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January 30, 2014

Ms. Sybil Kolon
Environmental Quality Analyst
Department of Environmental Quality
Jackson State Office Building
301 E. Louis Glick Highway
Jackson, MI 49201-1556

Re: Conceptual Site Model – MW-103

Dear Ms. Kolon:

Enclosed please find the Conceptual Site Model for 1,4-Dioxane at Monitoring Well MW-103.

Should you have any questions or concerns, please contact me at 734-913-6130.

Sincerely,

Farsad Fotouhi

Farsad Fotouhi
Vice President
Sustainability, Safety, Environmental Engineering

cc: Ms. Celeste R. Gill, MDAG
Michael Caldwell, Esq.

Conceptual Site Model
for 1,4-Dioxane at Monitoring Well MW-103

Prepared by Pall Life Sciences, Inc.

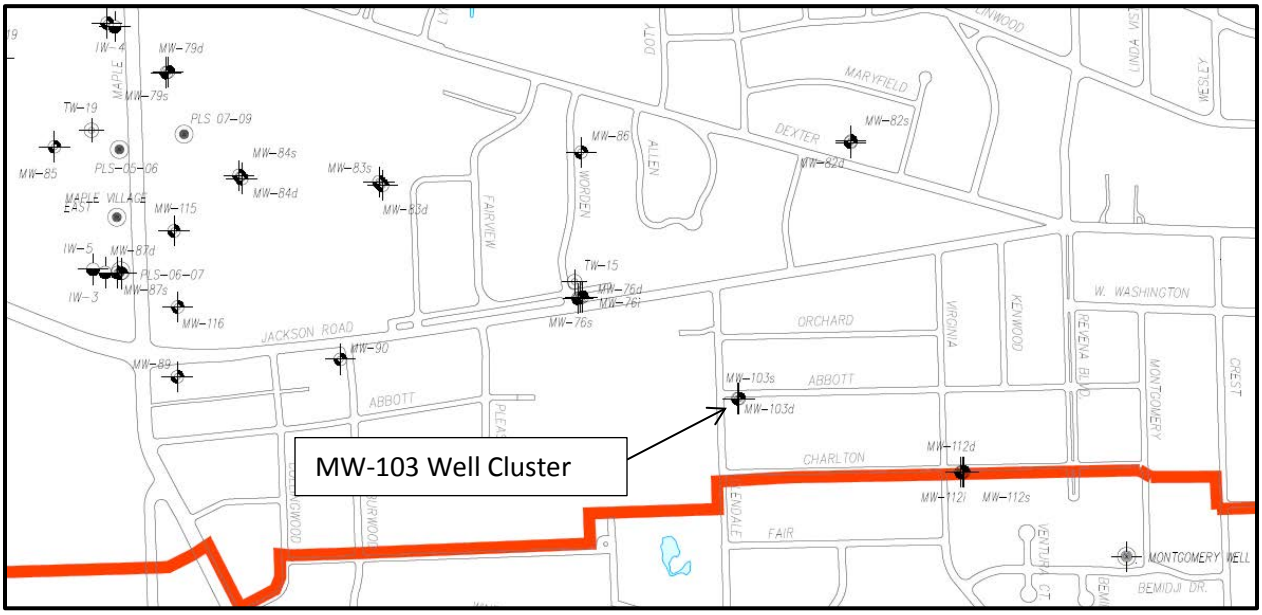
January 30, 2014

Table of Contents

I. INTRODUCTION

The Michigan Department of Environmental Quality (MDEQ) has requested that Pall Life Science (PLS) prepare a Conceptual Site Model (CSM). The purpose of the CSM is to provide PLS's interpretations of the conditions in the general area of Maple Road to the MW-103/112 area, and describe how those conditions relate to the 1,4-dioxane trends observed at the MW-103 well cluster.

The MW-103 well cluster consist of two wells (MW-103s/MW-103d) located near the southern edge of the Unit E plume, between Jackson Road and the southern boundary of the Prohibition Zone (PZ). The location of the area of interest is shown on the figure below:

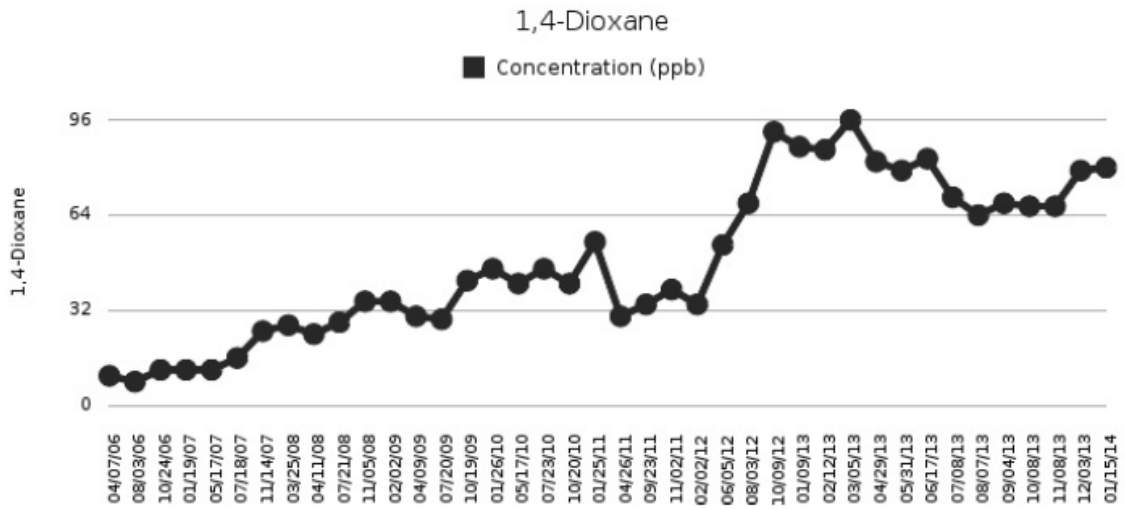


Map of the MW-103 Area

1,4-Dioxane concentrations in groundwater sampled from MW-103s are close to the MDEQ drinking water criterion for 1,4-dioxane (85 ug/L). 1,4-Dioxane levels in groundwater sampled from MW-103s have increased slowly over time and, 1,4-Dioxane levels were briefly above 85 ug/L during a period from January to March 2013, reaching a maximum level of 96 ug/L. 1,4-Dioxane levels in the last ten samples collected from this well since April of 2013 have decreased and have remained below 85 ug/L. A trend graph of data from MW-103s is provided below. Supporting water quality data are provided in Attachment 1. The concentrations in the deeper well, MW-103d, have been very stable at levels below 10 ug/L.

Well Name: MW-103s

Aquifer:	E	Date Installed:	03/06/2006	Boring Depth:	63.00 Feet bgl	Screen 1:	53.00 to 58.00 Feet
Map Location:	M-33	Well Driller:	Stearns Drilling	Ground Elevation:	903.97 Feet	Screen Length:	5.00
X Coordinate:	13284564.15	Well Type:	Monitoring Well	TOC Elevation:	903.26 Feet	Screen 2:	Unknown to Unknown Feet
Y Coordinate:	284811.70	Sampling Interval:	Monthly	TOC to screen bottom:	63.00 Feet		
Comments:							

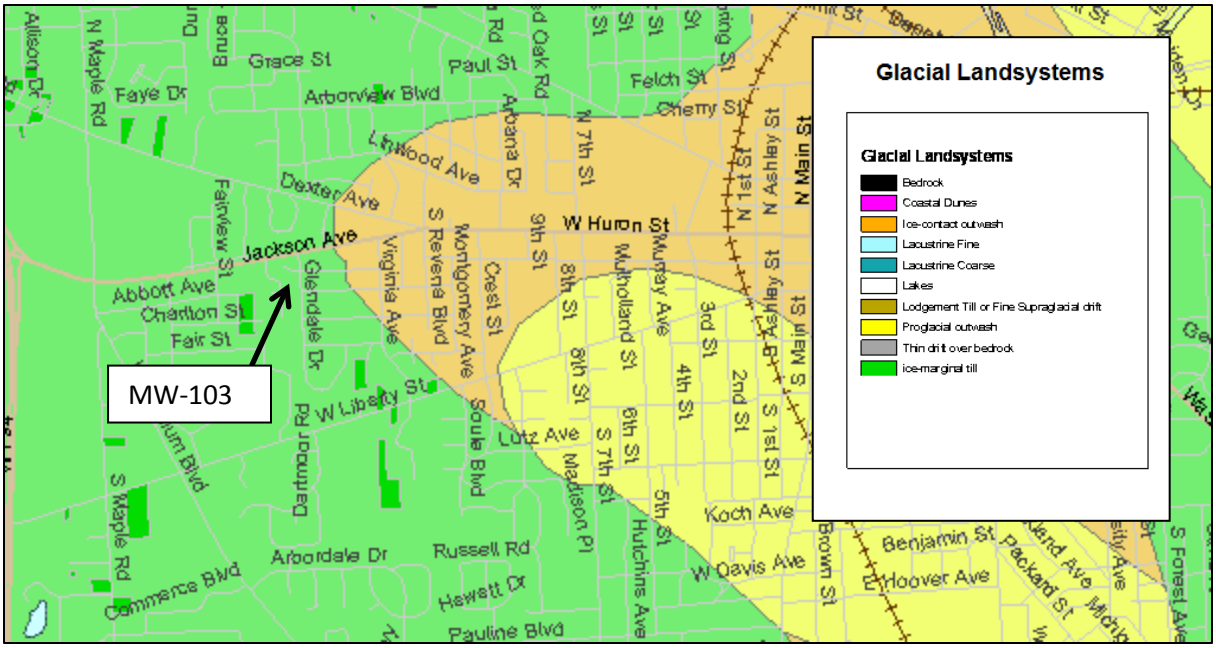


Because of the location of the MW-103 well cluster with respect to the southern boundary of the PZ, the MDEQ has requested PLS evaluate the conditions leading to the observed levels of 1,4-dioxane at the MW-103 cluster.

