TETRA TECH

September 15, 2015

Mr. Scott Miller
Remedial Project Manager
U.S. Environmental Protection Agency, Region 4
61 Forsyth Street, SW
Atlanta, GA 30303-3104

Subject: **Field Test of Organoclay Addition to ISGS Injectate**
Amendment to the Design for the Former Process Area In-Situ Geochemical Stabilization (ISGS)
Cabot/Koppers Superfund Site
Gainesville, Alachua County, Florida

Dear Mr. Miller:

On behalf of Beazer East, Inc., we are providing herein an amendment to the in-situ geochemical stabilization (ISGS) remediation program being implemented at the Former Process Area of the Cabot/Koppers Superfund Site in Gainesville, Florida. The ISGS program is described in the document *Pre-Final Design for Former Process Area In-Situ Geochemical Stabilization Remediation* (Version 2, Tetra Tech, April 20, 2015) that was approved by EPA for full-scale implementation on April 22, 2015. There are 255 ISGS full-scale injection points in the Former Process Area and the total planned treatment injection volume is 166,571 gallons. Full scale injections began on July 9, 2015 and are expected to be complete around September 25, 2015.

For ten of the injection points near the western edge of the ISGS treatment area (see attached **Figure 1** and **Table 1**), Beazer plans to amend the ISGS injection solution with 2.5% (by weight) organoclay. The specific product for the amendment is CETCO ORGANOCLAY P; technical data for this product are provided in **Attachment 1**. The material is a silicate clay mineral (montmorillonite) that has been treated to make it selectively absorb oils and hydrophobic organic constituents.

This product, and other organoclays like it, have shown an ability to absorb significant quantities of non-aqueous phase liquids (NAPLs) in various in-situ and ex-situ applications. **Attachment 2** includes several information sheets describing the successful use of organoclays to absorb NAPL and hydrophobic dissolved constituents. As such, this product may increase the effectiveness of ISGS injections by further sequestering creosote NAPL and dissolved constituents.

Laboratory testing was recently completed with organoclay-amended ISGS injection solution to determine if it would be suitable for injection and to ascertain whether the amended solution would have measurable beneficial (or detrimental) effects on constituent sequestration from Site soil. The bench test report[1] is provided as **Attachment 3**.

The organoclay-amended ISGS solution had approximately the same density and viscosity as the ISGS solution without organoclay, meaning that the amended solution should be equally suitable for injection. It is therefore not expected that field procedures or injection pressures will need to be modified to facilitate injection of the organoclay-amended solution.

The lab test of the organoclay-amended ISGS solution did not demonstrate any appreciable positive (or negative) effects on constituent sequestration or soil permeability relative to ISGS solution without organoclay. Both the ISGS solution and the organoclay-amended ISGS solution exhibited similar sequestration capabilities and permeability reductions, and both were much better than the control (no ISGS solution or organoclay). Further lab testing to better measure the potential sequestration effect of the organoclay-amended ISGS solution was considered, but Beazer elected to go ahead with a field test in hopes of getting better Site-specific information in a timely manner.

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[1] In the bench test report, the “Provect-GS” material is equivalent to the ISGS injection solution but with a different brand name.

Based on past laboratory and field testing, the ISGS solution alone is expected to be very effective at immobilizing creosote NAPL and sequestering constituents at the Site. Nonetheless, a solution that incorporates the organoclay amendment may prove to be even more effective because of the material's capacity to preferentially absorb organic hydrocarbons. The test will include over 1,600 lb of organoclay amendment (**Table 1**) which has the potential to absorb a significant volume of creosote DNAPL.

Though there may be factors that complicate interpretation of data, one way to ascertain the effectiveness of organoclay-amended ISGS vs. ISGS without organoclay is to compare the percent reduction in DNAPL recovery rates at TIPs and NAPL recovery wells inside and outside the organoclay test area. The organoclay test area of **Figure 1** includes a TIP (300N/180E) and an upper Hawthorn Group recovery well (HG-40SE) that have consistently had recoverable DNAPL prior to the beginning of the ISGS program (2.5 to 5 gallons recovered per point per biweekly event). Another TIP (320N/140E) adjacent to the test area has had lower amounts of DNAPL recovery (less than 1 gallon per event).

Beazer plans to begin injections with the organoclay-amended ISGS solution sometime between September 16 and September 21, 2015 and complete the injections over five days.

If you have any questions regarding the ISGS amendment planned, please contact us. We will be glad to discuss this potential remediation improvement with you and with others in the coming days.

Sincerely,

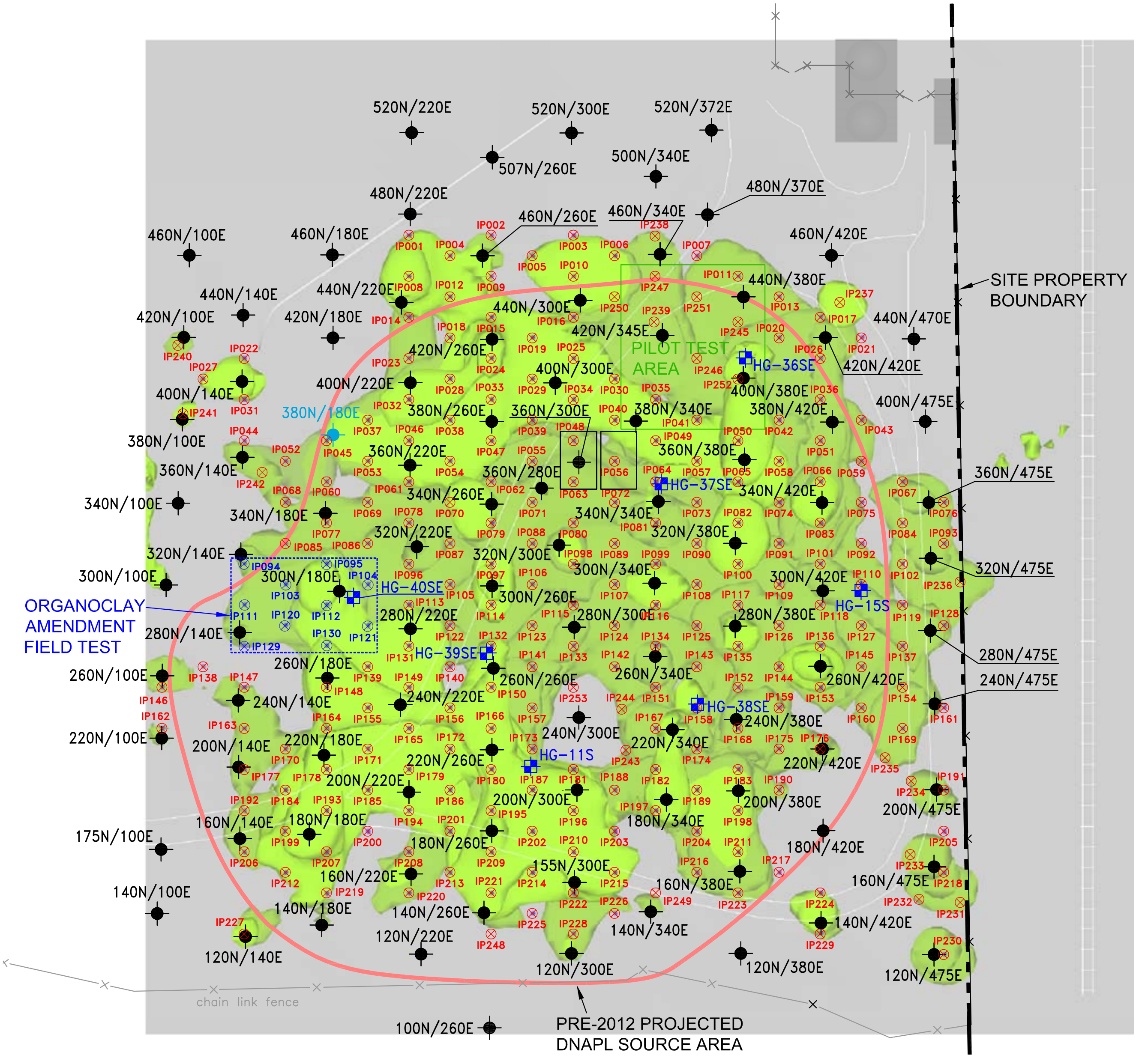
Miguel Garcia

Gregory W. Council
Principal Engineer

Miguel A. Garcia, PG
Senior Hydrogeologist

Table 1. Injection Points for Organoclay Amendment Test

Injection Point	ISGS Solution Volume (gal)	Organoclay Mass (lb)
IP094	527	117
IP095	1443	319
IP103	552	122
IP104	833	184
IP111	305	67
IP112	1638	362
IP120	444	98
IP121	611	135
IP129	305	67
IP130	750	166
Total	**7408**	**1638**



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SCALE IN FEET

EXPLANATION

IP094 ⊗	ORGANOCLAY-AMENDED INJECTION POINT
IP001 ⊗	FULL-SCALE ISGS INJECTION-POINT
380N/180E	TIP FOR FULL-SCALE ISGS INJECTION
100N/260E	TEMPORARY INJECTION POINT (TIP)
HG-11S	UPPER HAWTHORN DNAPL RECOVERY WELL

TITLE:
ORGANOCLAY-AMENDED ISGS INJECTION POINTS

LOCATION: Cabot Carbon/Koppers Superfund Site
Gainesville, Florida

TETRA TECH

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Attachment 1.
Organoclay Product Information

ORGANOCLAY® P

ORGANIC ADSORPTION MEDIA (POWDER GRADE)

Product Description:

Organoclay® P is a proprietary powder adsorption media effective in removing oils, greases other non-aqueous phase liquids (NAPL) and other dissolved high molecular weight/low solubility organic contaminants.

Characteristics:

- Hydrophobic; will not absorb water or swell when wetted
- Non-toxic to marine and benthic organisms
- High adsorption capacity of oils, greases and other NAPL
- Demonstrates noncompetitive sorption—can sorb multiple contaminants

Properties:

Property	Value	Test Method
Particle Size	70% Min. passing 200 mesh sieve	CETCO Test Method
Bulk Density	50-54 lbs/ft^3	CETCO Test Method
Oil Adsorption Capacity	0.5 lb/lb Min.	CETCO Test Method
Quaternary Amine Content	25% Min.	CETCO Test Method

Typical Uses:

- When agglomerated onto aggregate carrier particles, Organoclay P provides subaqueous isolation of NAPL and related chemicals in contaminated sediments.

- Solidification/Stabilization additive: improves hydraulic and leachability performance of pozzolanic mixes by adsorbing NAPL and dissolved low solubility organics.

Packaging:

50 lb bag; bulk sacks (1,500; 1,764; or 2,000 lbs)

Rev. 01/12

Attachment 2.
Information on Organoclay Applications and Benefits

NAPL SORPTION CAPACITY AND PERMEABILITY OF ORGANOCLAY/ SAND MIXTURE

This study was conducted by the University of Texas at Austin Department of Civil, Architectural and Environmental Engineering for the Oregon State Department of Environmental Quality. A series of experiments were conducted to assess the sorption capacity and permeability of organoclay when exposed to four different nonaqueous phase liquids (NAPLs) from the McCormick & Baxter Creosote Site. The capacity of the organoclay was independent of the type of NAPL. The sorption capacity of CETCO PM-200 organoclay as measured by batch testing was > 4.4 grams NAPL/gram organoclay. The sorption capacity of CETCO PM-200 organoclay as measured by column testing was >1.35 gram NAPL/ gram organoclay. The difference is likely attributed to partial saturation of the upper portion of organoclay in the column flow.

No significant swelling is expected with dilute aqueous emulsions of NAPL (e.g., <1% NAPL in water). Swelling of the organoclay and reduction of permeability did occur with concentrated NAPL. Swelling was reduced and permeability was less affected when sand was mixed with CETCO PM-200 organoclay in ratios of 3:1 to 10:1 (by weight), although sorption capacity was reduced.

The results indicate that optimal design of in-situ reactive caps and permeable reactive barriers need to take into account overall sorption capacity and effective permeability.

BACKGROUND

Strongly solids-associated contaminants such as metals, PCBs and PAHs can often be effectively managed with a combination of the conventional technologies of dredging or capping. Many of the most challenging sites awaiting effective remediation, however, are contaminated with separate phase contamination (nonaqueous phase liquids or NAPLs). Organoclays have a high capacity for sorption of nonaqueous phase liquids (NAPL) and have been employed in a variety of applications for the control of these contaminants. A developing application is the use of organoclay as a subaqueous cap to contain NAPL contaminants in sediments. At the McCormick and Baxter Creosote contaminated site in Portland OR, a 12" thick layer of organoclay was employed to contain NAPL migration front the site. Organoclay was also employed in CETCO reactive mats to control NAPL mobilized by gas seeps in particular areas at and near the river bank. The Oregon Department of Environmental Quality contracted with the University of Texas to evaluate the performance of the organoclay placement.

Initial studies with the bulk placement approach identified the potential for high NAPL sorption capacity of the placed organoclay but also identified problems with swelling and subsequent significant reductions in permeability of the organoclay (Reible, 2005). The permeability reductions suggested that full utilization of a pure bulk organoclay treatment bed might not occur due to flow diversion around the low permeability zones. Reible (2005) evaluated several possible approaches to overcoming this problem at future sites including placement of a bulk sand/organoclay mixture which would effectively disperse the organoclay for more efficient utilization.

These initial studies evaluated a limited range or organoclay and sand mixtures. In an effort to provide better guidance to subaqueous cap designers, the current study was undertaken. The objective of the current study was to determine the NAPL sorption capacity and permeability of a particular organoclay, CETCO PM-200, in a variety of sand/organoclay mixtures. Specific sand/organoclay mixtures evaluated included 3:1, 5:1 and 10:1. NAPL employed for the testing was collected from the McCormick and Baxter site. NAPL both less dense than water (LNAPL) and more dense than water (DNAPL) from both the tank farm area (TFA) and a former waste disposal area (FWDA) were used in the tests. Physical properties of the NAPLs are shown in Table 1:

Table 1. Physical properties of NAPLs

NAPLs	FWDA (LNAPL)	FWDA (DNAPL)	TFA (LNAPL)	TFA (DNAPL)
Density (g/cm^3)	0.9867	1.0028	0.9721	1.0919
Viscosity (cp	22.8	16.8	17.0	26.8
Water content (%)	11.9 (11.9-12)	32.8 (32.2-33.5)	45.7 (43.3-48.1)	5.3(4.3-6.3)

TR-821

Methods

The sorption capacity of the CETCO PM-200 organoclay with respect to the different NAPLs was measured in both batch tests and column flow through tests. In batch tests, approximately 2g organoclay were first saturated with water. After removing the extra water, an excess volume of NAPL was added to the water saturated organoclay and allowed to equilibrate. The free liquid phase including NAPL and water was removed by glass pipette, and the remaining organoclay and NAPL was dried at low temperature (~50 °C). Sorption capacity of NAPL was determined as the ratio of the weight of NAPL sorbed to the weight of organoclay.

In the column tests, NAPL was injected into a column (4.8*15cm) filled with an organoclay/sand mixture with a syringe pump. The organoclay was mixed with sand at different ratios (sand:organoclay of 3:1, 5:1 and 10:1). Two NAPLs from McCormick & Baxter Creosoting Company site, FWDA-LNAPL and TFA-LNAPL were pumped through the sand and PM-200 mixture at a superficial velocity of 1 cm/day. The effective sorption capacity was estimated by mass of NAPL injected at breakthrough. The conductivity of the NAPL saturated column was estimated from the pressure difference across the column required to maintain the superficial velocity of 1 cm/day. The conductivity was converted to an effective permeability with the viscosity and density of the injected NAPL.

Results

A) Batch test - Sorption Capacity

Extensive swelling and apparent loss of particle integrity was observed during batch sorption tests but these tests are designed to evaluate the maximum potential sorption capacity, not necessarily the sorption capacity. Organoclay and NAPL were not easily separated after two days sorption, the clay and the swollen aggregate could be broken during shaking. The free liquid was more viscous than the original NAPL, which was likely due to the presence of very fine organoclay particles of clay in the liquid phase. A summary of the sorption capacities of PM-200 measured in batch studies with each of the NAPLs and the calculated material balance closure is listed in Table 2. Material balance differences from 100% indicate potential error in the measured sorption capacity due to failure to completely separate phases. The results indicate oh at the potential capacity of the PM-200 again clay, however, is well in excess of 4 g NAPL/gr organoclay.

TABLE 2: Sorption capacity of PM-200 (g water free oil /g of organoclay) with respect to NAPLs in batch test

	SORPTION CAPACITY g/g (std dev)	NAPL BALANCE %	WATER BALANCE %
FWDA-LNAPL	4.60 (0.04)	97 (2)	120 (6)
FWDA-DNAPL	4.82 (0.06)	82 (1)	126 (4)
TFA-LNAPL	4.41 (0.03)	75 (3)	124 (3)
TFA-DNAPL	4.50(0.11)	84(4)	115(5)

B) Column test - Sorption Capacity

As shown in Table 3, the sorption capacity of PM-200 in the flow-through experiments was less than observed in batch tests due to flow non-uniformity and loss of organoclay utilization efficiency. However, swelling and loss of particle integrity were similarly reduced. At higher sand/organoclay mixtures organoclay utilization was higher due to better control over flow maldistribution. Sand/organoclay ratio of (10:1) allowed sorption of NAPL at close to batch sorption experiments (i.e. NAPL sorbed per gram of organoclay) (Table 2). Sorption capacity of the mixture with respect to FWDA-LNAPL was typically lower than the measurement with the TFA-DNAPL although batch tests did not show significant difference. The higher moisture content of the FWDA-LNAPL may have affected organoclay utilization.

Table 3. Sorption capacity of PM200 and sand mixture at slow continuous injections

	FWDA-LNAPL	TFA-DNAPL

Sand to clay ratio	10:1	5:1	3:1	10:1	5:1	3:1
Sorption capacity(g/g)	0.27 (2.97 g/gOC)	0.31 (1.86 g/gOC)	0.34 (1.35 g/gOC)	0.30 (3.30 g/gOC)	0.38 (2.28 g/gOC)	0.44 (1.76 g/gOC)
Effective sorption capacity (g/g)	0.24 (2.64 g/gOC)	0.29 (1.74 g/gOC)	0.34 (1.35 g/gOC)	0.30 (3.30 g/gOC)	0.35 (2.1 g/gOC)	0.43 (1.72 g/gOC)

Effective permeability

The sorption of NAPL by the organoclay will reduce the effective permeability of the media for two reasons. The partial saturation of the organoclays with NAPL decreases the relative permeability of the NAPL (i.e. the presence of residual water will limit the pore space available to the NAPL and resist its flow through the media). In addition, the media swells during the NAPL sorption process, filling some of the available pore space and further resisting flow of the NAPL. The time required for swelling to be complete (24-48 hours after coming in contact with NAPL) also meant that the permeability of organoclays with respect to NAPL was dependent upon time of exposure to NAPL and thus indirectly the injection flow rate. As a result, the injection of NAPL and allowance of time for NAPL sorption related swelling would give rise to dramatically decreased effective permeability.

The effective permeability of pure PM-200 with water injection was measured to be approximately 11 darcys and 2.5 darcys at 10:1 sand/organoclay ratio (1 darcy = 10^{-3} cm = 10^{-8} cm^2). The permeability of a pure PM-200 layer after saturation with NAPL was not measured because the experimental apparatus was designed to measure higher than the observed permeability. The permeability of the NAPL saturated pure PM-200 was below the measurable limit of the system at approximately 5 (10^{-4}) darcys, the approximate permeability of a fine silt. The permeability of a mixture of sand and PM-200 was much higher than this permeability due to the greater dispersion of the organoclay. The effective permeabilities of the sand and organoclay mixtures (10:1, 5:1 and 3:1) after NAPL saturation are listed in Table 4.

The variability between measurements, based upon a limited set of experiments with the FWDA-LNAPL, is approximately 10^{-2} darcys. Due to the particle size and density difference of the dilutent sand and organoclay, homogeneous packing is difficult and gives rise to the sample to sample variability. Thus the apparent slight decrease in effective permeability of the 5:1 versus 3:1 mixtures of sand and organoclay is not significant. If a large number of replicates were conducted it would be expected that the effective permeability of the 5:1 mixture would be between that of the 3:1 and 10:1 mixtures. The permeability changes in all 3 mixtures are relatively modest (factor of two to three from highest organoclay mixture to lowest). The permeability of all of these mixtures is in the range of a silty sand.

Table 4. Effective permeability of PM-200 and sand mixture at slow continuous injections

	FWDA-LNAPL			TFA-DNAPL		
Sand to clay ratio	10:1	5:1	3:1	10:1	5:1	3:1
Permeability (darcy)	$5.88*10^{-2}$	$2.16*10^{-2}$	$3.12*10^{-2}$	$2.24*10^{-2}$	$0.57*10^{-2}$	$0.67*10^{-2}$

The mixture of 10:1 exhibited highest permeability and highest organoclay utilization efficiency. Due to the comparatively small amount of organoclay in the 10:1 layer, however, the total NAPL sorption for a given layer thickness will be less than the other two mixtures. Utilization efficiency and total capacity must be balanced in any sand/organoclay mixture design. Permeability seems to be less of an issue for sand/organoclay mixtures of greater than 3:1 because of all such mixtures are relatively permeable.

Summary

Pure PM-200 organoclay has high sorption capacity but also shows significant swelling and subsequent permeability reduction after contact with NAPL. The sorption capacity of PM-200 during flow-through experiments was found to be less than in batch experiments due to flow maldistribution and the time-dependent nature of the swelling and permeability reduction. Mixtures with sand and PM-200 limited the impact of NAPL associated permeability changes and increased the effective capacity (g NAPL per g organoclay) and therefore provided a lower cost per unit NAPL absorbed. This suggests that an optimal organoclay design would be a mixture of PM-200 with sand, balancing overall layer thickness capacity with effective permeability of the layer and efficient utilization of organoclay.

References

Reible, D.D. (2005) Final Report Organoclay Laboratory Study - McCormick & Baxter, Oregon Department of Environmental Quality Project 005-05

TEST REPORT #13

AquaBlok+ORGANOCLAY™

PROVEN REMEDIATION PERFORMANCE OF ORGANOCLAY DELIVERED IN AN AQUATIC SETTING

Background

AquaBlok® is a patented, composite-aggregate technology resembling small stones and typically comprised of a dense aggregate core. In this application of the technology an organoclay coating is utilized with polymers (Figure 1). In other AquaBlok+ applications various alternative treatment materials can be incorporated to meet project-specific needs.

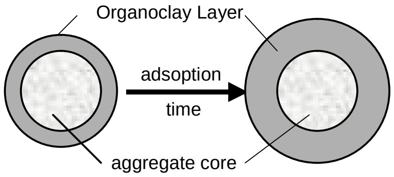


Figure 1. Configuration of an Organoclay Coated Particle.

AquaBlok+ORGANOCLAY particles adsorb oil and a wide range of hydrocarbon-based contaminants when contact is made in sediments. As the particles chemically bind the contaminants, the clay layer will expand. At a point when the full mass of the organoclay is achieved the particles coalesce into a continuous and relatively soft body of material, decreasing the permeability of the layer. The AquaBlok+ORGANOCLAY layer can also be used in conjunction with a standard AquaBlok cap layer to form an even lower permeability barrier layer above the sediment, if desired.

Organoclays are organically modified clays, typically produced by blending surfactants and clay minerals. This blend creates a new product, a surfactant with a solid base. By means of a partition process, the modified clays will fix non-polar organic compounds. In contrast to activated carbon, by which organic compounds are adsorbed into pores in the carbon and quickly become fouled, the partitioning phenomena takes place outside of the clay particles, minimizing the fouling problem.

Applications of AquaBlok+ ORGANOCLAY Technology

Organoclays are a proven remediation technology that addresses a wide range of hydrocarbon-based contamination. The following is a partial list of typical sites and/or contaminants where AquaBlok+ ORGANOCLAY cap can be a cost-effective solution:

- ***MGP Plants,***
- ***Wood Treating Facilities,***
- ***Creosote,***
- ***Coal Tar (BTEX),***
- ***PCBs,***
- ***PAHs / NAPL***

Although it has been established that similar weight of organoclay materials will remove, by means of partitioning, up to 7 times the rate of activated carbon, activated carbon can provide further absorption of trace amounts that may not be fully removed by organoclay. Thus, the materials can be used in series in a complimentary manner in some applications requiring very low levels of treatment.

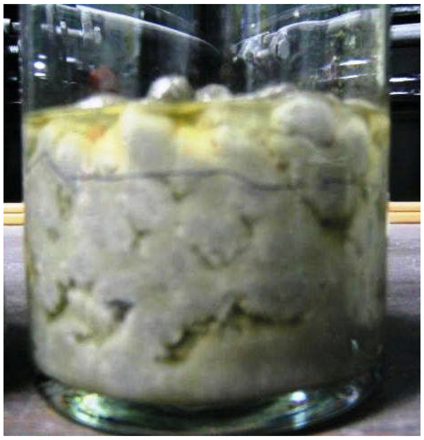


Photo 1. Example Design Mix – 300g of AquaBlok+ORGANOCLAY 4060 Blend Sample (120g of Active Organoclay), 3wks After Addition of 185ml Motor Oil.

Generally, AquaBlok+ ORGANOCLAY is expected to adsorb between 50-100% of the total weight of the organoclay present in the particle. This percentage of organoclay can vary from 20-40% depending on the desired cap / treatment design and contaminant material and concentration.

Additionally, by varying aggregate particle size, control over various properties of the cap can be obtained, thus creating a more versatile cap that can be easily engineered for project specific applications.

Use of AquaBlok+ORGANOCLAY

For many projects, use of the product will generally involve applying dry masses of the material through the water and across the surface of contaminated sediments or directly onto pools of free product. The material can also be placed below other more permeable capping materials such as sand or directly on soil/sediments in the dry if an area has been dewatered.

The use of organoclay in an AquaBlok matrix provides for an efficient delivery and placement option for materials that may otherwise be subjected to erosion by stream flow, wave action, or tidal fluctuations.

A variety of application methods have been implemented for similar materials, such as: barges, clamshells, stone slingers, conveyors, and many more. The ease of placement and ability to place AquaBlok+ ORGANOCLAY through a water column creates a practical method for addressing sediments contaminated by oils, PCBs or other difficult hydrocarbon based COCs.

Funnel & Gate Approach

An AquaBlok+ORGANOCLAY cap can be configured as a "gate" with a "funnel and gate" system to selectively capture discharges from submerged seeps of upland plume related discharges. Should breakthrough eventually occur, the gate material can be effectively removed and the gate replaced with fresh material. By capturing the product at the seep source, relatively modest volumes of material need to be handled as opposed to using oil sorbent booms and pads, etc. to capture and cleanup seeps that discharge through the water and rise to the surface.

