INTERIM FEASIBILITY STUDY

FOR THE UNIT E PLUME

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Pall Corporation

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EXECUTIVE SUMMARY

Pall Life Sciences (PLS) purchased Gelman Sciences Inc. (Gelman) in 1997. In so doing, PLS assumed Gelman's legal obligations under the 1992 Consent Judgment between Gelman and the State of Michigan to cleanup the groundwater contamination associated with Gelman's past operations. Since 1997, PLS has continuously operated a comprehensive groundwater remediation system – one of the largest groundwater purging remediations in the State -- to address the known groundwater contamination present in two relatively shallow underground aquifers. PLS has removed and treated over 2.2 billion gallons of groundwater and removed over 56,000 pounds of 1,4-dioxane from the affected aquifers.

Investigations initiated by PLS in 2000 revealed that groundwater contamination was also present in the deepest aquifer – referred to as the Unit E aquifer – which was previously believed to be unaffected. Since that discovery, PLS has aggressively investigated the nature and extent of the Unit E contamination. The contaminant plume extends east from PLS' Wagner Road facility, beneath the City of Ann Arbor. The leading edge of this contaminant plume is currently located just east of Veterans Park, beneath densely populated residential neighborhoods. The plume has not threatened any private water supply wells, and is not anticipated to do so in the foreseeable future, because the homes and businesses above the plume are serviced by City's municipal water system, which draws its water from the Huron River.

This Feasibility Study does not consider or analyze any interim response actions that may be available to address the Unit E contamination. Previous attempts by PLS to implement interim response actions were met by considerable resistance by those in the community who felt that the efficacy of such actions could not be determined until an comprehensive plan was developed. A comprehensive plan would provide a legitimate framework for evaluating proposed interim responses. In response to such concerns, PLS recommended to the Michigan Department of Environmental Quality ("MDEQ") that it should prepare this Feasibility Study.

This Interim Feasibility Study (Feasibility Study) presents PLS' systematic evaluation of all of the identified alternatives for comprehensively addressing the Unit E contamination. It should be noted that this analysis is considered "interim" because PLS is in the process of conducting further field studies of one potential method of addressing the groundwater contamination – in-situ treatment of the aquifer with the injection of hydrogen peroxide. Following the analysis of the data obtained from these field studies, this Feasibility Study will be revised, as necessary, and a final report will be submitted.

The conclusions resulting from this study are summarized below:

PLS has weighed the advantages and disadvantages of the available remedial alternatives as detailed in Chapter 5 and has selected Alternative 6 "Groundwater Pumping – Active Remediation and Treatment Proximate to Huron River" as the preferred remedial alternative for addressing the Unit E contamination.

As discussed below, all of the available remedial alternatives selected for detailed review are equally protective of the environment. Currently, the Unit E is contaminated with a significant plume of 1,4-dioxane that has expanded under the City of Ann Arbor. Because of the depth of the contamination and the fact that the City's municipal water supply relies on water drawn from the Huron River well upstream of the Unit E flow path, the plume does not present an imminent current threat to public health and safety or to the environment. All of the alternatives that are examined involve interception or reduction in contaminant levels to acceptable levels before reaching potential receptors. Of these equally protective alternatives, Alternative 6, Active Remediation Proximate to Huron River, is the preferred option because it avoids the disruption of the City neighborhoods and the uncertainty regarding the practical feasibility of the alternatives that would attempt to contain the leading edge of the plume closer to its current location.

Each of the alternatives that attempts to contain the leading edge of the plume near its current location would cause disruption of established neighborhoods, significant use of public and private rights-of-way for transmission pipelines and infrastructure, traffic interruptions, construction-related safety risks to residents, and incongruous use of property given the residential (and recreational) uses above the plume. The City of Ann Arbor and local residents have already expressed their concern that neighborhoods and streets not be unnecessarily interrupted. The detailed evaluation presented in Chapter 6 establishes that the “leading edge” alternatives offer no environmental benefit over the preferred Alternative 6, which involves investigating the fate of the plume and, if necessary, interception, capture, treatment, and disposal at a location near the Huron River that would be less intrusive.

Because of the current location of the leading edge of the plume, each of the “leading edge” alternatives necessarily requires the installation of lengthy transmission pipelines. As discussed in Chapter 4, the equally lengthy construction horizon for these alternatives (after obtaining necessary access) and the continued migration of the plume calls into question the practical feasibility of these alternatives. At a minimum, the goal of capturing the leading edge of the plume near its current location would be compromised because the recovery wells would have to be placed well downgradient to ensure that capture could be still achieved when the infrastructure became available.

From a cost standpoint, monitored attenuation with institutional controls (remedial Alternative 2) is the least costly alternative. PLS, however, does not believe that this alternative adequately addresses political and societal concerns and it is not favored for this reason. All of the other alternatives are extremely costly. Based on current dollars, the selected Alternative 6 is the most expensive option, but is in the same order of magnitude as the other alternatives. This alternative has the advantage, however, of avoiding the disruptions associated with the other active remediation alternatives, while providing the same level of protection.

CHAPTER 1 - INTRODUCTION

1.0 INTRODUCTION

The following is a Feasibility Study for the Unit E Plume associated with the Pall Life Sciences (PLS) site (Site) located in Washtenaw County, Michigan. A Site location map is provided as Figure 1.

The name Unit E refers to an aquifer system located in portions of Sections 25 and 26 of Scio Township and Section 30 of Ann Arbor, Washtenaw County, Michigan. This aquifer or aquifer sequence generally referred to as Unit E is positioned in the lower portion of the glacial drift sequence and above the regional bedrock surface. The relevant portion of Unit E for this document is the area where 1,4-dioxane is present in the aquifer above concentrations of 85 parts per billion (ppb) (Unit E plume area). This area is depicted on Figure 2.

In September of 2001, PLS identified contamination off-site in an aquifer previously thought to be uncontaminated. As the breadth and scope of the contamination was identified, various tentative interim response actions have been proposed and criticized. Also, because much of the Unit E contamination lies within the City of Ann Arbor under highly developed areas the City of Ann Arbor and local residents have expressed concerns that their neighborhoods not be unnecessarily disrupted by interim response actions in the absence of an acceptable global plan for dealing with the Unit E plume.

In response, PLS proposed to MDEQ in July, 2003, that it develop and submit a Feasibility Study to identify, evaluate, and select an appropriate response to the Unit E plume that meets the requirements of the Consent Judgment and Part 201 of the Michigan Natural Resources and Environmental Protection Act, MCL 324.1 et seq. This Feasibility Study is being submitted by PLS pursuant to Rule 530(2) of the Michigan Administrative Code (R299.5530(2)) and covers final response activities needed to meet the objectives described herein. This Feasibility Study does not directly select interim responses that PLS may conduct within the Unit E plume in addition to the selected final response action, although some technologies that are reviewed in this document may also be available for interim responses.

1.1 REPORT PURPOSE AND ORGANIZATION

The purpose of the Feasibility Study is to evaluate the alternatives that are available to meet the remedial action objectives specified in the Consent Judgment, Part 201 and the Part 201 rules. These options must take into account the complex nature of the geology and the aquifer system as well as the unique characteristics of the contaminant of concern itself. The Feasibility Study will identify and evaluate various remedial technologies or process options that might be used to attain the remedial action objectives. The surviving technologies and process options are then combined into remedial alternatives that are evaluated under the criteria identified in the Part 201 rules. Based on this evaluation, a remedial alternative will be recommended that satisfies the remedial action objectives.

Chapter 1 Introduction - The remainder of this chapter presents a brief summary of the history of the Site and the site investigation and a discussion of the characteristics of 1,4-dioxane. Additional details regarding these issues are included in various previous documents.

Chapter 2 Remedial Action Objectives - This chapter presents the general response objectives that any remedial action at the Site will be expected to meet. In addition, it identifies the current land use and potential land uses that can be reasonably anticipated for the Site, and initial contaminated media volumes and footprints used to screen technologies and process options.

Chapter 3 Identification and Screening of Technologies - The results of identifying and screening remedial technologies and process options for Unit E groundwater are presented in this chapter.

Chapter 4 Development of Remedial Action Alternatives - This chapter explains the assembly of remedial alternatives from the surviving remedial technologies and process options and the preliminary screening of the remedial alternatives.

Chapter 5 Detailed Analysis of Remedial Action Alternatives – This chapter presents the results of a detailed evaluation of the alternatives assembled in Chapter 4, using the evaluation criteria specified in Rule 530, Part 201 of the Natural Resources and Environmental Protection Act, 1994 P.A. 451, as amended. Based on this evaluation, a remedial alternative is recommended.

Chapter 6 Conclusions - This chapter summarizes the significant conclusions of the Feasibility Study.

1.2 SITE BACKGROUND

1,4-Dioxane was discovered at the Site in the mid-1980s. Gelman Sciences Inc., (Gelman) the previous owner/operator of the Site, conducted extensive investigations to determine the nature and extent of the 1,4-dioxane. These investigations led to the identification of several glacial stratigraphic deposits including aquifers identified as the Units C_3, D_2, D_0, and E. These investigations concluded that the contamination was limited to the C_3, D_2, and D_0 aquifers and that the Unit E aquifer was uncontaminated.

Gelman initiated remediation of the 1,4-dioxane contaminated groundwater in the Unit C_3 in the late 1980s by purging groundwater from the former water supply well located on the adjacent Redskin Industries property. Gelman disposed of the water removed from this well by injecting the water into its USEPA Class I (deepwell) injection well. These efforts resulted in the removal of approximately 25,000 pounds of 1,4-dioxane from the contaminated aquifer.

In October 1992, Gelman and the State of Michigan entered into a Consent Judgment resolving two lawsuits filed by the State to force Gelman to remediate the groundwater contamination and to recover the State's expenses. The Consent Judgment required Gelman to, among other things, design, install and operate a groundwater purge and treat system that: a) captured the most highly contaminated groundwater (referred to as the "Core Area") before it left the Gelman property; and b) captured the leading edge of the portion of the plumes that extended off the property. The Consent Judgment did not contain any deadline by which the cleanup criterion had to be achieved, but rather required Gelman to stop the contamination from spreading any further.

In 1993, Gelman began operating a purge well in the Evergreen Subdivision (LB-1). This well was designed to capture the leading edge of contamination in the D_2 aquifer. Gelman treated the contaminated water from the D_2 aquifer to non-detect levels using an Ultraviolet/Hydrogen Peroxide treatment system and then re-injected the treated water into the deeper Unit E aquifer using an injection well (IW-1) also located in the Evergreen Subdivision area. The groundwater from this area is now being removed by three to four purge wells (LB-1, LB-2, AE-1, and AE-2) and then transported via an underground transmission pipeline to the Wagner Road facility for treatment.

PLS purchased Gelman in February 1997. Since that time, PLS has assumed Gelman's responsibilities under the Consent Judgment and operated an extensive groundwater pump and treat system that meets those requirements. This system currently removes up to 1,300 gallons per minute of contaminated groundwater from the Core and Evergreen System areas. The purging of groundwater is accomplished through the use of 18 strategically placed groundwater extraction wells, including two horizontal wells totaling over 4,300 feet in length. Groundwater purged from the aquifers is treated by PLS on its property and discharged in to an unnamed tributary of the Honey Creek under an NPDES permit. PLS has treated over 2.2 billion gallons of groundwater and removed and over 56,000 pounds of 1,4-dioxane from the Core Area and Evergreen System since 1997.

The Unit E aquifer was identified by investigations dating back as early as 1986. Available geological data suggested this deposit was separated from shallower 1,4-dioxane contaminated aquifers by clay rich deposits. Investigations conducted by PLS in August 2000, however, identified an area where there was no distinct hydrogeological separation between contaminated aquifers referred to as the Units C_3 and D_2 and the lower Unit E deposits. This finding started an extensive investigation of the Unit E.

To date, PLS has installed 36 deep monitoring wells to map the extent of 1,4-dioxane in the Unit E. Almost all of the well borings were drilled down to the Coldwater Formation (shale), which serves as the base of the Unit E and is encountered at a depth of approximately 230 – 300 feet.

This investigation led to the identification of an extensive plume of 1,4-dioxane that had migrated eastward from the Site. Water quality investigations of the Unit E have identified a plume of 1,4-dioxane that is approximately 9,310 feet in length, extending from the area of PLS to Veterans Park, east of Maple Road. A location map showing the Unit E wells and 1,4-dioxane iso-concentration contours from data collected in July and August 2003 is attached as Figure 2.

1.3. Nature and Extent of Contamination

The Unit E has been described as a fine to coarse-grained sand with varying amounts of fine to coarse gravels. Portions of Unit E contain cobbles and boulders. In most instances, the Unit E is deposited directly on the bedrock surface. At some locations, the aquifer is deposited on fine-grained deposits. The Unit E is likely comprised of many individual deposits, which have varying degrees of hydraulic connection. In some areas, the Unit E has been divided into two distinct deposits, E_1 and E_2.

The distribution of 1,4-dioxane in the Unit E is related, in part, to the physical characteristics of this aquifer such as its hydraulic properties (hydraulic conductivity distribution), hydraulic gradients, and geometry. The distribution of 1,4-dioxane is also related to the aquifer’s geochemical environment.

The nature and extent of 1,4-dioxane in the Unit E plume area has been investigated by the installation of 36 monitoring wells and the collection of hundreds of groundwater samples. The Unit E plume is approximately 9,500 feet long and extends from the PLS site area to the area of Veterans Park. The width of the plume is approximately 2,000 feet. Vertically, the plume occupies portions of the Unit E aquifer. The aquifer ranges from approximately 7 feet thick (near MW-68) to 160 feet thick (near MW-65). The plume is not uniformly distributed vertically in the aquifer.

1.4 Contaminant Fate and Transport

1.4.1 Environmental Characteristics

The molecular formula for 1,4-dioxane (CAS Registry Number 123-91-1) is $C_4H_8O_2$. Its molecular weight is 88.10 and its density at 20 degrees Celsius is 1.0329 (Windholz, 1983). 1, 4-Dioxane is miscible in water, alcohol, ether, acetone, benzene, acetic acid and many other organic solvents (NIOSH, 1977). 1,4-Dioxane has a Henry’s Law Constant of 2.3×10^{-4}.

Dissolved 1,4-dioxane is very mobile in groundwater. 1,4-dioxane passes through saturated soils relatively quickly due to its high solubility and low affinity for sorption to soil organic matter (Mohr, 2001). Retardation factors derived from column tests and from field-derived estimates range from 1 to 1.6 (Priddle and Jackson, 1991).

1,4-Dioxane is relatively resistant to degradation by indigenous soil microorganisms under ambient conditions (Fincher et al, 1962; Howard, 1990). The aqueous aerobic half-life of 1,4-dioxane is estimated between 672 and 4,320 hours (28 and 180 days), based on data using unacclimated aerobic aqueous screening test data (Sasaki 1978; Kawasaki 1980; Howard et al. 1991). The aqueous anaerobic half-life of 1,4-dioxane is estimated to be between 2,688 and 17,280 hours (112 and 720 days), based on estimated aqueous aerobic biodegradation half-life (Howard et al. 1991).

1.4.2 Transport

The Unit E plume has migrated east, approximately 8,500 feet from the boundary of the PLS facility. The site history establishes that 1,4-dioxane was not directly introduced to the Unit E from plant disposal operations. 1.4 Dioxane apparently migrated downward through the shallower D_2 and C_3 aquifers into Unit E through apertures in the clay layer originally believed to separate the aquifer systems.

1,4-Dioxane in the Unit E plume has migrated to the east, primarily due to advective groundwater flow in the Unit E. The available groundwater elevation data and basic hydrogeological principles indicate that the plume will continue on an eastward pathway toward the regional hydraulic sink, the Huron River, which is located approximately 8,000 feet from the current leading edge. This conclusion is supported by the regional potentiometric surface maps for the area that PLS has obtained. The regional potentiometric surface maps are provided in Appendix A. Analysis of these maps indicates that the Unit E plume will migrate toward the Huron River and either discharge into the river, or flow south, parallel to the river. The 1,4-dioxane could also potentially underflow the Huron River, but this scenario would be very unlikely considering the size of this hydrologic feature. It should be noted that the point at which the plume could vent to the Huron River is located well downstream of the City of Ann Arbor's water intake located in Barton Pond. This is supported by each of the potentiometric surface maps provided in Appendix A.

The travel times necessary for the Unit E plume to arrive at potential receptors have been calculated. Supporting assumptions and calculations for this analysis are provided in Appendix B. If the plume migrates directly to the Huron River, the 85 ppb contour will reach the river in approximately 12 years. The approximate travel time to nearest domestic wells is approximately 24 years. These calculations assume the plume would follow a direct path to the receptors.

1.5 Source Control Measures

PLS initiated source control measures soon after discovery of the Unit E contamination by installing two Unit E purge wells on its property (TW-11 and TW-12). Currently PLS pumps and treats approximately 200 gpm of groundwater from these wells. Operation of these wells is helping to reduce the mass of 1,4-dioxane in the Unit E and minimize further off-site migration. Under any of the remedial alternatives evaluated in this Feasibility Study, PLS intends to continue pumping wells such as TW-11 and TW-12 to reduce 1,4-dioxane mass in the portion of the Unit E plume closest to the PLS facility on Wagner Road. The infrastructure for TW-11 and TW-12 is installed and water generated from these wells can be discharged to surface water under the existing NPDES permit. Installing additional wells in the vicinity of the PLS Wagner road facility to assist TW-11 and TW-12 in reducing source area mass is under consideration. Obviously, operation of TW-11 and TW-12, or other wells in the vicinity of these wells, will help reduce the mass of 1,4-dioxane moving hydraulically downgradient. As additional treatment/discharge capacity becomes available as purging from other aquifer systems is reduced, it may be feasible to increase purging from the Unit E in the area around the PLS facility.

CHAPTER 2 – REMEDIAL ACTION OBJECTIVES

2.0 INTRODUCTION

Remedial action objectives for this site come from two sources: the Consent Judgment and Part 201 and its administrative rules. The Consent Judgment requires that the remedial system for Unit E: (a) contain downgradient migration of the plume in excess of 85 ppb; and (b) remove groundwater contaminants from the affected aquifers. Under Part 201 and the administrative rules, all remedial actions must be protective of the public health and welfare and the environment. (Rule 705(1)). Under Part 201, protection of the public health, safety and welfare is determined with references to the numeric screening criteria for exposure pathways that are applicable and relevant and appropriate for the site. This Chapter identifies the relevant exposure pathways that must be addressed and the cleanup levels associated with each pathway and details the source of the remedial action objectives that will be applied. As noted earlier, this Feasibility Study is devoted to identifying an appropriate overall solution to the Unit E and is not intended to review possible interim response actions nor the effect of interim responses on the remedial alternatives.

2.1 RELEVANT CLEANUP LEVELS AND EXPOSURE PATHWAYS

2.1.1 Cleanup Criteria For 1,4-Dioxane

Groundwater is the only Unit E media impacted by 1,4-dioxane, which is the only known chemical of concern in Unit E. 1,4-dioxane in the Unit E plume area has been detected at concentrations up to 7,000 ppb on the PLS property in the source area for the Unit E plume during the TW-14 well installation. The highest concentration detected in an off-site monitoring well sample was from MW-72d (3,788 ppb in October 2003).

The State has developed rules for the development of risk-based screening criteria for various environmental contaminants including 1,4-dioxane. The methodologies for calculating each of the criteria are provided in Part 201 and the associated Part 201 rules. The following is a list of the Part 201 criteria for 1,4-dioxane for various exposure routes and land-use types.

