TO: Beth Vens, Project Manager
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FROM: Steve Hoin, Senior Geologist
Remediation and Redevelopment Division

DATE: October 3, 2006

SUBJECT: BASF Northworks GSI Review

Hydrogeology/Site Contamination

The site is located along the Detroit River (River) in an area typified by a regional clay sloping downward toward the River with a wedge of native and non-native (fill) material above that clay. The clay surface in the area can be complex and in this case, a clay ridge exists below grade parallel to the River. This ridge created conditions amenable to the formation of a large wetland along the River and also likely allowed for the deposition of native river sediments behind that ridge. These sediments form a rather thick saturated zone at the site. Over 30 feet of saturated permeable sediments exist in the central area of the site above the regional clay (see Figures 7-2 through 7-5 of the Phase I Report). The clay ridge extends along a line parallel to the river about 100 feet from the River's edge. The ridge terminates in the northern 1/2 of the site. This ridge will have an effect on the deeper groundwater flow, but water levels are above the top of the ridge and the ridge does not appear to significantly influence the shallow groundwater flow. A peat/clay layer was also found at the site. This layer likely represents the base of the historical wetland at the site that existed prior to development. The material above the peat is predominantly fill.

Overall groundwater flow at the site is toward the River. This flow is complicated by the groundwater extraction system. The existing capture system consists of three areas where groundwater extraction wells have been installed and operated since sometime shortly after 1986. The extraction wells were required under a 1986 consent decree between BASF and the State. The consent decree mandated water level measurements within the capture areas but did not require well sampling and contaminant monitoring.

The groundwater flow maps show that the system is capturing the groundwater, but only in an area very near the capture systems (see Figure 7-15). This figure is apparently a combination of actual data and modeled data. This should be considered a "best case" map. This figure includes erroneous flow arrows and a speculative groundwater divide along the River. Nevertheless, this groundwater flow diagram clearly shows that large areas exist where groundwater is migrating from the plant to the River. The unbiased groundwater flow maps (Figures 7-11 through 7-14) further illustrate the groundwater is exiting the site to the Detroit River even under pumping conditions.

It is apparent that the system, as designed, is ineffective in preventing contaminated groundwater from entering the River. The system is particularly ineffective for shallow groundwater above the peat. The extraction wells, if constructed as the CD specifies, had very short (two foot) screens set in the sand material beneath the peat/clay layer and would have a
limited effect on the shallow hydrogeology because the peat/clay clay would impede any vertical flow (i.e., it would act as an aquitard).

The groundwater monitoring system is not adequate to characterize flow conditions at the site. Most of the monitoring wells have been installed in the native sand material beneath the peat/clay layer. Few wells have been installed in the fill above the peat layer. As discussed previously this peat layer likely has a significant influence on groundwater flow and the flow in the shallow and deeper zones need to be characterized separately (i.e., we need monitoring wells above the peat and in the fill). The RCRA Facility Investigation Report on current conditions acknowledges the likely effect of the peat/clay layer and indicated the shallow horizon (the fill) needs to be investigated further. (Note: the Report was completed for the USEPA and was not part of the 1986 consent decree). The Report indicates that a groundwater divide exists parallel to the River. My review of the data suggests that this divide exists only in small areas and only exists when pumping is occurring at a maximum rate. Typically the effect of the groundwater extraction is not as significant as suggested. The actual water levels within the capture areas are several feet higher than the modeled levels. And, in the areas between the extraction systems, the divide does not appear to exist at all. Because the extraction wells are typically running at or near their maximum efficiency, it is unlikely that conditions could improve with increased pumping and it is apparent that contamination (particularly mercury) is escaping the system and entering the River.

The effect of the clay ridge also needs to be considered when evaluating the groundwater flow at the site. The various reports acknowledge the effect of the ridge and suggest that it impedes contaminant flow toward the River. This may be true for the deeper sands in certain areas of the site, but will not be the case for the fill material which exists above the clay ridge. In addition the clay ridge terminates near the center of the site and the various groundwater flow maps suggest that the deeper groundwater is entering the River on the northern half of the site. This deeper groundwater could also be migrating to the south, but data are lacking. The effect of this clay ridge has not been adequately characterized.