AquaBlok+ORGANOCLAY Compatible Product Manufacturers

AquaBlok+ORGANOCLAY has been produced and tested with organoclay product available from the following manufacturers:

- ***Aqua Technologies of Wyoming, Inc.***
- ***Biomin, Inc.***
- ***CETCO (Div. of Amcol, Intl.)***
- ***Polymer Ventures, Inc.***

In addition, AquaBlok+ORGANOCLAY material can be manufactured with other amendments, such as Adventus Group's ZVI or EHC products (see www.adventusgroup.com), to be used to deliver a treatment "train" approach for complex sediments with multiple contaminants.

Bench-Scale Testing & Application and Modeling

While organoclays were originally developed as a water treatment medium, they have more recently received consideration for sediment remediation applications, and when delivered to the sediment water interface as an AquaBlok+™ amendment, the range of applications increases. In addition, when used in the manufacture of AquaBlok+ ORGANOCLAY, cost efficiencies can be realized as a result of the more effective placement option.

Although other variations exist, the typical applications of AquaBlok+ ORGANOCLAYs would be one of the following:

- A composite cap with AquaBlok+ORGANOCLAY overlain by sand or other non-reactive material can be an effective remedy where contaminated sediments were transplanted to a deposition area that is not related to a continuous upland source.
- A composite cap with AquaBlok+ORGANOCLAY used to consolidate semi-suspended sediments (especially those with petrochemical components) prior to the application of a low permeability standard AquaBlok® cap layer.
- As a treatment gate material in a “funnel and gate” configuration with standard AquaBlok or other low permeable capping material to direct flow through the AquaBlok+ ORGANOCLAY treatment media, either through gate columns set at specific intervals, or laterally under a complete cap for capture along the entire cap length, essentially creating a long, thin horizontal column with significant residence times.

There are multiple manufacturers of organically modified clays and the individual products demonstrate different performance attributes as the chemicals of concern, levels of contamination, and salinity of the application area vary. In addition, different organoclays demonstrate varying swell factors, which are an important design consideration. AquaBlok+ORGANOCLAY has been successfully manufactured using a variety of organoclays from multiple vendors. ***Table 1 & 2*** demonstrates the relative efficiency of one such product (manufactured by Biomin, Inc.) at removing a surrogate vegetable oil in a series of three small column tests designed to demonstrate the effect of varying particle size (and resulting pore size and volume) and residence time, (which is a function of flow-through rates and column length). ***Figure 2*** graphically demonstrates this relationship between particle size (a 1/4” particle size vs. 3/8” particle size) and, in the case of the duplicate 3/8” particles, runs at different flow-through rates and how these variables affect the removal efficiency and the ultimate time (and pore volumes) for significant contaminant breakthrough.

The use of specifically designed bench scale tests can be very effective at selecting specific organoclays for particular applications (see Reible et al, University of Texas at Austin, *Organoclay Laboratory Study – McCormick & Baxter*, September 2005) and the selection of the appropriate AquaBlok+ particle size and layer thickness. Similarly, simple bench scale testing can also determine the appropriate application rates of specific AquaBlok+ORGANOCLAY applications for use as a flocculant to consolidate free-product layers and semi-suspended sediments to facilitate more efficient removal by dredging or excavation, or to create a stable base prior to the installation of a clean cap to meet restoration goals.

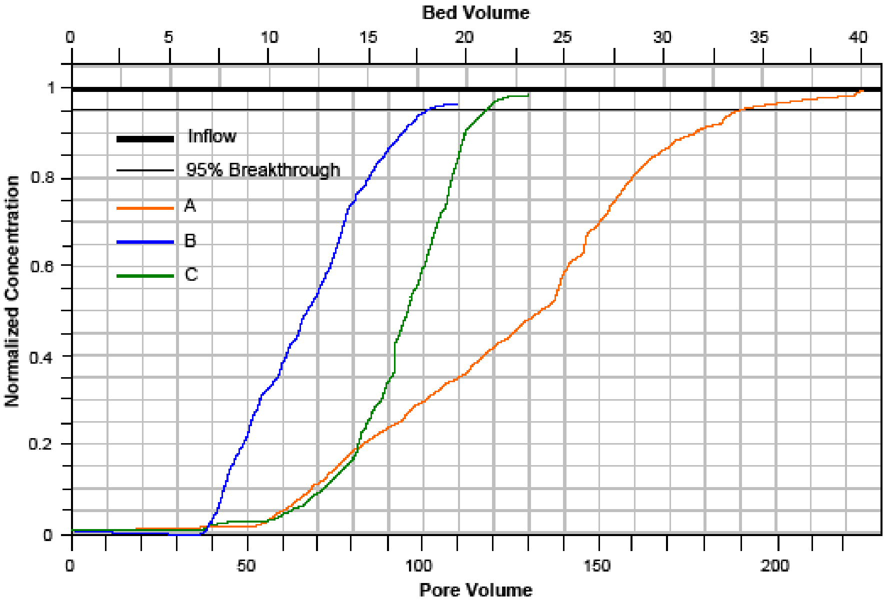
The results of bench scale testing can be used in conjunction with flow models to design composite systems that meet long-term risk assessment goals and subsequent targeted remediation goals, while minimizing overall project costs.

Table 1 (*)

Sorbent	Mass Sorbent		Porosity	Flowrate		Residence
	(kg)	(lb)		(mL/min)	(gal/hr)	(min)
A	0.16	0.34	0.19	2.4	0.038	30
B	0.155	0.341	0.21	7.0	0.114	10
C	0.157	0.345	0.20	3.8	0.061	21

Table 2 (*)

Sorbent	Breakthrough			Mass Sorbent		Mass Sorbed/Mass Sorbent		
	PV	BV	min	(kg)	(lb)	(mg/kg)	(lb/lb)	(% by sorbent)
A	207.7	39.5	6471	35687	0.079	223043	0.223	22.3
B	101.9	20.4	4256	15702	0.035	98139	0.098	9.8
C	117	23.6	9526	24518	0.054	156163	0.156	15.6



A - AquaBlok+ORGANOCLAY (30/70 Blend), 1/4" size, 30 min. residence and 3,810 mg/L Vegetable Oil.
B - AquaBlok+ORGANOCLAY (30/70 Blend), 3/8" size, 10 min. residence and ~3,400 mg/L Vegetable Oil.
C - AquaBlok+ORGANOCLAY (30/70 Blend), 3/8" size, 21 min. residence and ~3,400 mg/L Vegetable Oil.

Figure 2. Example Design Mix Variables (*)

(*) Independent testing completed by Vinka Cramer, Ph.D. and James Smith, Ph.D. for Biomin, Inc. on sample AquaBlok+ORGANOCLAY material, manufactured by AquaBlok, Ltd. using a Biomin, Inc. supplied Organoclay.

For more information, Contact AquaBlok, Ltd. at:

Phone: (800) 688-2649
Email: services@aquablokinfo.com visit us at our
Web: www.aquablokinfo.com

Last Revised: January 2, 2008

AquaBlok® Installation Profile

Site Location: *US EPA Region 2*

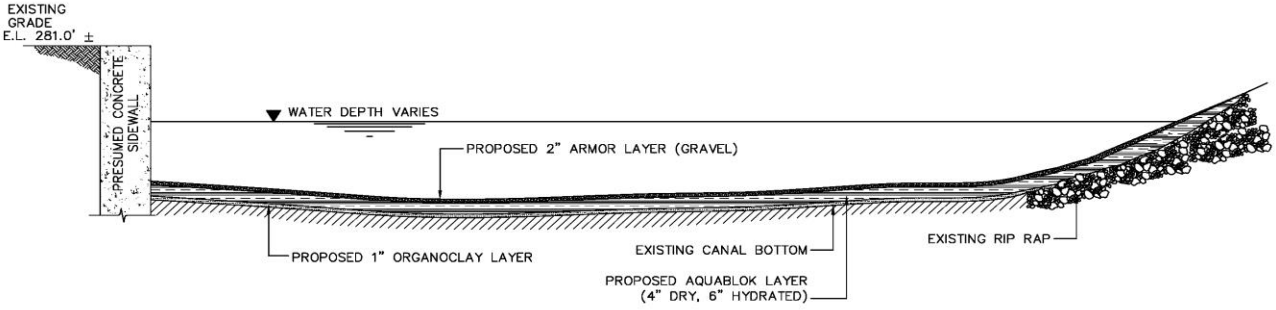
Glens Falls, New York (Hudson River)

Project Status: Completed February 2008

Completed Cap with Armor and rip rap on slope

Setting / Purpose: Canal/River (freshwater). MGP Site – Treatment barrier and low permeability barrier/cap over contaminated sediments. Site area was approximately 4,000 square feet.

AquaBlok Cap Design / Site Area: Multi-layer design comprised of a one inch basal layer AquaBlok+ORGANOCLAY covered with a hydrated layer (~6 inches in target thickness) of AquaBlok 3070FW. The cap was then armored with a two inch layer of AASHTO #2 stone.



PROPOSED SECTION A–A

SCALE 1/4"=1'–0"

AquaBlok® Installation Profile

Contaminant(s) of Concern: Coal Tar associated with historic MGP site, including PAH (polynuclear aromatic hydrocarbons) and DNAPL (Dense Non-Aqueous Phase Liquids).

Placement of AquaBlok+ORGANOCLAY product through the water for treatment/adsorption of petroleum-based hydrocarbon contaminants

Placement of stone armor over AquaBlok low permeability capping material

Method of AquaBlok Placement: Shore-based excavator

AquaBlok® Installation Profile

Site Location: *US EPA Region 6*

Arkansas River – Tulsa, OK

Project Status: Completed Fall of 2012

Setting / Purpose: Freshwater river bank and sediments. Intermittent sheening (depending upon river level) has been observed at many locations along the river bank. Objective is to provide both adsorptive treatment materials in combination with a low-permeability cap to limit the migration of residual contaminants within the shoreline to the river. River bank stabilization was also accomplished with the design.

Contaminant(s) of Concern: DNAPL - PAHs (polynuclear aromatic hydrocarbons) from active refinery site.

AquaBlok Cap Design / Site Area: The site area comprised a number of different shoreline conditions and combinations of material. Both AquaBlok (low-permeability materials) and AquaGate (permeable treatment materials) were incorporated into the design. Below is a summary description of some of the areas addressed together with photos of placement of materials.

<u>Area A</u> This segment consisted of approximately 1,200 feet of river bank with a steep slope (nearly 1 H :1 V) and a vertical drop from the crest of the slope to the river bank of approximately 30 feet. The river bank is heavily vegetated (estimated 30+ year old trees) and covered with demolition debris consisting of concrete, bricks, pipes, etc. In and amongst the demolition debris acid sludge has been observed in addition to river bank sheening. It was determined that Area A would receive a Horizontal Funnel & Gate capping system that consists of a permeable treatment system. No sub-base preparation would be performed, other than the removal of any woody debris, plants etc. from the shoreline capping area. Following this preparation, the AquaGate+Organoclay permeable treatment material would be placed along the base of the demo debris out into the river approximately 20 feet at an application rate of approximately 7 lb/SF directly over the existing sediment surface at a thickness of approximately 1 inches (+/- 0.5 inch). After placement of the permeable treatment layer, the low-permeability AquaBlok layer would be placed directly over the AquaGate+Organoclay with the material working back up the shoreline slope. Placement of the AquaBlok continued beyond the organoclay layer up over the existing demo debris. The application rate is estimated to be approximately 40 lb/SF to achieve a nominal 5 inch dry thickness (+/- 1.0 inch), which will swell when hydrated to achieve a final layer thickness greater than 6 inches.

Above – Demo Debris Area - Before

Above – Demo Debris Area - After

Area B LNAPL: Approximately 400 feet downstream (west) of the river bank improvement project (just described) consists of a tiered slope that contains an intermediate access road. The access road is approximately 11 feet above the water level and slopes down at approximately 1.5 H : 1V to the river. In this area sheening has been observed from the river bank and also from the river bottom sand further away from the river bank (approximately 10-40 feet beyond the toe of the river bank slope). This sheening and petroleum (rainbow) staining may be indication that an LNAPL plume has reached the riverbank.

Above – Placement of AquaGate+Organoclay

Left – Close-up of Telebelt Material Placement

Below – View of Telebelt During Armor Stone Placement

It was determined that Area B would receive a Horizontal Funnel & Gate capping system of essentially the same construction as Area A above. No sub-base preparation would be performed. AquaGate+Organoclay permeable treatment material was placed along the base of the rip rap zone out into the river approximately 50 feet at an application rate of approximately 7 lb/SF directly over the existing sediment surface at a thickness of approximately 1 inches (+/- 0.5 inch). After placement of the AquaGate, a low-permeability AquaBlok layer was placed directly over the AquaGate with the material working back up the shoreline slope. The application rate is estimated to be approximately 40 lb/SF to achieve a nominal 5 inch dry thickness (+/- 1.0 inch), which will swell when hydrated to achieve a final layer thickness greater than 6 inches.

AquaBlok® Installation Profile

Area C Rip Rap & LNAPL: Approximately 4-5 years ago a remediation project was completed in this area that included a river bank improvement (installation of clay, geotextile, and nominal 12-18 inch rip rap) along approximately 1,300 lineal feet of river bank. It has been determined that this approach failed as the result of observed sheening along a portion of the river bank. Sheening was observed at the toe of the slope and also emanating from the river bed sand approximately 10-20 feet beyond the toe of the slope. Some sheening was observed on the slope amongst the rip rap. This area is open and easily accessible, so it was determined that two approaches would be employed at this location. First, a layer of rip rap was removed and a layer of low permeability AquaBlok was placed along the slope of the shoreline as a means to cut-off seepage through the GCL and existing rip rap. Secondly, an attempt was made to place AquaBlok directly over and between the openings in the rip rap to determine if it would be possible to provide a low permeability barrier to prevent seepage without removal of the rip rap.

Photo 1 – Prior Removal of Rip Rap

Left – Placement of AquaBlok Over Rip Rap
Below - Using Blower to Distribute AquaBlok

Current Status: Since the completion of installation of each of the above river segments, no visible sheen has been reported by the facility. Efforts are underway to perform further monitoring of the capping zones, but the areas addressed are considered to be successful in accomplishing the objectives outlined by the engineer and site owner.

AquaBlok® Installation Profile

Site Location: *US EPA Region 5*

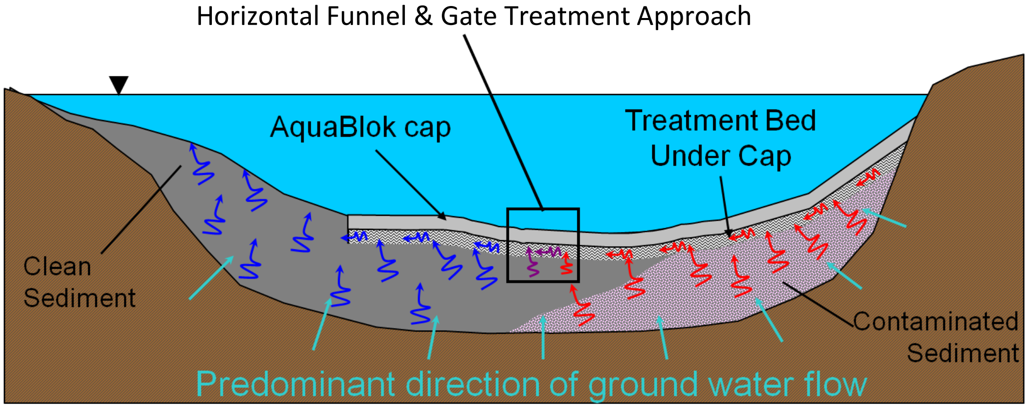
Oil Spill Impacted Pond Site, Hagerstown, Indiana **Project Status:** Completed August 2010

Setting / Purpose: Freshwater Pond – Provide treatment layer and low permeability barrier to address potential for residual oil seepage into pond.

Overview of AquaGate+ORGANOCLAY being applied to pond basin

Contaminant(s) of Concern: Pond was impacted by residual petroleum-based contaminants that resulted from a nearby pipeline failure. Subsurface contaminants being driven by groundwater were discharging into the pond and causing visual sheen. The remedy was the result of a settlement between the pond owner and the responsible oil company. Site area was approximately 50,000 square feet.

Treatment Material and Cap Configuration:



AquaBlok® Installation Profile

Hagerstown, Indiana (con’t)

Site Related Issues and Material Handling: Material was packaged in approximately 2,500 LB bulk bags (super sacks) and stored on-site under cover until a weather window allowed installation. The material was transferred from the bulk bags directly to the bucket of a loader that placed the product into the Stone Slinger for application.

On-site Storage of AquaBlok Material and Transfer into Loader Bucket

View of Rapid Loading the Stone Slinger

The actual installation time, including mobilization and all quality control aspects was approximately one week in duration.

Method of AquaBlok Placement: Shore-based Stone Slinger.

Contractor: Envirocon, Inc.

SAO
ENVIRONMENTAL
CONSULTING AB

REPORT

Project no:	AQB359
Written by:	Joe Jersak
Date:	September 2, 2015
To:	John Collins, AquaBlok, Ltd.
Copy:	John Hull, AquaBlok, Ltd.
Status:	**FINAL**

Title: Sorption of Separate- and Dissolved-Phase Organic Contaminants by Different EBGCR AquaGate+Organoclay Coating Materials

Background & Summary

AquaBlok, Ltd. (AquaBlok) recently supplied AquaGate+Organoclay™ product (AquaGate) for use in capping contaminated sediments for the East Branch Grand Calumet River (EBGCR) project. CETCO's Organoclay® P (a powder version of their PM-199 granular product), was used as the coating material in manufacture of the AquaGate.

SAO Environmental Consulting was engaged by AquaBlok to develop and supervise the testing program described herein, as well as provide an evaluation of the results.

In connection with manufacturing of AquaGate for the EBGCR project, AquaBlok performed quality control measures intended to evaluate and confirm the organoclay coating content on the as-manufactured product. Following placement of the product in the river, AquaBlok also performed evaluation of coating content of the AquaGate from samples recovered for quality control purposes. This data, which verifies the quantity of organoclay supplied and placed in the river, was provided to the project participants.

The purpose of the additional laboratory-based study described herein is to go beyond measurement of the quantity or weight of recovered coating and evaluate the potential extent, if any, that the manufacturing process (incorporating CETCO's organoclay powder material into AquaGate) or the act of placing AquaGate in the river may have on the organoclay sorption capability - for either separate-phase contamination (oil) and/or dissolved-phase contaminants (selected PAH compounds, including naphthalene; phenanthrene; pyrene and benzo(a) pyrene).

Three different organoclay materials were evaluated from EBGCR Samples:

1. *Powder organoclay as-received from CETCO;*
2. *Organoclay coating from as-manufactured AquaGate;*
3. *Organoclay coating material recovered and removed from AquaGate placed in the river.*

To measure oil sorption (pure phase), laboratory tests were designed and conducted by CETCO, and to measure sorption of dissolved-phase PAH compounds (determine K_d *values) were designed and performed by Prof. Danny Reible's laboratory at Texas Tech University (TTU).*

Summary of results from CETCO's oil-sorption testing:

- *Oil-sorption values for all three EBGCR organoclay materials are well above the minimum value of 50% (by dry weight), which is CETCO's value for their PM-199 granular organoclay product and was the stated design objective for the EBGCR project.*
- *Mean oil-sorption capacity for as-received powder material was ~70% (by dry wt.), whereas values for as-manufactured and as-placed coating materials were ~90% of this value (i.e. ~64 and ~62%, respectively).*
- *The difference between mean values for the two coating materials did not appear to be statistically significant. However, small yet significant differences were apparent when comparing mean values for coating materials with that for as-received powder material.*
- *If statistical interpretations of testing results are genuine, the slightly lower sorption capacities displayed by both coating materials may be a temporary phenomenon, observed only during short-term laboratory testing. Coating materials likely (and uniquely) contain "microaggregates" of organoclay + polymer, which may initially limit oil sorption onto some organoclay particle surfaces. Over time after AquaGate placement, the polymer should degrade and expose previously occluded organoclay particles for additional oil sorption.*
- *Mean values for oil sorption presented herein for the EBGCR coating materials are at least 10% higher than values previously determined by CETCO for organoclay coating material from earlier AquaGate+Organoclay™ samples. This difference is likely an artifact of differences in methods used by CETCO and AquaBlok for sample preparation and processing.*

Summary of results from TTU's sorption testing of selected dissolved-phase PAH compounds, including comparisons with previous testing results:

- *Results from sorption testing suggest all samples meet or exceed specified partition coefficient (*K_d*) values for light weight PAHs, e.g. phenanthrene (at least 50,000 L/Kg) and mid to heavy weight PAHs, e.g. pyrene (at least 350,000 L/Kg). Project specifications do not clarify the nature of these minimum values, e.g. means from replicate sample testing. Regardless, although the mean* K_d *value measured herein for pyrene on the as-received organoclay sample (~323,000 L/Kg) was slightly below the above target, the difference between this mean value and mean values measured for the two coating samples – both of which exceed the target - was not considered statistically significant. Therefore, it was concluded all three samples effectively met the project specification.*
- *The test report concluded there were no substantial differences in mean* K_d *values between the three EBGCR organoclay materials for each dissolved-phase PAH compound. For this work, "substantial differences" would be considered differences in* K_d *values of greater than a factor of 2.*

- *Due to recognized but unavoidable analytical challenges,* K_d *values derived for pyrene (PYR) and phenanthrene (PHE) are considered more precise than those derived for naphthalene (NAP) and benzo(a)pyrene (BaP).*
- *There were not only no substantial differences in PAH-specific* K_d *values amongst the three EBGCR materials, these PAH-specific values were also essentially equivalent to PAH-specific values previously determined for CETCO's granular PM-199 product.*
- *Comparisons between current and past PM-199 testing data indicate organoclay particle size appears to have no real affect on organoclay sorption of dissolved-phase PAH compounds.*
- *Contrary to oil-sorption testing, the microaggregate factor likely had little to no influence on the PAH* K_d *values derived.*

Overall, it can be concluded incorporating CETCO's organoclay powder material into AquaGate+Organoclay™ (AquaGate) product did not adversely impact the organoclay material's ability to sorb either separate-phase contamination (oil) or selected dissolved-phase PAH contaminants. Further, it was demonstrated that AquaGate provided placement of powdered organoclay through the water in a way that maintained the sorption characteristics of the organoclay.

Report: Sorption of Separate- and Dissolved-Phase Organic Contaminants by Different EBGCR AquaGate+Organoclay Coating Materials

1. INTRODUCTION

AquaBlok, Ltd. (AquaBlok) recently supplied AquaGate+Organoclay™ product (AquaGate) for use in capping contaminated sediments for the East Branch Grand Calumet River (EBGCR) project.

AquaBlok and others involved in the project are interested in determining whether or not the process of incorporating inherently non-settleable organoclay powder material into settleable AquaGate product could, in some way, adversely affect the organoclay material's reactivity towards - i.e. sorption capacity for – selected separate-phase and/or dissolved-phase organic contaminants.

AquaBlok asked SAO Environmental Consulting AB (SAO) to design and direct laboratory-based testing (performed by others) with the intent of determining sorption capacities of several different organoclay materials derived from the EBGCR project.

Provided herein is a summary and discussion of the materials tested; methods used and testing results derived.

2. OBJECTIVES

The objectives of this work were to measure and compare relative abilities of selected EBGCR organoclay materials to sorb either: (1) a standard separate-phase organic contaminant, i.e. oil; or (2) dissolved-phase organic contaminants, i.e. selected PAH compounds.

3. ORGANOCLAY MATERIALS

Three different organoclay materials – each representing a different chronological stage of the EBGCR project - were included in separate- and dissolved-phase sorption testing:

1. Organoclay powder as received from CETCO - *as-received powder material.*
2. Coating material from as-manufactured product - *as-manufactured coating material.*
3. Coating material from "bucket" samples, after placement in river - *as-placed coating material*.

4. PRE-TEST PROCESSING AND PREPARATION OF MATERIALS

Prior to submitting EBGCR organoclay materials to laboratories for sorption testing, the materials required some degree of pre-test preparation and processing.

Initially, the materials display different particle sizes. That is, the as-received material already occurs in powder form. In contrast, both the as-manufactured and as-placed coating materials – once physically separated from the aggregate –initially display a larger-sized, somewhat “chunky” character. The materials may also display somewhat different moisture contents as well.

Previous work by Reible et al. (2008) implies organoclay particle size may have an effect on sorption of dissolved-phase PAH contaminants. It is unknown whether or not particle size has any kind of effect on sorption of separate-phase organic contaminants.

Given the above, both pre-test material particle size and moisture content were equalized (to the extent possible and practical) to facilitate the most “oranges-to-oranges” comparisons of material sorption capacities achievable. Furthermore, as noted above, additional types of material processing were also required for some materials, as described below.

4.1 As-received powder material

The as-received powder material (referred to as CETCO ORGANOCLAY P – a powder version of their PM-199P) is reportedly graded such that approx. 95 percent passes a #150 mesh (~106 micron) sieve. This material was used as-is in sorption testing, although some pre-test preparation was necessary before the material could be sent to laboratories for testing.

Pre-test preparation of the as-received powder material involved the following steps:

1. To accommodate all testing, a single, ~300-gram composite sample was created by collecting ~50-gram sub-samples of powder from the tops of multiple as-received bags of organoclay into an appropriately sized plastic container.
2. Using AquaBlok’s standard laboratory procedures, the entire composite sample was oven-dried to a constant weight.
3. Following oven drying, the entire composite sample was homogenized by thorough mixing.
4. Appropriately sized sub-portions of the oven-dried/mixed composite were placed into separate, labled and sturdy ziplock bags, then shipped to the respective testing laboratories.

4.2 As-manufactured coating material

For this particular material, only the “settleable” fraction was included in sorption testing, to the extent possible and practical (see footnote 2). For the EBGCR project, settleable product, plus related coating material, is defined as all material retained by (larger than) a #50 mesh (300 micron) sieve.

As part of AquaBlok’s quality control (QC) program established for the EBGCR project, representative composite samples of as-manufactured AquaGate were routinely collected during off-load then processed in their laboratory. Standard laboratory QC procedures for processing each AquaGate composite sample included the following steps: (A) dry sieving the AquaGate composite to segregate it into multiple size fractions, including the “non-settleable” <#50 mesh fraction; (B) re-combining then oven-drying the composite; (C) physically separating the dried coating material from aggregate by crushing and grinding; and finally (D) further processing the removed coating material by further crushing/grinding, as needed, then passing it through a #50 mesh (300 micron) sieve.

For each QC AquaGate composite, AquaBlok routinely placed the bare aggregate (from step C) and the <#50 mesh processed coating material (from step D) into separate, labeled ziplock bags, retaining the bagged material for possible future use. It was these already-existing, bagged samples of <#50 mesh processed coating material which provided the base material for processing and preparing the as-manufactured coating material "mother" sample used in all sorption testing [1].

