STATE OF MICHIGAN

IN THE WASHTNAW COUNTY CIRCUIT COURT

ATTORNEY GENERAL FOR THE
STATE OF MICHIGAN, *ex rel.* MICHIGAN
DEPARTMENT OF NATURAL RESOURCES
AND ENVIRONMENT,

Case No. 88-34734-CE
Hon. Timothy P. Connors

Plaintiff,

and

CITY OF ANN ARBOR, WASHTENAW COUNTY, WASHTENAW COUNTY HEALTH DEPARTMENT, WASHTENAW COUNTY HEALTH OFFICER ELLEN RABINOWITZ, in her official capacity, the HURON RIVER WATERSHED COUNCIL, and SCIO TOWNSHIP,

Intervening Plaintiffs,

-v-

GELMAN SCIENCES, INC., d/b/a PALL LIFE SCIENCES, a Michigan Corporation,

Defendant.

INTERVENORS' EXPERT REPORT

Scientific/Technical Expert Report

Prepared for the Intervenors by:

Lawrence D. Lemke, Ph.D.

Keith Gadway, P.E.

Apr 30, 2021

The following expert report on the scientific and technical issues in this lawsuit was prepared to aid the court in understanding the matters in controversy.

The primary expert offering the scientific evaluations, interpretations and expert opinions for each subject area is identified in the following "Summary Table of Intervenor Concerns and Solutions", which also is incorporated in the Introduction to the Intervenors' Brief. The interpretations and opinions expressed in the scientific/technical expert report were formulated, supported by, and are stated with a reasonable degree of scientific certainty, based on available evidence. These interpretations and opinions are based upon the experience and professional expertise of the technical consultants to the Intervenors, which are summarized in the Appendix to the Report below. The interpretations and opinions are based on information available at the time of the report's preparation and may be amended in response to future data and information collected as part of ongoing monitoring and remediation operations at the Gelman Site and its surrounding environs in Washtenaw County, Michigan.

Summary Table of Intervenor Concerns and Solutions

Intervenor Concern	Proposed New Requirement for 2021 Order	What this would Achieve	Technical/Scientific Justification	Primary Expert
Incomplete delineation of groundwater contamination	**1A.** Semiannual maps showing extent of 1,4-dioxane concentrations at 1, 7.2, and 280 ppb	Provide a basis for assessing efficacy of remedial actions and assessing risk of future impacts to drinking water wells	Up-to-date maps depicting the extent of 1,4-dioxane contamination are essential for assessing attainment of remedial objectives.	Lemke
Perimeter monitoring well gaps	**1B.** Two additional Sentinel wells along northern PZ boundary (AA, BB); replacement well for MW-63 (CC)	Reduce spacing between monitoring wells in key areas of concern	Dioxane is known to migrate along narrower pathways in this complex aquifer system; these wells will reduce the likelihood that such plumes are not detected.	Lemke
Size of prohibition zone expansion	**1C.** More limited PZ expansion to the south	Appropriate buffer to account for uncertainty commensurate with the magnitude of reduction from 85 to 7.2 ppb	Expansion proportional to concentration gradient along southern edge of plume; expansion aligned with expected migration path	Lemke
Northward migration toward Barton Pond	**1D.** Three additional monitoring wells north of PZ boundary (DD, EE, FF)	Determine aquifer quality, hydraulic gradient, and presence/absence of dioxane in this area	Reliable information is needed to assess the potential for northward migration and put community concerns to rest	Lemke
Discharge to Allen Creek at concentrations exceeding the GSI criterion	**2A.** Two high-resolution transects (T_1-T_1' and T_2-T_2')	Identify zones of high dioxane concentrations migrating at all depths above bedrock that will guide additional remedial actions	High-resolution transects are commonly used to quantify mass flux and design remedial strategies	Lemke
	2B. Two additional downgradient investigation monitoring wells (GG, HH)	Delineation of 280 ppb extent in the downgradient Eastern Area	Determine if dioxane is venting to Allen Creek from north or south; detect dioxane migration further downgradient in artesian area	Lemke
	2C. Shallow groundwater profiling and monitoring along Allen Creek Drain	Delineate contamination at or above GSI on north and south flanks of Allen Creek Drain	Ensure "Groundwater-Surface Water Interface Objective" is met	Gadway / Lemke

Intervenor Concern	Proposed New Requirement for 2021 Order	What this would Achieve	Technical/Scientific Justification	Primary Expert
500 ppb extraction well termination criterion is too high	**3A.** Terminate extraction after pumping no longer contributes to beneficial reduction in 1,4-dioxane mass	Extend benefits of additional mass removal	Extraction well concentrations may not reflect maximum concentrations in the surrounding aquifer.	Lemke
Public opposition to Parklake Well discharge into First Sister Lake / NPDES permit risk	**3B.** Pipe treated water to the Gelman Property and discharge under existing NPDES permit	Avoids NDPES permit risk while providing flexibility and avoids potential adverse environmental impacts.	200 GPM exchanges the volume of First Sister Lake approximately once each month, giving rise to potential adverse environmental impacts.	Lemke
Limited reach of Source Area extraction wells pumping at low rates in low conductivity zones	**3C.** Concurrent pump-and-treat from 6 or more purge well locations on the Gelman property	Accelerating pumping from the shallow aquifer underlying the Source Area maximizes mass removal in the shortest time frame	Given demonstrated aquifer heterogeneity, wells distributed throughout the Source Area make sense, and there is no compelling reason to wait.	Gadway
Performance monitoring criteria have not been specified for the phytoremediation systems – How will we know if they're working?	**3D.** Gelman to develop phytoremediation effectiveness verification plans including monitoring groundwater dioxane concentrations, water table elevations, and dioxane in plant tissue	Ensure that the phytoremediation systems are achieving groundwater table control and mass removal objectives	This is relatively new technology. Performance monitoring is needed to demonstrate effectiveness of phytoremediation systems and verify that the Western Area GSI Objective is attained.	Gadway
Potential enhancements can be incorporated into the HSVE system design	**3E.** Install permanent cap prior to HSVE operation and cycle HSVE system before termination.	More efficient HSVE system operation and avoidance of premature termination	The HSVE system will operate more effectively with a cap in place. System cycling if exhaust air concentrations become asymptotic will demonstrate HSVE has reached its effective limit.	Gadway
Documented presence of 1,4-dioxane in Allen Creek, Third Sister Lake, unnamed tributary to Honey Creek	**4A.** Annual sampling of surface water bodies and drainage systems	Detection will trigger investigation to determine risk of exceeding the GSI criterion	Changes indicating venting of groundwater with 1,4-dioxane at new locations or rising concentrations will not be detected without regular surface water body testing.	Lemke

Intervenor Concern	Proposed New Requirement for 2021 Order	What this would Achieve	Technical/Scientific Justification	Primary Expert
Western Area Non-Expansion Cleanup Objective verification threshold is too high	**4B.** Reduce exceedance threshold from 7.2 to 3.5 ppb	Expansion of Western Area groundwater contamination will be detected before it has migrated to the compliance well locations	An increase in concentrations to 7.2 ppb at a compliance well is evidence that expansion of the horizontal extent of contamination has already taken place.	Lemke
Inconsistent requirements to initiate and subsequently scale back response activities based on threshold exceedances	**4C.** Adopt a consistent three-month-in-a-row requirement to initiate or cease responses at Sentinel, Boundary, and Compliance Wells	A three-in-a-row requirement to both initiate and interrupt remedial activities is more consistent and more protective	Statistical variation is just as likely to result in low concentration measurements as high concentration measurements.	Lemke
1,4-dioxane detections in residential drinking water wells	**4D.** Municipal Water Connection Contingency Plan (MWCCP) for Breezewood Ct; three-in-a-row requirement to stop bottled water supply	Proactive planning for Breezewood Ct residents (same as Elizabeth Rd); More consistent and protective bottled water requirements	1,4-dioxane has been detected in a residential well on Breezewood Ct (just like Elizabeth Rd). The same protections should be afforded there. Three-in-a-row is consistent with response activity threshold frequencies in 4C.	Lemke
	4E. Use of EPA Method 522 to analyze water from residential wells within 1,000 feet of the mapped limit of dioxane contamination	Lower analytical method detection limits for residential water well samples near the plume will give a greater sense of confidence to homeowners	Use of EPA Method 522 for the analysis of drinking water from wells in close proximity to the plume is consistent with the requirements imposed on operators of public drinking water supplies.	Gadway
Gaps, inconsistencies, and delays accessing Gelman analytical data	**4F.** Provide universal access to the Gelman database via a cloud-based system for all monitoring well, extraction well, and NPDES treatment and discharge activity information; Release copies of source area environmental and engineering studies.	A single database containing all relevant analytical information associated with monitoring, extraction, and permitted discharges will ensure that all parties are viewing and making decisions based on the same information	Accurate and timely access to site data are needed by all stakeholders including Gelman, EGLE, and the general public. Prior environmental and pilot engineering studies are essential for understanding the basis for selected source area remedies.	Lemke

Expert Report of Technical Justifications for Intervenor-Proposed Remedial Actions

By: Lawrence D. Lemke, Ph.D. and Keith Gadway P.E.

Introduction

Efforts to remediate 1,4-dioxane emanating from the Gelman Site in Washtenaw County, Michigan, have been underway for 35 years. Although substantial quantities of dioxane have been removed from the aquifer system through pump-and-treat operations that continue to this day, numerous factors make complete aquifer restoration technically infeasible at the Gelman Site. The glacial aquifer system affected by the Gelman dioxane contamination is highly heterogeneous, consisting of a complicated mixture of very permeable sand and gravel units interspersed with less permeable silts and clays making it difficult to determine connected groundwater flow pathways. As a consequence, contaminated plumes of groundwater have moved in a variety of directions and at different depths, making it difficult to predict contaminant movement. Other limiting factors include the large amount of 1,4-dioxane originally released (although that amount remains undetermined, more than 75 tons of dioxane have been recovered), the extended period of elapsed time since the original release (five decades or more), the enormous extent of the area impacted by dioxane (approximately 2 miles by 4 miles and growing), and the recalcitrant nature of 1,4-dioxane itself (dioxane is resistant to biodegradation and sorption).

In October 2016, the Michigan Department of Environmental Quality (MDEQ), now EGLE (Department of Environment, Great Lakes, and Energy), issued an emergency order lowering the 1,4-dioxane cleanup criterion for drinking water from 85 parts per billion (ppb) to 7.2 ppb. MDEQ subsequently reduced the Groundwater Surface Water Interface (GSI) criterion from 2,800 ppb to 280 ppb. These changes, representing reductions of an order of magnitude or more, are 'game changers' – necessitating profound changes in the remedial actions protecting human and environmental health at the Gelman Site. Hence, the proposed Fourth Amended Consent Judgment (Proposed 4th CJ) included new monitoring wells for dioxane detection and delineation, new groundwater extraction wells to remove mass from areas with remaining high dioxane concentrations, additional mass removal using advanced treatment methods in the source area on the Gelman Property, and expansion of the groundwater use Prohibition Zone (PZ). Following the public release of the Proposed 4th CJ, Larry Lemke described the nature and necessity of its components in a series of informational video presentations posted on the Gelman Proposed Settlement Documents website. Dr. Lemke's summary video presentation can be viewed here.

To reiterate, the response actions included in the Proposed 4th CJ are necessary, but insufficient to address all of the technical concerns triggered by the substantial reductions in groundwater cleanup standards. Consequently, the Intervenors propose modifications and additions to the actions described in the Proposed 4th CJ including: 1) delineating the extent of contamination at concentrations consistent with the revised standards, 2) preventing the discharge of dioxane to surface waters, 3) accelerating mass removal to limit the future spread of dioxane, and 4) strengthening monitoring and surveillance to ensure rapid and consistent response activities. These modifications and additions, which are summarized along with their technical justification below, represent initial actions needed to respond to the reduced groundwater cleanup standards. Additional remedial activities are likely to be necessary in response to information gained from the initial actions described herein.

1. Delineation of the lateral and vertical extent of contamination

At the present point in time, the extent of groundwater contamination (i.e., 1,4-dioxane concentrations at 7.2 ppb (parts per billion) or more) emanating from the Gelman Site has not been fully defined. When promulgating emergency rules setting the 7.2 ppb 1,4-dioxane residential drinking water cleanup criterion in 2016, EGLE (then MDEQ) stated: "The extent of 1,4-dioxane groundwater contamination … greater than 7.2 parts per billion is unknown (MDEQ, 2016)."

Since that time, neither Gelman's technical experts nor EGLE's technical experts have publicly presented a map showing 7.2 ppb or 1.0 ppb (the analytical detection limit) concentration lines based on currently available data. Consequently, we have relied upon maps generated by our own technical consultants and the Washtenaw County Health Department. Uncertainty in the present-day distribution of 1,4-dioxane and the location of 1,4-dioxane migration pathways gives rise to four primary Intervenor concerns regarding the proposed Fourth Amended Consent Judgment (Proposed 4th CJ):

1A. Contaminant delineation maps
1B. Perimeter monitoring well gaps
1C. Unwarranted Prohibition Zone expansion
1D. Northward migration toward Barton Pond

1A. Contaminant delineation maps

As stated above, today, more than four years after the MDEQ lowered Michigan's drinking water standard from 85 ppb to 7.2 ppb, Gelman has not provided a map showing the extent of 1,4-dioxane contamination exceeding 7.2 ppb to EGLE or the public. Although new monitoring wells are needed to define concentrations below the previous standard in many locations, the existing monitoring well network provides an adequate basis to construct such a map, with the provision that areas of uncertainty where additional wells are necessary would be identified.

The Intervenors assert that Gelman should produce and publish concentration maps for every segment of the impacted aquifer system showing the extent of 1,4-dioxane contamination at concentrations of 7.2 ppb. In addition, and on the same maps, concentration lines corresponding to the 1 ppb detection limit for the USEPA analytical Method 1624 (specified in Attachment B of the Proposed 4th CJ) and the current 280 ppb GSI standard also should be included.

Scientific Rationale. Up-to-date maps depicting the extent of 1,4-dioxane contamination are essential tools needed by all stakeholders including Gelman, EGLE, and the general public. Such maps provide a basis for assessing attainment of remedial objectives, assuring compliance with regulatory standards, evaluating the efficacy of remedial activities, documenting changes in contaminant distributions over time, and evaluating risks of future impacts on drinking water supply wells in the surrounding communities.

Given the frequency with which monitoring wells are sampled across the Gelman Site, semi-annual updates such as those currently provided in Quarterly Reports are appropriate and should be required as part of any court order providing comprehensive requirements that are necessary to address the Gelman dioxane.

1B. Perimeter monitoring well gaps

The Proposed 4th CJ that was publicly disclosed and voted upon by the Intervenors' respective governing bodies provided significant and necessary improvements to the effort to delineate the horizontal and vertical extent of the Gelman dioxane plumes and to aid in defining future movements of those plumes. However, those improvements are still insufficient to adequately delineate the dioxane plumes.

Both the Eastern Area Prohibition Zone Containment Objective and the Western Area Non-Expansion Cleanup Objective stated in the Proposed 4th CJ share the goal of preventing 1,4-dioxane from migrating beyond the (expanded) Prohibition Zone area of institutional control (Eastern Area) or present known extent of groundwater contamination (Western Area). Thus, the Proposed 4th CJ includes perimeter monitoring wells intended to serve as sentinel wells, boundary wells, delineation wells, and compliance wells. Those additional monitoring wells are all necessary to help delineate the extent of groundwater contamination, but are insufficient because gaps in the monitoring well network remain along the northern perimeter of the Eastern Area Prohibition Zone and the southern boundary of the Western Area dioxane plume. Gaps in the Eastern Area are significant because Scio Township residences, which rely on well water, and Barton Pond, which supplies the majority of Ann Arbor's municipal drinking water, are located north of the Prohibition Zone. The Western Area gap arises from the abandonment of MW-63, the southwestern most point in the compliance well network, in 2019.

In his *Professional Opinion Regarding Plume Migration to the North from the Evergreen Area*, (HydroGeoLogic, 2014), Doug Sutton offered recommendations in the event that the 1,4-dioxane cleanup criterion were "lowered to a value close to 6.7 micrograms per liter (µg/L)[1] or if stakeholders are interested in maintaining the standard level of protectiveness from groundwater contamination adopted elsewhere in Michigan." Among those recommendations was:

> Space monitoring wells at and near the Prohibition Zone boundary no more than 500 ft apart perpendicular to the direction of expected contaminant migration. This spacing would help detect relatively narrow contaminant flow paths that might be controlled by groundwater flow through localized variations in hydraulic conductivity as observed elsewhere at the site.

Additional monitoring well clusters in strategically important areas are needed to ensure early detection of contaminant migration to the north and potential expansion of the Western Plume to the southwest. Monitoring well clusters include nests of wells with screened intervals at different elevations designed to detect dioxane migrating through different layers of the glacial aquifer system. Multiple screens are necessary because it is difficult to know with certainty at what level contaminated water will migrate until it arrives at a monitoring well. Locations where additional monitoring well clusters are needed now include:

- A Sentinel Well (AA) closing the gap between MW-133 and MW-121
- A Sentinel Well (BB) near the northeast Prohibition Zone boundary between MW-135 and MW-97
- A replacement well (CC) in the vicinity of the former MW-63 well cluster

The first well (AA) reduces the spacing between MW-133 and MW-121 from 2,000 feet to 1,100 and 900 feet (**Table 1**, **Figure 1**). The second well (BB) reduces the spacing between MW-135 and MW-97 from 5,100 to 3,000 and 2,700 feet (**Table 1**, **Figure 1**). The third well (CC) replaces MW-63 (**Figure 2**).