II. HYDROGEOLOGICAL SETTING

Geological Setting

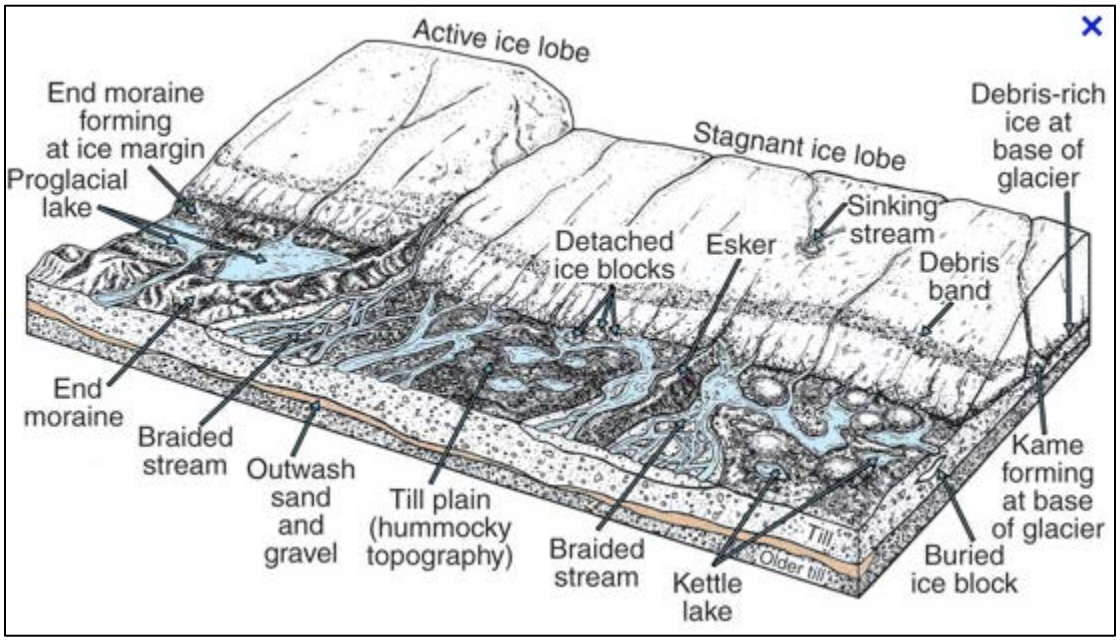
The MW-103 well cluster area is in a glacial ice-marginal depositional environment associated with the Fort Wayne Moraine. Ice-marginal areas are typically dominated by ablation tills with interbedded coarse-grained outwash channels and fan deposits. A Glacial Landsystems map showing the area is provided below:



Source – MDEQ Groundwater Mapping Site

Ice marginal environments often lead to complex depositional sequences. Ice-contact outwash and proglacial outwash typically consist of coarse-grained materials deposited in interwoven channels and braided streams. Complicated stratigraphic sequences are common in ice-margin depositional environmental due to rapidly changing energy regimes caused by cycles/pulses of advancing ice and melting ice. Aquifers within such deposits should be expected to exhibit complex stratigraphy and be non-uniform and anisotropic.

The following block diagram depicts the typical features of an ice marginal environment:



Source - Kansas Geological Survey, Public Information Circular (PIC) 28

Hydrostratigraphy

PLS has prepared four (4) hydrostratigraphic cross-sections for the MW-103 well cluster area (A-A', B-B', C-C' and D-D'). These cross-sections are provided along with a cross-section location map in Attachment 2. These sections are used to illustrate the generalized hydrostratigraphy in the Maple/MW-103 area. Consistent with previous PLS cross-sections, yellow depicts coarse-grained materials such as sands and gravels and green depicts fine-grained materials (clay, silt, diamictons). It is important to note that there is known interconnection between aquifers in the vicinity of the MW-103 well cluster. That said, there are other areas where aquitards/aquicludes separate and limit the connection of the aquifers. These separations play a role in the distribution and transport of contaminants, more specifically, 1,4-dioxane. It is also important to note that the interpretations provided by PLS represent one interpretation of hydrostratigraphy and that other interpretations are possible.

There are three (3) distinct aquifer zones in the area, excluding very shallow deposits which are not relevant for the transport of 1,4-dioxane and depicted as "Undifferentiated" on the cross-sections. For the purpose of this report, the terms: Upper Aquifer Zone, Intermediate Aquifer Zone and Lower Aquifer Zone will be used to describe the aquifers relevant to the understanding of the transport of 1,4-dioxane in the MW-103 well cluster area.

The following significant features are noted regarding the hydrostratigraphy in the site area:

- The drift thickness is greatest in the area of Maple Road (280-298 feet) and decreases steadily toward the east/southeast (MW-76 = 273, MW-103 = 238, MW-112 = 211, Montgomery Wells = 174 feet).

- The thickest sand sequences are observed in the Maple Village/MW-103 area around the MW-76 well cluster (211 feet). These sand sequences diminish to 150 feet at MW-103 and 77 feet at MW-112. (Total Sand Isopach, PLS Unit E Plume Downgradient Investigation).

- Along Maple Road (Cross section A-A'), there appears to be one connected aquifer sequence impacted by 1,4-dioxane. This aquifer has a channel or "V" shape, with the lowest portion of the aquifer/base of the channel in the vicinity of TW-19. As shown on the cross-section, the total sand thickness from the TW-19 increases to the north and decreases to the south until the MW-89 area where it thickens again.

- Between Maple Road and the MW-76 well cluster, the single aquifer at Maple Road "splits", forming two aquifer zones, a combined upper/intermediate aquifer zone and a lower aquifer zone (refer to Cross Section C-C').

- Between the MW-76 and MW-103 well clusters, the upper aquifer "splits" forming three distinct aquifer zones: Upper, Intermediate and Lower (refer to Cross Section C-C').

- Aquifers are unconfined and confined/semi-confined in the area. In the vicinity of MW-76 and MW-103 the uppermost aquifer is unconfined.

Aquifer testing has been performed at three locations in the area of the MW-103 cluster, the following results were obtained:

Well Name	Date Installed	Test Length	Test Flow Rate (gpm)	Aquifer Thickness (ft)	Hydraulic Conductivity (gpd/ft2)	Hydraulic Conductivity (ft/day)	Transmissivity (ft2/day)	Transmissivity (gpd/ft)	Storativity
TW-19	12/5/2005	24hr + rec	204	97	526	70	6,819	51,010	1.36E-04
IW-3 (aka TW-16)	8/15/2003	24hr + rec	200	78	1,688	226	17,605	131,682	1.36E-04
TW-15	2/4/2003	24hr + rec	200	125	1,630	218	27,243	203,775	0.00011 - 0.000279

The aquifer test data suggest the aquifers are comprised of coarse-grained materials and are transmissive. This testing also revealed anisotropic conditions in the aquifer(s).

Groundwater Flow

PLS has been collecting groundwater elevation data from the MW-103 well cluster area for years and has prepared numerous potentiometric surface maps. The most recent potentiometric surface map (October 2013) is provided as Attachment 3.

PLS routinely provides two potentiometric surface maps, one contouring data from the shallow wells; the second contouring data from the deeper wells. The general configuration of the shallow and deep potentiometric surfaces has been very consistent. Groundwater flow is regionally to the east. A steep hydraulic gradient has been observed in the vicinity of Maple Road. East of this area (starting centrally in Vets Park), the gradient becomes more gentle. Further downgradient, near the MW-82 well cluster, the hydraulic gradient steepens and remains steep to the Huron River.

The steep hydraulic gradient in the vicinity of Maple Village is believed to be related to the thinning of the aquifer in that area. Conversely, near Vets Park where the aquifer is thickest, the hydraulic gradient becomes gentler.

The gradients in the deeper portion of the aquifer are similar to the hydraulic gradient observed in the shallower portion in that they are steep along Maple Road, flat in the Vets Park to MW-103 well cluster area, and steepen to the east.

In the vicinity of the MW-103 well cluster, the apparent groundwater flow direction determined from the potentiometric surface in the shallower portion of the aquifer is to the northeast. When the deeper wells are included and contoured, the direction of groundwater flow is more west to east.

III. 1,4-DIOXANE DISTRIBUTION AND PATHWAY OF PLUME TO MW-103

A well-documented plume of 1,4-dioxane has migrated eastward from the PLS site. The estimated horizontal extent of 1,4-dioxane is shown on a recent (October 2013) Unit E Isoconcentration map which is provided as Attachment 4. The estimated vertical distribution of 1,4-dioxane is depicted on the previously referenced cross sections provided as Attachment 2.

1,4-Dioxane has been observed to “funnel” through the Maple Village area as it works its way toward the Huron River. The area where the plume crosses beneath Maple Road is a highly-investigated area of the plume which contains multiple nested monitoring wells positioned in a north-south row. As such, data from this area is valuable to understanding the geometry of the plume and how it relates to areas that are hydraulically downgradient of the Maple Road area.

The plume moving through the Maple Road area shows some distinct characteristics. As shown on Cross Section A-A’, there are two distinct mass centers, one positioned near MW-87/IW-5, the other near TW-19. As these two mass centers migrate, they “overlap” and are not hydraulically separated.

The mass center located in the TW-19 area is considerably deeper than that in the MW-87 area. To the north, the plume mass appears to be concentrated along the base of the aquifer.

1,4-Dioxane in the central and northern portion of Maple Village (TW-19 and north) appears to migrate to the north of the MW-103 well cluster (towards MW-81 and MW-91). It is important to note that the expansion to the north is predicted and NOT an indication that the plume will continue on a northern trajectory toward the northern border of the PZ. Rather, all indications are the plume will take an eastward path toward the area near where Allen Drain discharges to the Huron River.

1,4-Dioxane detected at MW-103s is along the southern border of the plume and is believed to be "connected" to 1,4-dioxane along the southern portion of the Maple Village (MW-87 area). This is supported by several lines of evidence:

- Geographically, this area is closer to the MW-103 well cluster area and more hydraulically downgradient;
- 1,4-dioxane at MW-103 is at an elevation consistent with this portion of the Maple Road area; and
- The "signature" of 1,4-dioxane trends in MW-87 area appear to match that of MW-103 area as compared to the TW-19 area (see graph later in this report).

The southern plume boundary in the MW-89/MW-90 area has been very stable. That said, the plume widens east of MW-90 toward the area of the MW-103 well cluster which has raised concerns due to the proximity of this well relative to the southern boundary of the PZ.

1,4-Dioxane at the MW-103 well cluster is concentrated in the upper aquifer zone. It is also being detected at low levels in the lower aquifer zone. The concentrations in the lower aquifer zone have been very stable at levels below 10 ug/L. 1,4-Dioxane concentrations at the MW-76 well cluster location are also concentrated in the upper aquifer (the upper aquifer and intermediate aquifer zones are combined at the MW-76 location) although 1,4-dioxane is also present at low levels in the lower aquifer zone at this location.

PLS believes the reason 1,4-dioxane is concentrated in the upper aquifer zone at MW-103s is related to the aquifer geometry and the connection to the southern plume mass center along Maple Road. Regarding the influence of the aquifer geometry, there is a rise in the elevation of the base of the shallower aquifer as you go eastward from the Maple Village area. This rise "forces" 1,4-dioxane to migrate upward as it moves east. The rise in the aquifer base can be seen on cross sections A-A' and D-D'.