Further pre-test processing and preparation of the as-manufactured coating material involved a number of follow-up steps:

1. ~50-gram sub-samples were collected from multiple ziplock bags of <#50 mesh processed coating material corresponding to multiple selected QC AquaGate composites [2] to create a combined, ~300 gram composite sample of the material.
2. The entire composite sample was homogenized by thorough mixing.
3. To accomplish an overall reduction in material particle size – to a final particle size comparable to that of the as-received powder material – the mixed material was then passed through a #150 mesh (~106 micron) sieve and the <#150 mesh material retained.
4. Using AquaBlok's standard laboratory procedures, the <#150 mesh material was oven-dried to a constant weight (note, moisture content of this material should be adequately comparable to that of oven-dried, as-received powdered material, since the same laboratory procedures were used, and the same types of materials were involved).
5. Following oven drying, the <#150 mesh material was again homogenized by thorough mixing.
6. Appropriately sized sub-portions of the oven-dried/mixed material were placed into separate, labled and sturdy ziplock bags, then shipped to the respective testing laboratories.

4.3 As-placed coating material

As indicated in Section 3, as-placed coating material was contained in and derived from project "bucket" samples, i.e. samples recovered after AquaGate placement in the river.

Once multiple bucket samples were retrieved from the project site by Natrual Resource Technology (NRT) [3] personnel and were delivered to AquaBlok the samples were initially processed by: (1) first pouring off all free water (present atop the deposited AquaGate) through a coffee filter, to trap and recover all material fines; then (2) the entire mass of wet material was oven-dried using AquaBlok's standard laboratory procedures.

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[1] As part of AquaBlok's laboratory QC program, the overall process of separating coating material from aggregate for a given sample collectively involves first conducting the "coating test", then the "scrape test". The relatively passive coating test first removes most of the coating from the aggregate, then the scrape test actively removes as much of the remaining coating from aggregate as possible (by scraping). Only material derived from the coating test (step D) was used in sorption testing.

[2] The as-manufactured coating material was selectively derived from QC AquaGate composites containing minimal weight-percentages of the "non-settleable" <#50 mesh size fraction (determined during QC step A).

[3] NRT is a member of the Great Lakes Sediment Remediation, LLC (GLSR) team, which also consists of J.F. Brennan Company, and Environmental Restoration. NRT performed quality control of the installed cap material and placed and recovered the pails of AquaGate evaluated by AquaBlok.

At this stage, the now-dried bucket samples were then first processed using AquaBlok's standard laboratory QC procedures (steps A to D, Section 4.2), then further processed and prepared as done for the as-manufactured coating material (follow-up steps 1 to 6, Section 4.2) [4].

5. METHODS FOR LABORATORY SORPTION TESTING

Laboratory sorption testing was conducted by other parties. Tests involving a standard, separate-phase organic contaminant, i.e. motor oil, were conducted by CETCO using established CETCO test methods. Tests involving dissolved-phase organic contaminants, i.e. selected PAH compounds, were conducted by Prof. Danny Reible's laboratory, at Texas Tech University (TTU) using test methods essentially similar to methods the laboratory previously used to provide data to CETCO for their PM-199 granular organoclay product.

Separate- and dissolved-phase sorption testing was conducted independently – that is, using "fresh" (virgin) replicate sub-samples of each of the three EBGCR organoclay materials.

Furthermore, all testing was conducted in "blind" fashion, such that CETCO and TTU were both aware they were testing organoclay materials, but did not know the origin of the samples being tested. To this end, the material samples provided to the respective laboratories were simply labeled "Sample 1"; "Sample 2" and "Sample 3".

5.1 Separate-phase, oil-sorption testing by CETCO

Separate-phase, oil-sorption testing was conducted in early January 2015 by CETCO at their facility in Chicago, Ill.

CETCO conducted sorption testing using their standard method for testing powdered / semi-powdered material, a method which involves use of commercial motor oil as the separate-phase organic contaminant. For method details, see Attachment A-1.

Replicate oil-sorption testing was conducted (n = 4) for each of the EBGCR organoclay materials.

Note, CETCO had previously conducted similar oil-sorption testing for AquaBlok in the past, using other AquaGate coating samples[3]. Based on results of previous testing, AquaBlok requested that, for current testing, CETCO extend the post-mix, oil + material contact time beyond their standard time (2 or 24 hours, depending on CETCO's specific method), in order to maximize oil adsorption

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[4] AquaBlok had previously (Spring 2014) submitted samples of AquaBlok+Organoclay™ product (Product) to CETCO for oil-sorption testing. As described in Attachment A-3, CETCO's sample-processing procedure involved separating coating from aggregate and reducing coating to finer-sized material by first blending intact (whole) Product for three minutes in a KitchenAid mixer, then segregating fines for use in testing using a #140 mesh sieve. AquaBlok's standard laboratory QC procedure for separating coating material from aggregate (step C, Section 4.2) appears to be less "aggressive" than CETCO's procedure, based on discussions with AquaBlok personnel (who have previously tried CETCO's blending-based technique). Due to these differences in techniques for material processing and particle size reduction, it is reasonable to assume relatively more non-sorptive aggregate fines end up in test samples derived from the CETCO method than from AquaBlok's method.

to the greatest extent possible. SAO confirmed with CETCO that a contact time of 3 days (72 hours) was used in all testing.

5.2 Dissolved-phase PAH sorption testing by TTU

Dissolved-phase sorption testing was conducted during spring/early summer 2015 in Prof. Reible's laboratory at Texas Tech University (TTU) in Austin, TX.

As requested by AquaBlok, TTU conducted sorption testing using, as a guide, the laboratory approach and procedures previously established and used by Prof. Reible and his colleagues (Reible et al., 2008), as documented in CETCO Technical Reference TR-840, "The use of organoclay in managing dissolved contaminants relevant to contaminated sediments" (see Attachment B-1). In essence, Prof. Reible was requested to "repeat" his past sorption-testing work – to the greatest extent possible and practical – but now using the three EBGCR organoclay materials provided by AquaBlok.

Detailed methods used by TTU to conduct dissolved-phase PAH sorption testing are provided in Attachment B-2.

The ultimate goal of this testing was to derive partition coefficient (K_d) values for each of the three EBGCR organoclay materials paired with each of the following dissolved-phase PAH compounds: naphthalene (NAP); phenanthrene (PHE); pyrene (PYR) and benzo(a)pyrene (BaP).

Replicate testing was conducted (n = 4) to derive K_d values for each of the 12 pairings of PAH compound + EBGCR organoclay materials.

6. RESULTS AND DISCUSSION

6.1 Sorption of separate-phase (oil) contamination by EBGCR organoclay materials

Results of CETCO's separate-phase sorption testing are provided in Attachment A-2, and graphically summarized in Figure 1.

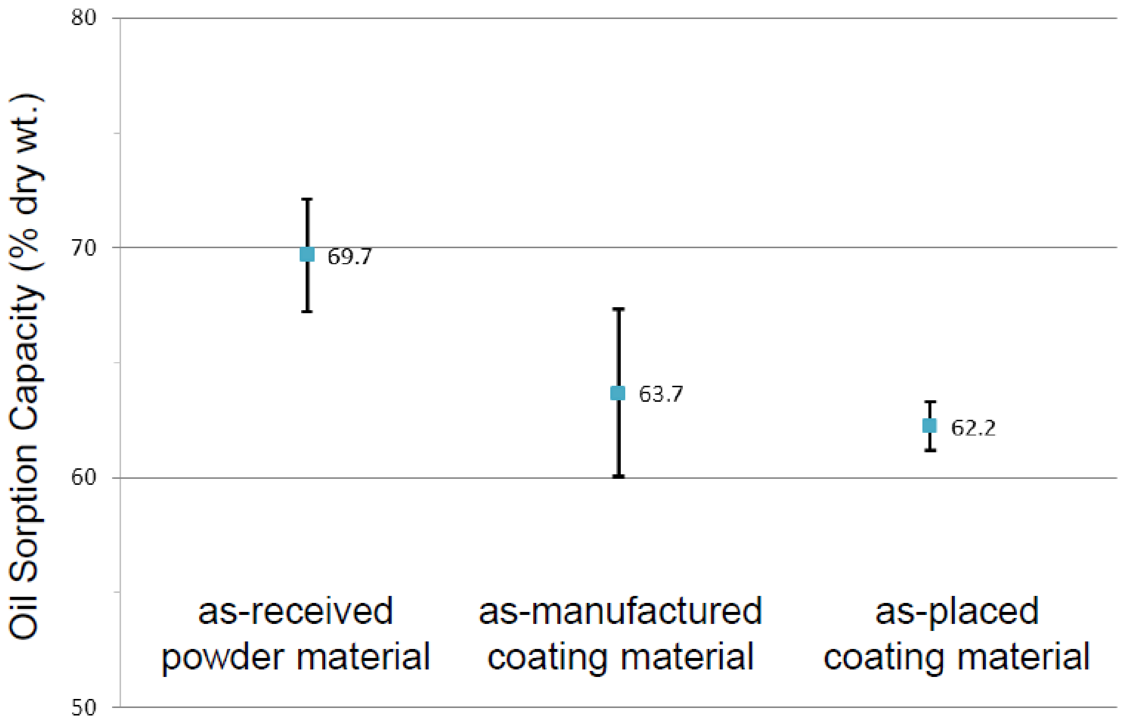


Figure 1. Oil sorption capacity (% dry wt.) for the different EBGCR organoclay materials. Error bars represent the 95% confidence interval (CI) around respective mean values; n = 4 for each material type.

As shown in Figure 1, mean oil-sorption capacity for as-received powder material was ~70%, whereas mean values for as-manufactured and as-placed coating materials were slightly less, ~64 and ~62%, respectively.

As also shown, no statistically significant difference is apparent between mean sorption values for the two coating materials, as implied by overlapping confidence intervals (CIs). In contrast, mean values for both coating materials - particularly as-placed coating material – appear somewhat lower than for as-received powder material, based on little to no CI overlap (and assuming required conditions for constructing and interpreting CIs are met, i.e. independence; random sampling and normal population distribution).

Regardless of apparent statistical differences, mean oil-sorption values for both coating materials are still only slightly less than (~90% of) the mean value for as-received powder material.

For additional reference and comparison, mean oil-sorption values for the two EBGCR coating materials (Figure 1) are at least 10% higher than values CETCO determined previously (Spring 2014) for organoclay coating material from earlier AquaGate+Organoclay™ samples, testing wherein which different oil + material contact times were used (see Attachment A-3). Lower oil-sorption values from earlier testing – including from a 7-day test (4 days longer than current testing) - probably resulted mainly from larger amounts of non-sorptive aggregate fines ending up in CETCO's test samples (see footnote 4).

It is also important to note mean oil-sorption values for all three EBGCR organoclay materials are well above the minimum value of 50% (by dry weight), which is CETCO's value for their PM-199 granular organoclay product (Attachment A-4), as well as the stated design objective for the EBGCR project.

If oil sorption capacity measured herein for EBGCR coating materials is indeed slightly less than that for as-received powder material, one reason could be coating materials likely (and uniquely) contain some quantity of silt-sized "microaggregates" of organoclay + polymer, which may initially limit oil sorption onto some organoclay particle surfaces. But if this is the case, such a slight reduction in oil sorption capacity should be only temporary. Over time after AquaGate placement, the polymer component (which is relatively labile) should microbially degrade and expose previously occluded organoclay particles for additional oil sorption.

It is likely some quantity of non-sorptive fines inherently contained in aggregate used in product manufacture ultimately ends up in EBGCR coating materials, which could theoretically "dilute" organoclay content and reduce oil-sorption capacity of coating material test samples to some degree. The influence of such an effect is expected to be relatively minor, since the quantity of fines in the aggregate is relatively quite low, on a total weight-percent basis.

6.2 Sorption of dissolved-phase PAH compounds by organoclay materials

6.2.1 PAH partition coefficient of EBGCR organoclay materials

Results of TTU's dissolved-phase sorption testing of the three EBGCR organoclay materials are provided in Attachment B-2, and graphically summarized in Figure 2.

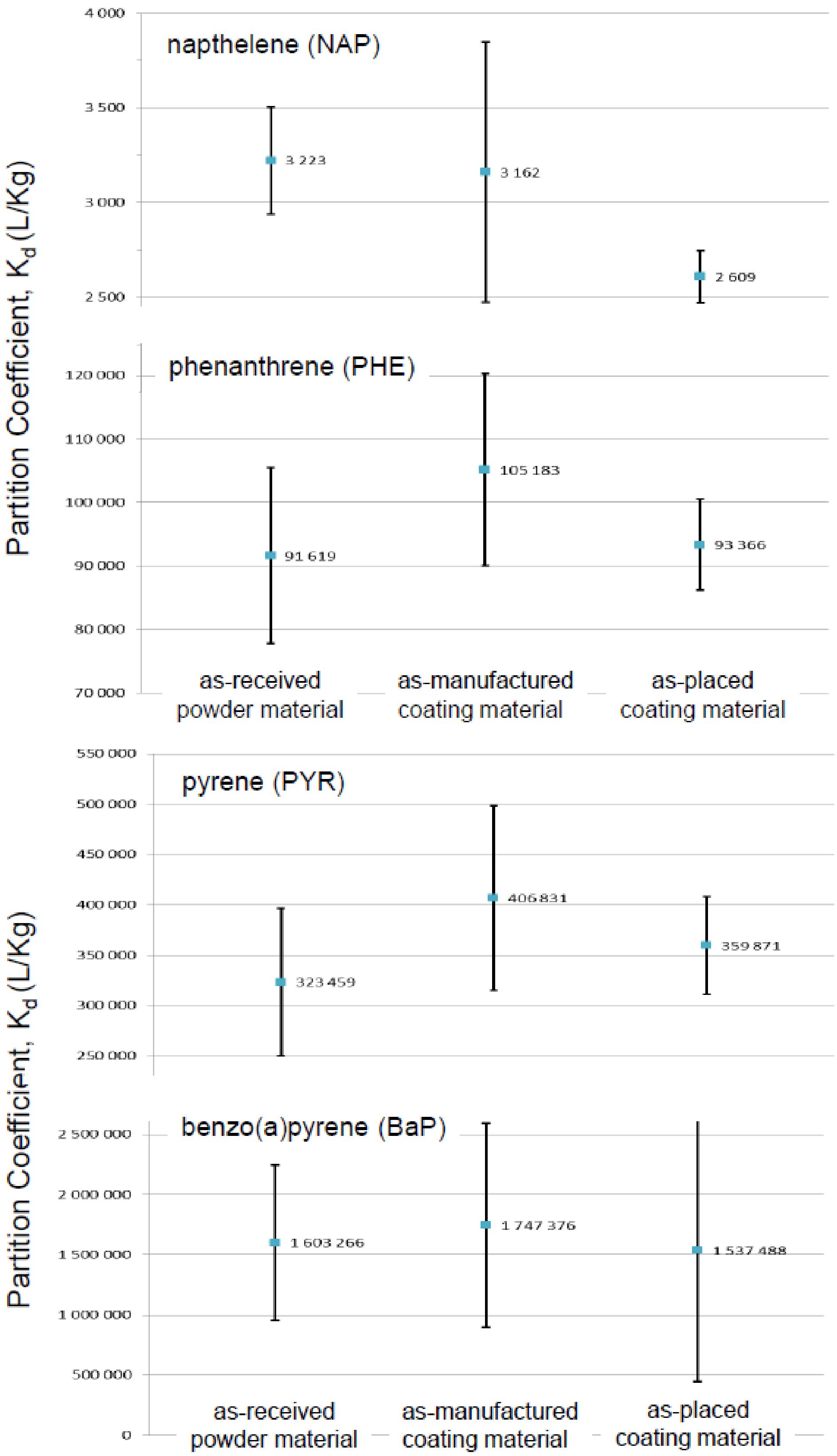


Figure 2. Measured dissolved-phase partition coefficient, K_d, values (L/Kg) for PAH compound + EBGCR material-type pairings. Error bars represent the 95% confidence interval (CI) around respective mean values; n = 4 for each material type.

For all PAH compounds except NAP, relative differences between mean K_d values for the three organoclay materials per PAH compound were similar. That is, mean values for as-received powder material and as-placed coating material were roughly similar, whereas mean values for manufactured coating material were slightly to somewhat higher than mean values for the other two materials (Figure 2).

In contrast, for NAP, mean K_d values for as-received powder material and as-manufactured coating material were roughly the same, with both higher than the mean value for as-placed coating material.

As also shown in Figure 2, no statistically significant difference in K_d values is apparent (as implied by overlapping CIs) between the three organoclay materials for any given PAH compound, with one possible exception, i.e. NAP K_d values for as-received powder material versus as-placed coating material. As for oil-sorption testing results (Section 6.1), such statistical comparisons assume certain required conditions for constructing and interpreting CIs are met.

Recognized but unavoidable analytical challenges during laboratory analysis likely affected some sorption-testing results, which needs to be taken into account when considering and comparing some of the K_d values derived. As discussed in the test report (Attachment B-2), losses of NAP (likely due to evaporation) and BaP (likely sorption onto glassware or slow uptake onto PDMS) led to greater uncertainty in the K_d values for these two compounds. In contrast, K_d values for PYR and PHE were not subject to significant losses, and are of relatively high precision.

Contrary to oil-sorption testing, the microaggregate factor likely had little to no influence on the dissolved-phase PAH K_d values derived. Although a biocide was added into test vials to inhibit microbial activity, the vials were continuously tumbled for five days in the laboratory (Attachment B-2), which should have dispersed most of the microaggregates and exposed organoclay particles for compound sorption. Furthermore, and similar to oil-sorption testing, the small quantity of non-sorptive fines from aggregate likely had little to no real influence on sorption-testing results.

In summary, and as concluded in the test report (Attachment B-2), there were no substantial differences in mean K_d values between the three EBGCR organoclay materials for each dissolved-phase PAH compound; this is especially the case for PYR and PHE, considering the related higher precision. As further noted in the report, “substantial differences” would be considered differences in K_d values of greater than a factor of 2 between two sets of samples for all PAH compounds.

6.2.2 Comparisons with PAH sorption by CETCO PM-199 granular organoclay

In addition to presenting PAH K_d values derived for the three EBGCR organoclay materials (tested in powdered form), the test report (Attachment B-2) also provides a comparison of current test results with K_d values the laboratory previously derived for CETCO’s PM-199 product for the same PAH compounds. As noted earlier, PM-199 is comprised of the same organoclay material, but in granular form, roughly mm-sized (Attachment A-4).

Plotted in Figure 1 of Attachment B-2 are compound-specific mean K_d values for PM-199, including the estimated 95% CI about the respective PM-199 mean values.

As concluded in the test report, there were not only no substantial differences in PAH-specific K_d values *amongst* the three EBGCR materials, these PAH-specific values were also essentially equivalent to values previously determined for PM-199, when comparisons *between* past and current testing data for respective PAH compounds were made.

Such a comparison is significant, because it would indicate organoclay particle size appears to have no real affect on sorption of dissolved-phase PAH compounds.

Furthermore, such a conclusion of particle-size insensitivity to PAH sorption is also interesting, because it *could* somewhat contradict results of previous dissolved-phase PAH sorption testing by Prof. Reible's laboratory. Namely, as described in Reible et al. (2008), measured PAH K_d values for CETCO's granular PM-200 organoclay product were significantly lower than those measured for PM-199, despite the fact that they are identical materials but with different particle sizes (PM-200 slightly coarser). They go on to say, thought, such differences may represent sample heterogeneity (fewer particles of PM-200 were employed for a given mass of organoclay in the sample vials), or slower uptake dynamics in the large particle sizes of PM-200.

7. CONCLUSIONS

Conclusions on CETCO's testing results for oil sorption by the three different EBGCR organoclay materials are as follows:

- Oil-sorption values for all three EBGCR organoclay materials are well above the minimum value of 50% (by dry weight), which is CETCO's value for their PM-199 granular organoclay product, as well as the stated design objective for the EBGCR project.
- Mean oil-sorption capacity for as-received powder material was ~70% (by dry wt.), whereas values for as-manufactured and as-placed coating materials were ~90% of this value (i.e. ~64 and ~62%, respectively).
- The difference between mean values for the two coating materials did not appear to be statistically significant. However, small yet significant differences were apparent when comparing mean values for coating materials with that for the as-received powder material.
- If statistical interpretations of testing results are genuine, the slightly lower sorption capacities displayed by both coating materials may be a temporary phenomenon, observed only during short-term laboratory testing. Coating materials likely (and uniquely) contain "microaggregates" of organoclay + polymer, which may initially limit oil sorption onto some organoclay particle surfaces. Over time after AquaGate placement, the polymer should degrade and expose previously occluded organoclay particles for additional oil sorption.
- Mean values for oil sorption presented herein for the EBGCR coating materials are at least 10% higher than values previously determined by CETCO for organoclay coating material from earlier AquaGate+Organoclay samples. This difference is likely an artifact of differences in methods used by CETCO and AquaBlok for sample preparation and processing.

Conclusions on TTU's testing results for sorption of selected dissolved-phase PAH compounds by different EBGCR organoclay materials, including comparisons with previous test results for another organoclay product, are as follows:

- Results from sorption testing suggest all samples meet or exceed specified partition coefficient (K_d) values for light weight PAHs, e.g. phenanthrene (at least 50,000 L/Kg) and mid to heavy weight PAHs, e.g. pyrene (at least 350,000 L/Kg). Project specifications do not clarify the nature of these minimum values, e.g. means from replicate sample testing. Regardless, although the mean K_d value measured herein for pyrene on the as-received organoclay sample (~323,000 L/Kg) was slightly below the above target, the difference between this mean value and mean values measured for the two coating samples – both of which exceed the target - was not considered statistically significant. Therefore, it was concluded all three samples effectively met the project specification.
- The test report concluded there were no substantial differences in mean K_d values between the three EBGCR organoclay materials for each dissolved-phase PAH compound. For this work, “substantial differences” would be considered differences in K_d values of greater than a factor of 2.
- K_d values derived for PYR and PHE are of relatively high precision, whereas recognized but unavoidable analystical challenges led to greater uncertainty in K_d values derived for NAP and BaP.
- There were not only no substantial differences in PAH-specific K_d values amongst the three EBGCR materials, these PAH-specific values were also essentially equivalent to PAH-specific values previously determined for CETCO’s granular PM-199 product.
- Comparisons between current and past PM-199 testing data indicate organoclay particle size seems to have no real affect on organoclay sorption of dissolved-phase PAH compounds.
- Contrary to oil-sorption testing, the microaggregate factor likely had little to no influence on the PAH K_d values derived.

Overall, it can be concluded incorporating CETCO’s organoclay powder material into AquaGate+Organoclay™ (AquaGate) product did not adversely impact the organoclay material’s ability to sorb either separate-phase contamination (oil) or selected dissolved-phase PAH contaminants. Further, it was demonstrated that AquaGate provided placement of powdered organoclay through the water in a way that maintained the sorption characteristics of the organoclay.

8. REFERENCES

Reible, D., X. Lu, J. Galijour and Y. Qi. 2008. Use of organoclay in managing dissolved organic contaminants. *CETCO Technical Reference TR 840*, June 2008.

Attachment 3.
Bench Test for ISGS with Organoclay

ReSolution
Partners, LLC

Final Treatability Study Report
Performance of Provect-GS and Provect-GS/OC
Former Koppers Inc. Wood Treating Site, Gainesville, Florida

Prepared for Provectus Environmental Products
10 September 2015

The proposed treatability study compared the performance of Provect-Geochemical Stabilization (Provect-GS) and Provect-GS/OC (organoclay, specifically CETCO Organoclay® PM-199™) on samples from the Koppers Site. The organoclay is a hydrophobic montmorillonite clay modified with quaternary amine and alcohol to absorb non-aqueous phase liquids (NAPLs).

These samples were tested in the laboratory to evaluate:

- the effect of organoclay addition on the physical characteristics of the Provect-GS/OC clay mixture prior to injection,
- the change in hydraulic conductivity produced by the two reagents, and
- the change in concentration of constituents of interest (COI, defined as analytes detected by SW-846 Method 8270C SIMS) as a result of reagent applications.

The study was divided into four tasks. The findings of the tasks are presented in this report.

TASK 1. Sample Preparation. Four Koppers Site samples were available in house at ReSolution Partners:

- Surficial NAPL – North Lagoon
- Surficial NAPL – Process Area
- Hawthorn NAPL – North Lagoon-Drip Track
- Hawthorn NAPL – Process Area

The Hawthorn NAPL – Process Area sample was used for testing. The sample was gently mixed by hand, and debris and large granular material was removed by hand and disposed.

Once homogenized, a representative aliquot of soil was collected and sent to ESC Laboratories, Mt. Juliet, TN for analysis of semi-volatile organic compounds (SVOCs) by USEPA SW-846 Method 8270C SIMS. The composition data is summarized in Table 1 and the laboratory report is provided in Appendix A.

Table 1. Baseline soil chemistry

	Concentration (mg/kg, dry wt.)		Concentration (mg/kg, dry wt.)
Anthracene	220	Dibenz(a,h)anthracene	6.2
Acenaphthene	510	Fluoranthene	540
Acenaphthylene	13	Fluorene	430
Benzo(a)anthracene	150	Indeno(1,2,3-cd)pyrene	15
Benzo(a)pyrene	43	1-Methylnaphthalene	440
Benzo(b)fluoranthene	71	2-Methylnaphthalene	560
Benzo(g,h,i)perylene	15	Naphthalene	1,600
Benzo(k)fluoranthene	20	Phenanthrene	1,200
2-Chloronaphthalene	< 1.0	Pyrene	360
Chrysene	120		

TASK 2. Provect-GS and OC Mix Evaluation.

