminated with 1,4-Dioxane" arising from Gelman's development of its Ozone/Hydrogen Peroxide treatment system and its overall management of the Site:

Nationally Recognized Cleanup

national ground water association®

1999 – Pall received the prestigious NGWA Remedial Project Award for design and construction of the Horizontal well/Transmission pipeline.

2010 – Pall received the prestigious NGWA Outstanding Ground Water Award in recognition of the Innovations and Advancements in the Remediation of Groundwater Contaminated with 1,4-Dioxane

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SECTION 2 – TECHNICAL JUSTIFICATION FOR GELMAN'S PROPOSED AMENDMENTS TO THE CJ

Gelman is offering numerous amendments to the existing 3rd CJ as part of its proposed 4th CJ. These amendments build on those that were agreed to between Gelman and EGLE. They also incorporate some amendments offered in a draft CJ agreed on by Gelman, EGLE and the Intervenors, prior to the Intervenors' local units of government voting to reject that agreement. Key amendments proposed by Gelman in its 4th CJ that are relevant to our technical analysis include:

- Changing the definition of 1,4-dioxane groundwater contamination to reflect the new, lower drinking water cleanup standard (85 ppb to 7.2 ppb). 4th CJ p 5, § III J, K.

  Expanding the Prohibition Zone (PZ) to cover additional area to account for the reduction in the drinking water cleanup standard. 4th CJ § V.A.2.

  Removing the objective to prevent concentrations of 1,4-dioxane above 2,800 ppb (the old groundwater-surface water interface (GSI) criterion) from migrating east of Maple Road, while adding that Gelman must prevent venting of 1,4-dioxane to surface waters in the Eastern Area above the new, lower GSI criterion (280 ppb), except in compliance with state law. 4th CJ § V.A.2.b.

  Installing three monitoring well clusters on the northern PZ boundary (called Sentinel Wells) and two clusters at the PZ boundary (PZ Boundary Wells) in order to detect and prevent potential breaches of the PZ boundary before they occur. 4th CJ § V.A.3.a.

- Establishing trigger levels which impose additional obligations on Gelman if exceeded (e.g., increased sampling, installation of additional monitoring wells, and provision of municipal water to potentially impacted drinking water wells). 4th CJ § V.A.4 -5.

- Establishing a new extraction system in the Evergreen Subdivision (Rose Remediation Area). 4th CJ § V.A.3.e.

- Installing three additional monitoring wells/clusters to further delineate the extent of 1,4-dioxane downgradient of Maple Road. 4th CJ § V.A.5.f.

- Preventing venting of 1,4-dioxane to surface waters in Western Area above the new, lower GSI criterion (280 ppb), except in compliance with state law. 4th CJ § V.B.2.

  Installing six additional monitoring wells/clusters to further delineate the extent of 1,4-dioxane in the Western Area. 4th CJ § V.B.3.b.

  Removing the requirement to prevent expansion of the horizontal extent of groundwater contamination in the Little Lake Area System, and instead including this System within the Western Area for purposes of the Western Area Objectives, creating a more robust

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Western Area compliance well verification process to ensure that Western Area objectives are met. 4th CJ § V.B.4.

The following sections are divided into Eastern and Western Area proposed remedial activities, the dividing line between these areas is Wagner Road.

Eastern Area Plume Proposed Remedial Activities

The Eastern Area of the Site generally extends from Wagner Road to the Huron River. For years, this area has been the focus of many of Gelman's remedial activities.

Potential Exposure Pathways

Potential exposure pathways present in the Eastern Area Plume include:

- **Drinking Water (DW):** Addressed by the PZ (and associated well replacements) and strategic pump and treat.
- **Groundwater Surface Water Interface (GSI):** Addressed by further investigations and Gelman's commitment to comply with Part 201.[1]

Structure to Address the Drinking Water Pathway in the 4th CJ

In the Eastern Area, the PZ has been established as a management strategy to prevent exposures through the drinking water pathway. Institutional controls such as the PZ have become a common means to eliminate the potential for human exposure to contaminated groundwater. By eliminating the potential for the use of groundwater as a drinking water source through use restrictions, an exposure pathway cannot be completed. The PZ supplements existing that Washtenaw County and City of Ann Arbor regulations that prevent the installation of wells in areas serviced by municipal water or that are contaminated.

Gelman must manage the Eastern Area plume in a way that ensures it remains within the boundaries of the PZ. Gelman has established an EGLE-approved monitoring network of wells to monitor groundwater and ensure 1,4-dioxane contaminated groundwater remains within the PZ. To date, there have been no areas where 1,4-dioxane above the 85 ug/L drinking water criterion in the Eastern Area is known to have migrated outside the PZ.

With the change in the drinking water criterion from 85 ug/L to 7.2 ug/L, additional monitoring is being proposed to ensure this objective will continue to be met. In addition, Gelman has proposed an expansion of the PZ as a result of the lowering of the drinking water standard. Both changes are discussed below, along with Gelman's proposed addition to the existing Eastern Area extraction well systems.

[1] The Vapor Intrusion (VI) pathway is not relevant because 1,4-dioxane concentrations in the Eastern Area Plume area do not approach relevant EGLE Vapor Intrusion screening concentrations. The VI pathway is discussed in greater detail in Section 4, below.

Additional Plume Definition and Monitoring

Gelman has defined the plumes of 1,4-dioxane to the standard of 85 ug/L (the drinking water criterion identified in the existing 3rd CJ). With the reduction of the drinking water criterion from 85 ug/L to 7.2 ug/L, the plumes will have to be delineated more precisely in some areas. In light of that, Gelman is proposing the installation of additional monitoring wells on the northern PZ boundary (called Sentinel Wells) and elsewhere on the PZ boundary (PZ Boundary Wells) in order to detect and prevent potential breaches of the PZ boundary before they occur, and three well clusters in the downgradient area of the plume.

The well cluster locations for the Eastern Area are shown on Attachment 1. It is anticipated that there will be up to three wells installed at each cluster location for a total of approximately 24 new monitoring wells in the Eastern Area.

Based on the findings from these wells, additional monitoring wells may be necessary, and Gelman is committed to installing additional wells if they are needed.

At the well cluster locations, Gelman plans to drill through the complete glacial drift sequence using state-of-the-art rotosonic drilling methods, including vertical aquifer sampling and continuous coring. Like all wells drilled by Gelman, the drilling will be documented by an experienced geologist, and findings of the drilling will be shared with EGLE for their input on well completion.

Changes to the Prohibition Zone

The original Gelman PZ was established in 2005 by the Court. With entry of the 3rd CJ, the PZ was expanded to include the Evergreen Subdivision area. This was not because the plume had recently expanded into this area, as critics of the cleanup commonly misrepresent. Gelman had been addressing a plume in the Evergreen Area for decades, well before the discovery of the Unit E plume (a deeper plume migrating to the east) that led to the establishment of the PZ. By 2011, Gelman and EGLE realized that in the Evergreen Area, the two plumes were indistinguishable and should be subject to the same remedial objectives.

When the initial PZ was established, an extensive drinking water well search was conducted, and it was determined that there were no drinking water wells in use in the PZ. When the PZ was expanded to include the Evergreen Subdivision, there were six township wells that needed to be addressed. Not only did Gelman pay to connect them to Ann Arbor municipal water as required, Gelman also voluntarily paid for them to connect to the municipal sewer system. As a result of these efforts, there is no potential for anyone located within the PZ to drink water contaminated with 1,4-dioxane.

The PZ is an institutional control specifically designed to protect people from drinking contaminated water. With the reduction in the drinking water criterion from 85 ug/L to 7.2 ug/L, the “buffer” existing between the plume boundary and the current PZ will be reduced. Gelman has thus proposed that the PZ be expanded to provide for the reestablishment of a buffer between the plume and PZ boundary. The proposed expansion areas are located on the north and south portions of the existing PZ and are shown on Attachment 1.

Gelman is proposing the PZ expansion, not because the plume is potentially expanding outside the boundaries of the current PZ, but rather because the standard has been reduced more than 10-fold. The buffer that was in place with the existing PZ will no longer exist. Without an adequate buffer between the delineated plume and the PZ boundary makes long-term management of the plume becomes much more difficult and the remedy becomes less protective of public health. In contrast, an appropriately expanded PZ provides a buffer from the influence of wells that are installed in the periphery of the PZ, especially large-capacity withdrawal wells such dewatering wells, open loop heating/cooling wells, and irrigation wells that could "pull" the plume outside of the PZ.

While our preliminary investigations indicate that there are no additional wells that will be impacted by this proposed PZ expansion, because the area has historically been serviced by Ann Arbor Municipal Water, the proposed PZ expansion is a safeguard to ensure that even more people are protected against potential exposure to contaminated drinking water.

In addition to the above efforts to ensure the protection of the public health, Gelman is proposing a protective contingency structure that includes contingency planning and a multi-stage monitoring and response activity process for the Eastern Area (described later in this report). This structure is designed to ensure that the plume will not expand beyond the PZ boundary and that no unacceptable exposures to the plume will occur.

Additional Groundwater Extraction

To help manage 1,4-dioxane concentrations in the Eastern Area, Gelman currently operates two extraction systems within the PZ, one in the Evergreen Subdivision and another at Maple Village. Existing and proposed remedial activities in the Eastern Area are shown on Attachment 2.

<u>Existing Evergreen Extraction System</u>

The Evergreen extraction system was established in 1994 and now consists of one well (LB-4) plus one backup well (LB-1) located near the intersection of Evergreen Street and Dexter Road. Gelman owns a former residence in this area that is used as part of the system operations. Gelman is required to pump 100 gpm from the Evergreen system. Groundwater that is extracted from the LB-4 is transferred back to the Wagner Road treatment facility via Gelman's deep transmission line/horizontal well system pipeline (see Attachment 1) where it is treated and discharged.

Pumping water at Evergreen is designed to: 1) minimize the likelihood that 1,4-dioxane will disperse beyond the northern PZ boundary, and 2) reduce the mass available to migrate to the east (see Attachment 2). The Evergreen extraction strategy allows Gelman to maximize the mass removed by concentrating the system's capacity on the areas of the highest groundwater concentrations.

Dispersion/diffusion are processes by which groundwater plumes expand through mechanical and chemical expansion. This process is important in the migration of the plume in the northern portion of the Evergreen Subdivision and contributes to the low 1,4-dioxane concentrations observed in some wells along the northern PZ boundary. No available data support that the plume is moving to the north with groundwater (advective) flow; rather, the plume is dispersing (fanning out) along the margins as higher concentrations of the plume migrate to the east toward the Evergreen extraction area. The approximate area where this process occurs is shown on Attachment 2. The Evergreen extraction system has been important in managing this process by encouraging the plume to continue to move to the east and help minimize dispersion/diffusion along the northern boundary of the plume.

Existing Maple Village Extraction System

The Maple Village extraction system consists of two extraction wells (TW-19 and TW-23) located along Maple Road between Jackson and Dexter Ann Arbor Roads. This extraction system, which has been modified over time, was initially established in 2005. Pumping water at Maple Village: 1) minimizes the potential that 1,4-dioxane will migrate outside the PZ, particularly along the southern boundary of the PZ, and 2) reduces the mass available to migrate to the east into areas where it may interface with surface water (see Attachment 2).

Groundwater pumped from Maple Village is transferred to the Evergreen System and then to the Wagner Road treatment facility via Gelman's deep transmission line/horizontal well system (Attachment 1) pipeline where it is treated and discharged.

The deep transmission line/horizontal well, which consists of two sections (north and south), was completed between October 1998 and June 1999. Installing the deep transmission line/horizontal well was a significant undertaking. The combined length of the north and south segments is approximately 4,380-feet and it is installed at a depth reaching 90-feet below ground surface. This system served dual purposes: 1) extracting groundwater and 2) allowing contaminated groundwater to be transferred from the Evergreen Subdivision area (north of I-94) back to the Gelman treatment facility at Wagner Road. The capacity of the deep transmission line is 200 gpm.

Gelman has developed an Options Array that sets forth various options for addressing the potential, but unlikey, risks that: 1) Gelman requires more extraction/treatment capacity to maintain compliance with the Eastern Area objectives that the 200 gpm provided by the current infrastructure; and 2) the northern portion of the deep transmission line fails. Note that the southern portion of the deep transmission system is no longer in use, replaced by other pipeline networks.

Proposed Rose Area Remediation

Gelman is proposing to extract groundwater from one or more wells in the vicinity of Valley Drive and Rose Drive (Attachment 2), including the option of using IW-2. This system would work in concert with the existing Evergreen Area extraction well (LB-4) and Maple Village wells.

1,4-Dioxane mapping has demonstrated that 1,4-dioxane is migrating northeastward into the Evergreen Area along a path that goes through the Rose area. 1,4-Dioxane concentrations in this area are estimated to be in the range of 1,000-2,000 ug/L, as depicted on Attachment 2. These current concentrations are well below the historical peak concentrations in the Evergreen subdivision that reached upwards of 4,285 ug/L (373 Pinewood Shallow, 2001). That said, these residual concentrations still warrant this substantial remedial effort.

The primary objective of extracting at the Rose location is to minimize the potential that 1,4-dioxane will migrate outside the northern portion of the PZ (Attachment 2) through plume dispersion/diffusion.

Groundwater pumped from the Rose location will be transferred to the Wagner Road treatment system via the horizontal pipeline. As discussed earlier in this report, this pipeline has a capacity of approximately 200 gpm. The amount of water that can be pumped from the Rose well will be combined with water from the other Evergreen extraction well (LB-4) and water from the Maple Village wells (TW-19 and TW-23). Gelman proposes to optimize flow rates from the combined wells to reach the total 200 gpm limit.

Gelman proposes to install test borings to determine the optimal location for extraction wells in the Rose area.

Contingency Planning/Trigger Process

Gelman's proposed 4th Amended CJ adds a protective contingency structure that includes contingency planning and a multi-stage monitoring and response activity process for the Eastern Area. This structure will help ensure that the plume does not expand beyond the Prohibition Zone boundary and that no unacceptable exposures to the plume occur. The Eastern Area trigger process includes the following. For reference, flow charts of this process are provided as Attachment 3.

- The initial phase of this process is Gelman's preparation of the "Municipal Water Connection Contingency Plan" ("MWCCP"). The MWCCP will identify the steps necessary to bring municipal water to the few areas near the Prohibition Zone where private water supply wells are in use and the time required for each step.

- The nine (estimated/dependent on geological conditions) new monitoring wells that will be installed well within the expanded Prohibition Zone's northern boundary (between 600 and 1,000 feet south of the northern Prohibition Zone boundary) along with the existing nine wells will provide an "early warning" line of wells (referred to as "PZ Sentinel Wells").

- If monitoring of the Sentinel wells indicates that the applicable trigger has been exceeded in any Sentinel well, Gelman will install additional well clusters along the expanded Prohibition Zone boundary (referred to as "Prohibition Zone Boundary Wells") and undertake a series of additional response activities to evaluate whether there is a reasonable likelihood that the plume could migrate beyond the expanded Prohibition Zone boundary.

- If such a possibility exists, Gelman will undertake additional response activities, including developing a "Remedial Contingency Plan" that identifies potential response actions that could be implemented to prevent prohibited expansion.