[1] Concentrations expressed as µg/L (micrograms per liter) are equivalent to ppb (parts per billion) in dilute aqueous solutions.

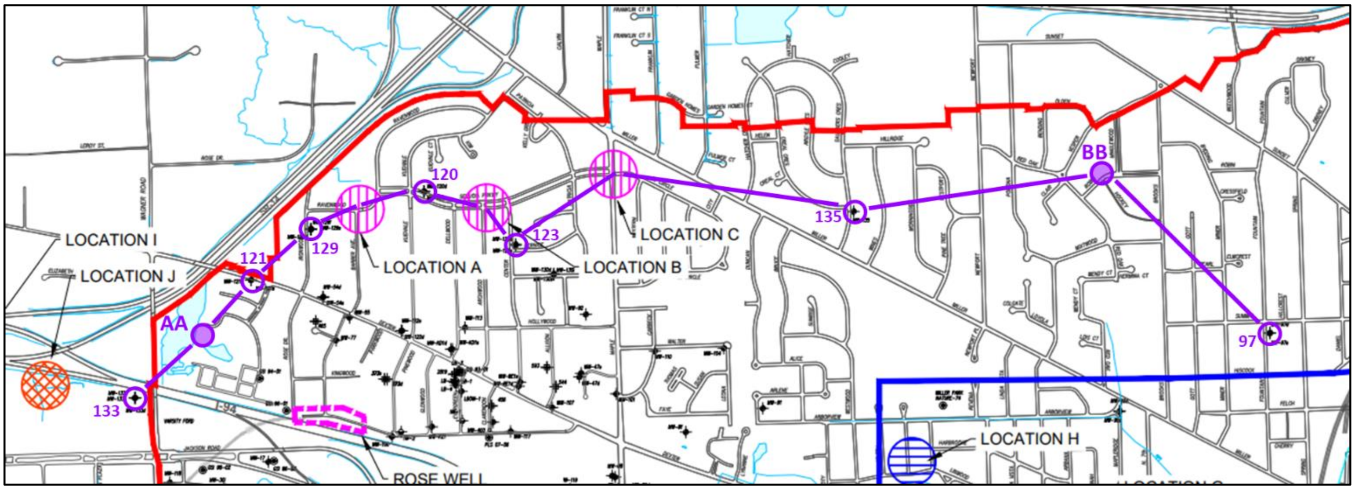

Figure 1. Proposed monitoring well spacing along northern perimeter of the Eastern Area Prohibition Zone.

Table 1. Approximate spacing between northern perimeter monitoring wells in the Eastern Area.

Proposed 4th CJ		Intervenor Proposal	
Well	**Spacing to next well (ft)**	**Well**	**Spacing to next well (ft)**
MW-133	2,000	MW-133	1,100
MW-121	950	[Proposed AA]	900
MW-129	600	MW-121	950
[Location A]	800	MW-129	600
MW-120	700	[Location A]	800
[Location B]	600	MW-120	700
MW-123	1,400	[Location B]	600
[Location C]	2,800	MW-123	1,400
MW-135	5,100	[Location C]	2,800
MW-97		MW-135	3,000
		[Proposed BB]	2,700
		MW-97	

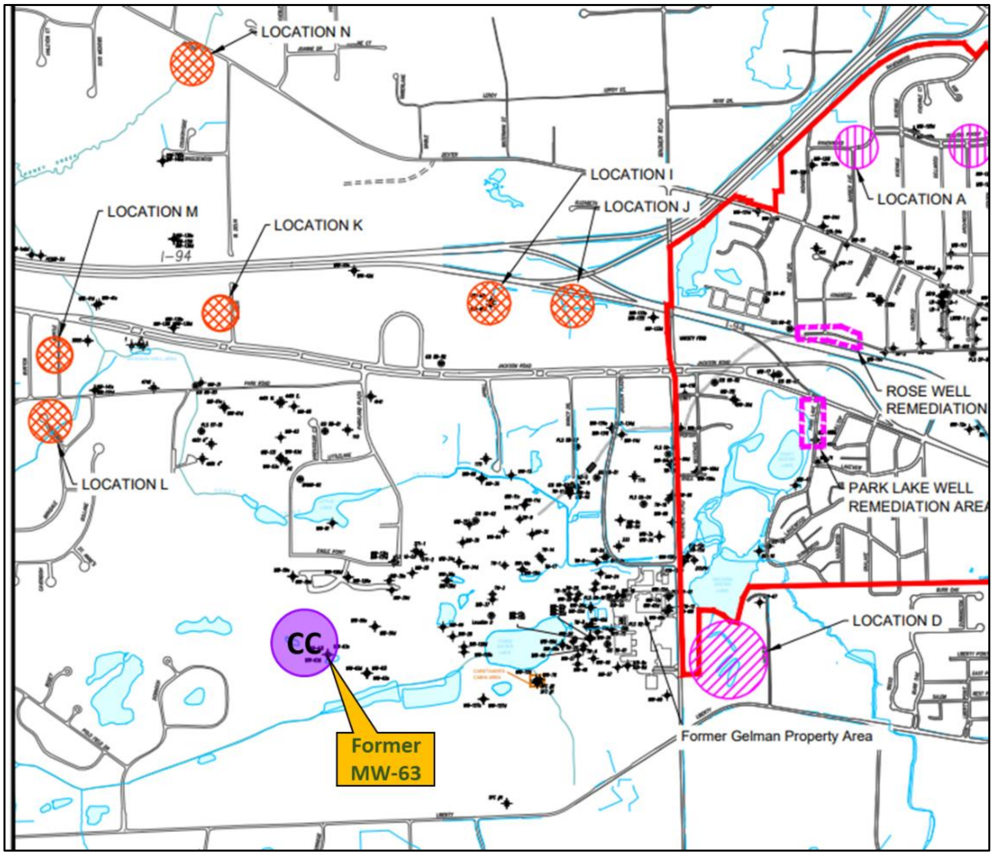

Figure 2. Proposed location of additional monitoring well to replace the MW-63 cluster.

Scientific Rationale. The rationale for including additional, more closely-spaced monitoring wells to detect potential migration along the perimeter of the known contamination extent relies on observations of 1,4-dioxane concentrations and migration in areas of densely-spaced monitoring wells. For example, in the area east of Wagner Road, wells MW-71 and MW-108s/d are spaced less than 200 feet from each other, yet display remarkably different concentration histories, despite being screened at the same elevation. Further downgradient, east of Maple Road, dioxane concentrations in MW-86 have been consistently non-detect, despite the fact that MW-86 is located approximately midway between MW-82s and MW-83s, which have seen dioxane concentrations as high as 370 and 645 ppb, respectively. <u>These observations indicate that contaminant transport pathways are narrower and more complex than shown on most site maps, and that bypassing of monitoring wells, either laterally or vertically, is possible</u>. Large gaps between monitoring wells along the plume perimeter should therefore be avoided, particularly in sensitive areas proximal to residences relying on private drinking water wells.

Proposed sentinel well AA will fill a perimeter gap in a sensitive area southeast of Elizabeth Road, where 1,4-dioxane has been detected in residential drinking water wells. Proposed sentinel well BB will fill the largest gap along the northern perimeter of the Prohibition Zone. Proposed monitoring CC will replace MW-63, formerly the farthest southwest point in the Western Area monitoring well network. The need to install additional perimeter monitoring wells in strategic positions may become apparent after the results of the new wells proposed here and in the Proposed 4th CJ are analyzed.

1C. Unwarranted Prohibition Zone expansion

A limited expansion of the groundwater use Prohibition Zone is necessary in response to the reduction of the 1,4-dioxane groundwater standard from 85 to 7.2 ppb because groundwater containing dioxane at concentrations above 7.2 ppb has already moved past the current Prohibition Zone boundary and retracting the plume back inside the current Prohibition Zone would involve significant additional extraction wells and pipelines disrupting City neighborhoods. Unfortunately, however, the size of the expansion in the proposed CJ revision is not supported by the available data at the site, particularly on the south side of the Prohibition Zone.

The large Prohibition Zone expansion contained in the Proposed 4th CJ is not justified by arguments such as: a) the more than 10-fold decrease in the dioxane criterion, or b) the need to prevent future exposure associated with eastward movement along the expected migration pathway. Such assertions are technically incorrect.

First, on its surface, a 10-fold decrease sounds large, seemingly making a commensurately large increase in the Prohibition Zone necessary. However, the extent to which the impacted area is enlarged as one moves from 85 ppb to 7.2 ppb depends on the concentration gradient[2] along the periphery of the zone of contamination (informally referred to as the 'edge of the plume'). Unfortunately, Gelman's technical experts have yet to produce publicly a map with a 7.2 ppb concentration line that would illustrate the spatial separation between the 85 ppb and 7.2 ppb contours. Such a map would facilitate an analysis of the concentration gradient and the extent to which the buffer zone that is already included in the PROHIBITION ZONE established for 85 ppb would plausibly need to be extended to accommodate 7.2 ppb. A map of this type produced by Intervenor technical consultant Larry Lemke (**Figure 3**) shows that separation between the 280 ppb and 7.2 ppb concentration contours is relatively narrow along the southern boundary of the plume – spanning less than 400 feet. The separation between 85 ppb and 7.2 ppb contours must be narrower still because the 85 ppb concentration line sits between 280 and 7.2 ppb. Therefore, expansion of the Prohibition Zone by as much as 2,500 feet (~1/2 mile) to the south across an east-west lateral extent of 12,000 feet (more than 2 miles) is not supported.

Second, the expectation that dioxane will continue to migrate due east is an oversimplification. Gelman has not offered credible modeling to support an expected eastward migration pathway. Even though technical consultants for the Intervenors agree with some aspects of the Gelman conceptual site model for the Eastern Area, they disagree on specific and important details concerning the identification of 1,4-dioxane migration pathways (see Section 2 below). After more than 30 years, a comprehensive model capable of explaining the observed dioxane migration and predicting future downgradient migration has yet to be produced by the Gelman consultants. Uncertainty in the ability to predict 1,4-dioxane migration pathways should not, therefore, be accepted as justification for an oversized prohibition zone meant to alleviate potential problems arising from incomplete delineation of the present day extent of groundwater contamination.

[2] The gradient is expressed by the spacing of concentration lines – closely spaced lines reflect a steep gradient indicating that the concentration falls off quickly as one moves toward the 'edge of the plume'.

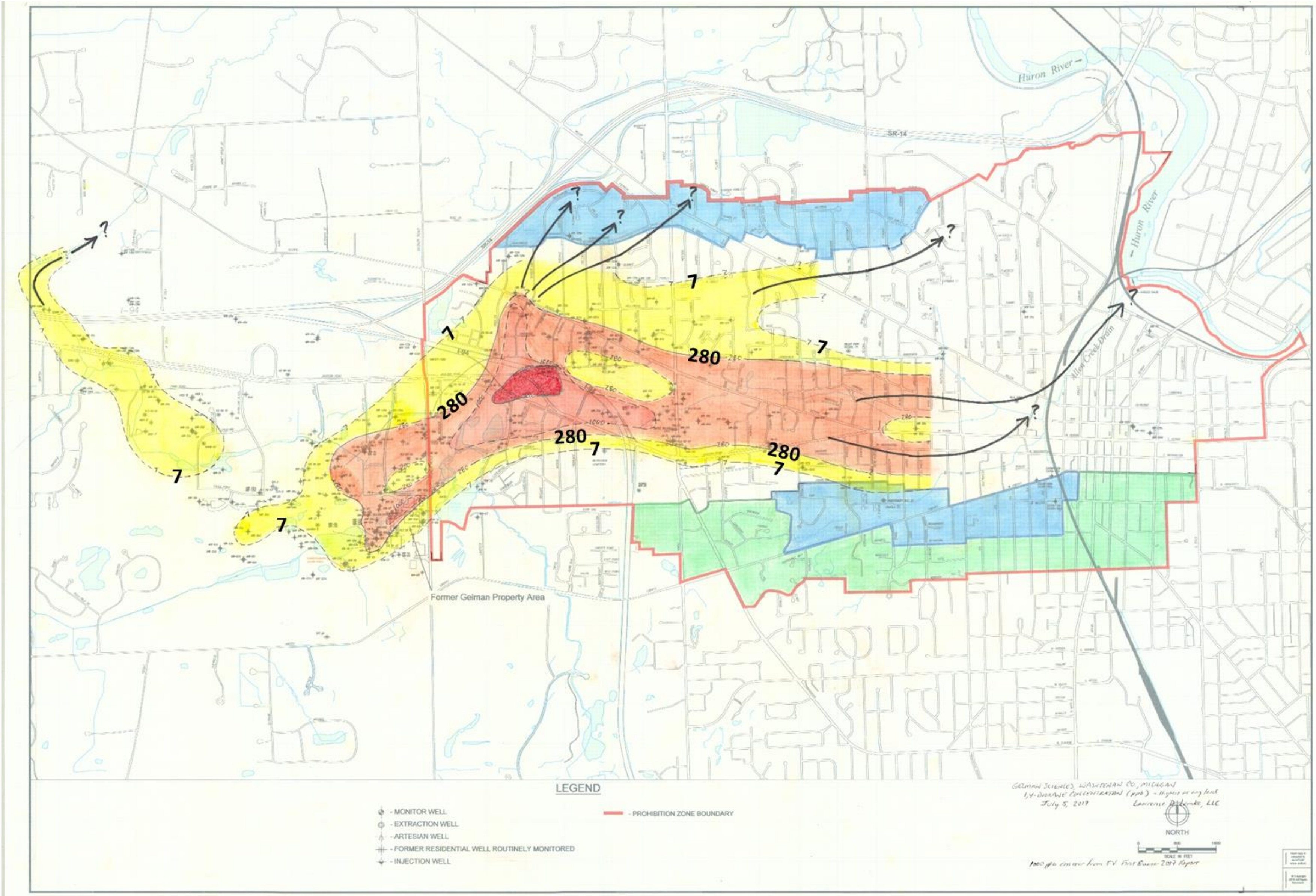

Figure 3. Distribution of 1.4-dioxane at concentrations exceeding 7.2 ppb in 2017.

As an alternative to the Prohibition Zone expansion included in the Proposed 4th CJ, the Intervenors' propose a more limited increase in the Prohibition Zone as shown on **Figure 4**. This modification accepts the entirety of the proposed expansion to the north, but limits Prohibition Zone expansion to the south to the area downgradient of monitoring well MW -112, which is situated on the current southern Prohibition Zone boundary, because MW-112i has seen 1,4-dioxane concentrations in the 9 to 11 ppb range since 2014 (**Figure 5**). Repositioning the proposed Boundary Well at location E to a more advantageous location, as shown on **Figure 4**, is also recommended by the Intervenors.

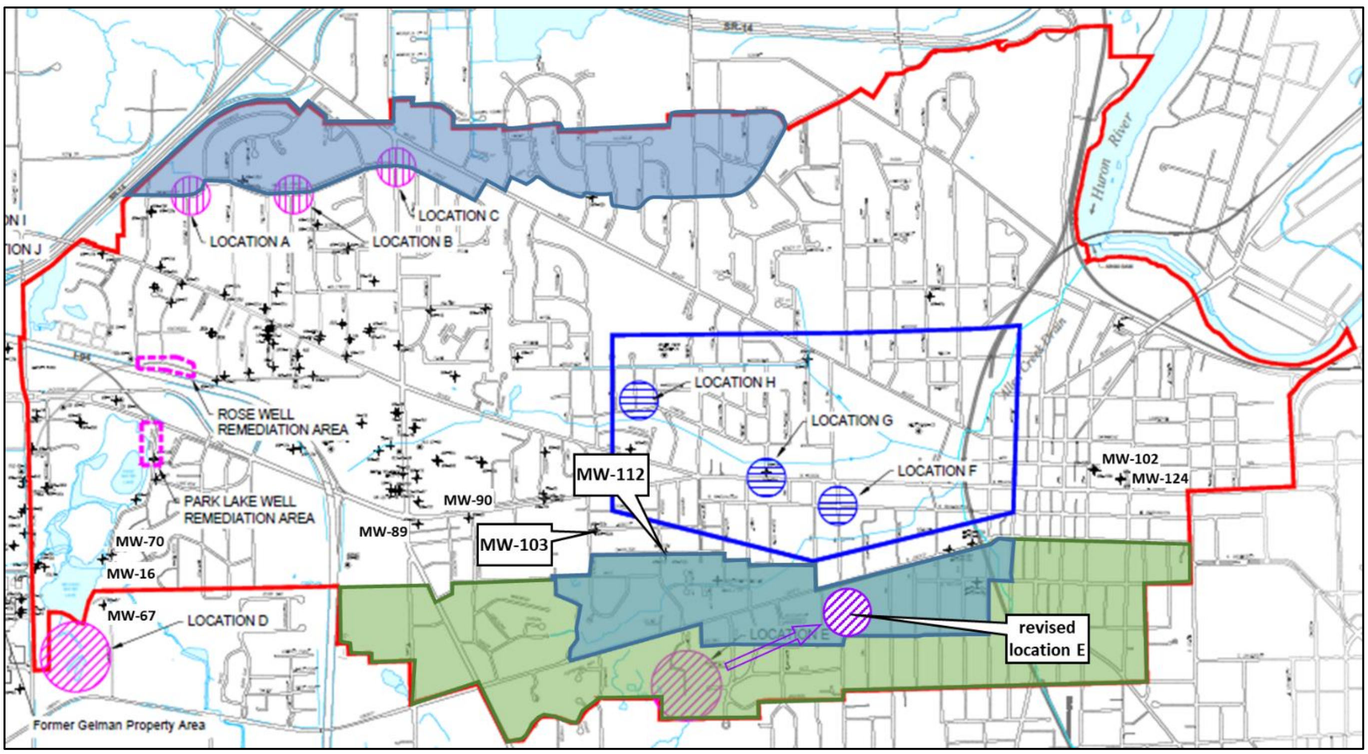

Figure 4. Proposed alternative Prohibition Zone expansion. Blue shaded areas represent Intervenor proposed expansion. Green shaded areas show the larger extent of the expanded Prohibition Zone in the Proposed 4th CJ.

