Work Plan for Dye Testing at Monitoring Well HG-29D

Cabot Koppers Superfund Site, Gainesville, FL

Prepared for
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Table of Contents

Page

List of Tables

List of Figures

1 Background and Purpose

Monitoring wells HG-29S and HG-29D are located approximately 60 feet north of the former eastern lagoon on the Cabot portion of the Cabot Koppers Superfund Site, and are screened in the Upper and Lower Hawthorn Group (HG) formation, respectively. Groundwater analytical data collected at well HG-29D continue to indicate concentrations of pine tar related constituents that are: a) significantly higher in comparison to other Lower HG monitoring wells located in its vicinity (*e.g.*, HG-28D and HG-30D) (see Table 1); and b) comparable to concentrations detected in the Upper HG monitoring well (HG-29S). Thus, a dye test will be performed with the goal of determining if the pine tar-related impacts detected at HG-29D are attributable to leakage of Upper HG groundwater *via* a compromised well seal, or are being caused by groundwater migration *via* fractures in the Middle Clay Unit.

2 Hypothesis

The potential migration pathways that could have resulted in the elevated pine tar constituents observed in groundwater samples at monitoring well HG-29D screened in the Lower HG formation are: 1) downward migration of impacted groundwater from the Upper to Lower HG formation *via* a compromised well seal; 2) groundwater migration from the Upper to Lower HG *via* fractures in the Middle Clay Unit; and 3) drag down of pine tar by drilling equipment during the installation of the monitoring well. The proposed dye test will be used to evaluate the first two migration mechanisms (*i.e.*, well seal leakage and migration through fractures in clay).

The travel time for the two mechanisms being evaluated by the dye test are expected to be adequately different. The estimated travel time for the former pathway (well leakage), if occurring, would be on the order of weeks (*i.e.*, including travel time between the injection point and the well), while the travel time for the latter (transport through clay fractures) would be on the order of months (Table 2). Thus, the results of the dye test described below will be interpreted in the context of these time periods to better understand potential migration mechanisms responsible for the impacts detected at well HG-29D.

3 Background Testing and Dye Selection

Fluorescein and rhodamine WT are the two tracer dyes that will likely be used for the test. Prior to initiating the dye test, background testing will be performed with the following objectives:

1. To determine the background levels of fluorescein and rhodamine WT (if any) in the Lower HG formation;
2. To evaluate if the presence of Site-related contaminants (*e.g.*, phenols) in groundwater will cause analytical interferences with the detection of the dyes; and
3. To evaluate if the presence of residual dye in the groundwater will inhibit or interfere with the detection of Site-related contaminants following the completion of the dye test.

In order to address the first two objectives, up to two groundwater samples will be collected from wells HG-29S and HG-29D; samples will be collected approximately seven days apart. Additionally, an activated charcoal packet will be placed at the top of the screened interval of each well and left in place for seven days. Groundwater samples and charcoal packets from the wells will be submitted to Ozark Underground Laboratories (Ozark) for analysis of fluorescein and rhodamine WT. Note, preliminary testing of groundwater performed by Ozark showed non-detectable levels of fluorescein and no evidence of interference from Site-related contaminants. However, the test will be repeated with both tracer dyes before the dye test is started.

In order to address the third objective, background groundwater samples collected from wells HG29S & HG 29D will be spiked with fluorescein and rhodamine WT dyes and submitted to Test America Labs for analysis of volatile and semi volatile organic compounds using Methods 8260 and 8270, respectively. Dye solutions will be prepared at an approximate concentration of 40 mg/L (*i.e.*, 1/10th of the dye injection concentration discussed below) in deionized water and will be added to the collected groundwater samples at a ratio of one volume of dye solution to one volume of groundwater sample.

The results of the background sampling will be reviewed to determine if fluorescein and/or rhodamine WT are appropriate tracers to use at the Site and evaluate the potential long-term implications of the dye test on the analysis of groundwater for Site-related contaminants.