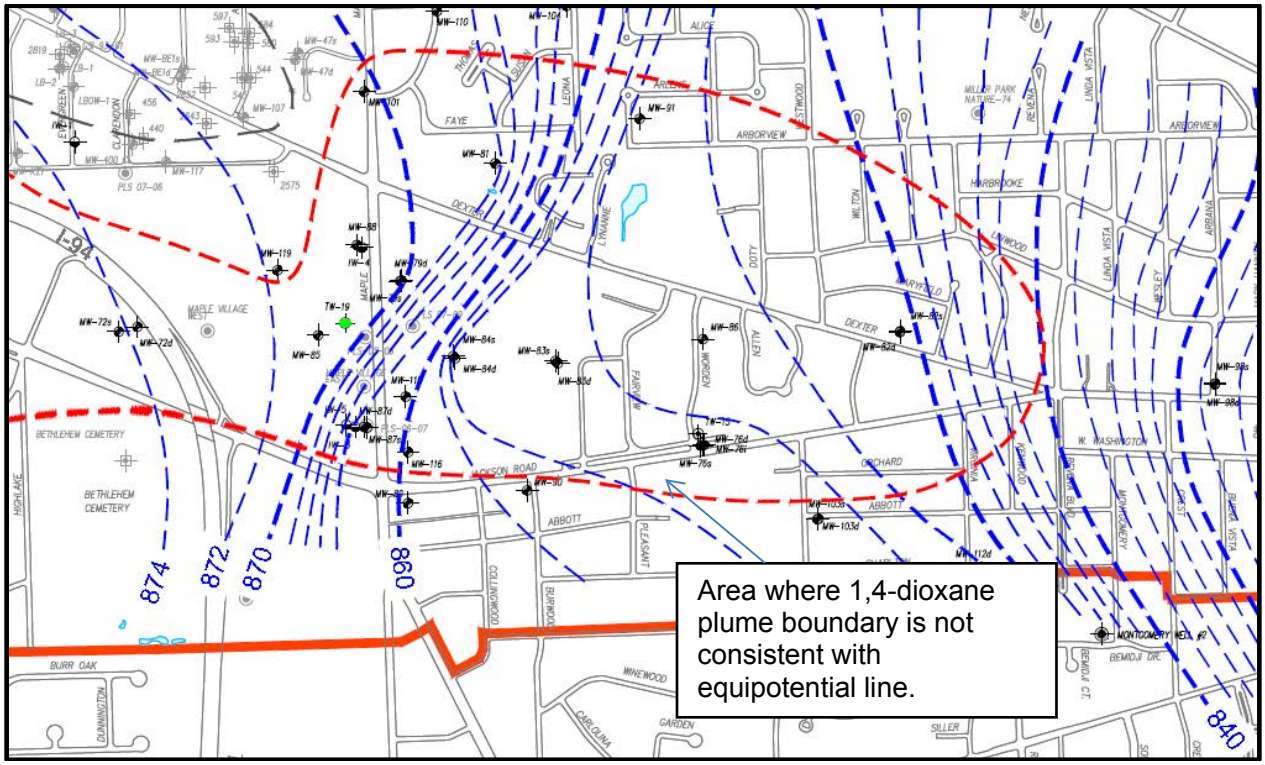
As 1,4-dioxane moves toward the MW-76 well cluster, the aquifer thickens considerably and the plume becomes distributed over a larger vertical sequence, thus lowering 1,4-dioxane levels. The aquifer also becomes unconfined in this area which also contributes to lower levels since the plume is receiving additional groundwater recharge vertically. In the area of the MW-103 cluster, an intervening confining unit separates the plume into the Upper Aquifer Zone and Intermediate Aquifer Zone.

MW-112s is strategically positioned to detect any potential expansion of the plume south of the MW-103 well cluster. At MW-112, 1,4-dioxane is only being detected in MW-112i which is in the Intermediate Aquifer Zone.

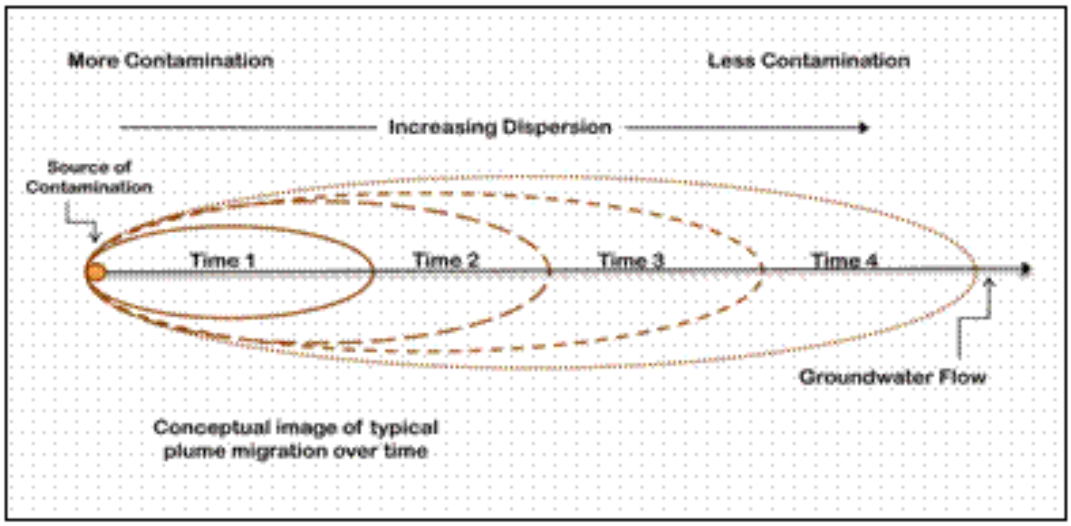
IV. PROCESSES CONTROLLING THE MIGRATION OF THE PLUME TOWARD MW-103

The most plausible explanation for plume widening in the area of the MW-103 well cluster is dispersion in an anisotropic aquifer.

The MDEQ and others have noted that the 1,4-dioxane plume in the MW-103 area is moving in a slightly different direction than that predicted by the potentiometric surface (see below):



This is not an unusual or troubling occurrence. As a plume migrates hydraulically downgradient, it will naturally widen as it disperses. This process is shown on the diagram below:



Source – modified from Freeze and Cherry, 1979, *Groundwater*

When anisotropic conditions are present, refraction of a plume can occur. Tracer tests have shown that horizontal anisotropy and preferential flow paths commonly refract plume paths from expected trajectories wherever aquifers do not approximate homogenous and isotropic conditions (e.g., well studied sand and gravel environments) (Siegel, 2007).

In an isotropic aquifer, flow lines will cross equipotential lines at right angles. If there is anisotropy in the plane of flow, then the flow lines will cross the equipotential lines at an angle (dictated by the degree of anisotropy and other factors). This is illustrated in the following graphics from the book *Applied Hydrogeology* by Fetter.

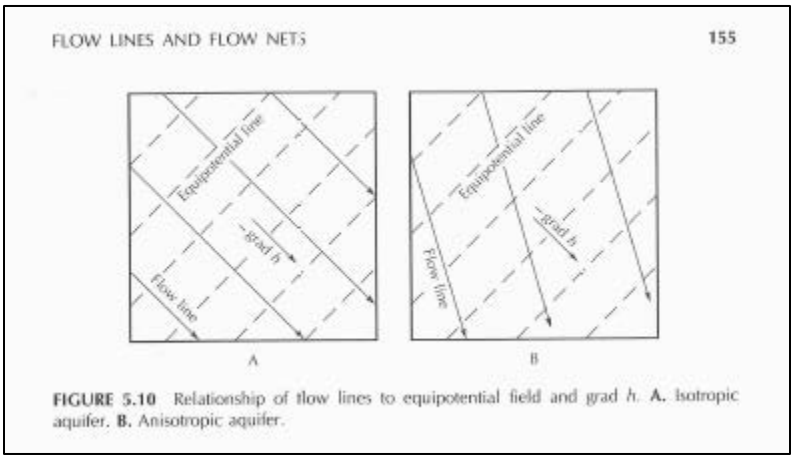
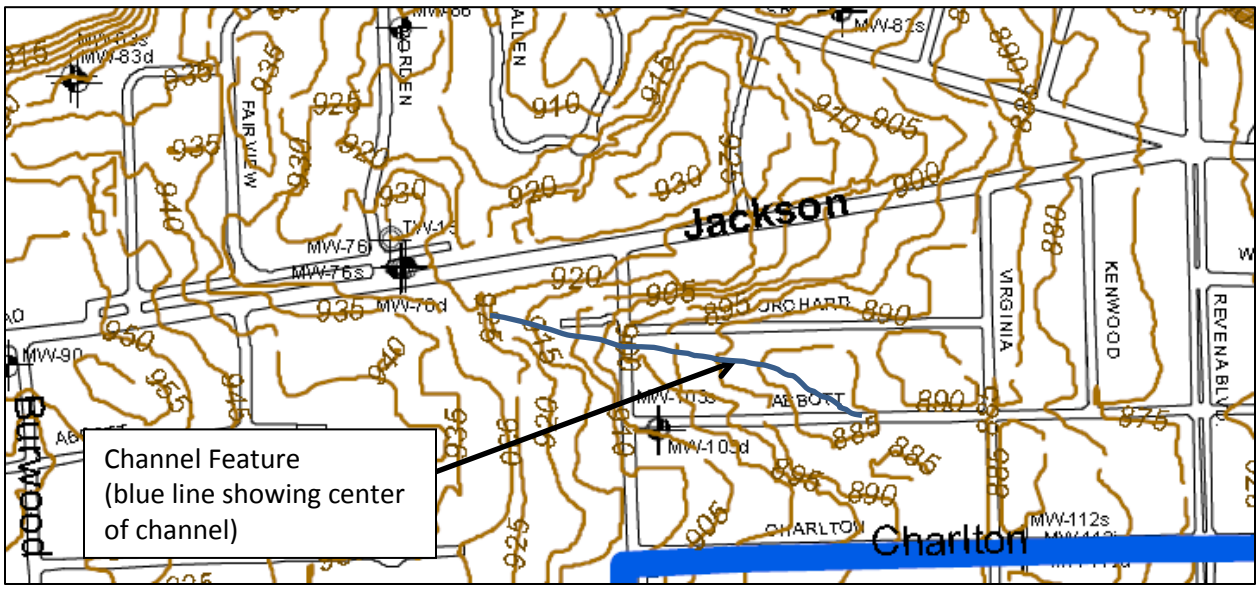


FIGURE 5.10 Relationship of flow lines to equipotential field and grad *h*. **A.** Isotropic aquifer. **B.** Anisotropic aquifer.

Anisotropic conditions can be created by preferred channels. An examination of the topography in the area of MW-103 suggests the development of a channel-like feature in the area between MW 76 and MW-103. It is quite plausible that there is a correlation between the widening of the plume near the MW-103 well cluster and this topographic feature. This feature, shown below, is localized to the area shown below. That is, it does not extend further east than Virginia Street, and the "bank" of the channel rises as it approaches Charlton, which would retard further dispersion to the south.



Source (Topographic Map) – City of Ann Arbor

To the extent that there is a correlation between the plume widening and this topographic feature, this feature is limited in geographic extent and not likely to control the plume beyond the Abbot/Virginia area.

The dispersion of the plume to the south of MW-103 well cluster will be limited and not expected to go beyond the PZ. This is because the groundwater flow in this area is to the east/northeast. To the extent that the plume refracts in this area due to aquifer anisotropy, it is competing with the hydraulic gradient which guides the plume to the east. Additionally, as noted above, the possible physical feature that might be causing some of the widening of the plume in the MW-103 well cluster area is limited in extent and does not extend out toward the PZ.