Groundwater conditions adjacent to the River are more complicated. BASF mapped flow toward the River in this area. However, the water levels in the wells directly adjacent to the River track the River elevations with little or no delay in some wells (see Figure 7-10). This indicates that some of these wells are directly influenced by the river and therefore reversals of flow from the River to the site are occurring during high water events. This results in a situation where the fill and native sands near the River are flushed. Samples from these wells, therefore, do not accurately represent the volume of mercury entering the River. These wells cannot be used to represent the groundwater/Surface water interface (GSI). River wells should be installed at a distance further back from the River where it is demonstrated that the dilution effect of the River does not exist. These River wells should be well pairs with wells placed in the shallow and deeper horizons.

Even considering these conditions (i.e., flushing from the River) some of these River wells RFIMW-6, 11, and 12 still had significant levels of mercury in 1997 (i.e., all were greater than 1000 ng/l). More recent results were lower (324, 1.6 and 14.2 ng/l respectively). These data indicate that mercury continues to discharge to River from the native sand unit at levels well above the GSI criterion. Note: typical river background in this area is less than 0.010 ug/l (10 ng/l). These variable levels of mercury would be expected for wells along the River since flushing will vary depending upon the season and the River water level.
Mercury levels in groundwater in the fill have been found to be much higher (see results for RFIMW-12) than the native sand wells and it is apparent that much higher levels of mercury are entering the River via discharge from the fill material. Additional site information supports this assertion. Soil sampling results provided in the RCRA Facility Investigation indicate that mercury (and likely other) contamination exists within the fill material. Samples collected from the fill material at many of the SWMU showed that mercury is present in fill at significant levels when compared to the State's default background.

SWMU F 21,100 ug/kg – Background = 130 ug/kg  
SWMU G 5,400 ug/kg  
SWMU H 52,900 ug/kg  
AOC 2 17,100 ug/kg

These levels are indicative of mercury waste material or mercury spills. The source of the mercury has not been identified and may simply be part of the fill material. These materials are described as various rubble and building material and DBO (distiller blow off) some of which are clearly from historical BASF operations and site demolition. The fill materials and associated mercury could have originated from off site locations (the DBO was likely not generated on site) and could have originated from BASF's nearby Chlor-Alkali Plant (South Works). Alternately the mercury may have originated on site since mercury cells were often used in the early Solvay process, which was used at the site.

BASF provided an estimate of the “total” mercury flux into the River in the September 2005 Supplemental Groundwater Sampling report. These results should not be used. The flux estimate is based upon wells along the River (i.e., non-GSI wells) and many of these samples are diluted from the effects of the River and the majority are from the less impacted native sand. True mercury flux could be orders of magnitude higher.

Note: there is a component of groundwater flow to the south and west along Jefferson Avenue. This is common in this area and it is likely that some contaminated groundwater is exiting the site in this direction. Further characterizations needed to assess off site geology and flow conditions in this area. Efforts should be made to identify and locate utility corridors along Jefferson Avenue.

My review focused on mercury contamination because the mercury GSI criterion is inevitably the most restrictive and typically drives the remedial measures. Other contaminants likely exist on the property that have not been adequately characterized. For example, many of the well purging forms from the Supplemental Groundwater Sampling report showed that groundwater had pH levels above 10 with some samples as high as 12 ((RFIMW-07). Clearly these levels exceed the GSI criterion, plus they are likely indicative of Ammonia in groundwater at the site (which has not been measured). Ammonia is a major component of the Solvay Soda Ash process. The process also utilizes brine from brine mining and it is likely that high levels of chlorides also exist in groundwater on the site. Again, the 1986 consent decree does not require any sampling and analysis for contaminants.

**GSI Characterization**

The U.S.EPA requested that BASF submit a plan for investigating the GSI pathway at the site. That Plan was sent to the U.S.EPA in early August of 2006. The investigation proposed by
BASF consists of seven new wells along the River and sampling of select existing wells. The plan is grossly insufficient because:

1) the proposed wells are in the area of influence of the River where flushing is occurring and only in select areas; and
2) other areas with elevated mercury likely exist, but are undetected because of the lack of groundwater data in the shallow fill and because of a lack of understanding of the source of the mercury.