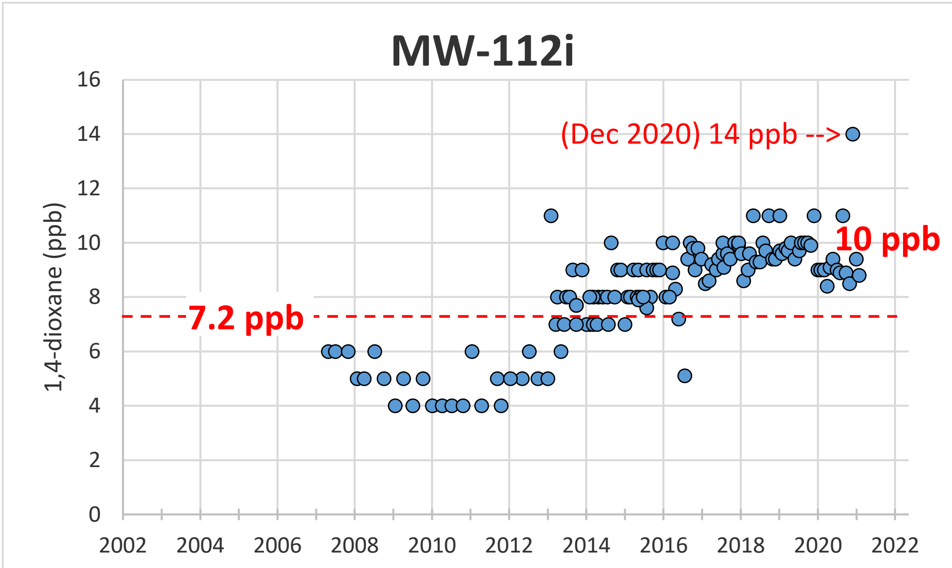

Figure 5. MW-112i concentration versus time at the southern boundary of the 85 ppb Prohibition Zone.

Scientific Rationale. A smaller, more limited Prohibition Zone expansion to the south is justified by the relatively steep concentration gradient along the southern edge of the plume. Less than 400 feet of separation between the 85 and 7.2 ppb concentration lines suggests that 400 feet or less of additional buffer are needed to accommodate the drinking water standard reduction to 7.2 ppb. With the exception of MW-103 and MW-112, monitoring wells near the current southern Prohibition Zone boundary (MW-16, MW-67, MW-70, MW-89, MW-90, MW-102, and MW-124) have concentrations below 7.2 ppb. Concentrations above 7.2 ppb observed in MW-103 and MW-112i justify additional expansion south and east of these wells, as shown in **Figure 4**.

Note that the scientific rationale for a smaller Prohibition Zone expansion is not based on reasoning that it is more or less protective of human and environmental health. Imposition of an institutional control represents a taking of water use rights away from affected property owners and should therefore be limited to the smallest extent possible based on available technical information. Arguments that larger institutional controls provide greater protection of the public could be extended *ad infintum* to justify a prohibition zone of limitless extent. Without delineation of the current extent of groundwater contamination at concentrations exceeding 7.2 ppb, a more extensive expansion is not technically defensible.

1D. Northward migration toward Barton Pond

The possibility of 1,4-dioxane migration north of the Prohibition Zone to Barton Pond, which supplies the majority of Ann Arbor's drinking water, is a persistent public concern. It arises from Barton Pond's location on the north side of a topographic ridge that roughly parallels M-14, north of the current and proposed expanded Prohibition Zone boundary (**Figure 6**). North of M-14, surface water drainage runs from approximately 925 feet in elevation downhill to Barton Pond at approximately 800 feet. South of M-14, surface water generally flows south, toward Allen Creek before reaching the Huron River downstream of Barton Pond. Hydrologically, this type of separation is called a drainage divide. We don't know whether a similar groundwater divide exists in the subsurface beneath M-14 because there are no monitoring wells in this area. Every technical expert who has examined this question has agreed that the likelihood of northward 1,4-dioxane migration to Barton Pond is small, but it cannot be ruled out.

Because the potential consequences of 1,4-dioxane in the groundwater plume reaching Barton Pond are enormous, the Intervenors seek three additional monitoring wells north of the prohibition zone in the vicinity of M-14 and Skyline High School (wells DD, EE, and FF on **Figure 6**). The purpose of these wells is to:

a. determine the presence or absence of aquifer material between the Prohibition Zone and Barton Pond;
b. measure static water level elevations to determine if a groundwater divide is present and ascertain the direction of groundwater flow in this area; and
c. although it is not expected, determine whether 1,4-dioxane is present north of the Prohibition Zone.

The Intervenors acknowledge that iterative investigations in areas of subsurface uncertainty, such as the region between the northern Prohibition Zone boundary and Barton Pond, are reasonable and customary. On such a basis, one might argue that investigating groundwater conditions north of the Prohibition Zone is unnecessary unless and until rising concentrations are observed in perimeter monitoring wells. Unfortunately, even with the addition of new Sentinel Wells at locations A, B, and C (**Figure 1**), the spacing between these wells would range from 600 to 1,400 feet (**Table 1**), providing space for 1,4-dioxane to move undetected between wells. The importance of safeguarding the source of Ann Arbor's municipal water at Barton Pond therefore justifies a proactive approach. In the event that 1,4-dioxane is detected in well DD, EE, or FF, additional investigations may be required to fully understand the hydraulic gradient and contaminant transport pathways in this area.

Scientific Rationale. In a recent study prepared for the City of Ann Arbor, environmental consultants at Tetra Tech evaluated potential sentinel monitoring well locations to provide advance warning to protect the City's drinking water supply in the event that the Gelman 1,4-dioxane plume were to migrate towards Barton Pond (Tetra Tech, 2020). Tetra Tech identified four potential sentinel well locations (**Figure 7**) based on their relation to topographic elevations and position opposite the surface water drainage divide. The additional wells proposed by the Intervenors are consistent with Tetra Tech's recommendations.

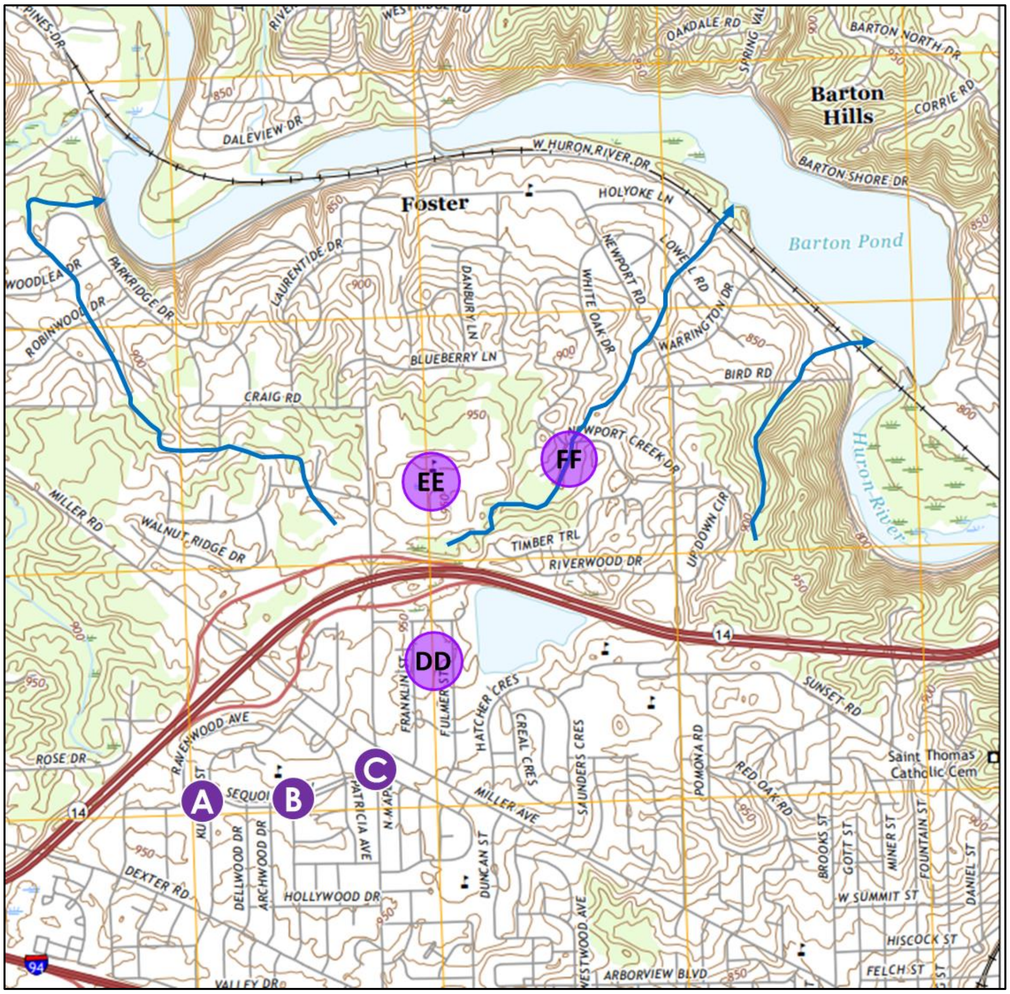

Figure 6. Surface water drainage patterns on 2019 USGS 7.5 minute Ann Arbor West topographic map (blue arrows represent intermittent streams). Contour interval 10 feet. Locations A, B, and C are included in the Proposed 4th CJ. Additional locations DD, EE, and FF are proposed by the Intervenors.

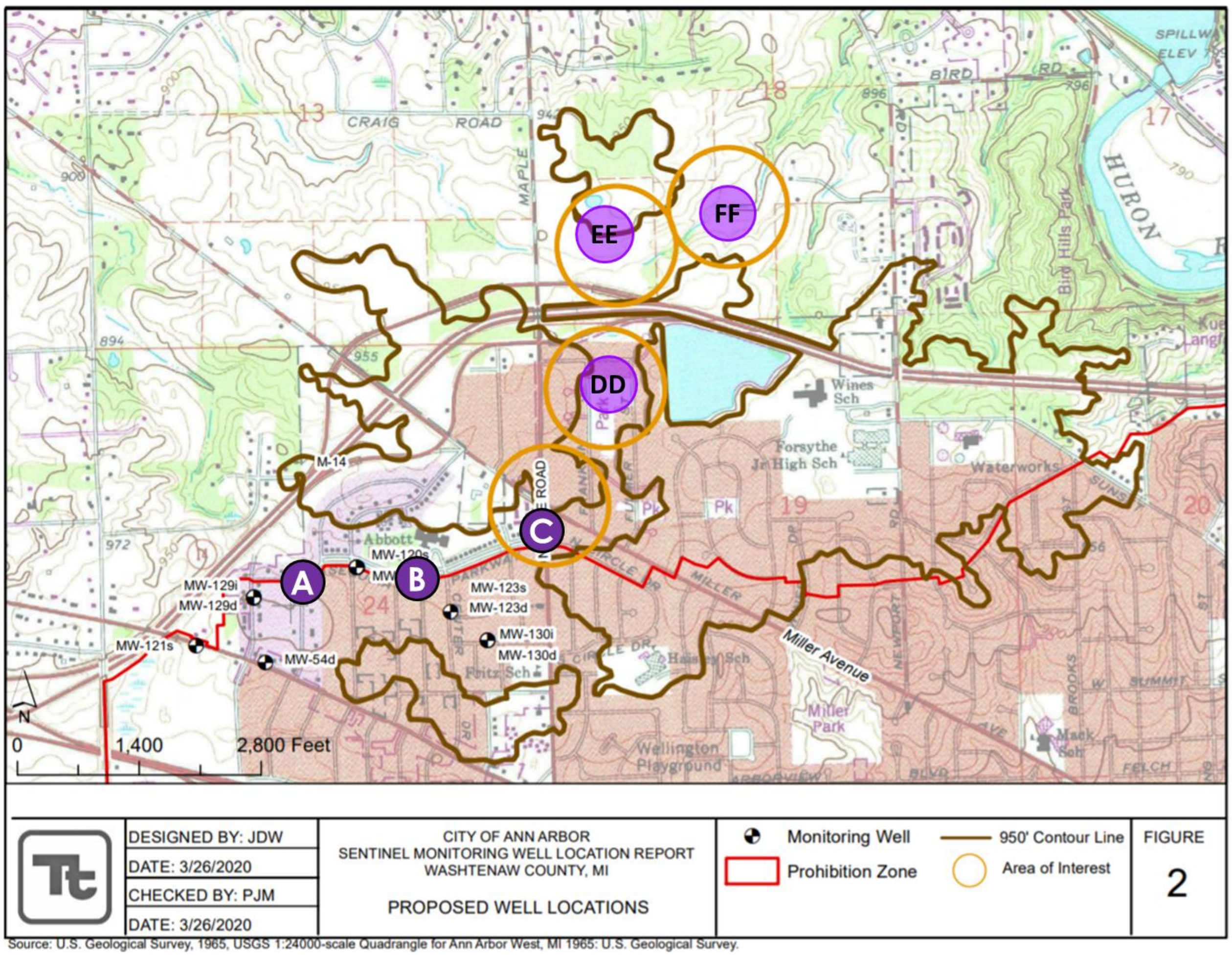

Figure 7. Correspondence between proposed Intervenor locations DD, EE, and FF and monitoring well locations identified by Tetra Tech (orange circles). Locations A, B, and C from the proposed CJ are also shown. Note that location C is positioned within the first Tetra Tech recommended location. Modified from Tetra Tech (2020) Figure 2.

2. Discharge to Allen Creek at concentrations exceeding GSI

The purpose of the "Groundwater Surface Water Interface Objective" in the Proposed 4th CJ is to prevent 1,4-dioxane from venting into surface waters at concentrations above the Generic GSI Cleanup Criterion, except in compliance with Part 201. In the Eastern Area, this stands in contrast to the current set of requirements, which compel Gelman to prevent contaminant migration above 2,800 ppb (the prior GSI value) from migrating east of Maple Road. Gelman agreed to this requirement as one of six conditions stipulated by the MDEQ before the MDEQ would consent to a revised CJ that did not require capture of the leading edge of contamination in the Eastern Area as required by Michigan statute.

In October 2017, the relevant GSI criterion for dioxane was reduced from 2,800 ppb to 280 ppb. A direct, scaled reduction of the requirement to prevent dioxane movement east of Maple Road at concentrations above 280 ppb is not possible because concentrations exceeding 280 ppb are already present in monitoring wells located as far as 3,200 feet east of Maple Road (e.g., MW-76s, MW-79s, MW-82s, MW-83s, MW-84s, MW-115, and MW-116). Similarly, establishing a 280 ppb containment line somewhere east of Maple Road is impractical because monitoring wells downgradient of MW-82s (the easternmost well with known concentrations exceeding 280 ppb) are too widely-spaced or screened at inappropriate depths to identify the current eastward limit of dioxane concentration greater than 280 ppb in the Eastern Area.

Nevertheless, the presence of 1,4-dioxane in the Allen Creek Drain system, initially detected in December, 2017 and followed by rapid concentration increases (**Figure 8**), has elevated concerns that groundwater is already venting to the surface water system at concentrations exceeding the GSI criterion somewhere east of Maple Road. Reported concentrations are diluted by water ordinarily flowing in the drain system at the time samples were taken. Thus, they already incorporate mixing zone effects caused by flow through the drain system; therefore, groundwater concentrations venting into the drain must be higher than those recorded by the samples. The concrete drain segments were installed with high quality gaskets designed to limit leakage from and infiltration into the pipes. If contaminated groundwater venting into the drain constituted as much as 10% of the flow (an improbably large proportion), then concentrations of 490 ppb would be required to register 49 ppb (the highest sample concentration observed to date in October 2020). Smaller groundwater infiltration proportions yield larger infiltrating concentration estimates.

The West Park SW sampling location is situated along the South Branch of Allen Creek, which runs roughly parallel to Linwood Avenue (**Figure 9**). We infer that 1,4-dioxane enters the drain somewhere between West Park SW and the Maryfield-Wildwood Park sampling site because Maryfield-Wildwood Park has been consistently non-detect for dioxane. However, it is not clear whether 1,4-dioxane is entering the South Branch of Allen Creek from the north, or the south, or both directions.