Prediction of Future 1,4-Dioxane Levels at MW-103

The increase of 1,4-dioxane levels in the area of MW-103s represents a slight widening of the Unit E plume as it continues to migrate to the east under the influence of the natural hydraulic (uninfluenced by anthropogenic) gradients. The dominant eastward hydraulic gradient will keep the plume from migrating beyond the southern boundary of the PZ. The MW-112 well cluster is an excellent location to monitor for any potential expansion to the south given its distance from MW-103 well cluster and its location slightly to the east (the general downgradient direction).

1,4-Dioxane concentrations at MW-103s are on a general trend upward at this time. Historic trends at this location suggest there is considerable variation in the trends. There are many variables that may be causing this variation. In looking at the totality of the data, there is a reasonable potential that 1,4-dioxane levels at this location may exceed 85 ug/L at some point in the future. For the reasons set forth above, however, it is unlikely that such concentrations will migrate further to the PZ boundary. Upgradient concentration trends also indicate that, while concentrations at MW-103 may rise for a period of time, the long-term trend will be downward.

The best indicator of future trends at MW-103 or MW-112 is to look at upgradient wells. Trend data for MW-87s, MW-115, MW-116, MW-83s, MW-84s, MW-76s and MW-76i are provided below:

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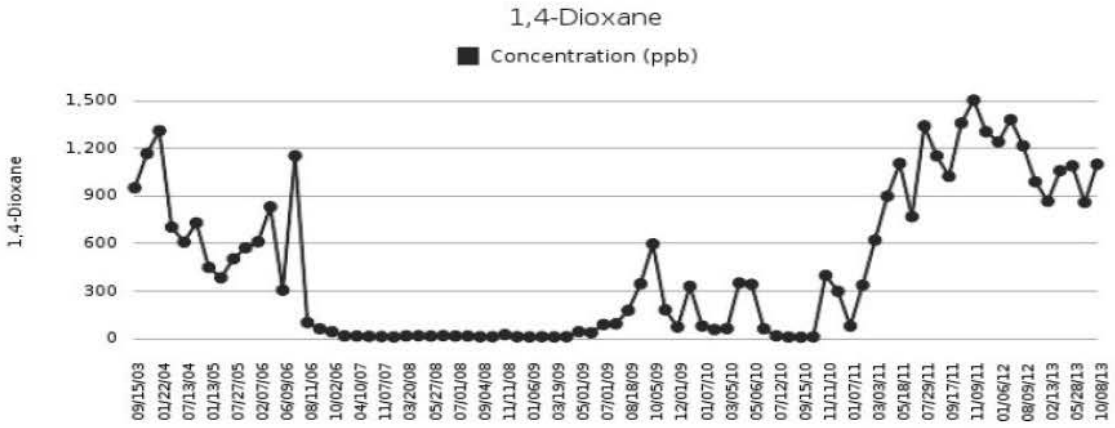
Analytical Data Graph

Printed: 12/17/2013

Well Name: MW-87s

Aquifer:	E	Date Installed:	08/18/2003	Boring Depth:	85.00 Feet bgl	Screen 1:	85.00 to 80.00 Feet
Map Location:	L-28	Well Driller:	Stearns	Ground Elevation:	928.00 Feet	Screen Length:	5.00
X Coordinate:	13281913.00	Well Type:	Monitoring Wells	TOC Elevation:	927.72 Feet	Screen 2:	NA to NA Feet
Y Coordinate:	285349.00	Sampling Interval:	Quarterly	TOC to screen bottom:	85.00 Feet		
Comments:							



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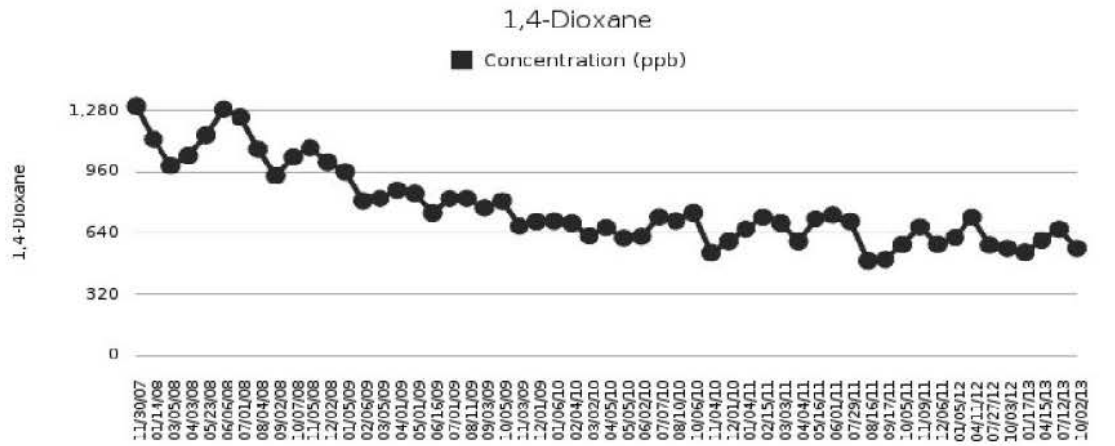
Analytical Data Graph

Printed: 01/21/2014

Well Name: MW-115

Aquifer:	E	Date Installed:	11/21/2007	Boring Depth:	245.00 Feet bgl	Screen 1:	130.00 to 125.00 Feet
Map Location:	L-20	Well Driller:	Stearns	Ground Elevation:	Unknown Feet	Screen Length:	Unknown
X Coordinate:	13282139.13	Well Type:	Monitoring Wells	TOC Elevation:	907.20 Feet	Screen 2:	Unknown to Unknown Feet
Y Coordinate:	285531.88	Sampling Interval:	Quarterly	TOC to screen bottom:	Unknown Feet		
Comments:							



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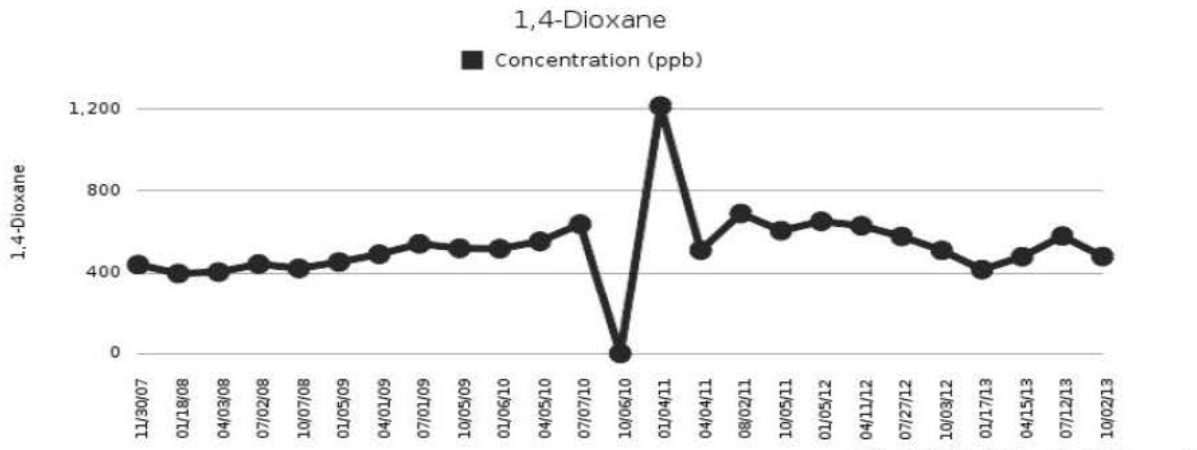
Analytical Data Graph

Printed: 12/17/2013

Well Name: MW-116

Aquifer:	E	Date Installed:	11/06/2007	Boring Depth:	284.50 Feet bgl	Screen 1:	140.00 to 135.00 Feet
Map Location:	L-28	Well Driller:	Stearns	Ground Elevation:	Unknown Feet	Screen Length:	Unknown
X Coordinate:	13282154.79	Well Type:	Monitoring Wells	TOC Elevation:	936.02 Feet	Screen 2:	Unknown to Unknown Feet
Y Coordinate:	285205.13	Sampling Interval:	Quarterly	TOC to screen bottom:	Unknown Feet		
Comments:							



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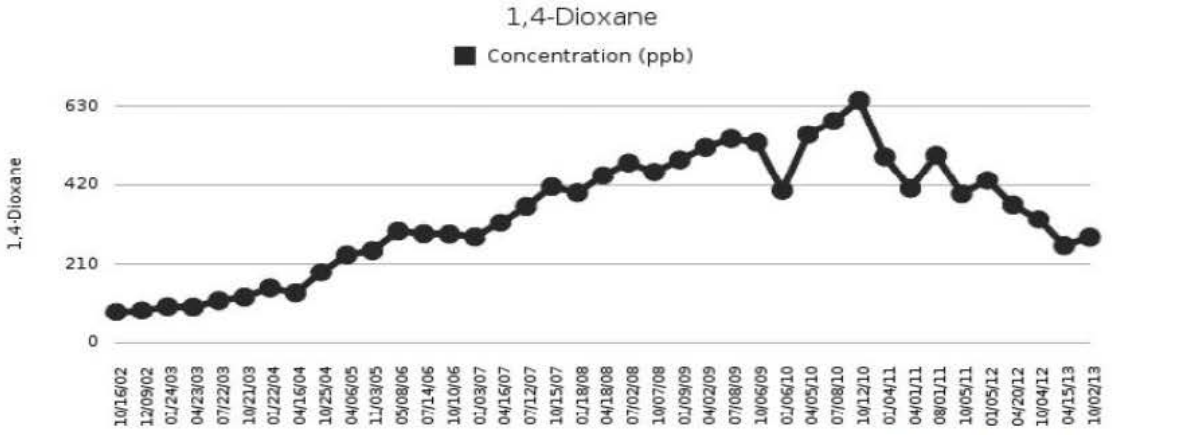
Analytical Data Graph

Printed: 12/17/2013

Well Name: MW-83s

Aquifer:	E	Date Installed:	10/14/2002	Boring Depth:	130.00 Feet bgl	Screen 1:	130.00 to 125.00 Feet
Map Location:	K-30	Well Driller:	Stearns	Ground Elevation:	927.00 Feet	Screen Length:	5.00
X Coordinate:	13283020.96	Well Type:	Monitoring Wells	TOC Elevation:	927.06 Feet	Screen 2:	NA to NA Feet
Y Coordinate:	285742.59	Sampling Interval:	Semi-Annual	TOC to screen bottom:	130.00 Feet		
Comments:							



