Concerns Regarding Mobilization of DNAPL by ISGS Injection
Gainesville Regional Utilities
August 17, 2015

This document expresses GRU's concerns with regard to the potential mobilization of DNAPL during ISGS treatment of the Former Process Area at the Koppers site in Gainesville, Florida.

Based on our review of the pilot study data provided thus far it appears that the ISGS treatment was successful in reducing DNAPL recovery in the wells and TIPs located interior to the treated area (HG36-SE, 420N 340E, 400N 380E). Although there was a pronounced reduction at these locations, recovery rates are still significant enough to indicate a substantial amount of mobile DNAPL remaining. We understand that the full-scale demonstration includes injection points in an around the pilot test area and that the results from the full scale demonstration study will provide further indication of the degree to which the ISGS treatment has succeeded in immobilizing DNAPL. However, we want to express some concerns that need to be addressed in evaluating the ISGS treatment.

GRU is concerned about mobilization of DNAPL during the injection process as a result of the pressures induced during ISGS injection. Our concern is that some of the DNAPL present within the treatment zones will be displaced or mobilized and moved either laterally or downward during the injection process. There is evidence of this occurrence resulting from the pilot injections. The extent to which this phenomenon will impact the overall success of the ISGS treatment is uncertain. It is critical that this phenomenon be considered in the monitoring and assessment of the full-scale treatment to ensure that untreated DNAPL is not being moved into areas outside of the targeted treatment zones.

Mechanisms for DNAPL Mobilization from ISGS Injection

It is very likely that DNAPL movement occurred during the injection process. Several mechanisms could individually, or in combination, cause this movement of DNAPL:

1. Displacement of DNAPL by the injected fluid;
2. Hydraulic fracturing and/or liquefaction of the Hawthorn formation occurring as result of the induced pressures, thereby creating new DNAPL migration pathways; and/or
3. Pressure waves propagated during injection causing dilation of pore throats and mobilizing previously immobile DNAPL (see attached article by Gale, Thomson, et. al. and literature cited in that paper).

Evidence of Mobilization of DNAPL by Pilot ISGS Injection

There are several observations from the DNAPL recovery data that suggest DNAPL mobilization has occurred during or after the pilot ISGS injection (plots attached):

- Temporal spike in DNAPL recovery evident during ISGS injection in TIP 420N 340E located inside the Pilot test Area;
- Temporal spike in DNAPL recovery evident immediately after ISGS injection in TIP 380N 340E located about 15 feet outside the Pilot Test Area. DNAPL recovery was higher than the pre-injection rate for 2 events following injection;
- Initiation of DNAPL recovery in July after ISGS injection in TIP 360N 380E located about 15 feet outside the Pilot Test Area;
- Temporal spikes in DNAPL recovery evident immediately after injection in recovery wells HG-37SE, HG-38SE, HG-39SE, and HG-40SE;
- Temporal spike in DNAPL recovery evident immediately after ISGS injection in TIP 460N 340E located inside the Pilot Test Area. In this case and for HG-38SE, DNAPL recovery was higher than pre-injection rates for only the first event after injection ceased. In the other cases above DNAPL recovery increased during injection, or for more than one event after injection ceased; and
- The appearance of DNAPL in six TIPs in May 2014 where DNAPL had not been previously reported (360N 140E, 400N 140E, 200N 220E, 280N 220E , 360N 220E, 280N 300E) (See Table 1). Figure 1 illustrates the episodic appearance of DNAPL in previously unimpacted TIPs since their installation July 2012 through April 2013. The appearance of DNAPL in six TIPs in a single gaging event (May 2014) in unprecedented.

