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MEMORANDUM

TO: Lisa Humphreys, USACE PBOW Coordinator, and others

FROM: Julie Weatherington-Rice

RE: Bedrock Monitoring Well Placement Amendment Review Request to the Technical Review for the RAB of the "Draft Site Specific Sampling and Analysis Plan Remedial Investigation, Part 1, at Acid Area 1" by Jacobs Engineering

DATE: June 12, 2007

Per our current contractual arrangement with USACE which requires both a technical memorandum for each report and an educational explanation to the RAB, this memorandum constitutes the technical review of the Bedrock Monitoring Well Placement Amendment Review Request to the Jacobs report "Draft Site-Specific Sampling and Analysis Plan Remedial Investigation, Part 1, at Acid Area 1". Please forward these comments to those who should receive them. As this is not one of the scheduled reviews, it is not my intention to produce an educational memo at this point in time for this request. This technical memo should serve if one needs to be sent to the RAB. If an additional educational memo is required, please let me know and I will develop one.

Per an e-mail request from Rick Meadows on June 6, 2007 to me to review additional information Re: the depth of the new monitoring wells planned for Acid Area 1, I am in receipt of the following e-mail and documents from Jim Beaujon:

1. **Attached Figure 6-5 (modified Shaw Figure 6-5 from the 2004 groundwater report) shows Acid Area #1 and highlighted wells AA1-BEDGW-001and MNTA-BEDGW-001 relative to the groundwater trough. Acid Area #1 is just south of AA1-BEDGW-001 with its eastern half covered by that well's label.**

2. **Attached portion of Table 4-2 from Shaw's 2004 groundwater report provides the well construction details for AA1-BEDGW-001 and MNTA-BEDGW-001 highlighted. Primary pieces of info are: ground surface at AA1-BEDGW-001 isat about 639 feet above mean sea level (msl); both wells are about 65 feetdeep or they reach an elevation of about 574 feet above msl.**

3. **Attached portion of Table 6-1 from Shaw's 2004 groundwater report provides in highlighting the groundwater elevation measurements we have for AA1-BEDGW-001 and MNTA-BEDGW-001. Relevant pieces of information. Apparently we had no monitoring well activities ongoing during the 1999 drought year as no readings are listed for that year. The lowest groundwater elevation reading we have for these two wells occurred in MNTA-BEDGW-001 in November 2002 at 606 feet above msl.**

4. **Our contract allows Jacobs to go as deep as 75 feet below ground surface. Generally there is some on-site professional judgment applied as to how deep to bore the hole after water is encountered but since AA1-BEDGW-001 and MNTA-BEDGW-001 are both 65 feet deep the new wells would tend to be expected to be at least that deep also.**

5. **I've attached the 2001 cross section (from Shaw's/IT's 2001 groundwater report), which has AA1-BEDGW-001 and MNTA-BEDGW-001 shown left of center, to help visualize the well installation. When the water level was at 606 feet msl these wells still had about 30 feet of groundwater in them.**

Conclusion- Unless there is a significant (>30') drop in the water table around Acid Area #1, wells installed to a depth of 65' or more should be ok.

Jim Beaujon

Introduction to This Review and General Water Level Recommendation

It is important to note that all of these documents were prepared before I became involved in this project and they demonstrate precisely the reason for generating regular water level maps for the area each time water levels are taken at the site. I understand that these water levels are now taken quarterly. It would be extremely helpful to provide tabular water level results by well (calibrated to above mean sea level data and/or with the calibration information attached) and a blank site map of the well locations at the RAB meetings so that members of the RAB and other members of the review team could create their own water level maps for their own reviews if they so choose. This level of request should significantly minimize the actual time required by US ACE staff to support as opposed to requesting staff and/or contractors to add an additional work effort, without funding, for the actual creation of fully developed ground water flow maps. It is important to separate the wells by shale/overburden and by limestone (and any other classification that may exist) since water levels from one type of well should be kept separate from other types of wells. If such a well location site map is available and/or developed, it should extend far enough north and east to include the Wagner Quarry sump since this ground water level is now known and basically "fixed" at 460 feet amsl (above mean sea level).

My review comment 12 to the original report stated as follows:

Figure 5-1 Acid Area 1 Groundwater Sampling Locations

12. The depths of the new bedrock ground water monitoring wells need to be determined, in part, by the lowest static water levels at AA1-BEDGW-001 and MNTA-BEDGW-001 for late summer and fall of 1999 if there are readings for that period for these wells. This was the last serious drought year for this area. In addition, the pumping cone from the Wagner Quarry must also be considered in determining the target depth for the three new wells. If they are finished too high, they will be dry part or all of the time.

Review from Tables 4-2 and 6-1

From the information on Table 6-1, it is apparent that not only were AA1-BEDGW-001 and MNTA-BEDGW-001 not measured during the drought year of 1999 to 2000, none of the other wells on the site were measured either so we have absolutely no idea how much lower the levels were during that drought period then that have been during other periods of time. We have data provided for May 5, 1998 and September 20, 2000 which bracket the drought period, but they are too early and too late a set of readings to be useful predictors of how much water levels fell over the site during the drought. We do know from ODNR's records, what the annual dewatering records for the Wagner Quarry are as follows for those years (but please remember that these numbers reflect calendar years and so therefore do not measure the reduced pumping rates for the worst part of the drought).

1998 332,280,000 gallons dewatered for the year
1999 242,100,000 gallons dewatered for the year
2000 275,310,000 gallons dewatered for the year
2001 308,690,000 gallons dewatered for the year
2002 328,810,000 gallons dewatered for the year.
2003 400,860,000 gallons dewatered for the year
2004 376,110,000 gallons dewatered for the year

When I review the water level measurements for AA1-BEDGW-001, MNTA-BEDGW-001, and BED-MW16, I don't see any obvious patterns from the data presented on the tables. There is no obvious change between 05/05/1998 (632.96' amsl [above mean sea level]) and 09/20/00 (630.70' amsl) for BED-MW16. The second reading is 2.26 feet lower than the first one. However, the next time the wells were checked, in 01/17/01, there was no measurement taken for that well (but I don't know why because that information is not present on the table).