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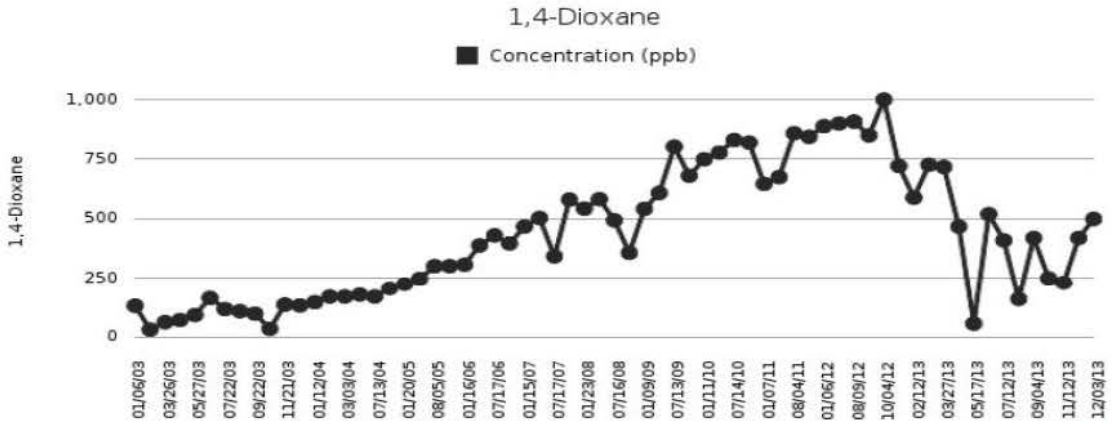
Analytical Data Graph

Printed: 12/17/2013

Well Name: MW-84s

Aquifer:	E	Date Installed:	01/03/2003	Boring Depth:	113.00 Feet bgl	Screen 1:	113.90 to 108.90 Feet
Map Location:	K-29	Well Driller:	Stearns	Ground Elevation:	906.00 Feet	Screen Length:	5.00
X Coordinate:	13282418.72	Well Type:	Monitoring Wells	TOC Elevation:	905.04 Feet	Screen 2:	NA to NA Feet
Y Coordinate:	285770.49	Sampling Interval:	Monthly	TOC to screen bottom:	113.90 Feet		
Comments:	Veterans Park						



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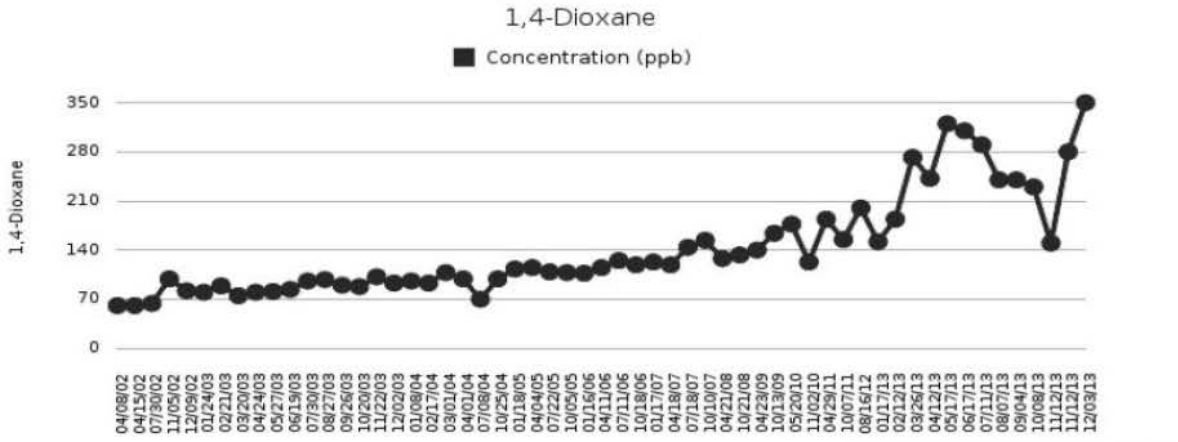
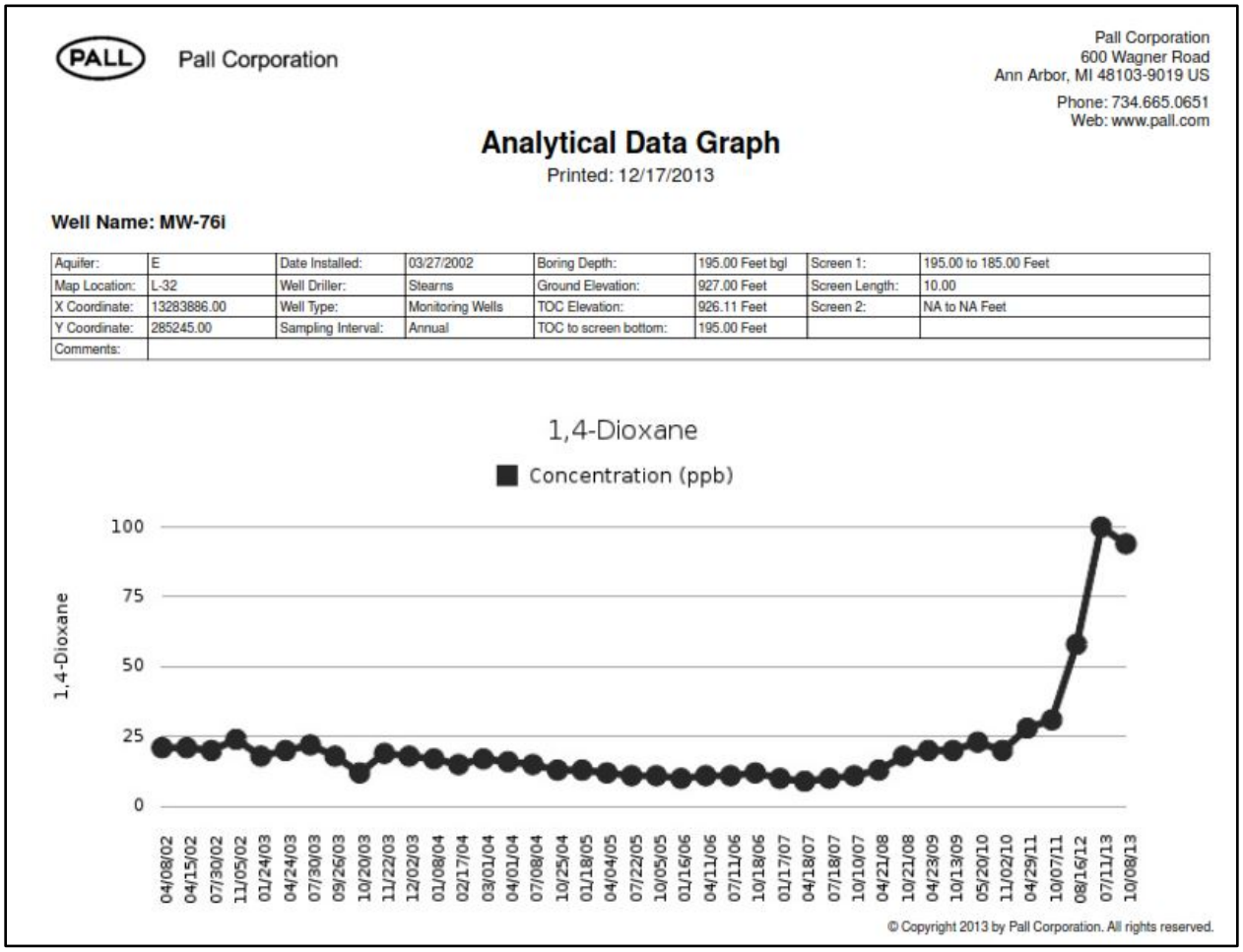
Printed: 12/17/2013

Well Name: MW-76s

Aquifer:	E	Date Installed:	03/25/2002	Boring Depth:	104.00 Feet bgl	Screen 1:	104.00 to 94.00 Feet
Map Location:	L-32	Well Driller:	Stearns	Ground Elevation:	927.00 Feet	Screen Length:	10.00
X Coordinate:	13283877.00	Well Type:	Monitoring Wells	TOC Elevation:	926.22 Feet	Screen 2:	NA to NA Feet
Y Coordinate:	285243.00	Sampling Interval:	Monthly	TOC to screen bottom:	104.00 Feet		
Comments:							





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Printed: 12/17/2013

Well Name: MW-76i

Aquifer:	E	Date Installed:	03/27/2002	Boring Depth:	195.00 Feet bgl	Screen 1:	195.00 to 185.00 Feet
Map Location:	L-32	Well Driller:	Stearns	Ground Elevation:	927.00 Feet	Screen Length:	10.00
X Coordinate:	13283886.00	Well Type:	Monitoring Wells	TOC Elevation:	926.11 Feet	Screen 2:	NA to NA Feet
Y Coordinate:	285245.00	Sampling Interval:	Annual	TOC to screen bottom:	195.00 Feet		
Comments:							

It is clear that wells west of the MW-76 area are either trending downward (MW-87s, MW-83s, MW-84s) or stable (MW-115, MW-116). These observed trends at upgradient wells suggest that the trends at MW-76s, MW-76i, MW-103s and MW-112i will stabilize or begin to decline in the near future.

V. SUMMARY OF KEY POINTS

The following is a summary of key points presented in this CSM:

1. The MW-103 well cluster is positioned in a complex depositional environment consisting of fine-grained ice-marginal tills and coarse-grained outwash.

2. 1,4-Dioxane in the MW-103 well cluster area believed to migrate from the plume center positioned on the south side of the plume at its intersection with Maple Road (the plume center located near MW-87).

3. The southern 1,4-dioxane plume boundary has widened slightly to the south in the area of MW-103. As a result, the MW-103 well cluster is located very close to the southern boundary of the plume.

4. The widening of the plume was not predicted by the potentiometric surface (equipotential contours). The most likely explanation for any apparent discrepancy of the plume boundary and groundwater flow in the MW-103 well cluster area is dispersion associated with anisotropy in the aquifer which causes the plume to refract in this area.

5. It is plausible that the 1,4-dioxane concentrations at MW-103s may exceed 85 ug/L before stabilizing and declining consistent with upgradient concentration trends.

6. Further widening of the plume south of the MW-103 well cluster will be limited and is not expected to extend to the PZ boundary. The MW-112 well cluster is an excellent monitoring location to determine if the plume will approach the PZ.

VI. REFERENCES

Fetter, C.W. *Applied Hydrogeology* Fourth Edition, Prentice Hall.

Pall Life Sciences, Phase 2 Downgradient Investigation of the Unit E Plume, November 2007

Freeze, R.A. & Cherry, J.A., 1979. *Groundwater*, Prentice-Hall.

Lyle, A. S., *Glaciers in Kansas*, Kansas Geological Survey, Public Information Circular (PIC) 28.

Siegel, D.I. and Otz, M.H., 2007. *The forgotten anisotrophy: is there scale-dependency for plume migration in the horizontal plane?* in Geological Society of America, Abstracts with programs, Annual Fall Meeting, October 28-31, 2007.