To address concerns over discharge to Allen Creek at concentrations exceeding the GSI criterion, the Intervenors propose the following additions to activities included in the Proposed 4th CJ:

- 2A. High-resolution characterization to identify downgradient migration pathways
- 2B. Additional delineation of 280 ppb extent in the downgradient Eastern Area
- 2C. Shallow groundwater profiling and monitoring along the Allen Creek Drain

These activities are sequential, with each informing and optimizing the next. Information generated by any of these activities could lead to the need for additional investigations.

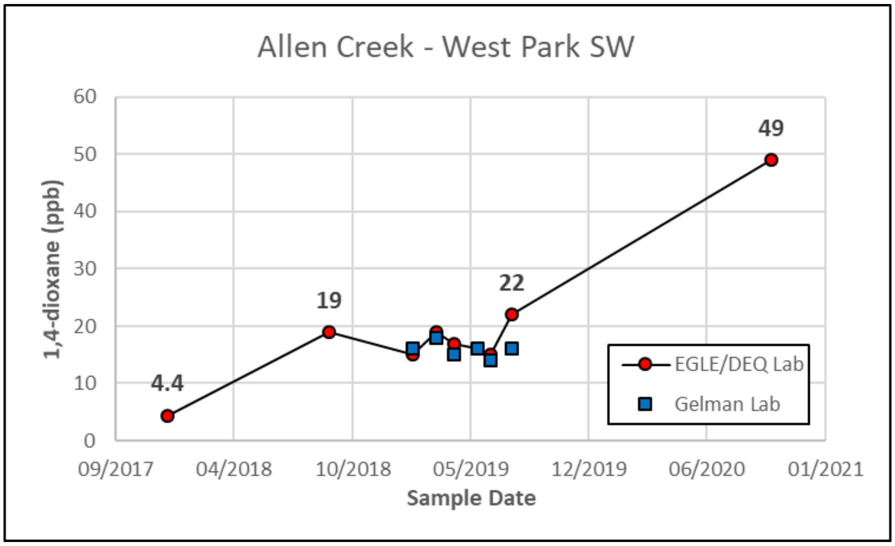

Figure 8. 1,4-Dioxane concentrations in the Allen Creek Drain beneath West Park. Split samples analyzed in EGLE/DEQ and Gelman laboratories are shown separately.

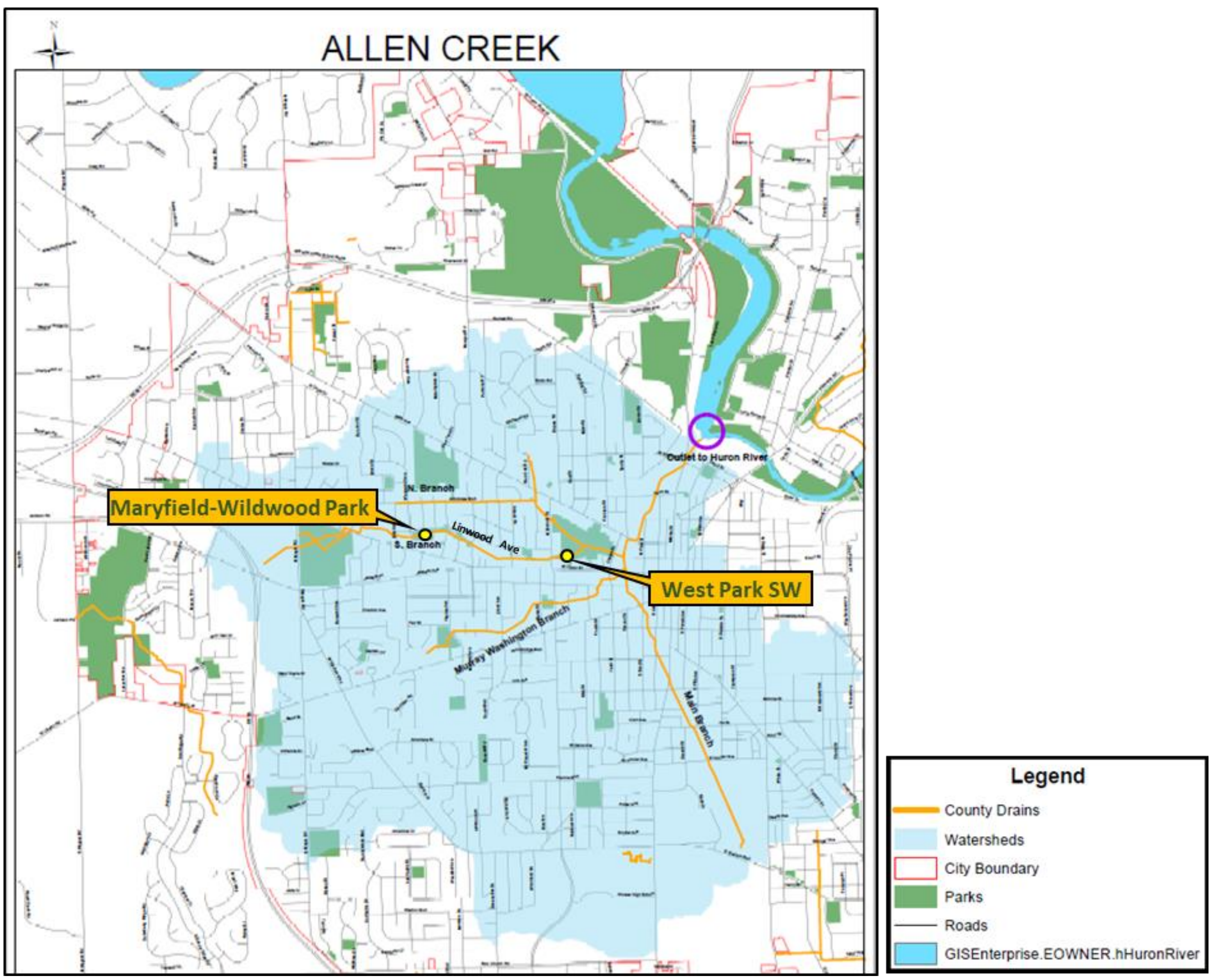

Figure 9. Allen Creek watershed, drain system, and two of the recent water sampling locations.

2A. High-resolution characterization to identify downgradient migration pathways

The most direct way to determine the distribution of aquifer segments conveying 1,4-dioxane at concentrations greater than 280 ppb is to complete high-resolution profiles of aquifer quality and dioxane concentrations. High-resolution site characterization (HRSC) is an EPA focus area that reflects the state-of-the-science for environmental site characterization (USEPA, 2016b). The USEPA has identified HRSC as the preferred method for evaluating sites and developing a conceptual site model of hydrogeology (USEPA, 2016b). The HRSC approach is considered a best practice to: 1) define groundwater flow paths and preferential contaminant pathways; 2) map and predict contaminant mass transport and storage zones; 3) identify data gaps; 4) determine appropriate locations for monitoring and potential remediation wells; 5) determine appropriate well construction design details; and 6) improve the efficiency of groundwater remediation (Shultz et al., 2017). High-resolution transects have been utilized to identify preferential flow pathways and quantify contaminant mass flux at many sites. The USEPA Contaminated Site Cleanup Information (CLU-IN) database lists more than 30 major sites, both commercial/industrial and government-led, where HRSC was used to develop a conceptual site model and guide remediation efforts (USEPA, 2016a).

The purpose of high-resolution profiles or 'transects' in the Eastern Area of the Gelman Site is to characterize the presence or absence of dioxane at concentrations above GSI migrating at all depths above bedrock at the present time. Temporary boreholes in each transect should be placed at a 200-foot minimum lateral spacing and water samples should be taken at 10-foot vertical increments to establish a concentration profile at each borehole location. Results can be used to position permanent monitoring wells in zones of highest observed concentrations, quantify contaminant mass flux across each transect, and to guide additional downgradient investigation (Sections 2B and 2C). Two north-south profiles (perpendicular to the primary direction of groundwater flow) are needed (**Figure 10**):

i. A transect along Maple Road between Dexter and Miller Roads (T_1-T_1').
ii. A transect along Glendale-Grandview-Westwood streets in the vicinity of MW-82s (T_2-T_2').

The Maple Road profile (T_1-T_1') will identify preferential flow pathways and maximum 1,4-dioxane concentrations crossing Maple Road downgradient of monitoring well MW-107. Concentrations in MW-107 rose to 700 ppb or more beginning in 2014 and have remained at similar levels since then (**Figure 11**). Unfortunately, the network of monitoring wells downgradient from MW-107 (**Figure 10**) are screened at elevations 20 to 75 feet *deeper* than MW-107 (**Table 2**), making it unlikely that they will detect dioxane as it migrates upward through the aquifer system east of Maple Road. Identification of preferential flow pathways conveying groundwater with elevated dioxane concentrations along transect T_1-T_1' will inform the process of installing monitoring wells to better delineate the extent of 280 ppb in the downgradient area north of the South Branch of the Allen Creek Drain (Section 2B).

The Glendale-Grandview-Westwood profile (T_2-T_2') will identify preferential flow pathways and maximum 1,4-dioxane concentrations immediately upgradient of the Allen Creek Drain segment that is receiving dioxane from venting groundwater (**Figures 9 and 10**). Information from this transect will therefore also help determine effective locations for monitoring wells needed to further delineate the extent of 280 ppb in the downgradient area (Section 2B) and, in addition, guide the design of shallow groundwater profiling on the north and south sides of the Allen Creek Drain (Section 2C).

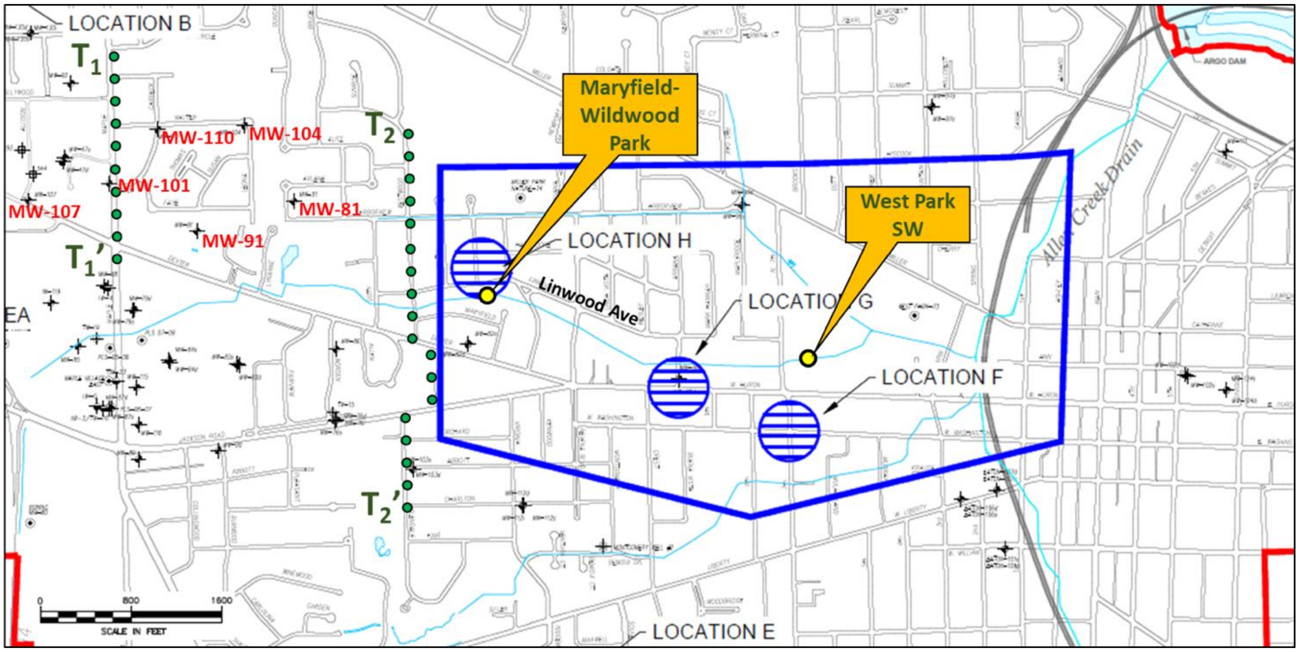

Figure 10. Locations of Allen Creek South Branch sampling points and proposed high-resolution transects.

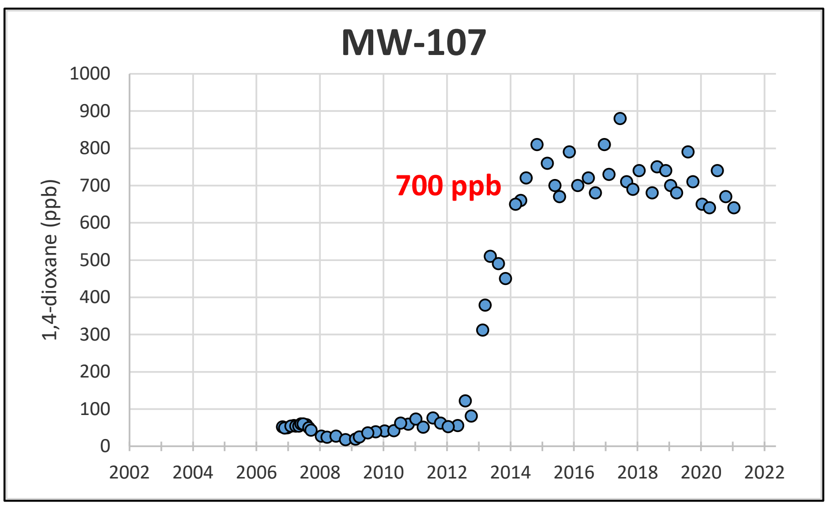

Figure 11. MW-107 concentration versus time west of Maple Road.

Table 2. Monitoring well screen depths and elevations downgradient of MW-107.

Well	Surface (TOC) elevation (ft)	Depth to screen top (ft)	Depth to screen bottom (ft)	Top screen elevation (ft)	Comparison to MW-107 (ft)	
MW-107	943.66	110	115	**833.66**	-	
MW-81	920.15	153	158	767.15	**-66.5**	**deeper**
MW-91	913.37	155	160	758.37	**-75.3**	**deeper**
MW-101	932.98	155	160	777.98	**-55.7**	**deeper**
MW-104	938.69	145	150	793.69	**-40.0**	**deeper**
MW-110	940.57	130	135	810.57	**-23.1**	**deeper**

These high-resolution transects represent definitive delineation at the time the boreholes are drilled (closely spaced borings minimize the chance of missing a significant pathway) that will test the Gelman conceptual site model used to predict downgradient migration paths and, if zones of high concentration are identified in either transect, can be used to select permanent monitoring well locations at optimized depths within each transect.

Scientific Rationale. Regionally, groundwater flows from areas of higher elevation to discharge points at lower elevations (**Figure 12**). The Gelman Property sits upon a glacial moraine that forms a prominent topographic ridge and a regional drainage divide. Groundwater containing 1,4-dioxane flowing beneath the Eastern Area originated as surface water that infiltrated the ground at the Gelman Property where it picked up 1,4-dioxane along the way.

Water infiltrating the ground to begin its journey as groundwater is like water entering a hose or pipe. It enters one end of the hose and exits at the opposite end. Because water is not compressible like air, one cannot add more water to the pipe entrance (like pumping air into a bicycle tire) without allowing water to flow out at the other end. In layman's terms, "what goes down must come up" and every groundwater flow path must have an entry and an exit point. At the Gelman site, groundwater flowing eastward from the Gelman Property has a downward directional component until somewhere in the vicinity of Maple Road. East of Maple Road, groundwater flow through the glacial aquifer system includes an upward component as it approaches discharge points along Allen Creek and the Huron River.

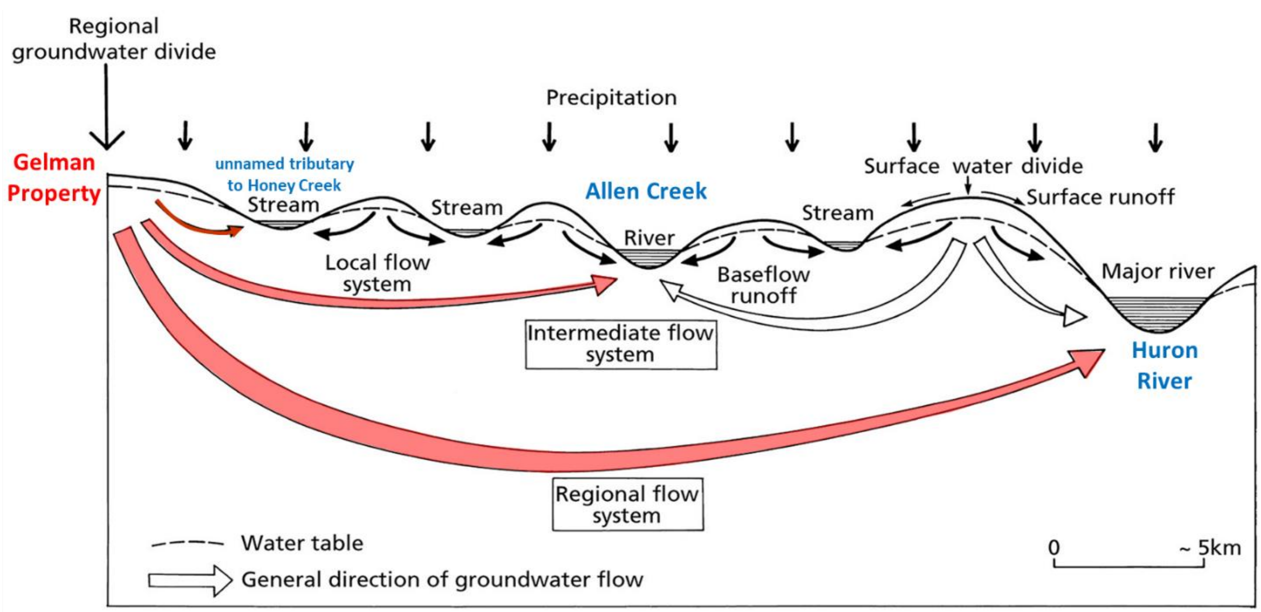

Figure 12. Groundwater flow patterns (modified from Hiscock and Bense, 2014, figure 2.45)

Until recently, it had been hoped or assumed that groundwater containing 1,4-dioxane in the Eastern Area would discharge exclusively at the Huron River. However, convincing evidence now exists that groundwater is venting to the Allen Creek system before it reaches the Huron River. Moreover, elevated dioxane concentrations observed in MW-107 (**Figure 11**) show that it sits along a groundwater flow path moving contaminated water eastward (downgradient). The question is: where is that water with more than twice the GSI limit for dioxane going from there? Transect T_1-T_1' is positioned to answer this question.