Part 201 Generic Cleanup Criteria and Screening Levels	Criteria (ppb)
Residential and Commercial 1 Drinking Water	85
Industrial & Commercial II, III, & IV Drinking Water	350
Groundwater Surface Water Interface	2,800
Residential & Commercial I Groundwater Volatilization to Indoor Air Inhalation	NLV
Industrial & Commercial II, III & IV Groundwater Volatilization to Indoor Air Inhalation	NLV
Groundwater Contact	1,700,000
Flammability and Explosivity Screening	140,000,000

NLV = Not Likely to Volatilize

The relevance and applicability of these criteria is discussed below:

2.1.2 Risk Analysis for 1,4-Dioxane in Unit E (Relevant and Appropriate Pathways)

Residential and Commercial 1 Drinking Water

These criteria are relevant if the contaminated groundwater is in an aquifer or if not in an aquifer, can reasonably be expected to transport the contaminant to an aquifer in concentrations in excess of the residential drinking water criteria. This criterion is relevant to the Unit E because the groundwater is in an aquifer. Also, there is a potential for Unit E groundwater to be used for drinking water from within the plume or along its future path. 1,4-Dioxane concentrations in the Unit E plume exceed this criterion. This is also the applicable criterion in the absence of institutional controls because it is the most restrictive applicable groundwater value. (R. 299.5708(1)).

There are a limited number of wells used as a source of drinking water in or in the vicinity of the Unit E plume. Known wells are shown on the location map attached hereto as Figure 3. There are no known drinking water wells impacted at concentrations above 85 ppb. The City's municipal water supply well referred to as the Montgomery Well is the only drinking water well in which 1,4-dioxane has been detected. The Montgomery well is located east-southeast of the plume. The City took the Montgomery Well off line after 1,4-dioxane was first detected in groundwater sampled from this well in April 2001. Concentrations of 1,4-dioxane in groundwater samples from the Montgomery well have been below 4 ppb. The well remains out of service.

1,4-Dioxane in the Unit E plume is migrating to the east, beneath the City of Ann Arbor, where drinking water is supplied by the publicly owned water system. As a result, there are no domestic drinking water wells east of the plume and likely to be impacted for a distance of approximately 15,750 feet. There are wells located closer on the east side of the Huron River, but it is unlikely the plume will underflow the river.

Industrial & Commercial II, III, & IV Drinking Water

This criterion is relevant since there is a potential for groundwater from the Unit E plume or along its pathway to be used for drinking water in a commercial or industrial setting. 1,4-Dioxane concentrations in a portion of the Unit E plume exceed this criterion. The residential drinking water criterion, however, is lower and will be applicable to the Unit E.

Groundwater Surface Water Interface

The groundwater surface water interface (GSI) criteria is considered a relevant pathway when a remedial investigation or application of best professional judgment leads to the conclusion that a hazardous substance in groundwater is reasonably expected to vent to surface water in concentrations that exceed the generic GSI criteria. Factors to be considered in determining whether the pathway is relevant include: (a) whether there is a hydraulic connection between the groundwater and the surface water in question; (b) the proximity of the surface water to source areas and areas of groundwater that currently or may in the future be expected to exceed the GSI criteria; (c) whether the receiving surface water is a water of the state; (d) the direction of groundwater movement; (e) the presence of artificial structures or natural features that would alter hydraulic pathways (such as utility corridors); and (f) the mass of hazardous substances present at the facility that may affect groundwater.

Based on these factors, GSI cannot be definitively ruled out as a relevant pathway based on the currently available information. Assuming that groundwater flow is ultimately toward the river, the distance from the Unit E plume to the Huron River is approximately 8,000 feet. The maximum concentration of 1,4-dioxane detected in the portion of the plume located beyond the PLS property limits was 3,788 ppb detected in a October 2003 groundwater sample from MW-72d, near the center of the plume. This maximum concentration would only have to reduce by approximately 25% percent in a distance of approximately 8,000 feet to not exceed the GSI value at the Huron River. Although this analysis suggests that the pathway may not be relevant, further investigation will be necessary to make this determination.

It should be noted that the Allen Drain, a nearby utility corridor that drains stormwater from Ann Arbor to the Huron River, is not considered a potential receptor in this regard. (Figure 3). The plume is expected to underflow this shallow drain by a significant margin. Moreover, the portion of the Allen Drain that is downgradient of the plume is enclosed in concrete and is intended to convey stormwater, not to allow significant volumes of groundwater to infiltrate. For both of these reasons, it is unlikely that there would be any interaction between the drain and any groundwater contamination in the Unit E.

Until further investigation is completed GSI will be considered a relevant criterion. If investigation confirms that GSI is a relevant criterion, GSI may also become the applicable criteria if institutional controls are relied upon to cut off the drinking water exposure pathways. If further investigation confirms that GSI is not relevant then it wound also not be applicable in the event institutional controls are adopted.

Residential & Commercial I Groundwater
Volatilization to Indoor Air Inhalation

This criterion is not relevant. 1,4-dioxane in the Unit E plume is well-below ground surface and significantly below the 3-meter limit specified in Rule 714. It is too far below ground surface to impact any foundation or foundation elements or to migrate to any below grade foundations. Moreover, this contaminant is considered “Not likely to Volatilize” (NLV).

Industrial & Commercial II, III & IV Groundwater
Volatilization to Indoor Air Inhalation

This criterion is not relevant. 1,4-dioxane in the Unit E plume is well-below ground surface and considered NLV.

Groundwater Contact

Concentrations of 1,4-dioxane in the Unit E plume are considerably below this criterion. Therefore, this criterion is not applicable.

Flammability and Explosivity Screening

Not relevant.

Based on the above evaluation, the residential drinking water pathway is the only exposure pathway that is relevant and applicable to the Unit E contamination. Currently, as requested by PLS and as agreed to by MDEQ and the State of Michigan, the cleanup level identified for 1,4-dioxane in aquifers covered by the Consent Judgment, such as Unit E, is 85 ppb. As discussed below, under the Consent Judgment and Section 2a of Part 201, PLS may request a different cleanup level derived under section 20120a of Part

201.   PLS may also request changes in response actions required under the Consent Judgment consistent with sections 20118 and 20120a or Part 201.

2.2 APPLICABLE STATE AND FEDERAL REQUIREMENTS

The applicable federal law is the Comprehensive Environmental Response, Compensation and Liability Act ("CERCLA"), 42 U.S.C. 9601 et seq. Applicable state laws are Parts 31 and 201 of NREPA, MCL 324.1 et seq.

In 1988, the State of Michigan commenced an action against Gelman Sciences Inc. under the predecessor laws to NREPA in *Frank J. Kelley, et al v. Gelman Sciences Inc,* (Washtenaw Circuit Court No. 88-34734-CE). In 1990, the State of Michigan commenced an action against Gelman Sciences Inc. under CERCLA in *State of Michigan v Gelman Sciences, Inc.*, (ED Mich, No. 90-CV-72946-DT). These two cases covered remediation and cost recovery for groundwater contaminated by Gelman Sciences. Both suits were resolved by Consent Judgments entered into by the State and Gelman in October 1992.

Under the state Consent Judgment, Gelman (and its successors) is required to investigate and remediate groundwater contamination to meet the objectives specified in that document. The federal Consent Judgment settled the State's monetary claims against the company subject to the implementation or remedial actions as specified in the underlying state Consent Judgment. Requirements under CERCLA for the instant site are, therefore, the same as required under the Consent Judgment.

Effective June 5, 1995, Part 201 amended Michigan's cleanup law (the Michigan Environmental Response Act "MERA", formerly MCL 299.601 et seq.).   Section 2a of Part 201 specified how the new law would apply to Consent Judgments (such as this one) entered under the pre-existing law. Section 2a provides that actions concluded with an enforceable agreement with the state on or before May 1, 1995, shall be governed by the provisions of the law in effect on May 1, 1995. However, upon request of a person implementing response activity, the department must approve changes in a plan for response activity to be consistent with sections 20118 and 20120a of Part 201. For this site, then, the applicable legal requirements are those specified in the Consent Judgment, except to the extent PLS (or Gelman before it) requested or in the future requests a change based on 20118 or 20120a of Part 201. PLS has requested, and MDEQ has agreed to change the residential drinking water criteria for 1,4-dioxane to 85 ppb as currently specified in the Part 201 rules.

2.3 REQUIREMENTS APPLICABLE TO CONTROL OF THE UNIT E

The Consent Judgment and Part 201 include requirements regarding control of the Unit E contamination in addition to the cleanup standard to be achieved. Under the Consent Judgment, PLS is required to contain downgradient migration of plumes of groundwater contamination in excess of the cleanup level (85 ppb). Part 201 Rule 705(5), (Mich Adm. Code R. 299.5705(5)) prohibits horizontal or vertical expansion of contamination in an aquifer at levels above the applicable cleanup level after initiation of remedial actions, and Rule 705(6) provides that all remedial actions that address the remediation of an aquifer provide for removal of hazardous substances from the aquifer either through active remediation or as a result of naturally occurring biological or chemical processes. Both rules can be waived by MDEQ under section 20118(5) and (6) of Part 201.

The standards for waiver of Rules 705(5) and (6) are summarized below. While PLS believes that it may be able to make appropriate demonstrations under section 20118 for a waiver, that is not the purpose of this Feasibility Study. In fact, evaluation of the feasibility of remedial options that can meet the requirements of the rules without a waiver is a necessary prerequisite to a waiver should one be requested.

Section 20118 (6) authorizes the MDEQ to waive the requirements of Rules 705(5) or (6), or both, if any 1 of the following conditions are satisfied:

(a) Compliance with R 299.5705(5) or R 299.5705(6), or both, of the Michigan administrative code is technically impractical.

(b) The remedial action selected or approved will, within a reasonable period of time, attain a standard of performance that is equivalent to that required under R 299.5705(5) or R 299.5705(6) of the Michigan administrative code.

(c) The adverse environmental impact of implementing a remedial action to satisfy R 299.5705(5) or R 299.5705(6), or both, of the Michigan administrative code would exceed the environmental benefit of the remedial action.

(d) The remedial action provides for the reduction of hazardous substance concentrations in the aquifer through a naturally occurring process that is documented to occur at the facility and both of the following conditions are met:

(i) It has been demonstrated that there will be no adverse impact on the environment as the result of migration of the hazardous substances during the remedial action, except for that part of the aquifer specified in and approved by the department in the remedial action plan.

(ii) The remedial action includes enforceable land use restrictions or other institutional controls necessary to prevent unacceptable risk from exposure to the hazardous substances, as defined by the cleanup criteria approved as part of the remedial action plan.

The MDEQ is not required to use its authority under 20118(6) even if 1 or more of the enumerated conditions are present. This Feasibility Study does not assume that a waiver could or would be granted by MDEQ for the purposes of establishing the remediation goals for the Feasibility Study.

2.4 SUMMARY OF APPLICABLE CRITERIA AND REQUIREMENTS FOR UNIT E

The applicable cleanup level for Unit E is 85 ppb, based on generic criteria established for the drinking water pathway by MDEQ under section 20120a of Part 201, and applicable to the Consent Judgment pursuant to request of PLS and section 20102a of Part 201.

In addition to the cleanup standard to be achieved, the Consent Judgment requires PLS to contain the leading edge of the groundwater contamination. Rule 705(5) requires PLS to prevent the vertical and horizontal extent of the groundwater contamination from expanding once remedial actions are commenced.

CHAPTER 3 – IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES (PROCESS OPTIONS)

3.0 INTRODUCTION

Process options are remedial technologies and/or techniques that can be used either individually or in combination to control risks to human health and the environment and satisfy the remedial action objectives unique to each contaminated site. The initial list of process options considered during the Feasibility Study were developed by PLS and its consultant: Fishbeck, Thompson, Carr, and Huber, Inc. (FTC&H). The MDEQ and a technical committee working on the project consisting of representatives of the City of Ann Arbor, Washtenaw County, the United States Geological Survey, and academia were given an opportunity to review the initial process option list and to provide feedback. After receiving such feedback, the list was then revised to reflect the comments received from both the MDEQ and the technical committee.

This Chapter: 1) presents the remedial technologies and process options that could potentially be used to achieve the remedial action objectives; 2) screens out the process options that are impractical given the site-specific conditions; and 3) assembles the surviving process options into remedial alternatives deemed capable of achieving the remedial action objectives. The remedial alternatives themselves are then evaluated and screened under the criteria discussed in Chapter 4. The surviving remedial alternatives are further evaluated in Chapter 5 and an alternative is selected in Chapters 5 and 6.

3.1 PROCESS OPTIONS POTENTIALLY AVAILABLE

The following process options were identified as potentially appropriate for remediation of the contaminated groundwater at the site:

1. <u>General methods of controlling or addressing plume</u>

    a. No Action
    b. Monitored Attenuation
    c. Institutional Controls
    d. Groundwater Extraction and Ex-situ Treatment
    e. In-situ Treatment

2. <u>Methods of Extracting Groundwater</u>

    a. Vertical Well
    b. Horizontal Well

3. <u>Methods of treating groundwater contamination</u>

    a. No treatment
    b. Ex-situ groundwater treatment.
        i. Ultra-Violet Light and Hydrogen Peroxide Oxidation
        ii. Ozone and Hydrogen Peroxide Oxidation
    c. In-situ groundwater treatment
        i. Recirculating Ozone Wells
        ii. Fenton's Reagent
        iii. Ozone-Rich Water Injection

iv. Ozone Sparging
v. Ozone Sparging and Hydrogen Peroxide Injection
vi. Hydrogen Peroxide Injection only

4. <u>Treatment Location</u>

a. PLS-Wagner Road Facility
b. Property near Maple Road
c. Property near Huron River

5. <u>Methods of Transferring Purged Water</u>

a. New Pipelines
b. Tanker Truck
c. Montgomery Well Pipeline

6. <u>Water Discharge Options</u>

a. Treated Water Discharge Points
   i. Surface Water Discharge
      1. County Drain (Allen Drain)
      2. Sanitary Sewer and Publicly Owned Treatment Works
      3. Huron River
      4. Honey Creek
      5. First Sister Lake

   ii. Below Grade Discharge into Unit E
      1 greater than 85 ppb
      2. between 1 ppb and 85 ppb
      3. less than 1 ppb

b. Untreated Water Discharge Points
   i. Deepwell Injection into Simon Formation
      1. Wagner Road Facility
      2. Near Maple Road

These process options and how they fared in the initial screening are summarized in Table 1.

3.2 INITIAL SCREENING OF PROCESS OPTIONS

The purpose of this section is to review the initial list of process options and screen that list to eliminate those options that are not appropriate to Unit E in accordance with the screening criteria identified in the Feasibility Study rule (Rule 530(4) of Part 201, Mich Adm Code R. 299.530(4)). Under the Feasibility Study rule, process options must be evaluated in terms of their effectiveness, cost, timeliness, and whether they are considered acceptable engineering practices given the option's feasibility for the location and reliability.

PLS applied these regulatory criteria to the site-specific information such as geologic or hydrogeologic conditions and contaminant type and concentration. Published and personal accounts of technology performance and professional judgment were also included in the evaluation process. Reasons for eliminating remedial technologies and process options are presented in Section 3.3 below and summarized in Table 1. Surviving options are then combined into remedial alternatives, which receive a more detailed review in Chapter 4 of this Feasibility Study.

3.3 ELIMINATED PROCESS OPTIONS

Thirteen process options were eliminated prior to forming the preliminary remedial alternatives. The basis for elimination of each is described below. These process options are denoted with "no" in the final column of Table 1.

3.3.1 Methods of Extracting Groundwater (1)

Two groundwater recovery options were identified for extraction of groundwater from the Unit E – vertical wells and horizontal wells. Vertical wells are retained as a groundwater recovery option. For the reasons explained below, horizontal wells are screened out.

Horizontal wells - Contaminated groundwater can be recovered with either vertical or horizontal wells. Three primary characteristics of the Unit E contamination are the depth, volume, and rate of movement of the contaminant plume. The use of horizontal wells for the Unit E was screened out because the dimensions and depth of the contamination make it unduly challenging (and perhaps infeasible) to construct such a well. A horizontal well is also unduly difficult to maintain in a residential neighborhood due to access and waste generation and disposal issues (waste generated from the "pigging" process). A horizontal well is also far more costly to install and maintain compared to vertical well construction techniques that could accomplish the same goals.

The contamination in Unit E plume is over 100 feet below grade and the Unit E is very thick, with contamination at different elevations depending on the area of Unit E that is being evaluated. Construction of a horizontal well or wells, which descend at an angle, to this depth would require a total casing and screen of significant length. It will be difficult to screen at the proper depth to maximize capture of the contaminant. Without detailed design work, it is difficult to know if there are available and suitable properties for access for drilling given the length, depth and angles required. There are a limited number of contractors available to drill such wells. A system relying on this type of construction lacks flexibility (the well cannot be moved or relocated, additional wells would have to be of vertical construction).

The process required to drill such wells is much more complicated than drilling vertical wells. As such, the time and cost to install such a well are often much higher than vertical wells.

Maintenance is required of all groundwater recovery or injection wells. It typically involves the use of a large service or drill rig, chemical treatment, and the collection and shipment of reagents or development water. The maintenance of horizontal wells is complicated by their great length and horizontal position, which makes removal and replacement of a pump more time-consuming and difficult and increases the quantity of acid or base used. The amount of waste produced during cleaning (pigging) a horizontal well is significantly higher than for vertical wells and this may complicate community relations in addition to requiring more trucks for hauling and disposal.

For the reasons above, this process option was eliminated.

3.3.2 Methods of Treatment

Ultra-violet light/Hydrogen Peroxide – PLS has used this treatment technology at its Wagner Road facility to treat the contaminated groundwater removed from other aquifers. There are, however, a number of considerations that make this technology unsuitable for use outside the Wagner Road facility. Ultraviolet light/hydrogen peroxide oxidation consumes a tremendous amount of electricity. Preliminary contact with electrical utilities indicates that sufficient service may not be available near Maple Road. Even if available, there are unacceptable risks associated with placing the necessary electrical service in the residential, recreational or even commercial settings present near Maple Road. This technology also requires large quantities of dangerous chemicals, most notably sulfuric acid. The risks posed by the delivery, storage and use of such chemicals in the residential, recreational or even commercial settings present near Maple Road are considered to be unacceptable.

For these reasons, this process option was eliminated for the Maple Road location..

3.3.3 Treatment Locations

Near Huron River - Treating purged groundwater near the Huron River was eliminated as a process option under any of the remedial alternatives that attempts to capture the leading edge near its current location. Such a scenario would involve transporting untreated water from the current location of the leading edge to the Huron River. There would likely be public resistance to any option that involves transporting untreated water a significant distance through congested residential neighborhoods. The cost of installing a double walled pipeline all the way from the proposed extraction well system to the Huron River would also be prohibitive.

This treatment location would, however, be appropriate under a remedial alternative that involves capturing the leading edge of contamination closer to the Huron River. It has been retained for that alternative.

3.3.4 Methods of Transferring Purged Water (2)

As explained below, two options for transfer of untreated groundwater were screened out – tanker trucks and the existing Montgomery well pipeline. A third option – construction of a new pipeline to convey water, was retained.

Tanker trucks **-** Tanker trucks could be used to convey recovered water to the PLS facility on Wagner Road for treatment. This option has been eliminated because it is not adequately reliable, presents a significant, unnecessary burden on the neighborhood, and presents an undue risk of accidental release.

At the pumping rate needed to control and reduce the plume and the anticipated time required to purge clean the aquifer, thousands of 5,000-gallon tanker trucks, approximately one every ten minutes, would be needed. These trucks would have to run 24 hours per day, 365 days per year, regardless of the weather. The high frequency of trucks would increase traffic volume, particularly during non-business hours. Also, the additional volume of heavy trucks will likely accelerate road degradation. Intense use of local surface streets in this manner is inconsistent with current uses and unduly burdensome.

Over the probable life of the remediation in excess of 1,000,000 tanker truck circuits would likely be required. The probability of at least one serious vehicular accident during this time is high. Injuries to persons or property due to truck-vehicle collision is significantly more likely than risks due to exposure to 1,4-dioxane in the groundwater.

For these two reasons, this process option was eliminated.

Existing Montgomery Well pipeline – The City of Ann Arbor Montgomery Well was taken off-line after the discovery of trace amounts of 1,4-dioxane in the well. The well is connected to the Ann Arbor Water Treatment Plant by a pipeline. With the Montgomery Well having been taken out of service, PLS considered adopting this existing pipeline for transmittal of purged water from the area of the Plume closer to the Huron River.

This option was eliminated as infeasible. PLS' investigation of this option revealed that the pipeline is currently used to transfer water from the City's Steer Farm Well Field to the Water Treatment Plant. Consequently, it is not available for use by PLS.