Analytical Data Report: MW-103s

Aquifer: E	**Date Installed:** 03/06/2006	**Boring Depth:** 63.00 Feet bgl	**Screen 1:** 63.00 to 58.00 Feet
Map Location: M-33	**Well Driller:** Stearns Drilling	**Ground Elevation:** 903.97 Feet	**Screen 1 Length:** 5.00
X Coordinate: 13284564.15	**Well Type:** Monitoring Wells	**TOC Elevation:** 903.26 Feet	**Screen 2:** Unknown to Unknown Feet
Y Coordinate: 284811.70	**Sampling Interval:** Monthly	**TOC to screen bottom:** 63.00 Feet	
	Static Interval: Monthly	**Notes:**	

Date Collected	Time Collected	1,4-Dioxane Results (ppb)	R.L.	Bromate Results	R.L.	Bromide Results	R.L.	Static Time	Static Reading	Comments
01/15/2014	12:35	80	1.0					11:47	48.12	
12/03/2013	11:35	79	1.0					11:25	47.97	
11/08/2013	14:15	67	1.0					13:23	48.03	
10/08/2013	10:05	67	5.0					10:00	48.05	
10/08/2013	10:05	76	5.0					10:00	48.05	
09/18/2013	14:44							14:44	47.80	
09/04/2013	13:25	68	1.0					13:15	47.82	
08/07/2013	10:12	64	1.0					10:05	47.67	
07/08/2013	13:55	70	1.0					13:10	47.53	
06/17/2013	11:15	83	1.0					11:05	47.64	
05/31/2013	11:30	79	1.0					11:25	47.6	
04/29/2013	13:05	82	1.0					12:55	47.59	
03/15/2013	14:05							14:05	47.75	

Date Collected	Time Collected	1,4-Dioxane Results (ppb)	R.L.	Bromate Results	R.L.	Bromide Results	R.L.	Static Time	Static Reading	Comments
03/05/2013	13:20	96	1.0					13:20	47.74	
02/12/2013	11:10	86	1.0					11:05	47.81	
01/09/2013	11:20	87	5.0					11:10	47.75	
10/09/2012	14:10	92	1.0					13:55	47.56	
09/19/2012	14:23							14:23	47.61	
08/03/2012	11:30	68	1.0					11:20	47.41	
06/05/2012	11:35	54	1.0					11:30	47.18	
03/14/2012	14:47							14:47	47.32	
02/02/2012	13:25	34	1.0					13:15	47.6	
11/02/2011	13:25	39	1.0					13:15	47.88	
09/23/2011	14:25	34	1.0					14:20	47.91	
09/22/2011	13:40							13:40	64.62	
04/26/2011	14:20	30	1.0					14:10	48.33	
03/17/2011	14:40							14:40	48.55	
01/25/2011	14:15	55	1.0					14:05	48.63	
10/20/2010	10:40	41	1.0					10:30	48.24	
09/01/2010	14:04							14:04	47.97	
07/23/2010	13:00	46	1.0					12:50	47.89	
05/17/2010	13:00	41	1.0					12:50	48.16	
03/09/2010	11:30							11:30	48.23	
01/26/2010	10:35	46	1.0					10:25	48.21	
10/19/2009	13:30	42	1.0					13:20	47.93	
09/24/2009			1.0					14:24	47.99	

Date Collected	Time Collected	1,4-Dioxane Results (ppb)	R.L.	Bromate Results	R.L.	Bromide Results	R.L.	Static Time	Static Reading	Comments
07/20/2009	11:00	29	1.0					10:50	47.86	
04/09/2009	12:15	30	1.0					11:20	48.3	
03/17/2009			1.0					14:37	48.31	
02/02/2009	12:35	35	1.0					12:25	48.65	
11/05/2008	13:25	35	1.0					13:15	48.56	
09/17/2008			1.0					13:15	48.51	
07/21/2008	12:25	28	1.0					12:15	48.24	
04/11/2008	12:55	24	1.0					12:45	48.09	
03/25/2008	09:50	27	1.0					09:40	48.3	
02/25/2008			1.0					15:09	48.36	
02/19/2008			1.0					11:15	48.53	
11/14/2007	11:20	25	1.0					11:10	48.31	
09/13/2007			1.0					13:57	48.19	
07/18/2007	13:22	16	1.0					13:15	47.98	
05/17/2007	10:10	12	1.0					09:55	47.96	
03/13/2007			1.0					11:05	47.95	
01/19/2007	11:35	12	1.0					11:25	48.12	
10/24/2006	09:25	12	1.0					09:15	48.59	
09/15/2006			1.0					10:47	48.63	
08/03/2006	10:35	8	1.0					10:20	48.5	
04/07/2006	13:40	10	1.0					13:29	48.9	
03/22/2006			1.0					13:35	49.14	

Analytical Data Report: MW-103d

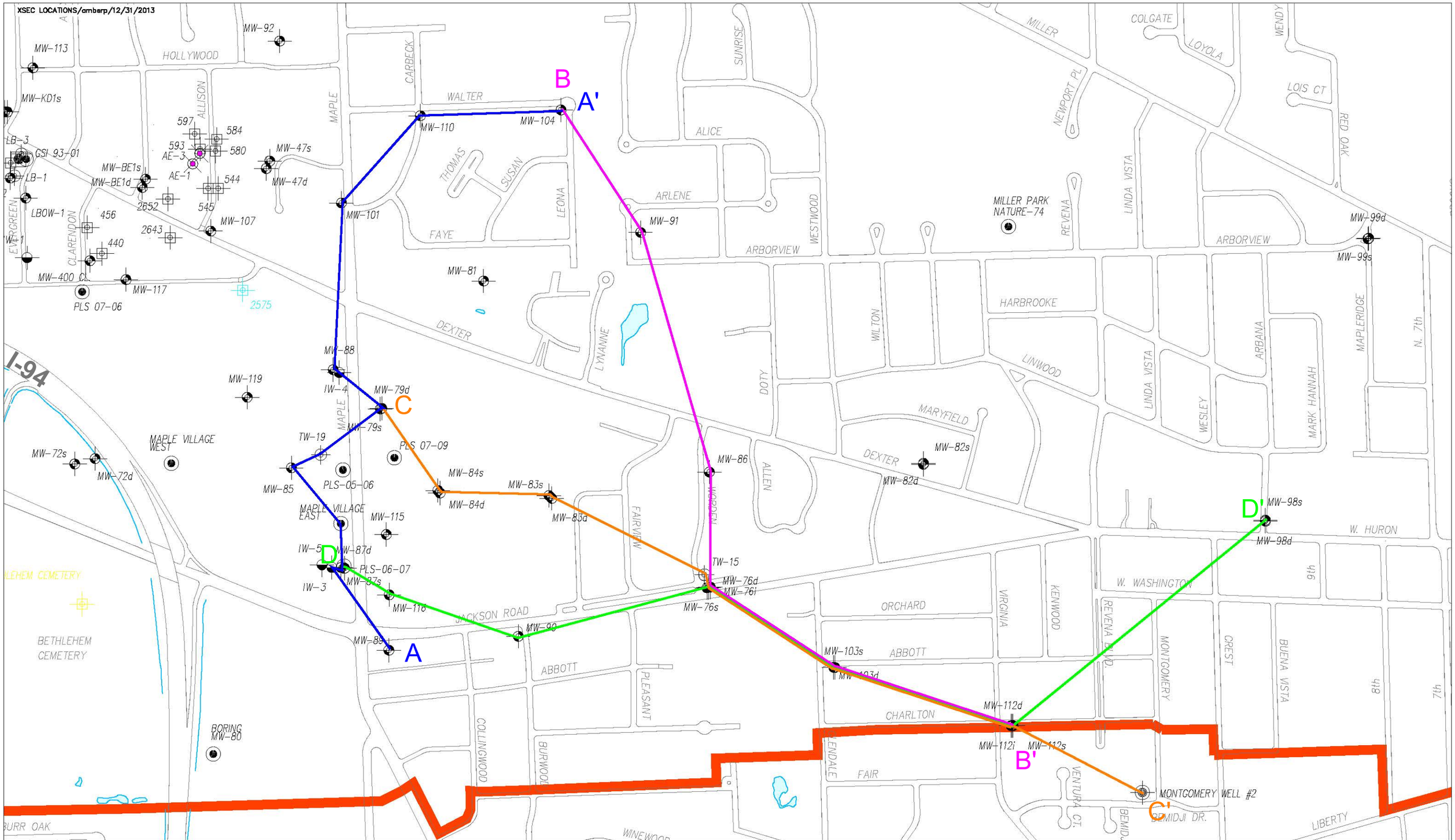
Aquifer: E	**Date Installed:** 03/13/2006	**Boring Depth:** 242.00 Feet bgl	**Screen 1:** 211.00 to 206.00 Feet
Map Location: M-33	**Well Driller:** Stearns Drilling	**Ground Elevation:** 903.80 Feet	**Screen 1 Length:** 5.00
X Coordinate: 13284569.84	**Well Type:** Monitoring Wells	**TOC Elevation:** 902.97 Feet	**Screen 2:** Unknown to Unknown Feet
Y Coordinate: 284811.47	**Sampling Interval:** Quarterly	**TOC to screen bottom:** 211.00 Feet	
	Static Interval: Quarterly	**Notes:** Ground elevation taken from nearby concrete.	

Date Collected	Time Collected	1,4-Dioxane Results (ppb)	R.L.	Bromate Results	R.L.	Bromide Results	R.L.	Static Time	Static Reading	Comments
11/08/2013	14:00	7	1.0					13:15	49.21	
09/18/2013	14:41							14:41	49.18	
07/08/2013	13:45	16	1.0					13:00	49.0	
04/29/2013	14:05	12	1.0					13:00	49.49	
03/29/2013	11:30	12	2.2					10:45	49.46	
03/15/2013	14:17							14:17	49.47	
02/26/2013	12:00	15	1.0					11:15	49.53	
10/09/2012	13:50	16	1.0					13:05	49.17	
09/19/2012	14:24							14:24	49.27	
08/03/2012	11:15	14	1.0					10:30	49.33	
06/05/2012	11:25	16	1.0					10:40	48.84	
03/14/2012	14:49							14:49	48.96	
02/02/2012	14:10	12	1.0					13:30	49.24	

Date Collected	Time Collected	1,4-Dioxane Results (ppb)	R.L.	Bromate Results	R.L.	Bromide Results	R.L.	Static Time	Static Reading	Comments
11/02/2011	14:20	15	1.0					13:30	50.31	
09/23/2011	15:10	15	1.0					14:30	50.49	
09/22/2011	13:39							13:39	47.97	
04/26/2011	13:50	13	1.0					13:00	51.02	
03/17/2011	15:00							15:00	50.93	
01/25/2011	14:00	20	1.0					13:20	51.1	
10/20/2010	10:20	18	1.0					09:30	50.79	
09/01/2010	14:02							14:02	50.83	
07/23/2010	12:45	20	1.0					11:55	50.69	
05/17/2010	12:45	16	1.0					12:00	51.03	
03/09/2010	11:29							11:29	50.83	
01/26/2010	10:20	16	1.0					09:30	50.8	
10/19/2009	14:20	21	1.0					13:35	50.73	
09/24/2009			1.0					14:26	50.81	
07/20/2009	10:45	18	1.0					10:00	50.4	
04/09/2009	11:55	17	1.0					11:15	50.63	
03/17/2009			1.0					14:35	50.92	
02/02/2009	12:20	18	1.0					11:40	51.29	
11/05/2008	14:15	18	1.0					13:30	51.57	
09/17/2008			1.0					13:14	51.5	
07/21/2008	13:20	20	1.0					12:30	51.19	
04/11/2008	13:45	17	1.0					13:05	52.09	
03/25/2008	10:30	18	1.0					09:55	51.76	

Date Collected	Time Collected	1,4-Dioxane Results (ppb)	R.L.	Bromate Results	R.L.	Bromide Results	R.L.	Static Time	Static Reading	Comments
02/25/2008			1.0					15:11	51.8	
02/19/2008			1.0					11:20	51.92	
11/14/2007	12:05	19	1.0					11:25	53.06	
09/13/2007			1.0					13:56	52.9	
07/18/2007	14:10	18	1.0					13:25	53.28	
05/17/2007	09:50	10	1.0					09:10	52.94	
03/13/2007			1.0					11:06	52.73	
01/19/2007	12:30	2	1.0					11:40	51.4	
10/24/2006	09:10	18	1.0					08:40	55.7	
09/15/2006			1.0					10:45	56.1	
08/03/2006	10:15	17	1.0					09:35	55.88	
04/07/2006	14:12	16	1.0					13:51	56.01	
03/22/2006			1.0					16:30	52.18	

XSEC LOCATIONS/amberp/12/31/2013



LEGEND

- MONITOR WELL
- RESIDENTIAL WELL (Active/Non-Active)
- PURGE WELL
- SOIL BORING
- TEMPORARY PURGE WELL
- PROHIBITION ZONE BOUNDARY

NORTH

0 500 1000

SCALE IN FEET

FLEIS & VANDENBRINK ENGINEERING, INC.