In the vicinity of MW-82s, it is unclear whether to expect higher concentrations north or south of MW-82s (Section 2B). Transect T_2-T_2' will therefore help optimize positioning of the monitoring well at location H on the north or south side of the Allen Creek Drain **(Figure 10)**.

2B. Delineation of 280 ppb extent in the downgradient Eastern Area

Rising concentrations of 1,4-dioxane observed in the Allen Creek drain in West Park, coupled with concentrations exceeding the 280 GSI criterion in monitoring well MW-82s, located 400 feet from the Allen Creek drain, underscore the growing need to delineate concentrations at or above 280 ppb in the downgradient Eastern Area.

The technical experts for Gelman and the Intervenors disagree over how to interpret the MW-82s concentration history (**Figure 13**). Gelman considers MW-82 to lie along the "center-line" of the main Eastern Area dioxane plume. Thus, it should reveal the maximum dioxane concentration (~ 350 ppb) as the leading edge of the plume of contaminated water moves eastward past the well. Although it's not impossible, it seems unlikely that Gelman could have fortuitously placed a monitoring well directly in the path of the plume when it installed MW-82 in 2002, long before elevated concentrations arrived there. North and south of MW-82, Gelman invokes lateral dispersion (mixing/spreading along the sides of the plume) to explain wells with similar concentration histories (MW-76s and MW-91, **Figure 14**) because observed dioxane concentrations plateau at lower concentrations in these wells (275 and 200 ppb, respectively).

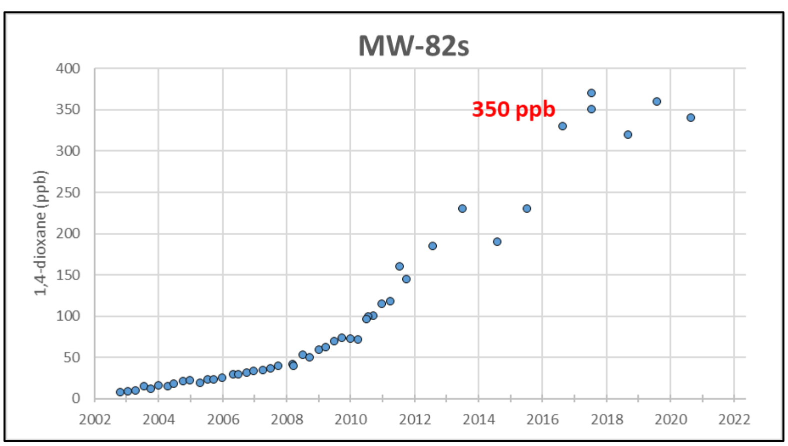

Figure 13. Concentration versus time in MW-82s near the South Branch of the Allen Creek Drain.

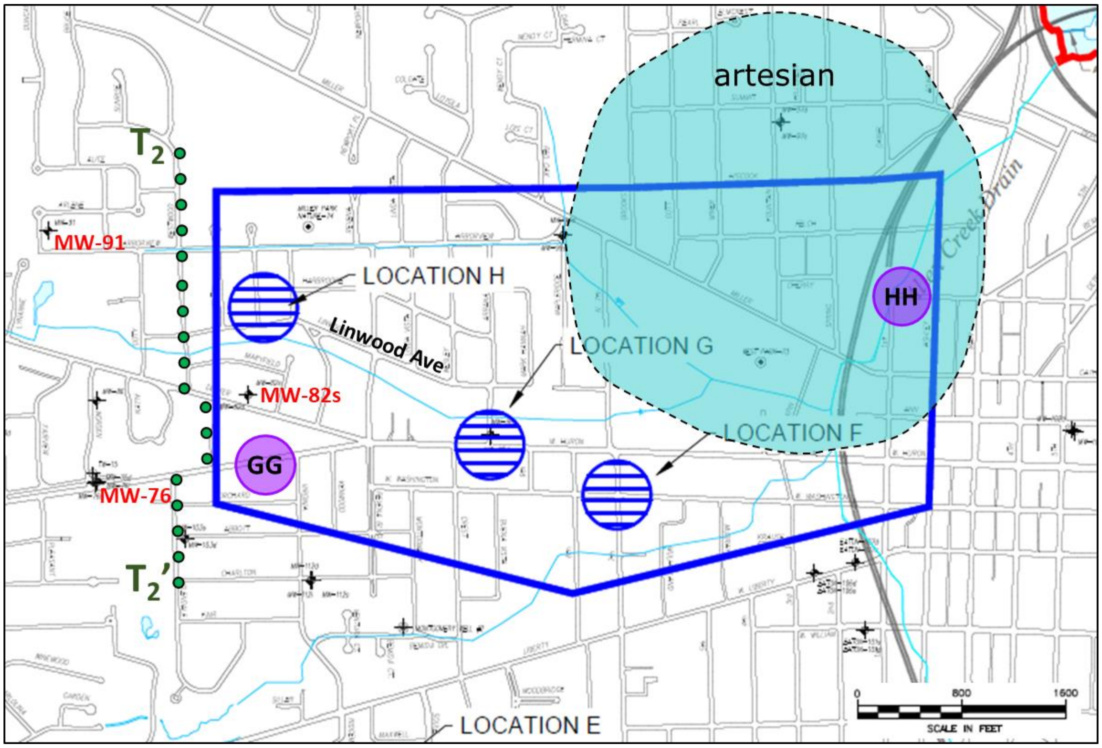

Figure 14. Proposed locations of downgradient monitoring wells GG and HH and approximate area of artesian groundwater conditions.

Instead of the leading edge of the center-line of a broad, diffuse plume, the Intervenors maintain that MW-82s represents lateral dispersion (like MW-76s or MW-91) from one or more unrecognized higher concentration fingers of dioxane migrating north or south of MW-82. This alternate interpretation cannot be ruled out by the current, widely-spaced monitoring well network and would only be partially evaluated by well locations F, G, and H (**Figure 14**) in the Proposed 4th CJ. Moreover, the Intervenors' alternate interpretation is supported by the high concentrations of dioxane observed at Allen Creek – West Park SW. Consequently, two additional monitoring wells are needed in the downgradient investigation at locations GG and HH as shown on **Figure 14**.

Scientific Rationale. The proposed monitoring well at location GG on the south side of MW-82s will complement the proposed well at location H on the north side of MW-82s (**Figure 14**). Both of these locations can be optimized based on the results of transect T_2-T_2'. Monitoring wells at locations GG and H will determine if higher concentrations of 1,4-dioxane are flanking MW-82s. An additional proposed monitoring well at location HH in the Allen Creek surface drainage way will investigate the potential for 1,4-dioxane at concentrations above GSI along the expected migration pathway through a loosely defined area of artesian groundwater conditions conducive to additional venting to the Allen Creek Drain or the creation of shallow groundwater conditions at elevations close to residential basements in this area. Together, monitoring wells at proposed locations GG and HH will help to ensure that the Eastern Area "Groundwater Surface Water Interface Objective" in the Proposed 4th CJ is met.

2C. Shallow groundwater profiling and monitoring along the Allen Creek Drain

In addition to the delineation work (transects and monitoring wells) described above, it is necessary to identify the extent of groundwater contamination greater than 280 ppb entering the Allen Creek Drain upgradient of West Park so that appropriate response activities can be undertaken.

The Intervenors propose a high-resolution profiling survey along the edges of the South Branch of the Allen Creek Drain, parallel to Linwood Avenue (**Figure 15**). Samples of groundwater should be collected from both sides of and closely adjacent to the Drain using direct push or percussive methods. Profiling should take place at a lateral spacing of 100 feet or less between points and discreet samples should be collected beginning at first groundwater and every five feet thereafter until a minimum depth of 10 feet below the drain level is reached. Profiles should be completed on the north and south sides of the Drain unless the high-resolution transects (Section 2A) and downgradient delineation wells (Section 2B) demonstrate to EGLE's satisfaction that contaminated groundwater at concentrations greater than the GSI is not present north or south of this portion of the Allen Creek Drain.

Results of the shallow groundwater profiling should be used to install a minimum of three shallow groundwater monitoring well nests along each side of the Allen Creek Drain where the presence of groundwater at or above GSI concentrations has been delineated. Each monitoring well nest location should include at least two monitoring wells screened at the equivalent depth of the drain and 5 feet deeper so that a vertical hydraulic gradient can be determined.

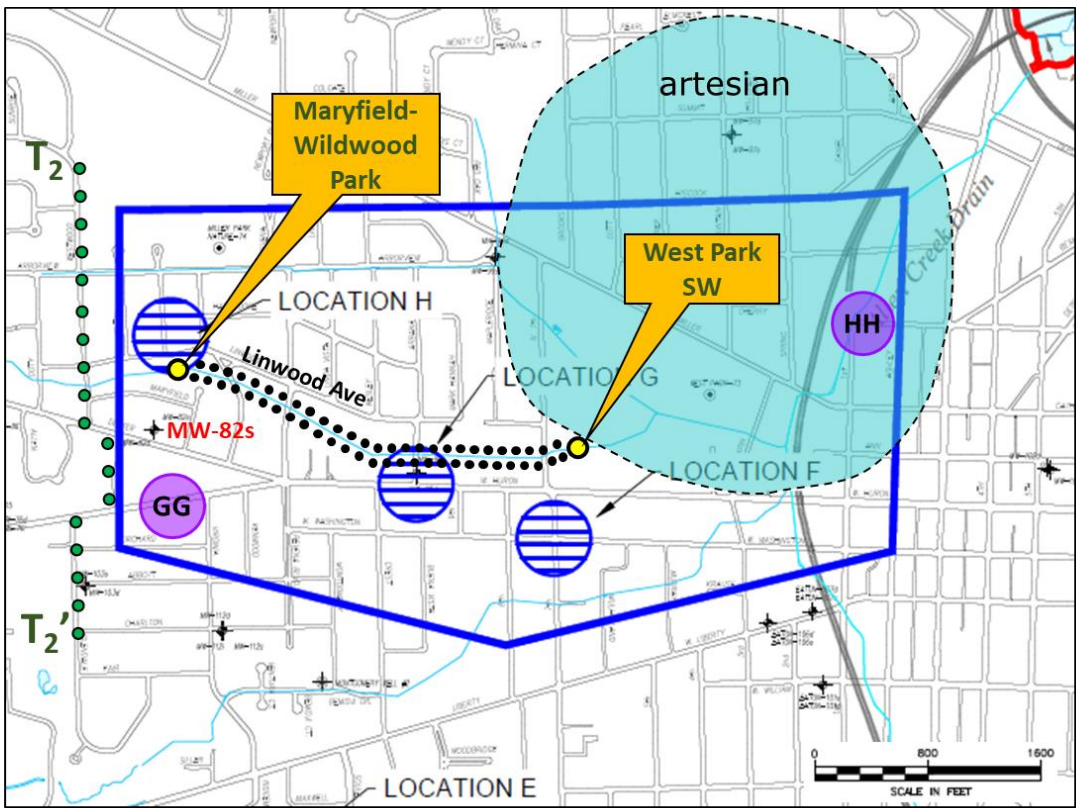

Figure 15. Proposed location of monitoring points (solid black dots) between the Maryfield-Wildwood Park and West Park SW sampling locations along the South Branch of the Allen Creek Drain.

Scientific Rationale. High-resolution profiles of groundwater concentrations will provide information about the distribution of 1,4-dioxane in excess of 280 ppb adjacent to the Allen Creek Drain. Establishing maximum concentrations is part of the requirement for use of the mixing zone criterion for GSI compliance under Part 201, as is estimating the cross-sectional area of the plume perpendicular to the groundwater flow that encompasses the entire portion of the plume exceeding GSI. Both of these requirements will be facilitated by the Drain profiles and the permanent, shallow groundwater monitoring well nests installed after the profiles are completed. Moreover, the wells can serve as alternative monitoring points (in the parlance of the GSI regulations) that will provide continuing information about the distribution of 1,4-dioxane in excess of 280 ppb near the Allen Creek Drain.

The Washtenaw County Water Resources Commissioner has determined that water containing 1,4-dioxane infiltrating into the Allen Creek Drain is an illicit discharge under Washtenaw County's Municipal Separate Storm Sewer System (MS4) permit. The actions requested by the Intervenors will assist in the detection and elimination of 1,4-dioxane entering the Allen Creek Drain, but should not in any way restrict the Washtenaw County Water Resources Commissioner's Office from requiring more stringent response actions under its separate regulatory authority.

3. 1,4-Dioxane mass removal

In almost every circumstance, removal of 1,4-dioxane from the Gelman system is beneficial. All of the remedial objectives (Eastern Area Prohibition Zone Containment, Western Area Non-Expansion, and Groundwater-Surface Water Interface) and the Gelman Property Response Activities specified in the Proposed 4th CJ are facilitated by removal of 1,4-dioxane from areas of high remaining concentration.

Targeted removal of 1,4-dioxane from the source area on the Gelman Property and high concentration zones ("hot spots") in the Eastern Area will enhance GSI compliance at Allen Creek and the Huron River and minimize potential for 7.2 ppb exceedances at the Prohibition Zone boundaries. Reduced upgradient concentrations will eventually lead to lower concentrations in downgradient regions, bolstering the probability of non-expansion in the Western Area and potentially decreasing time to site closure.

Planned mass removal at the Gelman site consists of three primary components: 1) additional groundwater extraction wells; 2) planting of trees to enable phytoremediation on the Site and to the north in the Marshy Area; and 3) installation of a heated soil vapor extraction system with associated impervious cap. Gelman has conducted sampling and analytical investigations as well as feasibility studies to help design these treatment elements. However, the intervenors have not been able to review all of the data and technical recommendations generated by these investigations and studies.

Although the Intervenors endorse the mass removal activities in the Proposed 4th CJ, concerns over restrictions or omissions that could limit the long-term benefits of the response actions remain. We therefore propose the following revisions to address these concerns:

- 3A. Revised termination criteria for extraction wells
- 3B. Revised disposal plan for Parklake Well treated water
- 3C. Accelerated source area groundwater extraction
- 3D. Phytoremediation performance monitoring and termination criteria
- 3E. HSVE system optimization

3A. Revised termination criteria for extraction wells

The Proposed 4th CJ includes several new extraction wells to purge dioxane from areas of known or suspected high concentrations. Extraction at two locations, the Parklake Well in the Eastern Area and three "Phase I" extraction wells on the Gelman Property, include provisions for terminating extraction after concentrations are reduced below 500 μg/L (500 ppb). This arbitrary threshold is too high because it precludes the additional benefits of mass removal at lower concentrations.

Many of the current Gelman extraction wells operate with concentrations below 500 ppb (**Figure 16**). Reasons for continuing to pump water at lower concentrations include hydraulic capture or prevention of dioxane migration, in addition to mass removal. Because extraction well concentrations may not be representative of the highest concentrations surrounding them (see Scientific Rationale below), it does not make sense to impose a high termination threshold, particularly one that exceeds the 280 ppb GSI criterion.

As an alternative to termination at 500 ppb, the Intervenors propose adopting language similar to that employed in the Proposed 4th CJ for the HVSE system: "Defendant shall operate [extraction well] until effluent 1,4-dioxane concentrations indicate continued extraction will no longer contribute to beneficial reduction in 1,4-dioxane mass." We endorse the concept of cycling wells on and off to demonstrate concentration rebound has not occurred before extraction is terminated included in the Proposed 4th CJ.