The 08/15/01 reading for BED-MW16 was 630.14' amsl but the follow up reading on 11/15/01 was 605.56' amsl which is a huge drop of 24.58 feet. After that, the well is not monitored for 02/27/02, 05/04/02, 08/06/02, and 11/21/02 (with no explanation as to why that is the case). On 03/18,19/03, that well is back up to 632.95' amsl, just about where it was in 05/05/1998. The bottom of that well is 559.36' amsl.

AA1-BEDGW-001 has a completely different pattern. That well begins to be measured 11/12/97 and, with the exception of one round in 01/17/01 where it is not measured either (again with no explanation as to why), all of the readings except one range in the 609 to 613' amsl range. The one notable exception is 09/20/00 where it jumps up to 626.74' amsl, a 14.8 foot increase from the previous reading.

MNTA-BEDGW-001 also begins to be measured 11/12/97. It shows its highest reading on 05/05/98 of 612.80' amsl, it is NOT measured on 09/20/00 or on 01/17/01 like the other two wells (again with no explanation on the table), but then it seems to settle down and for the last seven rounds, the water level has been maintained between 607 and 608' amsl. There is no obvious and/or predictable pattern to these three wells during the drought period. In addition, wells that are in close proximity to each other are behaving in opposite directions and, for some undocumented reason(s), then not being measured. The jumping around of the numbers in the years of 1998 to 2001 look like the wells are being influenced by something(s) on site and/or off site but it is not clear without constructing water level maps for these years and collecting data for on site and off site pumping operations what or why these patterns exist. It may also have something to do with precipitation, but if that was the case, the wells should be moving more in tandem than they are. Please see my Table 1 which is an excerpt from Table 6-1.

Table 1

Water Levels over time for Selected Wells

Date	AA1-BEDGW-001	MNTA-BEDGW-001	BED-MW16
05/05/98	611.94	612.80	632.96
09/20/00	626.74	----	630.70
01/17/01	-----	----	----
08/15/01	610.04	609.00	630.41
11/15/01	608.88	607.41	605.56
02/27/02	610.11	608.21	---- (k)

Notes: (k) Note for MK-MW17 put in the BED-MW16 column of the table and then not monitored any more

Given the lack of information available, the only suggestion that I can make about the installation of the new monitoring wells as is related to the 1999 low water levels of the drought year is to make them as deep as possible and make the screen length and/or the sand pack length as long as possible so as to take advantage of the intersection of as many vertical fractures as can be intersected by the well boring. The horizontal bedding layers generally supply less ground water flow than the vertical jointing fractures. However, because of the karstic nature of these formations, there can be significant solution enhancement of the horizontal bedding planes in some settings.

Care should be taken when logging the holes to note all the bedding planes and vertical fractures intersected. This is especially true if the coring rods drop through voids as the core is being taken. We have experienced that situation when drilling the

Delaware/Columbus Limestones close to the Olentangy/Ohio Shale crop here in Franklin County on more than one occasion. If that does occur, the distance of drop should be noted on the log as it will not be obvious when looking at the core in the core box. Photographic documentation of the full cores is also very helpful for other reviewers. If it is possible to annotate the photos and/or the logs by reference, that would also be helpful if it is not beyond the scope of the original contract.

Questions Generated from this part of the Review

1. Any explanations relating to the changing water levels at the three wells discussed over time would be appreciated. I am especially perplexed about the fact that unusual high readings and unusual low readings can occur at the same time in adjacent wells.

Review from Figure 6-5, Delaware Limestone Groundwater Elevation Contour Map (August 2004)

Typically in this part of Ohio, unless ground water levels are being stressed by ground water withdrawals for public water supplies and/or dewatering, static water levels closely mirror the flat surface topography. Once Lake Erie is reached (here Sandusky Bay), the lake level becomes the same as the ground water level and as you move out into the lake, the land level falls beneath the level of the lake. That is not the picture that is presented in this Figure 6-5. While the land surface is relatively flat, for instance, the drop in surface elevation from BED-MW16 (633.36' amsl) to BED-MW33 (619.87' amsl) is only 13.49' drop in elevation; the ground water drop is from 632.73 at BED-MW19 to 545.83' amsl at BED-MW33 for a drop of 86.9' over the same distance. According to the Erie County Soil Survey GIS map, the distance between BED-MW16 and BED-MW33 is about 8,500' for a ground water gradient of just over 0.01 or ~1:100. A gradient of 0.0018 or ~1:560 would have been more typical for this area. In fact, the static water level at BED-MW33 is on the order of 25 feet below the level of Lake Erie. Assuming that there is no physical problem with the construction of the well that static water level reading cannot physically happen unless there is a pumping source some point to the northeast beyond BED-MW33 that is exerting its influence as far south as BED-MW16. The southeast corner sump of the Wagner Quarry is about 3,500' beyond BED-MW33. The direction of ground water lowering is determined by placing a perpendicular line across the ground water contours. Such an arrow is shown near well IT-MW06. There the direction of ground water flow is projected to be to the northeast.

In fact, with the exception of the flat area to the southwest of the NASA Reactor, almost the entire portion of the site shown in the Figure 6-5 that was supplied to me is demonstrating significant static water lowering to the northeast. The corner of Acid Area 2 that is shown on this abbreviated version of what probably is a lager figure, shows a reversal in ground water flow to the southwest in the area of AA2-BEDGW-001. In addition, there are several locations where contour lines are drawn through water levels which do not support the placement of the lines.