One kilogram of Provect-GS (P-GS) was prepared according to standard procedures for a 4.5 wt. % strength solution. Organoclay (OC, specifically CETCO PM-200) was then added to the P-GS at 1, 2.5 and 5 wt. %. The P-GS (no OC) and three OC-amended P-GS samples (total of four) were stirred for 10 minutes. Once stirred, the following sequence of tests were performed to assess the P-GS and OC mixtures prior to exposure to dissolved and/or non-aqueous phase liquids (NAPLs):

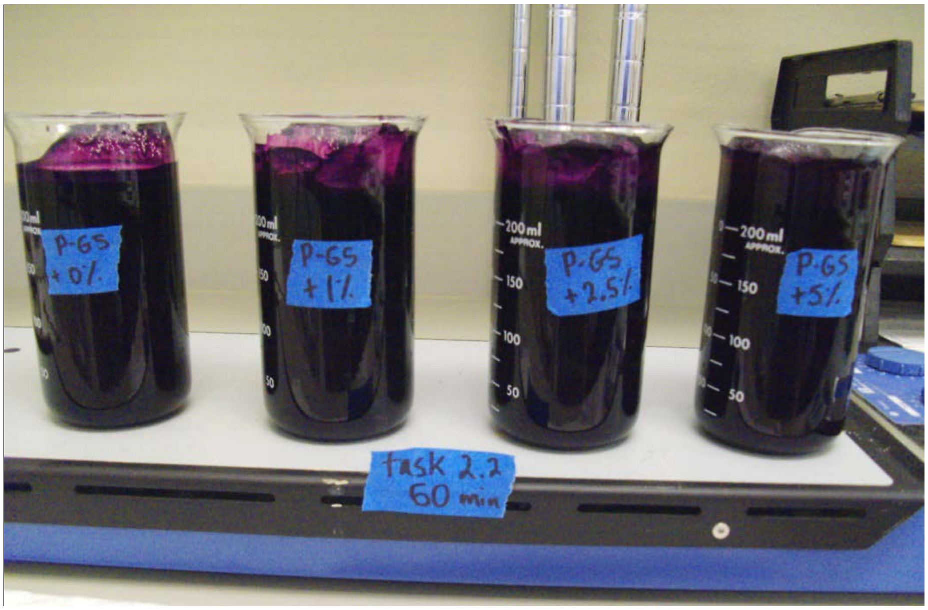
The weights of known volumes of the four solutions at ambient room temperature (22 °C) were measured to determine solution densities as follows:

a. P-GS (no OC): 1.060 g/mL
b. P-GS with 1% OC: 1.059 g/mL
c. P-GS with 2.5% OC: 1.058 g/mL
d. P-GS with 5% OC: 1.061 g/mL

There was virtually no difference in the densities between the mixtures, with or without OC.

As expected for a hydrophobic clay, the OC was difficult to hydrate. Relatively lengthy stirring with a stainless steel spatula and a Teflon stir bar was needed to mix the clay into the P-GS. A froth formed on top of each solution containing OC. The amount of froth was proportional to the amount of OC.

The four solutions were stirred for 10 minutes in clear glass jars. Once the stirring ceased visual observations of OC separation and settling (i.e., thickness of sediment) were made at 10, 30 and 60 minutes. There was no settling apparent in any of the solutions after 10, 30 or 60 minutes.



The kinematic viscosity of the four solutions were determined using Zahn-type Cups (Table 2). Fresh P-GS/OC solutions were prepared, stirred for 10 minutes and the viscosity determined at 0, 40, 70 and 190 minutes at a temperature of approximately 22 °C. The dynamic viscosity was computed from the kinematic viscosity and density data.

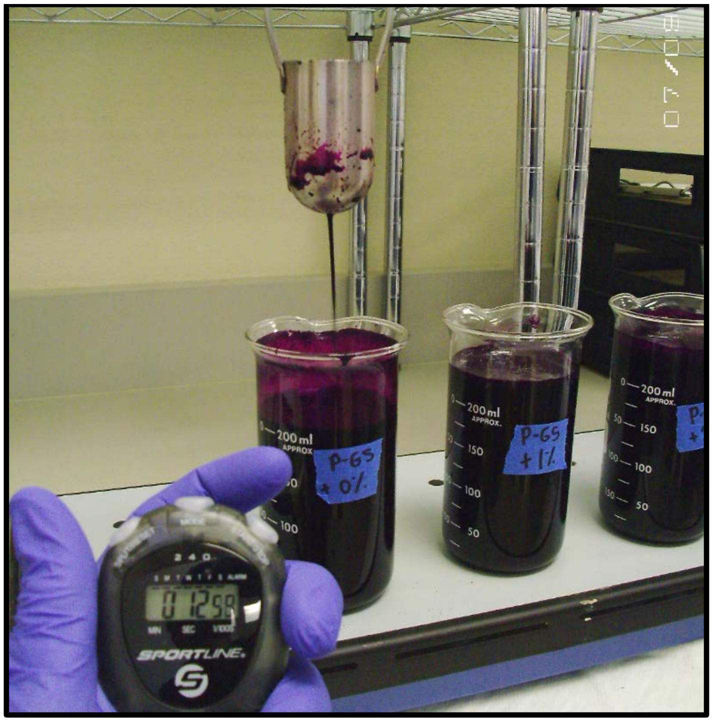


Table 2. Provect-GS/OC viscosity.

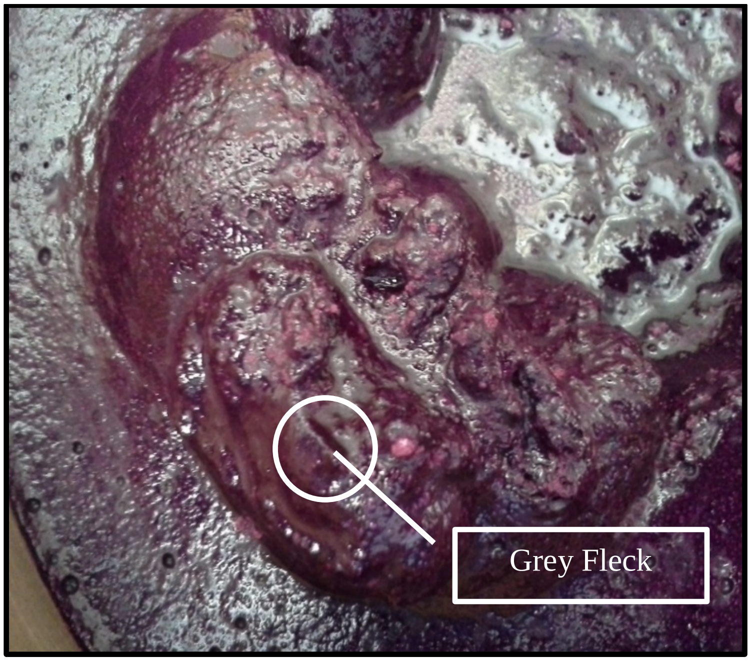
Sample ID	Time After Solution Prep. (min.)	Cup #	Kinematic Viscosity (mm^2/s)	Dynamic Viscosity (mPa•s)
P-GS	0	1	1.8	2.0
	30	2	7.8	8.2
	70	2	8.4	8.9
	190	2	8.2	8.7
P-GS + 1%OC	0	1	0.59	0.6
	30	2	7.1	7.5
	70	2	8.0	8.5
	190	2	7.8	8.3
P-GS + 2.5%OC	0	1	0.15	0.2
	0	2	5.1	5.4
	30	2	6.0	6.3
	70	2	7.0	7.4
	190	2	7.5	7.9
P-GS + 5%OC	0	1	-0.22	-0.2
	30	2	5.7	6.0
	70	2	6.9	7.3
	190	2	6.8	7.2

The Zahn-type cup #2 produced a more evident end point than cup #1. We are more confident in the results using cup #2. The results using cup #2 show a slight increase in viscosity over the 190 minutes of observation. The final kinematic viscosities ranged from 6.8 to 8.2 mm^2/s where the kinematic viscosity of water at 22°C is 0.95 mm^2/s.

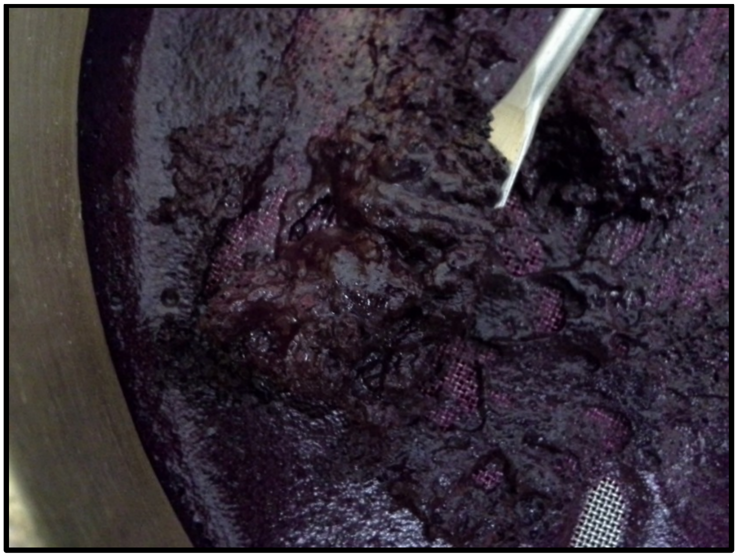
Two separate batches of P-GS with 10 wt. % OC were prepared and allowed to react with constant stirring using a large stir bar on a magnetic stir plate for 10 minutes and 60 minutes. After the specified time, the solution was allowed to gravity drain through a 425 µm screen and the retained material was visually evaluated to assess to what degree the OC formed clumps or aggregates. The organoclay added to the P-GS is predominantly less than 75 µm in size.

After the 10 minute stirring interval, 550 g of the solution was sieved. Thirty minutes later, little to no more free liquid was dripping to the collection pan. The substance retained on the sieve was a light frothy gel that weighed 213 g (39% of the amount sieved). The froth had visually evident grey flecks up to 1 mm (or 1,000 µm) diameter that are presumed to be aggregated OC.

After the 60 minute stirring interval, 550 g of the solution was sieved. When no more free liquid was dripping to the collection pan, only 103 g was retained on the sieve. The substance retained was again a light frothy gel, but no grey flecks were evident. Increased stirring appears to have reduced the size of solid particulate in the solution, including the OC.


Grey Fleck


task 2.4
60 min stir



Unmodified montmorillonite clay that forms the basis of OC can swell when exposed to aqueous sodium. The following trials assessed to what degree the sodium in the sodium permanganate used in the P-GS/OC will cause the OC to swell. The OC was determined to have a dry density of 0.84 g/mL. The density of OC saturated with deionized water was 1.37 g/mL. The pore volume of the water-saturated OC was 0.4. This information was used to dose aliquots of the dry OC with 1, 2.5 and 5 wt. % sodium permanganate solution to saturation. Immediately after blending the OC with solution, the mixture was added to a graduated cylinder and allowed to react for approximately 10, 60 and 180 minutes. The volumes of the mixtures were recorded and trends over time were noted. The potential sodium-induced swelling was compared to the swelling induced by oil absorption. The procedure described above was applied to a solution containing 5 wt. % vegetable oil and the results are compared to the 5 wt. % sodium permanganate results below (see Table 3).

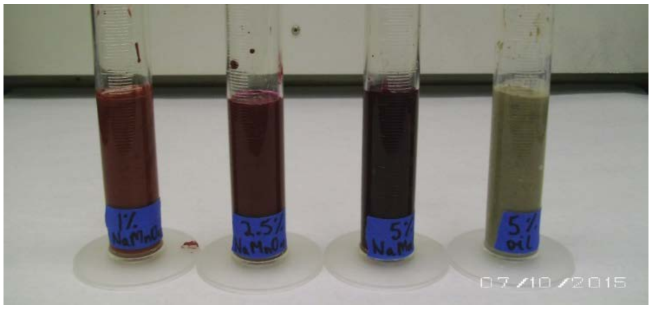


Table 3. OC swelling due to sodium permanganate addition.

Sample	Elapsed Time (min)	Sample Volume (mL)
OC + 1.0% $NaMnO_4$	14	52.0
	24	51.5
	72	52.0
	196	52.0
OC + 2.5% $NaMnO_4$	0	50.5
	11	50.5
	21	50.5
	69	50.0
	193	50.0
OC + 5.0% $NaMnO_4$	0	53.0
	7	53.0
	17	52.5
	65	51.0
	189	52.0
OC + 5.0 % soybean oil	0	52.0
	1	52.0
	11	52.0
	59	54.0
	183	53.5

Essentially, the addition of sodium permanganate showed little to no evidence of OC swelling over the 3-hour period. The addition of oil showed a possible small increase in volume after 1 hour of reaction.

TASK 3. Hydraulic Conductivity Changes with Reagent Addition.

Previous oxidant demand studies have determined that a dosage of 4.5 wt. % Provect-GS was sufficient for the site soils. No further testing of dosage was completed and a 4.5 wt. % dosage was used for both Provect-GS and Provect-GS/OC applications. In the presence of PAH-bearing soil, the OC may swell and reduce the permeability of the soil beyond what might be expected simply from the addition of several weight percent fines introduced with the Provect-GS/OC.

ReSolution Partners prepared one column for the determination of pre-treatment, baseline hydraulic conductivity. Chromaflex glass columns having a diameter of 4.8 cm, length of 15.0 cm and volume of 271 mL were packed with 350 g of as received soil (1.30 kg/L), with stirring and mild tamping to minimize void formation. The sample was saturated with a 1 mM $CaCl_2$ solution as the column was filled. The porosity and pore volume based on the mass of water added to the column were 0.38 and 102 mL, respectively. The saturated soil density was 1.66 kg/L. The hydraulic conductivity of the column was determined by falling head methods using the $CaCl_2$ solution as the permeant. Observations of head drop with time continued until stable values of hydraulic conductivity were obtained.

Two additional columns were constructed as described above using soil amended with 4.5 wt. % Provect-GS and 4.5 wt. % Provect-GS/OC. One column was filled with each reagent-amended soil to within 10 percent of the same soil density and porosity as the unamended soil. The two columns were allowed to react for approximately 1 day, at which time the falling head tests as described previously were completed. As described in Task 4, the reagent amended columns were flushed with $CaCl_2$ solution to assess COI leaching.

The hydraulic conductivity of the flushed columns was also determined after flushing. The flushing moved approximately 90 pore volumes of water through the soil samples. Visual observations of the soil columns noted physical disturbance such as void formation and channeling of the soil in the reagent-amended columns at the flow rates applied to the columns. This was most apparent in the Provect-GS column where the flow rates were the lowest. This makes the evaluation of the post-flushing results uncertain.

The hydraulic conductivity results of the unamended, 1-day reaction time and post-flushing period for the two amendments are summarized in Table 4 and the laboratory documentation is provided in Appendix B.

Table 4. Hydraulic conductivity summary (cm/s).

	Initial Conditions	Post-Flushing
Unamended Soil	73 E -5	160 E -5
Provect-GS	1.5 E -5	0.83 E -5
Provect-GS/OC	1.5 E -5	14 E -5

The addition of both reagents reduced the hydraulic conductivity by a factor of 48 times prior to flushing of the columns.

Following flushing, the measured hydraulic conductivity increased by factors of about 2 to 10 for the unamended and the Provect-GC/OC columns, and decreased by about a factor of 2 for the Provect-GC column when compared to the initial conditions prior to flushing. Comparing only the post-flushing data shows a 10 to 200 fold hydraulic conductivity reduction for the Provect-GC/OC and Provect-GC, respectively. As noted earlier, physical disturbance of the columns as a result of flushing make the post-flushing data uncertain. However, the general trend remains that both reagent-amended columns maintained lower hydraulic conductivities than the unamended column.

TASK 4. Reduction in COI Release.

This task was intended to assess the **relative** differences in COI release between the unamended soil, soil amended with Provect-GS at 4.5 wt. % and soil amended with P-GS/OC at 4.5 wt. %. The P-GS/OC contained 2.5 wt. % CETCO Organoclay® PM-199™.

This evaluation was completed with the same columns used for the permeability trials. The effluent from each of the three permeability tests was reintroduced to the bottom of their respective column with a peristaltic pump. Once the permeability test effluent has entered the column, the influent continued with fresh 1 mM $CaCl_2$ solution.

The flow rates maintained for the unamended soil and soil amended with P-GS/OC was 2.0 mL/min. This flow rate resulted in the build-up of high pressures, significant soil disturbance and column leaks in the Provect-GS column. The flow rate was therefore reduced to 0.84 mL/min. It required approximately 4 days of flow to complete the unamended and the Provect-GS/OC columns, and 11 days to complete the Provect-GS column. The same number of pore volumes were passed through all the columns but it required a longer period of flow to achieve that goal with the Provect-GS column. At these flow rates it required approximately 1 to 2 hours of flow duration to collect the required sample volume for analysis. Samples were collected at the flow intervals listed in Table 5.

Table 5. Actual flow intervals for sample collection (as pore volumes, ~100 mL per pore volume).

Unamended Column	Provect-GS Column	Provect-GS/OC Column
3.2	2.7	3.6
9.5	7.2	11
29	20	29
58	57	58
87	82	86

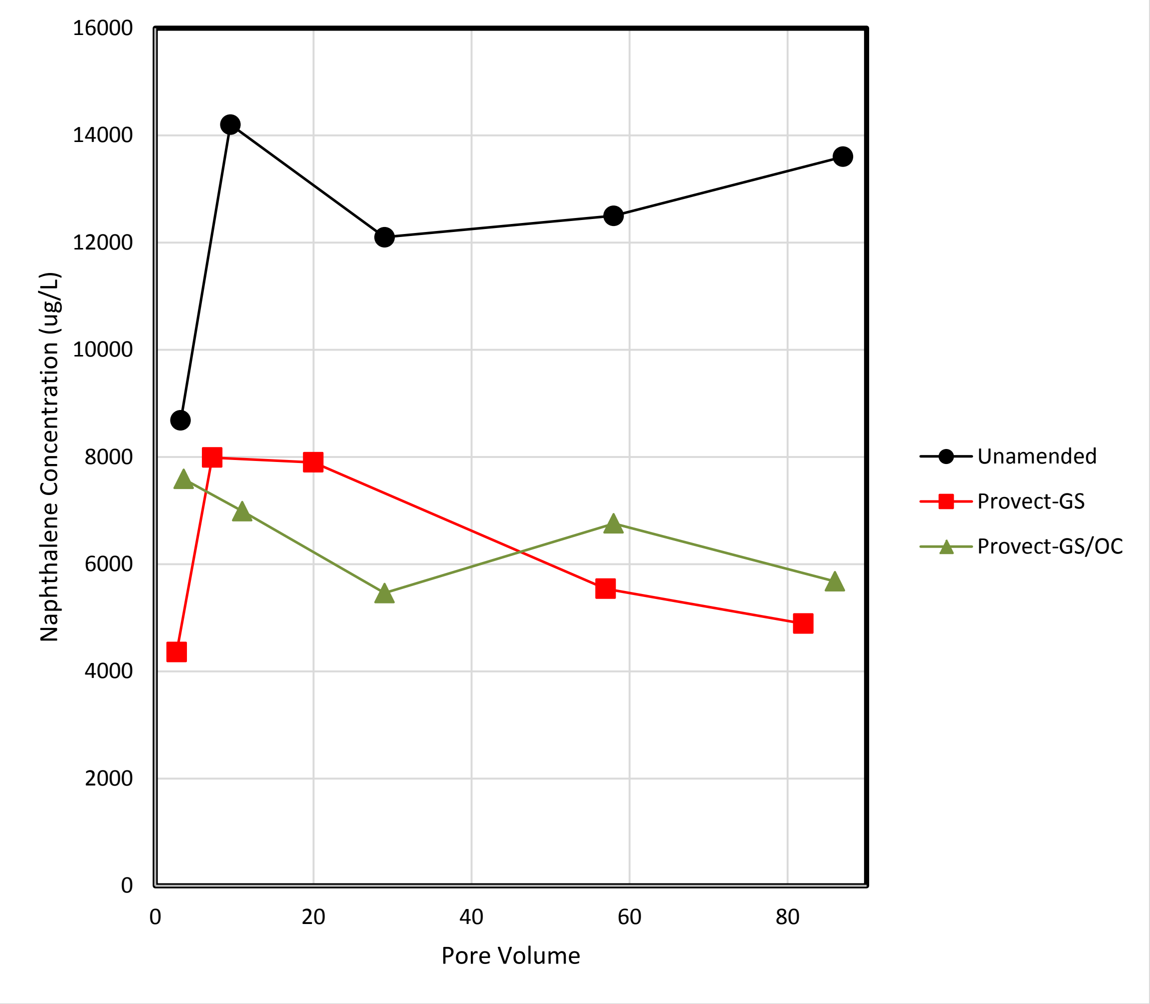
The samples were preserved on ice and submitted to ESC Laboratories, Mt. Juliet, TN for analysis by SW-846 Method 8270C SIMS. The laboratory reports are provided in Appendix A. The results are summarized in Table 6.

Table 6. Results of COI flushing from columns.

Constituent of Interest Concentrations (µg/L)	Unamended Column					Provect-GS Column					Provect-GS/OC Column				
Pore Volumes Flushed	3.2	9.5	29	58	87	2.7	7.2	20	57	82	3.6	11	29	58	86
Anthracene	**27.3**	**31.1**	<0.050	<0.050	<0.050	<0.050	<0.050	<50	**13**	**20**	<50	<50	<50	<50	<50
Acenaphthene	**404**	**662**	**605**	**604**	**692**	**182**	**465**	**258**	**196**	**160**	**415**	**232**	**373**	**484**	**450**
Acenaphthylene	<50	<50	<50	<50	<50	<50	<50	<50	<50	**2.3**	<50	<50	<50	<50	<50
Benzo(a)anthracene	**0.238**	**0.265**	**0.213**	**0.231**	**0.236**	**0.594**	**0.427**	<50	**0.73**	**0.48**	<50	<50	<50	<50	<50
Benzo(a)pyrene	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<50	<0.050	<0.050	<50	<50	<50	<50	<50
Benzo(b)fluoranthene	<0.050	<0.050	<0.050	<0.050	<0.050	**0.142**	<0.050	<50	<0.050	<0.050	<50	<50	<50	<50	<50
Benzo(g,h,i)perylene	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<50	<0.050	<0.050	<50	<50	<50	<50	<50
Benzo(k)fluoranthene	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<50	<0.050	<0.050	<50	<50	<50	<50	<50
2-Chloronaphthalene	<250	<250	<250	<250	<250	<250	<250	<250	<250	<5.0	<250	<250	<250	<250	<250
Chrysene	**0.137**	**0.165**	**0.208**	**0.190**	**0.189**	**0.274**	**0.32**	<50	**0.35**	**0.14**	<50	<50	<50	<50	<50
Dibenz(a,h)anthracene	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<50	<0.050	<0.050	<50	<50	<50	<50	<50
Fluoranthene	**7.76**	**9.76**	**14.4**	**18.5**	**20.6**	**7.11**	**30.9**	<50	**20**	**12**	<50	<50	<50	**55.4**	**60.2**
Fluorene	**187**	**308**	**277**	**264**	**302**	**106**	**200**	**125**	**97.1**	**81**	**175**	**118**	**161**	**209**	**201**
Indeno(1,2,3-cd)pyrene	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<50	<0.050	<0.050	<50	<50	<50	<50	<50
1-Methylnaphthalene	**517**	**866**	**710**	**720**	**790**	**278**	**622**	**537**	**340**	**220**	**588**	**425**	**470**	**590**	**517**
2-Methylnaphthalene	**793**	**1,360**	**1,130**	**1,160**	**1,310**	**407**	**1,030**	**698**	**479**	**350**	**959**	**607**	**790**	**1,010**	**899**
Naphthalene	**8,680**	**14,200**	**12,100**	**12,500**	**13,600**	**4,360**	**7,990**	**7,900**	**5,540**	**4,890**	**7,590**	**6,990**	**5,460**	**6,760**	**5,680**
Phenanthrene	**132**	**276**	**273**	**275**	**295**	**132**	**363**	**160**	**132**	**100**	**282**	**148**	**277**	**343**	**370**
Pyrene	**5.09**	**7.64**	**8.46**	**10.5**	**12.0**	**5.4**	**16.8**	<50	**11**	**6.0**	<50	<50	<50	<50	<50
Total Quantified PAHs	10,754	17,721	15,118	15,552	17,022	5,479	10,718	9,678	6,829	5,896	10,009	8,520	7,531	9,451	8,177
Cumulative COI Mass Removed (µg)	Unamended Column					Provect-GS Column					Provect-GS/OC Column				
Pore Volumes Flushed	3.2	9.5	29	58	87	2.7	7.2	20	57	82	3.6	11	29	58	86
Naphthalene	2,778	11,724	35,319	71,569	111,009	1,177	4,773	14,885	35,383	47,608	2,732	7,905	17,733	37,337	53,241
Total Quantified PAHs	3,441	14,605	44,086	89,188	138,552	1,479	6,303	18,690	43,958	58,698	3,603	9,908	23,464	50,873	73,769

Naphthalene was the compound detected at the highest concentrations followed by methylated naphthalenes. Other commonly detected compounds included acenaphthene, benzo(a)anthracene, chrysene, fluoranthene, fluorene, phenanthrene and pyrene. Figure 1 illustrates the change in naphthalene concentrations with flushing.

Figure 1. Naphthalene concentrations during column flushing.

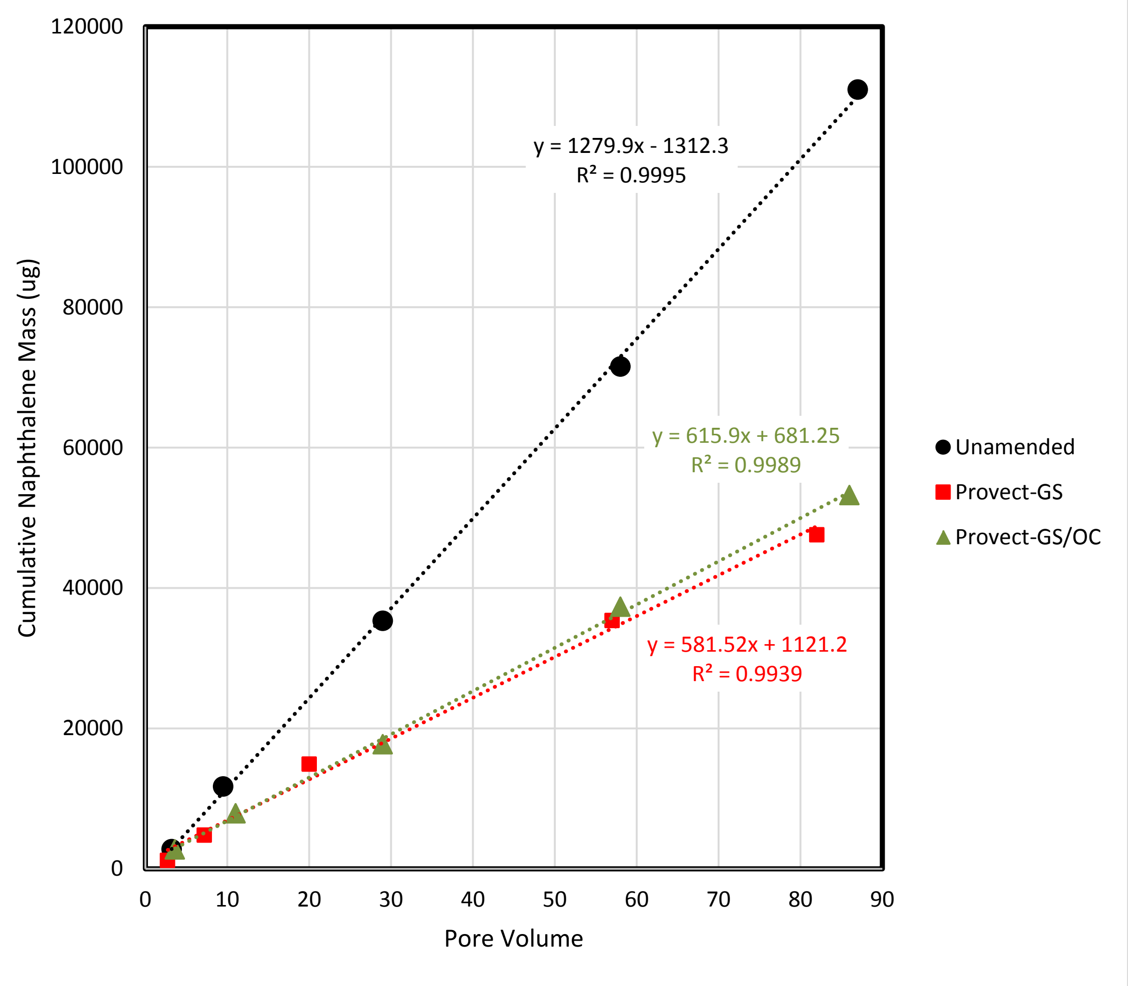


The addition of the 4.5 wt. % permanganate in both amended columns resulted in naphthalene concentration reductions on the order of 9,000 µg/L or approximately 60 percent by the end of the flushing. The difference in naphthalene concentrations between the two amendments does not appear to be significant. This is not unexpected since both amendments had the same amount of permanganate.