One factor that could contribute to an apparent spike in DNAPL recovered in the DNAPL recovery event *immediately after ISGS injection* is the fact that a longer period of time elapsed (43 days) between recovery events before and after injection than for the routine bi-monthly events (13-14 days). However, this rationale cannot explain the spikes in DNAPL recovery in 380N 340E, 360N 380E, HG-37SE, HG-39SE, or HG-40SE, since the temporal increases occurred over multiple sampling events. In 420N 340E the temporal increase occurred during the ISGS injection. Table 2 compares the amount of DNAPL recovered per event during September through October 2014. During this period the elapsed time between recovery events varied from 15 days to 20 days to 9 days and back to 13 days. There was no significant variation observed in DNAPL recovery in TIPS and no correlation between the length of time between DNAPL recovery events and the volume recovered.

Conclusions and Recommendations

Based on observation of data from the pilot study it is very likely some displacement of DNAPL will occur during the full-scale ISGS injection due to the volume of liquid being injected and the injection pressures. GRU's concern is that untreated DNAPL can potentially be moved into untreated zones. The extent to which this

phenomenon will impact the overall success and effectiveness of the treatment is uncertain.

Post-injection monitoring should be conducted at the periphery of the treated area to investigate this possibility. Furthermore, GRU believes that Beazer must provide assurance that the full-scale ISGS injection at the Former Process Area has not mobilized/displaced DNAPL before ISGS is implemented at the Former South Lagoon.

GRU recommends that:

1. The monitoring of DNAPL presence and recovery in the TIPs and DNAPL recovery wells should continue on the every-other week basis to the extent possible during the ISGS full-scale injection and should resume as soon as possible after the injection is complete. The most important locations are those TIPs located around the perimeter of the target ISGS injection area. If mobile DNAPL becomes apparent in the perimeter TIPs, the injection area should be expanded to include these areas;

2. It must be recognized that the lateral extent of DNAPL has not been delineated east of the former Process Area beyond the Beazer site boundary. Although recoverable DNAPL has not be found in the existing east boundary TIPs, the TIP borings indicate extensive residual and mobile DNAPL (see DNAPL Rating of 4 and 5 in boring logs for TIPs: 120N 475E, 160N 475E, 200N 475E, 240N 475E, 280N 475E, 320N 475E, 360N 475E). Additional characterization is required to delineate the eastern boundary of impacts;

3. Beazer should describe their response for the ISGS injections and for the barrier wall design and construction in the event that mobile DNAPL is identified at or beyond the barrier wall alignment.

Table 1. DNAPL Recovery in Individual TIPs Starting One Month Prior to the Pilot Test (February 2014).

Month	Events	340N 180E	320N 140E	300N 260E	360N 140E	400N 140E	200N 220E	280N 220E	360N 220E	280N 300E	360N 380E	507N 260E
Jan-13												
Oct-13												
Nov-13												
Dec-13												
Jan-14	3											
Feb-14	2	1.1										
Mar-14	2	0.5	5.1	5.4								
Apr-14	1	1.3	5.3	3.2								
May-14	2	2.1	1.7	1.0	2.3	4.8	4.4	8.6	6.2	5.3		
Jun-14	2	1.2	1.3	1.6	0.7	0.5	1.3	2.4	2.4	2.3		
Jul-14	3	1.9	1.8	3.1	0.6	0.2	2.8	3.4	3.9	3.6	12.3	
Aug-14	2	1.3	1.2	2.0	0.4	0.4	1.6	2.0	2.9	6.1	6.1	
Sep-14	2	0.5	1.2	2.2	0.4	0.5	1.4	2.1	2.5	2.7	8.0	
Oct-14	2	3.3	1.3	2.0	0.55	0.4	1.55	2	2.7	2.8	6.8	
Nov-14	2	1.7	1.2	2.0	0.55	0.4	1.55	2.2	2.9	2.9	6.7	1.0
Dec-14	3	2.3	1.8	3.2	0.7	0.4	2.6	3.1	4.0	4.4	10.0	0.4
Jan-15	2	1.5	1.4	2.4	0.6	0.5	1.8	2.2	2.8	3.0	6.9	0.0
Mar-15	2	1.5	1.0	2.1	0.4	0.5	1.7	2.0	2.6	3.2	6.5	0.0
Feb-15	2	1.2	1.2	2.2	0.4	0.4	1.7	2.0	2.6	3.0	6.6	0.0
Apr-15	2	2.3	1.2	2.1	0.4	0.3	1.6	2.0	2.5	2.9	6.5	0.0
May-15	2	1.3	1.1	2.1	0.5	0.6	1.4	2.0	2.6	2.9	6.5	0.0
		These TIPs started producing				These TIPs started producing DNAPL after treatment.						
		in the months preceding trtmt.										