Questions Generated from this part of the Review

2. Why is there at 86.9 foot drop between BED-MW16 and BED-MW33?
3. Why is the static water level reported in BED-MW33 approximately 25' below Lake Erie?
4. Does this Groundwater Elevation Contour Map (August 2004) generate information that supports a connection to the dewatering sump in the southeast corner of the Wagner Quarry? If not, why not? What other explanation can be developed for the significant changes in the ground water gradient over the site, especially to the north of the site?
5. The 630 contour is placed next to TNTA-BEDGW-001 but the Static Water level reading for that well is 604.45? Why did this happen?
6. By the time that this map is generated, BED-MW27, another "stinky" but also contaminated well on the northern perimeter of the site has been abandoned. The Abandoned well sits between the 600 and 595 foot contours. However, the static water levels for this well were never measured at higher than 582.54' amsl during the first measurement, falling to 573.69' amsl at its last reading. These historic lower water levels were not considered when the August 2004 map was drawn. Why?
7. There are a series of limestone bedrock monitoring wells surrounding the NASA Reactor. The 600' contour line is drawn though this group of points. However, the ground water elevations range from a high of 603.31' amsl at REACTOR 1 to a low of 577.46' amsl at RA-08D on the same contour. In addition, BED-MW23, which is considerably south of the NASA Reactor measures 599.77' amsl. Why was this contour constructed in this manner disregarding the two anomalous readings? Could the contours have been constructed in another way to honor the disregarded water level elevations at RA-08D and BED-MW23?
8. Could there be a relationship between the low levels at 2BG-BEDGW-001, BED-MW23, RA-08D, the abandoned BED-MW27, and BED-MW33 which seem to bisect the site? Where does the base of the "dry well" at Acid Area 3 fall into this set of "low" elevations? The static water level at 2BG-BEDGW-001 is still approximately 136 feet higher than the sump at the Wagner Quarry.
9. There are a group of three wells at the No. 2 Burning Grounds. They range in elevations between 615.50' amsl for 2BG-BEDGW-003 to 595.99' amsl for 2BG-BEDGW-001. The 610' contour is drawn through the set with the 615.50' amsl well down gradient of the 610 foot contour and the 595.99' amsl well up gradient of the 610 foot contour. Why did that happen?
10. If the contours were redrawn to better honor the static water level elevations in all of the measured wells, would that alter the "flat area between TNTC-BEDGW-001 (608.21' amsl) and the NASA Reactor high reading of 603.31' amsl measured at REACTOR 1.
11. This section of the site, referred to as the "groundwater trough" by Jacobs and Shaw has a drop of only 4.9 feet between these two monitoring wells. It is the flattest portion of the site, given the current contour arrangement. Why is it called the "groundwater trough"?
12. Ohio Department of Natural Resources Div. of Water tells us that the regional ground water flow is basically in a northern direction to Lake Erie? Why is there a ground water reversal in Acid Area 2, showing ground water flow to the southwest? What mechanism, either on-site or off-site is controlling this static

ground water dip to the southwest? Has any source been identified? Has any source been looked for? Are there data points beyond the portion of the map that I have that establishes a continuing downward trend?

While there may well be logical answers and/or explanations for the questions I have raised, those answers and/or explanations are not clearly contained in the information that is provided to me. Instead, my review of the August 2004 Groundwater Elevation Contour Map indicates a sharp downward gradient from the area of BED-MW16 to the north-northeast the the Wagner Quarry sump. In addition, there seems to be some control exerted by the NASA Reactor sump but its actual impact is not easily observed because of the number of data points that are not honored by the contour lines. At a minimum, this static ground water map of August 2004 does not have the appearance of a site that exists under natural static water conditions.

It will be important to take into consideration these relationships when the locations and depths for the new monitoring wells at Acid Area 1 are installed. Even more importantly, it will be critically important to take these static water level relationships into consideration when new monitoring well sites are selected for the ground water remediation of the various contaminated areas of the site. Different gradients will result in different times-of-travel across and off the site.

This concludes this preliminary review of the materials that have been provided to me for the purpose of determining the depths and screen lengths for the new Acid Area 1 limestone ground water wells. These tables and maps have triggered more questions in my mind than they have resolved. I am hoping that explanations are forthcoming. Please forward these comments to those who should receive them, including the relevant people at Jacobs and Shaw. I will be looking forward to their responses. If you have any additional questions and/or need further information from me regarding this review, please feel free to contact me. I will be pleased to walk you through the information contained on the August 2004 carbonate static ground water map as best I can.

Table 6-1

Summary of Groundwater Elevation Measurements
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

(Page 7 of 10)