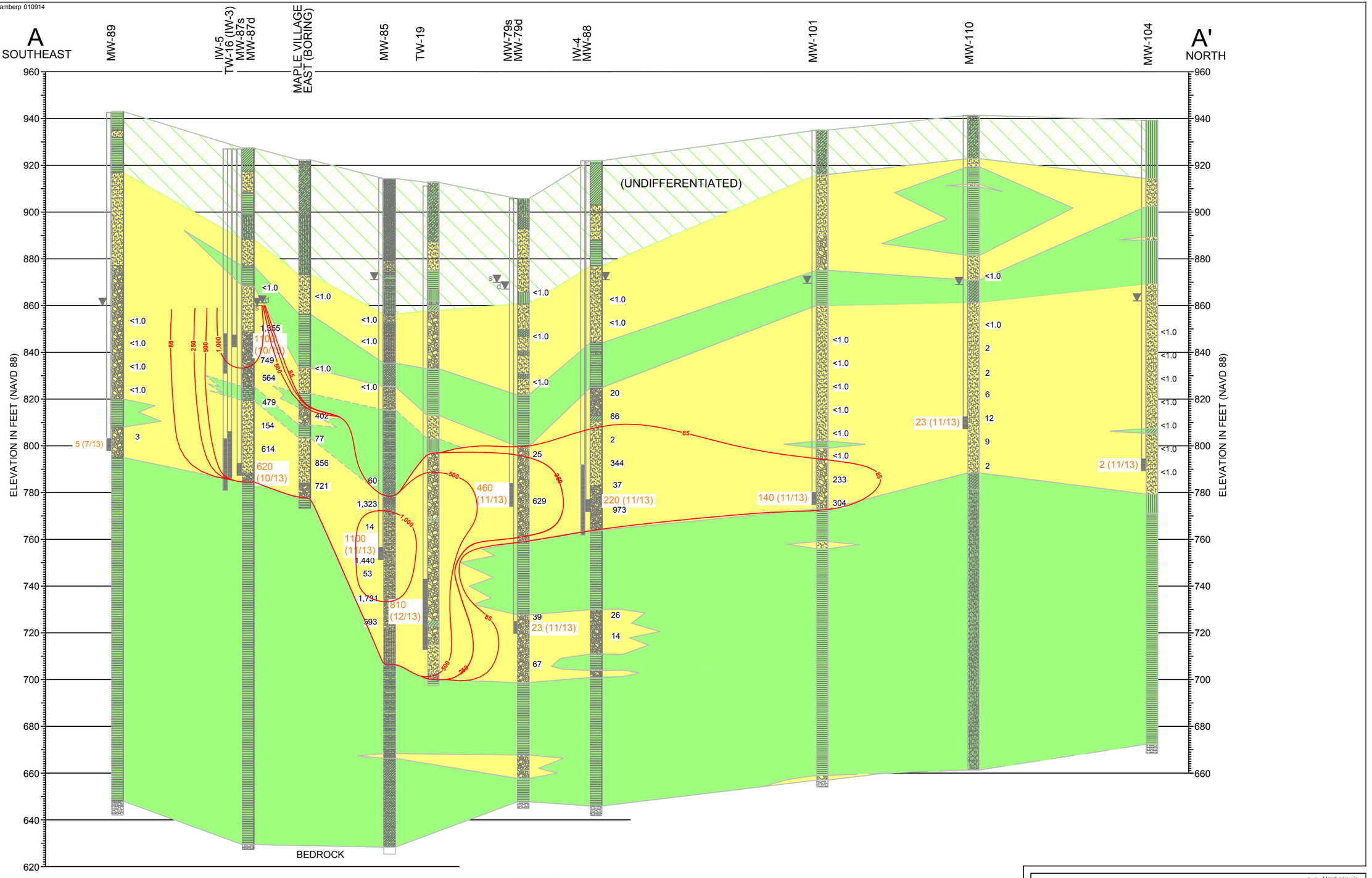
PALL LIFE SCIENCES
WASHTENAW COUNTY, MI

Hard copy is intended to be 11"x17" when plotted.

CONCEPTUAL SITE MODEL MW-103 AREA
CROSS SECTION LOCATION MAP

2014 806500

XSEC Conceptual Site Model / amberp 010914



0 400 800

SCALE IN FEET

VERTICAL EXAGGERATION = 10X

LEGEND

67 - VERTICAL SAMPLE AND 1,4-DIOXANE CONCENTRATION µ/L (Samples Collected During Installation Unless Noted)

130 - 1,4-DIOXANE CONCENTRATION (µ/L) AND COLLECTION DATE (Samples Collected From Well)

WELL

WATER LEVEL ELEVATION

SCREENED INTERVAL

SAND GRAVEL SHALE CLAY SILT DIAMICTON

NOTES:
-MOST RECENT WATER QUALITY DATA WAS USED.
-THE CORRELATIONS SHOWN ARE BASED ON PROFESSIONAL JUDGEMENT. OTHER INTERPRETATIONS ARE POSSIBLE AND SHOULD BE CONSIDERED.

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WASHTENAW COUNTY, MI

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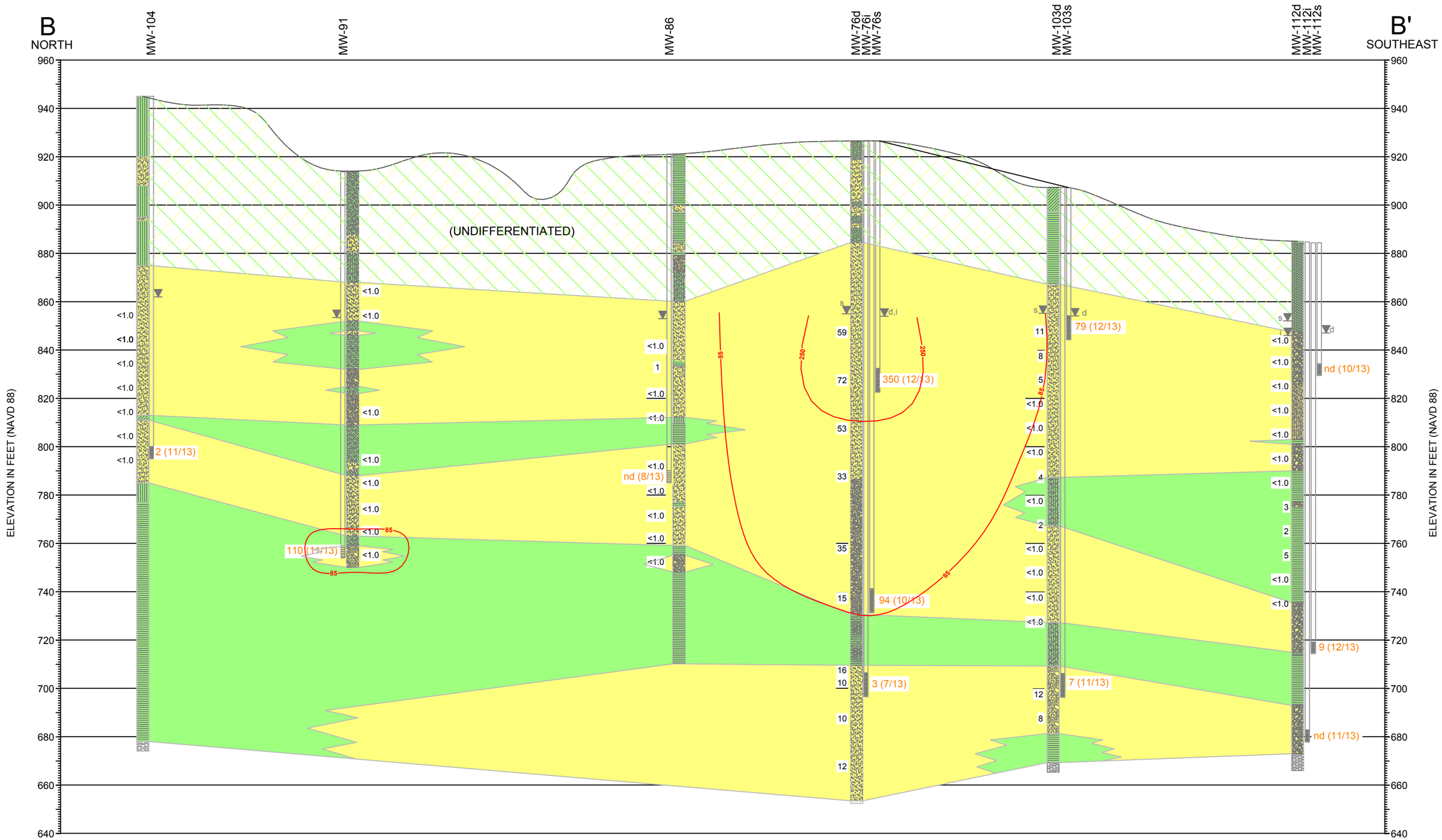
CONCEPTUAL SITE MODEL MW-103 AREA
CROSS SECTION A-A'

2014 806500

XSEC Conceptual Site Model / amberp 010914



0 400 800

SCALE IN FEET

VERTICAL EXAGGERATION = 10X

LEGEND

67 - VERTICAL SAMPLE AND 1,4-DIOXANE CONCENTRATION µ/L (Samples Collected During Installation Unless Noted)

130 - 1,4-DIOXANE CONCENTRATION (µ/L) AND COLLECTION DATE (Samples Collected From Well)

WELL

WATER LEVEL ELEVATION

SCREENED INTERVAL

SAND GRAVEL SHALE CLAY SILT DIAMICTON

NOTES:
-MOST RECENT WATER QUALITY DATA WAS USED.
-THE CORRELATIONS SHOWN ARE BASED ON PROFESSIONAL JUDGEMENT. OTHER INTERPRETATIONS ARE POSSIBLE AND SHOULD BE CONSIDERED.