- Gelman will also initiate the portion of the MWCCP that would need to be implemented to ensure that municipal water could be extended to properties utilizing private water supply wells before any unacceptable exposure occurs.

- Additional response actions are triggered before the plume above 7.2 ppb ever reaches the expanded Prohibition Zone boundary.

- These steps include residential well sampling (and the provision of bottled water to any property serviced by a well with 1,4-dioxane concentrations above 3.0 ppb), further implementation of the MWCCP to address any impact to residential well sources, and implementation of the previously developed Remedial Contingency Plan.

It is important to underscore that available data do not suggest a direct (advective) flow path that will result in the trigger of the Evergreen Area monitoring system. 1,4-Dioxane detected by this system is more likely to be from dispersion/diffusion of the plume. It has been suggested that the trigger levels for this monitoring system should be even lower. This would provide no additional benefit and would provide no further protection of human health or the environment. Furthermore, having lower trigger levels would likely result in the potential for false positives that would require additional EGLE and Gelman time to manage without real benefit and causing unnecessary worry to the community.

Structure to Address the GSI Pathway in the 4th CJ

The GSI is generally defined as the area where groundwater vents to surface water. According to the EGLE GSI Pathway Compliance Options guidance, “the GSI pathway is relevant when a remedial investigation or application of best professional judgment concludes that a hazardous substance in groundwater can be reasonably expected to vent to surface waters of the state in concentrations that exceed the generic GSI criteria currently or in the future.”

The GSI criterion for 1,4-dioxane was formerly 2,800 ug/L (as recognized in the 3rd Amended CJ). In 2018, the GSI criterion was reduced to 280 ug/L. Gelman’s proposed 4th Amended CJ fully incorporates the more restrictive 280 ppb GSI criterion.

The GSI criterion is based on the EGLE Rule 57 Surface Water Quality Value calculated using methodology specified in R 323.0157(4), specifically the Human Cancer Value (HCV). This methodology assumes the per capita daily water consumption from incidental water ingestion is equal to 0.01 liters/day. In other words, the GSI value of 280 ug/L is driven by a conservative assumption that someone would potentially ingest water while swimming on a daily basis (365 days per year) for their lifetime.

The Aquatic Life Values for 1,4-dioxane (i.e., those protective of aquatic life) are as follows: Chronic Final Value (FCV) 22,000 ug/L, Acute Aquatic Maximum Value (AMV) 200,000 ug/L, Acute Final Acute Value 390,000 ug/L. The concentrations of 1,4-dioxane related to the Gelman Site that could interface with surface waters are orders of magnitude below what would be a concern for aquatic life.

Compliance with GSI is a State requirement and Gelman's proposed 4th CJ amendments clearly demonstrate that it is fully committed to meeting its GSI obligations. There are two surface waters in the Eastern Area with the potential for GSI to occur: the small pond in West Park and the Huron River. Our preliminary assessment of the West Park pond is that it is not receiving groundwater, rather its perched and supported by surface water drainage. Our existing flow data indicate that to the extent the plume is not captured by the West Park Fairgrounds branch of the Allen Drain, the plume would likely flow along the Allen Creek Drain corridor on its way to the Huron River. For these reasons, it is very unlikely that the plume would advance to either of these surface waters at a concentration above the GSI criterion of 280 ug/L. It is more likely that the plume will intersect with the Allen Creek Drain system (discussed more below), which Gelman has a plan to address.

As outlined in Gelman's proposed 4th CJ amendments and as required by Part 201, Gelman will need to demonstrate that it is in compliance with GSI in the Eastern Plume area and is fully prepared to do so.

Downgradient Investigation

Gelman has committed to a downgradient investigation of the Eastern Area. This investigation will initially focus on the interaction of the plume and the Allen Creek Drain system (the Allen Creek Drain and three branches to the drain). To the extent to the plume interacts with the Allen Creek drainage, it is less likely to flow out of the PZ to the east and impact wells and or have the potential to underflow the Huron River.

Gelman's investigations will include an investigation of the drains and the installation of three strategically located monitoring wells as described below.

Working with EGLE and the Washtenaw County Water Resources Commissioners (WCWRC) office, Gelman prepared and submitted a proposal for continued investigations of the Allen Creek drainage system. Once approved by EGLE and the WCWRC, Gelman will initiate an extensive flow monitoring and surface water sampling program focusing on the three primary drains feeding into the Allen Creek Drain. The concept proposed in the work plan is to first determine where and at what concentrations 1,4-dioxane may be coming into the drain. Once that information is gathered, if it is necessary to confirm actual groundwater concentrations outside the drain, Gelman will have the information it needs to strategically investigate groundwater outside the drain. This will minimize disturbance to residents. A "drill first" approach to this investigation would be wasteful and result in unnecessary disturbances to landowners.

Three new monitoring wells are proposed along one of the primary branches of the Allen Creek Drain as part of the continuation of the downgradient investigation required by earlier CJs and incorporated into Gelman's proposed 4th Amended CJ (as well as into the proposed CJ rejected by the Intervenors). These wells will provide data at key locations to help further develop the conceptual model of how the 1,4-dioxane plume interacts with the Allen Creek drainage. The wells will augment the surface water sampling and flow monitoring proposal outlined above and the shallow groundwater sampling program conducted by Gelman in 2019 (discussed below).

Western, Little Lake/Park Road Areas Proposed Remedial Activities

The Western Area generally refers to the area west of Wagner Road northwest to Honey Creek. The Little Lake/Park Road Area generally refers to that portion of the plume from Little Lake to Honey Creek.

Potential Exposure Pathways

Potential exposure pathways present in the Western/Little Lake Areas include:

- **Drinking Water**: Addressed by water well replacements, the non-expansion requirements, and strategic pump and treat.
- **GSI**: Addressed by further investigations to be identified in a work plan to be submitted to EGLE. Not applicable in the Little Lake Area.
- **Soil (On Site Only)**

Structure to Address the Drinking Water Pathway in the 4th CJ

Success of the Existing Strategy to Protect Drinking Water Exposures

The Western area has been the subject of intensive remedial efforts since 1,4-dioxane was initially discovered around the Gelman Site. In the late 1980s, Gelman operated the Redskin extraction well (named after the business where the well was located – Redskin Industries), which purged groundwater with high concentrations of 1,4-dioxane resulting in significant mass reduction during its operations. Water from the Redskin well was disposed into the Gelman Class I deep injection well, which was eventually plugged in 1994.

Gelman later installed an additional 14 extraction wells in the Western System, which extracted thousands of pounds of dioxane from the core of the plume and considerably reduced the concentrations of 1,4-dioxane in the aquifers (described further in this report). The significant positive impacts of this work have been recognized by EGLE and others who have taken the time to study the mass balance of 1,4-dioxane at the Site.

As a result of Gelman's remedial efforts in the Western and Little Lake/Park Road Areas including, but not limited to well replacements and connections to municipal water, pump and treat, and monitoring, no one is drinking water with 1,4-dioxane above the 7.2 ug/L drinking water standard from the Gelman Site.

Non-Expansion Objective

<u>Site Area</u>

Years of compliance monitoring by Gelman has shown that the Western Plume has not expanded beyond the compliance monitoring locations. The overall footprint of the 1,4-dioxane has been very stable over the years, primarily as a result of the extensive mass removal that has occurred in the core of this plume and the fact that the expansion of the Western plume is controlled by the downward vertical migration of the plume into deeper aquifers that flow to the east toward the PZ.

Gelman currently operates a subset of extraction wells in the Western Area (approximately seven wells) pumping a combined rate of approximately 250 gpm. The objectives of this pumping are: 1) meet the CJ objective established in 2011 of non-expansion of the Western plume and 2) reduce the overall mass migrating into the Eastern Area. Gelman can operate the wells as it deems necessary to meet this performance objective but is subject to significant penalties if it fails to comply with the non-expansion objective. To demonstrate compliance with the non-expansion objective, eleven compliance wells (shown on Attachment 1) are routinely monitored to verify the plume is not expanding.

Gelman extracts from three wells along Wagner Road (TW-2 [Dolph Park],TW-18 and TW-21). These wells operate at a combined flow rate of approximately 120 gpm and work to effectively capture 1,4-dioxane migrating from the site area that is not captured by on-site extraction. The mass reduced by these wells has diminished since they were installed, an indicator of the reduction of the overall mass coming from on-site. That said, these wells work to hydraulically control the footprint of the Western Area plume and help minimize the potential for plume expansion in the Western Area other than allowable expansion into the PZ.

<u>Little Lake/Park Road Area</u>

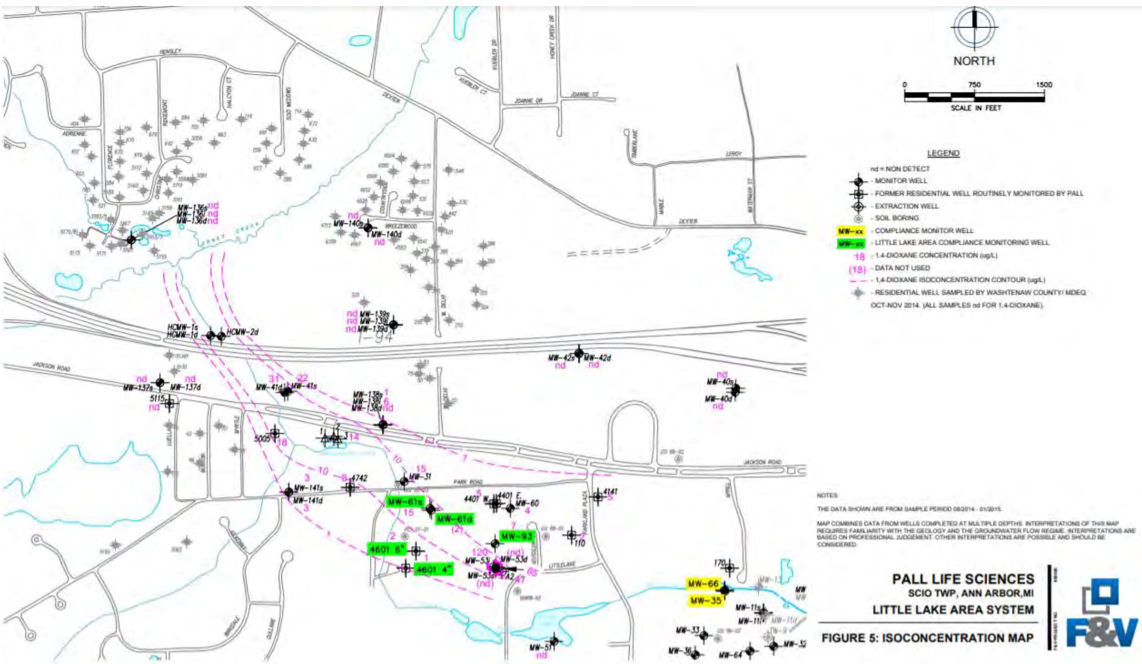
1,4-Dioxane that has migrated in the area northwest of Little Lake (the Little Lake/Park Road Area) is believed to be related to interaction between an unnamed tributary and the groundwater west of the Gelman Site. Water in the tributary that once contained elevated concentrations of 1,4-dioxane is believed to have recharged the groundwater and an ensuing plume developed. This plume has migrated to the northwest, toward the Honey Creek, where it vents to the creek at concentrations well below the applicable Groundwater Surface Water Interface cleanup criterion. The data demonstrate that there is no continuing source of 1,4-dioxane for the Little Lake portion of the plume, which is not connected to the source areas on the Gelman Property. This plume has been monitored for nearly 35 years and its core concentrations have steadily decayed/decreased, consistent with the lack of any continuing source of 1,4-dioxane (Pall Life Sciences, 2014 and 2015) and the venting of this plume to a tributary to Honey Creek via artesian conditions in the Park Road area. For years, Gelman has also conducted batch purging of a well in the Parkland Plaza area (Ann Arbor Supply Well), which has also reduced 1,4-dioxane mass in the plume from the most concentrated area.

In 2015, Gelman voluntarily conducted an investigation of the Little Lake/Park Road Area. This investigation was summarized in a report titled Pall Life Sciences, Hydrogeological Investigation of the Little Lake Area System and Portions of the Honey Creek Corridor, 2015. The purpose of the investigation was to further define the plume before a change in the drinking water standard from 85 ug/L to 7.2 ug/L.

Gelman drilled a series of wells and defined the plume. Figure 7 below shows the approximate outline of the plume to a 1 ug/L concentration. The plume in the Park Road area is very narrow, following the tributary leading to Honey Creek. The end of the plume is in an area that is very inaccessible because it is in a wetland area between I-94 and the Honey Creek. This plume has been monitored for over 30 years and has been contracting. There are no areas in the plume where 1,4-dioxane concentrations exceed 85 ug/L. Gelman has proposed an additional monitoring point near the intersection of Honey Creek and Dexter Road to determine if the plume may be moving along the creek corridor.

There was one well that was within this plume (5005 Jackson) that produced groundwater with 1,4-dioxane concentrations slightly over 7.2 ug/L. Gelman connected this location to municipal water before the 7.2 ug/L criterion was adopted.

Figure 7. Little Lake Area System Isoconcentration Map



Data from the existing compliance wells suggest that the non-expansion performance objective can be met at a 7.2 ug/L concentration in the Little Lake Area as shown by the 2015 investigation. Gelman has proposed additional delineation/compliance locations to tighten the monitoring network in this area. These wells will provide a robust monitoring to detect prohibited expansion before any residential wells are threatened.

Proposed Additional Compliance Monitoring

Gelman proposes to install new monitoring wells at six new locations in the portion of the Site west of Wagner Road, in Scio Township. Gelman proposes the same locations as were agreed to in the since-rejected Intervenor proposed 4th Amended CJ. At most of these locations, Gelman will install three "nested" wells at shallow, intermediate, and deep depths. Gelman and EGLE will use the data from these wells to identify a new compliance well network consisting of monitoring wells around the perimeter of the plume, between the plume boundary and any drinking water wells. The new wells and the compliance well network are designed to allow Gelman and EGLE to ensure that the plume, as defined by the new more restrictive 7.2 ug/L criterion, is not expanding in any direction so that it will not threaten any drinking water wells.

If expansion does occur, the compliance well network will provide Gelman and EGLE with sufficient notice to implement any response actions needed to prevent the plume from threatening any drinking water wells.

Proposed Additional Extraction

In addition to Gelman's ongoing extraction in the Western Area, Gelman proposes to increase its extraction by purging from a new well (TW-24) located north of the Green Pond. The goal of this well is to reduce 1,4-dioxane mass in a portion of the Site where a residual area of high concentration remains. Such areas of high concentration are generally limited in extent and will typically respond rapidly to extraction.

The proposed extraction from this well is not necessary to meet the non-expansion objective. For that reason, Gelman is planning to extract/treat 50 gpm of groundwater from this well until the mass reduction diminishes to a rate at which continued operation of the well would no longer be beneficial. For years, Gelman has optimized how extraction wells are managed and when they are turned off. Termination of extraction from this well will be managed in the same manner.