3.3.5 Water Discharge Options

Several options for discharge of treated or untreated groundwater were reviewed. As detailed below, discharge to the Allen Drain (Washtenaw County and City of Ann Arbor storm drain system), discharge to the City of Ann Arbor sanitary sewer system, and discharge to First Sister Lake were screened out. Discharge of untreated water to the Mt. Simon formation from a location near Maple Road was screened out. The process options involving discharge of treated water to the Huron River, , the Honey Creek tributary, and the three below grade groundwater re-injection options were all retained as was the below-grade discharge of untreated water to the Mt. Simon formation from a location on PLS' Wagner Road property.

County drain (Allen Drain) – The Allen Drain refers to the local storm water system. Portions of the Drain are administered by the Washtenaw County Drain Commissioner and other portions by the City of Ann Arbor. Part of the drain is still an open watercourse. As with all drains, its primary purpose is to carry storm water and run-off. PLS has in the past contacted both the Drain Commissioner and the City of Ann Arbor to determine if the Allen Drain could accept purged groundwater. Although both entities considered the request seriously, PLS has been informed that discharge of groundwater (treated or untreated) would not be permitted because the drain lacks capacity as is, and is not considered adequately isolated from exfiltration. Also, although a state discharge permit could be obtained, local ordinances of the City generally prohibit discharges of groundwater to the City's storm system and the Drain Commission has passed a resolution barring such discharges to the Allen Drain.

Therefore, this process option was eliminated as technically and practically infeasible.

Sanitary sewer – The local sanitary sewers are constructed and maintained by the City of Ann Arbor's Utilities Department. Treated groundwater could be discharged to the sanitary sewer for processing and incidental further treatment at the publicly owned treatment works, under a city permit.

This discharge is technically infeasible because the Utilities Department has notified PLS that there is inadequate capacity in the local sewer lines to carry the volumes of water needed. Although the City of Ann Arbor has in the past made some capacity available to PLS, this was on a temporary emergency basis and did approach the volumes needed for Unit E.

Therefore, this process option was eliminated as technically and practically infeasible.

First Sister Lake – First Sister Lake is located east of the PLS facility. This lake is entirely surrounded by the City's Dolph Park. First Sister Lake and it's the neighboring Second Sister Lake are the only naturally formed lakes in the City of Ann Arbor. Both lakes are hydraulically connected to the same unnamed tributary (a tributary to Honey Creek) into which PLS currently discharges treated groundwater.

First Sister Lake is a potential discharge location for treated groundwater from extraction options involving treatment in the Maple Road area. The advantage of this site would be the potential for a shorter pipeline route as compared to the one needed to bring the water back to the PLS facility on Wagner Road. This one advantage, however, does not appear to outweigh the many disadvantages of this process option.

The lake is in an important recreational property and a valuable natural resource for the community. It is unlikely that the community would find that use of the lake as a discharge point would be acceptable.

The lake's ability to efficiently convey additional water to the exiting tributary appears to be poor. Visual observations and a review of aerial photographs suggest this connection may be poor due to heavy vegetation bordering the lake. As such, discharge into First Sister Lake may tend to raise the lake levels before water would begin to convey out to the tributary. This would create hydrological and ecological uncertainties and complications and could negatively affect the public's enjoyment of Dolph Park. It may also adversely effect the wetlands currently bordering First Sister Lake.

Performing routine services such as line cleaning would also be very difficult in a park setting. Furthermore, the discharge point, even if it were designed to be unobtrusive, would likely change natural landscape.

Based on the above, this process option was eliminated as being politically and practically unacceptable.

<u>Deepwell Injection Near Maple Road</u> -- Deepwell injection for industrial disposal in Southeastern Michigan is typically into the Eau Claire and Mt. Simon sandstones. These zones are chosen due to their good injection potential and the depth of the injection interval. These formations are part of the Munising Group and are located directly above the basement Precambrian rocks. Other potential zones such as the Sylvania sandstone and the Dundee Limestone are located too shallow to be used for injection in Southeastern Michigan. A location where the formation could accept the necessary volume of water would have to be determined.

Placing a deepwell injection location near Maple Road would have the advantage of reducing the length (and cost) of the pipeline needed to convey the water from the extraction well system. This advantage, however, is negated by the legal challenges associated with this discharge location. Authorization for any discharge to the Mt. Simon or other formation must be obtained in the form of a permit from US. EPA. One of the permit requirements is that the permitee own the property on which the proposed well is to be located. Therefore PLS would be required to purchase property near Maple Road. Another requirement is that the property be properly zoned for such an industrial activity. Use of property by PLS for deep injection would be inconsistent with current zoning and the prospect of an acceptable change in zoning to accommodate this change in use is deemed to be very low. Therefore, this process option was eliminated.

3.3.6 In-Situ Groundwater Treatment (3)

Six options for in-situ groundwater treatment were considered. Five have been screened out.

<u>Recirculating Ozone Treatment Well</u> - Groundwater can be treated in large-diameter wells with two screened intervals. Ozone could be introduced at the base of the well, and circulation between the screen

zones would, in theory, set up a treatment cell in and around the well. Contaminants are oxidized as water moves within the well or after it has returned to the aquifer.

This technology is proprietary and has had mixed results (see literature articles). This technology has not been demonstrated as effective for an extensive application such as remediation of the Unit E plume. For the reasons above, this process option was eliminated.

Fenton's reagent - Fenton's reagent is formed when aqueous solutions of hydrogen peroxide and ferrous iron ions are mixed. The reaction creates hydroxyl radicals, which is second only to elemental fluorine as an oxidant and much stronger than hydrogen peroxide. However, hydroxyl radicals are short-lived in the aquifer due to their strength. This limited life span mandates the use of closely spaced treatment wells, and numerous injection events.

Large volumes of concentrated hydrogen peroxide and sulfuric acid (powerful oxidants), sodium hydroxide (strong base), and ferrous sulfate (catalyst) would be required to treat the contaminant plume and manage the aquifer pH. Transport, storage, and use of these materials would pose risks to human health and the environment far in excess of that associated with the Unit E contamination

For the reasons above, this process option was eliminated.

Ozone-rich water injection - Ozone is 10 to 15 times more soluble in water than oxygen. In this remedial technique, water is saturated with ozone through reverse air stripping or sparging in an above-grade vessel. The enriched water is then injected into Unit E. There, the ozone, or hydroxyl radicals formed during its reaction with water, destroys contaminants.

However, ozone molecules are very reactive, therefore unstable. Hydroxyl radicals are also highly reactive and unstable. Both oxidants can react with natural organic and inorganic components of groundwater, as well as other oxidant species. It is probable that the majority of the oxidant species in the enriched water would react with the inner surface of the injection well, reducing the strength of the solution. Therefore, this process option was eliminated.

Ozone Sparging/ Ozone Sparging and Hydrogen Peroxide Injection – PLS' initial field-testing of ozone sparging last summer demonstrated that 1,4-dioxane contamination could be destroyed by the introduction of ozone into a shallow underground aquifer. PLS initiated a multi-phase field study of this potential in-situ technology to determine if ozone (in gas form) could be reliably delivered to the Unit E (a much deeper aquifer) and whether the ozone sparging would result in any harmful bi-products, given the water chemistry of the Unit E. Of particular concern was the potential for producing bromate. The bromate can be created by the reaction of ozone and bromide, a naturally occurring compound in groundwater.

Last fall, PLS conducted a five-phase field study of three potential in-situ technologies using Unit E wells located on its property. The first phase of the study involved the injection of hydrogen peroxide into the formation. The results from the injection of hydrogen peroxide showed destruction of 1,4-dioxane without the formation of bromate. This process option has been retained, pending further field studies to be conducted in February and March. This option will be evaluated following this study in the final version of this Feasibility Study.

Ozone and then a combination of ozone and hydrogen peroxide were injected during the field-testing. The results from both phases that included ozone sparging again reflected impressive destruction rates for 1,4-dioxane. Unfortunately, the introduction of ozone under either scenario resulted in the formation of bromate at levels above the USEPA Maximum Contaminant Level (MCL) of 10 ppb. Although the ozone sparging technology is promising, given its demonstrated ability to destroy 1,4-dioxane in the aquifer, it cannot be considered as an available in-situ process option for the Unit E at this time because it creates unacceptable levels of bromate. The high levels of naturally occurring bromide in the Unit E appear to have accentuated the bromate problem. Therefore, the ozone sparging and ozone sparging combined with hydrogen peroxide injection process options were eliminated.

Hydrogen Peroxide Injection – The first phase of the above-described field study involved the injection of hydrogen peroxide into the aquifer. The results of this portion of the study were promising but not conclusive. The study appeared to show that the injection of hydrogen peroxide by itself destroyed 1,4-dioxane without creating bromate. PLS has submitted a follow up in-situ work plan to the MDEQ for comment and approval. This work plan calls for an extensive field study of this process option in the Maple Road area to determine if it can be used to address the Unit E contamination. The results of this study will be available in April 2004. Therefore, although this process option is not being eliminated for consideration at a future time, it is not carried further in this feasibility study.

3.4 SURVIVING PROCESS OPTIONS

The below-listed process options survived the initial screening and will be used to form remedial alternatives:

1. General methods of controlling or addressing plume

    a. No Action
    b. Monitored Attenuation
    c. Institutional Controls
    d. Groundwater Extraction and Ex-situ Treatment
    e. In-situ Treatment

2. Methods of Extracting Groundwater

    a. Vertical Well

3. Methods of treating groundwater contamination

    a. No treatment
    b. Ex-situ groundwater treatment.
        i. Ultra-Violet Light and Hydrogen Peroxide Oxidation (but not near Maple Road)
        ii. Ozone and Hydrogen Peroxide Oxidation
    c. In-situ groundwater treatment
        i. Hydrogen Peroxide Injection only (experimental and therefore not carried forward to Chapter 4)

4. Treatment Location

    a. Wagner Road Facility
    b. Property near Maple Road
    c. Property near the Huron River (under non-leading edge alternative)

5. <u>Methods of Transferring Purged Water</u>

    a. New Pipeline

6. <u>Water Disposal Options</u>

    a. Treated Water Discharge Points
        i. Surface Water Discharge
            1. Huron River
            2. Honey Creek
        ii. Below Grade Discharge
            1. greater than 85 ppb
            2. between 1 ppb and 85 ppb
            3. less than 1 ppb

    b. Untreated Water Discharge Points
        i. Deepwell Injection into Mt. Simon Formation at PLS Wagner Road Facility

3.5 DESCRIPTION OF REMEDIAL ALTERNATIVES

Using the surviving process options PLS has developed an array of remedial alternatives that can eliminate, reduce, or control the potential risks to human health and the environment present at the Site. The remedial alternatives are combinations of the surviving process options.

The remedial alternatives were developed in conformance with the criteria and standards presented in Rule 530 of Part 201 of the Natural Resources and Environmental Protection Act, 1994 P.A. 451, as amended (Rule 530). The following key Site-specific conditions were also considered during development of the Unit E alternatives:

- the distribution of 1,4-dioxane,
- existing remedial actions,
- a major transportation corridor (Interstate 94 crosses the contaminated area of Unit E), and
- the commercial and residential nature of the surface above the majority of the plume.

Seventeen remedial alternatives were developed from the above surviving process options. They differ primarily in the treatment location and the mode of treated water disposal. The alternatives are described below.

3.5.1 Alternative 1 - No Action

The No Action alternative (Alternative 1) would not actively control, treat, or monitor the impacted groundwater. The dissolved 1,4-dioxane would be allowed to migrate, dissipate, and decay naturally.

3.5.2 Alternative 2 - Monitored Natural Attenuation and Institutional Controls

Alternative 2 would include monitoring of groundwater conditions and contaminant movement while controlling potential exposure risks through either restrictive covenants or a local ordinance.

Changes in contaminant levels in the groundwater would be monitored by periodic sampling of groundwater from monitoring wells. Samples would be analyzed for 1,4-dioxane and selected monitored natural attenuation (MNA) parameters.

The components of this alternative include: initial hydrogeological investigations to determine the fate of 1,4-dioxane in the Unit E plume, the installation of a monitoring well network, long-term monitoring, and use of institutional controls to control exposure.

<u>Initial Hydrogeological Investigations</u>

Much of the investigations of the Unit E plume have been in or near the current boundaries of the plume. Outside and more specifically hydraulically downgradient of this area, there are limited hydrogeological data regarding aquifer conditions. Investigations will be required to determine aquifer characteristics such as groundwater flow direction, geometry and physical properties of aquifer materials. This investigation would be used to more reliably predict the migration pathway of the plume. It is assumed that this investigation will require a minimum of 10 strategically placed borings/wells. Vertical water quality and geological data would be collected at each of the well locations. Data from the investigation would be used to construct a groundwater flow and transport model to simulate the migration of the Unit E plume as it moves hydraulically downgradient.

<u>Monitoring Well Network</u>

Wells will need to be installed along the plume pathway to monitor the plumes fate in time and distance. It is assumed that a minimum of 10 additional monitoring wells (in addition to those installed for the investigation) will be necessary to provide adequate monitoring of the plume as it advances hydraulically downgradient. These wells would be used along with selected existing wells to monitor the Unit E plume over time and distance.

<u>Long-Term Monitoring</u>

Long-term monitoring of 1,4-dioxane and other MNA parameters will be necessary to document plume changes with time and distance. The monitoring will involve the collection of samples from wells inside and hydraulically downgradient of the Unit E plume.

<u>Institutional Controls</u>

Two exposure control methods using institutional controls are potentially applicable to the Unit E plume:

Restrictive Covenants – Under this scenario, pursuant to Section 20120b(4) of Part 201, restrictive covenants prohibiting the withdrawal of contaminated groundwater for drinking water purposes would need to be recorded on any land that lies above the plume, including and any areas to which the plume would migrate at concentrations above the cleanup criteria. It is not possible to restrict property not owned by PLS. Such restrictions would require the consent of individual landowners in the plume area. Given the large numbers of landowners from whom restrictive covenants would need to be obtained, it does not appear that this option is practical.

Local Ordinances – Under section 20120b(5) of Part 201, if the MDEQ determines that obtaining the necessary restrictive covenants would be impractical and that exposure to the groundwater contamination may be reliably restricted by an institutional control in lieu of restrictive covenants, the MDEQ may approve a cleanup that relies on other institutional controls, including an ordinance that prohibits use of groundwater. Arguably, the institutional controls prohibiting withdrawal of groundwater for drinking water purposes already exist in the form of Washtenaw County Heath Department regulations that prohibit the installation of drinking water wells in areas served by municipal water. But it is PLS' understanding that the MDEQ will not accept such existing institutional controls and that a specific ordinance meeting the requirements of section 20120b(5) would have to be adopted. This scenario would require the City of Ann Arbor to adopt such an ordinance. PLS has met with representatives of the City to determine if passage of such an ordinance could be accomplished, but at this time it is not known whether this can be accomplished.

3.5.3 Alternatives 3a-e - Groundwater Pumping - Pipeline to PLS Wagner Road Facility, Treatment Using Ozone/Hydrogen Peroxide or Ultra-violet Light/Hydrogen Peroxide

Five alternatives comprise this group. All four share:

- recovery of groundwater from multiple vertical extraction wells at the leading edge,
- transmission of recovered water through individual pipelines, which combine with others up stream of a new pipeline,
- transmission of the total flow of all individual wells through the new pipeline to the PLS facility,
- chemical oxidation of 1,4-dioxane using either the Ultra-violet light/Hydrogen Peroxide or Ozone/Hydrogen Peroxide oxidation technology without production of by-products at concentrations that pose risks, and
- disposal of treated water.

The alternatives within this group are distinguished by the treatment method and location where the treated water would be discharged.

<u>Shared Challenges</u>

The key challenges that are common to all of alternatives in this group are the installation of a new transmission pipeline able to convey water to the PLS Wagner Road facility and the location of extraction wells and related infrastructure east of Maple Road, where the plume has migrated under Veterans Park and densely populated residential neighborhoods. The technical feasibility of constructing and installing such infrastructure is well established both at this site and others. The lengthy and uncertain construction timeline associated with construction of these elements, however, calls into question the practical feasibility of any of the alternatives within this group. For example, the transmission pipeline back to the Wagner Road facility would have pass under Interstate 94, a significant physical obstacle. Obtaining the necessary access to both public and private property and then constructing the pipeline would be a difficult and lengthy process. Similarly, installing the extraction wells and the necessary infrastructure in the residential areas where the leading edge of the plume is currently located will necessarily cause disruption to residents and users of the area roads. Many residents have previously expressed resistance to PLS' efforts to install monitoring and test wells in their neighborhood and the disruption associated with the scale of construction necessary to implement any of these alternatives would be much greater and last for a longer period of time. Such community opposition to the construction of this infrastructure could delay the project.

The uncertainty regarding the length of time needed to obtain access and then to construct the necessary infrastructure will make it difficult to determine where the leading edge of the plume would be when such infrastructure is ready. Such delays would delay initiation of purging, which would allow the plume to migrate farther to the east, potentially requiring re-positioning of the recovery wells. This would in turn increase the level of disruption. Consequently, the practical feasibility of any of the remedial alternatives that involve construction of lengthy pipelines across property not owned by PLS is uncertain.

The increased control of groundwater treatment systems and reagents possible at the Wagner Road facility is a potentially compensating benefit.

Alternative 3a – Under this alternative, after the purged water is transported back to the PLS facility, it will be treated with either Ozone and hydrogen peroxide or ultra-violet light and hydrogen peroxide technology. The treated water would transported via a new pipeline directly to the Huron River where it would be discharged under a NPDES permit. A new, treated water pipeline to the Huron River would be as difficult and costly to construct as the pipeline from Maple Road to the Wagner Road facility. Installation of the pipeline would require access from three governmental units and numerous private landowners. The uncertainties discussed above regarding delays in obtaining access and building such a long pipeline would apply to this pipeline as well, injecting even greater uncertainty into PLS' ability to capture the leading edge of the contamination under this alternative.

Alternative 3b – Under this alternative, after the purged water is transported back to the PLS facility, it will be treated with either Ozone and hydrogen peroxide or Ultra-violet light and hydrogen peroxide technology. The treated water would then be injected into Unit E through multiple new wells at locations where 1,4-dioxane levels exceed 85ppb pursuant to Rule 2210(u) of the Part 22 Rules, R. 323.2210(u), which exempts groundwater injection back into the plume from the groundwater discharge permit requirement.

In addition to the shared issues associated with constructing pipeline from the extraction wells back to the PLS facility, the defining challenge associated with each of the reinjection alternatives (3b- _) is locating a sufficient number of injection wells to handle the necessary volume of water. Injection well locations must be carefully chosen to minimize dilution and, more importantly, deflection of the plume, both of which would reduce the effectiveness and efficiency of the plume and extend the remediation. Access to locations on the PLS property, as well as the construction of injection wells and pipelines from the treatment center would be simpler than if the wells were on property not owned by PLS. In addition, injecting the same amount of water into the plume as extracted will make capturing the plume difficult. A compensating potential benefit of this alternative is that the injection wells would likely be placed on PLS property, thus making the construction of injection wells and pipelines from the treatment center simpler than alternatives where wells would be installed off site.

Alternative 3c – Under this alternative, after the purged water is transported back to the PLS facility, it will be treated with either ozone and hydrogen peroxide or ultra-violet light and hydrogen peroxide technology. The treated water would then be injected into Unit E through multiple new injection wells at locations where 1,4-dioxane levels are less than 85 ppb but exceed 1 ppb. Discharge into this portion of the Unit E would be authorized under Rule 2213(5) of the Part 22 rules, R. 323.2213(5), which provides for a "permit by rule" for such discharges. The same concerns and challenges regarding locating the necessary injection wells in locations that would not exacerbate the contamination apply to this alternative as well. Moreover, the injection wells for this alternative may need to be installed off the PLS property, making access and construction more difficult.

