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Res#2 BG

SUBJECT: Response to review comments for the Interim Final Site Characterization Report, Remedial Investigation Part 1, at Reservoir No. 2 Burning Ground, Former Plum Brook Ordnance Works (PBOW), Sandusky, OH, July, 2005 Prepared by Jacobs Engineering Group, Inc., Contract Number DACW62-03-D-0004-0002

Reviewer: Julie Weatherington-Rice, TAPP

1. **Executive Summary, top of page ix. "None of the wells recharged quickly enough to enable a complete purge of all drill cuttings and fines or to allow the collection of water parameters". .."Three planned shallow overburden wells, co-located with the three bedrock wells, were not installed due to insufficient permeable zones within the overburden."**

The inability to generate enough water from the bedrock wells to be able to complete well development is probably due to one or a combination of factors. First, the monitoring wells may have not encountered a sufficient number of interconnected fractures and/or bedding planes. Second, the fractures and/or bedding planes that were encountered may have been "sealed off' during drilling and lack of development has only contributed to the problem. The Plum Brook Shale cuttings may have formed a mud and/or been carried down into the Delaware Limestone directly, thereby sealing the bedding planes and/or fractures that were intersected. In our experience with the Delaware Limestone, we have found it to be a water-bearing formation. According to the report, no attempt was made to locate wells in areas of intersecting fractures and jointing systems that transmit most of the water (and contaminants) through the Delaware Limestone. In this type of setting, an alternate approach to drilling vertical wells is horizontal or angled borings. This approach may need to be considered as an alternative in order to intersect greater amounts of fractures.

Based on our review, it appears as though the shallow overburden may provide preferential pathways for migration of contaminants from the bum area. Deletion of the shallow wells does not seem prudent in light of the observed shallow horizontal migration of contaminants to the ditch. Shallow monitoring wells must be installed. Although these lower flow wells are difficult to install, shallow overburden wells have been successfully installed in Ohio following recommendations found in Haeher (2000) and Strobe1 (1993).

Response: Based on the visual inspection of the cores, which was documented on the boring logs, the formation has occasional fractures and porous zones, however these zones appear to produce more hydrogen sulfide gas than water. Based on discussions with Shaw geologists and Jacobs observations from Acid Area 3, there are numerous areas across the site and off-site where the Delaware Limestone does not produce water. This is a natural occurrence and is not related to drilling methods. The location of the wells was based on the need to characterize upgradient, on-site, and downgradient groundwater within the site boundary. Additional bedrock wells are not recommended, considering that site contaminants were not detected in the bedrock groundwater and the fact that the formation is not a viable water resource because of the naturally occurring hydrogen sulfide and petroleum.

Further characterization of the shallow groundwater would not be prudent if contaminant source removal or treatment were to be performed. Any incidental migration of contaminants into the shallow groundwater would be a low priority because of the lack of an exposure scenario. The local shallow groundwater is not a viable water resource.

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may also be partly a function of insufficiently developed and/or incorrectly installed and constructed monitoring wells and/or it may also be a function of ground water pumping in the area. Such an important conclusion as the Delaware Limestone is "hydrogeologically isolated" needs to be supported by
definitive field tests as opposed to mere suggestions. Ohio does not have "hydrogeologically isolated" bedrock units. Bedrock units in Ohio allow water and contaminants to move through them by secondary fractures and jointing, even if limited by primary porosity. While not all formations serve as aquifers because of limited storage potential, they do not create confining conditions that lead to hydrogeologically isolated" conditions.

The term "hydrologically isolated" typically does not mean that water from overlying units cannot enter the isolated unit. In this context it means that some formation lying between the two aquifers is restricting downward flow from the overlying aquifer to the underlying aquifer, which prevents the water levels in the lower aquifer from stabilizing at a height equal to the shallow aquifer. For sake of confusion in interpretations the statement will be removed and the disparity in the water levels only will be noted.

5. **3.3.1 Trench Excavation page 3-3 top of page.**
How deep were the trenches dug and how deep were the sampling locations? We could not readily find that information in the report. A good reference for trench construction and preparation in Ohio's glacial materials is Christy and others (2000). There is also a safe trench design that meets OSHA requirements available at www.oardc.ohio-stated.edu/fractures.