Because mercury is considered a bioaccumulative contaminant, it must be prevented from entering the River at any location where the 1.3 ng/l criterion is exceeded (i.e., mixing is not allowed). Typically this is addressed in one of two ways, total containment of discharges to the River or localized containment with extensive investigation and monitoring to ensure that mercury is not entering the River in the uncontained areas. If the presumptive approach (total containment) is not selected, then a rigorous GSI characterization is necessary.

R299.5716 and the associated Operation Memoranda for the investigation of venting groundwater (DEQ Operational Memorandum #5) provide unambiguous guidance regarding the characterization of the GSI pathway. The Work Plan provided by BASF is not adequate to address investigate the pathway for several reasons.

- GSI wells need to be installed away from the influence of the River. As discussed early in this Memorandum, most of the River wells are within the influence of the River. These wells should be installed parallel to the River and should be installed both in the fill and the native sand units at spacings sufficient to detect any mercury plume.

- GSI wells should be installed to encompass the extent of the plume above GSI, both vertically and laterally. This either requires an extensive network of wells along the River at very close spacing or the identification and delineation of the sources of the mercury (and Ammonia) followed by the complete lateral and vertical characterization of any plumes.

- GSI wells need to characterize all potential routes of GSI exposure. At this site this should include wells to the west and southwest to assess migration into onsite and offsite storm sewers and to assess offsite migration.

- GSI wells should be installed to characterize the hydraulic effect of the clay ridge and the peat/clay aquitard. This ridge likely is affecting groundwater flow and may redirect contaminants in an unexpected manner. This is particularly crucial to the north where the clay ridge disappears. The peat/clay layer affects the vertical migration of contaminants and the interaction between the deeper and shallow zones needs to be understood to accurately predict the fate of the mercury.

The GSI characterization should also consider flow conditions when the groundwater capture system is operating and when the system is not operating. The 1986 consent decree will allow for the system to be shut down at some time in the future and flow conditions will be different after shutdown.
**Background Wells**

I do not have information on all of the proposed background wells. But, based on the information I have, it is apparent that some of the wells should not be considered as background. Background wells should be in native material away from any fill. The wells should also be in areas where groundwater consistently enters the well location from off site areas. The wells discussed in the southwest corner of the property (P35N and P34N) have been shown to be in an area downgradient of the site. Groundwater has been shown in this area to be flowing to the south and southwest from the site. Wells in this area should not be considered for background purposes.

Note: the hydrogeology of this site is such that it will be very difficult to obtain a background well. The “aquifer” typically inches out at or around Jefferson Avenue and if present is shallow and thin. This area can be influenced by flooding or rain and it is often difficult to determine if contaminants are from on-site or off site without extensive monitoring.

My experience is that mercury levels in background groundwater are typically less than 5 ng/l in Southeast Michigan.

**Overall Conclusions**

Following is a summary of my overall conclusions.

1) Mercury is entering the River and in some cases at levels 3 orders of magnitude above the 1.3 ng/l criterion.
2) Most of the wells are installed in the native materials, not the fill. The highest mercury levels were found in wells in the fill, where a clear correlation exists. The mercury problem is much more significant than the data suggest because groundwater from the fill is entering the River and the fill is a major source of mercury.
3) The Capture system is not effective in eliminating discharge to the River because of the localized effect of the capture and the presence of contaminants in fill outside of the zone of influence (both above and laterally).
4) High pH groundwater exists on the site and this likely represent high ammonia levels (above GSI Final Acute Value).
5) The measures taken as a result of the 1986 CD do not prevent mercury contaminated groundwater from entering the River.
6) Select proposed background well locations are not appropriate.
Figure 7-15.
Approximation of Potentiometric Surface for August 10, 1997

LEGEND
- Elevation contours (0.5 feet)
+ Point of known elevation
← Apparent direction of groundwater flow
— Estimated location of groundwater divide

1:6500 Revised: 02-26-99
BASF
RCRA Facility Investigation
Wyandotte, Michigan

LEGEND
- MW#8
- River N
- MW#18
- River S
- MW#11
- MW#20
- MW#6

Figure 7-10.
Water Level Data for July 14 - August 8, 1997

Revised: 02-26-99

QST ENVIRONMENTAL
**WELL PURGING**

**FIELD WATER QUALITY MEASUREMENTS FORM**

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**STEWART**

**Iron (Fe) = 0.1 mg/l**