<u>Alternative 3d</u> – Under this alternative, after the purged water is transported back to the PLS facility, it will be treated with either Ozone and hydrogen peroxide or ultra-violet light and hydrogen peroxide technology and then injected into Unit E through multiple new wells at locations where 1,4-dioxane levels are less than 1 ppb. A groundwater discharge permit under Rule 2218 of the Part 22 Rules (R. 323.2218) would be required to authorize a groundwater discharge to an uncontaminated portion of the Unit E. The Part 22 rules prohibit the effluent being discharged into an uncontaminated portion of the aquifer from containing any detectable amounts of contaminants. The ultra-violet light and hydrogen peroxide treatment technology has in the past been able to, in limited circumstances (e.g., low influent concentrations), reduce contaminant levels to non-detect levels for certain periods of time, but not continuously. Even under favorable conditions, large amounts of electricity and precise, non–linear control of the remedial equipment are needed to achieve this level of performance. PLS' ozone and hydrogen peroxide technology is unlikely to achieve significantly better treatment efficiencies, without additional testing and refining of the technology. Maintaining consistent non-detect effluent would be a considerable challenge with either technology.

The same concerns and challenges regarding installation of the necessary injection wells in locations that would not exacerbate the contamination apply to this alternative as well. In particular, it would likely be very difficult to find a location around the PLS site where 1,4-dioxane concentrations in the Unit E are below 1 ppb. Consequently, injection wells for this alternative may need to be installed off the PLS property, complicating the issues associated with access and construction of the injection wells and the pipelines from the treatment center.

Alternative 3e –Under this alternative, after the purged water is transported back to the PLS facility, it will be treated with either ozone and hydrogen peroxide or ultra-violet light and hydrogen peroxide technology. The treated water would then be discharged to the Honey Creek Tributary pursuant to an amendment of PLS' existing NPDES permit. Based on past permit challenges, increasing the volume discharge limit of the NPDES permit would be controversial. Any challenge to the permit amendment would delay implementation of this remedy and add to the difficulty of capturing the leading edge of the contamination.

One alternative to increasing the discharge volume limit to accommodate the approximately 500 gpm of additional water associated with the Unit E cleanup would be to reduce the volume of water currently being purged from the D_2 and C_3 aquifers by 500 gpm. The remaining 800 gpm would be more than enough to satisfy the Consent Judgment's remedial objectives of containing the plumes in these aquifers. The reduced purge rate would not, however, be adequate to accomplish the goal set forth in Judge Shelton's July 21, 2000 Remediation and Enforcement Order of completing the cleanup for these aquifers by July 2005. Consequently, relief from the Court would be necessary before this option would be available

3.5.4 Alternatives 4a-d - Groundwater Pumping – Treatment near Maple Road

Four alternatives fall within this group. All four share:

- recovery of groundwater from multiple vertical wells,

- transmission of recovered water through individual pipelines, which combine with others or proceed directly to a water treatment compound built on PLS-owned or PLS-leased property near Maple Road,

- chemical oxidation of 1,4-dioxane without production of by-products at concentrations that pose risks, and

- disposal of treated water.

As with the Group 3 alternatives above, the alternatives within this group are differentiated from each other by treatment method and the point of treated water disposal.

Shared Challenges

Though treatment of recovered groundwater at a location near Maple Road would eliminate the need for a pipeline from this area to the Wagner Road facility, this reduction in scope would be offset by challenges associated with locating one or more chemical oxidation treatment units in either congested commercial properties or Veterans Park and the need to site and install treated water injection wells (alternatives 4b, 4c, and 4d). Examples of these challenges are:

- Reagent handling and storage – Both treatment process options combine hydrogen peroxide with another chemical or physical oxidant. Concentrated hydrogen peroxide, the form in which the reagent would be received, is an energetic compound, which can explode under certain conditions. Transportation, handling, storage, and use of hydrogen peroxide near Maple Road, particularly in Veterans Park, may present unacceptable risks to human health and safety.

- System control and reliability – Either oxidation method incorporates remedial system components, which pose electrical shock and direct contact risks, in addition to those posed by direct contact with untreated water. Fences will have to be erected and maintained to protect the public from direct contact risks with contaminated media and remedial equipment.

- Number of treatment locations – Specific system performance and reliability issues may be multiplied if more than one treatment location is utilized. Conversely, any upset would impact only its proportionate share of total system capacity and performance.

There are additional challenges associated with the installation of the extraction wells, transmission pipelines, and related infrastructure in the densely populated residential areas where the leading edge of the plume is currently located. This effort will necessarily cause significant disruption to residents and users of the area roads. Many residents have already expressed concern with PLS' past efforts to install monitoring and test wells in their neighborhood and the disruption associated with the scale of construction necessary to implement this alternative would be much greater and last for a longer period of time. Given the amount of community disruption and the possibility of the lack of public acceptance, delays are anticipated for installation of recovery wells, allowing the plume to migrate farther east, requiring PLS to re-position the recovery wells further downgradient. This would in turn increase the scope of disruption.

Alternative 4a – Under this alternative, the purged groundwater would be treated at a location near Maple Road with either ozone and hydrogen peroxide or ultra-violet light and hydrogen peroxide technology and then conveyed directly to the Huron River by a new pipeline for disposal under an NPDES permit. A new, treated water pipeline to the Huron River would be as difficult and costly to construct as a pipeline from Maple Road to the Wagner Road facility, or one from the Wagner Road facility to the Huron River. The pipeline would originate near Maple Road. It will be constructed below grade and traverse both public and private property. It will also pass under Interstate 94. Obtaining access to both public and private property will be difficult and/or expensive or, in some cases, impossible.

The uncertainty regarding the length of time needed to obtain access and then to construct the necessary infrastructure will make it difficult to determine where the leading edge of the plume would be when such infrastructure was ready. Consequently, under this alternative, PLS will be unable to effectively capture the leading edge of the plume unless the extraction wells are located a significant distance downgradient of the current leading edge so as to accommodate the lengthy and uncertain access/construction timeline.

Alternative 4b – Under this alternative, the purged groundwater would be treated at a location near Maple Road with either ozone and hydrogen peroxide or ultra-violet light and hydrogen peroxide technology. The treated water would then be injected into Unit E through multiple new wells at locations where 1,4-dioxane levels exceed 85 ppb pursuant to Rule 2210(u) of the Part 22 rules (R. 323.2210(u)), which exempts groundwater injection back into the plume from the groundwater discharge permit requirement.

Injection well locations must be carefully chosen to minimize dilution and, more importantly, deflection of the plume, both of which would reduce the effectiveness and efficiency of the purge well capture zones and extend the remediation as well as PLS' ability to capture the leading edge. Given the volume of water that would need to be injected (500 gpm) and the very complicated geology of the aquifer in the Veterans Park/Maple Road area, siting a sufficient number of injection wells would be a shared challenge of all of the injection alternatives (4b-d). Additionally, injecting the same amount of water as is being extracted this close to the location of the extraction wells will make capturing the plume difficult – more difficult than if the water were transferred back to the PLS site.

Finally, access to such locations, which would not be on PLS-controlled property, as well as the construction of injection wells and pipelines from the treatment center, would be more difficult to obtain than for wells on PLS property.

Alternative 4c – Under this alternative, the purged groundwater would be treated at a location near Maple Road with either ozone and hydrogen peroxide or ultra-violet light and hydrogen peroxide technology. The treated water would then be injected into Unit E through multiple new wells at locations where 1,4-dioxane levels are less than 85 ppb but exceed 1ppb. Discharge into this portion of the Unit E would be authorized under Rule 2213(5) of the Part 22 rules (R. 323.2213(5)), which provides for a "permit by rule" for such discharges. The same concerns and challenges regarding locating the necessary injection wells in locations that would not exacerbate the contamination apply to this alternative as well

Alternative 4d - Under this alternative, the purged groundwater would be treated at a location near Maple Road with either ozone and hydrogen peroxide or ultra-violet light and hydrogen peroxide technology. The treated water would then be injected into Unit E through multiple new wells at locations where 1,4-dioxane are less than 1 ppb. A groundwater discharge permit under Rule 2218 of the Part 22 (R. 323.2218) would be required to authorize a groundwater discharge to an uncontaminated portion of the Unit E.

The Part 22 rules prohibit effluent being discharged into an uncontaminated portion of an aquifer from containing any detectable amounts of contaminants. The ultra-violet light and hydrogen peroxide treatment technology has in the past been able to, in favorable circumstances (e.g., low influent concentrations), reduce contaminant levels to non-detect levels for limited periods of time, but not continuously. Even under such favorable conditions, large amounts of electricity and precise, non–linear control of the remedial equipment would be needed to achieve this level of performance. PLS' ozone and hydrogen peroxide technology would not be expected to achieve significantly greater treatment efficiencies without additional testing and refinement. Maintaining consistent non-detect effluent would be a considerable challenge with either technology.

The same concerns and challenges regarding locating the necessary injection wells in locations that would not exacerbate the contamination apply to this alternative as well. In particular, locating sites in the Unit E where concentrations are below 1 ppb would be very difficult.

3.5.5 Alternative 5 - Groundwater Pumping – Injection into Deep Formation

Alternative 5 – Under this alternative, the untreated groundwater would be injected via a deep well located at the PLS Wagner Road facility. As discussed in the initial screening, this alternative utilizes injection of untreated groundwater into a deep geologic formation (e.g. the Mt. Simon formation, which lies deeper than 5,000 feet below ground level) for disposal of the purged groundwater. Because the depth of the receiving formation isolates it from any usable aquifers, the groundwater does not require treatment before it is injected.

The primary challenges associated with this alternative are: 1) identification of a deep formation that can accept at least 500 gallons per minute of untreated water; and 2) approval of a USEPA Underground Injection Control (UIC) Program permit for construction and operation of a deep disposal well. It is anticipated that both challenges could be met, though the permitting process could be lengthy. Since a Class I injection well had been installed on the PLS property in the past, the permitting process for a new well may be streamlined as compared to locating the well off-site. Also, there should be no concerns regarding zoning or inconsistent use of property with this alternative.

Based on past experience with previous deep well applications, some public opposition should be anticipated based on concerns that the untreated water may somehow “leak” back into the usable aquifers and/or because a significant portion of the groundwater resource will be depleted and placed beyond reach.

Additional challenges for this alternative will be construction of: 1) extraction wells in a densely populated residential area; 2) the pipeline from the leading edge to the PLS Wagner Road facility; and 3) the deep injection well itself. The uncertainty regarding the length of time needed to obtain access and then to construct the necessary infrastructure will make it difficult to determine where the leading edge of the plume would be when such infrastructure is ready. Consequently, the practical feasibility of this alternative is uncertain.

3.5.6 Alternative 6 – Groundwater Pumping -- Active Remediation and Treatment Proximate to the Huron River.

This alternative is similar to Alternatives 3a and 4a in that extraction wells would be used to control the plume and the purged groundwater would be conveyed to the Huron River via a new pipeline and then treated and discharged to the river under a new NPDES permit. The feature that distinguishes this alternative from the other active remediation alternatives is that the groundwater extraction, if necessary, would occur at a location closer to the Huron River. By implementing the active remediation proximate to the Huron River, this alternative would minimize the community disruption, potential delays, and uncertainties associated with the installation of the longer pipelines necessary under the other alternatives, while still being protective of any potential receptors. The institutional controls called for under Alternative 2 would not be required because, in the event that groundwater monitoring data indicate 1,4-dioxane concentrations at a receptor will exceed a Part 201 Generic Cleanup Criteria (e.g., water entering the Huron River with 1,4-dioxane above GSI or approaching drinking water wells at levels above 85 ppb), an active groundwater remedial system would be implemented. Thus, this alternative is not dependant on governmental decisions beyond PLS’ control.

Investigation and Remediation Plan

The potential downgradient receptors are domestic water wells and the Huron River. Immediately upon MDEQ approval of the necessary work plan, PLS would undertake a hydrogeological investigation to determine the fate of the Unit E plume and what receptors are implicated. This investigation would determine if, when, and at what concentrations 1,4-dioxane would arrive at the receptors. The migration of the Unit E plume would then be closely monitored to confirm its fate. Under this alternative, if groundwater monitoring data indicate 1,4-dioxane concentrations at a receptor will exceed the applicable Part 201 Generic Cleanup Criteria, an active remediation plan would be implemented near the Huron River as need to protect the relevant receptors.

The active remediation currently contemplated would involve the installation of extraction wells and a plume containment system. Such a system would employ technologies appropriate and available at the time of installation. Since the active remediation system may not be necessary for a number of years, it is expected that there could be advancements in remedial technologies that may have application to controlling the plume.

CHAPTER 4 - SCREENING OF REMEDIAL ALTERNATIVES

4.0 INTRODUCTION

In this Chapter, each of the 13 remedial alternatives described in Chapter 3 are subjected to an initial screening under the criteria specified in the Part 201 rules, as described below. The remedial alternatives that survive this screening are then subjected to a detailed evaluation in Chapter 5, which results in the identification of the preferred remedial alternative.

4.1 CRITERIA FOR SCREENING OF ALTERNATIVES

The anticipated construction and performance of each alternative were screened with respect to six criteria codified in Rule 530 (4) of the Part 201 rules, R 299.7530(4). The context of their use is described below. These criteria are then applied to the remedial alternatives in Section 4.2. The screening of the alternatives is summarized in Section 4.3.

- **Effectiveness**

  This criterion considers whether a control method or remedial technology will operate in the intended manner and have the desired impact on contaminant levels and risk.

- **Cost**

  Both the cost to install and the cost to operate, maintain, and monitor are considered.

- **Time**

  This criterion considers the total anticipated life of a project, which can be subdivided between construction and operation.

- **Acceptable Engineering Practices**

  The three engineering practices criteria are as follows:

  <u>Feasibility For The Location And Conditions Of Release</u> - Feasibility considers whether a method or technology is suitable for the physical, chemical, and biological system and whether it can be implemented.

  <u>Applicability To The Problem</u> – This criterion considers whether a remedial technology or risk control method can legally be applied. State and local government rules and regulations determine this question.

  <u>Reliability</u> – Reliability judges whether a technology or method can be depended upon to perform as designed in both the short and long-term.

4.2 Initial Screening of the Remedial Alternatives

As set forth below, each of the remedial alternatives is evaluated with respect to the five criteria that differ meaningfully among alternatives. All alternatives were created from process options that were individually considered effective for eliminating the risks posed by 1,4-dioxane in Unit E and each of the remedial alternatives themselves are effective. Therefore, this criterion is not discussed further within the discussion of each remedial alternative.

A narrative explanation of the initial screening is provided in the following text sections. The initial alternative screening is also summarized in tabular form in Table 2. In Table 2, each criterion, except cost, was ranked on a scale ranging from highly or moderately beneficial to little value to the project. Cost was ranked at five levels, due to the range in costs. Those five levels were: high, moderate-high, moderate, moderate-low, and low. The alternatives are ranked in accordance with their respective scores for each of the criteria.

4.3 Individual Alternatives

4.3.1 Alternative 1 - No Action

The No Action alternative would not actively control, treat, or even monitor the impacted groundwater. The dissolved 1,4-dioxane would be allowed to migrate, dissipate, and decay naturally.

Cost: There would be no capital or operating, maintenance, or monitoring cost for this alternative. It would be the least expensive alternative.

Time: Concentrations of 1,4-dioxane, a recalcitrant compound, would remain above clean-up goals until natural attenuation processes degrade or disperse the contaminant mass. Literature reports both aerobic and anaerobic biodegradation of 1,4-dioxane in nature. Groundwater dispersion, adsorption and biodegradation will continue to reduce 1,4-dioxane concentrations in the plume. The period of time required to achieve the applicable cleanup standard with no action would be dependant on the fate of the plume, identification of the receptor(s) potentially affected and the observed rate of attenuation. Additional investigation to obtain these data is necessary to determine when the applicable cleanup standard will be achieved under this alternative. It is anticipated that the cleanup horizon for this alternative would be somewhat longer than under the active remediation alternatives, but not significantly so.

Acceptable Engineering Practices:

Feasibility for the location and conditions of release -- The release is not threatening existing water supplies. The plume underlies and will spread under a densely populated area. This alternative avoids disruption of established uses. It is considered acceptable for the location and conditions of the release in the Unit E, making it moderately beneficial to the project.

Applicability to the problem – This alternative does not satisfy any of the remedial objectives under the Consent Judgment or Part 201 and, therefore, would not be acceptable to state and local governments and the public. It also would not include monitoring of remedial performance. Therefore, it does not satisfy this criterion.

Reliability – The only risk control methods are natural processes, which require no outside energy or resources to proceed; therefore, the alternative is reliable, though extremely slow.

This alternative was eliminated from further consideration.

4.3.2 Alternative 2 - Monitored Natural Attenuation and Institutional Controls

Alternative 2 would include monitoring of groundwater conditions and contaminated movement while controlling potential exposure risks through either deed restrictions or a local ordinance.

Cost: There would a limited amount of capital (it is assumed that up to 10 additional monitoring wells would be constructed) or operating and maintenance cost for this alternative. Monitoring costs would continue for an extended period of time, therefore, though the frequency of sampling, the number of monitoring wells sampled, and the number of analytes would decrease over time, total monitoring costs would be substantial. Also, legal costs may comprise an important component of this alternative due to the need to negotiate restrictive covenants or develop an appropriate ordinance. Enforcement (maintenance) of the restrictive covenants and/or the city ordinances would be triggered when a property sold or when construction permits or utility service are sought.

Time: Concentrations of 1,4-dioxane would remain above clean-up goals until natural attenuation processes degrade or disperse the contaminant mass. The period of time required to achieve the applicable cleanup standard would be dependant on the fate of the plume, identification of the receptor(s) potentially affected and the observed rate of attenuation. Additional investigation to obtain these data is necessary to determine when the applicable cleanup standard will be achieved under this alternative. It is anticipated that the cleanup horizon for this alternative would be somewhat longer than under the active remediation alternatives, but not significantly so.

Acceptable Engineering Practices:

<u>Feasibility for the location and conditions of release</u> -- The release is not threatening existing water supplies. The plume underlies and will spread under a densely populated area. This alternative avoids disruption of established uses. It is considered acceptable for the location and conditions of the release in the Unit E, making it moderately beneficial to the project.

<u>Applicability to the problem</u> – This alternative must meet two conditions: 1) that no adverse impact occurs as a result of contaminant migration, and 2) that enforceable land use restrictions or other institutional controls (such as a local groundwater control ordinance meeting the requirements of Part 201) prevent unacceptable risk from exposure to hazardous substances. Either of the two institutional control measures would adequately control risks to human health and the environment posed by the 1,4-dioxane in Unit E and would satisfy this criterion.

<u>Reliability</u> – The only risk control methods associated with natural attenuation are natural processes, which require no outside energy or resources to proceed. Deed restrictions and enforceable city ordinances would be easily maintained and essentially self-enforcing. Consequently, this alternative is reliable

This alternative was retained for detailed evaluation.

4.3.3 Alternatives 3a-e - Groundwater Pumping - Pipeline to and Treatment at Wagner Road

Five alternatives comprise this group. All five share:

- recovery of groundwater from multiple vertical wells,

- transmission of recovered water through individual pipelines, which combine with others up stream of a new pipeline,

- transmission of the total flow from all individual wells through the new pipeline to the PLS facility,

- chemical oxidation of 1,4-dioxane using either Ozone/Hydrogen Peroxide or Ultra-violet light/Hydrogen Peroxide technology without production of by-products at concentrations that pose risks, and

- disposal of treated water.

The alternatives within this group are distinguished by the treatment method and location where the treated water would be discharged. There are a number of considerations that are common to each of the alternatives in this group. Rather than repeat the discussion within each alternative, these issues are evaluated in summary fashion below:

Time: The time for adequate remediation would be in the same range for all alternatives that incorporate active remediation (groups 3, 4, 5, and 6) because overall duration would be primarily controlled by the natural rate of groundwater movement due to the large mass of contaminated groundwater. However, Alternative 3c would increase the clean-up duration by diluting or stalling the contaminant plume core.

Cost: The treatment system capital cost would be the same for each of the alternatives. (Of course, within each alternative, the cost of ozone and hydrogen peroxide treatment equipment would be less than for the UV/hydrogen peroxide system). The operating cost of groundwater recovery, transmission, and disposal would also be very similar. The capital cost of recovery wells, pumps, and the pipeline to the PLS Wagner Road facility would also be comparable among the four alternatives in this group. The cost of building the treated water disposal pipeline to the Huron River, however, would make Alternative 3a much more expensive than the other four in this group. Alternative 3e (Discharge to Honey Creek Tributary) would be the least expensive of the options within this group because it avoids the operation and maintenance costs associated with the three alternatives that use groundwater injection to dispose of the treated water.