Response: Additional depth information will be provided in Table 3-1

6. **3.4.1 Piezometer installation and Water Level Measurements, page 3-5.**
The report indicates that piezometers were installed to the top of rock by using a Geoprobe. These piezometers where screened with long screens. The report further indicates that these piezometers had water and were used to determine flow directions. Following up on our comments in issue 1 above, this supports the recommendation that shallow monitoring wells be installed at the site. When the "wells" were installed using methods that "pushed" the screen into the ground (as opposed to rotational drilling), the unconsolidated materials yielded water. Although water quality samples cannot easily be collected from one-inch diameter piezometers, installation of larger diameter monitoring wells using similar techniques (see Haefner, 2000) would appear to be quite promising.

Recent research in Denmark by the Danish Geological Survey, University of Copenhagen professors, and Dr. Larry McKay, University of Tennessee, Knoxville, also addresses the critical issue of spacing in investigation. Recent papers by that team have been published in the journal of Ground Water. The paper by Jorgensen, McKay, and Kistrup (2004) as well as their references, are particularly informative.

Response: Borings were advanced prior to installing the screens and casing materials. As described the remaining annulus was filled with a sand filter pack to within 6-inches bgs, which allows for communication between the overlying coarser silty zones and the screened interval. Further characterization of the shallow groundwater would not be prudent if contaminant source removal or treatment were to be performed.

7. **3.4.2 Monitoring Well Installation in Bedrock, page 3-5 and photographs in Appendix J.**

Based on our review of photographs in the report, no obvious vertical fractures were noted in the cores. While there are a number of horizontal breaks, it is not possible to determine from the pictures which fractures are "original" to the formation and which fractures are drilling induced. No Rock Quality Designation (RQD) data was presented on the boring logs. Since the cores are still available on site, we recommend that they be reevaluated for RQD determinations and that the fractures be inspected to see if any discoloration or reminieralization due to ground-water movement can be identified at the breaks. While the lack of discoloration or remineralization does not preclude the potential for ground-water movement along the bedding plane, the presence of discoloration or remineralization identifies the fracture as active.

Response: The cores are stored on-site and are available for further examination.

8. 3.4.3 Monitoring Well Development page 3-5
Please see comments to issue 1 above.

Response: See response to comment 1

9. 3.9.3 Data limitations, pages 3-10 and 3-11.
We are concerned that contaminants were found in the ditch sediments but surface water samples were not collected because of the "ephemeral nature of water" in the ditch. According to the report, either it was raining during the site investigations (and so did not meet the program-required 48-hour post rain delay for surface water sampling) or the water remaining in the ditch was found only in a few pools and, therefore, was determined not to be representative of surface water conditions. If the surface water conditions were never within the set of "representative conditions" and the ditch was truly ephemeral, how did the contaminants get carried into the sediments in the ditch in the first place? It is our recommendation that surface water samples be collected. It is further our recommend that pore water be sampled where ground water discharges to the ditch.

Response: Site contaminants such as nitroaromatics, PCBs, or lead, were not detected in the sediment. The only compounds detected were PAHs, which likely originated from the adjacent asphalt road. Further investigation of the surface water shouldn't be warranted if source contaminants at the burning ground are to be removed or treated.

10. 4.0 Soil Investigation Results and associated figures, pages 4-1 through 4- 4
There is an area on the western portion of the site shown on figure 4-3 where surface soils show contaminant levels above the Preliminary Remediation Goals (PRGs). The noted concentrations above the PRGs appear to have a "channelized" shape. One possible explanation is that these elevated concentrations are due to overland flow by contaminated surface water. Has an accurate topographic survey of the field and woods surrounding the Burning Ground been performed? If so, has the "channel" shape been evaluated from this surface water flow perspective?

Figure 4-5, also raises questions of surface to ground-water recharge. The two off-site contamination points south of the Burning Ground are both within the elevations of the Kibbie fine sandy loam profiles. Therefore, the contamination is moving through the soil horizons. Soil properties and internal drainage systems may be controlling this movement. There are physical properties at work that do not appear to have been recognized or identified in this investigation.