4 Injection Well Construction

Injection of dyes into the Upper HG formation will be accomplished *via* two newly constructed 2-inch diameter wells, designated as HIW-29A and HIW-29B, screened at different depth intervals. As discussed in further detail below, different dyes (fluorescein and rhodamine WT) will be used in the deep and shallow injection wells to trace the potential contaminant migration pathway(s). The first injection well (HIW-29A) will be screened from approximately 54 to 59 feet below ground surface (bgs). Based on a review of the boring log for wells HG-29S/D, this depth interval is the most permeable horizon in the lower portion of the Upper HG formation and is likely to more readily allow lateral distribution of the dye solution.

The second injection well (HIW-29B) will be screened from approximately 61 to 66 feet bgs (at the base of the Upper HG formation). However, the hydraulic conductivity of the Upper HG unit is lower in this interval compared to at mid-depth, so the lateral migration of the dye from HIW-29B will likely be slower than from HIW-29A. Dye injected into either injection well is expected to primarily migrate laterally due to the horizontally bedded nature of the Upper HG formation, although a vertical component of migration may also be generated due to density effects. If there is well leakage between either the mid-depth or base of the Upper HG formation and the Lower HG formation, then the dye will be drawn into the preferential vertical pathway and flow downward to HG-29D. With respect to the potential migration of dye through factures present in the Middle Clay unit, it is expected that only the dye injected into the lower injection well will encounter this pathway.

The proposed injection wells will be installed using a sonic drill rig. The injection wells will be installed approximately 5 feet upgradient (south-southwest) of monitoring well HG-29D. Soil coring will be started at approximately 20 feet bgs and continue until the top of the Upper Clay unit is identified. A 10 inch diameter borehole will be completed to the base of the surficial aquifer and a permanent 6 inch steel isolation casing will be advanced 1 to 2 feet into the Upper Clay to seal the surficial aquifer from the Upper HG formation. This casing will be sealed in-place with cement grout from bottom to top. The grout seal will be allowed 24 hours to cure before proceeding with the remainder of the well installation. The boring will continue by advancing a 6 inch borehole through the isolation casing. Soil coring will resume starting at approximately 50 feet bgs in each injection well boring and continue to the target depth (59 feet bgs for HIW-29A and 66 feet for HIW-29B). The screened intervals may be adjusted based on observations from the soil cores.

The injection wells will be constructed in the 6 inch boring using a 2 inch diameter by 5 foot long 0.010 slot size, pre-packed stainless steel well screen, and sufficient 2 inch riser pipe to reach the ground surface. A 2 foot thick bentonite-chip seal will be placed on top of the filter pack and the remainder of the borehole annulus will be filled from bottom to top with cement grout. The bentonite seal will be allowed a minimum of 8 hours hydration time and the grout seal will be allowed a minimum of 24 hours to cure. The well construction diagrams are provided as Figures 1 and 2.

The wells will be developed in accordance with protocols previously approved for the Site to remove fluids introduced during the drilling process and to establish good hydraulic connection with the formation. Physical and chemical properties of the water will be monitored during development including pH, specific conductance, dissolved oxygen, temperature, and turbidity. Development of the well will continue until the physical and chemical parameters are stable and are similar to adjacent well HG-29S.

5 Dye Injection

Dyes will be injected into the Upper HG formation upgradient of well pair HG-29S/D *via* the two injection wells described above. Dye will first be injected into HIW-29A. Once the desired volume of dye solution has been injected into HIW-29A, dye will be injected into the deep injection well (HIW-29B). Although the final decision regarding dye selection will be made based on the background testing results, the current plan is to use different dyes in the shallow and deep injections wells (fluorescein at HIW-29A and rhodamine WT at HIW-29B).

Prior to initiating the dye test, a fixed head injection test will be performed with potable water at the new injection wells to determine the volume of dye solution that can be readily injected into the Upper HG formation *via* each well (*i.e.*, evaluate the capacity of the formation to receive water). The test will be performed using the dye injection protocol described below. Based on the results of the test, the proposed injection volume of the dye solution may be adjusted.