Acceptable Engineering Practices:

<u>Feasibility for the location and conditions of release</u> – The key challenges that are common to all of alternatives in this group are the installation of a new transmission pipeline able to convey water to the PLS Wagner Road facility and the location of extraction wells and related infrastructure east of Maple Road, where the plume has migrated under Veterans Park and densely populated residential neighborhoods. The technical feasibility of constructing and installing such infrastructure is well established both at this site and others. The lengthy and uncertain construction timeline associated with construction of these elements, however, calls into question the practical feasibility of any of the alternatives within this group. For example, the transmission pipeline back to the Wagner Road facility would have pass under Interstate 94, a significant physical obstacle. Obtaining the necessary access to both public and private property and then constructing the pipeline would be a difficult and lengthy process. Similarly, installing the extraction wells and the necessary infrastructure in the residential areas where the leading edge of the plume is currently located will necessarily cause disruption to residents and users of the area roads. Many residents have objected to PLS' previous efforts to install monitoring and test wells in their neighborhood and the disruption associated with the scale of construction necessary to

implement any of these alternatives would be much greater and last for a longer period of time. Such community opposition to the construction of this infrastructure could delay the project.

The uncertainty regarding the length of time needed to obtain access and then to construct the necessary infrastructure will make it difficult to determine where the leading edge of the plume would be when such infrastructure is ready. Such delays would delay initiation of purging, which would allow the plume to migrate farther to the east, potentially requiring re-positioning of the recovery wells. This would in turn increase the level of disruption. Consequently, the practical feasibility of any of the remedial alternatives that involve construction of lengthy pipelines across property not owned by PLS is uncertain.

Applicability to the problem – All four alternatives in this group actively recover contaminated groundwater; treat the recovered water to reduce contaminant levels to required levels; and return treated water to the environment under one or more permits. They would all be applicable to the problem under present rules and regulations.

Reliability --

> Treatment Technology. Each of the alternatives within this group would utilize oxidation treatment technology, either ozone and hydrogen peroxide or UV/hydrogen peroxide. Both methods of removing 1,4-dioxane are considered reliable and properly engineered and operated systems are consistently able to reduce contaminants to below clean-up criteria.

> Infrastructure. Recovery and transmission of impacted groundwater, treatment, and disposal of treated water in the manner contemplated by these alternatives involve well-proven basic engineering procedures, construction materials, and O&M procedures. Most components of this system would be reliable to the same degree as any well-engineered public water supply or wastewater treatment system.

The above evaluations apply to each of the alternatives within this group. The differences between the alternatives are discussed and evaluated below:

Alternative 3a – Treated groundwater is transmitted through a new pipeline to the Huron River for disposal under an NPDES permit.

Cost: The cost of constructing a transmission pipeline to the Huron River would make this the most expensive of the alternatives in this group.

Acceptable Engineering Practices:

Feasibility for the location and conditions of release **--** In addition to the shared issues associated with constructing pipeline from the extraction wells back to the PLS facility, this alternative presents the challenges and potential delays associated with the construction of a lengthy transmission pipeline needed to convey treated water from the PLS Wagner Road facility to the Huron River. Access for this pipeline would have to be obtained from three governmental bodies as well as private landowners. The feasibility of this alternative is believed to be comparable to the reinjection alternatives, each of which presents analogous challenges associated with the placement of multiple injection wells. Alternative 3e (Discharge to Honey Creek Tributary) involves the fewest construction/access issues and is considered the most feasible alternative within this group.

Reliability -- Under this alternative, control of biological growths and precipitated inorganics will be less difficult than for alternatives 3b, 3c, and 3d because a single, large-diameter pipeline to the Huron River, rather than individual smaller pipelines to each injection well are used. This reduces the total footage of pipeline as well as the footage of small diameter piping, whose diameter, overall cross-section, and transmission capability is more greatly impacted by a similar degree of coating than is that of a larger pipeline.

This alternative was retained for further evaluation.

Alternative 3b – Treated groundwater is injected into the Unit E through multiple new injection wells at locations where 1,4-dioxane levels exceed 85 ppb under Part 22 permit.

Acceptable Engineering Practices:

Feasibility for the location and conditions of release -- In addition to the shared issues associated with constructing pipeline from the extraction wells back to the PLS facility, the defining challenge associated with each of the reinjection alternatives (3b- 3d) is locating a sufficient number of injection wells that are able to receive the necessary volume of water and do so without disruption of capture or other remedial objectives. Injection well locations must be carefully chosen to minimize dilution and, more importantly, deflection of the plume, both of which would reduce the effectiveness and efficiency of the plume and extend the remediation. In addition, injecting the same amount of water into the plume as extracted will make capturing the plume difficult. A compensating potential benefit of this alternative is that the injection wells would likely be placed on PLS property, thus making the construction of injection wells and pipelines from the treatment center simpler than alternatives where wells would be installed off site. The reinjection alternatives also avoid the Huron River transmission pipeline called for in alternative 3a.

Reliability -- Injection of treated water within the most contaminated portion of the plume would have two significant adverse effects on the overall remediation: 1) contamination would be diluted, increasing the total volume of water that would have to be treated to destroy the targeted 1,4-dioxane mass and the length of the remediation: and 2) the injection of water within the plume core would be expected to occur up gradient of the recovery wells; this would stall or retard the down gradient movement of contaminated groundwater up gradient of the injection wells. Reliability of this alternative for containment of the plume is uncertain because the addition of water upgradient into contaminated portions of the plume may cause the plume to override current flow patterns and compromise capture.

Consistent pipeline and production and injection well cleaning and maintenance to remove biological growths and precipitated, oxidized materials will be necessary to maintain disposal rates. This process is extremely important given the much greater impact of a coating of similar thickness inside a small diameter pipe versus a larger pipe.

The alternative was eliminated due to plume distortion and dilution and increased project duration.

Alternative 3c – Treated groundwater is injected into the Unit E through multiple new wells at locations where 1,4-dioxane levels are less than 85 ppb but exceed 1 ppb under a Part 22 permit.

Acceptable Engineering Practices:

Feasibility for the location and conditions of release -- In addition to the shared issues associated with constructing pipeline from the extraction wells back to the PLS facility, the defining challenge associated with each of the reinjection alternatives (3b- 3d) is locating a sufficient number of injection wells that are able to accept the necessary volume of water and do so without disruption of containment or other remedial objectives. Injection well locations must be carefully chosen to minimize dilution and, more importantly, deflection of the plume, both of which would reduce the effectiveness and efficiency of the plume and extend the remediation. In addition, injecting the same amount of water into the plume as extracted will make capturing the plume difficult. A compensating potential benefit of this alternative is that the injection wells would likely be placed on PLS property, thus making the construction of injection wells and pipelines from the treatment center simpler than alternatives where wells would be installed off site. The reinjection alternatives also avoid the Huron River transmission pipeline called for in alternative 3a.

Reliability – The reliability of this option are similar to that of Alternative 3b, with one main difference. Treated groundwater would be injected into the contaminated groundwater plume at points where 1,4-dioxane concentrations are below the clean-up goal of 85 µg/L and above 1 µg/L. Careful placement and use of these wells could force more impacted water toward the centerline of the plume and toward the recovery wells, which would increase the reliability of this alternative and potentially shorten the cleanup horizon.

This alternative was retained for detailed evaluation.

Alternative 3d – Treated groundwater is injected into the Unit E through multiple new wells at locations where 1,4-dioxane levels are less than 1 ppb under a Part 22 permit.

Acceptable Engineering Practices:

Feasibility for the location and conditions of release -- In addition to the shared issues associated with constructing pipeline from the extraction wells back to the PLS facility, the defining challenge associated with each of the reinjection alternatives (3b- 3d) is locating a sufficient number of injection wells to handle the necessary volume of water. Injection well locations must be carefully chosen to minimize dilution and, more importantly, deflection of the plume, both of which would reduce the effectiveness and efficiency of the plume and extend the remediation. In addition, injecting the same amount of water into the plume as extracted will make capturing the plume difficult. A compensating potential benefit of this alternative is that the injection wells would likely be placed on PLS property, thus making the construction of injection wells and pipelines from the treatment center simpler than alternatives where wells would be installed off site. The reinjection alternatives also avoid the Huron River transmission pipeline called for in alternative 3a.

Reliability –

Treatment Technology. A groundwater discharge permit under Part 22 would be required to authorize a groundwater discharge to an uncontaminated portion of the Unit E. The Part 22 rules prohibit the effluent being discharged into an uncontaminated portion of the aquifer from containing any detectable amounts of contaminants. The ultra-violet light and hydrogen peroxide treatment technology has in the past been able to, in limited circumstances (e.g., low influent concentrations), reduce contaminant levels to non-detect levels for certain periods of time, but not continuously. Even under favorable conditions, large amounts of electricity and precise, non–linear control of the remedial equipment are needed to achieve this level of performance. PLS' ozone and hydrogen peroxide technology is unlikely to achieve significantly better treatment efficiencies, without additional testing and refining of the technology. Maintaining consistent non-detect effluent would be a considerable challenge with either technology.

Infrastructure. The injection wells would be placed outside the identified contaminant plume. The treated water pipelines connecting the treatment center to each injection well would be longer, presenting a statistically greater probability of failure than for alternatives 3b and 3c. Control of biological growths and precipitated inorganics will be slightly more difficult that in alternatives 3b and 3c because individual treated-water pipelines to each injection well will be longer.

This alternative was eliminated based on the lack of a reliable technology that would consistently reduce 1,4-dioxane to non-detectable levels, as would be required by an injection permit.

Alternative 3e -- Groundwater Pumping, Pipeline to Wagner road Facility, Treatment at Wagner Road, Discharge into Honey Creek Tributary

Cost: This is the least costly alternative within this group because it avoids both the need for an extremely long pipeline from the Wagner Road facility to the Huron River and the placement of multiple injection wells.

Acceptable Engineering Practices:

Feasibility for the location and conditions of release – This alternative is the most feasible of the alternatives in this group because it avoids the potential delays and uncertainties associated with both the construction of the transmission pipeline from the Wagner Road facility to the Huron River and the placement of multiple injection wells. There has, however, been stiff community opposition to the current NPDES permit discharge to Honey Creek and to past efforts to modify that permit. The opposition has contended that discharge to the Honey Creek of significant volumes of water is inappropriate for that watercourse given downstream uses. PLS does not agree with these contentions.
Applicability to the problem – Based on experience with past NPDES permit amendments, it is expected that any attempt to increase the discharge volume limit of the permit will be opposed. Although such opposition may delay implementation of this remedy, such a permit amendment is considered likely to be granted in compliance with the relevant regulations.

This alternative was retained for further evaluation.

4.3.4 Alternative 4a-d - Groundwater Pumping – Treatment near Maple Road

Four alternatives fall within this group. All four share:

- recovery of groundwater from 3 vertical wells,
- transmission of recovered water through individual pipelines, which combine with others or proceed directly to a water treatment compound built on PLS-owned or PLS-leased property near Maple Road,
- chemical oxidation of 1,4-dioxane without production of by-products at concentrations that pose risks, and
- disposal of treated water.

The alternatives within this group are distinguished by the treatment method and location where the treated water would be discharged. The four alternatives within this group are very similar to those of Group 3. The primary difference is the location of the treatment equipment: at one or more locations near Maple Road in Group 4 versus at the PLS Wagner Road facility in Group 3. As a result, the screening of the alternatives in Group 4 produces analogous results to that of Group 3.

There are a number of considerations that are common to each of the alternatives in this group. Rather than repeat the discussion within each alternative, these issues are evaluated in summary fashion below:

Time: As stated above, the time for remediation is anticipated to be approximately the same for all active alternatives in Groups 3, 4, 5, and 6 because overall duration would be primarily controlled by the natural rate of groundwater movement. However, Alternative 4c would conceivably increase the clean-up duration by diluting or stalling the contaminant plume core.

Cost: The capital cost of recovery wells, pumps, and pipelines to a treatment center or centers near Maple Road would be comparable among the four alternatives in this group. The operating cost of groundwater recovery, transmission, and disposal would be similar for the four alternatives. However, the cost of treated water disposal via a pipeline to the Huron River would make Alternative 4a more expensive than the other three.

Acceptable Engineering Practices:

Feasibility for the location and conditions of release – The key challenges that are common to all of alternatives in this group are the location of extraction wells and related infrastructure east of Maple Road, where the plume underlies Veterans Park and has migrated under densely populated residential neighborhoods and the installation of transmission pipelines to convey water from the recovery wells to the treatment center located near Maple Road. The technical feasibility of constructing and installing such infrastructure is well established both at this site and others. The lengthy and uncertain construction timeline associated with construction of these elements, however, calls into question the practical feasibility of any of the alternatives within this group. For example, installing the extraction wells and the necessary infrastructure in the residential areas where the leading edge of the plume is currently located will necessarily cause disruption to residents and users of the area roads. Many residents have objected to PLS' previous efforts to install monitoring and test wells in their neighborhood and the disruption associated with the scale of construction necessary to implement any of these alternatives would be much greater and last for a longer period of time. Community opposition to the construction of this infrastructure could delay the project. Obtaining access (for the duration of the project) to a property that is large enough to accommodate one or more treatment units in this congested area will be difficult, if not impossible. At a minimum obtaining access for the treatment center would be a lengthy process and would likely involve litigation. Although Veterans Park presents an attractive alternative, it is anticipated that there would be significant public opposition to locating a treatment center in such a heavily utilized recreational facility.

The uncertainty regarding the length of time needed to obtain access and then to construct the necessary infrastructure will make it difficult to determine where the leading edge of the plume would be when such infrastructure is ready. Such delays would delay initiation of purging, which would allow the plume to migrate farther to the east, potentially requiring PLS to re-position the recovery wells. This in turn would increase the level of disruption. Consequently, the practical feasibility of any of the remedial alternatives in this group is uncertain.

Applicability to the problem – All four alternatives in this group actively destroy contaminants and can reduce contaminant levels to required levels; therefore, they would be applicable to the problem under present rules and regulations.

Reliability --

Treatment Technology. Each of the alternatives within this group would utilize the ozone and hydrogen peroxide treatment technology since UV/hydrogen peroxide technology was eliminated during the process option screening as inappropriate for this location. This method of removing 1,4-dioxane is considered reliable and properly engineered and operated systems are consistently able to reduce contaminants to below clean-up criteria.

Infrastructure. Recovery and transmission of impacted groundwater, treatment, and disposal of treated water in the manner contemplated by these alternatives involve well-proven basic engineering procedures, construction materials, and O&M procedures. Most components of this system would be reliable to the same degree as any well-engineered public water supply or wastewater treatment system.

The above evaluations apply to each of the alternatives within this group. The differences between the alternatives are discussed and evaluated below:

Alternative 4a – Ozone and hydrogen peroxide treatment followed by transmission through a new pipeline to the Huron River for disposal under an NPDES permit.

Cost: The cost of constructing a transmission pipeline to the Huron River would make this the most expensive of the alternatives in this group.

Acceptable Engineering Practices:

Feasibility for the location and conditions of release -- A new, treated water pipeline to the Huron River would be as difficult and costly to construct as a pipeline from Maple Road to the Wagner Road facility, or one from the Wagner Road facility to the Huron River. The pipeline would originate near Maple Road. It will be constructed below grade and traverse both public and private property. It will also pass under Interstate 94. Access for this pipeline would have to be obtained from three governmental bodies as well as private landowners. The feasibility of this alternative is believed to be comparable to the reinjection alternatives, each of which presents analogous challenges associated with the placement of multiple injection wells.

Reliability --Biological growths and precipitated inorganics will be less problematic than for alternatives 4b, 4c, and 4d because a single, large-diameter pipeline to the Huron River, rather than smaller pipelines to each treated water disposal well would be used. This would reduce the total footage of pipeline and the footage of small diameter piping, whose transmission capacity is more greatly impacted by a similar degree of coating than is that of a larger pipeline.

This alternative was retained for further evaluation.

Alternative 4b – Ozone and hydrogen peroxide treatment followed by injection into Unit E through multiple new wells at locations where 1,4-dioxane levels exceed 85 ppb.

Acceptable Engineering Practices:

Feasibility for the location and conditions of release -- Injection well locations must be carefully chosen to minimize dilution and, more importantly, deflection of the plume, both of which would reduce the effectiveness and efficiency of the plume and extend the remediation as well as PLS' ability to capture the leading edge. Given the volume of water that would need to be injected (500 gpm) and the very complicated geology of the aquifer in the Veterans Park/Maple Road area, siting a sufficient number of injection wells would be a shared challenge of all of the injection alternatives (4b-d). Additionally, injecting the same amount of water as is being extracted this close to the location of the extraction wells will make capturing the plume difficult – more difficult than if the water were transferred back to the PLS site as contemplated under alternatives 3(b-d). The reinjection alternatives, however avoid the Huron River transmission pipeline called for in alternatives 3a and 4a. Finally, access to such locations, which would not be on PLS-controlled property, as well as the construction of injection wells and pipelines from the treatment center, would be more difficult to obtain than for wells on PLS property.

Reliability – Treated water injection within the plume core would have two significant adverse effects: 1) contamination levels would be lowered, increasing the total mass of water that would have to be treated to destroy the targeted 1,4-dioxane mass and, as a result, the length of the remediation; and 2) the injection of water up gradient of the recovery wells would stall the down gradient movement of contaminated groundwater and delay its capture by the recovery (production) wells. Reliability of this alternative for containment of the plume is uncertain because the addition of water upgradient into contaminated portions of the plume may cause the plume to override current flow patterns and compromise capture.

Consistent pipeline and well maintenance to remove biological growths and precipitants will be necessary to maintain disposal rates. This process is particularly important to the proper operation of the small diameter pipe associated with the reinjection alternatives within this group.

The alternative was eliminated due to plume distortion and dilution and increased project duration.

Alternative 4c – Ozone and hydrogen peroxide treatment followed by injection into Unit E through multiple new wells at locations where 1,4-dioxane levels are less than 85 ppb but exceed 1 ppb.

Acceptable Engineering Practices:

Feasibility for the location and conditions of release -- Injection well locations must be carefully chosen to minimize dilution and, more importantly, deflection of the plume, both of which would reduce the effectiveness and efficiency of the plume and extend the remediation as well as PLS' ability to capture the leading edge. Given the volume of water that would need to be injected (500 gpm) and the very complicated geology of the aquifer in the Veterans Park/Maple Road area, siting a sufficient number of injection wells would be a shared challenge of all of the injection alternatives (4b-d). Additionally, injecting the same amount of water as is being extracted this close to the location of the extraction wells will make capturing the plume difficult – more difficult than if the water were transferred back to the PLS site, as contemplated under alternatives 3(b-d). The reinjection alternatives, however avoid the Huron River transmission pipeline called for in alternatives 3a and 4a.

Finally, access to reinjection well locations, which would not be on PLS-controlled property, as well as the construction of injection wells and pipelines from the treatment center, would be more difficult to obtain than for wells on PLS property.

Reliability – Except as explained here, the reliability of this alternative is the same as Alternative 4b. The chemical, construction, and operational reliability of this option differs from that of Alternative 4b, in one important way. Treated groundwater would be injected into the contaminant plume where 1,4-dioxane concentrations are below the clean-up goal of 85 ppb and above 1 ppb. Careful placement and use of these wells could guide water with contaminant levels above clean-up goals toward the centerline of the plume and the recovery wells, which would increase the reliability of this alternative and potentially shorten the cleanup horizon.

This alternative was retained for detailed evaluation.

Alternative 4d - Treated groundwater is injected into the Unit E through multiple new wells at locations where 1,4-dioxane levels are less than 1 ppb under a Part 22 permit.