Table 2. Variation in DNAPL Recovery Rates (gallons per event) in TIPs During September-October 2014

Location	Oct. 23, 2014	Nov. 5, 2014	Sept. 9, 2014	Sept. 24, 2014	Oct. 14, 2014
Days since previous event	9	13	13	15	20
220N 180E	2.3	2.3	2.4	2.5	2.5
280N 380E	3.2	3.1	3.5	3.2	3.2
300N 180E	4.8	4.6	5.4	5.2	5.1
300N 420E	3.5	3.4	3.3	3.4	3.5
320N 220E	3.2	4.1	2.9	3.1	2.9
320N 300E	3.1	3.2	2.9	2.9	2.7
340N 340E	5.5	5.8	4.6	4.8	5.6
360N 280E	3.3	3.6	3.8	3.7	3.7
380N 340E	5.6	5.5	5.8	5.9	5.5
440N 380E	1.4	1.4	1.1	1.1	1.2
460N 340E	1.5	1.4	1.4	1.5	1.4
420N 340E	4.4	4.9	4.3	4.5	4
220N 340E	1	1	0.9	0.9	1.2
240N 380E	1.5	1.5	1.4	1.5	1.4
340N 180E	1.8	0.8	0.2	0.3	1.5
320N 140E	0.6	0.7	0.6	0.6	0.7
300N 260E	1	1	1.1	1.1	1
360N 140E	0.3	0.3	0.2	0.2	0.3
400N 140E	0.2	0.2	0.3	0.2	0.2
200N 220E	0.8	0.8	0.7	0.7	0.8
280N 220E	1	1.1	1	1.1	1
360N 220E	1.3	1.4	1.3	1.2	1.4
280N 300E	1.4	1.4	1.4	1.3	1.4
360N 380E	3.3	3.4	4.4	3.6	3.5
No. TIPs w/ Max Recovery*	8	12	7	6	8

Highest reported recovery.

Values within 0.2 gallon of the highest reported recovery.

*No. TIPs w/ Max Recovery: This indicates the number of TIPs for which the maximum DNAPL recovery volume was reported at a particular DNAPL collection interval. The total number of records calculated by summing all numbers in the Max Recovery row is greater than the number of TIPS because several TIPS have produced the same maximum amount for a particular sampling interval.

Recovery wells are not shown because the Sept. 2014 monthly report is missing a date for one of the events. Data are arranged in order of lowest to highest time between DNAPL recovery events. It is apparent that the natural variability of DNAPL production rates generally falls in a narrow range for each individual TIP and that the volume of DNAPL production does not correlate to the time since the last recovery event. Note that a gap of 9 days resulted in the highest DNAPL production rate in 8 TIPs – the same as a recovery period of 20 days.

Figure 1. Map View of TIPs that Started Producing DNAPL Just Before and Immediately After the Pilot Test Injections.

We do not have data on DNAPL production rates from individual TIPs prior to January 2014 (Beazer has yet to provide us those data so we are severely constrained in the interpretations we can make) however; it is evident that from the time the TIPs were installed (September 2012) until October 2014 (12 months) 10 TIPs had started producing DANPL. Between November 2013 and February 2014 (4 months) an additional 6 TIPs had begun producing DNAPL. And 8 TIPs began producing creosote in the first sampling event following the pilot test injections. These data are presented in the following map and table.