Contingency Planning/Trigger Process

Gelman's proposed 4th Amended CJ includes a protective contingency structure for the Western Area that includes contingency planning and a multi-stage monitoring and response activity process. This structure ensures that plume expansion will be prevented and that no unacceptable exposures to the plume occur. Gelman's proposed Western Area contingency structure will include the following. A flow chart of this process is provided as Attachment 4.

- In addition to monitoring the existing well network, Gelman will install and monitor wells at six additional locations to refine the existing delineation of the newly defined plume.

- Consistent with the Eastern Area process, Gelman will develop a MWCCP that describes the necessary steps and timeframes for the potential provision of municipal water to the residences using private water supply wells on Elizabeth Road (where low (1-2 ppb) detections have been periodically observed).

- Gelman will monitor a network of compliance wells located between the Western Area plume and any water supply wells to detect any potential plume expansion.

- If the applicable thresholds are exceeded at any of the compliance monitoring wells, Gelman is committed to undertaking a series of tiered response actions, including sampling nearby residential wells, conducting a focused hydrogeological investigation and statistical analysis, conducting an interim measures feasibility study, and, if needed, providing bottled water to affected residences (3.0 ppb).

- Under Gelman's proposal for the 4th Amended CJ, Gelman will be responsible for providing a permanent alternative water supply to property owners that have persistent elevated 1,4-dioxane levels in their drinking water well.

In the Western Area, no one is drinking water with 1,4-dioxane concentrations over the 7.2 ug/L criterion. The only residents whose wells are impacted by trace levels of 1,4-dioxane from the Gelman plumes are two to three properties on Elizabeth Drive, and more recently, a single detection of 1,4-dioxane at a location on Breezewood Court (4709 Breezewood Court – refer to Attachment 1) in the Park Road Area. 1,4-Dioxane concentrations at these locations have always been below the applicable drinking water criterion. Additionally, there is no indication that 1,4-dioxane concentrations at these locations will exceed 7.2 ug/L in the future.

For over 30 years, routine monitoring of groundwater at residential wells on Elizabeth Drive has taken place. 1,4-Dioxane was first discovered in this area in 1992, although one unreproducible detection of 1,4-dioxane was identified in a groundwater sample from 3600 Elizabeth Drive in 1986. Low levels of 1,4-dioxane have been periodically detected in groundwater sampled from two wells on Elizabeth Drive (3563 and 3573 Elizabeth Drive). The data indicate 1,4-dioxane in groundwater samples from 3563 Elizabeth peaked in 2006 with a concentration of 4 ug/L and have been declining since that time. 1,4-Dioxane in groundwater sampled from 3573 Elizabeth peaked around 3 ug/L in the years 1999-2001 and has declined ever since. 1,4-Dioxane has not been detected in groundwater sampled from this residential location since 2006. Over 30 years of monitoring data from wells in the Elizabeth Drive area, along with other data, provide support that the portion of the Gelman plume that impacted the Elizabeth Drive area is decaying. There are no data to suggest that higher concentrations of 1,4-dioxane will reach this area in the future.

1,4-Dioxane was detected on one occasion at the well at 4709 Breezeway Court in May 2019 at a concentration of 1 ug/L. This resulted in additional sampling of groundwater from other residential wells in the area of this well. 1,4-Dioxane was not detected in any other nearby wells. The 4709 Breezeway Court well has been routinely sampled since that time and there have been no further detections of 1,4-dioxane.

In summary, for over three decades, samples checked for 1,4-dioxane have been collected from hundreds of residential wells in the areas surrounding the Gelman plume. In recent years, approximately 120 samples have been collected on an annual basis. Data from this and decades of monitoring confirm the only location where residents have the potential to drink water with any detectable concentration of 1,4-dioxane is the well-monitored Elizabeth Drive area and a single well at 4709 Breezewood Court. None of these locations is threatened with contaminant concentrations that might exceed the state-wide drinking water criterion of 7.2 ug/L.

Structure to Address GSI Pathway in the 4th CJ

Consistent with Part 201 and EGLE guidance, Gelman will investigate where 1,4-dioxane may exceed the GSI criterion of 280 ug/L. The GSI pathway is potentially relevant in a limited number of locations in the Western Area, including a small segment of the unnamed tributary near the Marshy Area and in the vicinity of Third Sister Lake. Gelman has committed to submitting to EGLE for its review and approval a work plan for investigation of the groundwater-surface water interface in the Western Area and a schedule for implementing the work plan.

Structure to Address Soil Pathways in the 4th CJ

Under Part 201, soil refers to the unsaturated material above the water table. Unsaturated soils at the Gelman Site range in thickness from less than five feet to over 60 feet, with the average thickness in the 10-15 feet range. Relative to the remainder of the site areas where 1,4-dioxane is present in thick aquifer sequences, this thin veneer of soil harbors a very small mass. For example, the approximate mass in the soils in the area of Pond I, Pond II and the Burn Pit is estimated to be approximately 1,000 pounds. Gelman has already extracted and treated nearly 110,000 pounds of 1,4-dioxane from the aquifer systems. The thought that actively remediating the onsite soil will have a material impact to the overall groundwater remediation program is unfounded.

Soil data collected from the Gelman Site indicate soils do not exceed the non-residential Part 201 direct contact or particulate inhalation values of 710,000,000 and 2,400,000 ug/kg, respectively. There are limited areas where 1,4-dioxane in soil is above the residential drinking water protection value of 1,700 ug/Kg. The characteristics of 1,4-dioxane are conducive to it leaching from soil to groundwater. As such, much of the 1,4-dioxane that was in the soil has already migrated down to the groundwater where it is being managed. Site soil can serve as potential source for off-site migration of 1,4-dioxane in groundwater. Gelman has an obligation to address off-site groundwater migration in a manner that is protective of human health and the environment. Groundwater monitoring data have demonstrated that minor contribution of 1,4-dioxane from on-site soils has not impacted Gelman's ability to meet its non-expansion compliance objective and Gelman does not anticipate this will change under a lowered 7.2 ug/L plume definition. Therefore, at this time, Gelman is proposing no additional remediation of site soils because additional soil remediation would not increase the protectiveness of the remedy.

After further definition of the plume (as described previously), Gelman will be implementing an EGLE-approved Compliance Monitoring Plan to verify that the Gelman Property soil contamination does not cause or contribute to non-compliance with the Western Area objectives and to verify the effectiveness of any implemented remedial system.

SECTION 3 – AN EVALUATION OF RESPONSE ACTIVITIES INCLUDED IN THE INTERVENOR 4TH AMENDED CJ

As disclosed in the proposed settlement documentation made public in August 2020, which was ultimately rejected by the Intervenors, Gelman offered some additional remedial actions/CJ Amendments during its negotiations with the Intervenors. These proposed CJ amendments were in addition to those amendments negotiated with EGLE. Although Gelman was willing to offer these amendments in good faith, the additional amendments were not and are not necessary to be protective of human health and the environment or to comply with Part 201. Given the Intervenors' rejection of the 4th Amended CJ, Gelman is no longer offering many of these amendments. Technical justification for why these CJ amendments are not required for compliance with Part 201 or for the protection of human health and the environment is provided below.

Proposed Parklake Extraction System – Eastern Area

Gelman had previously proposed to extract groundwater from the area near Parklake Avenue and Jackson Road. This is an area that has been interpreted to feed 1,4-dioxane migrating to the northeast (toward the Evergreen Subdivision) and to a limited extent, east toward Maple Village. 1,4-Dioxane concentrations in the Parklake area are shown on Attachment 2. Gelman is no longer offering this proposed extraction for these reasons.

Gelman's initial plan was to position a treatment system the City sewer lift station at the corner of Parklake and Jackson with the plan of discharging treated water to the sanitary sewer. It is our understanding that discharge into the sanitary sewer has been rejected.

Alternatives to discharging to the sewer include after treatment discharge into First Sister Lake, transporting the water in a pipeline to the Gelman Wagner Road treatment facility for treatment/discharge, and after treatment re-injection of the water into the subsurface.

The treated groundwater could be discharged into First Sister Lake under a NPDES permit. Water discharged into First Sister Lake eventually flows into the unnamed tributary on the west side of the lake near Wagner Road, and continues downstream where it merges with Gelman's current outfall (Outfall-001). This discharge would require approval by EGLE. The NPDES permitting process for the proposed Parklake treatment system discharge would take into account the ability of the receiving waters (both the lake and wetlands) to handle the proposed rate of discharge and level of contaminants. We anticipate that EGLE would approve the discharge because the discharge is not expected to cause water quality issues in the receiving water or cause hydrological issues such as flooding. That said, there has been significant opposition to this proposed disposal method and it is anticipated that there would be considerable opposition to issuance of a permit from the public, perhaps including an administrative challenge to the permit.

A pipeline back to the Gelman Site is a possibility, but the installation of a pipeline will cause considerable disruption and also raise citizen concerns as the pipeline would go through Dolph Park or portions of the Westover Subdivision. A pipeline is a solution more appropriate for a permanent remedial activity. This proposed extraction was not intended to be a long-term remedial approach that is needed to meet cleanup objectives rather a short-term "hot-spot" extraction. As discussed below, 1,4-dioxane concentrations in this area have already significantly declined and will decline even further before the multiple approvals for this project would be granted and infrastructure installed, significantly reducing the effectiveness of this extraction.

Extracting/treating and injecting the water is possible but not at all practical. Installing the infrastructure would also result in considerable disruption. Additionally, injection wells are prone to fouling (primarily due to high iron levels typical in the plume areas) and would require considerable maintenance which results in further disruption. A permit would also be required from EGLE which would likely be difficult to obtain due to concerns of displacing the plume.

The dilemmas of what to do with the water at the formally proposed Parklake extraction system are examples of the difficulties Gelman faces when managing the 1,4-dioxane plumes and underscores some of the difficult logistical issues facing this cleanup. Extracting and treating a recalcitrant chemical like 1,4-dioxane is not easy as it requires significant infrastructure and the use of hazardous chemicals (strong oxidants and sodium bisulfite). To date, Gelman has faced significant opposition to implementing these alternatives, despite the general community desire that Gelman should be required to do more.

Overcoming these types of challenges would be appropriate if the remedial benefit to be gained required it. However, 1,4-dioxane concentrations in the Parklake area have been on a general decline to the point where the disruption and risks associated with this proposed work are no longer justified. These declines are evident on the 1,4-dioxane trend graphs for two wells positioned in the general vicinity of the proposed Parklake extraction (see MW-108s and MW-108d graphs below). Due to the continued delays in implementing this remedial action, 1,4-dioxane concentrations in the vicinity of the proposed Parklake extraction area have declined even further, thus lessening the effectiveness of this proposed remedial action. MW-108s had a peak concentration of 2,946 ug/L and is now at 280 ug/L, a 10-fold decrease. MW-108d had a peak concentration of 4,054 ug/L and is now at 670 ug/L, a 6-fold decrease. These declines reflect the effectiveness of Gelman's Wagner Road extraction. The Wagner Road extraction has resulted in less 1,4-dioxane migrating toward the Parklake area which is why 1,4-dioxane concentrations of 1,4-dioxane have been decreasing in this area. By the time Gelman were to gain its approvals to install the infrastructure for this system from all the parties that will be involved, and work through the significant local opposition to this plan, these trend data suggest the 1,4-dioxane concentrations in this area will be even less and the value of installing this system will diminish even further.

PALL Life Sciences

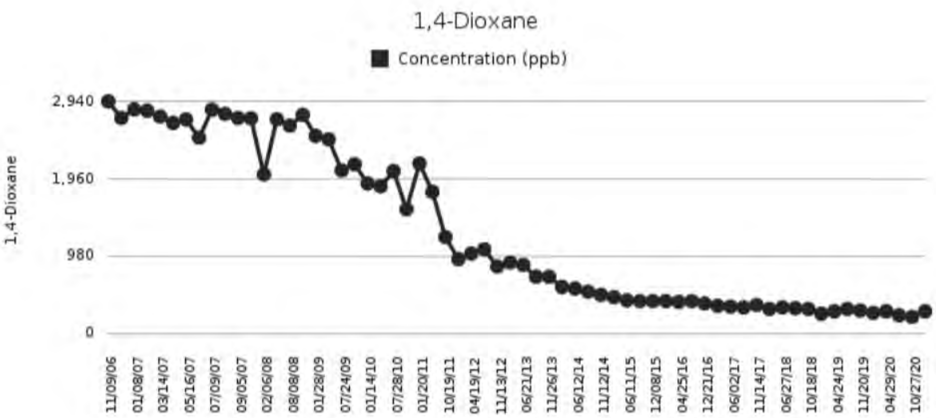
Gelman Sciences, Inc. d/b/a
Pall Life Sciences
642 South Wagner Road
Ann Arbor, MI 48103-9019 US
www.pall.com

Analytical Data Graph

Printed: 04/07/2021

Well Name: MW-108s

Aquifer:	E	Date Installed:	10/24/2006	Boring Depth:	155.00 Feet bgl	Screen 1:	155.00 to 150.00 Feet
Map Location:	K-21	Well Driller:	Stearns	Ground Elevation:	Unknown Feet	Screen Length:	5.00
X Coordinate:	13278563.99	Well Type:	Monitoring Wells	TOC Elevation:	910.38 Feet	Screen 2:	Unknown to Unknown Feet
Y Coordinate:	285774.15	Sampling Interval:	Quarterly	TOC to screen bottom:	155.00 Feet		
Comments:							



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Ann Arbor, MI 48103-9019 US
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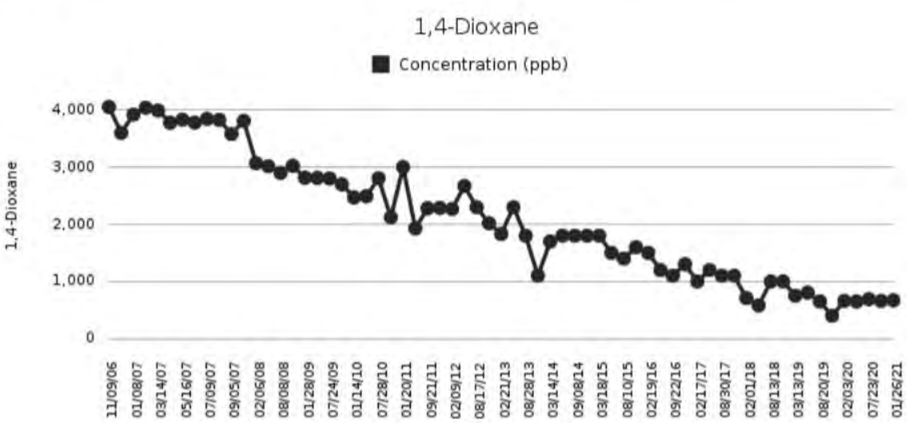
Analytical Data Graph

Printed: 04/07/2021

Well Name: MW-108d

Aquifer:	E	Date Installed:	10/23/2006	Boring Depth:	226.00 Feet bgl	Screen 1:	182.00 to 177.00 Feet
Map Location:	K-21	Well Driller:	Stearns	Ground Elevation:	Unknown Feet	Screen Length:	5.00
X Coordinate:	13278564.36	Well Type:	Monitoring Wells	TOC Elevation:	910.64 Feet	Screen 2:	Unknown to Unknown Feet
Y Coordinate:	285789.94	Sampling Interval:	Quarterly	TOC to screen bottom:	182.00 Feet		
Comments:							



Our data indicate 1,4-dioxane mass from the Parklake area will migrate either toward the proposed Rose extraction area, or to a limited degree, east toward Maple Village. 1,4-Dioxane concentrations in the plume core to the east of the Parklake lake area have been declining. For example, the next key downgradient indicator well to the east is the MW-72 cluster. Concentrations at this location have been on a steady decline since their peak. MW-72s had a peak concentration of 168 ug/L and is now at 1 ug/L. MW-72d had a peak concentration of 3,788 ug/L and is now at 610 ug/L. 1,4-Dioxane trends at these locations suggest continued declines. These declines are related to Gelman’s remedial efforts both upgradient (Wagner Road and onsite) as well as downgradient at Maple Village. It’s important to note that Gelman has operated a long-term extraction along Wagner Road since 2005.