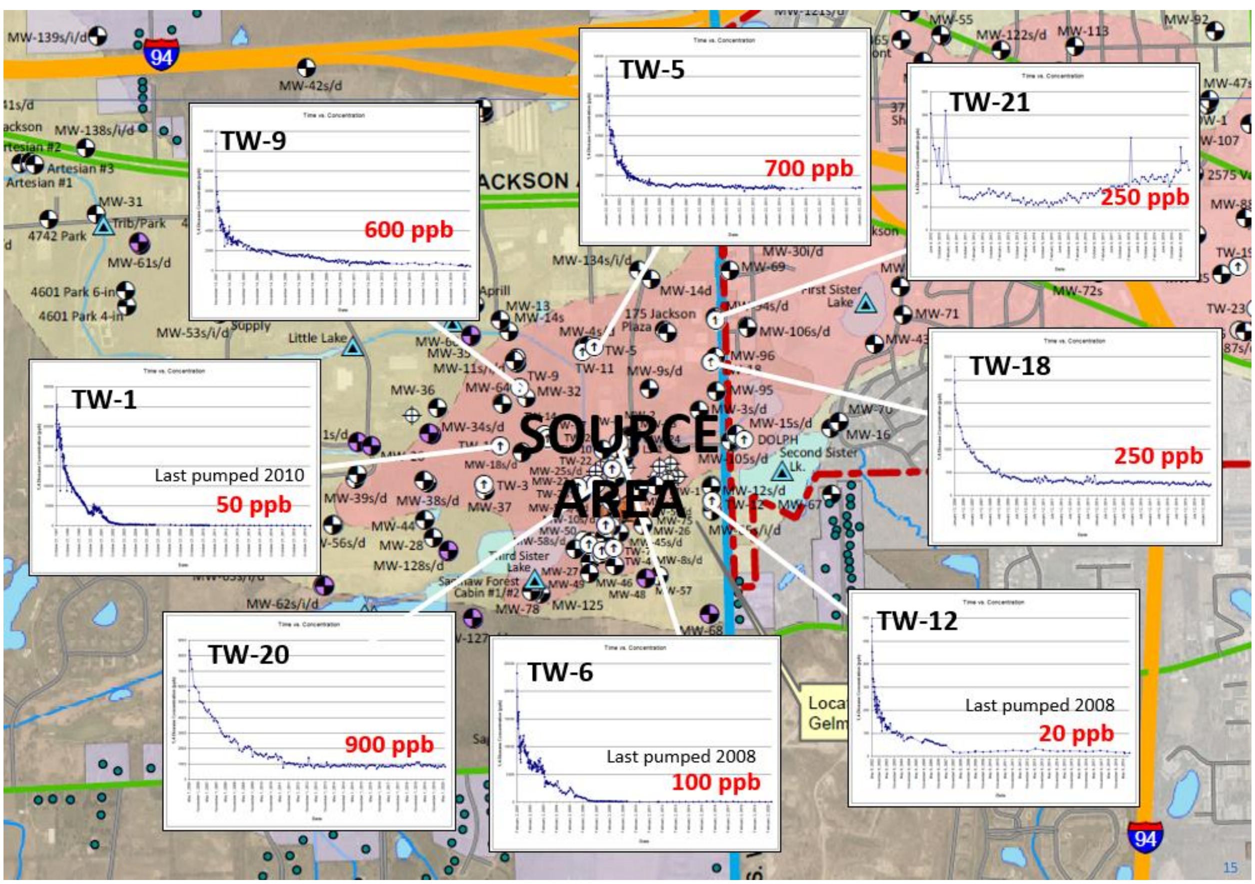

Figure 16. Concentration vs. time in Gelman extraction wells.

Scientific Rationale. Unlike monitoring wells, which are designed to passively sample concentrations in the groundwater that surrounds them, extraction wells draw water in from the surrounding water in all directions (**Figure 17**). Consequently, concentrations measured in extraction well effluent represent an average concentration from water reaching the well from every direction. Actual concentrations in parts of the aquifer within the well's radius of influence could be much greater than the average concentration in water coming out of the extraction well. Access restrictions and contaminant distribution uncertainty make it impossible to perfectly position each of the proposed extraction wells in the optimal location to capture the targeted hot spots; therefore, it is necessary to adopt more flexible termination criteria.

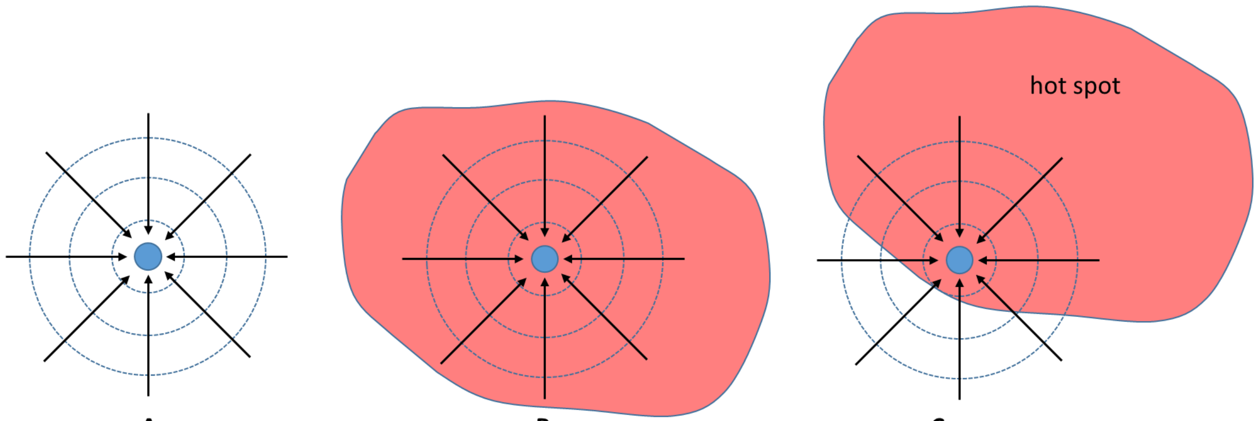

Figure 17. A) Map view of a pumping well showing groundwater flow lines (arrows) converging toward a the well from all directions; B) pumping well centered in a hotspot draws high concentration groundwater from all directions; C) pumping well near the edge of a hot spot draws high and low concentrations, diluting the concentrations in the effluent stream.

3B. Revised disposal plan for Parklake Well purge water

The proposed plan to extract contaminated water from an inferred hot spot east of Wagner Road at the location designated as the Parklake Well has the potential to significantly increase the rate of 1,4-dioxane mass removal across the entire site. Installation and operation of the Parklake Well depends upon Gelman's capacity to treat up to 200 gallons per minute (gpm) of purged water and the ability to dispose of an equivalent volume of water after it is treated to reduce dioxane concentrations to acceptable levels.

The Proposed 4th CJ plan to discharge treated water from the Parklake Well into the adjacent First Sister Lake, subject to issuance of an appropriately restricted National Pollutant Discharge Elimination System (NPDES) permit by EGLE, has elicited extensive public opposition. Although the Proposed 4th CJ conditioned the discharge into First Sister Lake upon Gelman obtaining an NPDES permit for that discharge, subsequent review of the proposed discharge and its impacts on the environment by an environmental consulting firm concluded that discharge into First Sister Lake "may not be permittable because the volume added could be significant and will likely cause an irreparable change to the ecosystem (Tetra Tech, 2021)." This leads the Intervenors to conclude that an NPDES permit for that discharge likely would be denied. Anticipated environmental impacts supporting this conclusion include:

- The discharge would raise the water level of First Sister Lake by about 6 to 12 inches, adversely affecting a raingarden recently installed by the City if Ann Arbor adjacent to the eastern edge of First Sister Lake and potentially impeding pedestrian access and walkability along the lake perimeter.
- Because groundwater maintains a constant temperature of approximately 55° F year round, we can anticipate that the temperature of the groundwater will be colder than the water of First Sister Lake during the summer and warmer than the lake water during the winter. This could warm the water temperature and prevent freezing in winter, thereby disturbing the habitat for plants and animals that depend on the water temperature dropping in winter and potentially impeding recreational activities such as ice fishing and ice-skating during winter months.
- When compared to the volume of the lake itself, 200 gpm generates enough water to completely displace the entire lake volume every 35 to 40 days, which does not occur now, and could have an adverse impact on fish and other amphibious creatures, as well as the flora in and around First Sister Lake, by changing the temperature or water chemistry of the lake.

The Proposed 4th CJ does not provide for an alternate discharge location to be considered if the NPDES permit for discharge to First Sister Lake is denied. Because application for an NPDES permit for discharge into First Sister Lake appears to be a futile pursuit, the Intervenors propose that a court order mandate piping treated groundwater extracted from the Parklake well to the Gelman Property with subsequent discharge joining the existing flow of treated groundwater from the Gelman Property to the NPDES-permitted discharge point along the unnamed tributary to Honey Creek. The advantage of this approach is that piping from the Parklake parcel to the Gelman Property can be installed almost entirely within road rights-of-way under the jurisdiction of Intervenor City of Ann or Intervenor Scio Township, although Gelman would need to follow relevant requirements of the City or Township for permits to install facilities in those rights-of-way. Several options could be considered within this framework:

- Piping the treated water directly to the NPDES-permitted discharge point along the unnamed tributary to Honey Creek;
- Piping the treated water to discharge into the pipe from the treatment building on the Gelman Property that leads to and discharges treated groundwater into the unnamed tributary to Honey Creek; or
- Piping the treated water to discharge at a different location on the Gelman Property.

If piping the treated groundwater to the Gelman Property is determined not to be a viable option, Gelman should undertake a feasibility study to identify and propose a different option for discharge of the treated water to another location under a new NDPES permit.

Scientific Rationale. Although 200 gpm may not sound like a large amount of water, over the course of a week or a month or a year it adds up to a considerable volume, and if the treated water from the Parklake Extraction Well were discharged into First Sister Lake, the impacts on First Sister Lake and the surrounding areas likely would preclude issuance of an NPDES permit. To avoid a likely unsuccessful application for an NPDES permit, other options need to be considered and the effects of those options need to be fully assessed.

Alternatives to direct discharge into First Sister Lake involve questions of engineering and access. Therefore, flexibility is warranted to enable Gelman and the affected communities to devise an acceptable solution while navigating the NPDES permitting process.

3C. Accelerated source area groundwater extraction

In the Proposed 4th CJ, Gelman would be required to install two new extraction wells and rehabilitate an existing extraction well to capture groundwater in the source areas of the site. These three proposed wells were to collect groundwater at a combined rate of approximately 75 gallons per minute (gpm) and the recovered water directed to existing treatment facilities to remove 1,4-dioxane. After the concentration of 1,4-dioxane in the groundwater extracted from these wells fell below 500 µg/L, Gelman was to cycle[3] the wells until consistent concentrations stayed below the target level and no rebound effect was observed. After an evaluation of the performance achieved by installation of the first three extraction wells, Gelman would install three additional wells if EGLE determined that these wells "would accelerate mass removal to a degree that meaningfully benefits the remediation."

The benefit of mass removal in the source area has been repeatedly demonstrated. Data collected from extraction wells located in and near the source area indicate that significant removal takes place over a two-to-four-year period following installation before diminishing returns in the form of asymptotically lower concentrations follow. The three initial recovery wells in the Proposed 4th CJ are positioned in the northwestern, central, and southwestern portion of the source area, whereas the three contingent additional wells are positioned in the northern, eastern, and southeastern portion of the source area (**Figure 18**).

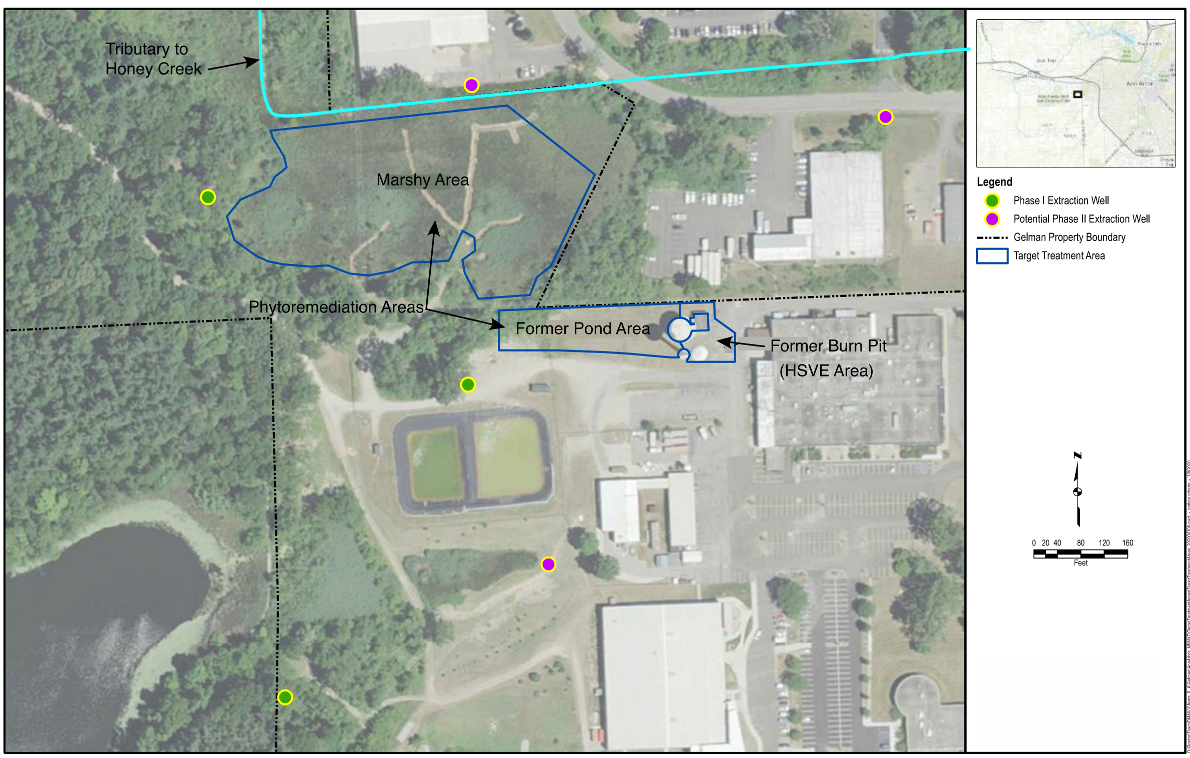

Figure 18. Source treatment areas and proposed extraction wells on the Gelman Property. Adapted from Attachment I of the Proposed 4th CJ.

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3 Cycling involves turning the pumping well off and waiting for a period of time before turning it back on to see if concentrations increase (rebound) in response to additional dioxane release from low permeability zones.

Given the demonstrated complex aquifer heterogeneity at the site, it is likely that the proposed wells will leave a large portion of the source area without effective hydraulic control if they are operated individually or in small subsets. Conversely, operation of six or more wells distributed across the area of concern will decrease the probability of continued groundwater migration toward deeper aquifers, including those that transport water to the Eastern Area, and lateral migration of contaminated groundwater to vent in an uncontrolled manner into nearby surface water, including Third Sister Lake, Honey Creek, and its tributaries. In short, installation of all proposed wells within a narrow time frame, with a contingency to add additional wells as individual well performance is assessed, will accelerate mass removal and enhance compliance with Western Area GSI objectives.

A 500 ppb termination criterion for the source area extraction wells fails to ensure that groundwater concentrations of 1,4-dioxane will not vent to nearby surface waters in excess of the 280 ppb GSI criterion. As explained earlier (see scientific rationale for Section 3A), extraction well concentrations are not likely to be representative of the highest concentrations. Therefore, a termination criterion is not the most effective means of ensuring broader remedial objectives. As an alternative to termination at 500 ppb, the Intervenors propose adopting language similar to that employed in the Proposed 4th CJ for the HVSE system: "Defendant shall operate [extraction well] until effluent 1,4-dioxane concentrations indicate continued extraction will no longer contribute to beneficial reduction in 1,4-dioxane mass." We endorse the concept of cycling wells on and off to demonstrate concentration rebound has not occurred before extraction is terminated.

Scientific Rationale. The intervenors propose that all six proposed wells be installed and operated in the source area as quickly as possible, with a collective extraction rate of 150 gpm or more. In the Marshy Area in particular, aquifer heterogeneity is compounded by the presence of organic rich peat layers that impede groundwater flow in response to pumping (PGSI, 2000). Therefore, the spacing of the original three extraction wells is likely insufficient to affect groundwater flows over the entire targeted region, regardless of their initial performance removing contaminant mass.

There is no compelling reason to wait for data from the initial extraction wells before installing the additional three wells. Recognizing that it is not possible to position each of the proposed extraction wells in the optimal position to capture targeted hot spots, the greatest benefit would be achieved by operating six or more wells from the start of the proposed groundwater extraction to provide the maximum possible mass removal within the shortest time frame.

3D. Phytoremediation performance monitoring

The Proposed 4th CJ requires that Gelman perform phytoremediation for Former Ponds 1 and 2 as well as the Marshy Area of the site (**Figure 18**). The Intervenors have not seen or reviewed the investigation reports and feasibility studies that led to the selection of phytoremediation as a viable method to both reduce 1,4-dioxane mass in groundwater and to lower the groundwater table to reduce infiltration and mobilization of contaminants. Review of the existing Gelman reports pertaining to phytoremediation is essential to understanding and monitoring cleanup objectives.

Proposed phytoremediation in the Former Pond 1 and 2 Areas will consist of poplar and hardwood trees planted primarily to withdraw shallow groundwater and capture precipitation near the ground surface before it infiltrates beyond the tree root systems. This hydraulic capture will reduce available water moving through contaminated soil, where 1,4-dioxane can partition from the soil to the underlying groundwater with the potential to migrate offsite. Trees will also remove contaminant mass via transpiration and biodegradation.

