MEMO

To: Peter Britz, Coakley Landfill Group

From: Christopher Buckman

Re: Surface Water Treatment Options – House Bill 494

Date: September 17, 2020

New Hampshire House Bill 494 (HB 494) requires that the New Hampshire Department of Environmental Services (NHDES) propose a remedy to "ensure the substantial reduction of the contaminants entering Berrys Brook from the Coakley Landfill Superfund site." The Coakley Landfill Group (CLG) has evaluated available treatment technologies feasible in design and implementation to address HB 494 requirements.

HB 494 does not define specific contaminants to be addressed, however, the United States Environmental Protection Agency (USEPA) and NHDES focus has primarily been on per- and polyfluoroalkyl substances (PFAS) and 1,4-dioxane. Given that 1,4-dioxane has generally not been detected in surface water samples outside the groundwater management zone (GMZ), this discussion of the proposed remedy will focus on reducing PFAS concentrations in general.

Investigations to date have demonstrated that PFAS in overburden and shallow bedrock groundwater discharge to the large wetland complex located west of the landfill. This complex ultimately becomes Berrys Brook, although a defined stream channel does not exist until the north end of the wetland complex, near Breakfast Hill Road, approximately 3,000 feet north of the landfill (**Figure 1**). Except during significant rain events, it appears that most or all of the PFAS entering the wetland complex result from the discharge of groundwater to the surface. This is supported by regular flow (baseflow) observed within the stream channel during prolonged periods of no measurable precipitation. During rain events, PFAS found in landfill stormwater discharge is also a source of contamination to the complex. For the reasons provided in this letter, the area near Breakfast Hill Road where the defined stream channel exists is the most appropriate location for treating PFAS that enter Berrys Brook from the Site. Although the treatment will not occur until after the PFAS has entered the headwaters of Berrys Brook, the system described below appears to be the most feasible way to treat the groundwater and periodic stormwater flows containing PFAS discharging to what becomes Berrys Brook.

The approach to treatment options will be the implementation of a passive remedy that requires minimal maintenance and provides an assessment of concentration reduction. The recommended remedy has proven capability to absorb PFAS and is designed to provide a reduction in PFAS concentrations exiting the GMZ. The treatment area, as illustrated on **Figure 1**, is generally located at the north end of the GMZ, west of the former railroad easement, and east of the

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residential property located at 368 Breakfast Hill Road (where private well R-3 is located). Although this area is not within the current GMZ boundary, the area was submitted to the NHDES for inclusion within a proposed GMZ expansion area in December 2018.

The viability of the remedy will be based on its effective reduction of PFAS from the surface water. It is understood that bypass during high precipitation events and seasonal treatment during warm weather months (April through October), will be considered during implementation. These considerations will include placement within the treatment area to limit potential for flow restriction and seasonal deployment to avoid freezing conditions that may reduce remedy effectiveness. This technology allows for the addition of individual components to assess the additive benefit of each and determine which system element or combination of elements provides the best overall approach. Current commercially available technologies developed and tested for the removal of PFAS are focused primarily on the treatment of soil or groundwater, where the application, mixing, or rates of treatment can be more easily controlled. With variable rates of flow, changes in seasonal contaminant concentrations, icing over of the Brook during winter, sediment loading, and potential for contribution from multiple source areas, the treatment of surface water requires a different approach.

TREATMENT TECHNOLOGY

The following treatment technology has been shown to reduce the concentration of PFAS in groundwater (soil mixing and permeable reactive barriers) and offers a potential for application in the passive treatment of surface water. The treatment of surface water has not been as widely investigated or implemented as that for soil and groundwater, in large part due to limited established surface water regulatory standards. The passive treatment option discussed below is capable of being scaled to address future objectives and take into consideration the characteristics of the identified treatment area.

Bioavailable Absorbent Media (BAM)

BAM is a recycled cellulose bio-mass product that provides a substrate for contaminant absorption. The characteristics of BAM, analogous to that of granular activated carbon (GAC), allows for a large surface area per unit weight of material for sorption to take place. BAM is a trademark material manufactured and marketed by ORIN Technologies, LLC. (ORIN). Implementation to date has been primarily though soil blending and injection; however, ORIN has been treating surface water and stormwater passively through deployment of floating booms and curtains/blankets containing BAM (**Attachment A**) within stormwater vaults and is comparable to the passive treatment of surface water being proposed at the Site.