In sum, the highest concentrations from the Parklake area peaked in 2006 and have long-since migrated away from the area of the previously proposed Parklake extraction. There is no reason that the continued migration of 1,4-dioxane from the Parklake area at the current much lower concentrations toward either the MW-72/Maple Village area or the Evergreen Subdivision will cause any compliance issues.

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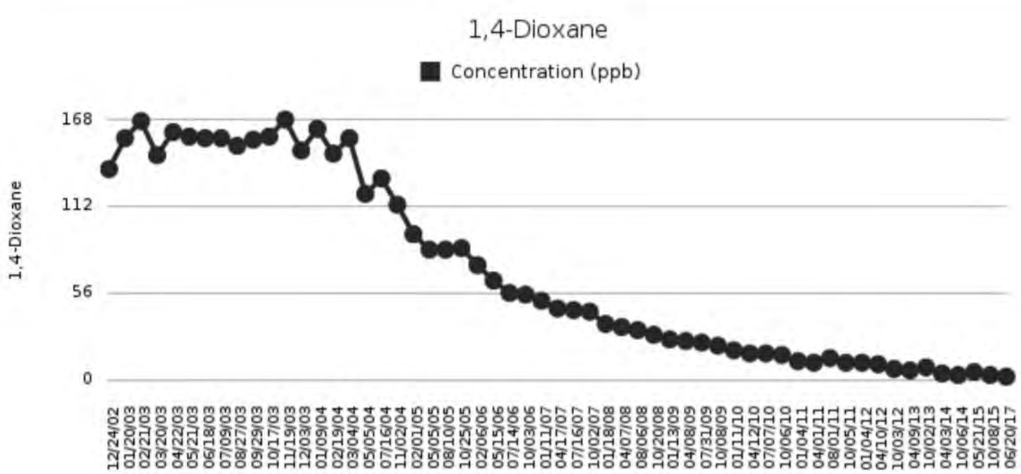
Analytical Data Graph

Printed: 04/08/2021

Well Name: MW-72s

Aquifer:	E	Date Installed:	12/18/2002	Boring Depth:	123.50 Feet bgl	Screen 1:	123.50 to 118.50 Feet
Map Location:	K-25	Well Driller:	Stearns	Ground Elevation:	943.00 Feet	Screen Length:	5.00
X Coordinate:	13280450.66	Well Type:	Monitoring Wells	TOC Elevation:	942.93 Feet	Screen 2:	NA to NA Feet
Y Coordinate:	285914.03	Sampling Interval:	Semi-Annual	TOC to screen bottom:	123.50 Feet		
Comments:							



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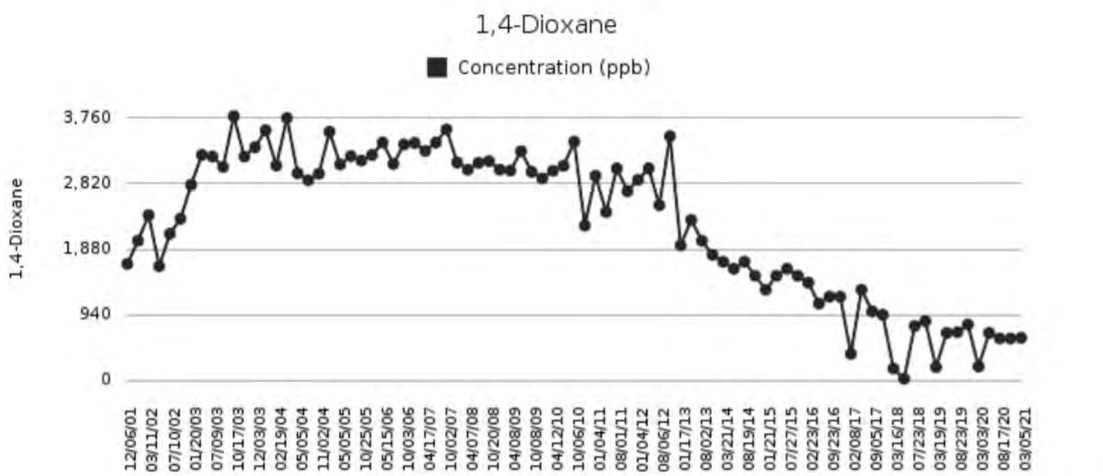
Analytical Data Graph

Printed: 04/08/2021

Well Name: MW-72d

Aquifer:	E	Date Installed:	11/28/2001	Boring Depth:	280.00 Feet bgl	Screen 1:	200.00 to 190.00 Feet
Map Location:	K-25	Well Driller:	Stearns	Ground Elevation:	943.00 Feet	Screen Length:	10.00
X Coordinate:	13280561.00	Well Type:	Monitoring Wells	TOC Elevation:	942.49 Feet	Screen 2:	NA to NA Feet
Y Coordinate:	285943.00	Sampling Interval:	Quarterly	TOC to screen bottom:	200.00 Feet		
Comments:							



Available data support that most of the mass migrating from the Parklake area is, and has been, moving toward the Evergreen Area, more specifically toward the proposed Rose extraction area. The peak concentrations that have already migrated past the Parklake area have either migrated through the Evergreen Subdivision or are working their way through the Rose extraction area and towards the LB4 extraction well. These higher concentrations have not caused dispersion/diffusion of 1,4-dioxane beyond the existing PZ boundary at levels above 7.2 pbb, but extraction in the Rose area where higher concentrations are present to be used in concert with the existing Evergreen system is considered to be an important extra layer of protection in this area. Capturing the mass between Parklake and the Rose extraction area is not practical considering the presence of Jackson Road (a boulevard in this area), I-94 and a hotel.

On/Off-Site Extraction – Western Area

Gelman had previously offered additional, voluntary on and offsite extraction in the Western Area. This extraction is no longer part of Gelman's proposed 4th CJ amendments, with the exception of one new extraction well to be identified as TW-24. This well is in the area south of former Pond II (between former Pond II and the Green Pond). This well has been installed by Gelman and will be operated at a flow rate of 50 gpm.

Gelman has been extracting groundwater in on-site areas for nearly three decades. This work has resulted in the removal of a significant amount of 1,4-dioxane (see Figure 9). While there are remaining limited areas of higher concentrations of 1,4-dioxane, the voluntary extraction program from these localized zones is not required in order to meet Gelman's non-expansion objective or be protective of human health or the environment.

If future groundwater monitoring suggests that additional extraction from new wells or existing wells is necessary to meet the non-expansion objectives, Gelman will consider such extraction in the future.

Phytoremediation – On-Site, Western Area

As with the voluntary extraction discussed above, Gelman voluntarily offered the use of phytoremediation in the former Pond I/II areas and the Marshy Area as part of the now-rejected proposed Intervenor 4th CJ amendments. These remedial efforts are no longer offered as part of Gelman's 4th CJ amendments because these voluntary remedial actions are not necessary to protect human health and the environment. The amount of 1,4-dioxane mass prevented from mobilization as result of this effort would be minimal.

If future groundwater monitoring suggests that additional remediation in either the Marshy or Ponds I/II areas is necessary to meet the non-expansion objectives, Gelman will implement appropriate remedial measures.

Heated Soil Vapor Extraction – On-Site, Western Area

As with the onsite remedial activities just discussed, Gelman had previously offered the use of Heated Soil Vapor Extraction in the former Burn Pit area as part of the now-rejected proposed Intervenor 4th CJ amendments. This plan is no longer offered as part of the 4th CJ amendments because this voluntary remedial action is not necessary to protect human health and the environment. Gelman will cap remaining uncovered areas in the Burn Pit area help further minimize infiltration of water into the subsurface in the Burn Pit area (this area is already partially covered by a parking lot and water tower infrastructure).

If data suggests that a remedial action in this area is necessary to meet its non-expansion objective in the Western Area, Gelman will evaluate this other remedial action in the future.

SECTION 4 – TECHNICAL RESPONSES TO COMMON MISCONCEPTIONS ABOUT THE GELMAN SITE

The following are responses to misconceptions often heard about the Gelman site.

Claim: "The Gelman Plumes Just Continue to Expand"

This statement is often used out of context. The overall plume footprint of the Gelman plumes has not changed significantly for the last decade. Most changes in 1,4-dioxane concentrations have occurred internally within the plumes as 1,4-dioxane concentrations have been reduced by Gelman's remedial efforts or shifted over time as the plume moves from higher to lower concentrations through groundwater flow (advective transport) or dispersion/diffusion. Dispersion/diffusion has played a role in certain areas, such as along the northern portion of the deeper plume in the Evergreen Subdivision area. This means that edges of the plumes can gain slightly in width over time, and the mass disperses along the flow path of the plume.

The changes observed in the Gelman plumes have been anticipated and were accounted for in the establishment of the non-expansion objective in the Western Area and the PZ in the Eastern Area.

Western Plume Footprint

Years of compliance monitoring by Gelman has shown that the Western Plume has not expanded beyond the compliance monitoring locations. The overall footprint of the 1,4-dioxane has been very stable over the years, primarily as a result of the extensive mass removal that has occurred in the core of this plume.

In the Little Lake/Park Road area, data suggest that there is no longer a plume above 85 ug/L. Even when the plume is defined at a concentration of 7.2 ug/L, there is no evidence to show that the boundaries of the plume are expanding. As shown by more than 30 years of groundwater monitoring, residential wells around the periphery of this plume have not been impacted (except for trace levels at one well on Breezeway – as discussed in this report). Additional monitoring, as proposed by Gelman, will be used to further define the boundaries of the 7.2 ug/L plume and demonstrate it will not expand into residential areas.

Water quality data suggest that the 7.2 ug/L plume has already reached Honey Creek. To the extent the plume is migrating along Honey Creek corridor to the northeast, Gelman has agreed to install a monitoring well in the vicinity of Dexter Road and Honey Creek to monitor for such migration.

Eastern Area Plume Footprint

The overall Eastern Area Plume footprint has experienced some minor expansion over the years, primarily in the area east of Maple Road at the leading edge of the plume. The core of the plumes have been reduced substantially through aggressive pumping in four key areas:

1. Wagner Road, where much of the 1,4-dioxane mass that has the potential to enter the Eastern Area is captured.

2. Along the Plume by the northern Horizontal Well – This well strategically reduced mass along the axis of the plume core migrating toward Evergreen Subdivision, removing approximately 2,000 pounds of 1,4-dioxane during its operation.

3. Evergreen, where a long-term groundwater extraction system has been operating at flow rates of approximately 100 gpm.

4. Maple Village, where a long-term groundwater extraction system consisting of two wells has been operating at a flow rate of approximately 100 gpm.

By reducing 1,4-dioxane levels along the axes of the two primary Eastern Area plumes and controlling water levels, Gelman has been able to meet its Eastern Area objective of not allowing the plume to migrate beyond the PZ.

EGLE has been extensively evaluating plume changes over time using a three-dimensional geological model developed with the software ROCKWORKS. Much of EGLE's efforts have been spent evaluating how the how the plumes have changed over time. Preliminary discussions with EGLE suggests their findings generally support our interpretations of the Eastern Area, including:

1. The cores of the Eastern Area plumes have been reducing/retracting.

2. 1,4-Dioxane concentrations in wells downgradient of Maple Village have shown overall declines in the Maple Village/Veterans Park area while concentrations have increased further down gradient as the plume migrates toward the Allen Creek/Huron River drainages.

Claim: "Gelman Needs to Reduce the Concentrations Below the Generic GSI Criterion of 280 in the Eastern Area to Ensure GSI Compliance"

The 2004 Unit E Order stipulates that Gelman must prevent 1,4-dioxane concentrations of greater than 2,800 ug/L (former GSI criterion) from migrating east of Maple Road. As a result of mass reduction efforts upgradient (west of) Maple Village, 1,4-dioxane concentrations never reached 2,800 ug/L in the Maple Village area. Despite that fact, Gelman continues to operate this extraction system at approximately 100 gpm. The 2,800 ug/L objective at Maple Village was an arbitrary requirement. Meeting the 2,800 ug/L GSI criterion at Maple Road was not necessary to satisfy the downgradient GSI compliance objectives: the point of compliance for GSI is at the actual interface where groundwater discharges into surface water which is a considerable distance downgradient (nearly one mile).

It has been suggested that the CJ be revised to require Gelman to capture the plume at the new GSI criterion of 280 ug/L. Such an attempt at a mid-plume capture is not necessary to meet GSI requirements at an actual point of compliance that is a nearly one mile away from Maple Village.

Secondly, it will be very difficult to demonstrate and verify that a system was actually "capturing" the plume at this concentration from the middle of the plume.

Gelman is fully committed to evaluating whether the GSI pathway is complete in the Eastern Area. Gelman will investigate if there is, or potentially could be, a GSI exceedance at a potential point of compliance. To the extent such an exceedance is determined or anticipated, Gelman will develop specific strategies to comply with its GSI obligations. Pumping groundwater without even knowing if there is a GSI issue makes no sense. Additionally, enforcing Gelman to remediate the Eastern area to an arbitrary goal is not necessary, and would also result in significant unwanted disruption to residents of the area.

Claim: "Gelman Needs to Install Even More Monitoring Wells/Test Borings (Transects)"

Some have claimed that Gelman does not have enough monitoring wells. To the contrary, Gelman has installed approximately 250 wells and has committed to install approximately 32 additional wells drilled to the bedrock surface. To date, Gelman has drilled nearly 44,000 linear feet of soil core.

Monitoring a large site such as Gelman is much different than monitoring smaller sites. While installing a high density of wells at a small site is often practical, that is not the case at a site like Gelman where wells are drilled to depths often reaching over 200-feet and working in a dense landscape of commercial and residential structures.

There is no specific guidance that determines what is an adequate number of wells or borings to define the hydrogeological characteristics of a site and the distribution of contaminants in the subsurface. The number of wells needed depends on a number of factors such as the complexity of the subsurface conditions, the locations of potential receptors, and the objective of collecting new data.