Response: Particulate transport via overland flow is unlikely due to the heavy vegetative cover and the limited relief to generate enough energy for erosion to occur. Further investigation shouldn't be warranted other than additional contaminant delineation, if source contaminants are to be removed or treated. The contaminants referred to south of the burn area are naturally occurring metals. This does not constitute contaminant migration from the burn area.

11. 5.0 Groundwater Investigation Results, pages 5-1 and 5-2 and associated figures. Note quote from Section 5.1.2 "Based on the depths of these wells (referring to the bedrock wells) and water levels in other PBOW bedrock wells, the water column should be 20 to 30 ft. higher when fully recovered."
We don't have confidence in the ground-water information gathered at the site because we don't have confidence in the well installations. See our comments above.

Response: See response to comment 1 & 2

12. 7.1 Conclusions and Recommendations Soil Investigation pages 7-1 and 7-2.
This discussion seems to be more about statistics rather than the clustering at locations where contamination has been found outside the bum area. It is very clear from Figure 4-3 that there is a clustering of hits caused by off-site migration of contamination from the bum area to the area beyond to the west. How did the contamination move there? Is this a condition that occurred as part of the original clean-up action in the 1960s or is it overland surface drainage migration that occurred while the area was a Burning Ground and/or since the original clean-up? Is there an alternate explanation? If these questions can be answered, then the identification of the full area of impact will be greatly aided.

Is there a relationship between the elevated levels to the south at BH-09 and BH-10 in the 0 to 1 foot level and the elevated levels at BH-09 and BH-10 in the 3 to 5 foot levels? Is this a function of surface and/or subsurface drainage from the original burn area? While the report states at the bottom of page 7-1
"Based on this data, downward and lateral migration of contaminants is minimal", it must be noted for the record that migration does occur and that physical properties of the soil horizons at the site and surface/subsurface drainage control the movement. An informed discussion would be helpful in understanding the horizontal and vertical of contamination and the past and future migration pathways from the original Burning Ground.

Response: Further discussion will be included in section 7.1 relative to the possible origins of the contaminated area west of the burn area.

13. 7.2 Groundwater Investigation, page 7-2 and Appendix J. "The bedrock at the site is characterized as massive and impermeable, with minimal fracturing". Based on our review of the photographs of the bedrock cores and the information contained on the logs, this characterization of the bedrock is unsupported. Please refer to our comments in issue 7 above regarding the additional information needed on fractures prior to drawing such a conclusion.

Response: The text will be revised to indicate the formation is massive, with minimal fracturing and low permeability, rather than "impermeable"

14. 7.3 Surface Water and Sediment Investigation, page 7-2.
Please see our comments to issue 9.

Response: See response to comment 9

15. 7.4 Conceptual Model, pages 7-3 and 7-4

We have many comments and suggestions for this section. There is a notation in the 1" paragraph that the "Collection of ecological data was not within the scope of these investigations; therefore, data is not available for the development of an ecological profile." Some of the contaminants found at the No. 2 Reservoir Burning Ground, especially the heavy metals can easily be translocated by mineral up-take to the grasses and herbs growing at the site. At a minimum, the surface vegetation should be collected and analyzed. This is not a fenced, restricted area and there are wildlife, especially deer and other small animal that live in the area. Deer that roam this facility are harvested by Ohio hunters and are therefore a food source. Other smaller mammals are also a part of the food chain. If there is a bioaccumulation of heavy metals that have translocated out of the burn zone either into the pasture vegetation or into the small mammals via soil ingestion, then that information must be included in the final site evaluation. There is an established risk pathway that can affect human health. When site clean-up determinations are made, if the contaminated burn area is not stripped and removed and there is found to be a reservoir of heavy metals in the vegetation, the area should be, at a minimum, fenced with deer-proof fencing to prevent further foraging.