Likewise, willow trees planted in the Marshy Area will capture contaminated groundwater and infiltration water moving through contaminated soil before it can move vertically and migrate offsite into deeper groundwater and laterally into the nearby tributary to Honey Creek. In the Marshy Area 1,4-dioxane will also be eliminated by both the tree root systems and transpired through leaves.

An important shortcoming of the phytoremediation responses included in the Proposed 4th CJ is the absence of specified performance criteria. Without clearly defined performance metrics, it will not be possible to determine if phytoremediation is achieving its intended benefits. The Intervenors therefore propose adopting the following requirements to ensure the effectiveness of the phytoremediation systems within the larger context of all site cleanup measures and controls can be demonstrated:

> Within 180 days of entry of a new court order, Gelman shall submit to EGLE for its review and approval a plan to verify the effectiveness of the phytoremediation installations. The plan should include: (i) estimated rates of biodegradation and transpiration for 1,4-dioxane in both the Former Pond and Marshy Areas; (ii) measurement of 1,4-dioxane concentrations in groundwater beneath the Former Pond and Marshy Areas; (iii) groundwater logging throughout the tree plots to verify expected dewatering; (iv) verification of the extent to which trees planted in caissons have root systems that penetrate lower aquifers containing high concentrations of 1,4-dioxane; (v) a modeled estimate of the impact of the tree plots on the availability and migration of 1,4 dioxane from the phytoremediation areas; (vi) an evaluation of the 1,4-dioxane content of the trees for categorization purposes once disposal becomes necessary, (vii) monitoring points along the Honey Creek Tributary to determine compliance with the GSI criterion, and (vii) any additional monitoring criteria Gelman deems appropriate.

Scientific Rationale. Trees planted as part of the phytoremediation will likely not significantly affect site hydrogeology and contaminant concentrations until maturity, 2 to 3 years or more after planting. After root systems have been well-established, groundwater removal and 1,4-dioxane removal via biological processes should continue at optimal rates for many years. Because the tree plots are connected both to deep groundwater and adjacent surface water in the nearby tributary to Honey Creek, monitoring beneath and adjacent to the tree plantings is necessary to evaluate their effectiveness. Shallow groundwater monitoring points along the tributary to Honey Creek will ultimately serve as GSI compliance points, which will verify that the Western Area GSI Groundwater-Surface Water Interface Objective is attained.

The primary line of evidence demonstrating overall effectiveness of the phytoremediation systems is reduced 1,4-dioxane concentrations in groundwater beneath and downgradient from the tree plots. Additional lines of evidence are required to evaluate the rate at which 1,4-dioxane is taken up into trees and degraded or transpired. Monitoring should include the direct observation of changes in the groundwater table due to the presence of trees in the phytoremediation area along with the rate of transpiration as a function of tree sap transport (ITRC, 2009). This information should be combined with data from monitoring wells situated within the tree plots to show that phytoremediation is making a meaningful impact on overall 1,4-dioxane concentrations in source area and Marshy Area groundwater. Within the Marshy Area, use of tree tissue or leaf analysis to determine the location of highest dioxane concentrations in the northernmost trees will also help to identify appropriate locations for groundwater monitoring points adjacent to the tributary to Honey Creek. These points can then be used to verify that 1,4-dioxane concentration limits are not being exceeded at the groundwater-surface water interface.

3E. HSVE system optimization

Heated soil vapor extraction (HSVE) is a viable method for reducing the mass of 1,4-dioxane in unsaturated source area soil. The process includes blowing heated air into subsurface soil via injection wells to volatilize 1,4-dioxane into a vapor that can be collected using vacuum extraction wells. A map view of HSVE configurations and an associated representative cross-section are provided in **Figures 19 and 20**, respectively.

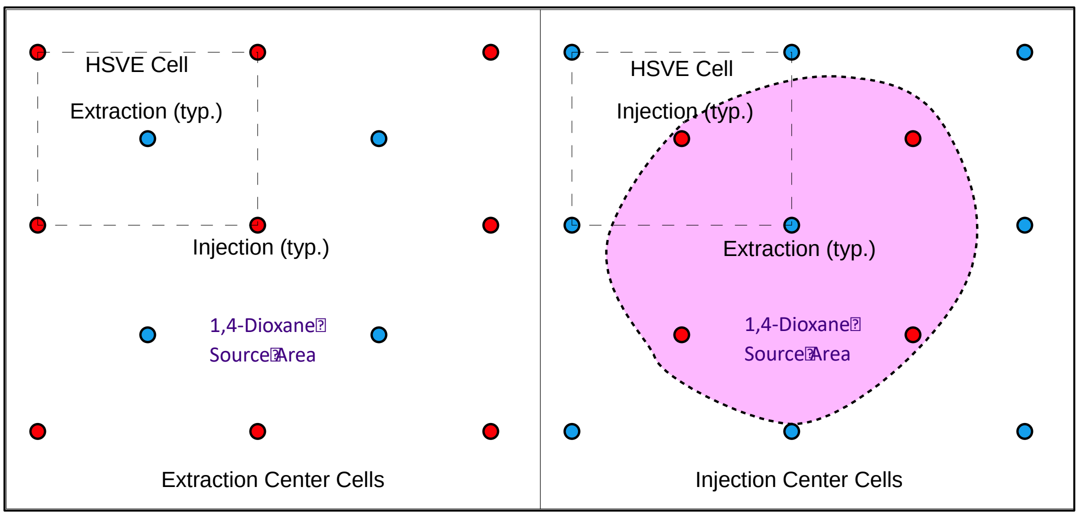

Figure 19. Map view of typical HSVE extraction (blue) and injection (red) well configurations. Adapted from DOD (2017).

The Proposed 4th CJ requires Gelman to install, operate, and maintain an HSVE system in the former Burn Pit area of the Gelman Property (**Figure 18**). At the completion of HSVE operation, the treated areas will be covered by an impervious cap to limit the infiltration of moisture into deeper soil, thereby limiting the availability of residual 1,4-dioxane, if any, to move into groundwater or surface water.

Depending on the starting soil concentration, site conditions, and desired endpoint, hundreds to thousands of pore-volume exchanges may be required through each given horizontal and vertical cross-section of the HSVE treatment area to uniformly achieve soil cleanup goals. The mass transfer process is influenced by several properties of the contaminant and subsurface conditions, as well as the magnitude of the applied vacuum. Gelman has conducted investigative and pilot studies in the Former Burn Pit Area to evaluate the feasibility of HSVE for the site. The Intervenors have not been given the opportunity to review the reports generated by Gelman and its contractors related to soil vapor remediation.

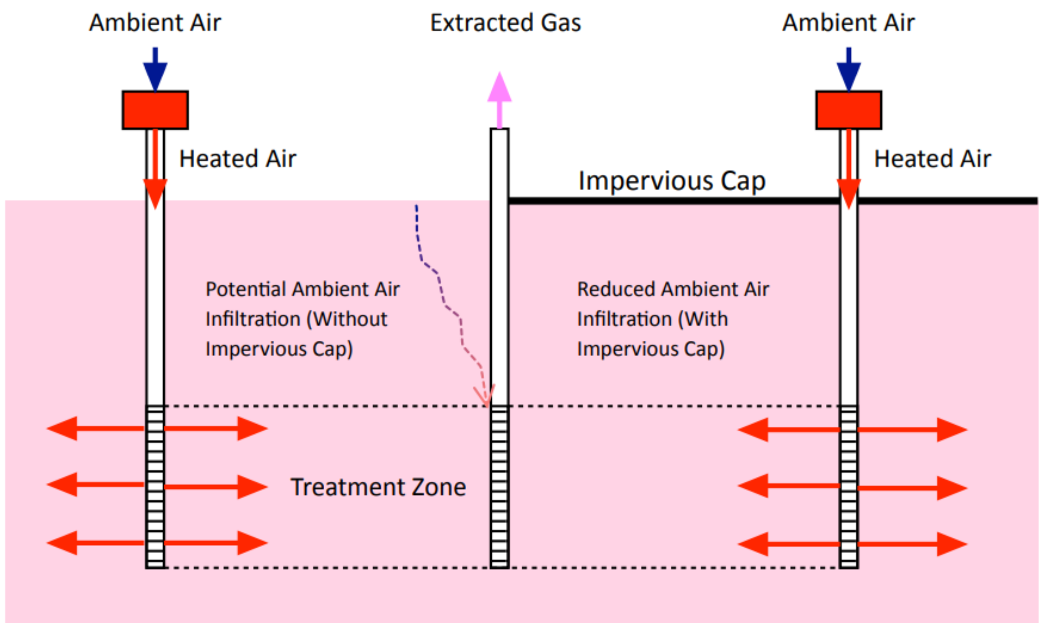

Figure 20. Simplified conceptualization of the HSVE treatment process in cross-section using extraction center configuration, with and without an impervious cap. Adapted from DOD (2017).

Nevertheless, based on the information presented to date, we believe that adequate air throughput/pore volume exchanges have been used as design criteria for determining extraction and injection well air flow rates and spacings. Based on USEPA review of sites where HSVE has been used as a remedy, many vacuum system designs underestimate the likelihood that ambient air will preferentially be drawn into a subsurface vacuum extraction well. Short-circuiting ambient air drawn vertically into an extraction well results in a lower percentage of the total extraction well airflow rate originating at target depths, which means that fewer air pore volume exchanges occur with increasing distance through cross-sections (USEPA, 2018). Because we have not seen design data, and Gelman has already committed to installing a cap over the HSVE treatment area, the Intervenors propose that the impervious cap be installed prior to operation of the HSVE system. This will limit infiltration of water and ambient air, and potentially help to retain heat in subsurface soil, resulting in more effective treatment. Design of the cap also may need to be modified to ensure that permeable materials placed under the finished cap will not contribute to short-circuiting of air from the surface, thus diminishing the horizontal recovery of soil vapors in the Burn Pit Area.

Because virtually all HSVE systems will eventually exhibit a diminished rate of contaminant extraction over time, we expect asymptotic conditions, where 1,4-dioxane mass removal rates decline to a minimum value, within several years. The current Proposed 4th CJ calls for operating the HSVE system until levels of 1,4-dioxane in the exhaust discharge air have been reduced to levels such that continued operation of the system will no longer contribute to meaningful mass reduction. At that point, Gelman is to submit to EGLE a request to significantly reduce or terminate operation of the system. The Intervenors also propose that the SVE system operation should be cycled after an asymptotic removal rate has been achieved to ensure that a diminished extraction rate of 1,4-dioxane is not a temporary phenomenon. This cycling will ensure that maximum mass removal of the HSVE is achieved.

Scientific Rationale. The HSVE system will operate more effectively if the proposed remedy incorporates two modifications: 1) the addition of the impervious cap prior to vapor extraction; and 2) the cycling of the HSVE system after levels of 1,4-dioxane in the exhaust air become asymptotic. Prior implementation of the cap specified within the Proposed 4th CJ will ensure that surface air is not drawn from the immediate vicinity of each extraction well. This will make the system more effective at depth in the soil column, limit water infiltration, and enhance contaminant removal. The cycling modification, like that proposed for groundwater extraction, will ensure that the vacuum system operation is not terminated prematurely.

4. Other response activities

The remaining Intervenor concerns involve matters of monitoring and response. Because the Proposed 4th CJ includes a number of mechanisms to ensure early detection of potential violations of its objectives, it is essential that these mechanisms are complete and as rigorous as is reasonably possible to ensure public and environmental health and safety. To that end, the Intervenors propose the following revisions to address their concerns:

4A. Annual surface water testing
4B. Lower Western Area Compliance Well triggers
4C. Consistent application of response activity threshold frequencies
4D. More stringent residential well sampling/response requirements
4E. Lower analytical method detection limits for residential water well samples near the plume
4F. Data reporting and access

4A. Annual surface water testing

The documented presence of 1,4-dioxane in Allen Creek, Third Sister Lake, and at multiple locations along the unnamed tributary to Honey Creek clearly indicates a need for routine and regular surface water sampling. The purpose of this type of sampling is to detect changes in concentrations that could indicate the venting of groundwater containing 1,4-dioxane at new locations or rising concentrations so that appropriate responses are taken in a timely manner.

To this end, the Intervenors propose requiring sampling of surface water bodies and drainage systems following protocols developed by EGLE as implemented in 2019 and 2020 sampling (EGLE 2019). Sampling should be conducted annually under low flow conditions during the months of August, September, or October. Sampling should include Allen Creek, the Allen Creek Drain, and each of its tributaries including the Main, North, South, and Murray Washington branches as well as the outflow into the Huron River below Argo Dam. Sampling should also include surface water bodies including First Sister Lake, Second Sister Lake, Third Sister Lake, West Park Pond, Arbor Landing Pond, Smith Ponds, and Little Lake, and Honey Creek and its tributaries. The following response actions should also be incorporated into a court order providing a comprehensive set of requirements that are necessary to address the Gelman dioxane:

With the exception of Third Sister Lake and the South Branch of the Allen Creek Drain downgradient of Maryfield-Wildwood Park, if sampling of any of these surface water bodies or drainage systems detects the presence of 1,4-dioxane at a concentration greater than 7 ug/L, then, within 60 days of receiving such a sampling result, Defendant shall investigate and submit a report to EGLE containing at least the following information: (1) a determination of where and how 1,4-dioxane is likely entering the affected water body, (2) an assessment of the risk that the GSI Cleanup Criterion will be exceeded in the affected water body, (3) proposed Response Activities for preventing 1,4-dioxane from entering the affected water body in a concentration greater than the GSI Cleanup Criterion, and (4) an assessment of the risk that 1,4-dioxane from the affected water body could migrate to groundwater. After receipt and review of Defendant's report, EGLE may require Defendant to undertake additional Response Activities to address the sampling result, including, but not limited to, the installation of additional monitoring wells.

Scientific Rationale. The technical basis for supporting annual surface water testing rests upon common sense and proactive surveillance to ensure GSI compliance. Unless and until there are monitoring wells located along all of the potential groundwater-surface water discharge points, surface water monitoring is a sensible way to detect discharge of contaminated groundwater and trigger additional subsequent actions required to address whether that discharge represents an exceedance of the GSI criterion.

4B. Lower Western Area Compliance Well triggers

The Proposed 4th CJ relies upon a Compliance Well Network and Compliance Monitoring Well Plan to ensure that the Western Area Non-Expansion Cleanup Objective is met. After conducting the Western Area Delineation Investigation (i.e., installation of monitoring wells at locations I, J, K, L, M, and N), Gelman and EGLE will determine wells to be included in the Compliance Well Network. Thereafter, groundwater in these wells will be sampled quarterly and concentrations will be used to test for exceedances based on a Verification Process outlined in the Proposed 4th CJ. The Intervenors believe that the specified 7.2 ug/L (ppb) concentration triggering response actions is too lenient. Consequently, we propose using a concentration of 3.5 ppb, which is approximately ½ the drinking water standard.

Scientific Rationale. It doesn't take an increase of compliance well concentrations all the way up to 7.2 ppb to provide evidence of contamination migration in the Western Area. Rising concentrations of any degree in a compliance well are an indication that the 7.2 ppb concentration line defining the horizontal extent of contamination is moving outward toward the compliance well. This concept is illustrated in **Figure 21**. For this reason, the Verification Process (and subsequent response activities) need to be applied at a lower threshold to provide earlier warning of contaminant migration and protect public health and private drinking water wells.

3.5 ppb represents the USEPA Drinking Water Concentration for a cancer risk level of 1 in 100,000. 3.5 ppb is sufficiently higher than the 1 ppb detection limit for the USEPA analytical Method 1624 (specified in Attachment B of the Proposed 4th CJ) to avoid concerns over statistical variability. Therefore, 3.5 ppb is a reasonable and workable threshold to trigger response actions investigating potential noncompliance with the Western Area Non-Expansion Cleanup Objective.

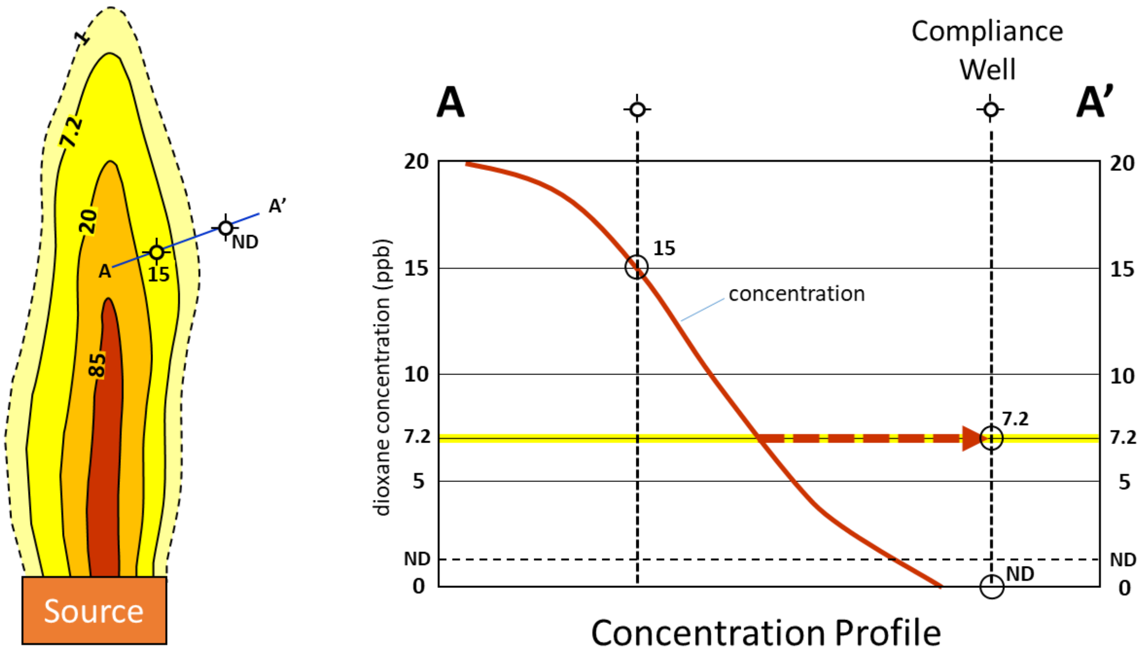

Figure 21. Concentration profile through two wells near the perimeter of a dioxane plume (shown in map view). It is not possible for concentrations in the Compliance Well to rise from non-detect to 7.2 ppb (or a lower concentration) without the position of the 7.2 ppb concentration line shifting toward the Compliance Well. This would constitute *de facto* expansion of the horizontal extent of groundwater contamination.