The dye injection will be performed as follows:

- The static water level in the injection well will be measured.
- The standing water in the well will then be evacuated.
- A solution of dye in water will be prepared in a storage tank placed adjacent to the injection well (*i.e.*, the injection reservoir tank). The dye solution will be prepared by mixing 1 to 2 pounds of dye in approximately 300 gallons of water, which is slightly more than one third of the radial volume between the injection point and well HG-29D.[1] This will yield an injection concentration of at least ~397 mg/L. Due to the low hydraulic conductivity of the Upper HG formation, it would be challenging and potentially time-consuming to inject one radial volume (883 gallons) of dye solution into the formation. Given the high strength of the dye solution, and the expectation that the injected solution will travel along the groundwater flow path and be intercepted by well HG-29S, we believe that the use of one third of the radial volume, or 300 gallons of dye solution, will suffice. As explained further below, a potable water injection head will be maintained on the injection wells following dye injection. This injection head will serve to continue to expand the dye plume beyond one third of the radial distance.
- The dye solution will be allowed to gravity drain into each well until the level of the dye solution in the well rises to approximately 1 foot below ground surface.
- The well will be refilled with potable water by continuing to replenish the injection reservoir tank with water *via* a truck mounted tank, as needed, to maintain the head pressure at the injection well for a period of approximately 18 days (estimated travel time from the injection well to HG-29D; Table 2). The duration of the test may be adjusted based on the results of the clean water fixed head injection test performed prior to the dye test.

[1] Assuming a radius of influence of 5 feet, well screen interval of 5 feet and porosity of 0.3, the radial volume is estimated to be ~883 gallons. Hence, one third of the estimated radial volume is ~294 gallons.

6 Monitoring

To monitor for the presence of fluorescein and rhodamine WT in well HG-29D, three charcoal packets suspended on a rope will be lowered into the well and positioned at the top, middle, and bottom of the well screen. The packets will be deployed one day before the dye is injected into the Upper HG formation. Charcoal packets will be replaced weekly for 6 weeks. Additionally, groundwater samples will be collected from wells HG-29D and HG-29S on a weekly basis for up to 8 weeks, and then monthly monitoring will occur for 4 sampling events (*i.e.*, a total monitoring period of 6 months).

The charcoal packets and groundwater samples will be shipped to Ozark for fluorescein or rhodamine WT analyses. The monitoring program may be modified based on the early results of the dye test monitoring. Monitoring may be stopped after two consecutive detections of dye in samples from HG-29D.

7 Quality Control

Precautions will be taken to avoid cross contamination of the equipment, because both dyes can be detected at very low levels (*i.e.*, on the order of part per trillion). Precautions for the test include the following:

- The dye solution will be prepared at an off-site location and placed in a sealed container. This container will not be brought to the injection site until the well is completed to the desired depth and the final grout seal has cured for at least 24 hours.
- To the extent practicable, equipment used to inject dye will be discarded immediately after the injection. Equipment that cannot be discarded will be decontaminated at a location distant from HG-29S/D using a chlorine bleach solution to destroy the dye. The equipment will then undergo the typical decontamination steps prescribed in the 2013 Hawthorn Group Investigation Work Plan. Decontamination fluids will be containerized for appropriate off-site disposal. Similarly, disposable sampling equipment will be used to the extent practicable.
- The well plug at HG-29D and HG-29S will be checked to make sure they are secure before the dye test is initiated. Plastic sheeting will be placed over HG-29D and HG-29S and secured with duct tape as an added measure of protection against accidental leakage of tracer solution into the well.
- Wells HG-29D and HG 29S will remain closed until it is time to remove the charcoal packets from well HG-29D one week after the dye injection.
- Prior to starting the dye injection boring, the drilling equipment will be decontaminated in accordance with the approved 2013 Hawthorn Group Investigation Work Plan.

8 Reporting

A report will be prepared to document the results of the dye testing. The report will include a description of the testing methodologies, field observations, photographs, and laboratory data. It will also include a discussion of the findings and recommendations.

References

Gainesville Regional Utilities (GRU). 2006. "Review and Recommendations Report for the Cabot Carbon/Koppers Superfund Site." Prepared by Jones Edmunds & Associates, Inc., Gainesville, FL, February.