The unamended and Provect-GS-amended columns showed significant concentration increases between the first and second sampling events after which both amended columns showed decreasing naphthalene concentrations with flushing. The final concentrations in both columns were about 2,000 µg/L lower than the maximum observed concentrations.

The cumulative mass of naphthalene removed is presented on Figure 2. The masses were determined assuming the measured concentration at a given sampling event applied to all of the flow between that sampling event and the previous sampling event.

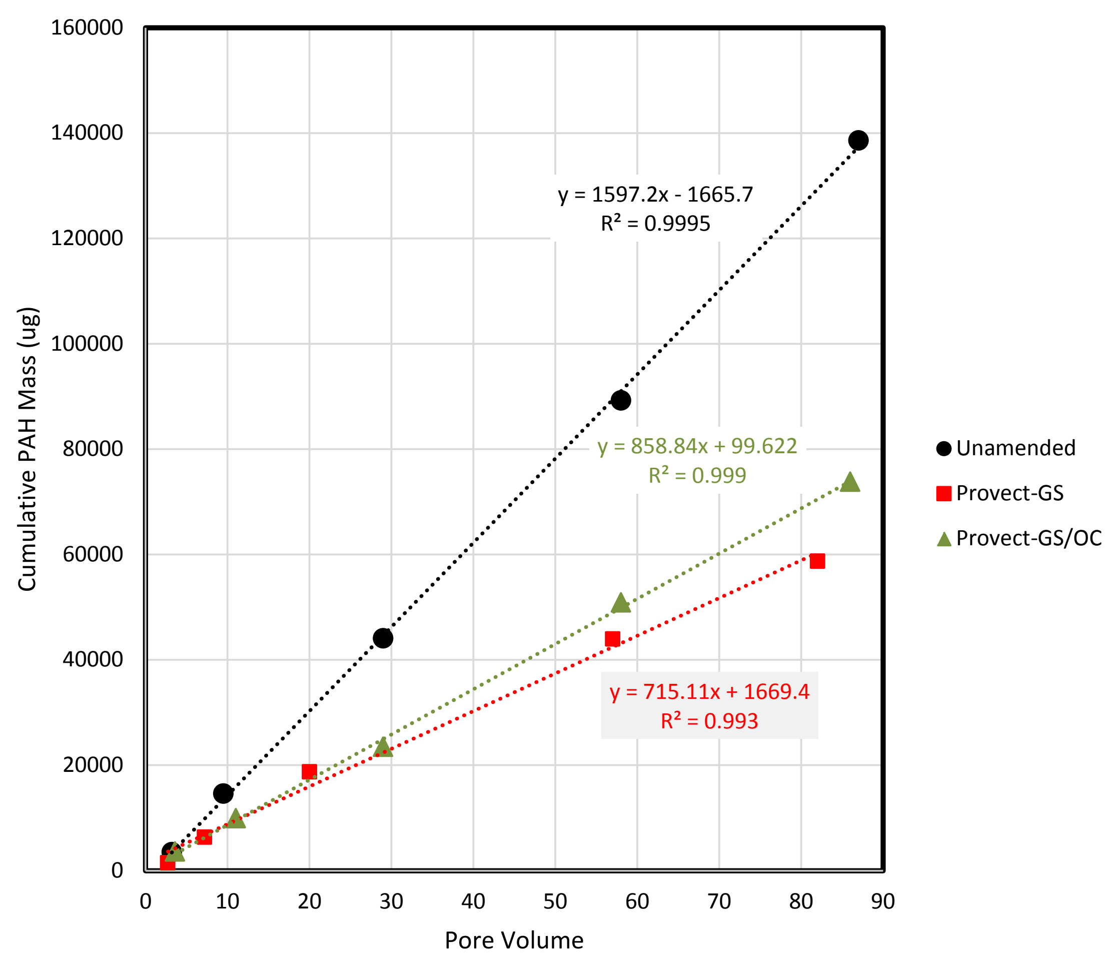
Figure 2. Cumulative naphthalene removal.



All three trials show a constant rate of naphthalene removal. However, the rate of removal for the reagent-amended columns is approximately one-half of the unamended naphthalene flushing rate. There is no significant difference as a result of the organoclay addition to the Provect-GS. By the end of the trial approximately 20-percent of the naphthalene mass had been removed from the unamended column based on the final cumulative mass removal of 111 mg, baseline soil concentration of 1,600 mg/kg and a soil mass of 0.35 kg in the column.

Several of the lower concentration PAHs listed in Table 6 appear to show an increase in concentration with flushing of the unamended column: acenaphthene, chrysene, fluoranthene, the methylated naphthalenes, phenanthrene and pyrene. These trends were not evident in the reagent-amended columns. The cumulative mass of quantified PAHs is presented on Figure 3.

Figure 3. Cumulative quantified PAH mass removal.



The slopes of all three trials are slightly greater than those of naphthalene alone, but there is still about a 50 % reduction in the PAH flushing rate with the addition of the reagents.

The difference in flushing rates between the two amendments may be slightly greater than of the naphthalene alone.

Conclusions.

The addition of organoclay in a series of batch experiments found that additional mixing energy would be required to incorporate the hydrophobic clay into the Provect-GS solution. Separation and settling of the clay was not observed and viscosity differences were minimal with clay addition. Mixing produced a frothy gel over the clay-amended reagent but the clay was not observed to aggregate. The clay was not observed to swell in the presence of the sodium in the sodium permanganate.

Both the Provect-GS and the Provect-GS/OC reduced the hydraulic conductivity of the amended soil by a factor of 48 times. The presence of the clay did not result in a measureable decrease in the hydraulic conductivity. Post-column flushing permeability reductions were also evident in the amended columns but the magnitude of the differences is uncertain due to physical disturbance of the columns during flushing.

The addition of the reagents reduced the leachable naphthalene concentrations by about 60-percent in the column trials. Both reagents also reduced the rate of naphthalene flushing by approximately 50-percent. There was no appreciable difference in the performance of the Provect-GS and the Provect-GS/OC.

Appendix A

Laboratory Reports

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Est. 1970

Angela Hassell
ReSolution Partners LLC
967 Jonathon Drive
Madison, WI 53713

Report Summary

Monday July 20, 2015

Report Number: L776653
Samples Received: 07/14/15
Client Project:

Description: Provect-GS/OC

The analytical results in this report are based upon information supplied by you, the client, and are for your exclusive use. If you have any questions regarding this data package, please do not hesitate to call.

Entire Report Reviewed By: John Hawkins

John Hawkins , ESC Representative

Laboratory Certification Numbers

A2LA - 1461-01, AIHA - 100789, AL - 40660, CA - 01157CA, CT - PH-0197,
FL - E87487, GA - 923, IN - C-TN-01, KY - 90010, KYUST - 0016,
NC - ENV375/DW21704/BIO041, ND - R-140. NJ - TN002, NJ NELAP - TN002,
SC - 84004, TN - 2006, VA - 460132, WV - 233, AZ - 0612,
MN - 047-999-395, NY - 11742, WI - 998093910, NV - TN000032011-1,
TX - T104704245-11-3, OK - 9915, PA - 68-02979, IA Lab #364, EPA - TN002

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REPORT OF ANALYSIS

Angela Hassell
ReSolution Partners LLC
967 Jonathon Drive
Madison, WI 53713

July 20,2015

ESC Sample # : L776653-01

Date Received : July 14, 2015
Description : Provect-GS/OC

Site ID :

Sample ID : HAWTHORN NAPL-PROCESS

Project # :

Collected By :
Collection Date : 07/13/15 13:00

Parameter	Dry Result	MDL	RDL	Units	Qualifier	Method	Date	Dil.
Total Solids	81.6	0.0333		%		2540 G-2	07/18/15	1
Polynuclear Aromatic Hydrocarbons								
Anthracene	220	0.30	3.7	mg/kg		8270C-SI	07/20/15	500
Acenaphthene	510	0.30	3.7	mg/kg		8270C-SI	07/20/15	500
Acenaphthylene	13.	0.30	3.7	mg/kg		8270C-SI	07/20/15	500
Benzo(a)anthracene	150	0.060	0.74	mg/kg		8270C-SI	07/19/15	100
Benzo(a)pyrene	43.	0.060	0.74	mg/kg		8270C-SI	07/19/15	100
Benzo(b)fluoranthene	71.	0.060	0.74	mg/kg		8270C-SI	07/19/15	100
Benzo(g,h,i)perylene	15.	0.060	0.74	mg/kg		8270C-SI	07/19/15	100
Benzo(k)fluoranthene	20.	0.060	0.74	mg/kg		8270C-SI	07/19/15	100
Chrysene	120	0.060	0.74	mg/kg		8270C-SI	07/19/15	100
Dibenz(a,h)anthracene	6.2	0.060	0.74	mg/kg		8270C-SI	07/19/15	100
Fluoranthene	540	0.30	3.7	mg/kg		8270C-SI	07/20/15	500
Fluorene	430	0.30	3.7	mg/kg		8270C-SI	07/20/15	500
Indeno(1,2,3-cd)pyrene	15.	0.060	0.74	mg/kg		8270C-SI	07/19/15	100
Naphthalene	1600	1.0	12.	mg/kg		8270C-SI	07/20/15	500
Phenanthrene	1200	0.30	3.7	mg/kg		8270C-SI	07/20/15	500
Pyrene	360	0.30	3.7	mg/kg		8270C-SI	07/20/15	500
1-Methylnaphthalene	440	0.20	2.4	mg/kg		8270C-SI	07/19/15	100
2-Methylnaphthalene	560	1.0	12.	mg/kg		8270C-SI	07/20/15	500
2-Chloronaphthalene	U	1.0	12.	mg/kg		8270C-SI	07/20/15	500
Surrogate Recovery								
p-Terphenyl-d14	60.5			% Rec.	J7	8270C-SI	07/19/15	100
Nitrobenzene-d5	128.			% Rec.	J7	8270C-SI	07/19/15	100
2-Fluorobiphenyl	116.			% Rec.	J7	8270C-SI	07/20/15	500

Results listed are dry weight basis.
U = ND (Not Detected)
MDL = Minimum Detection Limit = LOD = TRRP SDL
RDL = Reported Detection Limit = LOQ = PQL = EQL = TRRP MQL
Note:
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The reported analytical results relate only to the sample submitted
Reported: 07/20/15 12:28 Printed: 07/20/15 12:29

Attachment A
List of Analytes with QC Qualifiers

Sample Number	Work Group	Sample Type	Analyte	Run ID	Qualifier
L776653-01	WG802352	SAMP	p-Terphenyl-d14	R3051064	J7
	WG802352	SAMP	Nitrobenzene-d5	R3051064	J7
	WG802352	SAMP	2-Fluorobiphenyl	R3051176	J7

Attachment B
Explanation of QC Qualifier Codes

Qualifier	Meaning
J7	Surrogate recovery cannot be used for control limit evaluation due to dilution.

Qualifier Report Information

ESC utilizes sample and result qualifiers as set forth by the EPA Contract Laboratory Program and as required by most certifying bodies including NELAC. In addition to the EPA qualifiers adopted by ESC, we have implemented ESC qualifiers to provide more information pertaining to our analytical results. Each qualifier is designated in the qualifier explanation as either EPA or ESC.
Data qualifiers are intended to provide the ESC client with more detailed information concerning the potential bias of reported data. Because of the wide range of constituents and variety of matrices incorporated by most EPA methods,it is common for some compounds to fall outside of established ranges. These exceptions are evaluated and all reported data is valid and useable "unless qualified as 'R' (Rejected)."

Definitions

Accuracy - The relationship of the observed value of a known sample to the true value of a known sample. Represented by percent recovery and relevant to samples such as: control samples, matrix spike recoveries, surrogate recoveries, etc.

Precision - The agreement between a set of samples or between duplicate samples. Relates to how close together the results are and is represented by Relative Percent Differrence.

Surrogate - Organic compounds that are similar in chemical composition, extraction, and chromotography to analytes of interest. The surrogates are used to determine the probable response of the group of analytes that are chemically related to the surrogate compound. Surrogates are added to the sample and carried through all stages of preparation and analyses.

TIC - Tentatively Identified Compound: Compounds detected in samples that are not target compounds, internal standards, system monitoring compounds, or surrogates.

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ReSolution Partners LLC
Angela Hassell
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Quality Assurance Report
Level II

July 20, 2015

L776653

Laboratory Blank

Analyte	Result	Units	% Rec	Limit	Batch	Date Analyzed
1-Methylnaphthalene	< .02	mg/kg			WG802352	07/16/15 04:45
2-Chloronaphthalene	< .02	mg/kg			WG802352	07/16/15 04:45
2-Methylnaphthalene	< .02	mg/kg			WG802352	07/16/15 04:45
Acenaphthene	< .006	mg/kg			WG802352	07/16/15 04:45
Acenaphthylene	< .006	mg/kg			WG802352	07/16/15 04:45
Anthracene	< .006	mg/kg			WG802352	07/16/15 04:45
Benzo(a)anthracene	< .006	mg/kg			WG802352	07/16/15 04:45
Benzo(a)pyrene	< .006	mg/kg			WG802352	07/16/15 04:45
Benzo(b)fluoranthene	< .006	mg/kg			WG802352	07/16/15 04:45
Benzo(g,h,i)perylene	< .006	mg/kg			WG802352	07/16/15 04:45
Benzo(k)fluoranthene	< .006	mg/kg			WG802352	07/16/15 04:45
Chrysene	< .006	mg/kg			WG802352	07/16/15 04:45
Dibenz(a,h)anthracene	< .006	mg/kg			WG802352	07/16/15 04:45
Fluoranthene	< .006	mg/kg			WG802352	07/16/15 04:45
Fluorene	< .006	mg/kg			WG802352	07/16/15 04:45
Indeno(1,2,3-cd)pyrene	< .006	mg/kg			WG802352	07/16/15 04:45
Naphthalene	< .02	mg/kg			WG802352	07/16/15 04:45
Phenanthrene	< .006	mg/kg			WG802352	07/16/15 04:45
Pyrene	< .006	mg/kg			WG802352	07/16/15 04:45
2-Fluorobiphenyl		% Rec.	74.10	40.6-122	WG802352	07/16/15 04:45
Nitrobenzene-d5		% Rec.	90.60	22.1-146	WG802352	07/16/15 04:45
p-Terphenyl-d14		% Rec.	64.20	32.2-131	WG802352	07/16/15 04:45
Total Solids	< .1	%			WG802829	07/18/15 08:10

Duplicate

Analyte	Units	Result	Duplicate	RPD	Limit	Ref Samp	Batch
Total Solids	%	80.5	80.0	0.531	5	L776849-04	WG802829

Laboratory Control Sample

Analyte	Units	Known Val	Result	% Rec	Limit	Batch
1-Methylnaphthalene	mg/kg	.08	0.0627	78.4	50.6-122	WG802352
2-Chloronaphthalene	mg/kg	.08	0.0564	70.5	53.9-121	WG802352
2-Methylnaphthalene	mg/kg	.08	0.0599	74.9	50.4-120	WG802352
Acenaphthene	mg/kg	.08	0.0522	65.2	52.4-120	WG802352
Acenaphthylene	mg/kg	.08	0.0552	68.9	49.6-120	WG802352
Anthracene	mg/kg	.08	0.0651	81.4	50.3-130	WG802352
Benzo(a)anthracene	mg/kg	.08	0.0560	70.0	46.7-125	WG802352
Benzo(a)pyrene	mg/kg	.08	0.0619	77.3	42.3-119	WG802352
Benzo(b)fluoranthene	mg/kg	.08	0.0568	71.0	43.6-124	WG802352
Benzo(g,h,i)perylene	mg/kg	.08	0.0534	66.8	45.1-132	WG802352
Benzo(k)fluoranthene	mg/kg	.08	0.0631	78.9	46.1-131	WG802352
Chrysene	mg/kg	.08	0.0571	71.4	49.5-131	WG802352
Dibenz(a,h)anthracene	mg/kg	.08	0.0574	71.7	44.8-133	WG802352
Fluoranthene	mg/kg	.08	0.0641	80.2	49.3-128	WG802352
Fluorene	mg/kg	.08	0.0563	70.4	50.6-121	WG802352
Indeno(1,2,3-cd)pyrene	mg/kg	.08	0.0586	73.3	46.1-135	WG802352
Naphthalene	mg/kg	.08	0.0578	72.3	49.6-115	WG802352
Phenanthrene	mg/kg	.08	0.0539	67.3	48.8-121	WG802352
Pyrene	mg/kg	.08	0.0601	75.1	44.7-130	WG802352
2-Fluorobiphenyl				69.80	40.6-122	WG802352
Nitrobenzene-d5				85.20	22.1-146	WG802352
p-Terphenyl-d14				60.30	32.2-131	WG802352
Total Solids	%	50	50.0	100.	85-115	WG802829

* Performance of this Analyte is outside of established criteria.
For additional information, please see Attachment A 'List of Analytes with QC Qualifiers.'

ReSolution Partners LLC
Angela Hassell
967 Jonathon Drive

Madison, WI 53713

Quality Assurance Report
Level II

L776653

July 20, 2015

Analyte	Units	Laboratory Control Sample Duplicate Result	Ref	%Rec	Limit	RPD	Limit	Batch
1-Methylnaphthalene	mg/kg	0.0663	0.0627	83.0	50.6-122	5.63	20	WG802352
2-Chloronaphthalene	mg/kg	0.0594	0.0564	74.0	53.9-121	5.11	20	WG802352
2-Methylnaphthalene	mg/kg	0.0633	0.0599	79.0	50.4-120	5.46	20	WG802352
Acenaphthene	mg/kg	0.0551	0.0522	69.0	52.4-120	5.46	20	WG802352
Acenaphthylene	mg/kg	0.0581	0.0552	73.0	49.6-120	5.20	20	WG802352
Anthracene	mg/kg	0.0683	0.0651	85.0	50.3-130	4.71	20	WG802352
Benzo(a)anthracene	mg/kg	0.0592	0.0560	74.0	46.7-125	5.64	20	WG802352
Benzo(a)pyrene	mg/kg	0.0636	0.0619	80.0	42.3-119	2.81	20	WG802352
Benzo(b)fluoranthene	mg/kg	0.0610	0.0568	76.0	43.6-124	7.24	20	WG802352
Benzo(g,h,i)perylene	mg/kg	0.0565	0.0534	71.0	45.1-132	5.60	20	WG802352
Benzo(k)fluoranthene	mg/kg	0.0626	0.0631	78.0	46.1-131	0.940	20	WG802352
Chrysene	mg/kg	0.0584	0.0571	73.0	49.5-131	2.22	20	WG802352
Dibenz(a,h)anthracene	mg/kg	0.0601	0.0574	75.0	44.8-133	4.55	20	WG802352
Fluoranthene	mg/kg	0.0683	0.0641	85.0	49.3-128	6.31	20	WG802352
Fluorene	mg/kg	0.0589	0.0563	74.0	50.6-121	4.39	20	WG802352
Indeno(1,2,3-cd)pyrene	mg/kg	0.0609	0.0586	76.0	46.1-135	3.85	20	WG802352
Naphthalene	mg/kg	0.0610	0.0578	76.0	49.6-115	5.37	20	WG802352
Phenanthrene	mg/kg	0.0571	0.0539	71.0	48.8-121	5.81	20	WG802352
Pyrene	mg/kg	0.0628	0.0601	78.0	44.7-130	4.38	20	WG802352
2-Fluorobiphenyl				74.30	40.6-122			WG802352
Nitrobenzene-d5				92.00	22.1-146			WG802352
p-Terphenyl-d14				64.60	32.2-131			WG802352

Batch number /Run number / Sample number cross reference

WG802352: R3050266 R3051064 R3051176: L776653-01
WG802829: R3050896: L776653-01

* * Calculations are performed prior to rounding of reported values.
* Performance of this Analyte is outside of established criteria.
For additional information, please see Attachment A 'List of Analytes with QC Qualifiers.'

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Quality Assurance Report
Level II

July 20, 2015

L776653

The data package includes a summary of the analytic results of the quality control samples required by the SW-846 or CWA methods. The quality control samples include a method blank, a laboratory control sample, and the matrix spike/matrix spike duplicate analysis. If a target parameter is outside the method limits, every sample that is effected is flagged with the appropriate qualifier in Appendix B of the analytic report.

Method Blank - an aliquot of reagent water carried through the entire analytic process. The method blank results indicate if any possible contamination exposure during the sample handling, digestion or extraction process, and analysis. Concentrations of target analytes above the reporting limit in the method blank are qualified with the "B" qualifier.

Laboratory Control Sample - is a sample of known concentration that is carried through the digestion/extraction and analysis process. The percent recovery, expressed as a percentage of the theoretical concentration, has statistical control limits indicating that the analytic process is "in control". If a target analyte is outside the control limits for the laboratory control sample or any other control sample, the parameter is flagged with a "J4" qualifier for all effected samples.

Matrix Spike and Matrix Spike Duplicate - is two aliquots of an environmental sample that is spiked with known concentrations of target analytes. The percent recovery of the target analytes also has statistical control limits. If any recoveries that are outside the method control limits, the sample that was selected for matrix spike/matrix spike duplicate analysis is flagged with either a "J5" or a "J6". The relative percent difference (%RPD) between the matrix spike and the matrix spike duplicate recoveries is all calculated. If the RPD is above the method limit, the effected samples are flagged with a "J3" qualifier.

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Angela Hassell
ReSolution Partners LLC
967 Jonathon Drive
Madison, WI 53713

Report Summary

Tuesday August 18, 2015

Report Number: L781720
Samples Received: 08/08/15
Client Project:

Description: Provect-GS/OC

The analytical results in this report are based upon information supplied by you, the client, and are for your exclusive use. If you have any questions regarding this data package, please do not hesitate to call.

Entire Report Reviewed By: John Hawkins

John Hawkins , ESC Representative

Laboratory Certification Numbers

A2LA - 1461-01, AIHA - 100789, AL - 40660, CA - 01157CA, CT - PH-0197,
FL - E87487, GA - 923, IN - C-TN-01, KY - 90010, KYUST - 0016,
NC - ENV375/DW21704/BIO041, ND - R-140. NJ - TN002, NJ NELAP - TN002,
SC - 84004, TN - 2006, VA - 460132, WV - 233, AZ - 0612,
MN - 047-999-395, NY - 11742, WI - 998093910, NV - TN000032011-1,
TX - T104704245-11-3, OK - 9915, PA - 68-02979, IA Lab #364, EPA - TN002

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Angela Hassell
ReSolution Partners LLC
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Madison, WI 53713

Case Narrative

Tuesday August 18, 2015

Report Number: L781720
Samples Received: 08/08/15
Client Project:

Description: Provect-GS/OC

Sample Receiving

The samples were received in proper containers and in good condition.

The samples were received on ice (less than or equal to 6 degrees Celsuis), in properly preserved containers and in good condition.

Data

All samples were treated according to method protocol, no other treatment was necessary.

All Samples were extracted and analyzed within appropriate holding times.

QA/QC was within acceptable ranges. See Qualifiers where applicable.

ESC Level 2 Data Package

I certify that, for other than the conditions detailed herein, this data package is in compliance with the terms and conditions of this Agreement, both technically and for completeness. Release of this data has been authorized by the Laboratory Manager or his designee.