Well Identification	Coordinates (Ohio St. Plane)[a] Northing (y)	Easting (x)	Top of Casing Elevation[a] (ft msl)	Ground Elevation[a] (ft msl)	Groundwater Elevation Measurements (Elevations mean sea level [ft msl]) 12/94	12/19/94[b]	3/13	03/19/95[b]	10/96	10/19/96[b]	8/97	08/21/98[b]	11/12	11/12/1998[b]	3/04	03/24/1999[b]
Monitoring Wells Screened in Limestone (Delaware)																
AA1-BEDGW-001	-123669	1917719	641.04	638.80	-[c]	-	-	-	-	-	-	-	30.92	610.02	30.50	610.54
AA2-BEDGW-001	-123600	1920512	644.06	643.50	-	-	-	-	-	-	-	-	13.11	630.95	11.58	632.48
AA3-BEDGW-001	-123537	1919457	636.43	634.10	-	-	-	-	-	-	-	-	23.22	613.21	21.53	614.90
MWTA-BEDGW-001	-123669	1918669	636.40	636.09	-	-	-	-	-	-	-	-	28.04	610.36	27.05	611.35
BED-MW03	-121044	1912175	647.86	645.49	46.10	607.46	28.66	623.29	28.18	621.79	27.88	620.19	27.08	620.87	46.47	609.48
BED-MW04	-122722	1915417	645.72	642.73	23.96	621.76	21.10	624.59	20.49	625.23	18.61	627.21	18.72	626.63	16.44	629.28
BED-MW15	-120276	1918243	628.31	626.75	27.77	600.54	32.49	595.81	21.09	610.22	20.95	615.36	21.12	610.19	20.34	610.97
BED-MW16	-120396	1920544	635.70	633.36	64.32	571.38	7.02	628.68	5.53	630.17	11.00	623.93	7.41	628.29	2.08	633.42
BED-MW17	-125417	1924121	629.63	627.02	27.06	602.57	26.75	602.90	26.08	603.79	26.48	603.17	27.75	601.90	26.85	602.89
BED-MW18	-120845	1923453	651.18	648.51	28.13	623.05	30.79	620.39	29.58	621.60	30.58	620.60	30.22	620.96	30.55	620.63
BED-MW19	-123669	1918174	642.75	640.19	21.68	621.07	19.20	623.62	19.63	622.92	19.66	622.92	20.55	622.03	19.00	623.75
BED-MW02	-120779	1918367	629.67	627.22	-	-	-	-	-	-	-	-	-	-	-	-
BED-MW03	-120908	1918110	636.71	634.11	-	-	-	-	-	-	-	-	-	-	-	-
BED-MW04	-122916	1908158	646.98	644.20	-	-	-	-	-	-	-	-	-	-	-	-
BED-MW07 (abandoned)	-127886	1920731	627.14	625.24	-	-	-	-	-	-	-	-	-	-	-	-
BED-MW09	-120082	1907116	649.67	647.26	-	-	-	-	-	-	-	-	-	-	-	-
BED-MW03	-121694	1921879	619.74	619.87	-	-	-	-	-	-	-	-	-	-	-	-
TNTA-BEDGW-001	-123447	1920540	638.79	636.99	-	-	-	-	-	-	-	-	-	-	-	-
TNTC-BEDGW-001	-120014	1912918	667.04	664.04	-	-	-	-	-	-	-	-	-	-	-	-
2SG-BEDGW-001	-122246	1913066	645.66	643.88	-	-	-	-	-	-	-	-	-	-	-	-
2SG-BEDGW-002	-122164	1913130	684.27	681.67	-	-	-	-	-	-	-	-	-	-	-	-
2SG-BEDGW-003	-122043	1913245	676.82	674.22	-	-	-	-	-	-	-	-	-	-	-	-
RA-MW-01[d]	-126707	-1918033	637.67	635.00	-	-	-	-	-	-	-	-	-	-	-	-
RA-01C[d]	-126685	-1918100	634.34	632.45	-	-	-	-	-	-	-	-	-	-	-	-
RA-02C[d]	-126669	-1918042	632.96	630.56	-	-	-	-	-	-	-	-	-	-	-	-
REACTWR1[e]	-126779	1917918	639.51	636.49	-	-	-	-	-	-	-	-	15.32	615.19	22.30	608.45	30.25	597.25
REACTWR2	-126641	1918003	631.06	631.00	16.34	614.71	29.19	601.89	-	-	-	-	15.40	615.66	4.81	626.24	31.93	600.53
REACTWR3[e]	-126680	1918118	631.21	631.10	-	-	-	-	-	-	-	-	14.53	616.51	22.17	609.04	37.45	593.76
REACTWR4	-126638	1918147	630.83	630.44	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PT-3012 (private well)	-126032	-1907641	635.22	634.51	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 6-1

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2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

(Page 8 of 10)

Well Identification	Groundwater Elevation Measurements (feet above mean sea level [ft msl]) 3/5	03/24/1999[b]	9/07	09/08/99	1/17	2/01/2001	8/15	08/15/01	11/13	11/13/01	3/27/02	03/27/02	5/6	05/06/02	6/6	06/06/02	11/21	11/21/02
Monitoring Wells Screened in Limestone (Delaware)																		
AA1-BEDGW-001	29.1	611.54	14.36	626.74	-	-	31.06	610.04	32.16	608.88	30.18	610.1	32.50	608.54	31.90	609.14	31.20	609.74
AA2-BEDGW-001	8.55	634.57	14.36	629.08	-	-	13.26	630.81	15.91	628.15	15.06	628.98	13.62	630.44	13.60	630.46	18.47	625.18
AA3-BEDGW-001	21.62	614.68	23.26	611.23	24.90	611.53	21.64	610.92	22.98	609.85	20.66	611.7	25.90	606.53	20.68	609.75	28.70	607.73
MWTA-BEDGW-001	23.60	612.80	-	-	-	-	28.40	608.00	30.99	605.41	28.19	608.21	31.50	605.00	32.78	603.72	32.43	603.57
BED-MW03	41.40	606.06	27.90	620.05	28.40	619.55	30.31	617.64	45.00	602.95	37.50	610.45	39.67	591.28	36.64	611.41	33.32	614.09
BED-MW04	15.90	626.73	18.00	626.62	17.90	627.02	19.63	625.09	21.73	620.99	18.59	627.13	17.30	628.42	19.62	626.10	23.30	621.02
BED-MW15	19.79	611.52	20.40	610.91	18.40	612.51	17.13	614.18	21.58	610.13	23.16	607.35	30.05	601.26	21.47	609.84	22.96	608.45
BED-MW16	2.74	632.98	5.30	630.72	-	-	5.29	630.41	30.54	605.96	NM[f]	-	-	-	-	-	-	-
BED-MW17	26.40	603.25	26.40	599.65	0.07	629.65	29.30	600.32	31.30	598.15	29.05	600.60	31.52	599.05	30.42	598.73	31.05	598.10
BED-MW18	30.72	605.46	30.90	603.28	31.90	602.28	31.79	602.39	33.10	600.08	32.43	600.75	32.38	600.80	32.94	600.24	32.66	600.52
BED-MW19	18.45	624.30	21.20	621.55	21.30	620.95	21.38	617.38	24.91	617.84	23.27	619.48	22.75	620.00	28.38	614.37	27.58	615.17
BED-MW02	-	-	-	-	-	-	-	-	-	-	29.78	598.01	28.50	601.17	32.51	596.16	34.13	595.54
BED-MW03	-	-	-	-	-	-	-	-	-	-	50.99	572.31	73.04	550.67	57.38	566.19	51.46	571.91
BED-MW04	-	-	-	-	-	-	-	-	-	-	28.08	620.19	24.80	621.18	27.88	618.18	26.29	619.72
BED-MW07 (abandoned)	-	-	-	-	-	-	-	-	-	-	44.59	582.34	46.10	581.24	45.60	581.74	52.45	573.89
BED-MW09	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BED-MW03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TNTA-BEDGW-001	-	-	-	-	-	-	-	-	-	-	52.08	574.28[g]	54.58	573.80[g]	56.84	577.52[g]	52.44	576.12[g]
TNTC-BEDGW-001	-	-	-	-	-	-	-	-	-	-	57.64	609.50	55.86	610.08	59.51	607.73	59.05	607.79
2SG-BEDGW-001	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2SG-BEDGW-002	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2SG-BEDGW-003	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RA-MW-01[d]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RA-01C[d]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RA-02C[d]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
REACTWR1[e]	32.30	596.23	25.30	606.25	31.80	599.71	30.20	609.31	36.94	601.87	NM	-	-	-	-	-	-	-
REACTWR2	27.92	603.50	27.40	603.98	27.10	602.98	9.13	630.03	3.00	631.05	NM	-	-	-	-	-	-	-
REACTWR3	37.64	594.13	35.60	595.61	35.20	596.01	34.43	596.78	34.43	596.78	NM	-	-	-	-	-	-	-
REACTWR4	-	-	20.40	610.43	20.20	610.63	20.98	609.18	20.40	610.43	NM	-	-	-	-	-	-	-
PT-3012 (private well)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 6-1