To offer a frame of reference, we have compared the number of monitoring wells at the Gelman Site to a another well-known 1,4-dioxane site in Michigan, the KL Landfill. The KL Landfill is in Kalamazoo County and is a listed National Priorities List (Superfund) site run by EPA with a viable group of responsible parties to fund necessary remedial work. The KL Landfill plume is rather large and, like the Gelman Site, is within an area of restricted groundwater use (an institutional control). Unlike the Gelman Site that is being actively remediated, the KL Landfill site relies on an institutional control and has no active remediation to address the 1,4-dioxane plume. We analyzed the ratio between the number of wells at this this site and the Gelman Site. At the KL site, there is one monitoring well per 8.36 acres of plume. At Gelman, there is one monitoring well per 3.08 acres of plume, more than twice as many wells per acre as the EPA-led KL site.

Gelman collects an estimated 800 groundwater samples each year. In order to meet this sampling demand from the number of wells its samples, the Site has a full-time groundwater sampler. Additionally, the Site has its own state-of-the-art laboratory capable of analyzing 1,4-dioxane and bromate.

One criticism of Gelman's depiction of the plumes is that it does not reflect the complex nature of the aquifer that a more granular delineation would reveal. Gelman recognizes that its depiction of the plumes is often over-simplified. In reality, the glacial processes have resulted in a complex intertwining network of glacial deposits that the plumes migrate within. Professor Lemke, a researcher and consultant to the Intervenors, has used an example of Play Doh being extracted from a press, an finding these pathways is analogous to finding a battleship during a game of Battleship. To identify these pathways, Professor Lemke has routinely suggested closely spaced transects to gain more resolution of the distribution of 1,4-dioxane. In some unique circumstances, identifying these pathways in such detail may be relevant to a specific objective or site area. But in the absence of a clear need for such detailed data, such efforts are only a means to satisfy intellectual curiosity and there are generally more efficient means to address relevant questions. This is particularly true within the PZ.

The extensive investigations that would be required to gain this granular understanding of the geology must be balanced by the disruption such investigations would cause in congested residential areas. One must remember that drilling deep boreholes with extensive sampling takes time and very large drilling equipment and supporting equipment. This drilling is a disruptive process to residents of the areas where the drilling occurs. Additionally, in response to requests by EGLE and others, Gelman uses sonic drilling methods. Although there are distinct benefits to this drilling method, it is also quite disruptive. This type of drilling creates high frequency vibrations that are transmitted by the subsurface and can be disturbing to residents because it often results in the vibration of structures. Residents then raise concerns about structural damage to their homes or buildings.

Below are some photos of a typical drilling set up (Photos from the drilling of MW-136)

Photos 4 and 5 – Rotosonic Drilling at Gelman MW-136 – Typical Rig Setup

In summary, Gelman has always carefully considered reasonable requests from EGLE and others for additional test borings and monitoring wells. Many factors are considered when determining if a test boring or well is necessary. At some point, one must distinguish between what is simply intellectual curiosity and what is necessary to demonstrate regulatory compliance while balancing out the risks and inconveniences associated with this work.

Claim: "1,4-Dioxane from Gelman Will Migrate to Barton Pond"

Some continue to suggest that the Gelman plumes have the potential to migrate toward Barton Pond. This position is simply not supported by data.

1. If groundwater containing 1,4-dioxane were to flow toward Barton Pond, it would be from the Eastern Area, specifically the Evergreen Subdivision area. For years, Gelman has monitored several strategically placed wells in that area to detect migration northeast of this area toward Barton Pond. There is no indication that a 1,4-dioxane has or will migrate toward Barton Pond. Gelman is proposing to augment the monitoring system to further examine potential flow pathways toward Barton Pond.

2. The City of Ann Arbor hired Tetra Tech and their consultant HGL Hydrogeologic, Inc. (hydrogeologist Dr. Doug Sutton), to assess the potential for the plume to migrate toward Barton Pond. This consultant examined extensive amounts of data from the Site, particularly the Evergreen Area. Dr. Sutton prepared a report of his findings and submitted that report to the City (HGL Hydrogeologic, Inc., April 4, 2014). His primary conclusion was as follows:

   > "In general, I find it highly unlikely that contamination from the Evergreen area is migrating to Barton Pond. However, I cannot definitively demonstrate that contamination above the standard of 85 μg/L will not migrate out of the

> Prohibition Zone to the north, particularly in the area east of the MW-120 cluster. My understanding is that there are residential wells in this area. Further information about groundwater flow and contaminant transport in this area is merited. One or two monitoring well clusters to the east of MW-120 would be helpful in evaluating the direction of groundwater flow and contaminant transport east of MW-120. In addition, improvements could likely be made in interpreting water levels and groundwater flow directions that may lead to a better understanding of contaminant transport in this area." (emphasis added)

As recommended by Dr. Sutton, Gelman has committed to installing the two well clusters he mentioned (see Attachment 1).

3. Barton Pond is an impoundment. The hydraulic head difference between the pond and water of the Huron River downstream of the pond is 15 to 20 feet. In the very unlikely event groundwater containing 1,4-dioxane were to flow toward Barton pond, it would more than likely discharge downstream in the Huron River, not in the pond.

4. Gelman uses a network of monitoring wells to detect 1,4-dioxane before it would migrate toward the Barton Pond area. Some have claimed its possible for 1,4-dioxane to migrate between these wells. In the unlikely event this would occur, the plume width would have to be less than approximately 750 feet (the maximum spacing on the wells). Additionally, 1,4-dioxane concentrations would likely be less than 20 ug/L. The probability of a narrow, low concentration 1,4-dioxane plume making migrating approximately 12,000 feet to the Barton Pond area is extremely unlikely. If it were to make it that far at detectable concentrations, it would likely discharge downstream of the impoundment at a level well below the most restrictive GSI criterion.

The City of Ann Arbor has worked with their consultant Tetra Tech to develop plans to identify monitoring well locations well north of the PZ boundary, in addition to the monitoring wells to be included in the proposed 4th CJ. The monitoring system and contingency process developed jointly by Gelman and EGLE is designed to detect and prevent migration of 1,4-dioxane toward the northern boundary of the PZ well before it would reach the City's well locations.

Claim: "Gelman Needs to Pump More Water"

Gelman runs groundwater extraction wells continuously and has pumped and treated more than 8.9 billion gallons of 1,4-dioxane contaminated groundwater to date. The Gelman Site is certainly one of the most active remediation sites in the State of Michigan.

In the earlier stages of remediation, aggressively pumping groundwater to capture high mass areas made sense. Gelman extracted between 1,200 and 1,300 gpm during a period from approximately 2002 to 2011. This effort resulted in significant mass removal but underscored the fact that a more sustainable cleanup program was necessary. Amendments to the 3rd CJ made for a more sustainable cleanup program that did not require as aggressive pumping but protected human health and the environment.

There have been calls for Gelman to "do more" and "pump more water." Extracting more water for some incremental increase in mass reduction with no identified objective is not defensible and indeed could be counterproductive. Any such efforts need to be balanced against the associated negative consequences: the disruption associated with the installation and operation of more environmental infrastructure, energy consumption/greenhouse gas emissions and of course the risks associated with the generation, transport and storage of treatment chemicals. Extracting more groundwater does not necessarily result in a more effective cleanup (one that is more protective of human health and the environment). Gelman has consistently demonstrated that it is able to provide a protective remedy and meet its regulatory objectives with its remedial efforts even though they have been optimized relative to earlier more aggressive pumping efforts.

Claim: "Gelman Should Restore the Aquifers"

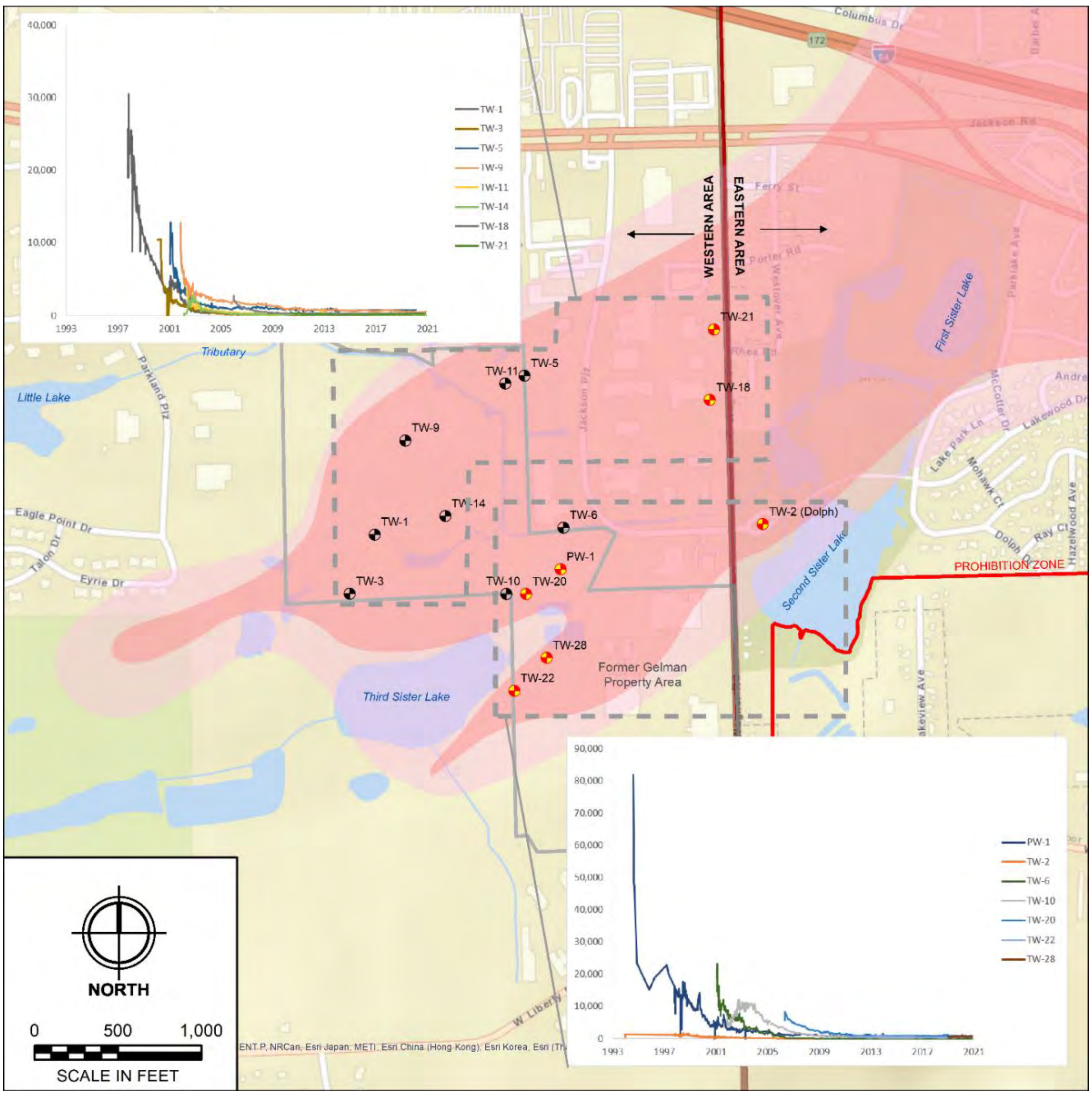
Having been the focus of intensive remedial efforts for decades, the Gelman Site is a mature site. Despite being a very effective approach to remediating the Gelman Site, pump and treat, like all remedial technologies, has its limitations, especially in geologically heterogenous sites such as the Gelman Site. Contaminants such as 1,4-dioxane migrate into finer-grained materials and tend to release slowly over time, causing tailing and/or rebound effects. These limitations, coupled with the large footprint of the Gelman plumes, the concentrations of 1,4-dioxane released at the Site, the complexity of the geology, and significant accessibility issues, make the goal of restoring the aquifers at the Gelman Site impractical and technically infeasible. These limits manifest themselves at mature sites such as the Gelman site that have been subject to years of aggressive remedial activities.

Hydrophilic contaminants such as 1,4-dioxane "back/matrix diffuse" into finer-grained materials like the clay-rich soils that make up the aquitards/aquicludes that separate the water-bearing zones/aquifers. These finer-grained materials become infused with 1,4-dioxane, and then tend to "re-release" the contaminant slowly over time back into the water bearing zones even as those zones are being remediated via pump and treat efforts. This phenomenon can cause tailing and/or rebound effects in the groundwater concentrations. (Adamson, 2016). These limitations, coupled with the over 20 year delay between the initial significant contaminant release and the date the groundwater contamination was discovered, the resulting large footprint of the Gelman plumes, the high initial concentrations in the groundwater, the complexity of local geological conditions, and significant accessibility issues, make restoration of the aquifers to State risk-based standards impracticable and technically infeasible. Additionally, considering the size of the of the plume footprint and the density of infrastructure, it would be nearly impossible to verify such a goal could be met. Aquifer heterogeneities are such that there would remain pockets of contamination. One would never be able to prove that the aquifer remediated to a level that a local sanitarian would likely be comfortable allowing a well to be installed in the plume area.

Given the impracticability and technical infeasibility of restoring the aquifers at a mature site, the Gelman remediation program, like many other mature legacy sites in the State and nation, has evolved to managing the plumes in a manner that is protective to human health and the environment. Gelman manages the 1,4-dioxane plumes through the following tools: strategic pumping to hydraulically control the plumes and reduce mass, and institutional controls (PZ).

1,4-Dioxane concentrations in many key extraction wells in the Gelman Site area have reduced to asymptotic levels, especially wells positioned in the Western Area (see Figure 9). It is important to note the following regarding these graphs: 1) the dramatic reduction in 1,4-dioxane concentrations observed and 2) how 1,4-dioxane concentrations in most wells have become asymptotic at relatively low concentrations that remain above drinking water cleanup levels no matter how long the wells are operated. These data reflect both the success of Gelman's remedial efforts in reducing contaminant concentrations to the point where the remaining plume is manageable, and the technological and hydrogeological limitations that prevent complete restoration of the aquifers.

Figure 8. Time vs. Concentration Graphs for Western Area Extraction Wells



1,4-dioxane concentrations at extraction wells have reduced dramatically over time and have become asymptotic, in most cases well before reaching the drinking water criterion. Continued pumping from many of these wells provides little benefit.

Remnants of the Gelman plume west of Wagner Road can move into the PZ from the Western Area. Concentration data from extraction wells and numerous monitoring wells in the Wagner Road area have demonstrated that 1,4-dioxane concentrations entering the PZ from the west have declined considerably over the years due to the extensive pumping Gelman has done in the Western (including the Wagner Road wells and Dolph Park [TW-2]). As a result of these efforts, concentrations in excess of 280 ug/L are now being captured before they enter the PZ from the west, recognizing that the closest potential GSI receptor is over two-miles downgradient from Wagner Road.

Claim: "Gelman Should Consider Technologies Other than Pump and Treat"

Gelman has investigated numerous other remediation technologies to determine whether they could be used to supplement or even replace the pump and treat remedial system. Specifically, Gelman has participated in field scale and pilot/bench-scale tests of in situ biological treatment of 1,4-dioxane, other biological methods to treat 1,4-dioxane, in-situ chemical oxidation of 1,4-dioxane, and in situ well air stripping (ART technology). Findings from this and other work at the Gelman Site have helped advance the science of remediating 1,4-dioxane sites nationwide.