TRC. 2003. "Final Workplan Addendum for Additional Characterization of the Hawthorn Group, Cabot Carbon/Koppers Superfund Site, Gainesville, Florida." Report to Beazer East, Inc. Submitted to US EPA Region IV. April.

Tables

Table 1 Summary of Groundwater Analytical Data

Well ID	HG-29S		HG-29D		HG-28S		HG-28D		HG-30S		HG-30D	
Sample Date	**Mar-12**	**Apr-13**	**Mar-12**	**Apr-13**	**Mar-12**	**Apr-13**	**Mar-12**	**Apr-13**	**Mar-12**	**Apr-13**	**Mar-12**	**Apr-13**
Analyte (µg/L)												
2-Butanone	9,800	5,600	2,800	2,800	7,600	6,300	ND	ND	7,800	3,400	ND	ND
Acetone	17,000	25,000	7,600	7,300	20,000	19,000	ND	ND	15,000	11,000	ND	ND
Benzene	390	380	120	ND	210	ND	78	70	250	ND	42	34
3+4-Methylphenol	42,000	57,000	36,000	45,000	37,000	51,000	ND	ND	46,000	12,000	ND	ND
Phenol	51,000	76,000	14,000	21,000	61,000	83,000	ND	ND	64,000	7,000	ND	ND

Note:

ND - Non-detect

Table 2 Travel Time Calculations

Parameter	Unit	Value	Source	Comment
1 - Travel Time in the Upper HG Formation - Injection Well to HG-29S/D				
Horizontal Hydraulic Conductivity (Kh)	cm/s	1.00E-05	TRC, 2003	
Hydraulic Gradient (i)	ft/ft	3	Calculated	15'(head difference between injection point and HG-29S)/5'
Porosity		0.3	Assumed	
Groundwater Velocity	cm/s	1.00E-04	Calculated	
Distance between Injection Well and HG-29S/D	ft	5	Assumed	
	m	1.5		
Travel Time	days	18	Calculated	
2 - Travel Time Across Middle Clay Unit (through naturally occurring fractures)				
Vertical Hydraulic Conductivity (Khv)	cm/s	1.00E-07	TRC, 2003	
HG Fracture Porosity		3.00E-03	GRU R&R report, 2006	Used in GRU calculations
Vertical Hydraulic Gradient (i)		1.7	Calculated	Head difference between UHG and LHG = ~25'; thickness of Middle Clay Unit = 15'
Groundwater Velocity	cm/s	5.56E-05	Calculated	
Thickness of Middle Clay Unit	ft	15	Assumed	
	m	4.6		
Travel Time	days	95	Calculated	

