Unit E

FINAL FEASIBILITY STUDY

&

PROPOSED INTERIM RESPONSE PLAN

FOR THE UNIT E PLUME

June 1, 2004

PALL Pall Corporation

TABLE OF CONTENTS

List of Tables

List of Figures

Appendices

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, because the homes and businesses in the path of the plume are serviced by City's municipal water system, which draws its water from the Huron River. Although testing of the only municipal water supply well (referred to as the Montgomery Well) in the vicinity of the contamination has revealed low levels of 1,4-dioxane, the well does not appear to be in the flow path of the plume and levels are not expected to rise above levels deemed to be safe for drinking.

As requested by the Michigan Department of Environmental Quality (MDEQ), this Final Feasibility Study and Interim Response Plan (Feasibility Study) evaluates the interim response actions that may be available to address the Unit E contamination as well as final remedies. 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. In response to such concerns, PLS recommended to the MDEQ that it should prepare a Feasibility Study so that the parties and the community would have a framework for evaluating the need for, and the potential benefit of, interim response measures. In January, PLS submitted its Interim Feasibility Study, which described the available final remedies. Having completing additional testing of potential interim response measures, PLS is now submitting its "Final" Feasibility Study, which incorporates its analysis of interim as well as final remedies.

The conclusions resulting from this study are summarized below:

PLS has weighed the advantages and disadvantages of the available remedial alternatives as detailed in Chapters 5 and 6. Because of the depth of the contamination and the fact that the City's municipal water supply relies primarily 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, and are therefore equally protective of the environment and human health. 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 Chapters 5 and 6, the equally lengthy construction horizon for these alternatives and the continued migration of the plume calls into question the practical feasibility of these alternatives. Delays associated with obtaining necessary access from the City are likely to occur, particularly since the City recently initiated a lawsuit against PLS. 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.

Based on these considerations, PLS has selected a combination of Alternative 6 "Groundwater Pumping – Active Remediation and Treatment Proximate to Huron River" and interim response measures in the form of aggressive mass removal both on the PLS property and in the vicinity of Maple Road, as the preferred remedial alternative for addressing the Unit E contamination. The proposed interim response consists of groundwater extraction at the rate of approximately 200gpm in the vicinity of Maple Road, treatment of extracted groundwater and reinjection of the treated water into the plume. Interim response at the PLS facility will include the operation of at least three purge wells intended to reduce mass before it reaches the Maple Road area. The active remediation for the interim response will be combined with Alternative 6 (including monitoring) to protect downgradient receptors. This combination is the preferred option because it promptly addresses the most highly contaminated portions of the plume and protects all potential receptors, while avoiding the disruptions and technical feasibility problems associated with 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 Chapters 5 and 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. The aggressive interim mass removal PLS has proposed will promptly address the most highly contaminated areas of the plume as an additional protection for the potential receptors. The proposed interim responses will also reduce the possibility that it will be necessary to conduct an active remediation program near the Huron River, thus avoiding the disruption and inconveniences associated with that effort.

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 combination of interim response measures and Alternative 6 is potentially 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. Also, an adequate interim response will result in reduction of 1,4-dioxane in the plume sufficient to reduce or eliminate the likelihood of the need for interception of the plume before it reaches the Huron River.

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 identifies final response alternatives to meet the objectives described herein. Unlike the Interim Feasibility Study PLS submitted in January, this Final Feasibility Study also evaluates interim responses that PLS may conduct within the Unit E plume in addition to the selected final response action.

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 Evaluation of Interim Responses – This chapter identifies and evaluates the available interim responses that could be initiated within the plume boundaries based on the ability of such measures to assist in protection of potential receptors.

Chapter 5 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 6 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.

Chapter 7 Overall Response Plan and Request for Waiver -- This chapter describes the combination of interim response activities and final response actions PLS intends to implement and evaluates whether the circumstances of this cleanup satisfy the requirements for a waiver of Administrative Rule 299.5705.