Other Comments

Please note Naphthalene results impacted by contamination in the Batch QC, Sample results are qualified for naphthalene contamination. Blank at 3.2 ppb (RL is 0.25ppb) LCS @ 266% recovery LCSD @ 298% recovery ; JVH 8-17-15

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REPORT OF ANALYSIS

Angela Hassell
ReSolution Partners LLC
967 Jonathon Drive
Madison, WI 53713

August 18, 2015

ESC Sample # : L781720-01

Date Received : August 08, 2015
Description : Provect-GS/OC

Site ID :

Sample ID : 3PV UNAMENDED

Project # :

Collected By :
Collection Date : 07/27/15 14:00

Parameter	Result	Det. Limit	Units	Method	Date	Dil.
Polynuclear Aromatic Hydrocarbons						
Anthracene	0.0273	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Acenaphthene	0.404	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Acenaphthylene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Benzo(a)anthracene	0.000238	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Benzo(a)pyrene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Benzo(b)fluoranthene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Benzo(g,h,i)perylene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Benzo(k)fluoranthene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Chrysene	0.000137	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Dibenz(a,h)anthracene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Fluoranthene	0.00776	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Fluorene	0.187	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Indeno(1,2,3-cd)pyrene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Naphthalene	8.68	0.250	mg/l	8270 C-SIM	08/18/15	1000
Phenanthrene	0.132	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Pyrene	0.00509	0.0000500	mg/l	8270 C-SIM	08/14/15	1
1-Methylnaphthalene	0.517	0.250	mg/l	8270 C-SIM	08/18/15	1000
2-Methylnaphthalene	0.793	0.250	mg/l	8270 C-SIM	08/18/15	1000
2-Chloronaphthalene	BDL	0.250	mg/l	8270 C-SIM	08/18/15	1000
Surrogate Recovery						
Nitrobenzene-d5	38.6		% Rec.	8270 C-SIM	08/18/15	1000
2-Fluorobiphenyl	86.0		% Rec.	8270 C-SIM	08/18/15	1000
p-Terphenyl-d14	56.9		% Rec.	8270 C-SIM	08/14/15	1

BDL - Below Detection Limit
Det. Limit - Practical Quantitation Limit(PQL)
Note:
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REPORT OF ANALYSIS

Angela Hassell
ReSolution Partners LLC
967 Jonathon Drive
Madison, WI 53713

August 18, 2015

ESC Sample # : L781720-02

Date Received : August 08, 2015
Description : Provect-GS/OC

Site ID :

Sample ID : 9PV UNAMENDED

Project # :

Collected By :
Collection Date : 07/28/15 11:30

Parameter	Result	Det. Limit	Units	Method	Date	Dil.
Polynuclear Aromatic Hydrocarbons						
Anthracene	0.0311	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Acenaphthene	0.662	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Acenaphthylene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Benzo(a)anthracene	0.000265	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Benzo(a)pyrene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Benzo(b)fluoranthene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Benzo(g,h,i)perylene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Benzo(k)fluoranthene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Chrysene	0.000165	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Dibenz(a,h)anthracene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Fluoranthene	0.00976	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Fluorene	0.308	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Indeno(1,2,3-cd)pyrene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Naphthalene	14.2	0.250	mg/l	8270 C-SIM	08/18/15	1000
Phenanthrene	0.276	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Pyrene	0.00764	0.0000500	mg/l	8270 C-SIM	08/14/15	1
1-Methylnaphthalene	0.866	0.250	mg/l	8270 C-SIM	08/18/15	1000
2-Methylnaphthalene	1.36	0.250	mg/l	8270 C-SIM	08/18/15	1000
2-Chloronaphthalene	BDL	0.250	mg/l	8270 C-SIM	08/18/15	1000
Surrogate Recovery						
Nitrobenzene-d5	488.		% Rec.	8270 C-SIM	08/18/15	1000
2-Fluorobiphenyl	155.		% Rec.	8270 C-SIM	08/18/15	1000
p-Terphenyl-d14	70.1		% Rec.	8270 C-SIM	08/14/15	1

BDL - Below Detection Limit
Det. Limit - Practical Quantitation Limit(PQL)
Note:
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REPORT OF ANALYSIS

Angela Hassell
ReSolution Partners LLC
967 Jonathon Drive
Madison, WI 53713

August 18, 2015

ESC Sample # : L781720-03

Date Received : August 08, 2015
Description : Provect-GS/OC

Site ID :

Sample ID : 36PV UNAMENDED

Project # :

Collected By :
Collection Date : 07/29/15 13:30

Parameter	Result	Det. Limit	Units	Method	Date	Dil.
Polynuclear Aromatic Hydrocarbons						
Anthracene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Acenaphthene	0.605	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Acenaphthylene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Benzo(a)anthracene	0.000213	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Benzo(a)pyrene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Benzo(b)fluoranthene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Benzo(g,h,i)perylene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Benzo(k)fluoranthene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Chrysene	0.000208	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Dibenz(a,h)anthracene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Fluoranthene	0.0144	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Fluorene	0.277	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Indeno(1,2,3-cd)pyrene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Naphthalene	12.1	0.250	mg/l	8270 C-SIM	08/18/15	1000
Phenanthrene	0.273	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Pyrene	0.00846	0.0000500	mg/l	8270 C-SIM	08/14/15	1
1-Methylnaphthalene	0.710	0.250	mg/l	8270 C-SIM	08/18/15	1000
2-Methylnaphthalene	1.13	0.250	mg/l	8270 C-SIM	08/18/15	1000
2-Chloronaphthalene	BDL	0.250	mg/l	8270 C-SIM	08/18/15	1000
Surrogate Recovery						
Nitrobenzene-d5	20.0		% Rec.	8270 C-SIM	08/18/15	1000
2-Fluorobiphenyl	137.		% Rec.	8270 C-SIM	08/18/15	1000
p-Terphenyl-d14	71.1		% Rec.	8270 C-SIM	08/14/15	1

BDL - Below Detection Limit
Det. Limit - Practical Quantitation Limit(PQL)
Note:
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REPORT OF ANALYSIS

Angela Hassell
ReSolution Partners LLC
967 Jonathon Drive
Madison, WI 53713

August 18, 2015

ESC Sample # : L781720-04

Date Received : August 08, 2015
Description : Provect-GS/OC

Site ID :

Sample ID : 72PV UNAMENDED

Project # :

Collected By :
Collection Date : 07/30/15 13:30

Parameter	Result	Det. Limit	Units	Method	Date	Dil.
Polynuclear Aromatic Hydrocarbons						
Anthracene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Acenaphthene	0.604	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Acenaphthylene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Benzo(a)anthracene	0.000231	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Benzo(a)pyrene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Benzo(b)fluoranthene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Benzo(g,h,i)perylene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Benzo(k)fluoranthene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Chrysene	0.000190	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Dibenz(a,h)anthracene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Fluoranthene	0.0185	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Fluorene	0.264	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Indeno(1,2,3-cd)pyrene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Naphthalene	12.5	0.250	mg/l	8270 C-SIM	08/18/15	1000
Phenanthrene	0.275	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Pyrene	0.0105	0.0000500	mg/l	8270 C-SIM	08/14/15	1
1-Methylnaphthalene	0.720	0.250	mg/l	8270 C-SIM	08/18/15	1000
2-Methylnaphthalene	1.16	0.250	mg/l	8270 C-SIM	08/18/15	1000
2-Chloronaphthalene	BDL	0.250	mg/l	8270 C-SIM	08/18/15	1000
Surrogate Recovery						
Nitrobenzene-d5	69.7		% Rec.	8270 C-SIM	08/18/15	1000
2-Fluorobiphenyl	135.		% Rec.	8270 C-SIM	08/18/15	1000
p-Terphenyl-d14	70.9		% Rec.	8270 C-SIM	08/14/15	1

BDL - Below Detection Limit
Det. Limit - Practical Quantitation Limit(PQL)
Note:
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REPORT OF ANALYSIS

Angela Hassell
ReSolution Partners LLC
967 Jonathon Drive
Madison, WI 53713

August 18, 2015

ESC Sample # : L781720-05

Date Received : August 08, 2015
Description : Provect-GS/OC

Site ID :

Sample ID : 108PV UNAMENDED

Project # :

Collected By :
Collection Date : 07/31/15 13:30

Parameter	Result	Det. Limit	Units	Method	Date	Dil.
Polynuclear Aromatic Hydrocarbons						
Anthracene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Acenaphthene	0.692	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Acenaphthylene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Benzo(a)anthracene	0.000236	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Benzo(a)pyrene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Benzo(b)fluoranthene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Benzo(g,h,i)perylene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Benzo(k)fluoranthene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Chrysene	0.000189	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Dibenz(a,h)anthracene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Fluoranthene	0.0206	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Fluorene	0.302	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Indeno(1,2,3-cd)pyrene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Naphthalene	13.6	0.250	mg/l	8270 C-SIM	08/18/15	1000
Phenanthrene	0.295	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Pyrene	0.0120	0.0000500	mg/l	8270 C-SIM	08/14/15	1
1-Methylnaphthalene	0.790	0.250	mg/l	8270 C-SIM	08/18/15	1000
2-Methylnaphthalene	1.31	0.250	mg/l	8270 C-SIM	08/18/15	1000
2-Chloronaphthalene	BDL	0.250	mg/l	8270 C-SIM	08/18/15	1000
Surrogate Recovery						
Nitrobenzene-d5	20.5		% Rec.	8270 C-SIM	08/18/15	1000
2-Fluorobiphenyl	127.		% Rec.	8270 C-SIM	08/18/15	1000
p-Terphenyl-d14	73.2		% Rec.	8270 C-SIM	08/14/15	1

BDL - Below Detection Limit
Det. Limit - Practical Quantitation Limit(PQL)
Note:
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REPORT OF ANALYSIS

Angela Hassell
ReSolution Partners LLC
967 Jonathon Drive
Madison, WI 53713

August 18, 2015

ESC Sample # : L781720-06

Date Received : August 08, 2015
Description : Provect-GS/OC

Site ID :

Sample ID : ISGS/P-GS 4.5% 3PV

Project # :

Collected By :
Collection Date : 07/27/15 14:05

Parameter	Result	Det. Limit	Units	Method	Date	Dil.
Polynuclear Aromatic Hydrocarbons						
Anthracene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Acenaphthene	0.182	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Acenaphthylene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Benzo(a)anthracene	0.000594	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Benzo(a)pyrene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Benzo(b)fluoranthene	0.000142	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Benzo(g,h,i)perylene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Benzo(k)fluoranthene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Chrysene	0.000274	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Dibenz(a,h)anthracene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Fluoranthene	0.00711	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Fluorene	0.106	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Indeno(1,2,3-cd)pyrene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Naphthalene	4.36	0.250	mg/l	8270 C-SIM	08/18/15	1000
Phenanthrene	0.132	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Pyrene	0.00540	0.0000500	mg/l	8270 C-SIM	08/14/15	1
1-Methylnaphthalene	0.278	0.250	mg/l	8270 C-SIM	08/18/15	1000
2-Methylnaphthalene	0.407	0.250	mg/l	8270 C-SIM	08/18/15	1000
2-Chloronaphthalene	BDL	0.250	mg/l	8270 C-SIM	08/18/15	1000
Surrogate Recovery						
Nitrobenzene-d5	19.6		% Rec.	8270 C-SIM	08/18/15	1000
2-Fluorobiphenyl	117.		% Rec.	8270 C-SIM	08/18/15	1000
p-Terphenyl-d14	66.1		% Rec.	8270 C-SIM	08/14/15	1

BDL - Below Detection Limit
Det. Limit - Practical Quantitation Limit(PQL)
Note:
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REPORT OF ANALYSIS

Angela Hassell
ReSolution Partners LLC
967 Jonathon Drive
Madison, WI 53713

August 18, 2015

Date Received : August 08, 2015
Description : Provect-GS/OC

Sample ID : ISGS/P-GS 4.5% 9PV

Collected By :
Collection Date : 07/29/15 08:00

ESC Sample # : L781720-07

Site ID :

Project # :

Parameter	Result	Det. Limit	Units	Method	Date	Dil.
Polynuclear Aromatic Hydrocarbons						
Anthracene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Acenaphthene	0.465	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Acenaphthylene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Benzo(a)anthracene	0.000427	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Benzo(a)pyrene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Benzo(b)fluoranthene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Benzo(g,h,i)perylene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Benzo(k)fluoranthene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Chrysene	0.000320	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Dibenz(a,h)anthracene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Fluoranthene	0.0309	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Fluorene	0.200	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Indeno(1,2,3-cd)pyrene	BDL	0.0000500	mg/l	8270 C-SIM	08/14/15	1
Naphthalene	7.99	0.250	mg/l	8270 C-SIM	08/18/15	1000
Phenanthrene	0.363	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Pyrene	0.0168	0.0000500	mg/l	8270 C-SIM	08/14/15	1
1-Methylnaphthalene	0.622	0.250	mg/l	8270 C-SIM	08/18/15	1000
2-Methylnaphthalene	1.03	0.250	mg/l	8270 C-SIM	08/18/15	1000
2-Chloronaphthalene	BDL	0.250	mg/l	8270 C-SIM	08/18/15	1000
Surrogate Recovery						
Nitrobenzene-d5	0.00		% Rec.	8270 C-SIM	08/18/15	1000
2-Fluorobiphenyl	116.		% Rec.	8270 C-SIM	08/18/15	1000
p-Terphenyl-d14	76.0		% Rec.	8270 C-SIM	08/14/15	1

BDL - Below Detection Limit
Det. Limit - Practical Quantitation Limit(PQL)
Note:
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REPORT OF ANALYSIS

Angela Hassell
ReSolution Partners LLC
967 Jonathon Drive
Madison, WI 53713

August 18, 2015

ESC Sample # : L781720-08

Date Received : August 08, 2015
Description : Provect-GS/OC

Site ID :

Sample ID : ISGS/P-GS 4.5% 36PV

Project # :

Collected By :
Collection Date : 07/31/15 13:30

Parameter	Result	Det. Limit	Units	Method	Date	Dil.
Polynuclear Aromatic Hydrocarbons						
Anthracene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Acenaphthene	0.258	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Acenaphthylene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Benzo(a)anthracene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Benzo(a)pyrene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Benzo(b)fluoranthene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Benzo(g,h,i)perylene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Benzo(k)fluoranthene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Chrysene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Dibenz(a,h)anthracene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Fluoranthene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Fluorene	0.125	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Indeno(1,2,3-cd)pyrene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Naphthalene	7.90	0.250	mg/l	8270 C-SIM	08/18/15	1000
Phenanthrene	0.160	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Pyrene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
1-Methylnaphthalene	0.537	0.250	mg/l	8270 C-SIM	08/18/15	1000
2-Methylnaphthalene	0.698	0.250	mg/l	8270 C-SIM	08/18/15	1000
2-Chloronaphthalene	BDL	0.250	mg/l	8270 C-SIM	08/18/15	1000
Surrogate Recovery						
Nitrobenzene-d5	0.00		% Rec.	8270 C-SIM	08/18/15	1000
2-Fluorobiphenyl	119.		% Rec.	8270 C-SIM	08/18/15	1000
p-Terphenyl-d14	103.		% Rec.	8270 C-SIM	08/18/15	1000

BDL - Below Detection Limit
Det. Limit - Practical Quantitation Limit(PQL)
Note:
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L781720-08 (8270PAHSIM) - Dilution due to matrix

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REPORT OF ANALYSIS

Angela Hassell
ReSolution Partners LLC
967 Jonathon Drive
Madison, WI 53713

August 18, 2015

ESC Sample # : L781720-09

Date Received : August 08, 2015
Description : Provect-GS/OC

Site ID :

Sample ID : ISGS/P-GS 4.5% 72PV

Project # :

Collected By :
Collection Date : 08/05/15 08:30

Parameter	Result	Det. Limit	Units	Method	Date	Dil.
Polynuclear Aromatic Hydrocarbons						
Anthracene	0.013	0.000050	mg/l	8270 C-SIM	08/11/15	1
Benzo(a)anthracene	0.00073	0.000050	mg/l	8270 C-SIM	08/11/15	1
Benzo(a)pyrene	BDL	0.000050	mg/l	8270 C-SIM	08/11/15	1
Benzo(b)fluoranthene	BDL	0.000050	mg/l	8270 C-SIM	08/11/15	1
Benzo(g,h,i)perylene	BDL	0.000050	mg/l	8270 C-SIM	08/11/15	1
Benzo(k)fluoranthene	BDL	0.000050	mg/l	8270 C-SIM	08/11/15	1
Chrysene	0.00035	0.000050	mg/l	8270 C-SIM	08/11/15	1
Dibenz(a,h)anthracene	BDL	0.000050	mg/l	8270 C-SIM	08/11/15	1
Fluoranthene	0.020	0.000050	mg/l	8270 C-SIM	08/11/15	1
Indeno(1,2,3-cd)pyrene	BDL	0.000050	mg/l	8270 C-SIM	08/11/15	1
Pyrene	0.011	0.000050	mg/l	8270 C-SIM	08/11/15	1
Surrogate Recovery						
p-Terphenyl-d14	91.5		% Rec.	8270 C-SIM	08/11/15	1
Polynuclear Aromatic Hydrocarbons						
Acenaphthene	0.196	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Acenaphthylene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Fluorene	0.0971	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Naphthalene	5.54	0.250	mg/l	8270 C-SIM	08/18/15	1000
Phenanthrene	0.132	0.0500	mg/l	8270 C-SIM	08/18/15	1000
1-Methylnaphthalene	0.340	0.250	mg/l	8270 C-SIM	08/18/15	1000
2-Methylnaphthalene	0.479	0.250	mg/l	8270 C-SIM	08/18/15	1000
2-Chloronaphthalene	BDL	0.250	mg/l	8270 C-SIM	08/18/15	1000
Surrogate Recovery						
Nitrobenzene-d5	0.00		% Rec.	8270 C-SIM	08/18/15	1000
2-Fluorobiphenyl	101.		% Rec.	8270 C-SIM	08/18/15	1000

BDL - Below Detection Limit
Det. Limit - Practical Quantitation Limit(PQL)
Note:
The reported analytical results relate only to the sample submitted.
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Reported: 08/18/15 20:19 Printed: 08/18/15 20:20
L781720-09 (8270PAHSIM) - Dilution due to matrix

REPORT OF ANALYSIS

Angela Hassell
ReSolution Partners LLC
967 Jonathon Drive
Madison, WI 53713

August 18, 2015

ESC Sample # : L781720-10

Date Received : August 08, 2015
Description : Provect-GS/OC

Site ID :

Sample ID : ISGS/P-GS 4.5% 108PV

Project # :

Collected By :
Collection Date : 08/07/15 13:30

Parameter	Result	Det. Limit	Units	Method	Date	Dil.
Polynuclear Aromatic Hydrocarbons						
Anthracene	0.020	0.000050	mg/l	8270 C-SIM	08/11/15	1
Acenaphthene	0.16	0.0010	mg/l	8270 C-SIM	08/11/15	20
Acenaphthylene	0.0023	0.0010	mg/l	8270 C-SIM	08/11/15	20
Benzo(a)anthracene	0.00048	0.000050	mg/l	8270 C-SIM	08/11/15	1
Benzo(a)pyrene	BDL	0.000050	mg/l	8270 C-SIM	08/11/15	1
Benzo(b)fluoranthene	BDL	0.000050	mg/l	8270 C-SIM	08/11/15	1
Benzo(g,h,i)perylene	BDL	0.000050	mg/l	8270 C-SIM	08/11/15	1
Benzo(k)fluoranthene	BDL	0.000050	mg/l	8270 C-SIM	08/11/15	1
Chrysene	0.00014	0.000050	mg/l	8270 C-SIM	08/11/15	1
Dibenz(a,h)anthracene	BDL	0.000050	mg/l	8270 C-SIM	08/11/15	1
Fluoranthene	0.012	0.000050	mg/l	8270 C-SIM	08/11/15	1
Fluorene	0.081	0.0010	mg/l	8270 C-SIM	08/11/15	20
Indeno(1,2,3-cd)pyrene	BDL	0.000050	mg/l	8270 C-SIM	08/11/15	1
Phenanthrene	0.10	0.0010	mg/l	8270 C-SIM	08/11/15	20
Pyrene	0.0060	0.000050	mg/l	8270 C-SIM	08/11/15	1
1-Methylnaphthalene	0.22	0.0050	mg/l	8270 C-SIM	08/11/15	20
2-Methylnaphthalene	0.35	0.0050	mg/l	8270 C-SIM	08/11/15	20
2-Chloronaphthalene	BDL	0.0050	mg/l	8270 C-SIM	08/11/15	20
Surrogate Recovery						
Nitrobenzene-d5	54.1		% Rec.	8270 C-SIM	08/11/15	20
2-Fluorobiphenyl	60.8		% Rec.	8270 C-SIM	08/11/15	20
p-Terphenyl-d14	93.7		% Rec.	8270 C-SIM	08/11/15	1
Polynuclear Aromatic Hydrocarbons						
Naphthalene	4.89	0.250	mg/l	8270 C-SIM	08/18/15	1000
Surrogate Recovery						

BDL - Below Detection Limit
Det. Limit - Practical Quantitation Limit(PQL)
Note:
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Reported: 08/18/15 20:19 Printed: 08/18/15 20:20
L781720-10 (8270PAHSIM) - Dilution due to matrix

REPORT OF ANALYSIS

Angela Hassell
ReSolution Partners LLC
967 Jonathon Drive
Madison, WI 53713

August 18, 2015

ESC Sample # : L781720-11

Date Received : August 08, 2015
Description : Provect-GS/OC

Site ID :

Sample ID : P-GS/OC 4.5% 3PV

Project # :

Collected By :
Collection Date : 07/27/15 14:10

Parameter	Result	Det. Limit	Units	Method	Date	Dil.
Polynuclear Aromatic Hydrocarbons						
Anthracene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Acenaphthene	0.415	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Acenaphthylene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Benzo(a)anthracene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Benzo(a)pyrene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Benzo(b)fluoranthene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Benzo(g,h,i)perylene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Benzo(k)fluoranthene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Chrysene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Dibenz(a,h)anthracene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Fluoranthene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Fluorene	0.175	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Indeno(1,2,3-cd)pyrene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Naphthalene	7.59	0.250	mg/l	8270 C-SIM	08/18/15	1000
Phenanthrene	0.282	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Pyrene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
1-Methylnaphthalene	0.588	0.250	mg/l	8270 C-SIM	08/18/15	1000
2-Methylnaphthalene	0.959	0.250	mg/l	8270 C-SIM	08/18/15	1000
2-Chloronaphthalene	BDL	0.250	mg/l	8270 C-SIM	08/18/15	1000
Surrogate Recovery						
Nitrobenzene-d5	0.00		% Rec.	8270 C-SIM	08/18/15	1000
2-Fluorobiphenyl	90.3		% Rec.	8270 C-SIM	08/18/15	1000
p-Terphenyl-d14	99.9		% Rec.	8270 C-SIM	08/18/15	1000

BDL - Below Detection Limit
Det. Limit - Practical Quantitation Limit(PQL)
Note:
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Reported: 08/18/15 20:19 Printed: 08/18/15 20:20
L781720-11 (8270PAHSIM) - Dilution due to matrix

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Tax I.D. 62-0814289

Est. 1970

REPORT OF ANALYSIS

Angela Hassell
ReSolution Partners LLC
967 Jonathon Drive
Madison, WI 53713

August 18, 2015

ESC Sample # : L781720-12

Date Received : August 08, 2015
Description : Provect-GS/OC

Site ID :

Sample ID : P-GS/OC 4.5% 9PV

Project # :

Collected By :
Collection Date : 07/28/15 11:30

Parameter	Result	Det. Limit	Units	Method	Date	Dil.
Polynuclear Aromatic Hydrocarbons						
Anthracene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Acenaphthene	0.232	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Acenaphthylene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Benzo(a)anthracene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Benzo(a)pyrene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Benzo(b)fluoranthene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Benzo(g,h,i)perylene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Benzo(k)fluoranthene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Chrysene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Dibenz(a,h)anthracene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Fluoranthene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Fluorene	0.118	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Indeno(1,2,3-cd)pyrene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Naphthalene	6.99	0.250	mg/l	8270 C-SIM	08/18/15	1000
Phenanthrene	0.148	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Pyrene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
1-Methylnaphthalene	0.425	0.250	mg/l	8270 C-SIM	08/18/15	1000
2-Methylnaphthalene	0.607	0.250	mg/l	8270 C-SIM	08/18/15	1000
2-Chloronaphthalene	BDL	0.250	mg/l	8270 C-SIM	08/18/15	1000
Surrogate Recovery						
Nitrobenzene-d5	0.00		% Rec.	8270 C-SIM	08/18/15	1000
2-Fluorobiphenyl	138.		% Rec.	8270 C-SIM	08/18/15	1000
p-Terphenyl-d14	109.		% Rec.	8270 C-SIM	08/18/15	1000

BDL - Below Detection Limit
Det. Limit - Practical Quantitation Limit(PQL)
Note:
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L781720-12 (8270PAHSIM) - Dilution due to matrix

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Tax I.D. 62-0814289

Est. 1970

REPORT OF ANALYSIS

Angela Hassell
ReSolution Partners LLC
967 Jonathon Drive
Madison, WI 53713

August 18, 2015

ESC Sample # : L781720-13

Date Received : August 08, 2015
Description : Provect-GS/OC

Site ID :

Sample ID : P-GS/OC 4.5% 36PV

Project # :

Collected By :
Collection Date : 07/29/15 13:20

Parameter	Result	Det. Limit	Units	Method	Date	Dil.
Polynuclear Aromatic Hydrocarbons						
Anthracene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Acenaphthene	0.373	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Acenaphthylene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Benzo(a)anthracene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Benzo(a)pyrene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Benzo(b)fluoranthene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Benzo(g,h,i)perylene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Benzo(k)fluoranthene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Chrysene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Dibenz(a,h)anthracene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Fluoranthene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Fluorene	0.161	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Indeno(1,2,3-cd)pyrene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Naphthalene	5.46	0.250	mg/l	8270 C-SIM	08/18/15	1000
Phenanthrene	0.277	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Pyrene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
1-Methylnaphthalene	0.470	0.250	mg/l	8270 C-SIM	08/18/15	1000
2-Methylnaphthalene	0.790	0.250	mg/l	8270 C-SIM	08/18/15	1000
2-Chloronaphthalene	BDL	0.250	mg/l	8270 C-SIM	08/18/15	1000
Surrogate Recovery						
Nitrobenzene-d5	0.00		% Rec.	8270 C-SIM	08/18/15	1000
2-Fluorobiphenyl	97.8		% Rec.	8270 C-SIM	08/18/15	1000
p-Terphenyl-d14	75.4		% Rec.	8270 C-SIM	08/18/15	1000

BDL - Below Detection Limit
Det. Limit - Practical Quantitation Limit(PQL)
Note:
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Reported: 08/18/15 20:19 Printed: 08/18/15 20:20
L781720-13 (8270PAHSIM) - Dilution due to matrix

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(615) 758-5858
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Fax (615) 758-5859

Tax I.D. 62-0814289

Est. 1970

REPORT OF ANALYSIS

Angela Hassell
ReSolution Partners LLC
967 Jonathon Drive
Madison, WI 53713

August 18, 2015

ESC Sample # : L781720-14

Date Received : August 08, 2015
Description : Provect-GS/OC

Site ID :

Sample ID : P-GS/OC 4.5% 72PV

Project # :

Collected By :
Collection Date : 07/30/15 13:30

Parameter	Result	Det. Limit	Units	Method	Date	Dil.
Polynuclear Aromatic Hydrocarbons						
Anthracene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Acenaphthene	0.484	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Acenaphthylene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Benzo(a)anthracene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Benzo(a)pyrene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Benzo(b)fluoranthene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Benzo(g,h,i)perylene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Benzo(k)fluoranthene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Chrysene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Dibenz(a,h)anthracene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Fluoranthene	0.0554	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Fluorene	0.209	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Indeno(1,2,3-cd)pyrene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Naphthalene	6.76	0.250	mg/l	8270 C-SIM	08/18/15	1000
Phenanthrene	0.343	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Pyrene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
1-Methylnaphthalene	0.590	0.250	mg/l	8270 C-SIM	08/18/15	1000
2-Methylnaphthalene	1.01	0.250	mg/l	8270 C-SIM	08/18/15	1000
2-Chloronaphthalene	BDL	0.250	mg/l	8270 C-SIM	08/18/15	1000
Surrogate Recovery						
Nitrobenzene-d5	0.00		% Rec.	8270 C-SIM	08/18/15	1000
2-Fluorobiphenyl	117.		% Rec.	8270 C-SIM	08/18/15	1000
p-Terphenyl-d14	86.7		% Rec.	8270 C-SIM	08/18/15	1000

BDL - Below Detection Limit
Det. Limit - Practical Quantitation Limit(PQL)
Note:
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Reported: 08/18/15 20:19 Printed: 08/18/15 20:20
L781720-14 (8270PAHSIM) - Dilution due to matrix

REPORT OF ANALYSIS

Angela Hassell
ReSolution Partners LLC
967 Jonathon Drive
Madison, WI 53713

August 18, 2015

ESC Sample # : L781720-15

Date Received : August 08, 2015
Description : Provect-GS/OC

Sample ID : P-GS/OC 4.5% 108PV

Collected By :
Collection Date : 07/31/15 13:30

Site ID :