Summary of Groundwater Elevation Measurements
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

(Page 9 of 10)

Well Identification	Groundwater Elevation Measurements (feet above mean sea level ft msl)																	
	3/03	03/18-19/03	5/03	5/19-21/03	8/03	8/5-7/03	9/03	9/14/03	11/03	11/6-7/03	3/04	03/31-2/04	5/04	05/11-12/04	8/04	08/10-11/04
Monitoring Wells Screened in Limestone (Delaware)																		
AA1-BEDGW-001	31.51	609.53	31.40	609.64	31.09	609.96	31.21	609.83[a]	31.02	610.02[a]	31.09	609.95[a]	31.44	609.60[a]	31.00	610.04[a]
AA2-BEDGW-001	15.02	629.04	15.50	627.16	14.03	630.05	14.25	629.81	14.56	629.48	12.64	631.32	11.14	632.82	11.08	632.38
AA3-BEDGW-001	28.78	607.80	27.50	608.93	25.85	609.58	27.18	609.25	27.50	608.93	26.63	609.80	26.15	610.28	26.12	610.33
MW1-BEDGW-001	31.79	606.61	31.22	607.18	30.69	607.72	31.13	607.27	31.20	607.20	30.86	607.41	30.65	607.79	30.51	607.79
BED-MW13	31.34	616.44	31.22	616.73	30.82	617.15	31.32	616.65	31.71	616.24	30.95	617.40	30.46	617.49	30.74	617.21
BED-MW14	21.09	624.64	18.56	627.14	18.54	627.18	19.20	626.52	19.60	626.92	16.96	628.76	16.53	629.27	17.64	628.09
BED-MW15	22.59	609.72	22.40	609.91	22.10	610.21	22.35	609.96	21.20	609.11	20.76	610.55	20.65	610.46	20.57	611.24
BED-MW16	3.10	632.60	2.08	633.65	3.10	632.60	3.11	632.64[a]	3.50	632.20	2.62	633.08	2.60	633.60	2.97	632.73
BED-MW17	32.42	597.22	31.58	598.06	31.20	597.95	32.71	596.54	31.59	596.32	33.71	595.94	32.96	596.79	32.56	597.07
BED-MW18	33.35	617.63	33.30	617.69	33.05	618.13	32.98	618.19	31.38	617.40	32.93	618.23	33.27	617.91	33.04	618.14
BED-MW19	25.08	617.87	24.80	617.95	24.36	618.39	25.47	617.28	21.29	617.46	23.58	619.17	23.56	619.39	24.08	618.87
BED-MW22	32.90	596.77	31.65	598.12	31.25	598.42	31.36	598.31	31.12	591.55	30.90	591.17	30.73	592.94	27.85	591.82
BED-MW23	54.50	677.21	52.10	591.06	48.20	587.91	44.50	589.21	41.60	591.91	36.91	596.82[a]	34.12	599.10[a]	33.94	599.77[a]
BED-MW24	27.39	618.53	26.00	619.98	25.53	619.45	27.58	618.10	27.48	618.20	25.81	620.17	25.49	620.49	27.00	618.98
BED-MW27 (abandoned)	AB	–	AB	–	AB	–	AB	–	AB	–	AB	–	AB	–	AB	–
BED-MW30	–	–	–	–	–	–	–	–	–	–	–	–	27.00	619.03	27.02	618.95
BED-MW33	–	–	–	–	–	–	–	–	–	–	–	–	81.19	528.69	73.91	545.80
TNTA-BEDGW-001	47.82	590.67[a]	44.55	593.94[a]	41.51	597.26[a]	40.26	598.47[a]	33.30	599.49[a]	27.72	604.07[a]	35.64	603.15[a]	34.32	604.46[a]
TNTC-BEDGW-001	59.11	597.33	50.24	609.03	58.30	598.74	58.10	597.72	58.32	597.72	57.71	598.33	57.60	598.54	58.60	598.21
28G-BEDGW-001	–	–	–	–	–	–	–	–	–	–	–	–	–	–	49.57	555.95
29G-BEDGW-002	–	–	–	–	–	–	–	–	–	–	–	–	–	–	71.75	511.52
28G-BEDGW-003	–	–	–	–	–	–	–	–	–	–	–	–	–	–	61.99	519.90
RA-MW-06[a]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	24.00	603.07
RA-01[a]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	26.00	597.94
RA-06[a]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	30.00	577.48
REACTOR1[b]	–	–	–	–	–	–	27.49	623.00	NM	–	NM	–	NM	–	26.00	603.91
REACTOR2	–	–	–	–	–	–	–	–	NM	–	NM	–	NM	–	NM	–
REACTOR3[b]	–	–	–	–	–	–	37.00	594.19	NM	–	NM	–	NM	–	35.49	595.81
REACTOR4	–	–	–	–	–	–	19.86	610.57	NM	–	NM	–	NM	–	NM	–
PT-STG[c] (private well)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	7.33	629.10

Table 6-1

Summary of Groundwater Elevation Measurements
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[a] Northings and Eastings are scaled to the Ohio State Plane Coordinate System (North Zone), NAD 1983. Vertical datums NGVD 1929.