Figures

Dye Injection Well HIW-29A

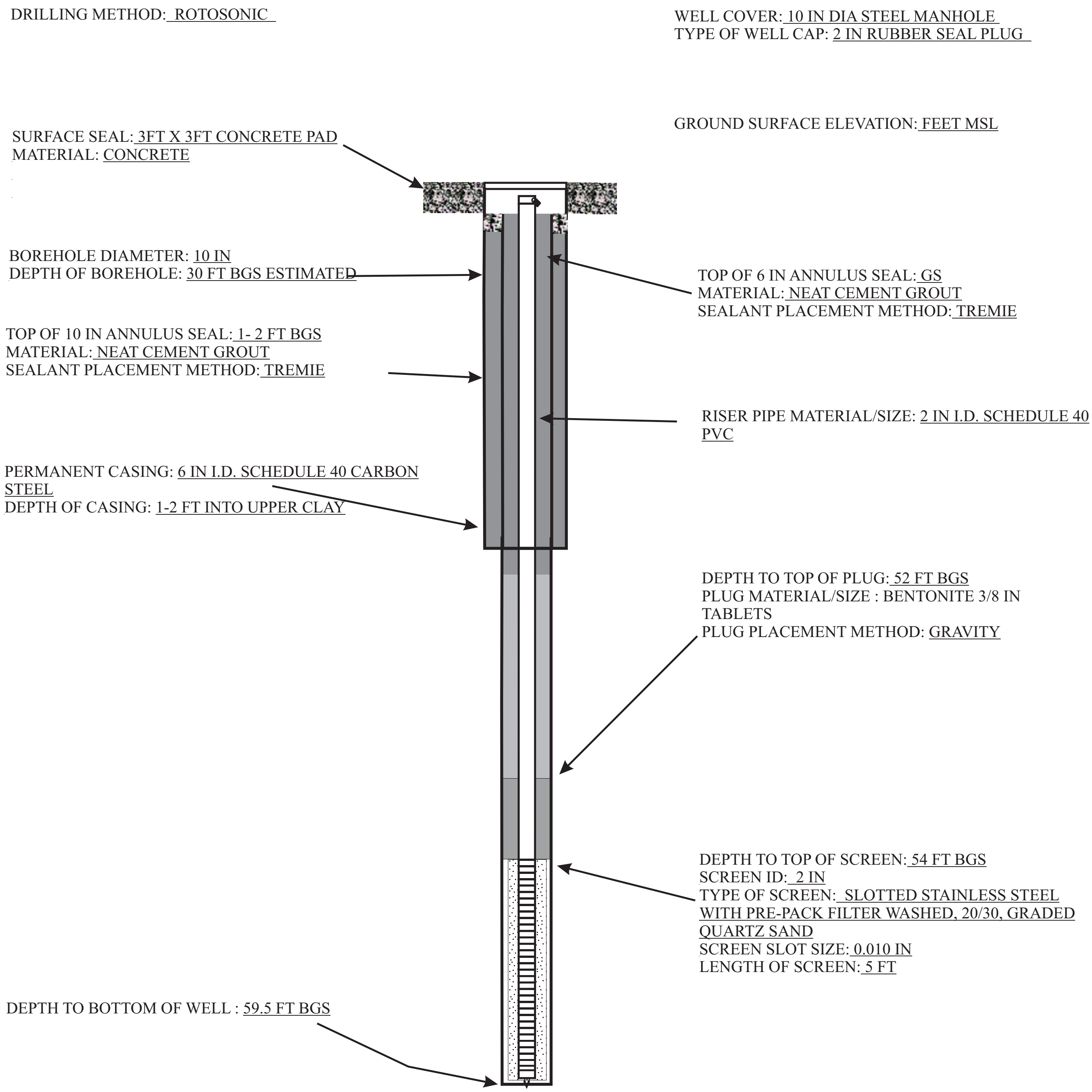

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FIGURE IS NOT DRAWN TO SCALE

Figure 1

Dye Injection Well Diagram

DRAWN	DATE	WORK ORDER NO.	FILE NAME
MAT	6/17/2013	05791.004.007	Well Construction Diagram

Dye Injection Well HIW-29B

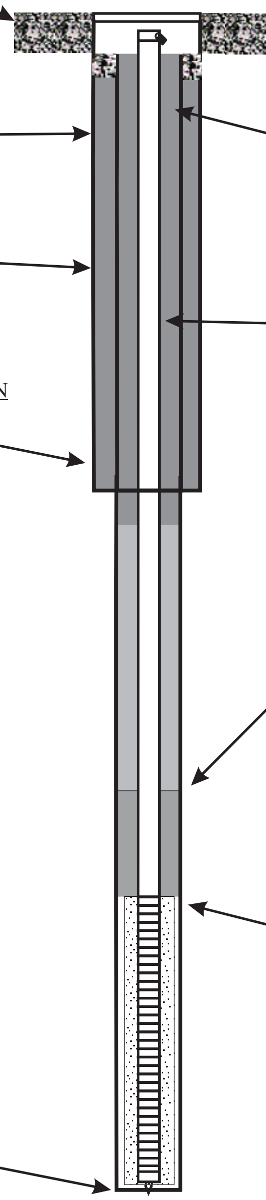

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Figure 2

Dye Injection Well Diagram

DRAWN	DATE	WORK ORDER NO.	FILE NAME
MAT	6/17/2013	05791.004.007	Well Construction Diagram