Project # :

Parameter	Result	Det. Limit	Units	Method	Date	Dil.
Polynuclear Aromatic Hydrocarbons						
Anthracene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Acenaphthene	0.450	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Acenaphthylene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Benzo(a)anthracene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Benzo(a)pyrene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Benzo(b)fluoranthene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Benzo(g,h,i)perylene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Benzo(k)fluoranthene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Chrysene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Dibenz(a,h)anthracene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Fluoranthene	0.0602	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Fluorene	0.201	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Indeno(1,2,3-cd)pyrene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Naphthalene	5.68	0.250	mg/l	8270 C-SIM	08/18/15	1000
Phenanthrene	0.370	0.0500	mg/l	8270 C-SIM	08/18/15	1000
Pyrene	BDL	0.0500	mg/l	8270 C-SIM	08/18/15	1000
1-Methylnaphthalene	0.517	0.250	mg/l	8270 C-SIM	08/18/15	1000
2-Methylnaphthalene	0.899	0.250	mg/l	8270 C-SIM	08/18/15	1000
2-Chloronaphthalene	BDL	0.250	mg/l	8270 C-SIM	08/18/15	1000
Surrogate Recovery						
Nitrobenzene-d5	0.00		% Rec.	8270 C-SIM	08/18/15	1000
2-Fluorobiphenyl	151.		% Rec.	8270 C-SIM	08/18/15	1000
p-Terphenyl-d14	116.		% Rec.	8270 C-SIM	08/18/15	1000

BDL - Below Detection Limit
Det. Limit - Practical Quantitation Limit(PQL)
Note:
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Reported: 08/18/15 20:19 Printed: 08/18/15 20:20
L781720-15 (8270PAHSIM) - Dilution due to matrix

Attachment A
List of Analytes with QC Qualifiers

Sample Number	Work Group	Sample Type	Analyte	Run ID	Qualifier
L781720-01	WG808695	SAMP	Anthracene	R3063344	T8
	WG808695	SAMP	Acenaphthene	R3063700	T8
	WG808695	SAMP	Acenaphthylene	R3063700	T8
	WG808695	SAMP	Benzo(a)anthracene	R3063344	T8
	WG808695	SAMP	Benzo(a)pyrene	R3063344	T8
	WG808695	SAMP	Benzo(b)fluoranthene	R3063344	T8
	WG808695	SAMP	Benzo(g,h,i)perylene	R3063344	J3T8
	WG808695	SAMP	Benzo(k)fluoranthene	R3063344	T8
	WG808695	SAMP	Chrysene	R3063344	T8
	WG808695	SAMP	Dibenz(a,h)anthracene	R3063344	J3T8
	WG808695	SAMP	Fluoranthene	R3063344	T8
	WG808695	SAMP	Fluorene	R3063700	T8
	WG808695	SAMP	Indeno(1,2,3-cd)pyrene	R3063344	T8
	WG808695	SAMP	Naphthalene	R3063700	J4BT8
	WG808695	SAMP	Phenanthrene	R3063700	T8
	WG808695	SAMP	Pyrene	R3063344	T8
	WG808695	SAMP	1-Methylnaphthalene	R3063700	T8
	WG808695	SAMP	2-Methylnaphthalene	R3063700	T8
	WG808695	SAMP	2-Chloronaphthalene	R3063700	T8
	WG808695	SAMP	Nitrobenzene-d5	R3063700	J7
	WG808695	SAMP	2-Fluorobiphenyl	R3063700	J7
L781720-02	WG808695	SAMP	Anthracene	R3063344	T8
	WG808695	SAMP	Acenaphthene	R3063700	T8
	WG808695	SAMP	Acenaphthylene	R3063700	T8
	WG808695	SAMP	Benzo(a)anthracene	R3063344	T8
	WG808695	SAMP	Benzo(a)pyrene	R3063344	T8
	WG808695	SAMP	Benzo(b)fluoranthene	R3063344	T8
	WG808695	SAMP	Benzo(g,h,i)perylene	R3063344	J3T8
	WG808695	SAMP	Benzo(k)fluoranthene	R3063344	T8
	WG808695	SAMP	Chrysene	R3063344	T8
	WG808695	SAMP	Dibenz(a,h)anthracene	R3063344	J3T8
	WG808695	SAMP	Fluoranthene	R3063344	T8
	WG808695	SAMP	Fluorene	R3063700	T8
	WG808695	SAMP	Indeno(1,2,3-cd)pyrene	R3063344	T8
	WG808695	SAMP	Naphthalene	R3063700	J4BT8
	WG808695	SAMP	Phenanthrene	R3063700	T8
	WG808695	SAMP	Pyrene	R3063344	T8
	WG808695	SAMP	1-Methylnaphthalene	R3063700	T8
	WG808695	SAMP	2-Methylnaphthalene	R3063700	T8
	WG808695	SAMP	2-Chloronaphthalene	R3063700	T8
	WG808695	SAMP	Nitrobenzene-d5	R3063700	J7
	WG808695	SAMP	2-Fluorobiphenyl	R3063700	J7
L781720-03	WG808695	SAMP	Anthracene	R3063344	T8
	WG808695	SAMP	Acenaphthene	R3063700	T8
	WG808695	SAMP	Acenaphthylene	R3063700	T8
	WG808695	SAMP	Benzo(a)anthracene	R3063344	T8
	WG808695	SAMP	Benzo(a)pyrene	R3063344	T8
	WG808695	SAMP	Benzo(b)fluoranthene	R3063344	T8
	WG808695	SAMP	Benzo(g,h,i)perylene	R3063344	J3T8
	WG808695	SAMP	Benzo(k)fluoranthene	R3063344	T8
	WG808695	SAMP	Chrysene	R3063344	T8
	WG808695	SAMP	Dibenz(a,h)anthracene	R3063344	J3T8
	WG808695	SAMP	Fluoranthene	R3063344	T8
	WG808695	SAMP	Fluorene	R3063700	T8
	WG808695	SAMP	Indeno(1,2,3-cd)pyrene	R3063344	T8
	WG808695	SAMP	Naphthalene	R3063700	J4BT8
	WG808695	SAMP	Phenanthrene	R3063700	T8
	WG808695	SAMP	Pyrene	R3063344	T8
	WG808695	SAMP	1-Methylnaphthalene	R3063700	T8
	WG808695	SAMP	2-Methylnaphthalene	R3063700	T8
	WG808695	SAMP	2-Chloronaphthalene	R3063700	T8
	WG808695	SAMP	Nitrobenzene-d5	R3063700	J7
	WG808695	SAMP	2-Fluorobiphenyl	R3063700	J7
L781720-04	WG808695	SAMP	Anthracene	R3063344	T8
	WG808695	SAMP	Acenaphthene	R3063700	T8
	WG808695	SAMP	Acenaphthylene	R3063700	T8
	WG808695	SAMP	Benzo(a)anthracene	R3063344	T8
	WG808695	SAMP	Benzo(a)pyrene	R3063344	T8
	WG808695	SAMP	Benzo(b)fluoranthene	R3063344	T8

Attachment A
List of Analytes with QC Qualifiers

Sample Number	Work Group	Sample Type	Analyte	Run ID	Qualifier
	WG808695	SAMP	Benzo(g,h,i)perylene	R3063344	J3T8
	WG808695	SAMP	Benzo(k)fluoranthene	R3063344	T8
	WG808695	SAMP	Chrysene	R3063344	T8
	WG808695	SAMP	Dibenz(a,h)anthracene	R3063344	J3T8
	WG808695	SAMP	Fluoranthene	R3063344	T8
	WG808695	SAMP	Fluorene	R3063700	T8
	WG808695	SAMP	Indeno(1,2,3-cd)pyrene	R3063344	T8
	WG808695	SAMP	Naphthalene	R3063700	J4BT8
	WG808695	SAMP	Phenanthrene	R3063700	T8
	WG808695	SAMP	Pyrene	R3063344	T8
	WG808695	SAMP	1-Methylnaphthalene	R3063700	T8
	WG808695	SAMP	2-Methylnaphthalene	R3063700	T8
	WG808695	SAMP	2-Chloronaphthalene	R3063700	T8
	WG808695	SAMP	Nitrobenzene-d5	R3063700	J7
	WG808695	SAMP	2-Fluorobiphenyl	R3063700	J7
L781720-05	WG808695	SAMP	Anthracene	R3063344	T8
	WG808695	SAMP	Acenaphthene	R3063700	T8
	WG808695	SAMP	Acenaphthylene	R3063700	T8
	WG808695	SAMP	Benzo(a)anthracene	R3063344	T8
	WG808695	SAMP	Benzo(a)pyrene	R3063344	T8
	WG808695	SAMP	Benzo(b)fluoranthene	R3063344	T8
	WG808695	SAMP	Benzo(g,h,i)perylene	R3063344	J3T8
	WG808695	SAMP	Benzo(k)fluoranthene	R3063344	T8
	WG808695	SAMP	Chrysene	R3063344	T8
	WG808695	SAMP	Dibenz(a,h)anthracene	R3063344	J3T8
	WG808695	SAMP	Fluoranthene	R3063344	T8
	WG808695	SAMP	Fluorene	R3063700	T8
	WG808695	SAMP	Indeno(1,2,3-cd)pyrene	R3063344	T8
	WG808695	SAMP	Naphthalene	R3063700	J4BT8
	WG808695	SAMP	Phenanthrene	R3063700	T8
	WG808695	SAMP	Pyrene	R3063344	T8
	WG808695	SAMP	1-Methylnaphthalene	R3063700	T8
	WG808695	SAMP	2-Methylnaphthalene	R3063700	T8
	WG808695	SAMP	2-Chloronaphthalene	R3063700	T8
	WG808695	SAMP	Nitrobenzene-d5	R3063700	J7
	WG808695	SAMP	2-Fluorobiphenyl	R3063700	J7
L781720-06	WG808695	SAMP	Anthracene	R3063344	T8
	WG808695	SAMP	Acenaphthene	R3063700	T8
	WG808695	SAMP	Acenaphthylene	R3063700	T8
	WG808695	SAMP	Benzo(a)anthracene	R3063344	T8
	WG808695	SAMP	Benzo(a)pyrene	R3063344	T8
	WG808695	SAMP	Benzo(b)fluoranthene	R3063344	T8
	WG808695	SAMP	Benzo(g,h,i)perylene	R3063344	J3T8
	WG808695	SAMP	Benzo(k)fluoranthene	R3063344	T8
	WG808695	SAMP	Chrysene	R3063344	T8
	WG808695	SAMP	Dibenz(a,h)anthracene	R3063344	J3T8
	WG808695	SAMP	Fluoranthene	R3063344	T8
	WG808695	SAMP	Fluorene	R3063700	T8
	WG808695	SAMP	Indeno(1,2,3-cd)pyrene	R3063344	T8
	WG808695	SAMP	Naphthalene	R3063700	J4BT8
	WG808695	SAMP	Phenanthrene	R3063700	T8
	WG808695	SAMP	Pyrene	R3063344	T8
	WG808695	SAMP	1-Methylnaphthalene	R3063700	T8
	WG808695	SAMP	2-Methylnaphthalene	R3063700	T8
	WG808695	SAMP	2-Chloronaphthalene	R3063700	T8
	WG808695	SAMP	Nitrobenzene-d5	R3063700	J7
	WG808695	SAMP	2-Fluorobiphenyl	R3063700	J7
L781720-07	WG808695	SAMP	Anthracene	R3063344	T8
	WG808695	SAMP	Acenaphthene	R3063700	T8
	WG808695	SAMP	Acenaphthylene	R3063700	T8
	WG808695	SAMP	Benzo(a)anthracene	R3063344	T8
	WG808695	SAMP	Benzo(a)pyrene	R3063344	T8
	WG808695	SAMP	Benzo(b)fluoranthene	R3063344	T8
	WG808695	SAMP	Benzo(g,h,i)perylene	R3063344	J3T8
	WG808695	SAMP	Benzo(k)fluoranthene	R3063344	T8
	WG808695	SAMP	Chrysene	R3063344	T8
	WG808695	SAMP	Dibenz(a,h)anthracene	R3063344	J3T8
	WG808695	SAMP	Fluoranthene	R3063344	T8
	WG808695	SAMP	Fluorene	R3063700	T8
	WG808695	SAMP	Indeno(1,2,3-cd)pyrene	R3063344	T8

Attachment A
List of Analytes with QC Qualifiers

Sample Number	Work Group	Sample Type	Analyte	Run ID	Qualifier
	WG808695	SAMP	Naphthalene	R3063700	J4BT8
	WG808695	SAMP	Phenanthrene	R3063700	T8
	WG808695	SAMP	Pyrene	R3063344	T8
	WG808695	SAMP	1-Methylnaphthalene	R3063700	T8
	WG808695	SAMP	2-Methylnaphthalene	R3063700	T8
	WG808695	SAMP	2-Chloronaphthalene	R3063700	T8
	WG808695	SAMP	Nitrobenzene-d5	R3063700	J7
	WG808695	SAMP	2-Fluorobiphenyl	R3063700	J7
L781720-08	WG808695	SAMP	Anthracene	R3063700	T8
	WG808695	SAMP	Acenaphthene	R3063700	T8
	WG808695	SAMP	Acenaphthylene	R3063700	T8
	WG808695	SAMP	Benzo(a)anthracene	R3063700	T8
	WG808695	SAMP	Benzo(a)pyrene	R3063700	T8
	WG808695	SAMP	Benzo(b)fluoranthene	R3063700	T8
	WG808695	SAMP	Benzo(g,h,i)perylene	R3063700	J3T8
	WG808695	SAMP	Benzo(k)fluoranthene	R3063700	T8
	WG808695	SAMP	Chrysene	R3063700	T8
	WG808695	SAMP	Dibenz(a,h)anthracene	R3063700	J3T8
	WG808695	SAMP	Fluoranthene	R3063700	T8
	WG808695	SAMP	Fluorene	R3063700	T8
	WG808695	SAMP	Indeno(1,2,3-cd)pyrene	R3063700	T8
	WG808695	SAMP	Naphthalene	R3063700	J4BT8
	WG808695	SAMP	Phenanthrene	R3063700	T8
	WG808695	SAMP	Pyrene	R3063700	T8
	WG808695	SAMP	1-Methylnaphthalene	R3063700	T8
	WG808695	SAMP	2-Methylnaphthalene	R3063700	T8
	WG808695	SAMP	2-Chloronaphthalene	R3063700	T8
	WG808695	SAMP	Nitrobenzene-d5	R3063700	J7
	WG808695	SAMP	2-Fluorobiphenyl	R3063700	J7
	WG808695	SAMP	p-Terphenyl-d14	R3063700	J7
L781720-09	WG808141	SAMP	Nitrobenzene-d5	R3064024	J7
	WG808141	SAMP	2-Fluorobiphenyl	R3064024	J7
L781720-10	WG808141	SAMP	Nitrobenzene-d5	R3059660	J7
	WG808141	SAMP	2-Fluorobiphenyl	R3059660	J7
L781720-11	WG808695	SAMP	Anthracene	R3063700	T8
	WG808695	SAMP	Acenaphthene	R3063700	T8
	WG808695	SAMP	Acenaphthylene	R3063700	T8
	WG808695	SAMP	Benzo(a)anthracene	R3063700	T8
	WG808695	SAMP	Benzo(a)pyrene	R3063700	T8
	WG808695	SAMP	Benzo(b)fluoranthene	R3063700	T8
	WG808695	SAMP	Benzo(g,h,i)perylene	R3063700	J3T8
	WG808695	SAMP	Benzo(k)fluoranthene	R3063700	T8
	WG808695	SAMP	Chrysene	R3063700	T8
	WG808695	SAMP	Dibenz(a,h)anthracene	R3063700	J3T8
	WG808695	SAMP	Fluoranthene	R3063700	T8
	WG808695	SAMP	Fluorene	R3063700	T8
	WG808695	SAMP	Indeno(1,2,3-cd)pyrene	R3063700	T8
	WG808695	SAMP	Naphthalene	R3063700	J4BT8
	WG808695	SAMP	Phenanthrene	R3063700	T8
	WG808695	SAMP	Pyrene	R3063700	T8
	WG808695	SAMP	1-Methylnaphthalene	R3063700	T8
	WG808695	SAMP	2-Methylnaphthalene	R3063700	T8
	WG808695	SAMP	2-Chloronaphthalene	R3063700	T8
	WG808695	SAMP	Nitrobenzene-d5	R3063700	J7
	WG808695	SAMP	2-Fluorobiphenyl	R3063700	J7
	WG808695	SAMP	p-Terphenyl-d14	R3063700	J7
L781720-12	WG808695	SAMP	Anthracene	R3063700	T8
	WG808695	SAMP	Acenaphthene	R3063700	T8
	WG808695	SAMP	Acenaphthylene	R3063700	T8
	WG808695	SAMP	Benzo(a)anthracene	R3063700	T8
	WG808695	SAMP	Benzo(a)pyrene	R3063700	T8
	WG808695	SAMP	Benzo(b)fluoranthene	R3063700	T8
	WG808695	SAMP	Benzo(g,h,i)perylene	R3063700	J3T8
	WG808695	SAMP	Benzo(k)fluoranthene	R3063700	T8
	WG808695	SAMP	Chrysene	R3063700	T8
	WG808695	SAMP	Dibenz(a,h)anthracene	R3063700	J3T8
	WG808695	SAMP	Fluoranthene	R3063700	T8
	WG808695	SAMP	Fluorene	R3063700	T8
	WG808695	SAMP	Indeno(1,2,3-cd)pyrene	R3063700	T8
	WG808695	SAMP	Naphthalene	R3063700	J4BT8

Attachment A
List of Analytes with QC Qualifiers

Sample Number	Work Group	Sample Type	Analyte	Run ID	Qualifier
	WG808695	SAMP	Phenanthrene	R3063700	T8
	WG808695	SAMP	Pyrene	R3063700	T8
	WG808695	SAMP	1-Methylnaphthalene	R3063700	T8
	WG808695	SAMP	2-Methylnaphthalene	R3063700	T8
	WG808695	SAMP	2-Chloronaphthalene	R3063700	T8
	WG808695	SAMP	Nitrobenzene-d5	R3063700	J7
	WG808695	SAMP	2-Fluorobiphenyl	R3063700	J7
	WG808695	SAMP	p-Terphenyl-d14	R3063700	J7
L781720-13	WG808695	SAMP	Anthracene	R3063700	T8
	WG808695	SAMP	Acenaphthene	R3063700	T8
	WG808695	SAMP	Acenaphthylene	R3063700	T8
	WG808695	SAMP	Benzo(a)anthracene	R3063700	T8
	WG808695	SAMP	Benzo(a)pyrene	R3063700	T8
	WG808695	SAMP	Benzo(b)fluoranthene	R3063700	T8
	WG808695	SAMP	Benzo(g,h,i)perylene	R3063700	J3T8
	WG808695	SAMP	Benzo(k)fluoranthene	R3063700	T8
	WG808695	SAMP	Chrysene	R3063700	T8
	WG808695	SAMP	Dibenz(a,h)anthracene	R3063700	J3T8
	WG808695	SAMP	Fluoranthene	R3063700	T8
	WG808695	SAMP	Fluorene	R3063700	T8
	WG808695	SAMP	Indeno(1,2,3-cd)pyrene	R3063700	T8
	WG808695	SAMP	Naphthalene	R3063700	J4BT8
	WG808695	SAMP	Phenanthrene	R3063700	T8
	WG808695	SAMP	Pyrene	R3063700	T8
	WG808695	SAMP	1-Methylnaphthalene	R3063700	T8
	WG808695	SAMP	2-Methylnaphthalene	R3063700	T8
	WG808695	SAMP	2-Chloronaphthalene	R3063700	T8
	WG808695	SAMP	Nitrobenzene-d5	R3063700	J7
	WG808695	SAMP	2-Fluorobiphenyl	R3063700	J7
	WG808695	SAMP	p-Terphenyl-d14	R3063700	J7
L781720-14	WG808695	SAMP	Anthracene	R3063700	T8
	WG808695	SAMP	Acenaphthene	R3063700	T8
	WG808695	SAMP	Acenaphthylene	R3063700	T8
	WG808695	SAMP	Benzo(a)anthracene	R3063700	T8
	WG808695	SAMP	Benzo(a)pyrene	R3063700	T8
	WG808695	SAMP	Benzo(b)fluoranthene	R3063700	T8
	WG808695	SAMP	Benzo(g,h,i)perylene	R3063700	J3T8
	WG808695	SAMP	Benzo(k)fluoranthene	R3063700	T8
	WG808695	SAMP	Chrysene	R3063700	T8
	WG808695	SAMP	Dibenz(a,h)anthracene	R3063700	J3T8
	WG808695	SAMP	Fluoranthene	R3063700	T8
	WG808695	SAMP	Fluorene	R3063700	T8
	WG808695	SAMP	Indeno(1,2,3-cd)pyrene	R3063700	T8
	WG808695	SAMP	Naphthalene	R3063700	J4BT8
	WG808695	SAMP	Phenanthrene	R3063700	T8
	WG808695	SAMP	Pyrene	R3063700	T8
	WG808695	SAMP	1-Methylnaphthalene	R3063700	T8
	WG808695	SAMP	2-Methylnaphthalene	R3063700	T8
	WG808695	SAMP	2-Chloronaphthalene	R3063700	T8
	WG808695	SAMP	Nitrobenzene-d5	R3063700	J7
	WG808695	SAMP	2-Fluorobiphenyl	R3063700	J7
	WG808695	SAMP	p-Terphenyl-d14	R3063700	J7
L781720-15	WG808695	SAMP	Anthracene	R3063700	T8
	WG808695	SAMP	Acenaphthene	R3063700	T8
	WG808695	SAMP	Acenaphthylene	R3063700	T8
	WG808695	SAMP	Benzo(a)anthracene	R3063700	T8
	WG808695	SAMP	Benzo(a)pyrene	R3063700	T8
	WG808695	SAMP	Benzo(b)fluoranthene	R3063700	T8
	WG808695	SAMP	Benzo(g,h,i)perylene	R3063700	J3T8
	WG808695	SAMP	Benzo(k)fluoranthene	R3063700	T8
	WG808695	SAMP	Chrysene	R3063700	T8
	WG808695	SAMP	Dibenz(a,h)anthracene	R3063700	J3T8
	WG808695	SAMP	Fluoranthene	R3063700	T8
	WG808695	SAMP	Fluorene	R3063700	T8
	WG808695	SAMP	Indeno(1,2,3-cd)pyrene	R3063700	T8
	WG808695	SAMP	Naphthalene	R3063700	J4BT8
	WG808695	SAMP	Phenanthrene	R3063700	T8
	WG808695	SAMP	Pyrene	R3063700	T8
	WG808695	SAMP	1-Methylnaphthalene	R3063700	T8
	WG808695	SAMP	2-Methylnaphthalene	R3063700	T8

Attachment A
List of Analytes with QC Qualifiers

Sample Number	Work Group	Sample Type	Analyte	Run ID	Qualifier
	WG808695	SAMP	2-Chloronaphthalene	R3063700	T8
	WG808695	SAMP	Nitrobenzene-d5	R3063700	J7
	WG808695	SAMP	2-Fluorobiphenyl	R3063700	J7
	WG808695	SAMP	p-Terphenyl-d14	R3063700	J7

Attachment B
Explanation of QC Qualifier Codes

Qualifier	Meaning
B	(EPA) - The indicated compound was found in the associated method blank as well as the laboratory sample.
J3	The associated batch QC was outside the established quality control range for precision.
J4	The associated batch QC was outside the established quality control range for accuracy.
J7	Surrogate recovery cannot be used for control limit evaluation due to dilution.
T8	(ESC) - Additional method/sample information: Sample(s) received past/too close to holding time expiration.

Qualifier Report Information

ESC utilizes sample and result qualifiers as set forth by the EPA Contract Laboratory Program and as required by most certifying bodies including NELAC. In addition to the EPA qualifiers adopted by ESC, we have implemented ESC qualifiers to provide more information pertaining to our analytical results. Each qualifier is designated in the qualifier explanation as either EPA or ESC.
Data qualifiers are intended to provide the ESC client with more detailed information concerning the potential bias of reported data. Because of the wide range of constituents and variety of matrices incorporated by most EPA methods,it is common for some compounds to fall outside of established ranges. These exceptions are evaluated and all reported data is valid and useable "unless qualified as 'R' (Rejected)."

Definitions

Accuracy - The relationship of the observed value of a known sample to the true value of a known sample. Represented by percent recovery and relevant to samples such as: control samples, matrix spike recoveries, surrogate recoveries, etc.

Precision - The agreement between a set of samples or between duplicate samples. Relates to how close together the results are and is represented by Relative Percent Differrence.

Surrogate - Organic compounds that are similar in chemical composition, extraction, and chromotography to analytes of interest. The surrogates are used to determine the probable response of the group of analytes that are chemically related to the surrogate compound. Surrogates are added to the sample and carried through all stages of preparation and analyses.

TIC - Tentatively Identified Compound: Compounds detected in samples that are not target compounds, internal standards, system monitoring compounds, or surrogates.