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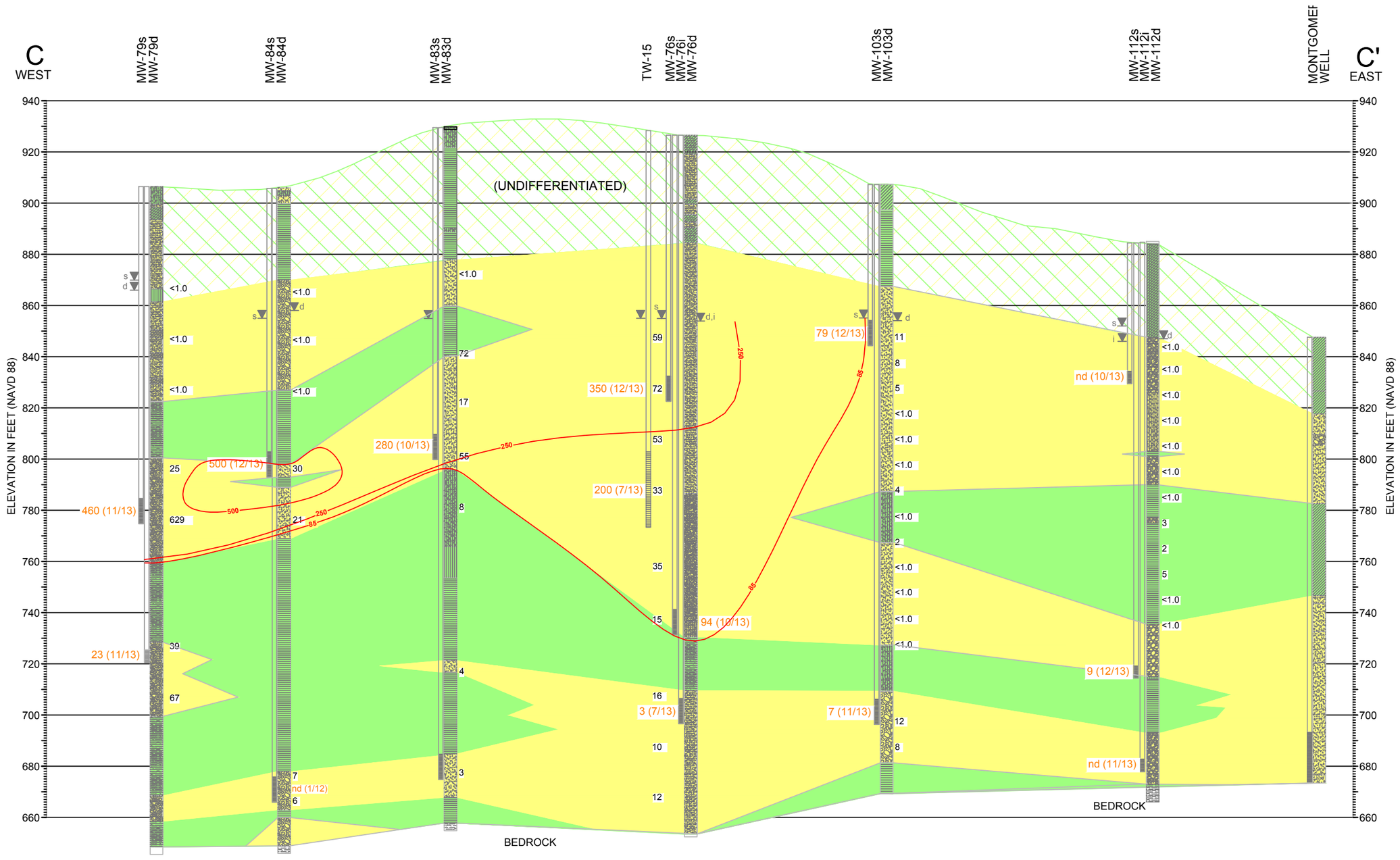
CONCEPTUAL SITE MODEL MW-103 AREA
CROSS SECTION B-B'

2014 806500

XSEC Conceptual Site Model / amberp 010914



0 400 800

SCALE IN FEET

VERTICAL EXAGGERATION = 10X

LEGEND

67 - VERTICAL SAMPLE AND 1,4-DIOXANE CONCENTRATION µ/L (Samples Collected During Installation Unless Noted)

130 - 1,4-DIOXANE CONCENTRATION (µ/L) AND COLLECTION DATE (Samples Collected From Well)

WELL

WATER LEVEL ELEVATION

SCREENED INTERVAL

SAND GRAVEL SHALE CLAY SILT DIAMICTON

NOTES:
-MOST RECENT WATER QUALITY DATA WAS USED.
-THE CORRELATIONS SHOWN ARE BASED ON PROFESSIONAL JUDGEMENT. OTHER INTERPRETATIONS ARE POSSIBLE AND SHOULD BE CONSIDERED.

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Hard copy is intended to be 11"x17" when plotted.

CONCEPTUAL SITE MODEL MW-103 AREA
CROSS SECTION C-C'

2014 806500

XSEC Conceptual Site Model / amberp 010914

D WEST — D' EAST

MW-87s MW-87d | MW-116 | MW-90 | MW-76s MW-76i MW-76d | MW-103s MW-103d | MW-112s MW-112i MW-112d | MW-98s MW-98d

ELEVATION IN FEET (NAVD 88)

(UNDIFFERENTIATED)

<1.0 d
1,355
1100 (10/13)
749
564
479
154
614
913
620 (10/13)
23
64
246
131
26
364
480 (10/13)
477
278
5 (10/13)
<1.0
<1.0
<1.0
4
<1.0
<1.0
350 (12/13)
d,i
59
72
53
33
35
15
94 (10/13)
16
10
12
3 (7/13)
79 (12/13)
d
11
8
5
<1.0
<1.0
<1.0
4
<1.0
2
<1.0
<1.0
<1.0
7 (11/13)
12
8
nd (10/13)
d
<1.0
<1.0
<1.0
<1.0
<1.0
<1.0
<1.0
3
2
5
<1.0
<1.0
9 (12/13)
nd (11/13)
nd (08/13)
<1.0
<1.0
<1.0
<1.0
<1.0
<1.0
<1.0
<1.0
<1.0
2
<1.0
<1.0
7 (11/13)

-500 -250 -95

960 940 920 900 880 860 840 820 800 780 760 740 720 700 680 660 640 620

0 400 800
SCALE IN FEET
VERTICAL EXAGGERATION = 10X

LEGEND

67 - VERTICAL SAMPLE AND 1,4-DIOXANE CONCENTRATION µ/L (Samples Collected During Installation Unless Noted)

130 - 1,4-DIOXANE CONCENTRATION (µ/L) AND COLLECTION DATE (Samples Collected From Well)

WELL
WATER LEVEL ELEVATION
SCREENED INTERVAL

SAND GRAVEL SHALE CLAY SILT DIAMICTON

NOTES:
-MOST RECENT WATER QUALITY DATA WAS USED.
-THE CORRELATIONS SHOWN ARE BASED ON PROFESSIONAL JUDGEMENT. OTHER INTERPRETATIONS ARE POSSIBLE AND SHOULD BE CONSIDERED.

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WASHTENAW COUNTY, MI

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CONCEPTUAL SITE MODEL MW-103 AREA
CROSS SECTION D-D'

2014 806500

Pall Life Sciences

DEEPER UNIT *E* WELLS IN SELECT AREA.

LEGEND

- MONITOR WELL
- EXTRACTION WELL
- UNIT E EXTRACTION WELL OPERATING DURING SAMPLING
- DOMESTIC WELL
- INJECTION WELL
- UNIT E POTENTIOMETRIC CONTOUR
- *865.81* - UNIT E POTENTIOMETRIC ELEVATION
- *(858.46)* - DATA NOT USED
- PROHIBITION ZONE BOUNDARY
- MW–xx - COMPLIANCE MONITOR WELL

NOTES:

MAP COMBINES DATA FROM WELLS COMPLETED AT MULTIPLE DEPTHS. INTERPRETATION OF THIS MAP REQUIRES FAMILIARITY WITH THE GEOLOGY AND THE GROUNDWATER FLOW REGIME.

POTENTIOMETRIC SURFACE ELEVATION DATA ARE IN FEET NAVD88.

NORTH

SCALE IN FEET

FLEIS & VANDENBRINK
ENGINEERING, INC.
2960 Lucerne Drive SE, Grand Rapids, MI 49546
Fax: (616) 977-1005

PALL Life Sciences

PALL LIFE SCIENCES
Scio Twp., Washtenaw County, Michigan

POTENTIOMETRIC SURFACE MAP UNIT E (SEPTEMBER 18, 2013)

PROJECT MGR. JWB	DATE 10/16/13
DRAWN BY AJP	DATE 10/16/13
ECOLOGIST JWB	DATE 10/16/13
CAD FILE Current_E_PSC	
DWG amberp 010214	
SCALE 1"=750'	

Hard copy is intended to be 24"x36" when plotted.

PROJECT 806500

PSC

SHEET NO.

DEEPER MIGRATION (MERGES WITH SHALLOWER D PLUME TO EAST)

Pall Life Sciences

LEGEND

- MONITOR WELL
- EXTRACTION WELL
- UNIT E EXTRACTION WELL OPERATING DURING SAMPLING
- DOMESTIC WELL
- INJECTION WELL
- UNIT E 1,4-DIOXANE ISOCONCENTRATION CONTOUR (µg/L)
- UNIT D_2 1,4-DIOXANE ISOCONCENTRATION CONTOUR (µg/L)
- 3076 - 1,4-DIOXANE CONCENTRATION (µg/L)
- (307) - DATA NOT USED
- PROHIBITION ZONE BOUNDARY
- MW-xx - COMPLIANCE MONITOR WELL

NOTES:

THE DATA SHOWN IS FROM SAMPLE PERIOD 04/13 - 09/13.

MAP COMBINES DATA FROM WELLS COMPLETED AT MULTIPLE DEPTHS. INTERPRETATION OF THIS MAP REQUIRES FAMILIARITY WITH THE GEOLOGY AND THE GROUNDWATER FLOW REGIME.

NORTH

0 500 1000

SCALE IN FEET

Hard copy is intended to be 24"x36" when plotted.

FLEIS & VANDENBRINK
ENGINEERING, INC
2960 Lucerne Drive SE, Grand Rapids, MI 49546
Fax: (616) 977-1005

PALL Life Sciences

PALL LIFE SCIENCES
Scio Twp., Washtenaw County, Michigan

1,4 DIOXANE ISOCONCENTRATION MAP UNIT E (APRIL 2013 - SEPTEMBER 2013)

PROJECT MGR. JWR	DATE 10/16/13
DRAWN BY AJP	DATE 10/16/13
GEOLOGIST JWR	DATE 10/16/13
CAD FILE Current_E_ISO	
XREF amberp 010214	
SCALE 1"=500'	DRAWING
PROJECT 806500	
ISO	
SHEET NO.	