Acceptable Engineering Practices:

Feasibility for the location and conditions of release -- Injection well locations must be carefully chosen to minimize dilution and, more importantly, deflection of the plume, both of which would reduce the effectiveness and efficiency of the plume and extend the remediation as well as PLS' ability to capture the leading edge. Given the volume of water that would need to be injected (500 gpm) and the very complicated geology of the aquifer in the Veterans Park/Maple Road area, siting a sufficient number of injection wells would be a shared challenge of all of the injection alternatives (4b-d). Additionally, injecting the same amount of water as is being extracted this close to the location of the extraction wells will make capturing the plume difficult – more difficult than if the water were transferred back to the PLS site. Finally, access to reinjection well locations, which would not be on PLS-controlled property, as well as the construction of injection wells and pipelines from the treatment center, would be more difficult to obtain than for wells on PLS property.

Reliability –

> Treatment Technology. A groundwater discharge permit under Part 22 would be required to authorize a groundwater discharge to an uncontaminated portion of the Unit E. The Part 22 rules prohibit the effluent being discharged into an uncontaminated portion of the aquifer from containing any detectable amounts of contaminants. The ultra-violet light and hydrogen peroxide treatment technology has in the past been able to, in limited circumstances (e.g., low influent concentrations), reduce contaminant levels to non-detect levels for certain periods of time, but not continuously. Even under favorable conditions, large amounts of electricity and precise, non–linear control of the remedial equipment are needed to achieve this level of performance. PLS' ozone and hydrogen peroxide technology is unlikely to achieve significantly better treatment efficiencies, without additional testing and refining of the technology. Maintaining consistent non-detect effluent would be a considerable challenge with either technology.
>
> Infrastructure. The injection wells would be placed outside the identified contaminant plume. The treated water pipelines connecting the treatment center to each injection well would be longer, presenting a statistically greater probability of failure than for alternatives 4b and 4c. Control of biological growths and precipitated inorganics will be slightly more difficult that in alternatives 4b and 4c because individual treated-water pipelines to each injection well will be longer.

This alternative was eliminated based on the lack of a reliable technology that would consistently reduce 1,4-dioxane to non-detectable levels, as would be required by an injection permit.

4.3.5 Alternative 5 - Groundwater Pumping – Injection into Deep Formation at Wagner Road

Many of the criteria related to this alternative have been discussed in Section 4.3.3. (Alternatives 3(a-e) - Groundwater Pumping - Pipeline to and Treatment at Wagner Road) since this alternative involves conveying the purged groundwater via a new pipeline to the Wagner Road Facility. What differs in this alternative is that the water would not be treated but rather would be injected into a deep geologic formation, via a deep injection well to be constructed at the PLS site.

Time: The time for adequate remediation would be the same as for all alternatives that incorporate active remediation (groups 3, 4, 5, and 6) because overall duration would be primarily controlled by the natural rate of groundwater movement.

Cost: The capital cost of recovery wells, pumps, and the pipeline to the PLS Wagner Road facility would be comparable among with group 3 alternatives. The operating costs of groundwater recovery and transmission would be very similar to the group 3 alternatives. There would be no costs for treatment, but rather a cost for the installation of one or more deep injection wells. By eliminating treatment, there is a significant reduction in both capital and operation and maintenance costs over time. Even with the significant cost of installing a deep well, this cost is low relative to the alternatives that require treatment.

Acceptable Engineering Practices:

<u>Feasibility for the location and conditions of release</u> -- The key challenges associated with this alternative include the installation of a new transmission pipeline able to convey water to the PLS Wagner Road facility, and the location of extraction wells and related infrastructure east of Maple Road, where the plume underlies Veterans Park and has migrated under densely populated residential neighborhoods. The technical feasibility of constructing and installing such infrastructure is well established both at this site and others. The lengthy and uncertain construction timeline associated with construction of these elements, however, makes the feasibility of this alternative uncertain. For example, the transmission pipeline back to the Wagner Road facility would have pass under Interstate 94, a significant physical obstacle. Obtaining the necessary access to both public and private property and then constructing the pipeline would be a difficult and lengthy process. Similarly, installing the extraction wells and the necessary infrastructure in the residential areas where the leading edge of the plume is currently located will necessarily cause disruption to residents and users of the area roads. Many residents have previously objected to PLS' previous efforts to install monitoring and test wells in their neighborhood and the disruption associated with the scale of construction necessary to implement any of these alternatives would be much greater and last for a longer period of time. Community opposition to the construction of this infrastructure could delay the project.

The uncertainty regarding the length of time needed to obtain access and then to construct the necessary infrastructure will make it difficult to determine where the leading edge of the plume would be when such infrastructure is ready. Such delays would delay initiation of purging, which would allow the plume to migrate farther to the east, potentially requiring PLS to re-position the recovery wells. This would in turn increase the level of disruption. Consequently, the practical feasibility of any of the remedial alternatives that involve construction of lengthy pipelines across property not owned by PLS is uncertain.

Installation of the deep injection well itself uses well-established technology. Strict USEPA procedures are in place to ensure wells are installed to acceptable engineering practices. Gelman formerly installed and operated a deep injection well for process wastewater at the Wagner Road facility (and closed it when it reached the end of its life).

Applicability to the problem – This alternative actively recovers contaminated groundwater and returns water to the environment under one or more permits into a safe (inaccessible) environment. This alternative would be applicable to the problem under present rules and regulations.

Reliability -- A properly designed and maintained deep injection well is expected to be reliable.

This alternative has been retained for further evaluation.

4.3.6 Alternative 6 – Groundwater Pumping -- Active Remediation and Treatment Proximate to Huron River.

This alternative is similar to Alternatives 3a and 4a in that extraction wells would be used to control the plume. Under each of these alternatives the purged groundwater would be conveyed to the Huron River via a new pipeline and then treated and discharged to the river under a new NPDES permit. The feature that distinguishes this alternative from the other active remediation alternatives is that the groundwater extraction, if necessary, would occur at a location closer to the Huron River.

Time: The period of time required to achieve the applicable cleanup standard would be dependant on the fate of the plume, identification of the receptor(s) potentially affected and the observed rate of attenuation. Additional investigation to obtain these data is necessary to determine when the applicable cleanup standard will be achieved under this alternative.

Cost: Costs for this alternative are expected to be very high in comparison to the other active remediation alternatives due to the additional costs associated with the required hydrogeological investigation/monitoring and the somewhat longer cleanup horizon if active remediation is necessary. The effect of these additional costs are offset to some degree because costs associated with implementing an active remediation system will not be incurred as soon as under the other alternatives. If active remediation were not necessary, costs would be comparable to Alternative 2.

Acceptable Engineering Practices:

Feasibility for the location and conditions of release -- The release is not threatening existing water supplies. The plume underlies and will spread under a densely populated area. This alternative avoids disruption of established uses and pushes the installation of infrastructure nearer to the river, where land uses are more suitable and pipe runs can be shorter. The active remediation plan assures that no downgradient receptors will be exposed to the plume as it migrates. By implementing the active remediation proximate to the Huron River, this alternative would minimize the community disruption, potential delays, and uncertainties associated with the installation of the longer pipelines necessary under the other alternatives, while still being protective of any potential receptors. The institutional controls called for under Alternative 2 would not be required because, in the event that groundwater monitoring data indicate 1,4-dioxane concentrations at a receptor will exceed a Part 201 Generic Cleanup Criteria (e.g., water entering the Huron River with 1,4-dioxane above GSI or approaching drinking water wells at levels above 85 ppb), an active groundwater remedial system would be implemented. Thus, this alternative is not dependant on governmental decisions beyond PLS' control. Both of these factors support the feasibility of this alternative, it is considered acceptable for the location and conditions of the release in the Unit E.

Applicability to the Problem – This alternative active remediation and natural processes to reduce contaminant levels to legally acceptable concentrations. As such, it is applicable to the problem.

Reliability – The initial hydrogeological investigation will be used to predict the fate of the Unit E plume. The actual migration of the plume would then be closely monitored with the placement of additional monitoring wells. Such investigatory techniques are considered reliable. The contemplated active remediation plan involves installation of groundwater recovery wells, pumps and pipelines. Groundwater recovery wells and pumps, pipelines, and ex-situ treatment vessels have been shown to be reliable during the chemical oxidation remediation of shallower 1,4-dioxane contaminated aquifers. Periodic inspection and cleaning of wells, pumps, and pipelines will maintain the mechanical efficiency of the system.

Pilot testing has indicated that a combination of ozone and hydrogen peroxide can destroy 1,4-dioxane during the time available for ex-situ treatment involving high volumes of groundwater. Ozone and hydrogen peroxide are energetic and reliably degrade 1,4-dioxane when applied in sufficient quantity. To assure the latter, 1,4-dioxane in the recovered groundwater will be measured periodically and the treatment system operating conditions changed as needed. This technology is currently under evaluation and appears to be promising. However, if it proves infeasible or inappropriate, the U-V oxidation system currently in use at the PLS site, or some other appropriate substitute, will be implemented.

This alternative has been retained for further analysis.

CHAPTER 5 – DETAILED ANALYSIS OF REMEDIAL ACTION ALTERNATIVES

5.0 INTRODUCTION AND SUMMARY OF ASSESSMENT

In this Chapter, the remedial alternatives that survived the initial screening in Chapter 4, are subjected to a more detailed evaluation under the criteria specified in Rule 530(5) of the Part 201 rules (R. 299.7530(5)). The purpose of this analysis is to develop additional information about each alternative so that an objective recommendation of an appropriate remedy can be made. The detailed evaluations of the alternatives presented in this chapter are based on many technical assumptions. A summary of these assumptions is provided in Appendix C. The alternatives and other information discussed in this chapter are presented on Table 3.

As discussed below, all of the remedial alternatives reviewed in this Chapter are equally protective of the environment. Currently, the Unit E is contaminated with a significant plume of 1,4-dioxane that has expanded under the City of Ann Arbor. Because of the depth of the contamination and the fact that the City's municipal water supply relies on water drawn from the Huron River, the plume does not present an imminent current threat to public health and safety or to the environment. All of the alternatives that are examined involve interception or reduction in contaminant levels to acceptable levels before reaching potential receptors. Of these equally protective alternatives, Alternative 6, Active Remediation Proximate to Huron River, is the preferred option because it avoids the disruption of the City neighborhoods and the uncertainty regarding the practical feasibility of the alternatives that would attempt to contain the leading edge of the plume closer to its current location.

Each of the alternatives that attempts to contain the leading edge of the plume near its current location would cause disruption of established neighborhoods, significant use of public and private rights-of-way for transmission pipelines and infrastructure, traffic interruptions, construction-related safety risks to residents, and incongruous use of property given the residential (and recreational) uses above the plume. The City of Ann Arbor and local residents have already expressed their concern that neighborhoods and streets not be unnecessarily interrupted. The detailed evaluation presented in this Chapter establishes that the "leading edge" alternatives offer no environmental benefit over remedial Alternative 6, which involves investigating the fate of the plume and, if necessary, interception, capture, treatment, and disposal at a location near the Huron River that would involve less disruption.

Because of the current location of the leading edge of the plume, each of the "leading edge" alternatives necessarily requires the installation of lengthy transmission pipelines. As discussed in Chapter 4, the equally lengthy construction horizon for these alternatives (after obtaining necessary access) and the continued migration of the plume calls into question the practical feasibility of these alternatives. At a minimum, the goal of capturing the leading edge of the plume would be compromised because the recovery wells would have to be placed well downgradient of the current leading edge to ensure that capture could be still achieved when the infrastructure became available.

From a cost standpoint, monitored attenuation with institutional controls (remedial Alternative 2) is the least costly alternative. PLS, however, does not believe that this alternative adequately addresses political and societal concerns and it is not favored for this reason. All of the other options are extremely costly. Based on current dollars, the selected Alternative 6 is the most expensive option, but is in the same order of magnitude as the other alternatives. This alternative has the advantage, however, of avoiding the disruptions associated with the other active remediation alternatives, while providing the same level of protection.

5.1 CRITERIA FOR ANALYSIS

Rule 530(5) of the Part 201 rules (R. 299.7530(5)) lists nine factors to be used for the detailed evaluation of remedial alternatives. These factors are:

1. Assessment of the effectiveness of the alternative in protecting the public health, safety, and welfare and the environment and in responding to the remedy selection factors identified in R 299.5601 and R 299.5603.

2. Refinement and specification of alternatives in detail.

3. Detailed cost estimation, including operation and maintenance costs, over time, of implementing the final remedy.

4. Evaluation of engineering implementation, reliability, and constructability.

5. Evaluation of technical feasibility

6. Analysis of whether recycling, reuse, waste minimization, waste biodegradation, waste destruction, or other advanced, innovative, or alternative technologies are appropriate.

7. An analysis of any adverse environmental impacts, methods of mitigation, and costs of mitigation, including those adverse impacts, which may result from, planned demolition activities.

8. Analysis of the risks and impacts remaining after implementation of the remedy.

9. Analysis of the extent to which the alternative attains a degree of cleanup or control of hazardous substances that complies with legally applicable or relevant and appropriate requirements, rules, criteria, limitations, and standards of state and federal environmental law.

In addition, as required by the first factor, the evaluation will also consider the selection factors identified in R 299.5601 and R 299.5603. Although some of these factors are similar to those listed in Rule 530, they are all listed below for completeness:

1. The effectiveness of alternatives in protecting the public health, safety, and welfare and the environment.

2. The long-term uncertainties associated with the proposed remedial action.

3. The persistence, toxicity, mobility, and propensity to bioaccumulate of the hazardous substances.

4. The short and long-term potential for adverse health effects from human exposure.

5. Costs of remedial action, including long-term maintenance costs.

6. Reliability of the alternatives.

7. The potential for future remedial action costs if an alternative fails.

8. The potential threat to human health, safety, and welfare and the environment associated with excavation, transportation, and redisposal or containment.

9. The ability to monitor remedial performance.

10. For remedial actions that require the opportunity for public comment under section 20120d of the act, the public's perspective about the extent to which the proposed remedial action effectively addresses requirements specified in [Part 201 and the Part 201 rules].

5.2 DETAILED ANALYSIS OF ALTERNATIVES

Eight alternatives survived the screening process. The alternatives are evaluated in detail, as required by Rule 530 in the subsections that follow. The remainder of this section discusses those Rule 530 factors that have been judged to be equivalent for the eight surviving alternatives.

5.2.1 Evaluation of Common Criteria

The evaluation of each of the alternatives is equivalent for a number of the criteria. In order to avoid unnecessary repetition within the discussion of the individual alternatives, the evaluation under these criteria is summarized below:

Assessment Of The Effectiveness Of The Alternative In Protecting The Public Health, Safety, And The Environment

Currently, the Unit E is contaminated with a significant plume of 1,4-dioxane that has expanded under the City of Ann Arbor. Because of the depth of the contamination and the fact that the City relies on municipal water drawn from the Huron River, the plume does not present an imminent current threat to public health and safety or to the environment.

All of the alternatives that were examined involve interception or reduction in contaminant levels to acceptable levels before reaching potential receptors. The only differences between alternatives from this standpoint do not appear to be material. The "leading edge" alternatives (all but 2 and 6) would attempt to prevent expansion of areas of contamination above drinking water criterion. Alternative 2 would not, by design, contain the plume at all, while Alternative 6 would contain the plume as necessary prior to any potential impact on downgradient receptors. These distinctions make little or no practical difference in terms of protection of public health and the environment. Under any alternative, no one would actually be consuming groundwater contaminated with 1,4-dioxane. Over time roughly the same area of Unit E would contain detectable levels of 1,4-dioxane (no matter which alternative is selected) because, by design, even the "leading edge" alternatives do not capture all of the 1,4-dioxane. Finally, it is not possible to quantify the difference in area inside a "leading edge" containment alternative versus alternatives 2 and 6. This is because all of the leading edge alternatives are subject to significant uncertainty (in timeliness) because of access and other practical implementation issues. At a minimum, the goal of capturing the leading edge of the plume near its current location would be compromised because the recovery wells would have to be placed well downgradient of the current leading edge to ensure that capture could be still achieved when the infrastructure became available.

Alternative 2 and Alternative 6 would allow the plume (as defined by concentrations above 85 ppb of 1,4-dioxane) to migrate within the Unit E beyond the current estimated contours. This movement, however, does not itself have a different impact on the public health and safety or the environment. Both alternatives protect downgradient receptors. In addition, under all of the options, the termination criteria are the same and the flow paths for any residual 1,4-dioxane (<85 ppb) would be the same, even under the "leading edge" options considered below.

Analysis Of Whether Recycling, Reuse, Waste Minimization, Waste Biodegradation, Waste Destruction, Or Other Advanced, Innovative, Or Alternative Technologies Are Appropriate

Recycling and reuse would require collection of 1,4-dioxane, dissolved in groundwater at part per billion levels. The miscibility of the contaminant with water and the large volume of water that must be processed each minute to control the Unit E plume make recycling 1,4-dioxane impossible. Chemical oxidation to destroy the contaminant is the only practical means for handling the contaminant.

Ex-situ treatment raises the possibility that groundwater, once it has been treated to remove 1,4-dioxane, could be consumed as either drinking water or process water. At this time PLS does not consider reuse of water after treatment to be viable because the primary customer for consumption of the water (the City of Ann Arbor) does not need the water supply and may justifiably reject it as presenting an unnecessary and unacceptable risk for its customers. No significant industrial consumer of water has been identified in proximity to Unit E. Accordingly, there does not appear to be any realistic opportunity at this time to recycle or reuse (as opposed to discharge) treated groundwater and this factor will not be discussed under the individual alternatives analyses.

Analysis Of The Risks And Impacts Remaining After Implementation Of The Remedy

The risks posed by the Unit E contamination are very low at this point in time. In general, greater risks are generated by construction and operations of the remedial systems than by the presence and continued migration of 1,4-dioxane in Unit E. The risks presented by the construction and implementation that are common to the surviving alternatives (except for monitored attenuation) are summarized below:

<u>Construction</u> – Construction of recovery and injection wells, pipelines, and treatment facilities employs traditional civil and mechanical engineering practices and contractor methods. Though the scope of design and construction will differ among alternatives, the relative reliability of the practices and methods will reduce risks and impacts to levels that are essentially equivalent.

<u>Operations</u> – Monitoring and/or operations of the remedial systems will not pose significantly different risks or impacts because automatic and manual control systems will be interlocked with critical function or parameter sensors. This will reduce the probability and duration of system upsets to essentially equivalent probabilities among active alternatives.

<u>Post-operations</u> – Each alternative will operate until 1,4-dioxane concentrations in the targeted portion of Unit E have been reduced to or below 85 ppb. Therefore, the risks and impacts remaining after the post-operations period do not differ materially among the alternatives.

5.2.2 Detailed Evaluation of Individual Alternatives

Based on the above unified comparison of alternatives to Rule 530 criteria, the remedial alternatives will be evaluated in detail with respect to four criteria below.

1. Detailed cost estimation, including operation and maintenance costs

2. Engineering implementation, reliability, and constructability

3. Technical feasibility

4. Adverse environmental impacts of remediation, including methods and costs of mitigation

5. Protection of public welfare and the public's perspective

5.2.2.1 Alternative 2 - Monitored Natural Attenuation and Institutional Controls

Alternative 2 would include monitoring of groundwater conditions and contaminant movement while controlling potential exposure risks through either restrictive covenants or a local ordinance.

Changes in contaminant levels in the groundwater would be monitored by periodic sampling of groundwater from monitoring wells. Samples would be analyzed for 1,4-dioxane and selected monitored natural attenuation (MNA) parameters. It is expected that with the passage of time, the concentration of 1,4-dioxane in the Unit E will fall below the applicable standards.

The components of this alternative include: (1) initial hydrogeological investigations to determine the fate of 1,4-dioxane in the Unit E plume, (2) installation of a monitoring well network, (3) long-term monitoring of the contaminant in Unit E, and (4) development and implementation of institutional controls to control exposure consistent with Part 201.

Detailed Cost Estimation, Including Operation And Maintenance Costs: Costs for monitored natural attenuation are presented in Table 4 and detailed in Appendix D. Alternative 2 is estimated to be the least costly, longest duration alternative.