Laboratory Blank

Analyte	Result	Units	% Rec	Limit	Batch	Date Analyzed
1-Methylnaphthalene	< .00025	mg/l			WG808141	08/11/15 02:24
2-Chloronaphthalene	< .00025	mg/l			WG808141	08/11/15 02:24
2-Methylnaphthalene	< .00025	mg/l			WG808141	08/11/15 02:24
Acenaphthene	< .00005	mg/l			WG808141	08/11/15 02:24
Acenaphthylene	< .00005	mg/l			WG808141	08/11/15 02:24
Anthracene	< .00005	mg/l			WG808141	08/11/15 02:24
Benzo(a)anthracene	< .00005	mg/l			WG808141	08/11/15 02:24
Benzo(a)pyrene	< .00005	mg/l			WG808141	08/11/15 02:24
Benzo(b)fluoranthene	< .00005	mg/l			WG808141	08/11/15 02:24
Benzo(g,h,i)perylene	< .00005	mg/l			WG808141	08/11/15 02:24
Benzo(k)fluoranthene	< .00005	mg/l			WG808141	08/11/15 02:24
Chrysene	< .00005	mg/l			WG808141	08/11/15 02:24
Dibenz(a,h)anthracene	< .00005	mg/l			WG808141	08/11/15 02:24
Fluoranthene	< .00005	mg/l			WG808141	08/11/15 02:24
Fluorene	< .00005	mg/l			WG808141	08/11/15 02:24
Indeno(1,2,3-cd)pyrene	< .00005	mg/l			WG808141	08/11/15 02:24
Naphthalene	< .00025	mg/l			WG808141	08/11/15 02:24
Phenanthrene	< .00005	mg/l			WG808141	08/11/15 02:24
Pyrene	< .00005	mg/l			WG808141	08/11/15 02:24
2-Fluorobiphenyl		% Rec.	96.00	38.8-115	WG808141	08/11/15 02:24
Nitrobenzene-d5		% Rec.	96.50	18-137	WG808141	08/11/15 02:24
p-Terphenyl-d14		% Rec.	88.00	33.9-128	WG808141	08/11/15 02:24
1-Methylnaphthalene	< .00025	mg/l			WG808695	08/14/15 09:55
2-Chloronaphthalene	< .00025	mg/l			WG808695	08/14/15 09:55
2-Methylnaphthalene	< .00025	mg/l			WG808695	08/14/15 09:55
Acenaphthene	< .00005	mg/l			WG808695	08/14/15 09:55
Acenaphthylene	< .00005	mg/l			WG808695	08/14/15 09:55
Anthracene	< .00005	mg/l			WG808695	08/14/15 09:55
Benzo(a)anthracene	< .00005	mg/l			WG808695	08/14/15 09:55
Benzo(a)pyrene	< .00005	mg/l			WG808695	08/14/15 09:55
Benzo(b)fluoranthene	< .00005	mg/l			WG808695	08/14/15 09:55
Benzo(g,h,i)perylene	< .00005	mg/l			WG808695	08/14/15 09:55
Benzo(k)fluoranthene	< .00005	mg/l			WG808695	08/14/15 09:55
Chrysene	< .00005	mg/l			WG808695	08/14/15 09:55
Dibenz(a,h)anthracene	< .00005	mg/l			WG808695	08/14/15 09:55
Fluoranthene	< .00005	mg/l			WG808695	08/14/15 09:55
Fluorene	< .00005	mg/l			WG808695	08/14/15 09:55
Indeno(1,2,3-cd)pyrene	< .00005	mg/l			WG808695	08/14/15 09:55
Naphthalene	< .00025	mg/l			WG808695	08/14/15 09:55
Phenanthrene	< .00005	mg/l			WG808695	08/14/15 09:55
Pyrene	< .00005	mg/l			WG808695	08/14/15 09:55
2-Fluorobiphenyl		% Rec.	83.70	38.8-115	WG808695	08/14/15 09:55
Nitrobenzene-d5		% Rec.	78.20	18-137	WG808695	08/14/15 09:55
p-Terphenyl-d14		% Rec.	75.80	33.9-128	WG808695	08/14/15 09:55

Laboratory Control Sample

Analyte	Units	Known Val	Result	% Rec	Limit	Batch
1-Methylnaphthalene	mg/l	.002	0.00182	90.8	48.8-109	WG808141
2-Chloronaphthalene	mg/l	.002	0.00186	93.0	50.3-105	WG808141
2-Methylnaphthalene	mg/l	.002	0.00185	92.4	46.7-107	WG808141
Acenaphthene	mg/l	.002	0.00188	94.1	50.6-107	WG808141
Acenaphthylene	mg/l	.002	0.00179	89.4	50.1-108	WG808141
Anthracene	mg/l	.002	0.00216	108.	51.8-119	WG808141
Benzo(a)anthracene	mg/l	.002	0.00182	91.2	47.4-121	WG808141
Benzo(a)pyrene	mg/l	.002	0.00214	107.	49.8-119	WG808141
Benzo(b)fluoranthene	mg/l	.002	0.00198	98.8	47.4-119	WG808141

* Performance of this Analyte is outside of established criteria.
For additional information, please see Attachment A 'List of Analytes with QC Qualifiers.'

Analyte	Units	Laboratory Control Sample Known Val	Result	% Rec	Limit	Batch
Benzo(g,h,i)perylene	mg/l	.002	0.00197	98.7	37.2-129	WG808141
Benzo(k)fluoranthene	mg/l	.002	0.00233	117.	47.5-122	WG808141
Chrysene	mg/l	.002	0.00238	119.	48.6-126	WG808141
Dibenz(a,h)anthracene	mg/l	.002	0.00180	90.2	34.1-130	WG808141
Fluoranthene	mg/l	.002	0.00212	106.	50.9-123	WG808141
Fluorene	mg/l	.002	0.00196	98.1	50.2-110	WG808141
Indeno(1,2,3-cd)pyrene	mg/l	.002	0.00188	94.1	45.3-125	WG808141
Naphthalene	mg/l	.002	0.00173	86.6	45.7-101	WG808141
Phenanthrene	mg/l	.002	0.00186	93.0	47.7-113	WG808141
Pyrene	mg/l	.002	0.00205	103.	44.5-125	WG808141
2-Fluorobiphenyl				91.80	38.8-115	WG808141
Nitrobenzene-d5				89.50	18-137	WG808141
p-Terphenyl-d14				84.30	33.9-128	WG808141
1-Methylnaphthalene	mg/l	.002	0.00178	89.2	48.8-109	WG808695
2-Chloronaphthalene	mg/l	.002	0.00161	80.5	50.3-105	WG808695
2-Methylnaphthalene	mg/l	.002	0.00189	94.3	46.7-107	WG808695
Acenaphthene	mg/l	.002	0.00161	80.6	50.6-107	WG808695
Acenaphthylene	mg/l	.002	0.00165	82.5	50.1-108	WG808695
Anthracene	mg/l	.002	0.00177	88.5	51.8-119	WG808695
Benzo(a)anthracene	mg/l	.002	0.00164	81.8	47.4-121	WG808695
Benzo(a)pyrene	mg/l	.002	0.00174	86.9	49.8-119	WG808695
Benzo(b)fluoranthene	mg/l	.002	0.00164	82.1	47.4-119	WG808695
Benzo(g,h,i)perylene	mg/l	.002	0.00170	84.8	37.2-129	WG808695
Benzo(k)fluoranthene	mg/l	.002	0.00171	85.7	47.5-122	WG808695
Chrysene	mg/l	.002	0.00182	90.9	48.6-126	WG808695
Dibenz(a,h)anthracene	mg/l	.002	0.00166	83.2	34.1-130	WG808695
Fluoranthene	mg/l	.002	0.00180	89.9	50.9-123	WG808695
Fluorene	mg/l	.002	0.00173	86.6	50.2-110	WG808695
Indeno(1,2,3-cd)pyrene	mg/l	.002	0.00169	84.7	45.3-125	WG808695
Naphthalene	mg/l	.002	0.00596	298.*	45.7-101	WG808695
Phenanthrene	mg/l	.002	0.00156	77.8	47.7-113	WG808695
Pyrene	mg/l	.002	0.00163	81.5	44.5-125	WG808695
2-Fluorobiphenyl				83.10	38.8-115	WG808695
Nitrobenzene-d5				77.60	18-137	WG808695
p-Terphenyl-d14				73.10	33.9-128	WG808695

Analyte	Units	Laboratory Control Sample Duplicate Result	Ref	%Rec	Limit	RPD	Limit	Batch
1-Methylnaphthalene	mg/l	0.00177	0.00182	88.0	48.8-109	2.45	20	WG808141
2-Chloronaphthalene	mg/l	0.00179	0.00186	90.0	50.3-105	3.72	20	WG808141
2-Methylnaphthalene	mg/l	0.00178	0.00185	89.0	46.7-107	3.90	20	WG808141
Acenaphthene	mg/l	0.00182	0.00188	91.0	50.6-107	3.10	20	WG808141
Acenaphthylene	mg/l	0.00173	0.00179	87.0	50.1-108	3.16	20	WG808141
Anthracene	mg/l	0.00213	0.00216	107.	51.8-119	1.34	20	WG808141
Benzo(a)anthracene	mg/l	0.00179	0.00182	90.0	47.4-121	1.92	20	WG808141
Benzo(a)pyrene	mg/l	0.00206	0.00214	103.	49.8-119	3.98	20	WG808141
Benzo(b)fluoranthene	mg/l	0.00191	0.00198	95.0	47.4-119	3.47	20.2	WG808141
Benzo(g,h,i)perylene	mg/l	0.00182	0.00197	91.0	37.2-129	8.31	21.3	WG808141
Benzo(k)fluoranthene	mg/l	0.00236	0.00233	118.	47.5-122	1.07	20	WG808141
Chrysene	mg/l	0.00228	0.00238	114.	48.6-126	4.23	20	WG808141
Dibenz(a,h)anthracene	mg/l	0.00158	0.00180	79.0	34.1-130	13.3	21	WG808141
Fluoranthene	mg/l	0.00207	0.00212	104.	50.9-123	2.45	20	WG808141
Fluorene	mg/l	0.00189	0.00196	94.0	50.2-110	3.73	20	WG808141
Indeno(1,2,3-cd)pyrene	mg/l	0.00171	0.00188	85.0	45.3-125	9.71	20	WG808141
Naphthalene	mg/l	0.00167	0.00173	84.0	45.7-101	3.64	20	WG808141
Phenanthrene	mg/l	0.00183	0.00186	92.0	47.7-113	1.54	20	WG808141

* Performance of this Analyte is outside of established criteria.
For additional information, please see Attachment A 'List of Analytes with QC Qualifiers.'

		Laboratory Control Sample Duplicate						
Analyte	Units	Result	Ref	%Rec	Limit	RPD	Limit	Batch
Pyrene	mg/l	0.00201	0.00205	101.	44.5-125	1.86	20	WG808141
2-Fluorobiphenyl				89.40	38.8-115			WG808141
Nitrobenzene-d5				85.50	18-137			WG808141
p-Terphenyl-d14				83.10	33.9-128			WG808141
1-Methylnaphthalene	mg/l	0.00182	0.00178	91.0	48.8-109	1.89	20	WG808695
2-Chloronaphthalene	mg/l	0.00171	0.00161	85.0	50.3-105	5.86	20	WG808695
2-Methylnaphthalene	mg/l	0.00188	0.00189	94.0	46.7-107	0.440	20	WG808695
Acenaphthene	mg/l	0.00168	0.00161	84.0	50.6-107	4.04	20	WG808695
Acenaphthylene	mg/l	0.00172	0.00165	86.0	50.1-108	3.95	20	WG808695
Anthracene	mg/l	0.00186	0.00177	93.0	51.8-119	4.75	20	WG808695
Benzo(a)anthracene	mg/l	0.00169	0.00164	84.0	47.4-121	3.30	20	WG808695
Benzo(a)pyrene	mg/l	0.00179	0.00174	89.0	49.8-119	2.77	20	WG808695
Benzo(b)fluoranthene	mg/l	0.00162	0.00164	81.0	47.4-119	1.62	20.2	WG808695
Benzo(g,h,i)perylene	mg/l	0.00137	0.00170	68.0	37.2-129	21.4*	21.3	WG808695
Benzo(k)fluoranthene	mg/l	0.00183	0.00171	92.0	47.5-122	6.63	20	WG808695
Chrysene	mg/l	0.00191	0.00182	96.0	48.6-126	5.19	20	WG808695
Dibenz(a,h)anthracene	mg/l	0.00114	0.00166	57.0	34.1-130	37.2*	21	WG808695
Fluoranthene	mg/l	0.00185	0.00180	93.0	50.9-123	3.02	20	WG808695
Fluorene	mg/l	0.00178	0.00173	89.0	50.2-110	2.82	20	WG808695
Indeno(1,2,3-cd)pyrene	mg/l	0.00159	0.00169	80.0	45.3-125	6.26	20	WG808695
Naphthalene	mg/l	0.00533	0.00596	266*	45.7-101	11.3	20	WG808695
Phenanthrene	mg/l	0.00163	0.00156	82.0	47.7-113	4.87	20	WG808695
Pyrene	mg/l	0.00172	0.00163	86.0	44.5-125	5.14	20	WG808695
2-Fluorobiphenyl				86.30	38.8-115			WG808695
Nitrobenzene-d5				68.30	18-137			WG808695
p-Terphenyl-d14				75.10	33.9-128			WG808695

Batch number /Run number / Sample number cross reference

WG808141: R3059660 R3061109 R3064024: L781720-09 10
WG808695: R3063344 R3063700: L781720-01 02 03 04 05 06 07 08 11 12 13 14 15

* * Calculations are performed prior to rounding of reported values.
* Performance of this Analyte is outside of established criteria.
For additional information, please see Attachment A 'List of Analytes with QC Qualifiers.'

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ReSolution Partners LLC
Angela Hassell
967 Jonathon Drive

Madison, WI 53713

Quality Assurance Report
Level II

August 18, 2015

L781720

The data package includes a summary of the analytic results of the quality control samples required by the SW-846 or CWA methods. The quality control samples include a method blank, a laboratory control sample, and the matrix spike/matrix spike duplicate analysis. If a target parameter is outside the method limits, every sample that is effected is flagged with the appropriate qualifier in Appendix B of the analytic report.

Method Blank - an aliquot of reagent water carried through the entire analytic process. The method blank results indicate if any possible contamination exposure during the sample handling, digestion or extraction process, and analysis. Concentrations of target analytes above the reporting limit in the method blank are qualified with the "B" qualifier.

Laboratory Control Sample - is a sample of known concentration that is carried through the digestion/extraction and analysis process. The percent recovery, expressed as a percentage of the theoretical concentration, has statistical control limits indicating that the analytic process is "in control". If a target analyte is outside the control limits for the laboratory control sample or any other control sample, the parameter is flagged with a "J4" qualifier for all effected samples.

Matrix Spike and Matrix Spike Duplicate - is two aliquots of an environmental sample that is spiked with known concentrations of target analytes. The percent recovery of the target analytes also has statistical control limits. If any recoveries that are outside the method control limits, the sample that was selected for matrix spike/matrix spike duplicate analysis is flagged with either a "J5" or a "J6". The relative percent difference (%RPD) between the matrix spike and the matrix spike duplicate recoveries is all calculated. If the RPD is above the method limit, the effected samples are flagged with a "J3" qualifier.

page 1 of 2

Analytical Lab: ESC Lab Sciences
Address: 12065 Lebanon Road
City/State/Zip: Mt. Juliet, TN
Lab Contact: John Hawkins
Phone Number: 615-758-5858

Sampler Name (print): Kevin Baker
Phone Number: 608-669-6949

Client Name: ReSolution Partners, LLC
Project ID: Provect-GS/OC
Project Number:
Address: 967 Jonathon Drive
City/State/Zip: Madison, WI 53713
Project Manager: Angela Hassell
ESC Quote: RESPARMWI120209B

Report To: Angela Hassell
Email Address: ahassell@resolutionpartnersllc.net
Report To: Kevin Baker
Email Address: kbaker@resolutionpartnersllc.net
Report To: Bernd Rehm
Email Address: brehm@resolutionpartnersllc.net
Invoice To: Angela Hassell

Sample Information								Preservative							Matrix						Analyze For:		TAT		
Description		Date Sampled	Time Sampled	No. of Containers	Grab	Composite	Filtered	Ice	HNO3	HCl	NaOH	H2SO4 plastic	H2SO4 glass	Other:	Groundwater	Waste Water	Drinking Water	Sludge	Soil	Other :	SVOCs (8270C SIMS)	1218	RUSH:	Standard	
Unamended	3 PV	7-27-15	1400	1				x											x		x			x	L781720-01
Unamended	9 PV	7-28-15	1130	1				x											x		x			x	-02
Unamended	36 PV	7-29-15	1330	1				x											x		x			x	-03
Unamended	72 PV	7-30-15	1330	1				x											x		x			x	-04
Unamended	108 PV	7-31-15	1330	1				x											x		x			x	-05
ISGS/P-GS 4.5%	3 PV	7-27-15	1405	1				x											x		x			x	-06
ISGS/P-GS 4.5%	9 PV	7-29-15	0800	1				x											x		x			x	-07
ISGS/P-GS 4.5%	36 PV	7-31-15	1330	1				x											x		x			x	-08
ISGS/P-GS 4.5%	72 PV	8-5-15	0830	1				x											x		x			x	-09
ISGS/P-GS 4.5%	108 PV	8-7-15	1330	1				x											x		x			x	-10

Special Instructions:

Method of Shipment:
Tracking No: 6443 1353 7082

Relinquished By/Date: Kevin L Baker 8/7/15 1700
Received By/Date: 8/8/15 1230

Relinquished By/Date:
Received By/Date:

Laboratory Comments:

M7
3/1

Analytical Lab:	ESC Lab Sciences	**Client Name:**	ReSolution Partners, LLC	Report To:	Angela Hassell
Address:	12065 Lebanon Road	Project ID:	Provect-GS/OC	Email Address:	ahassell@resolutionpartnersllc.net
City/State/Zip:	Mt. Juliet, TN	Project Number:		Report To:	Kevin Baker
Lab Contact:	John Hawkins	Address:	967 Jonathon Drive	Email Address:	kbaker@resolutionpartnersllc.net
Phone Number:	615-758-5858	City/State/Zip:	Madison, WI 53713	Report To:	Bernd Rehm
Sampler Name (print):	Kevin Baker	Project Manager:	Angela Hassell	Email Address:	brehm@resolutionpartnersllc.net
Phone Number:	608-669-6949	ESC Quote:	RESPARMWI120209B	Invoice To:	Angela Hassell

Sample Information							Preservative							Matrix						Analyze For:	TAT		
Description		Date Sampled	Time Sampled	No. of Containers	Grab	Composite	Filtered	Ice	HNO3	HCl	NaOH	H2SO4 plastic	H2SO4 glass	Other:	Groundwater	Waste Water	Drinking Water	Sludge	Soil	Other :	SVOCs (8270C SIMS)	RUSH:	Standard
P-GS/OC 4.5%	3 PV	7-27-15	1410	1				x											x		x		x
P-GS/OC 4.5%	9 PV	7-28-15	1130	1				x											x		x		x
P-GS/OC 4.5%	36 PV	7-29-15	1320	1				x											x		x		x
P-GS/OC 4.5%	72 PV	7-30-15	1330	1				x											x		x		x
P-GS/OC 4.5%	108 PV	7-31-15	1330	1				x											x		x		x

L781720
-11
-12
-13
-14
-15

Special Instructions:

Method of Shipment:

Tracking No: 6443 1353 7082

Relinquished By/Date: 8/7/15 1700 Kevin Baker

Received By/Date:

Relinquished By/Date:

Received By/Date:

Laboratory Comments:

3.1

Appendix B

Hydraulic Conductivity Testing Reports

ReSolution Partners, LLC

Project: Provectus - Koppers GS
Project No.: 165.01 a

Falling Head Permeability Test

Sample Identification: Hawthorn NAPL-Process Area --- Column without amendment
Sample Description: 350 g soil without amendment
Dry Soil Density: 1.30 g/cm3
Permeant: 1 mM $CaCl_2$ solution in DI water

Hydraulic Conductivity (K) = $$2.3 \frac{(\text{"a"})(L)}{(\text{"A"})(\Delta T)} \log_{10} \frac{h_1}{h_2}$$

a= 0.47 cm^2 A= 18.10 cm^2 L= 15 cm

ChromaFlex Column

Date (dd/mm)	**Time 1 (H:m:s)**	**Time 2 (H:m:s)**	**(ΔT) (s)**	**h_1 (cm)**	**h_2 (cm)**	**K (cm/s)**
24-Jul			86	73.0	57.0	1.1E-03
			113	73.0	57.0	8.5E-04
			136	73.0	55.0	8.1E-04
			106	73.0	59.0	7.8E-04
			91	73.0	61.0	7.7E-04
			132	73.0	57.0	**7.3E-04**
			135	73.0	57.0	**7.1E-04**
			139	73.0	57.0	**6.9E-04**
					Average	**7.3E-04**

Project: Provectus - Koppers GS
Project No.: 165.01 a

Falling Head Permeability Test

Sample Identification: Hawthorn NAPL-Process Area --- Column with Provect-PG
Sample Description: 350 g soil without amendment. Post flushing
Dry Soil Density: 1.30 g/cm3
Permeant: 1 mM $CaCl_2$ solution in DI water

$$\text{Hydraulic Conductivity (K)} = 2.3 \frac{(\text{"a"})(L)}{(\text{"A"})(\Delta T)} \log_{10} \frac{h_1}{h_2}$$

a= 0.47 cm^2
A= 18.10 cm^2
L= 15 cm
ChromaFlex Column

Date (dd/mm)	Time 1 (H:m:s)	Time 2 (H:m:s)	(ΔT) (s)	h_1 (cm)	h_2 (cm)	K (cm/s)
31-Jul			46	73.0	56.8	2.1E-03
			56	73.0	55.0	2.0E-03
			57	73.0	55.0	1.9E-03
			59	73.0	55.0	1.9E-03
			61	73.0	55.0	1.8E-03
			62	73.0	55.0	1.8E-03
			64	73.0	55.0	1.7E-03
			65	73.0	55.0	1.7E-03
			65	73.0	55.0	1.7E-03
			68	73.0	55.0	1.6E-03
			67	73.0	55	1.6E-03
			68	73.0	55	1.6E-03
					Average	**1.6E-03**

Project: Provectus - Koppers GS
Project No.: 165.01 a

Falling Head Permeability Test

Sample Identification: Hawthorn NAPL-Process Area --- Column with Provect-PG
Sample Description: 350 g soil saturated with 100 mL 4.5 wt% GS solution

Soil Density: 1.30 g/cm3
Permeant: 1 mM $CaCl_2$ solution in DI water

$$\text{Hydraulic Conductivity (K)} = 2.3 \frac{(\text{"a"})(\text{L})}{(\text{"A"})(\Delta\text{T})} \log_{10} \frac{h_1}{h_2}$$

a= 0.47 cm^2

A= 18.10 cm^2

L= 15 cm
ChromaFlex Column

Date (dd/mm)	Time 1 (H:m:s)	Time 2 (H:m:s)	(ΔT) (s)	h_1 (cm)	h_2 (cm)		K (cm/s)
23-Jul	14:49:00	15:20:00	1860	73.0	67.6		**1.6E-05**
	15:20:00	16:12:00	3120	67.6	59.8		**1.5E-05**
24-Jul	8:10:00	8:40:00	1800	73.0	67.7		**1.6E-05**
	8:40:00	9:10:00	1800	67.7	63.2		**1.5E-05**
	9:10:00	9:40:00	1800	63.2	58.9		**1.5E-05**
	9:42:00	10:12:00	1800	73.0	68.3		**1.4E-05**
	10:12:00	10:42:00	1800	68.3	64.0		**1.4E-05**
						Average	**1.5E-05**

ReSolution Partners, LLC

Project: Provectus - Koppers GS
Project No.: 165.01 a

Falling Head Permeability Test

Sample Identification: Hawthorn NAPL-Process Area --- Column with Provect-PG
Sample Description: 350 g soil saturated with 100 mL 4.5 wt% GS solution Post-flushing
Dry Soil Density: 1.30 g/cm3
Permeant: 1 mM $CaCl_2$ solution in DI water

Hydraulic Conductivity (K) = $$2.3 \frac{(\text{"a"})(L)}{(\text{"A"})(\Delta T)} \log_{10} \frac{h_1}{h_2}$$

a= 0.47 cm^2 A= 18.10 cm^2 L= 15 cm

ChromaFlex Column

Date (dd/mm)	Time 1 (H:m:s)	Time 2 (H:m:s)	(ΔT) (s)	h_1 (cm)	h_2 (cm)	K (cm/s)
11-Aug	14:28:30	14:56:00	1680	73.0	70.2	**9.1E-06**
	14:56:00	15:17:00	1260	70.2	68.3	**8.5E-06**
	15:17:00	15:47:00	1800	68.3	65.7	**8.4E-06**
	15:47:00	16:22:00	1500	65.7	63.0	**1.1E-05**
	16:22:00	16:42:00	1200	63.0	61.4	**8.3E-06**
	16:42:00	17:18:00	2160	61.4	58.6	**8.4E-06**
12-Aug	8:20:00	10:02:00	6120	73	64.4	**8.0E-06**
	10:02:00	10:54:00	3360	64.4	60.4	**7.4E-06**
	10:54:00	11:56:00	3720	73	67.8	**7.7E-06**
	13:10:00	13:56:00	2760	73	69.3	**7.3E-06**
	13:56:00	14:30:00	2100	69.3	66.5	**7.6E-06**
					Average	**8.3E-06**

ReSolution
Partners, LLC

Project: Provectus - Koppers GS/OC
Project No.: 165.01 a

Falling Head Permeability Test

Sample Identification: Hawthorn NAPL-Process Area --- Column with Provect-PG+OC
Sample Description: 350 g soil saturated with 100 mL 4.5 wt% GS/OC solution
Dry Soil Density: 1.30 g/cm3
Permeant: 1 mM $CaCl_2$ solution in DI water

$$\text{Hydraulic Conductivity (K)} = 2.3 \; \frac{(\text{"a"})(\text{L})}{(\text{"A"})(\Delta \text{T})} \; \log_{10} \frac{h_1}{h_2}$$

a= 0.47 cm^2
A= 18.10 cm^2
L= 15 cm

ChromaFlex Column

Date (dd/mm)	Time 1 (H:m:s)	Time 2 (H:m:s)	(ΔT) (s)	h_1 (cm)	h_2 (cm)		K (cm/s)
23-Jul	13:39:00	14:39:00	3600	73.0	63.9		1.4E-05
	15:22:00	15:22:00	2040	73.0	68.2		1.3E-05
	15:22:00	16:13:00	3060	68.2	62.2		1.2E-05
24-Jul	8:10:00	8:40:00	1800	73.0	67.4		1.7E-05
	8:40:00	9:10:00	1800	67.4	62.9		**1.5E-05**
	9:10:00	9:40:00	1800	62.9	58.8		**1.5E-05**
	9:42:00	10:12:00	1800	73.0	67.8		**1.6E-05**
	10:12:00	10:42:00	1800	67.8	63.3		**1.5E-05**
						Average	**1.5E-05**

ReSolution Partners, LLC

Project: Provectus - Koppers GS/OC
Project No.: 165.01 a

Falling Head Permeability Test

Sample Identification: Hawthorn NAPL-Process Area --- Column with Provect-PG+OC
Sample Description: 350 g soil saturated with 100 mL 4.5 wt% GS/OC solution. Post Flushing.
Dry Soil Density: 1.30 g/cm3
Permeant: 1 mM $CaCl_2$ solution in DI water

$$\text{Hydraulic Conductivity (K)} = 2.3 \frac{(\text{"a"})(L)}{(\text{"A"})(\Delta T)} \log_{10} \frac{h_1}{h_2}$$

a= 0.47 cm^2
A= 18.10 cm^2
L= 15 cm

ChromaFlex Column

Date (dd/mm)	Time 1 (H:m:s)	Time 2 (H:m:s)	(ΔT) (s)	h_1 (cm)	h_2 (cm)	K (cm/s)
31-Jul	15:22:00	15:36:10	850	73.0	55.0	1.3E-04
	15:37:50	15:50:50	780	73.0	55.0	1.4E-04
	15:51:57	16:04:47	770	73.0	55.0	1.4E-04
	16:05:33	16:18:33	780	73.0	55.0	1.4E-04
					Average	**1.4E-04**