4C. Consistent application of response activity threshold frequencies

The Proposed 4th CJ uses a combination of Sentinel Wells and Boundary Wells to monitor movement of dioxane toward and near the boundary of the Prohibition Zone and to ensure that the Eastern Area Prohibition Zone Containment Objective is met. Response activities are triggered for verified exceedances of 7.2 ppb in Sentinel Wells and 4.6 ppb in Boundary Wells. In addition to monthly sampling after any individual exceedance, the Proposed 4th CJ requires specific actions after three successive monthly samples exceed these trigger values. Curiously, the Proposed 4th CJ requires only two consecutive months below the trigger levels to return to quarterly sampling.

A verified detection above 7.2 ppb in a Boundary Well confirms non-compliance with the Prohibition Zone Containment Objective and triggers monthly sampling of the affected well. Curiously, four successive monthly sampling events are required to initiate remedial responses thereafter. One of the required responses is the provision of bottled water to potentially impacted residences relying on private water wells if concentrations exceed 3.0 ppb. This provision terminates after two consecutive sampling events below 3.0 ppb.

A similar provision allows Gelman to discontinue bottled water supply after only two consecutive sampling events below 3.0 ppb in active private drinking water wells in the Western Area.

The Intervenors propose to simplify and rectify inconsistencies embedded within the Proposed 4th CJ by requiring <u>three</u> consecutive monthly concentrations above or below the relevant threshold to trigger the initiation or cessation of the applicable response activities.

Scientific Rationale. Requiring response actions following three consecutive monthly exceedances is justifiable based on statistical variability of concentration measurements. This provision essentially protects Gelman against actions triggered by one or two spuriously high dioxane measurements. An asymmetry in requirements to return to quarterly sampling (two months instead of three) is inconsistent, however, because spuriously low dioxane measurements may be just as common as high measurements (for example, see the concentration history of MW-112i, which sits at the boundary of the 85 ppb Prohibition Zone, shown in **Figure 4**). Similarly, cessation of bottled water should not be predicated on only two monthly samples. Clearly a three-in-a-row requirement to both initiate and terminate remedial activities would be more consistent and more protective of the health of residents depending on bottled water should an exceedance occur.

4D. More stringent residential well sampling/response requirements

The supply of safe, potable water is fundamental to individual, public, and community health. Detection of 1,4-dioxane in wells that currently provide drinking water to residents of Washtenaw County (**Figure 22**) has understandably heightened public concerns over the protection of drinking water wells.

Early detection is essential to protecting public health and arranging for alternate water supplies in the event contaminant levels rise above drinking water standards. To that purpose, Washtenaw County is contracted by EGLE to collect 1,4-dioxane samples from drinking water wells within 1,000 feet of the known limits of the plume. Samples are collected twice-per-year, once-per-year, or every-other year. Since 2014 this effort has sampled more than 130 drinking water wells. EGLE pays for the laboratory analyses and reimburses the County a small amount per sample collected. The County notifies homeowners and residents of sampling, coordinates the sampling with the lab and their staff, sends result letters, and discusses results with residents.

Currently, Gelman only monitors 4 drinking water wells at 697, 723, 745 and 777 S. Wagner Road. Comments at public hearings on the Proposed 4th CJ have clearly expressed the sentiment that Gelman should be taking greater responsibility for drinking well monitoring efforts associated with 1,4-dioxane in Washtenaw County. Western Area Response Activities in the Proposed 4th CJ include a Municipal Water Connection Contingency Plan (MWCCP) addressing the potential provision of township water to properties using private drinking water wells on Elizabeth Road. <u>The Intervenors request that a similar requirement be included for Breezewood Ct.</u>, where 1,4-dioxane was detected in a residential well (at a concentration less than 7.2 ppb) in 2019.

Private Drinking Water Well Response Activities in the Western Area require Gelman to provide property owners the option of receiving bottled water if, at any time, 1,4-dioxane is detected above 3.0 ppb in an active private drinking water well. This obligation terminates, however, if the 1,4-dioxane concentration in the well drops below 3.0 ppb in <u>two</u> consecutive sampling events. The Intervenors request that this obligation be amended to terminate after <u>three</u> consecutive sampling events below 3.0 ppb.

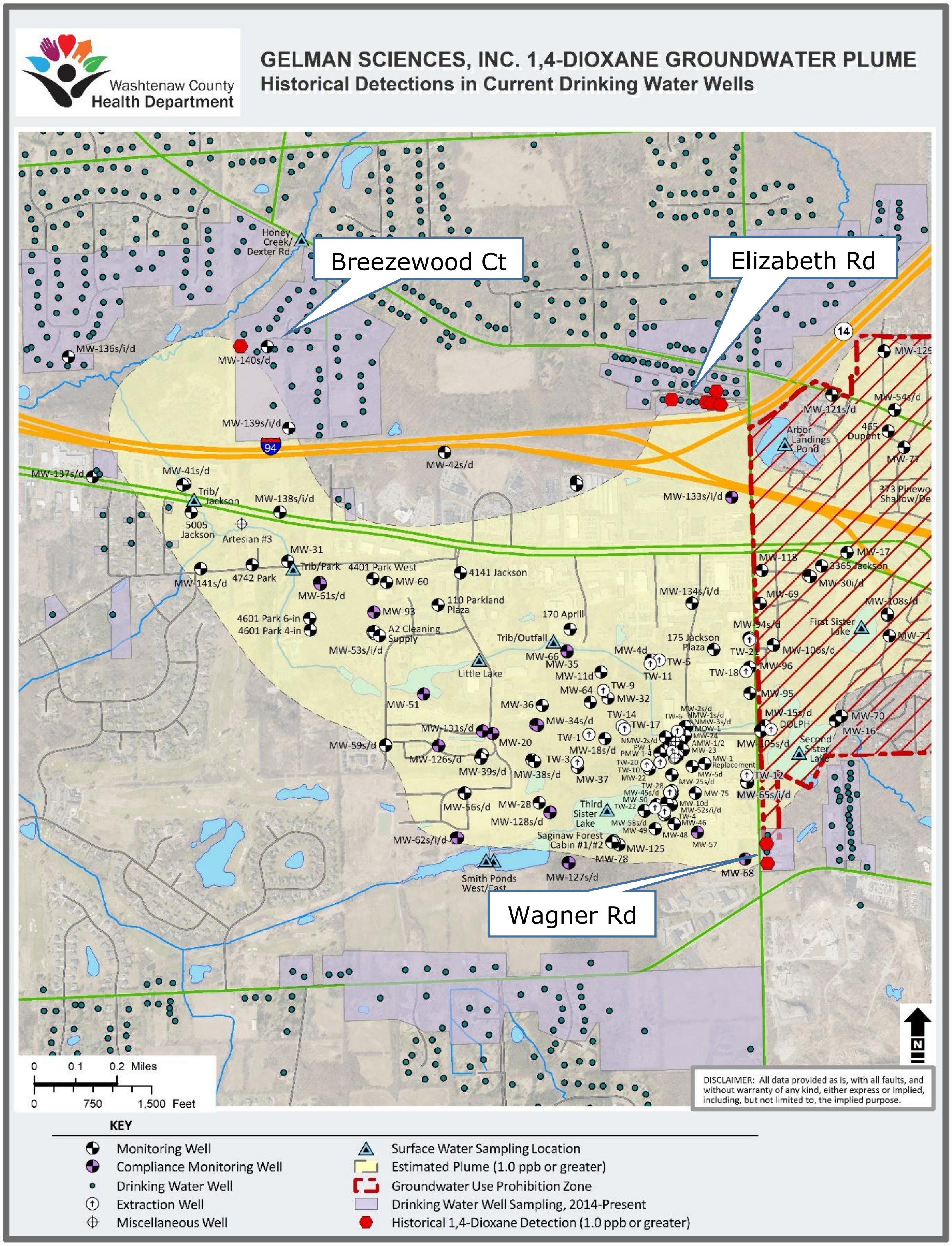

Figure 22. Location of residential and commercial water wells with 1,4-dioxane detections.

Scientific Rationale. The same rationale for proactively developing a MWCCP plan for Elizabeth Road residences should apply to residences on Breezewood Ct., where 1,4-dioxane has also been detected. Such contingency plans are necessitated by the long lead times required to design, construct, and activate municipal water supply systems in outlying areas.

Requiring or terminating response actions following three consecutive measurements is justifiable based on statistical variability of concentration measurements. A three-in-a-row requirement to terminate bottled water supplies to private residences would also be consistent with the Intervenors' proposed application of response activity threshold frequencies in Section 4C.

4E. Lower analytical method detection limits for residential water well samples near the plume

The USEPA has determined that 1,4-dioxane is a probable human carcinogen. Although the EPA has not established a federal drinking water standard for 1,4-dioxane, the State of New York adopted a 1 ppb maximum contaminant level (MCL) for 1,4-dioxane in 2020, and drinking water standards in other states range from 0.3 ppb in Vermont to 7.2 ppb in Michigan (Mohr and DiGuiseppi 2020). As a result, residents of households with private water supplies located close to the Gelman plumes are anxious to know if dioxane is present in their drinking water, even at levels below the State of Michigan drinking water standard.

To that end, the intervenors request that Gelman assume responsibility for collecting residential drinking water well samples within 1,000 feet of the known limits of the 1,4-dioxane as defined by the 1 ppb concentration line (Section 1A). These samples should be collected twice yearly and analyzed in accordance with USEPA Method 522, which was developed by USEPA specifically for the analysis of 1,4-dioxane in drinking water. This method must be used for the analysis of public drinking water supplies, so the application of this method to any other drinking water sources is both consistent and appropriate.

Scientific Rationale. USEPA Method 522 can achieve minimum reporting limits of less than 0.15 ppb. Gelman has a responsibility to identify the impact of its 1,4-dioxane plume on drinking water wells in the Western Area. Use of USEPA Method 522 for the analysis of drinking water from wells in close proximity to the plume is consistent with the requirements imposed on operators of public drinking water supplies and will provide residents and County health officials with information needed to evaluate exposure risks at levels consistent with the current USEPA Regional Screening Level (RSL) of 0.46 ppb for potentially potable groundwater for residential use ("tapwater").

4F. Data reporting and access

The long history and widespread extent of the Gelman plumes have led to the generation of enormous amounts of data including well locations and elevations, boring logs and engineering descriptions, static water level and 1,4-dioxane concentration measurements in monitoring wells, extraction well pumping rates, 1,4-dioxane mass removal rates, and NPDES discharge rates and concentrations, to name a few. Countless reports, maps, cross sections, and other tables and figures have also been produced.

Initially, hard copies of publicly available data were placed in repositories located in public libraries. Eventually, MDEQ (now EGLE) began collating and electronically posting data received from Gelman on

State of Michigan hosted websites. At the same time, public watchdog groups such as Scio Residents for Safe Water (SRSW) have maintained their own digital records and websites. Discrepancies in data sets maintained by Gelman, EGLE, SRSW, and academic researchers have raised questions about the completeness and accuracy of historic records and prompted public frustration because data are not provided by Gelman in common electronically readable formats, and delays arise between the provision of data to EGLE and its subsequent dissemination to the public.

To rectify this situation, the Intervenors propose that the court order addressing Gelman dioxane response actions require Gelman to establish a cloud-based database designed specifically for the storage and validation of data and information associated with all monitoring wells, extraction wells, and NPDES treatment and discharge activity. This database should be identical to the database maintained by Gelman, without modification, and should include all historical as well as future information. The information should be available for read-only electronic download in one or more native Excel files (or in a successor program to Excel, provided that when the data are migrated to a new program, no data are lost). Gelman should be required to investigate and remedy any data gaps or discrepancies identified by the Intervenors and members of the public. If information needed to fill data gaps is not available, Gelman will explain why the information is not available.

In addition, the Intervenors request that the court direct Gelman to provide copies of technical analyses and environmental or engineering studies or reports pertaining to the selection and design of remedial activities proposed for the Gelman Site (phytoremediation and HSVE). These documents should be posted on EGLE's Gelman Sciences Selected Documents public website.

Scientific Rationale. Accurate and timely access to site data are needed by all stakeholders including Gelman, EGLE, and the general public. A single database containing all relevant analytical information associated with monitoring, extraction, and permitted discharges will ensure that all parties are viewing and making decisions based on the same information. It will also reduce delays and errors from double data entry. Moreover, a common database will enhance accessibility for all parties while providing transparency to build public confidence in the availability and reliability of the data.

The Proposed 4th CJ requires Gelman to provide "as-built" installation reports describing the components and operational specifications of each of the source control systems (i.e., phytoremediation and HSVE) installed on the Gelman Property. However, reports documenting prior on-site environmental investigations and pilot engineering studies are also essential for understanding the basis for the selection of the proposed remedies, as well as for formulating expectations about their anticipated performance. Thus, these documents should also be in the public domain.

Technical Justification Document Prepared by:

Lawrence D. Lemke, Ph. D. Principal Lawrence D Lemke, LLC	Keith A. Gadway, P. E. Principal & Technical Director, Quantum Environmental, Inc.

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Appendix 1. Expert Qualifications

The primary expert offering the scientific evaluations, interpretations and expert opinions on each subject area is identified in the "Summary Table of Intervenor Concerns and Solutions", incorporated in the Introduction to the Intervenors' Brief. The interpretations and opinions expressed in the scientific/technical expert report were formulated, supported by, and are stated with a reasonable degree of scientific certainty, based on available evidence. These interpretations and opinions are based upon the experience and professional expertise of the technical consultants to the Intervenors, which are summarized below. The interpretations and opinions are based on information available at the time of the report's preparation and may be amended in response to future data and information collected as part of ongoing monitoring and remediation operations at the Gelman Site and its surrounding environs in Washtenaw County, Michigan.

Keith Gadway

Keith Gadway is an environmental engineer with 40 years of experience in consulting for industry, commercial interests, and government. He holds B.S degrees in Environmental Science Engineering and Atmospheric and Oceanic Science from the University of Michigan. Mr. Gadway spent eight years working as an engineer for two private consulting firms and the U. S. EPA prior to founding Quantum Environmental, Inc. in 1988. At Quantum, the firm's focus has been investigation and remediation of contamination issues in air, soil, surface water, and groundwater. Mr. Gadway has managed a diverse group of environmental professionals, including engineers, geologists, chemists, and environmental scientists. Quantum staff have completed projects in 21 states, Mexico, Canada, Germany, and England. Now with more than 1,500 projects successfully completed, Quantum has extensive experience in evaluating and remediating contamination using the latest technologies, and typically designs, builds, and operates treatment systems to achieve results meeting or exceeding regulatory goals. Mr. Gadway has served as an expert witness on numerous cases involving groundwater, surface water, and air contaminated with chlorinated solvents, petroleum compounds, and metals. Mr. Gadway is currently Principal and Technical Director of Quantum Environmental, Inc. and RK2, Inc, the latter a developer of environmental assessment tools such as real-time water level data loggers.

Lawrence D. Lemke

Larry Lemke is a geologist and environmental scientist with extensive industry, academic, and environmental consulting experience. He holds a B.S. in Geology from Michigan State University, an M.S. in Geosciences from the University of Arizona, an M.B.A. from the University of Denver, and a Ph.D. in Environmental Engineering from the University of Michigan. Prior to leaving industry to earn his doctorate degree, Dr. Lemke spent 12 years working for Exxon and its subsidiaries exploring for oil and gas in the Rocky Mountains, Gulf of Mexico, North Sea, and the Peoples' Republic of China. His academic research interests focus on the fate and transport of contaminants in groundwater, air, and soil, with particular emphasis on human health and exposure risks in urban environments. His research on the behavior of 1,4-dioxane in glacial aquifer systems beneath Washtenaw County, Michigan, was funded by the National Science Foundation and, together with the efforts of six graduate students working under his direction, has led to the completion of five Master's theses and four peer-reviewed publications in respected scientific journals. In 2005, Dr. Lemke founded his own consulting company, Lawrence D Lemke, LLC and began applying his scientific and subsurface hydrogeological skills to questions of groundwater contamination. He has acted as an expert witness on groundwater contamination lawsuits involving chlorinated solvents, gasoline (BTEX) compounds, and per- and polyfluorinated alkyl substances (PFAS). Dr. Lemke currently serves as Professor and Chair of the Department of Earth and Atmospheric Sciences at Central Michigan University.