We concur that "Major components of the physical profile are the silt layer at 7 to 9 ft bgs (the KibbieJine sandy loam parent material -our addition), and the highly plastic clay layer ranging from 10 to 15 ft bgs, and extending to the bedrock interface. These two units control the movement of shallow groundwater at the site. Based on this model, the preferential flow path for shallow groundwater is laterally through the silt layer towards the drainage ditches." Vertical movement through the clay layer, through the Plum Brook Shale, and into the Delaware Limestone also exists. Vertical movement is controlled primarily by primary porosity in the 7 to 9 foot bgs interval and by fractures and secondary porosity within the clay and underlying bedrock. Questions about contaminant movement are not answered by the ground-water investigation that has been conducted at the site. See our previous comments. Additional ground-water investigation must be a high priority for future work at this site.

"The primary release mechanism for PAH and nitroaromatics are removal of the vegetative and backfill layer and leaching to shallow groundwater." Again, we note that the pasture growing at the site is grazed by biota, including deer which are harvested by Ohio hunters and consumed. In addition, the deer may drink the shallow ground water that is contaminated where it enters the drainage ditch. "Release of contaminants into the deeper bedrock groundwater is unlikely because of the highly impermeable clay layer beneath the site and the absence of fractures and low permeability observed in the Delaware limestone." As stated above, we do not concur. We recommend that additional ground water investigation be performed and that a mass balance be used to account for contamination and migration pathways. Eliminating migration of contaminants to the Delaware Limestone is premature.

"The primary release mechanism for PCBs, lead, and dioxinslfurans is the removal of the vegetative and backfill layer. As discussed above, some form of construction or other human activity would be required for this release mechanism to be viable ..." This is not necessarily the only "primary" release mechanism that must be considered. For example, lead can be translocated into a growing pasture and become a food source for deer, which are consumed by people. It is possible that other contaminants listed in this section are also translocated into vegetation. The report should address this pathway and include information on the potential for uptake by plants of other contaminants present at the site. This topic needs more exploration.

Response: No further investigation is warranted if the source area is to be removed or treated. The vegetative cover would be removed in the event of a removal action and would therefore be a non-issue. Likewise as discussed in response to comments 1 and 2, additional groundwater investigations are not recommended, considering that site contaminants were not detected in the bedrock groundwater and the fact that the formation is not a viable water resource because of the naturally occurring hydrogen sulfide and petroleum.

16. 7.5 Recommendations, page 7-4

A. **We concur that additional surface soil sampling needs to be conducted and we recommend that a detailed surface topography survey be added to identify the surface runoff routes over the surrounding site. This is particularly important in identifying source(s) and routing(s) for the contaminants detected above the surface soil above the PRGs in the western portion of the study area.**

B. **We recommend that if the bedrock ground-water wells cannot be adequately purged and developed so that they function with some level of replication to other wells at the site, that they be abandoned and new, properly sited and constructed wells be drilled to replace them.**

C. **We recommend fracture trace analysis be conducted and ground truthed in the field (at local Delaware Limestone quarries) so that bedrock monitoring well construction success will be improved.**

D. **We recommend that angled boring techniques be considered as an alternative to vertical wells because these borings will have a higher probability of encountering vertical fracturing and jointing systems.**

E. **We recommend that the original concept of installing shallow overburden wells be reinstituted. These shallow wells are necessary to ascertain the levels of contamination migrating horizontally towards the ditch as well as the levels of contaminants that may recharge the underlying bedrock by migrating through the glacial deposits. Based on the successful installation of piezometers in these materials and providing that appropriate well installation techniques are employed, these wells should be able to be installed.**

F. **We recommend that a mass balance that accounts for volume and routing of contaminants at the Burning Grounds be preformed. It is important to understand all the migration pathways (either discharge to air, surface water, andlor ground water). It is critical that all pathways be definitively determined so that all contaminant migration routes are adequately accounted for and monitored.**

G. **We recommend that the pasture vegetation growing in the vicinity of the Reservoir No. 2 Burning Ground be analyzed for the contaminants of concern and if the plant tissues are found to contain contaminants, that, at a minimum, the site be fenced with deer-proof**

fencing to prevent further grazing of the contaminated site by deer who are consumed by people.

Response: No further survey work or vegetative investigation is recommended since the source of contamination is to be removed or treated. No further groundwater investigation is recommended. See response to comments 1 &2.