The footprint of the Gelman plumes combined with the dense land use in the plume areas make application of this or other "in situ" treatments for 1,4-dioxane impractical as a management tool for a majority of the plume areas. In-situ methods typically require closely spaced injection of media (oxidants, bacteria, and/or associated bacteria food sources). In addition, the 1,4-dioxane plumes at the Gelman Site are generally deeper in the glacial drift sequence. This means that injections would have to be conducted using more robust equipment that would make this technology very disruptive.

These alternatives have application at sites with smaller plumes (ideally shallow plumes) and better access to injection points, or larger sites where access is not as much of an issue. In general, these remedial technologies have limited application at the Gelman Site, and their application would not achieve the desired impacts or offer advantages offered by the pump-and treat-remedial approach employed by Gelman.

One of the more promising in-situ methods is the injection of oxidants (DiGuiseppi, 2016). Gelman also conducted a field scale test of in-situ chemical oxidation. This test, conducted in wells in the Maple Village area, showed in situ-chemical oxidation was not a viable option for site remediation.

A photograph of the typical equipment used to implement an injection of oxidants is shown below. (Photo from internet source)

Photo 4 – Example Injection of Oxidant

Other promising technology for the in-situ treatment of 1,4-dioxane is enhanced in situ bioremediation. Introduction of propane, oxygen and nutrients to the subsurface has been shown to enhance the rate of intrinsic biodegradation of 1,4-dioxane. This technology has been shown to be difficult to implement because enhanced 1,4-dioxane biodegradation occurs only within a narrow range of oxygen and propane concentrations and within a limited radius of influence and requires frequent replenishment of gases to be sustained. Other than some possible limited applications, this is not a viable technology for the large Gelman plumes in congested areas.

Gelman continues to monitor emerging treatment technologies for 1,4-dioxane that could be effectively used in concert with or even replace the technologies it currently employs. But until such a technology becomes available, it plans to continue with the application of pump and treat to meet its remedial obligations.

Claim: "Gelman Should Not be Allowed to Rely on an Institutional Control Such as the PZ"

The use of institutional controls is commonplace in the management of contaminated sites on both a State and federal level, especially mature sites like Gelman. Part 201 and Part 213 explicitly allow for the use of institutional controls. There are an estimated 2,000 sites in the State where institutional controls are being applied (University of Michigan School for Environment and Sustainability, 2020). Institutional controls are used at the vast majority of CERCLA remedial actions to enhance and ensure their effectiveness and protectiveness (EPA, 2010)

Institutional controls are most applicable to sites such as the Gelman Site where restoration is unlikely to be achieved and the remedies employed are in a mature stage. The assumption of critics is that Gelman is using the PZ to avoid active remediation, when in fact, the PZ provides another layer of protection from drinking contaminated water. The PZ only avoids the need to capture the leading edge of the plume, which is already at the Allen Creek drainage. Eliminating the PZ would only weaken the protection provided by the PZ.

> “**Alternatives for Managing the Nation's Complex Contaminated Groundwater Sites** estimates that at least 126,000 sites across the U.S. still have contaminated groundwater, and their closure is expected to cost at least $110 billion to $127 billion. About 10 percent of these sites are considered "complex," meaning restoration is unlikely to be achieved in the next 50 to 100 years due to technological limitations. At sites where contaminant concentrations have plateaued at levels above cleanup goals despite active efforts, the report recommends evaluating whether the sites should transition to long-term management, where risks would be monitored and harmful exposures prevented, but at reduced costs. “
>
> - National Research Council 2013.

A similar institutional control has been used at another high-profile site (and others presented later in this report) of contamination managed by the USEPA, the KL Landfill site in Kalamazoo. The consent decree and record of decision for this site prohibit the use of water for drinking purposes if that water is impacted above Michigan drinking water limits or is within a 1,000-foot downgradient “buffer zone." In 2003, Kalamazoo County adopted an amendment to the Kalamazoo County Sanitary Code that includes a process to legally prohibit wells within a designated restricted zone. The KLA worked with USEPA and EGLE to formally establish such a "groundwater restricted zone" (GRZ) in accordance with the County Sanitary Code. The GRZ was approved by the Kalamazoo County Board of Commissioners on December 1, 2015 and became effective on March 9, 2016. Residences within the proposed GRZ are required to hook up to municipal water and have their private drinking water supply wells abandoned and/or disconnected from their domestic supply. Well waivers maybe be granted by the County and EGLE to retain private wells for irrigation or non-potable purposes (e.g., heat pumps), provided applications for such waivers meet the criteria specified in the County Sanitary Code.

A description of the GRZ and map of the boundary is included in the Sanitary Code, found here: https://www.kalcounty.com/hcs/eh/pdf_files/SanitaryCode.pdf

Gelman’s use of the PZ has provided a sustainable and reliable means to eliminate drinking water exposures. Because the existing city and county ordinances already preclude the installation of drinking water wells within the area serviced by municipal water, the additional layer of protection provided by the PZ does not meaningfully affect property owners. Notably, the City of Ann Arbor imposed similar resource restrictions in relation to its City landfill. In a December 15, 2014 resolution, the City indicated the following:

> "A groundwater use restriction implemented by deed restriction is a common precautionary approach by MDEQ to insure that there is no human contact with potentially contaminated groundwater. As a practical matter, this restriction does not impose a substantive change on the use of the property because Ann Arbor City Code prohibits the installation and use of wells for drinking water purposes and requires parcels within the city to connect to the City's water supply".
>
> - (File 14-1557, 12/15/14 Resolution passed, Deed Covenant Ann Arbor City Landfill)

Claim: "Gelman Should be Treating Water with UV/H_2O_2"

Several have advocated that Gelman utilize UV/H_2O_2 to treat 1,4-dioxane instead of Ozone/H_2O_2 (the current technology used by Gelman). Until 2005, Gelman did use a UV/H_2O_2 treatment system. As such, Gelman is very experienced in the technology (USEPA, 2006).

UV/H_2O_2 is a very effective technology for the treatment of 1,4-dioxane contaminated groundwater, and in some cases, a preferred technology. The main challenge with applying UV at the Gelman Site is the high naturally occurring iron concentrations found in the influent water to the treatment system. The combined concentration of iron in this water is approximately 3 to 4 mg/L. To put this into perspective, the federal Secondary Maximum Contaminant Level for iron is 0.3 mg/L, approximately 10 times less than the Gelman influent water. Iron impacts the transmitting capacity of UV light by fouling the quartz tubes that shield the light (Peng, 2005).

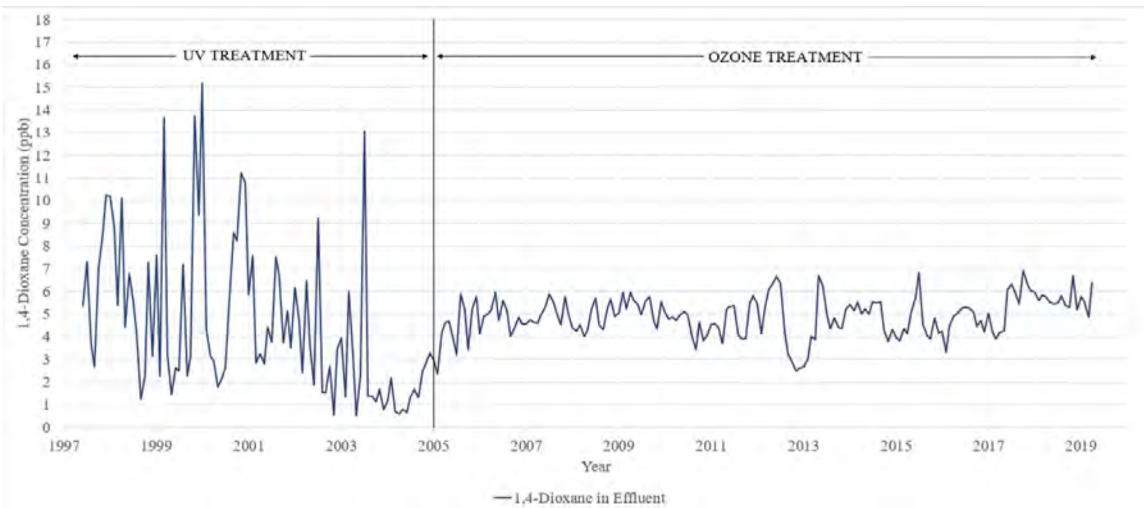
Gelman had to adjust pH levels to acidic conditions to keep the iron in suspension. This required significant amounts of hydrochloric acid (HCl). Then, the pH had to be increased to meet NPDES discharge requirements which required significant amounts of sodium hydroxide. The transport and use of the large volumes of chemicals needed to facilitate treatment posed a considerable risk.

Because the UV treatment was susceptible to high iron concentrations and other water quality factors, treatment results were inconsistent. This can be seen on Figure 9, which shows the considerable variability in water quality during the period UV was used compared to the period when ozone was used.

Ozone treatment requires less chemical usage and has been significantly more reliable for treatment of 1,4-dioxane at the Gelman Site. The primary downside to ozone treatment is the conversion of naturally occurring bromide to bromate. Gelman has proven that it can optimize its reactions to maximize 1,4-dioxane destruction while minimizing bromate formation (at all times kept below the safe drinking water limit of 10 ug/L) and complying with its NPDES permit.

As EGLE stated in their November 2020 Responsiveness Summary to Public Comments on the CJ… "The ozone/hydrogen peroxide system has been in use since 2005. During this operation period Gelman has complied with the discharge limitations of the NPDES permit. In addition, the Interstate Technology and Regulatory Council (ITRC) identifies ozone/hydrogen peroxide oxidation treatment as a fully demonstrated treatment for 1,4-dioxane across a wide range of starting concentrations." (EGLE Public Comment Responsiveness Summary, November 9, 2020, Page 7)

Figure 9. Treatment System Effluent Concentrations Over Time



Finally, it is important to note that when Gelman was operating the UV treatment system, Gelman struggled to meet EGLE-imposed chronic toxicity requirements for its discharge. At one point, Gelman was ordered to cease its discharge due to these testing failures.

Claim: "The Community will Accept the Disruption Associated with More Aggressive Remediation Activities"

Investigating and remediating groundwater, especially at the scale required at the Gelman Site, requires community disruption and inconvenience. For years, Gelman has faced opposition to the installation of infrastructure, the most recent being the proposal to treat water and discharge that water under a NPDES permit into First Sister Lake. Extracting groundwater requires wells to be installed, pipelines to transport contaminated water, easements, and transfer pumping systems. Treatment of water requires large treatment systems that are noisy, the use of dangerous chemicals that require transport and storage, and a discharge location for treated water.

Based on our history with this site, we believe the infrastructure necessary to implement more aggressive remediation this site would cause disruptions that would simply not be acceptable to the community, and with no associated increase in the protectiveness of the remedy. There is little doubt that the disruption associated with such an aggressive remedial approach would be opposed. An example of this is when plans were being developed for remediation of the Eastern Area, a local community group formed called "Protect Our Neighborhoods". This group opposed the concept of more aggressive remediation in their neighborhoods.

Another example of opposition Gelman has encountered was when it installed its horizontal well/pipeline. This project was aggressively fought by the City of Ann Arbor and others. Ultimately a court order allowed the project to proceed. More recently, there has been significant opposition to Gelman's proposal to discharge treated water into First Sister Lake.

Claim: "1,4-Dioxane in Groundwater is a Vapor Intrusion Issue"

Vapor Intrusion to Indoor Air Pathway

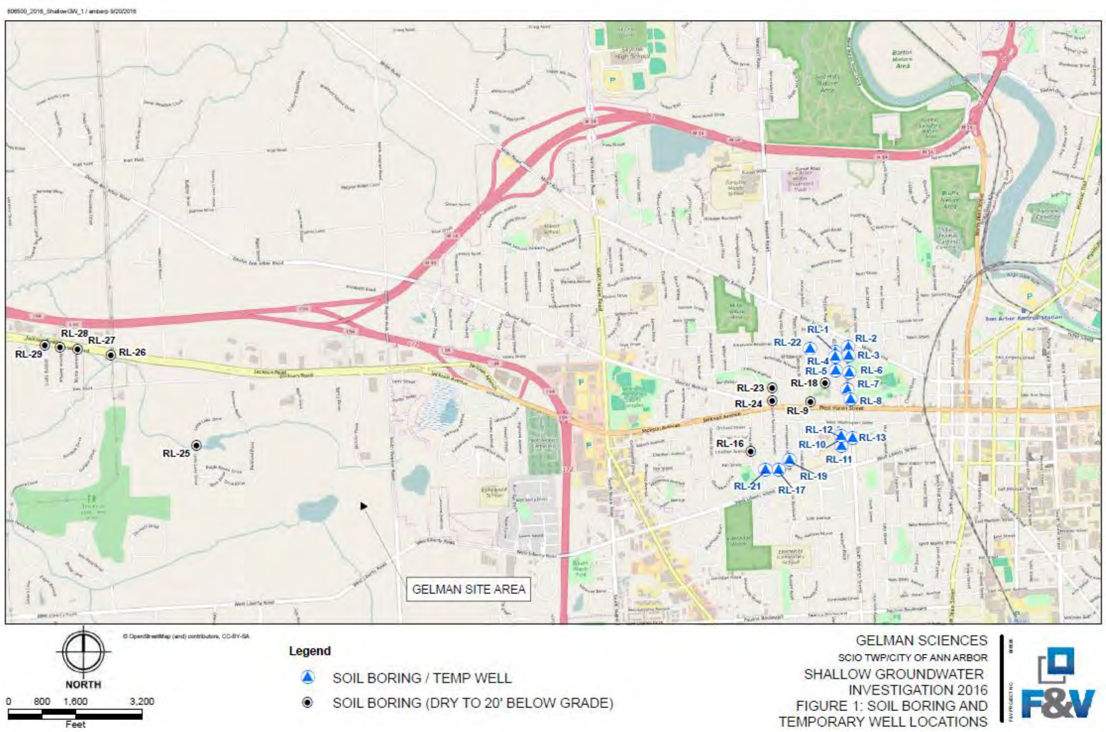
The newly updated EGLE "Guidance Document for the Vapor Intrusion Pathway", September 2020 (VI Guidance Document) lists proposed screening levels for the vapor intrusion to the indoor air pathway (VIAP). The screening levels are voluntary and are generally much lower than the vapor intrusion criteria currently promulgated under Part 201. Gelman is voluntarily evaluating the pathway according to these lower screening levels.

The EGLE VI Guidance Document identifies the proposed residential VIAP screening level for 1,4-dioxane in shallow groundwater (groundwater 10 feet or less below ground surface) as 1,900 ug/L. This document also identifies a nonresidential VIAP screening level of 4,600 ug/L for 1,4-dioxane in groundwater within five feet of the ground surface (possible utility worker exposure). The proposed groundwater-not-in-contact VIAP screening level of 56,000 ug/L applies when the depth to first encountered groundwater is greater than 10 feet below ground surface.

The 1,4-dioxane plumes associated with the Gelman Site are generally located well below ground surface. In groundwater discharge areas, such as where the Eastern Plume intersects with the Allen Creek drainage, groundwater contaminated with 1,4-dioxane has the potential to be closer to the surface. There are no areas east of Maple Road where 1,4-dioxane concentrations exceed the unrestricted 1,900 ug/L VIAP screening level. In fact, concentrations in the Eastern Area are less than one-half of this concentration.