Engineering Implementation, Reliability, And Constructability:

Implementation – Implementation of the hydrogeological investigation and monitoring well network will require access to appropriate parcels of land. The difficulty of obtaining access is not known at this time. Institutional controls will require either restrictive covenants (restricting groundwater use) for each property owner proximate to the Unit E, or the passage by the City of Ann Arbor of an ordinance restricting groundwater use consistent with Section 20120b(5) of Part 201. Due to the large number of potentially affected properties, obtaining restrictive covenants from each property owner would be complicated and difficult and may not be possible without cooperation of a large number of individuals. The City of Ann Arbor has discretion as to whether to adopt and ordinance and is entitled to exercise that discretion in a manner it deems appropriate. At a minimum such an ordinance will be subject to extensive public scrutiny and possibly hearings prior to action, with no certainty as to the result.

Reliability – Natural processes attenuate 1,4-dioxane under Alternative 2. These are self-sustaining and, therefore, extremely reliable, though potentially slow.

Constructability – Constructing monitoring wells is an established process. Access to monitoring well sites for installation may present challenges, depending on the property owners. In the past, PLS has been able to obtain access for this type of project.

Technical Feasibility: Long-term access to and maintenance (and replacement) of monitoring wells presents a moderate challenge that should be resolved with access to the well location for construction.

Adverse Environmental Impacts Of Remediation, Including Methods And Costs Of Mitigation: This alternative does not create potentially significant adverse impacts during remediation. Migration of the plume under this scenario does not increase risks because the risks are controlled through institutional controls.

Protection Of Public Welfare And Public Perspective: This alternative involves a temporary disruption of neighborhoods due to the need to install monitoring wells for investigation and long-term monitoring. Use of public right-of-way can minimize infringement on private property. The impact on public welfare in comparison to other alternatives appears to be minimal.

From a political and societal standpoint, groundwater remedies that rely on institutional controls are controversial and tend to be viewed as "not as good" as pro-active remedies. One of the objectives of the Feasibility Study is to describe the alternatives more fully so that a more informed public opinion can form over whether an alternative is, in fact, "as good" overall as another. It is currently not known whether there will be sufficient public support to implement this option. The possibility that a consensus around this remedy may fail due to political and societal concerns is deemed by PLS to be high. This alternative cannot be implemented without adequate public support.

5.2.2.2 Alternatives 3a, 3c and 3e - Groundwater Pumping - Pipeline to and Treatment at Wagner Road

Three alternatives (3a, 3c, and 3e) survive in this group. All three share the following common characteristics:

- recovery of groundwater from multiple vertical wells,
- transmission of recovered water through individual pipelines, which combine with others up stream of a new pipeline,
- transmission of the total flow of all individual wells through the new pipeline to the PLS facility,
- chemical oxidation of 1,4-dioxane without production of by-products at concentrations that pose risks, and
- disposal of treated water.

Figures 4, 5, and 6 show the general layout of Alternatives 3a, 3c, and 3e, respectively.

Alternative 3a – Pipeline to Wagner Road facility where treated groundwater would be transmitted through a new pipeline to the Huron River for disposal under an NPDES permit.

Detailed Cost Estimation, Including Operation And Maintenance Costs: Costs for ozone and hydrogen peroxide treatment followed by discharge to the Huron River are presented in Table 5 and detailed in Appendix D. Costs for UV/Hydrogen peroxide treatment followed by discharge to the Huron River are presented in Table 6 and detailed in Appendix D. Alternative 3a is ranked as the sixth least expensive alternative.

Engineering Implementation, Reliability, And Constructability:

Implementation – Design, construction, and operations of water recovery, treatment, and disposal systems would utilize well-tested engineering and construction techniques and methods. In addition, PLS staff has extensive experience and expertise in ex-situ treatment of contaminated groundwater, including the receipt, storage, and transmission of hydrogen peroxide. As a result, start-up and operation of the treatment system should proceed quickly and uneventfully.

Also, the discharge of treated water into the Huron River will have to be done pursuant to a new NPDES permit. This involves an application, draft permit, public comment, final permit, followed by the possibility of a contested case. It is possible that implementation could be delayed until the resolution of all permit issues and appeals. Based on PLS' experience with its NPDES permit for discharge into Honey Creek, the possibility of permit issues creating implementation problems is considered to be moderate.

Reliability – Pilot testing indicated that a combination of ozone and hydrogen peroxide can destroy 1,4-dioxane during the time available for ex-situ treatment during high-volume groundwater pumping to control the plume. The technology is suitable to the contaminant and the planned groundwater pumping rate. PLS intends to phase-in this technology at the PLS facility for existing discharges to Honey Creek. Bromate formation can be an issue with the use of ozone and hydrogen peroxide, but is expected to be manageable to meet anticipated NPDES permit conditions. If ozone-hydrogen peroxide is not acceptable, UV/hydrogen peroxide can be used, although it is significantly more expensive. This is the technology currently in use at the PLS facility under its current NPDES permit.

Groundwater recovery wells and pumps, pipelines, and ex-situ treatment vessels have been shown to be reliable during the chemical oxidation remediation of shallower 1,4-dioxane contaminated aquifers. Periodic inspection and cleaning of wells, pumps, and pipelines will maintain the mechanical efficiency of the system.

Ozone and hydrogen peroxide are energetic and reliably degrade 1,4-dioxane when applied in sufficient quantity. To assure the latter, 1,4-dioxane in the recovered groundwater will be measured periodically and the treatment system operating conditions changed as needed.

Constructability – This option presents difficult constructability problems.

The most significant constructability concern is access to public and private property for the construction of transmission pipelines for untreated water (from purge wells to PLS) and treated water (to the Huron River). The length of the pipelines involved means that a large number of third parties will have an interest in the project, any one or more of whom may raise challenges to the use of his or her property by PLS for the pipelines. Although access is always an unknown for all of the options, those that involve significant transmission pipelines, such as this option, are considered to be more problematic because the scope of the access question increases dramatically. Under this alternative, access would have to be obtained from at least three governmental units as well as private landowners.

The law governing access to private property for the purpose of installing transmission pipelines is untested and resort to the courts in any event creates a significant uncertainty in the outcome. Until access is obtained, pipelines cannot be constructed. Until pipelines can be constructed, the plume cannot be captured. While the plume continues to move, capture using this option becomes a "moving target." Accordingly, constructability concerns for this option are heightened and are considered high.

As discussed above, the construction of water recovery, treatment, and disposal systems would use proven engineering and construction methods, and does not present heightened concerns.

A treatment facility, including hydrogen peroxide storage and ozone generation systems, as well as ex-situ treatment chambers will be built at the PLS Wagner Road facility. Ample area and utilities are available at this location.

Technical Feasibility: This option raises some concerns regarding technical feasibility. From an engineering standpoint, the longer the pipelines, the more problematic it becomes to assure that the system is adequately pressurized and protected. In general, pipelines are most efficient and reliable when their length and the horsepower of pumps can be minimized. This option involves an estimated 33,748 linear feet of pipeline carrying untreated or treated groundwater. While it is feasible to design such a pipeline, the requirements that private and/or public right of way owners may demand to assure safety are undetermined. Based on past experience (with transmission lines in Evergreen and the horizontal well) the question of the safety of any design will be raised and may be an obstacle to timely installation of an acceptable system.

The time needed to obtain access and construct the pipelines also raises a technical concern. This alternative attempts to capture the leading edge of the plume near its current location. The leading edge changes with time. The amount of time needed for development, comment and approval of a design and layout, for securing access, for road closures and construction, is undetermined. Comparable municipal utility projects (storm and sewer reconstruction, for example) have taken a year or more, even without the disputes regarding access and design safety that can be anticipated during this project. During the undetermined time it will take to accomplish these tasks the plume will continue to move. Movement of the plume may render the design obsolete (causing the need for realignment) and may cause additional delay in addressing the contamination. PLS considers the likelihood of this concern arising to be high.

As for the treatment aspects of this option, pilot testing indicated that a combination of ozone and hydrogen peroxide can destroy 1,4-dioxane during the time available for ex-situ treatment during high-volume groundwater pumping to control the plume. The technology is suitable to the contaminant and the planned groundwater pumping rate. PLS intends to phase-in this technology at the PLS facility for existing discharges to Honey Creek

Adverse Environmental Impacts Of Remediation, Including Methods And Costs Of Mitigation: The potential adverse impacts of alternative 3a are leaks or accidents during receipt and storage of hydrogen peroxide, generation of oxygen and ozone, transmission and use of both oxidants, and transmission of treated and untreated water via long large diameter underground pipelines. However, these risks are not deemed to be unacceptable because the transmission and storage of such materials in other contexts is routine. Leaks of untreated groundwater are not of concern because of the relatively low levels of dissolved 1,4-dioxane and its relatively high clean-up goals for most exposure pathways. Treated water, prior to discharge to the Huron River, does not pose any significant potential risks, other than erosion due to unlikely, large-volume, pipeline leaks. While PLS does not view leakage from the pipelines as a significant risk, this issue has been raised in the past and has caused significant dispute with respect to transmission pipelines elsewhere in the project area. This concern is discussed above in the sections on Constructability and Technical Feasibility.

This option will require an NPDES permit for the discharge. The NPDES permit will account for environmental impacts on the Huron River in accordance with state and federal law. The discharge point is expected to be downstream of drinking water intakes and is not expected to raise any new issues.

Monitoring of the treatment building interior and periodic inspection and repair of the remedial equipment and pipelines are low-cost efforts well suited to control of these potential impacts.

Protection Of Public Welfare And Public Perspective: This alternative involves significant disruption of public and private use of property along the length of the pipelines during construction, with some minor subsequent disruption for operation and maintenance. Use of public right-of-way can minimize infringement on private property, although street and lane closings may still be necessary during the installation of the pipelines. The impact on public welfare in comparison to other alternatives appears to be significant.

During previous public meetings, concerns about disruption for installation of infrastructure were expressed, albeit in the context of interim response proposals. Public perception of whether the disruption caused by this option when weighed with the benefits of this and other options is not known, but is expected to be a concern. This concern is particularly relevant under this option given the length of the pipelines and number of persons potentially affected.

Alternative 3c – Pipeline to PLS facility for treatment, where treated water would be injected into the Unit E through multiple new wells at locations where 1,4-dioxane levels are less than 85 ppb, but greater than 1 ppb.

Detailed Cost Estimation, Including Operation And Maintenance Costs: Costs for ozone and hydrogen peroxide treatment followed by discharge to the Huron River are presented in Table 7 and detailed in Appendix D. Costs for UV/Hydrogen peroxide treatment followed by discharge to the Huron River are presented in Table 8 and detailed in Appendix D. This alternative is ranked as the fifth least expensive option.

Engineering Implementation, Reliability, And Constructability:

Implementation – Alternative 3c differs only slightly from 3a. The difference is the use of multiple injection wells rather than a pipeline and outfall to the Huron River for treated water disposal. Injection wells require maintenance, especially to assure long-term reliability, and may have to be rehabilitated or replaced from time to time. This is not considered to be a significant implementation concern.

Groundwater discharge will have to be authorized by MDEQ. Although it is expected that certain technical issues may be raised (see below), groundwater discharge is expected to be less controversial than surface water discharge, particularly in this case where Unit E has already been impacted.

Reliability – Alternative 3c utilizes the same system components as 3a with one exception. Treated groundwater will be injected into Unit E through multiple injection wells rather than piped to the Huron River. The injection wells and small-diameter pipelines to each should be as reliable as the Huron River discharge if they are maintained, as described above. The ex-situ destruction of 1,4-dioxane will be managed in the same manner as described in 3a.

Constructability – For the reasons discussed in connection with Alternative 3a, construction of a transmission pipeline for untreated water is expected to raise constructability issues. Fewer property owners, however, would be involved because only one leg of pipeline (from leading edge to PLS) will be constructed. Because of the length of the transmission pipeline, the number of property owners involved, public concerns about safety and reliability, and uncertainty regarding timing (as explained above), this is considered to be a major concern for this option.

As discussed above, the construction of water recovery, treatment, and disposal systems would use proven engineering and construction methods.

A treatment facility, to house hydrogen peroxide storage vessels, ozone generation systems, and ex-situ treatment chambers will be built at the PLS Wagner Road facility. Ample area and utilities are available.

Technical Feasibility: In addition to the shared issues associated with constructing pipeline from the extraction wells back to the PLS facility, the defining challenge associated with this alternative is locating a sufficient number of injection wells that are able to accept the necessary volume of water and do so without disruption of containment or other remedial objectives. Injection well locations must be carefully chosen to minimize dilution and, more importantly, deflection of the plume, both of which would reduce the effectiveness and efficiency of the plume and extend the remediation. In addition, injecting the same amount of water into the plume as extracted will make capturing the plume difficult. A compensating potential benefit of this alternative is that the injection wells would likely be placed on PLS property, thus making the construction of injection wells and pipelines from the treatment center simpler than alternatives where wells would be installed off site.

No NPDES permit will be required, although permission from MDEQ to discharge to groundwater will be necessary. Technical concerns over whether such permission will be granted are considered comparable to the issuance of an NPDES permit. Bromate formation can be an issue with the use of ozone and hydrogen peroxide, but is expected to be manageable to meet anticipated regulatory requirements. If ozone-hydrogen peroxide is not acceptable, UV-peroxide can be used, although it is significantly more expensive.

Adverse Environmental Impacts Of Remediation, Including Methods And Costs Of Mitigation: See analysis for Alternative 3a. The only difference is that there will need to be MDEQ approval of a groundwater discharge for this alternative instead of the NPDES permit required for Alternative 3a. This approval will resolve questions regarding adverse environmental impacts of injection of treated groundwater.

Protection Of Public Welfare And Public Perspective: This alternative involves significant disruption of public and private use of property along the length of the pipelines during construction, with some minor subsequent disruption for operation an maintenance. Use of public right-of-way can minimize infringement on private property, although street and lane closings may still be necessary during the installation of the pipelines. The impact on public welfare in comparison to other alternatives appears to be significant, although it may be slightly less than for Alternative 3a due to the fact that the pipeline to the Huron River will not be needed.

During public meetings on interim response proposals, concerns about disruption for installation of infrastructure were expressed although in the context of the lack of an overall plan. Public perception of whether the disruption caused by this option when weighed with the benefits of this and other options is not known, but is expected to be a concern.

<u>**Alternative 3e**</u> – Pipeline to PLS facility for treatment to be followed by discharge to Honey Creek under an amended NPDES permit.

Detailed Cost Estimation, Including Operation And Maintenance Costs: Costs for ozone and hydrogen peroxide treatment followed by discharge to the Honey Creek (Alternative 3e-1) are presented in Table 9 and detailed in Appendix D. Costs for UV/Hydrogen Peroxide treatment followed by discharge to the Honey Creek (Alternative 3e-2) are presented in Table 10 and detailed in Appendix D. Alternative 3e is estimated to be the third least costly alternative.

Engineering Implementation, Reliability, And Constructability:

<u>Implementation</u> – Design, construction, and operations of water recovery, treatment, and disposal systems would utilize well-tested engineering and construction techniques and methods. In addition, PLS staff has extensive experience and expertise in ex-situ treatment of contaminated groundwater, including the receipt, storage, and transmission of hydrogen peroxide. As a result, start-up and operation of the treatment system should proceed quickly and uneventfully.

PLS' current NPDES permit would also have to be amended to authorize the discharge of treated water into the Honey Creek. Based on PLS' experience with its current NPDES permit, the possibility of permit issues creating implementation problems is considered to be high.

Reliability – Pilot testing indicated that a combination of ozone and hydrogen peroxide can destroy 1,4-dioxane during the time available for ex-situ treatment during high-volume groundwater pumping to control the plume. The technology is suitable to the contaminant and the planned groundwater pumping rate. PLS intends to phase-in this technology at the PLS facility for existing discharges to Honey Creek. Bromate formation can be an issue with the use of ozone and hydrogen peroxide, but is expected to be manageable to meet anticipated NDPES permit conditions. If ozone-hydrogen peroxide is not acceptable, UV-peroxide can be used, although it is significantly more expensive. This is the technology currently in use at the PLS facility under its current NPDES permit.

Groundwater recovery wells and pumps, pipelines, and ex-situ treatment vessels have been shown to be reliable during the chemical oxidation remediation of shallower 1,4-dioxane contaminated aquifers. Periodic inspection and cleaning of wells, pumps, and pipelines will maintain the mechanical efficiency of the system.

Ozone and hydrogen peroxide are energetic and reliably degrade 1,4-dioxane when applied in sufficient quantity. To assure the latter, 1,4-dioxane in the recovered groundwater will be measured periodically and the treatment system operating conditions changed as needed.

Constructability – This option presents difficult constructability problems.

The most significant constructability concern is access to public and private property for the construction of transmission pipelines for untreated water (from purge wells to PLS). These considerations are the same as for Alternative 3a, although the concern is somewhat lessened because the pipeline to the Huron River is not needed.

Technical Feasibility: Except as provided below, this alternative raises the same concerns as described for Alternative 3a.

In addition, this alternative will require an amendment to PLS' current NPDES permit for the discharge. The NPDES permit will account for environmental impacts on the Honey Creek. PLS has had a series of permits for its current discharges to that watercourse and intervernors have consistently raised technical and legal issues about the discharge. Based on past experience the likelihood of a permit contest raising technical issues is high.

Protection Of Public Welfare And Public Perspective: This alternative involves significant disruption of public and private use of property along the length of the pipelines during construction, with some minor disruption thereafter for operation and maintenance. Use of public right-of-way can minimize infringement on private property, although street and lane closings may still be necessary during the installation of the pipelines. The impact on public welfare in comparison to other alternatives appears to be high. In addition, discharge to Honey Creek has been the source of significant public concern (and opposition). This alternative can be expected to engender significant public debate.

5.2.2.3 Alternatives 4a & c - Groundwater Pumping – Treatment near Maple Road

Two alternatives in this group remain. Both of these alternatives share:

- recovery of groundwater from multiple vertical wells,

- transmission of recovered water through individual pipelines, which combine with others or proceed directly to a water treatment compound built on PLS-owned or PLS-leased property at or near Maple Road,

- chemical oxidation of 1,4-dioxane without production of by-products at concentrations that pose risks, and

- disposal of treated water.

Figures 7 and 8 show the general layout of Alternatives 4a and 4c, respectively.

Alternative 4a – Treatment at a location near Maple Road, followed by transmission through a new pipeline to the Huron River for disposal under an NPDES permit.

Detailed Cost Estimation, Including Operation And Maintenance Costs: Alternative 4a is ranked as the fourth least costly alternative. Its preliminary scope and cost estimate are in Table 11 and detailed in Appendix D.

Engineering Implementation, Reliability, And Constructability:

Implementation – Alternative 4a differs from 3a only in the elimination of the pipeline from Maple Road to the PLS Wagner Road facility and the path of the discharge pipeline to the Huron River. Therefore, the design, construction, and operations of water recovery, treatment, and disposal systems used would be the same well-tested engineering and construction techniques and methods. As a result, construction, start-up, and operations of the treatment system would proceed uneventfully.

Liability insurance for chemical oxidation treatment of groundwater in a residential and commercial neighborhood rather than at the Wagner Road facility may be a significant cost.

Reliability – Groundwater recovery wells and pumps, pipelines, and ex-situ treatment vessels have been shown to be reliable during the chemical oxidation remediation shallower 1,4-dioxane contaminated aquifers, as discussed in Alternative 3a. Periodic inspection, cleaning, and repair of the remedial system components would maintain the performance of the overall system.

Hydrogen peroxide and ozone can reliably degrade dissolved 1,4-dioxane in recovered groundwater. Periodic monitoring and adjustment of the system would maintain destruction performance.

Constructability – As discussed in 3a above, the construction of water recovery, treatment, and disposal systems would use proven engineering and construction methods. The ex-situ oxidation treatment equipment could be modified to optimize performance, as has the Unit C and D system from time to time.

A treatment facility will be built on property near Maple Road, owned or leased by PLS. Area and utility service may be limited at this location.

Access to public and private property for construction and maintenance of remedial systems and structures would be important. Recovery well locations would be those specified in alternatives 3a, 3c, 4c, or 5; therefore, access would be no more or less difficult to secure. Overall, access for Alternative 4a is anticipated to be less difficult to secure than for Alternative 3a, due to elimination of the pipeline to the Wagner Road facility.