Chapter 8 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 Potential Receptors

Potential receptors of the Unit E plume include a limited number of wells and the Huron River. All known are shown on the location map attached hereto as Figure 3, and are discussed in the following paragraphs.

Municipal Wells

The City of Ann Arbor has two municipal well fields: the Montgomery Well Field, which is located approximately 2,520 feet southeast of the plume, and the Steer Farm Well Field, which is located approximately 5 miles southeast of the PLS Wagner Road facility and the Unit E Plume. Prior to 2001, when both well fields were in operation, a majority of the City's groundwater came from Steer Farm. The Montgomery well field was used primarily to supply relatively warm water during the winter months to assist in the treatment of the City's Huron River surface water supply.

There are two production wells at the Montgomery well field, PW-1 and PW-2. These wells are located approximately 30 feet apart. In February 2001, the City detected low levels of 1,4-dioxane (2 ppb) in PW-1. The City took the Montgomery Well offline shortly thereafter and it is the only drinking water supply well (municipal or private) where 1,4-dioxane has been detected. Concentrations of 1,4-dioxane in groundwater samples from the Montgomery well have been below 4 ppb. As discussed below, available groundwater flow direction data indicates that the plume will not migrate toward the well. The City has continued to use the Steer Farm well field, which is unaffected by the groundwater contamination, to supplement and, in the winter months, to warm the City's Huron River water supply

In its comments to the Interim Feasibility Study, MDEQ stated that this well has not been permanently removed from service and "must still be considered in any decision about remedial actions." Since those comments, however, the City has sued PLS for, among other things, the cost of replacing the Montgomery well. The City's suit also seeks injunctive relief in the form of an order requiring PLS to remove all hazardous substances from the soil and aquifers below its property. The City's requests for well replacement costs and a "non-detect" cleanup order make it clear that the City has no intention of

using this well even if PLS implements a containment alternative that prevents 1,4-dioxane from reaching the well at levels above the legally enforceable cleanup standard, so long as any detectable levels are present. This is consistent with the City's decision not to use the well, even though the level of 1,4-dioxane detected in the well remains well below the cleanup criteria. Consequently, detailed consideration of the extent to which the potential remedial alternatives protect this well would not appear to serve any useful purpose. These issues are likely to be addressed in the City suit and PLS will respond as needed in that forum.

The City of Ann Arbor has completed wellhead protection area (WHPA) delineations for both the Steer Farm and Montgomery well fields. The WHPAs for these well fields are shown on Figure 4. The Montgomery well field delineation was completed in September of 2002 by Flieis & Vanderbrink, Inc (The F&V Report). The F&V Report indicates that a majority of the Unit E plume falls within the WHPA. A potentiometric surface map prepared by and contained in the F&V report, however, indicates that according to the natural flow path of the aquifer, the Unit E plume would migrate directly towards the Huron River and would not flow directly to the Montgomery Well. This map is provided in Appendix A (F&V Figure 4-E). It should be noted that the fact that portions of the Unit E plume are within the WHPA presented in the F&V Report does not mean that concentrations of 1,4-dioxane will ever reach the Montgomery well at levels above the applicable criteria.

The Steer Farm delineation was completed in August 1996 by ICARD, Eastern Michigan University. The Unit E plume is well outside the WHPA associated with the Steer Farm well field. Geologically, the Unit E and the Steer Farm well field are on separate outwash deposits and separated by the deposits of the Fort Wayne Moraine, a large geomorphic feature. There are no data that suggests this well field would be impacted by the Unit E plume.

Non-Municipal Wells

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. A limited number of wells have been identified in the possible pathway of the Unit E Plume. These wells are discussed below.