[b] Data from Dames & Moore, Sitewide Groundwater Investigation Final Report (4/97).

[c] Data from Dames & Moore, Sitewide Groundwater Investigation Final Report (4/97).

[d] Data from IT Corporation, Site-Wide Groundwater Investigation Report (9/97).

[e] Data from IT Corporation, 1st Quarterly Water Level Measurement Event Report (10/97).

Data from IT Corporation, 2nd Quarterly Water Level Measurement and 1st Semi-Annual Groundwater Sampling Event Report (5/98).

[f] Data from IT Corporation, 3rd Quarterly Water Level Measurement Event Report (8/98).

[g] Data from IT Corporation, 4th Quarterly Water Level Measurement and 2nd Semi-Annual Groundwater Sampling Event Report (2/99).

Data received from ICI field measurements.

Symbol denotes data are not available.

[i] Monitoring well MW-MW17 near cut and resurveyed August 2003. Previous TOC elevation was 624.32. GW elevations due to August '03 based on previous TOC measurements.

Hydrocarbon product suspected in well. No measurement recorded.

[k] Groundwater elevation corrected for hydrocarbon product in well. TOC elevation - (depth to groundwater - (product thickness x 0.8)).

AB - Abandoned.

Temporary observation well IT-MW07 abandoned 4/1/02.

Monitoring well PB-MW06 abandoned in January 2003 for soil remediation (IT, September 2002 FFS Report).

Monitoring well PB-BED-MW27 was abandoned at the public request in January 2003 due to "nuisance" (hydrogen sulfide) odors.

[l] Static depth to groundwater recorded on August 17, 2004. Depth to groundwater in nearby well RA-01 was approximately 0.6 feet higher in the well on August 17 as compared to August 10 or 11, 2004. Therefore, 0.6 feet was added to the depth to water to make the elevation comparable.

[m] Static depth to groundwater recorded on August 24, 2004. Depth to groundwater in nearby wells PB-BED-MW22 and PB-BED-MW19 was approximately 0.9 feet deeper August 24 as compared to August 10 or 11, 2004. Therefore, 0.9 feet was subtracted from the depth to water to make the elevation comparable.

[n] Survey coordinates and water level measurements for wells RA-MW-02 through RA-MW-06 were obtained from NASA. Horizontal coordinates estimated. Vertical coordinates used the Ohio State Plane system. Groundwater level measured August 17, 2004.

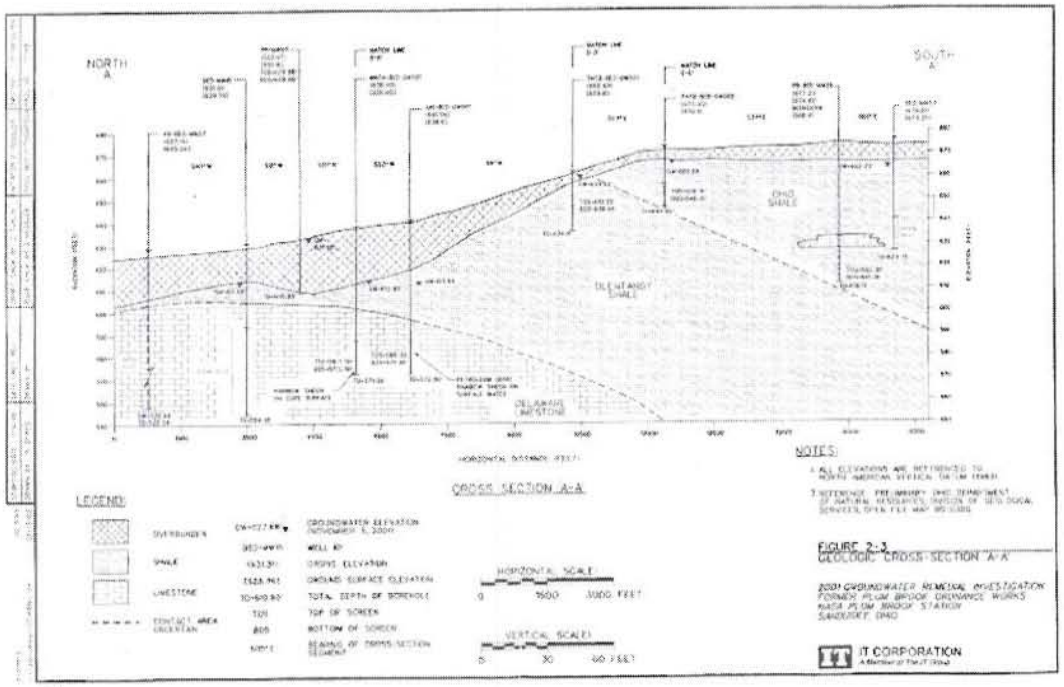
[o] Surveyed August 2004 using Reactor Area benchmark. Benchmark was not certified. Groundwater levels measured by NASA on August 17, 2004.