Technical Feasibility: See Alternative 3a, page __.

Adverse Environmental Impacts Of Remediation, Including Methods And Costs Of Mitigation – As for the other active remedial alternatives, the most significant potential adverse impacts of 4a include leaks or accidents during receipt and storage of hydrogen peroxide, generation of oxygen and ozone, and transmission and use of both oxidants. Leaks of untreated groundwater are again a lesser concern because of the relatively low levels of dissolved 1,4-dioxane and its relatively high clean-up goals for most exposure pathways. Treated water transmission and discharge does not pose any significant potential risks, other than erosion due to large-volume leaks.

Monitoring of the treatment building interior and periodic inspection and repair of the remedial equipment are low-cost efforts well suited to control of these potential impacts.

Protection Of Public Welfare And Public Perspective: This alternative involves significant disruption of public and private use of property along the length of transmission pipelines to Maple Road and then to the Huron River during construction, with some minor subsequent disruption for operation and maintenance. Use of public right-of-way can minimize infringement on private property, although street and lane closings may still be necessary during the installation of the pipelines. The treatment system would have to be installed in either a retail area bordering residential neighborhoods and Veterans Park, in Veterans Park itself, or in the surrounding neighborhoods. This is not consistent with current land uses and may raise public objection and legal challenges (for zoning or other public safety reasons).

The impact on public welfare in comparison to other alternatives appears to be significant.

During public meetings on interim response proposals, concerns about disruption for installation of infrastructure were expressed, although in the context of the lack of an overall plan. Public perception of whether the disruption caused by this option is acceptable when weighed against the benefits of this and other options is not known, but is expected to be a concern. For this option, the length of the pipelines and number of affected persons heightens this concern.

<u>Alternative 4c</u> – Ozone and hydrogen peroxide treatment followed by injection into Unit E through multiple new wells at locations where 1,4-dioxane levels are less than 85 ppb but exceed 1 microgram per liter under a Part 22 permit.

Detailed Cost Estimation, Including Operation And Maintenance Costs: Scope and costs for Alternative 4c are detailed in Appendix D and summarized in Table 12. Alternative 4c is ranked as the seventh least costly alternative.

Engineering Implementation, Reliability, And Constructability:

<u>Implementation</u> – Alternative 4c differs from 4a in the elimination of the pipeline from Maple Road to the Huron River. The design, construction, and operations of water recovery, treatment, and disposal systems used would again use well-tested engineering and construction techniques and methods. As a result, construction, start-up, and operations of the treatment system is anticipated to be uneventful.

Liability insurance for chemical oxidation treatment of groundwater in a residential and commercial neighborhood may be a significant cost.

Reliability – Groundwater recovery wells and pumps, pipelines, and ex-situ treatment vessels have been shown to be reliable during the chemical oxidation remediation of Units C and D, as discussed above. Periodic inspection, cleaning, and repair of the remedial system components would be required but easily accomplished.

Hydrogen peroxide and ozone would reliably degrade dissolved 1,4-dioxane if the system were periodically monitored and adjusted.

Constructability – As discussed above, the construction of water recovery, treatment, and disposal systems would use proven engineering and construction methods. The ex-situ oxidation treatment equipment could be modified on-site to optimize performance, as has the present Unit C&D ex-situ oxidation units.

A treatment facility will be built near Maple Road, on property owned or leased by PLS. The availability of area and utility service may be limited at this location.

Access to public and private property would remain critical for construction and maintenance of remedial systems and structures. Access for Alternative 4c is anticipated to be less difficult to secure than for Alternative 3c, due to elimination of the pipeline to the Wagner Road facility.

Technical Feasibility: The defining challenge associated with this alternative is locating a sufficient number of injection wells that are able to accept the necessary volume of water and do so without disruption of containment or other remedial objectives. Injection well locations must be carefully chosen to minimize dilution and, more importantly, deflection of the plume, both of which would reduce the effectiveness and efficiency of the plume and extend the remediation. In addition, injecting the same amount of water into the plume as extracted will make capturing the plume difficult, particularly under this alternative because of the proximity of the extraction and injection wells.

No NPDES permit will be required, although permission from MDEQ to discharge to groundwater will be necessary. Technical concerns over whether such permission will be granted are considered comparable to the issuance of an NPDES permit. Bromate formation can be an issue with the use of ozone and hydrogen peroxide, but is expected to be manageable to meet anticipated regulatory requirements. Unlike Alternative 3c, UV/hydrogen peroxide technology is not available at this location if the ozone-hydrogen peroxide technology does not prove feasible.

Adverse Environmental Impacts Of Remediation, Including Methods And Costs Of Mitigation: As for the other active remedial alternatives, the most significant potential adverse impacts of 4c include leaks or accidental releases of hydrogen peroxide, oxygen, and ozone. Untreated groundwater leaks are of less concern because of the low levels of dissolved 1,4-dioxane and its relatively high clean-up goals. Treated water transmission and discharge does not pose any significant potential risks, other than erosion or flooding due to pipeline leaks, which would be expected to be smaller than for a single discharge line to the Huron River.

Monitoring of the treatment building and inspection and repair of the remedial equipment are low-cost and effective control methods for these potential impacts.

Protection Of Public Welfare And Public Perspective: This alternative involves some disruption of public and private use of property along the length of the pipelines connecting extraction and treatment and injection points during construction, with some minor subsequent disruption for operation an maintenance. If injection wells can be installed on retail property, concerns about inappropriate infrastructure in neighborhoods or in Veterans Park may be mitigated somewhat. However, the treatment system would have to be installed in either a retail area bordering residential neighborhoods, in Veterans Park, or in the surrounding neighborhoods. This is not consistent with current land uses and may raise public objection and legal challenges (for zoning or other public safety reasons).

During previous public meetings, concerns about disruption for installation of infrastructure were expressed albeit in the context of interim response proposals. Public perception of whether the disruption caused by this option when weighed with the benefits of this and other options is not known, but is expected to be a concern.

The impact on public welfare in comparison to other alternatives appears to be significant, primarily because of the need to locate treatment and injection facilities in areas used for retail, residential or recreational uses.

5.2.2.4 Alternative 5 - Groundwater Pumping – Injection into Deep Formation

Purged groundwater would be conveyed to PLS' Wagner Road facility and then injected, without treatment, into a deep well located at the PLS Wagner Road facility.

Detailed Cost Estimation, Including Operation And Maintenance Costs: Alternative 5 scope and costs are presented in Table 13 and detailed in Appendix D. Alternative 5 is estimated to be the second least costly remedial alternative.

Engineering Implementation, Reliability, And Constructability:

Implementation – From an engineering standpoint, the design, construction, and operation of water recovery, treatment, and deep disposal well systems would involve well-tested engineering and construction techniques and methods. Such wells are commonly used in Michigan and others have been permitted for the Mt. Simon formation, including one such well formerly located at the PLS facility. Assuming that adequate capacity exists to accept the expected volumes of water, there do not appear to be any engineering issues that would disrupt implementation.

The well would have to be permitted under the federal UIC program, which involves preparation of an application, study of the formation, public comment, and the issuance by USEPA of an enforceable permit. Commercial UIC well permits, which would allow the permit holder to accept liquid waste from other enterprises, have been controversial. Permits for disposal of the permit holder's wastewaters, however, have been far less contentious. In this case, the untreated groundwater would be non-hazardous liquid waste that, with the exception of 1,4-dioxane, would not contain any hazardous substances above non-background levels. Pall does not anticipate significant implementation issues raised by the permit process.

Reliability – Groundwater recovery wells, pumps, and pipelines have been shown to be reliable during the remediation of shallower 1,4-dioxane contaminated aquifers. Deep injection well construction methods and pumps able to inject into deep formation have been available and in use for decades. All components would perform well if inspected and cleaned periodically.

Constructability – As discussed above, the construction of water recovery, treatment, and disposal systems would use proven engineering and construction methods.

The deep injection well and associated pumps and controls would be constructed on PLS property. Access to public and private property would be needed for construction and maintenance of recovery wells and the pipeline to the Wagner Road facility. The constructability issue related to construction of the transmission line are the same as for Alternatives 3a and 3c. Although only one leg of the pipeline would be required, this is still considered to be a significant potential obstacle. The recovery wells would be the same as for alternatives 3a, 3c, 4a, and 4c. Acquisition of access rights for recovery wells would be no less difficult.

A deep disposal well for hazardous material must be permitted as a Class I Underground Injection well by the United States Environmental Protection Agency. A Class I well was previously permitted, constructed, used, and abandoned on the PLS Wagner Road property. This historic use may or may not shorten the permitting time for a new deep disposal well. Regardless, the need for a permit is not considered to be a significant concern.

Technical Feasibility: Licensed, deep, injection wells exist throughout Michigan. Many of these inject into the Mt. Simon, or shallower formations. Well construction techniques, pumps able to inject liquids into deep formations, and experienced sub-contractors are available. A deep injection well formerly existed and was used for several years at the PLS facility, although at much lower flow rates than would be needed for capturing the Unit E plume. The information available on the Mt. Simon formation is currently being reviewed to verify that adequate flow rates can be injected beneath the PLS facility on Wagner Road.

Adverse Environmental Impacts Of Remediation, Including Methods And Costs Of Mitigation: This option presents the same (minimal) risks with respect to the need for a transmission pipeline for untreated water. Injection into the Mt. Simon formation places the water beyond the reach of human and environmental receptors and is considered safe. Reliability of the injection well must be tested in accordance with applicable regulations to safeguard against leaks. At the PLS facility, the aquifers above the Mt. Simon formation are already contaminated with 1,4-dioxane so there is no additional risk if the system were to fail. This alternative does not present significant adverse environmental risks.

5.2.2.5 Alternative 6- Groundwater Pumping with Active Remediation and Treatment Proximate to Huron River.

This alternative is similar to Alternatives 3a and 4a in that extraction wells would be used to control the plume and the purged groundwater would be conveyed to the Huron River via a new pipeline and then treated and discharged to the river under a new NPDES permit. The feature that distinguishes this alternative from the other active remediation alternatives, is that the groundwater extraction, if necessary, would occur at a location closer to the Huron River. By implementing the active remediation proximate to the Huron River, this alternative would minimize the community disruption, potential delays, and uncertainties associated with the installation of the longer pipelines necessary under the other alternatives, while still being protective of any potential receptors. The institutional controls called for under Alternative 2 would not be required because, in the event that groundwater monitoring data indicate 1,4-dioxane concentrations at a receptor will exceed a Part 201 Generic Cleanup Criteria (e.g., water entering the Huron River with 1,4-dioxane above GSI or approaching drinking water wells at levels above 85 ppb), an active groundwater remedial system would be implemented. Thus, this alternative is not dependant on governmental decisions beyond PLS' control.

Detailed Cost Estimation, Including Operation And Maintenance Costs: Costs for the hydrogeological investigation, monitoring, and the active remediation system that may be needed are presented in Table 14 and detailed in Appendix D. Alternative 6 is estimated to be the most expensive option (assuming active remediation is implemented).

Engineering Implementation, Reliability, And Constructability:

Implementation - Design, construction, and operations of water recovery, treatment, and disposal systems would utilize well-tested engineering and construction techniques and methods. In addition, PLS staff has extensive experience and expertise in ex-situ treatment of contaminated groundwater, including the receipt, storage, and transmission of oxidants. As a result, start-up and operation of the treatment system should proceed quickly and uneventfully.

Reliability – The initial hydrogeological investigation will be used to predict the fate of the Unit E plume. The actual migration of the plume would then be closely monitored with the placement of additional monitoring wells. Such investigatory techniques are considered reliable. The contemplated active remediation plan involves installation of groundwater recovery wells, pumps and pipelines. Groundwater recovery wells and pumps, pipelines, and ex-situ treatment vessels have been shown to be reliable during the chemical oxidation remediation of shallower 1,4-dioxane contaminated aquifers. Periodic inspection and cleaning of wells, pumps, and pipelines will maintain the mechanical efficiency of the system.

Groundwater recovery wells and pumps, pipelines, and ex-situ treatment vessels have been shown to be reliable during the chemical oxidation remediation of shallower 1,4-dioxane contaminated aquifers. Periodic inspection and cleaning of wells, pumps, and pipelines will maintain the mechanical efficiency of the system.

Ozone and hydrogen peroxide are energetic and reliably degrade 1,4-dioxane when applied in sufficient quantity. To assure the latter, 1,4-dioxane in the recovered groundwater will be measured periodically and the treatment system operating conditions changed as needed. This technology is currently under evaluation and appears to be promising. However, if it proves infeasible or inappropriate, the U-V oxidation system currently in use at the PLS site, or some other appropriate substitute, will be implemented.

Constructability – As discussed above, the construction of water recovery, treatment, and disposal systems would use proven engineering and construction methods and should not present any particularly difficult challenges.

A treatment facility, as well as ex-situ treatment chambers, will need to be built at a location near the Huron River if active remediation is required. Recovery and injection wells must be placed at or very near locations determined by an analysis of the hydrogeoloical system. Similarly, pipelines are most efficient and reliable when their length and the horsepower of pumps can be minimized. As with all of the other alternatives, access is an uncertainty. Given enough lead-time, however, access at an appropriate location can be obtained. Also, interference with conflicting land uses and residential neighborhoods is expected to be minimized using locations near the river.

Technical Feasibility: Pilot testing indicated that a combination of ozone and hydrogen peroxide can destroy 1,4-dioxane during the time available for ex-situ treatment during high-volume groundwater pumping to control the plume. The technology is suitable to the contaminant and the planned groundwater pumping rate. This technology (if successful) is planned for phase in at the PLS facility for existing discharges to Honey Creek. It is expected that by the time the active remediation system under this alternative is implemented, the technology will have seen significant field use. It is also possible that some other new technology may be developed that is superior. In any event, UV-Ozone or a suitable substitute can be implemented in the event ozone and hydrogen peroxide is not effective.

Adverse Environmental Impacts Of Remediation, Including Methods And Costs Of Mitigation:
The potential adverse impacts of Alternative 6 remediation are leaks or accidents during receipt and

storage of hydrogen peroxide, generation of oxygen and ozone, and transmission and use of both oxidants. However, these risks are not deemed to be unacceptable because the transmission and storage of such materials in other contexts is routine. Leaks of untreated groundwater are not of concern because of the relatively low levels of dissolved 1,4-dioxane and its relatively high clean-up goals for most exposure pathways. Treated water, prior to discharge to the Huron River, does not pose any significant potential risks, other than erosion due to unlikely, large-volume, pipeline leaks.

Monitoring of the treatment building interior, routine operation and maintenance, and periodic inspection and repair of the remedial equipment and pipelines will control the potential impacts.

Protection Of Public Welfare And Public Perspective: This alternative involves a temporary disruption of commercial areas due to the need to install monitoring wells for investigation and long-term monitoring. Use of public right-of-way can minimize infringement on private property. The impact on public welfare in comparison to other alternatives appears to be minimal.

Public support for this alternative depends on whether the contemplated plan to implement active remediation closer to the Huron River as necessary is viewed to be as “as good” as the other active remediation alternatives. Alternative 6 has the advantage of not causing long term (and in some cases, permanent) disruption of neighborhoods by incongruous uses, and of not raising fear over risks (reasonable or not) of failure of a pipeline carrying untreated water. Land uses near the river are more compatible with treatment (if needed) and this alternative would not require extensive pipelines.

CHAPTER 6 – CONCLUSIONS

This Feasibility Study has systematically evaluated all identified alternatives for a comprehensive response to the Unit E contamination. Eight remedial alternatives survived initial screening and were evaluated in detail. Twelve primary and secondary Rule 530 (5) criteria were considered in the detailed evaluation of each alternative. Each alternative was evaluated with respect to these criteria.

PLS has weighed the advantages and disadvantages of the remedial alternatives detailed in Chapter 5 and has selected Alternative 6 "Groundwater Pumping – Active Remediation and Treatment Proximate to Huron River" as the preferred remedial alternative.

All seven of the surviving alternatives were judged to be equally protective of the public health and the environment. All assure that receptors are not exposed to 1,4-dioxane levels in excess of allowable criteria. The only differences between alternatives from this standpoint do not appear to be material. The five "leading edge" alternatives (all but 2 and 6) would by design prevent expansion of areas of contamination above drinking water criterion. Alternative 2 would not, by design, contain the plume at all, while Alternative 6 would contain the plume as necessary prior to any potential impact on downgradient receptors. These distinctions make little or no practical difference in terms of protection of public health and the environment. Under any alternative, no one would actually be consuming groundwater contaminated with 1,4-dioxane. Over time roughly the same area of Unit E would contain detectable levels of 1,4-dioxane (no matter which alternative is selected) because, by design, even the "leading edge" alternatives do not capture all of the 1,4-dioxane. Finally, it is not possible to quantify the difference in area inside a "leading edge" containment alternative versus alternatives 2 and 6. This is because all of the leading edge alternatives are subject to significant uncertainty (in timeliness) because of access and other practical implementation issues.

All of the alternatives are extremely expensive. The least expensive alternative is monitored attenuation (Alternative 2). PLS has not selected that alternative because it does not have sufficient indication that the alternative would enjoy any public support, much less the public support necessary for successful adoption of institutional controls. PLS does not believe it is appropriate to recommend Alternative 2 at this time, although if public support develops for this alternative, it may become viable at a later time. With respect to the remaining alternatives, deep well injection is the second least costly alternative. This alternative, however, also involves construction of a lengthy pipeline and there is also some uncertainty as to whether adequate injection capacity exists in the Mt. Simon formation. The remaining alternatives are all extremely expensive, but otherwise comparable in overall costs.

The five "leading edge" alternatives all face significant timing, construction and implementation issues. Because of the current location of the leading edge of the plume, each of these alternatives would necessarily include the installation of lengthy transmission pipelines. The equally lengthy construction horizon for these alternatives (after obtaining necessary access) and the continued migration of the plume calls into question the practical feasibility of these alternatives. At a minimum, the goal of capturing the leading edge of the plume would be compromised because the recovery wells would have to be placed well downgradient of the current leading edge to ensure that capture could be still achieved when the infrastructure became available. Otherwise, the continued expansion of the plume would require PLS to reconfigure and relocate the groundwater recovery infrastructure to respond to the new shape of the plume.

The Unit E reinjection options (3c and 4b) suffer from significant technical challenges. Injection of the volumes needed to contain the plume near Maple Road may not be possible if the objective is to control the plume. Injection back at the PLS facility will create significant uncertainty in terms of containment and may also force contaminated water back into shallower aquifers that are covered under the

Washtenaw County Circuit Court's 5 year plan. Also, any Unit E reinjection option will require pretreatment. Although ozone-hydrogen peroxide is a strong candidate for ex-situ treatment generally, it is a weaker option for injection strategies because there will be the need to control the formation of bromate. UV-hydrogen peroxide does not have this drawback, but reliance on that technology greatly increases remediation costs (see Appendices).

Although a deep injection well is a possibility, the former deep well at PLS had far less capacity than what would be needed for capturing the leading edge of unit E and additional study will be needed to ascertain whether the deep formations can actually accept the required volumes.

Finally, alternatives 3a, 3c, 3d, 4a, 4c and 5 all have the same drawback. Each would cause a significant disruption to neighborhoods, streets and parks. Each would also involve using property in a way inconsistent with current and surrounding zoning. Alternatives 4a and 4c would require a significant treatment system to be constructed in an area that is otherwise inconsistent with such land use. The residents in neighborhoods where monitoring and purge wells have already been installed have legitimately questioned those intrusions in light of the apparent lack of environmental benefit. All of the "leading edge" alternatives multiply this concern by orders of magnitude. PLS views this is an important public welfare consideration.

Alternative 6 avoids the drawbacks of the other alternatives. It is superior to Alternative 2 because it does not rely on natural attenuation or institutional controls to cut off exposures. It is superior to alternatives 3c, 4c and 5 because it avoids the problems associated with reinjection. It is superior to alternatives 3a, 3c and 4a because it would involve less pipeline. It is superior to all of the "leading edge" alternatives because it does not have a drastic impact on public welfare, residential or recreational uses. For these reasons, PLS recommends this alternative.

CHAPTER 7 - REFERENCES

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