In 2016, Gelman, in cooperation with EGLE, collected shallow groundwater samples at 27 locations where there was a potential for shallow water interaction in the Huron River/Allen Creek drainage area, as well as in the Park Road area along a tributary of Honey Creek. A map showing the sample locations is provided as Figure 10.

Figure 10. Sample Locations – 2016 Shallow Groundwater Investigation



Shallow groundwater was encountered at depths less than 20 feet bgl at 16 of the 27 drilling locations. Groundwater sampled from the temporary wells identified 1,4-dioxane at only 2 locations: RL-12 (2.7-3.3 ug/L), and RL-13 (1.9-2.0 ug/L). These concentrations are well below EGLE's 1,900 ug/L screening level.

Vapor Intrusion to Indoor Air Pathway – Groundwater Sources

Off Site Residential Properties

The proposed residential Volatilization to Indoor Air Pathway (VIAP) screening level for shallow groundwater is 1,900 ug/L and applies when the depth to first groundwater is 10 feet below surface or less. The proposed groundwater-not-in-contact VIAP screening level of 56,000 ug/L applies when the depth to first encountered groundwater is greater than 10 feet below ground surface. Gelman groundwater monitoring data demonstrate that these VIAP screening levels are not exceeded in areas of off-site residential properties.

On/Off Site Nonresidential Properties

The proposed nonresidential VIAP screening level for shallow groundwater level is 4,000 ug/L and applies when the depth to first groundwater is five feet below surface or less. The proposed nonresidential groundwater-not-in-contact VIAP screening level of 130,000 ug/L applies when the depth to first encountered groundwater is greater than five feet below ground surface. Gelman groundwater monitoring data demonstrate that these VIAP screening levels are not exceeded at the site.

Claim: "Gelman Should be Analyzing for 1,4-Dioxane Using USEPA Method 522"

Gelman analyzes 1,4-dioxane using a method EPA 1624 to analyze 1,4-dioxane. This method uses isotopic dilution gas chromatography-mass spectrometry (GS-MS) to detect 1,4-dioxane in water, soil and other discharges. The method allows Gelman to reliably achieve a target detection level of 1 ug/L. This method and target detection level of 1.0 ug/L have been approved by EGLE (MDEQ Target Detection Limits and Designated Analytical Methods, March 10, 2016).
The current EGLE Drinking Water Criterion for 1,4-dioxane is 7.2 ug/L. As such, analyzing samples to a 1.0 ug/L detection limit is considerably lower than the drinking water criterion. The State of Michigan Environmental Laboratory uses EPA Method 8260 Modified to analyze for 1,4-dioxane. They also report to a detection limit of 1.0 ug/L.

There have been calls for Gelman to utilize EPA Method 522. This method is a Drinking Water Method. This method uses a solid phase extraction and GS-MS with selected ion monitoring to detect 1,4-dioxane. This method allows for a target detection limit of approximately 0.02 ug/L.
At locations where 1,4-dioxane is currently being detected/monitored (including a vast majority of the locations being monitored by Gelman), the lower detection limit achieved by EPA Method 522 provides no benefit. Even at locations where Gelman is proposing more sensitive trigger levels in its contingency plans, monitoring having a lower detection limit would provide little benefit and would mostly likely result in having to respond to false positives. It's important to note that 1,4-dioxane is associated with many commonly used personal care products such as detergents. Studies have associated 1,4-dioxane with wastewater discharges, including septic systems (Cheng-Shiuan Lee, 2021). Finding low level detections of 1,4-dioxane unrelated to Gelman in peripheral areas of the plumes, is entirely possible.

It is not typical when investigating or monitoring site of contamination to analyze below a regulatory-based target method detection that is already below the most restrictive criterion. In other words, just because one can analyze to very low levels, that does not mean it's necessary or the right thing to do so.

Claim: "Gelman Should Be Doing Even More"

There is a general sense in the community that Gelman should be doing more. However, Gelman is committed to managing the Site in a manner that remains protective of human health and the environment. To examine how Gelman's remedial efforts compare to other remediation sites, we compared Gelman's remedial efforts to other significant 1,4-dioxane releases in the State of Michigan. From our reviews, the most notable 1,4-dioxane sites in the State are:

Gelman Sciences – Washtenaw County, Regulatory Agency – EGLE

KL Landfill – Kalamazoo County, Regulatory Agency – USEPA

Metamora Landfill – Lapeer County, Regulatory Agency – USEPA

Forest Waste – Genesee County, Regulatory Agency – USEPA

City of Clare – Clare County, Regulatory Agency – USEPA

Table 1 (attachment) summarizes key aspects in the management of these sites.

Based on this analysis, is important to note the following:

1. All sites reviewed rely on institutional controls to prevent exposures. Gelman's use of an institutional control is not unique.

2. **Gelman is the only site where there has been active remediation specifically to remove and/or treat 1,4-dioxane.**

3. All sites other than Clare have viable responsible parties to fund remedial actions.

CONCLUSIONS

For over three decades, Gelman has been working on the remediation of 1,4-dioxane in and around its former manufacturing facility in Scio Township. As quoted earlier in this report, *"The engineers at [Gelman], and the regulators with the State of Michigan and Washtenaw County, together with scientists at the University of Michigan, were pioneers who developed the earliest 1,4-dioxane analysis, treatment technologies, toxicological profiles, and regulatory solutions to a massive 1,4-dioxane contamination problem.*"

When compared to other large sites of 1,4-dioxane in the State, the vast amount of remediation at this site is simply unprecedented. Gelman has significantly reduced the plume concentrations over the years through its remedial activities removing nearly 110,000 pounds of 1,4-dioxane and treating nearly 8.9 billion gallons of water. That said, like many large, complicated sites of environmental contamination, verifiable restoration of the groundwater is not a technically realistic goal. Any attempt to reach such a goal will come with considerable disruption to the community and other environmental trade-offs, without a corresponding increase in the protectiveness of the cleanup.

Consistent with Part 201, Gelman, like many similar sites across the country, has established a sustainable cleanup framework that relies on a combination of active remediation, institutional controls, and contingency planning. This process has been proven to be protective of human health and the environment. Gelman is proposing to enhance its existing cleanup framework with several proposed amendments to the CJ that will make the cleanup even more protective in the future.

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TABLES

Table 1 - Comparison of Management of the Gelman Site vs. Other Large 1,4-Dioxane Sites in the State of Michigan
806500: Gelman Sciences Inc.
April 2021

	Clare Water Supply Superfund Site	Metamora Landfill Superfund Site	West KL Ave Landfill Superfund Site	Forest Waste Products Superfund Site	Gelman Sciences Inc Site
Current contaminants of concern in groundwater	VOCs, 1,4-dioxane	VOCs, THF, metals, chloride, 1,4-dioxane	Benzene, THF, PFAS, 1,4-dioxane	VOCs, SVOCs, metals, 1,4-dioxane, etc.	1,4-dioxane
Maximum current 1,4-dioxane concentration	75 µg/L (10/2019)	110 µg/L (Spring 2019)	260 µg/L (Fall 2019)	3,400 µg/L (2016)	6,800 µg/L (8/2020)
Year environmental work began	1981	1981	1979	1989	1985
Year 1,4-dioxane discovered	2011	2006	2004	2011	1985
Plume extent above 7.2 µg/L 1,4-dioxane	Not fully delineated.	Not fully delineated.	Approx. 17,500 feet long; 4,000 feet wide at its widest point; over 150 feet thick. (Based on contouring from Spring 2020 monitoring results.)	Approx. 5,500 feet long; 1,200 feet wide at its widest point; 50-67 feet thick. (Based on contouring from 2016 monitoring results.)	Eastern plume is approx. 15,500 feet long; 3,700 feet wide at its widest point; up to 160 feet thick. (Based on contouring from Fall 2018 monitoring results.)
Current remediation strategy for 1,4-dioxane	No remedy decision has been made for 1,4-dioxane.	No remedy decision has been made for 1,4-dioxane.	MNA with source control (landfill cap).	MNA and landfill cap.	Pump & treat (hydrogen peroxide and ozone). Average extraction rate 488 GPM in 2020.
Mass of 1,4-dioxane removed	0 pounds	0 pounds	0 pounds	0 pounds	Approximately 110,000 pounds (1997 through 2020)
Proposed remediation strategy for 1,4-dioxane	A site-wide technical evaluation has been initiated by EPA. The need for additional action to address 1,4-dioxane will be evaluated.		The PRP and EGLE/EPA are currently disputing that the MNA and source control remedies are working. Proposed contingent remedial alternatives include: Enhanced In Situ Bioremediation (EISB) and pump & treat using advanced oxidation processes.	Currently being studied. Field work for a Pre-Design Investigation Work Plan is planned to continue through Summer 2019. Pump & treat is being considered.	
Institutional controls	City of Clare ordinance to prohibit installation of wells in the areas of groundwater contamination.	Use restrictions to prohibit future development at the landfill and installation of wells within the impacted aquifers.	Groundwater restricted zone (GRZ) through a county health code. All residents within the GRZ are required to connect to municipal water. GRZ expansions have been proposed to account for expanding plume and lower criterion. Since the plume has expanded into an adjoining county, a new county ordinance is also proposed.	Deed restrictions prevent excavation of soil and landfill contents and potable use of groundwater.	Prohibition zone restricting groundwater use within impacted aquifers.
Remedial action objective	Return the groundwater to benficial use within a reasonable timeframe.	Restore groundwater to drinking water standards.	Restore aquifer to beneficial use within a reasonable timeframe.	Not established yet for 1,4-dioxane. For most other COCs at the site, cleanup goals were set at Part 201 drinking water criterion.	Contain 1,4-dioxane plume >85 within prohibition zone boundary, prevent plume migration in western area and protect against unacceptable exposures.
Other notes	Current remedial actions to address VOC plume include pump & treat (air stripper), ozone sparge wells and permeable reactive barrier.	The 1989 ROD called for a pump & treat system. In 2001, an amendment changed the remedy to MNA.	Since EGLE proposed a new 1,4-dioxane standard of 7.2 µg/L, the PRP has voluntarily provided bottled water, municipal water connections or replacement wells to residents outside the GRZ with wells above 7.2 µg/L.	ISCO with potassium permanganate was suspended after detection of 1,4-dioxane since this remedy does not work for 1,4-dioxane.	

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ATTACHMENTS

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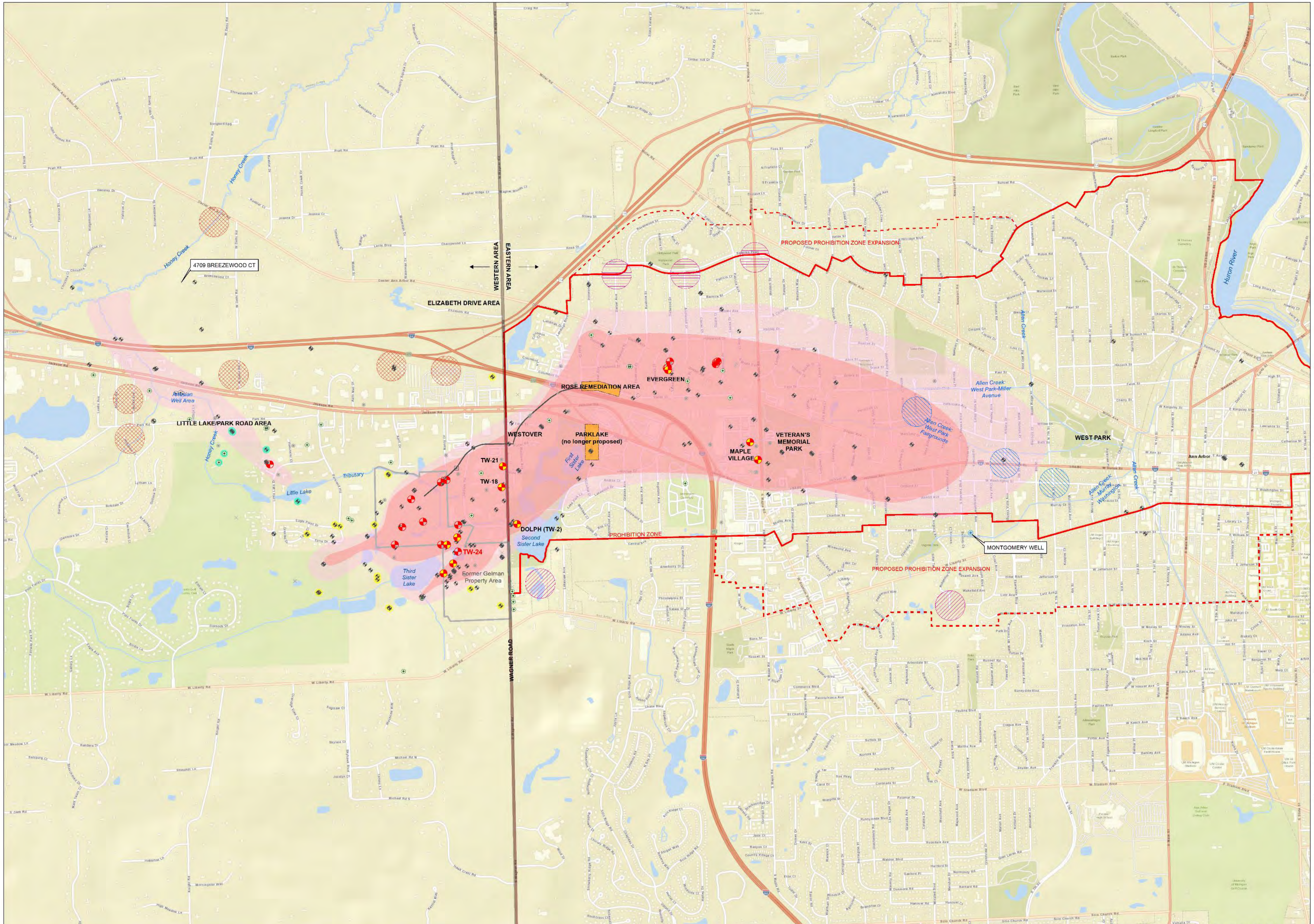

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DESIGN. BUILD. OPERATE.