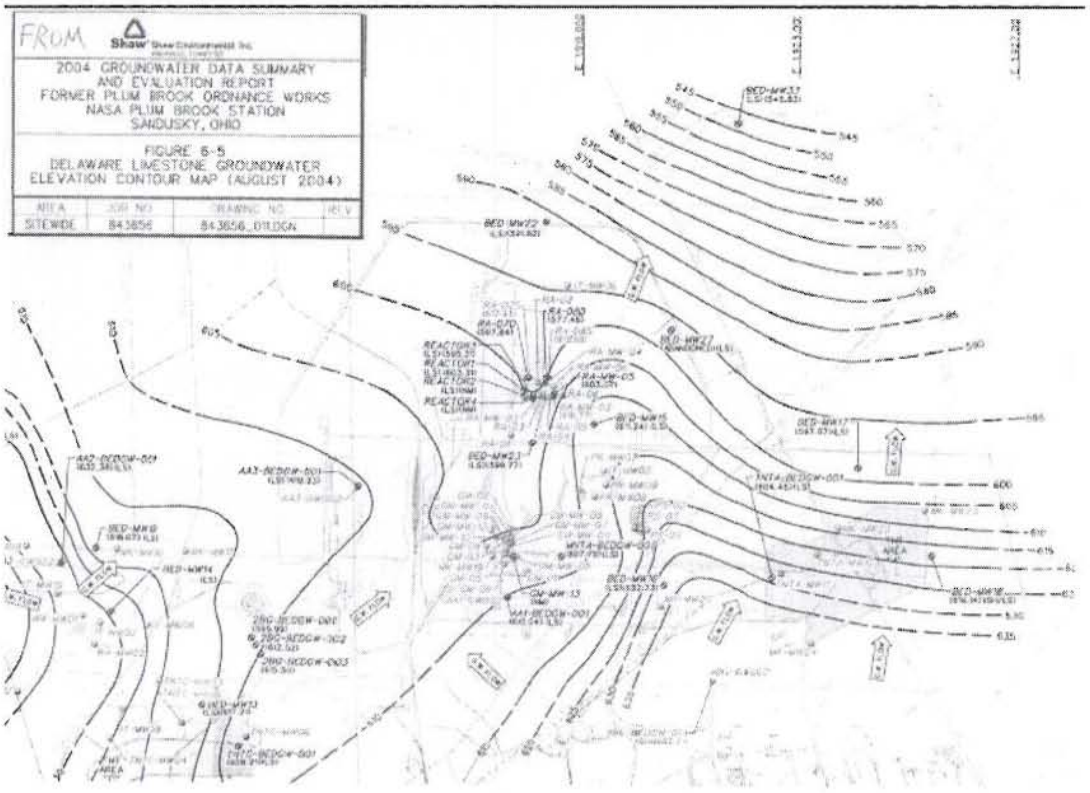
Table 4-2

Monitoring Well Construction Details
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

(Page 3 of 4)