Two residential wells servicing homes on Ridgemor are located approximately 2,500 feet southeast of the leading edge of the plume. These wells remain in service despite the availability of municipal water. PLS has been advised that these homes are scheduled to be connected to municipal water sometime in the near future. The groundwater flow data collected in connection with the Montgomery well field WHPA indicate that the Unit E plume is not flowing toward these wells. If subsequent investigations indicate that these drinking water wells are likely to become contaminated at unacceptable levels before they are taken out of service, PLS will facilitate an earlier connection to municipal water.

There are three water wells operated by the University of Michigan that are located in the City of Ann Arbor, approximately 10,000 feet southeast of the leading edge. These wells are not used as drinking water supply wells, but rather for laboratory purposes. Water level data collected for the Montgomery well field WHPA delineation suggests the Unit E plume is not flowing toward these wells. Nevertheless, if subsequent investigations indicate that contaminant levels in these wells are likely to rise above the drinking water criterion, PLS will secure an agreement with the University that would preclude use of these wells for drinking water purposes.

There is also a group of private water supply wells in Ann Arbor Township wells approximately 16,000 feet southeast of the edge of the plume. Water level data collected for the Montgomery well field WHPA delineation suggests the Unit E plume is not flowing toward these wells.

Finally, there are wells located on east side of the Huron River, but it is unlikely the plume will underflow the river.

Surface Water

The Huron River is located approximately 8,000 feet east northeast of the plume edge. This regional hydrographic feature is the likely receiving water body for the Unit E plume.

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.

1.4.3 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 water level data collected by F&V on behalf of the City of Ann Arbor. F&V collected water level data for the WHPA delineation of the Montgomery well field. The data represents the most recent comprehensive analysis of water level data for the lower aquifer(s) in the Ann Arbor area, including data from Unit E. The potentiometric maps prepared by F&V suggest the Unit E plume would follow a pathway east northeast to the Huron River. The F&V potentiometric surface map is provided in Appendix A. Groundwater from the Unit E is expected to discharge into the Huron 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.

1.4.4 Groundwater Flux Calculations

PLS has conducted two aquifer performance tests to learn more about the characteristics of the Unit E aquifer. The first test was conducted using TW-15, which is located on Wardon Street, near what is currently considered the "leading edge" of the plume. The second test utilized TW-16, near Maple Village. Using the data obtained from these tests along with measurements of the aquifer cross sectional areas and hydraulic gradients, PLS was able to determine the pumping rate necessary to halt or capture the plume at these two locations. The calculations used this analysis are provided in Appendix B. The calculations suggest the flow rate necessary to halt the plume near Maple Road is approximately 433 gpm. To halt the Unit E plume further downgradient toward the "leading edge", the flow rate increases to approximately 570 gpm. A purge system that could reliably capture the plume at these locations would

likely be designed to purge approximately 500 gpm (Maple Road) and 650 gpm (leading edge), respectively at these two locations.

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. As discussed in Chapter 4, 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.

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)).

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.

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 GSI (potentially) and residential drinking water pathways are the only exposure pathways that are relevant and applicable to the Unit E contamination. Of the two criteria applicable to these pathways, the drinking water cleanup criterion is more restrictive than the GSI criterion. Currently, the cleanup criterion set forth in the Consent Judgment is 77 ppb. . As discussed below, under the Consent Judgment and Section 2a of Part 201, PLS may request a less restrictive cleanup level derived under section 20120a of Part 201. Since the last amendment to the Consent Judgment, the cleanup criterion promulgated under Part 201 for 1,4-dioxane is 85 ppb. PLS has requested the MDEQ to agree to amend the Consent Judgment to reflect this change. 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.

While PLS does not believe that a waiver of these rules is required, the MDEQ has requested PLS to make such a request if it will recommend a Remedial alternative the allows the plume to expand. The standards for waiver of Rules 705(5) and (6) are summarized below. The circumstances justifying such a waiver are discussed in Chapter 7.

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. Under Section 18 of Part 201, MCL 324.20118, the MDEQ can waive compliance with Rule 705(5) under the conditions set forth in Subsections 18(5) or (6), MCL 324.20118(5), (6).