Gelman Site of Remediation Offsite Reference Map

Gelman Sciences, Scio Twp, Washtenaw County, Michigan

DRAWN BY KSHS/SWL	DATE 4/29/2021
PROJECT NO. 806500	SCALE 1:9,600

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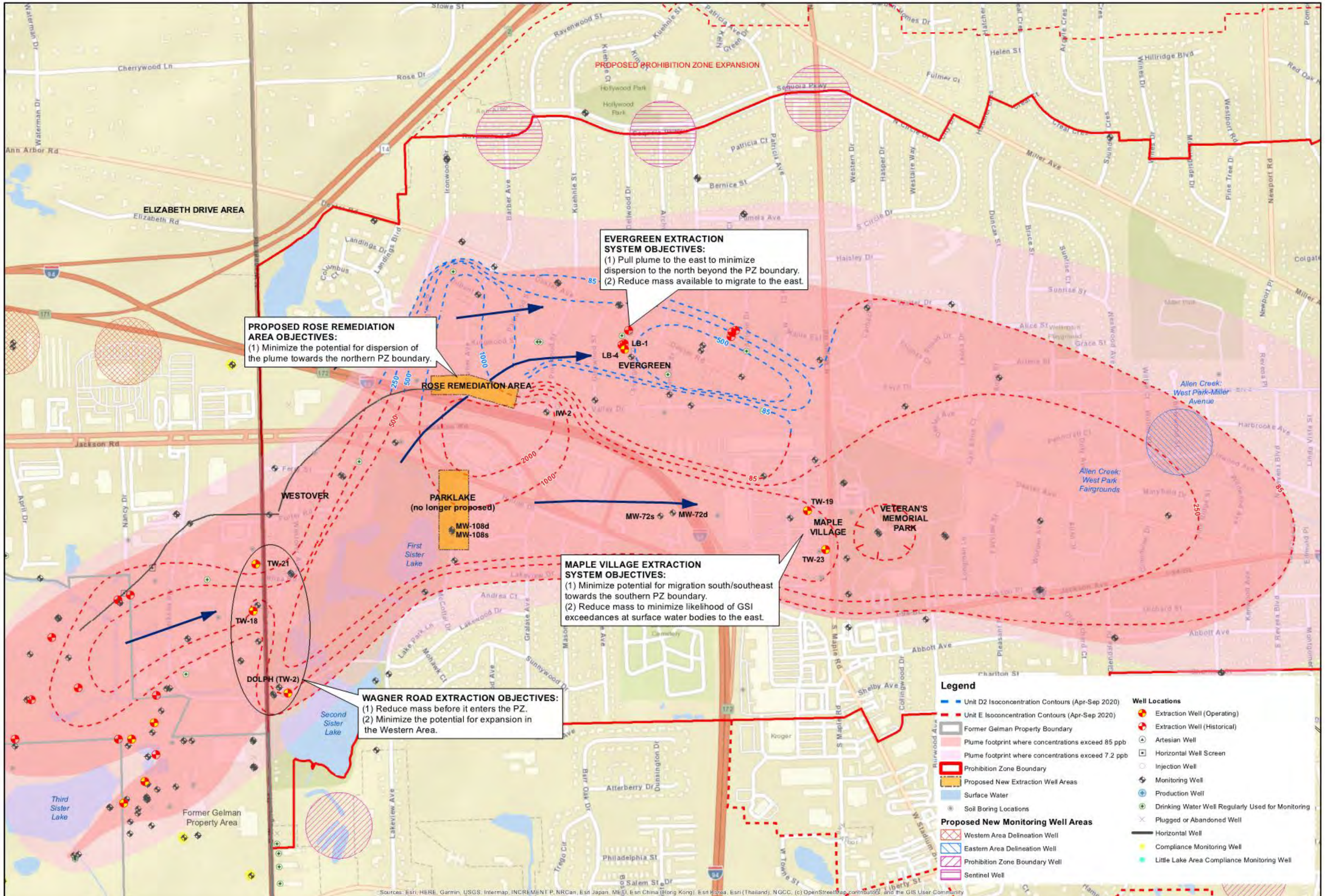


FLEIS & VANDENBRINK
DESIGN. BUILD. OPERATE.

Eastern Area Current and Proposed Remedial Actions and Objectives

Gelman Sciences, Scio Twp, Washtenaw County, Michigan

DRAWN BY	DATE
KSHS	4/29/2021
PROJECT NO.	SCALE
806500	1:9,600

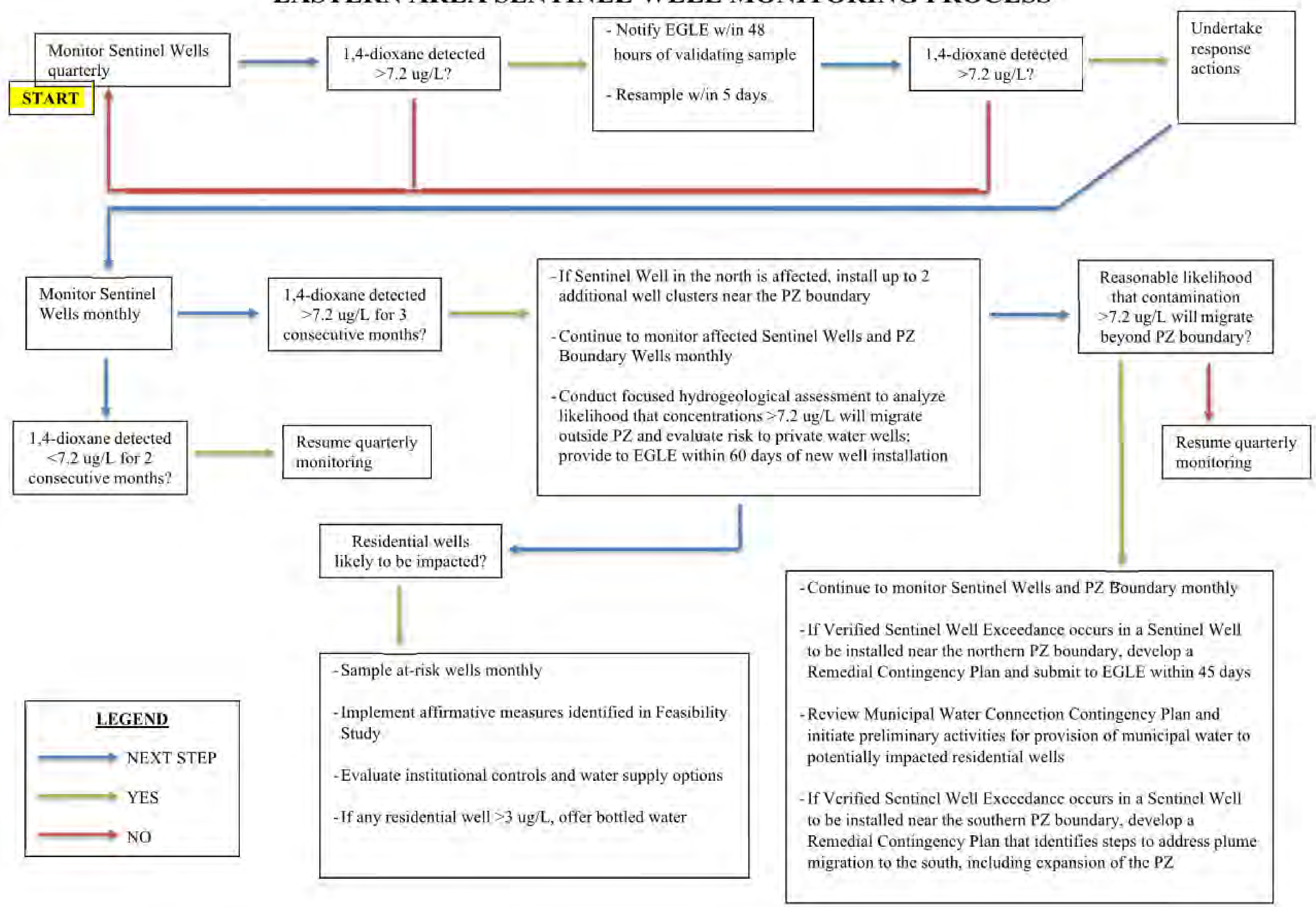
NORTH

0 400 800 SCALE IN FEET

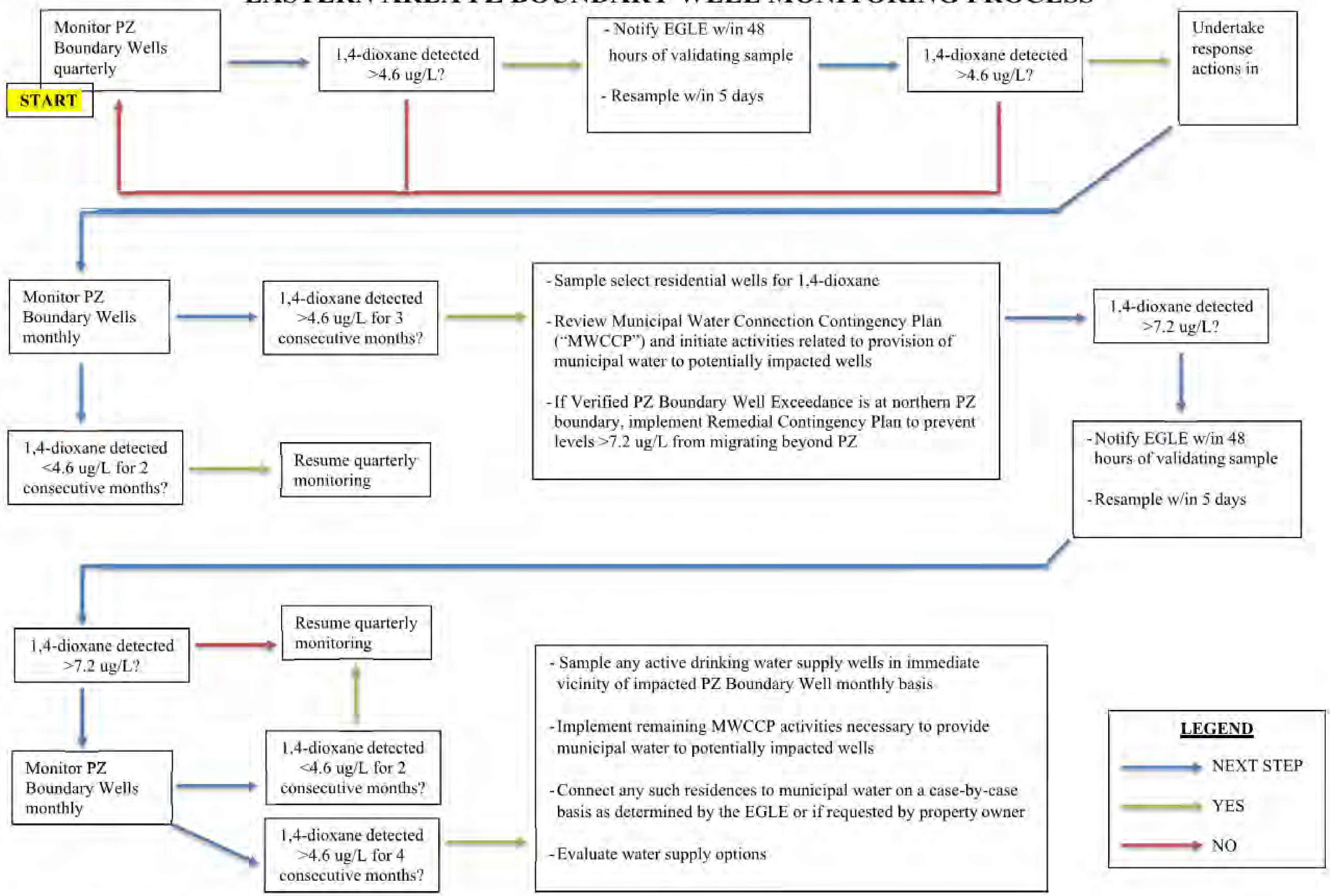
ATT 2

ATTACHMENT 3

EASTERN AREA SENTINEL WELL MONITORING PROCESS



ATTACHMENT 3
EASTERN AREA PZ BOUNDARY WELL MONITORING PROCESS



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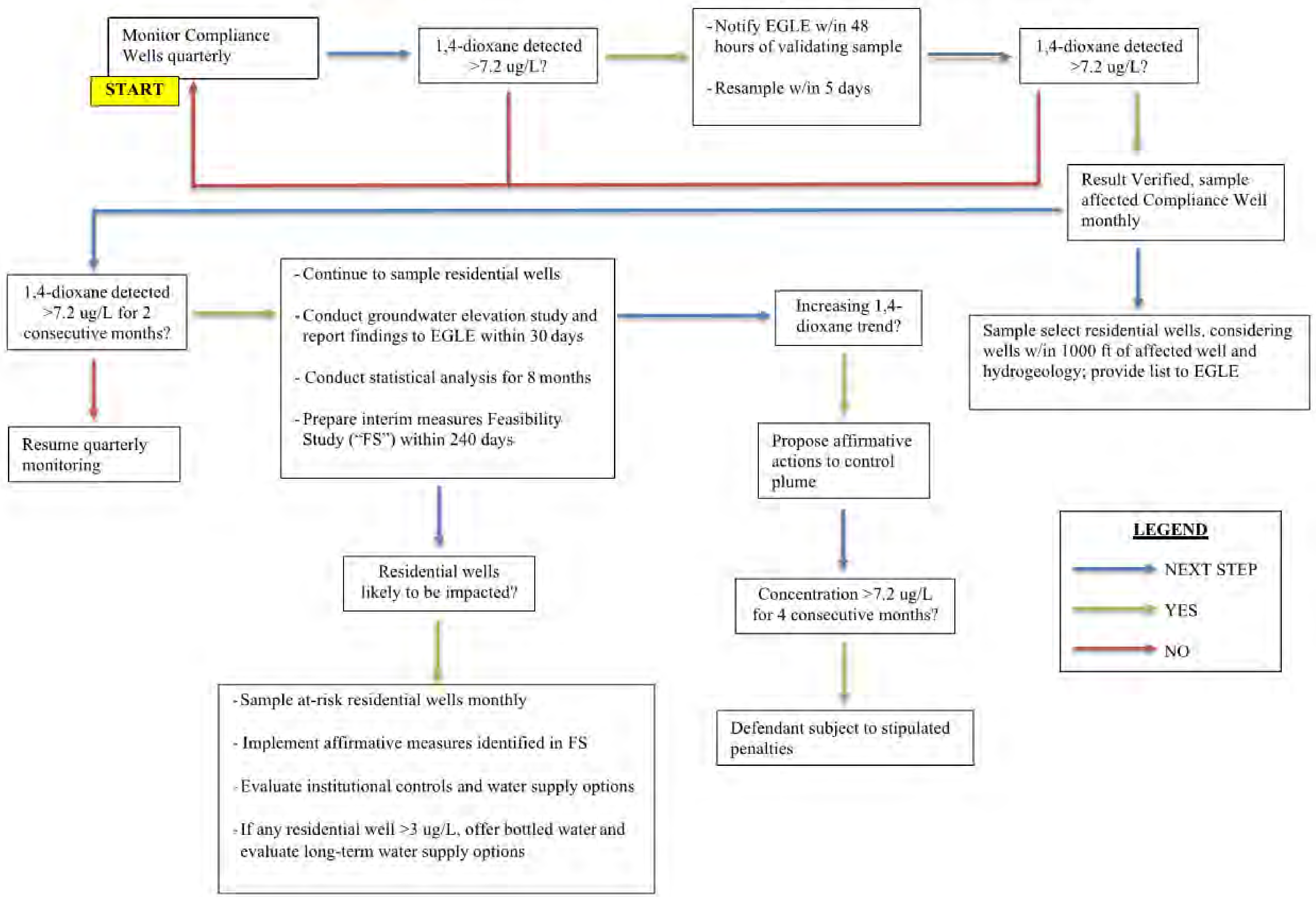
ATTACHMENT 4
WESTERN AREA COMPLIANCE WELL MONITORING PROCESS



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