Well ID	Coordinates (Ohio Plane) Northings (y)	Eastings (x)	Well Depth (feet bgs)	Date Installed	Installed By	Casing Type	Casing Diameter (inches)	Borehole Diameter (inches)	Screen Interval (feet bgs)	Geologic Unit Screened	Top of Filter Pack (feet bgs)	TOC Elevation (feet msl)	Ground Elevation (feet msl)	Bedrock Elevation (feet msl)	Well Bottom Elevation (feet msl)
Monitoring Wells Screened in Shale															
AKG-BEDGW-001	[illegible]	[illegible]	21.00	9/10/1997	IT	Steel to 7', PVC (40) to 21'	10" to 7', 2" to 21'	14.25" to 7', 8" to 22'	16.75-20.75	Ohio Sh	8.0	[illegible]	[illegible]	[illegible]	[illegible]
PGP-BEDGW-001	[illegible]	[illegible]	20.02	9/10/1997	IT	Steel to 4', PVC (40) to 30'	10" to 4', 2" to 30'	14.25" to 4', 8" to 31'	4.75-19.75	Olentangy Sh	4	[illegible]	[illegible]	[illegible]	[illegible]
BED-MW02	[illegible]	[illegible]	46.50	1/11/1994	D&M	PVC	4" to 35', 2" to 46.5'	8	26.5-46.5	Ohio Sh	none ?	[illegible]	[illegible]	[illegible]	[illegible]
BED-MW03	[illegible]	[illegible]	38.00	9/12/2001	IT	PVC	2	4	27.5-37.5	Olentangy Sh	23.0	[illegible]	[illegible]	[illegible]	[illegible]
BED-MW04	[illegible]	[illegible]	57.75	9/10/2001	IT	PVC	2	4	42.25-57.25	Olentangy Sh	40	[illegible]	[illegible]	[illegible]	[illegible]
BED-MW05	[illegible]	[illegible]	41.50	9/10/2001	Shaw	6" Steel to 23.55'	6	10" to 14, 8" to 41.5	26.85-41.85	Ohio Sh	23.65	[illegible]	[illegible]	[illegible]	[illegible]
BED-MW06	[illegible]	[illegible]	37.90	9/12/2001	Shaw	6" Steel to 29'	6"	10" to 24, 8" to 40	27.85-37.85	Olentangy Sh	25	[illegible]	[illegible]	[illegible]	[illegible]
EMB-BEDGW-001	[illegible]	[illegible]	24.00	9/3/1997	IT	Steel to 9', PVC (40) to 24'	10" to 9', 2" to 24'	14.25" to 9', 8" to 25'	6.75-23.75	Olentangy Sh	7.5	[illegible]	[illegible]	[illegible]	[illegible]
EMB-BEDGW-002	[illegible]	[illegible]	24.00	9/24/1997	IT	Steel to 8', PVC (40) to 24.5'	10" to 8', 2" to 24.5'	14.25" to 8', 8" to 25.2'	13.95-22.95	Ohio Sh	11.2	[illegible]	[illegible]	[illegible]	[illegible]
EMB-BEDGW-003	[illegible]	[illegible]	43.00	9/9/2001	IT	PVC	2	4	32.5-42.5	Ohio Sh	30.5	[illegible]	[illegible]	[illegible]	[illegible]
EMB-BEDGW-004	[illegible]	[illegible]	25.00	9/7/2001	IT	PVC	2	4	15-25	Ohio Sh	13	[illegible]	[illegible]	[illegible]	[illegible]
Monitoring Wells Screened in Delaware Limestone															
AA1-BEDGW-001	[illegible]	[illegible]	65.00	9/24/1997	IT	Steel to 27', PVC (40) to 65'	10" to 27', 2" to 65'	14.25" to 27', 8" to 66'	43.75-64.75	Delaware LM	40	[illegible]	[illegible]	[illegible]	[illegible]
AA2-BEDGW-001	[illegible]	[illegible]	45.00	9/22/1997	IT	Steel to 28', PVC (40) to 45'	10" to 28', 2" to 45'	14.25" to 28', 8" to 44'	27.75-42.75	Delaware LM	23	[illegible]	[illegible]	[illegible]	[illegible]
AA3-BEDGW-001	[illegible]	[illegible]	53.00	9/23/1997	IT	Steel to 28', PVC (40) to 53'	10" to 28', 2" to 53'	14.25" to 28', 8" to 54'	37.75-52.75	Delaware LM	35.0	[illegible]	[illegible]	[illegible]	[illegible]
MW14-BEDGW-001	[illegible]	[illegible]	64.00	9/23/1997	IT	Steel to 31', PVC (40) to 64'	10" to 31', 2" to 64'	14.25" to 31', 8" to 65'	48.75-63.75	Delaware LM	44	[illegible]	[illegible]	[illegible]	[illegible]
BED-MW13	[illegible]	[illegible]	75.50	1994	D&M	PVC	4	8" 46.5-75.5'	46.5-75.5 (est)	Delaware LM	none	[illegible]	[illegible]	[illegible]	[illegible]
BED-MW14	[illegible]	[illegible]	55.20	1994	D&M	PVC	4	8" 24.4-55.4'	24.4-55.4	Delaware LM	none	[illegible]	[illegible]	[illegible]	[illegible]
BED-MW15	[illegible]	[illegible]	74.40	1994	D&M	PVC	4	8" 31.5-74.4'	31.5-74.4 (est)	Delaware LM	none	[illegible]	[illegible]	[illegible]	[illegible]
BED-MW16	[illegible]	[illegible]	74.00	1994	D&M	PVC	4	8" 43.2-74.0'	43.2-74.0 (est)	Delaware LM	none	[illegible]	[illegible]	[illegible]	[illegible]
BED-MW17	[illegible]	[illegible]	64.40	1994	D&M	PVC	4	8" 45.9-64.4'	45.9-64.4 (est)	Delaware LM	none	[illegible]	[illegible]	[illegible]	[illegible]
BED-MW18	[illegible]	[illegible]	75.40	1994	D&M	PVC	4	8" 46.4-75.4'	46.4-75.4	Olentangy Sh / Delaware LM	none	[illegible]	[illegible]	[illegible]	[illegible]
BED-MW19	[illegible]	[illegible]	49.50	1994	D&M	PVC	4	8" 24.5-49.5'	24.5-49.5	Delaware LM	none	[illegible]	[illegible]	[illegible]	[illegible]
BED-MW02	[illegible]	[illegible]	40.00	9/10/2001	IT	PVC	2	6	27-40	Delaware LM	25	[illegible]	[illegible]	[illegible]	[illegible]
BED-MW03	[illegible]	[illegible]	73.00	9/9/2001	IT	PVC	2	6	53-73	Delaware LM	49	[illegible]	[illegible]	[illegible]	[illegible]
BED-MW04	[illegible]	[illegible]	41.00	9/10/2001	IT	PVC	2	6	25.5-40.5	Delaware LM	23.5	[illegible]	[illegible]	[illegible]	[illegible]
BED-MW07 (abandoned)	[illegible]	[illegible]	106.00	9/5/2001	IT	8" Steel to 26.50'	6	12" to 18.5', 8" to 36.5', 6" to 106'	26.5-105(A)	Delaware LM	none	[illegible]	[illegible]	[illegible]	[illegible]
BED-MW08	[illegible]	[illegible]	57.30	9/10/2001	Shaw	6" Steel to 23.5'	6"	10" to 23.5', 8" to 58.3'	42.3-57.3	Delaware LM	39	[illegible]	[illegible]	[illegible]	[illegible]
BED-MW01 (abandoned)	[illegible]	[illegible]	58	3/2/94	Shaw	NA	NA	NA	NA	Delaware LM	NA	NA	[illegible]	[illegible]	NA
BED-MW02 (abandoned)	[illegible]	[illegible]	55	3/2/94	Shaw	NA	NA	NA	NA	Delaware LM	NA	NA	[illegible]	[illegible]	NA
BED-MW03	[illegible]	[illegible]	48.50	9/10/2001	Shaw	6" Steel to 19.5'	6"	10" to 19.5', 6" to 49.5	38.5-48.5	Delaware LM	35.5	[illegible]	[illegible]	[illegible]	[illegible]
BED-MW04 (abandoned)	[illegible]	[illegible]	58	3/2/94	Shaw	NA	NA	NA	NA	Delaware LM	NA	NA	[illegible]	[illegible]	NA
TMB-BEDGW-001	[illegible]	[illegible]	55.00	9/10/2001	IT	PVC	2	6	40-55	Delaware LM	37	[illegible]	[illegible]	[illegible]	[illegible]
TMB-BEDGW-001	[illegible]	[illegible]	55.00	9/10/2001	IT	PVC	2	6	40-55	Delaware LM	37	[illegible]	[illegible]	[illegible]	[illegible]




FROM
Shaw
2004 GROUNDWATER DATA SUMMARY
AND EVALUATION REPORT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO
FIGURE 6-5
DELAWARE LIMESTONE GROUNDWATER
ELEVATION CONTOUR MAP (AUGUST 2004)
AREA
JOB NO
DRAWING NO
REV
SITEWIDE
843856
843856_01.DGN