EVALUATION REQUIREMENTS

BAM requires specific criteria for proper evaluation that include, but are not limited to, information on flow rates, defining a test area or fixture to hold the media, access to the treatment area, and a sampling schedule to determine the effectiveness of the remedy components. Flow rate measurements will be made as part of the surface water evaluation, with baseline flow measurements scheduled following beaver dam removal and prior to deployment of the remedy. Access to the proposed treatment area has been coordinated between the New Hampshire Department of Transportation and CES through the execution of an access agreement dated August 19, 2020. It is anticipated that BAM will provide the needed flexibility with regards to meeting HB 494 implementation requirements with little maintenance required beyond deployment. This maintenance includes sampling for assessment of PFAS removal and periodic inspection for debris removal (leaves and detritus) and water passage.

Treatment Area
The treatment area is at the north end of the GMZ and located where Berrys Brook transitions from flow within an engineered channel and box culvert to a natural channel (**Figure 1**). The south end of this transition is currently identified by the presence of a beaver dam where a surface water impoundment has been created. The portion of the treatment area selected for deployment of the remedy is the channel that exits the wetland headwaters of Berrys Brook immediately north of the dam before entering a box culvert and heading east under the railroad easement to the outfall located south of Breakfast Hill Road (**Figure 1**). This location provides regular flow throughout the year, is clearly defined with no outside contribution from railroad easement drainage features, and is an area easily accessible for implementation and monitoring. These characteristics, together with the length, width, and depth of the channel, supports the deployment of BAM-filled blankets.

The area located behind the current beaver dam impoundment is well-suited for the deployment of floating booms; however, this impoundment will undergo changes in width and depth following the removal of the beaver dam and will require reassessment for remedy options following dam removal (**Figure 1**). As such, the use of blankets within the channel will be the primary focus of the remedy assessment once surface water levels reach an equilibrium level following dam removal as discussed below. Beaver mitigation and dam removal efforts are ongoing at the time of this memorandum.

Evaluation Sampling
The evaluation of BAM effectiveness will require defined sample locations for pre- and post-treatment free from the dilution that may occur via other sources of surface drainage (railroad easement ditches) with long-term viability determined based on the effectiveness of PFAS removal in attaining the statutory criterion.

Baseline sampling will occur in conjunction with the regular Fall groundwater and surface water sampling event required under the GMP. This sampling is typically completed in late September/early October of each year and will include the establishment of a sampling location within the specified channel where water that has been in contact with the BAM can be sampled for an evaluation of PFAS removal. The nearest downstream surface water sampling location (SW-110) will continue to be sampled as part of the Fall event but will not be considered a representative post-treatment sample due to the contribution of untreated surface drainage (i.e., easement ditches and surface runoff) and unknown contribution to surface water from within the inaccessible box culvert by infiltration and seepage of precipitation.

The first BAM component to be evaluated will be blankets placed within the channel as identified above. One end of each blanket placed in the channel will be anchored to each side of the channel at the water surface allowing for the flow of water over and under the blankets thus facilitating the greatest surface area to be in contact with the water. It is currently anticipated that up to four blankets will be deployed in the channel, spaced evenly along its length. Pre-treatment sampling will occur upstream of the blankets with post-treatment samples collected downstream, immediately before where the channel enters the box culvert under the easement.

Initial post-treatment sampling will occur every three weeks following deployment (up to three total post-treatment samples for this season). Due to the current schedule, it is proposed that the blankets will be removed in November to reduce the likelihood of damage to the blankets from freezing or the buildup of ice. The effectiveness of the blankets will be evaluated based on their achievement of a substantial reduction of PFAS in the surface water. Recommendations will be made for the deployment of blankets in the Spring of 2021 and whether the evaluation of floating booms (or other BAM products) will be required upstream of the blankets. Each system component deployed as part of the remedy will be evaluated separately to assess the benefit each has on the overall reduction of PFAS with changes in system design based on review of post-treatment analytical results.

Should the evaluation of floating booms be needed as part of the remedy implementation, a sampling location immediately upstream of the booms will be established for pre-treatment collection. Post-treatment sampling for the booms will be performed at the blanket evaluation pre-treatment location. Analysis will be completed for the full list of PFAS compounds as included in **Attachment B** to allow for a more direct comparison with surface water samples collected in accordance with the GMP .

IMPLEMENTATION SCHEDULE

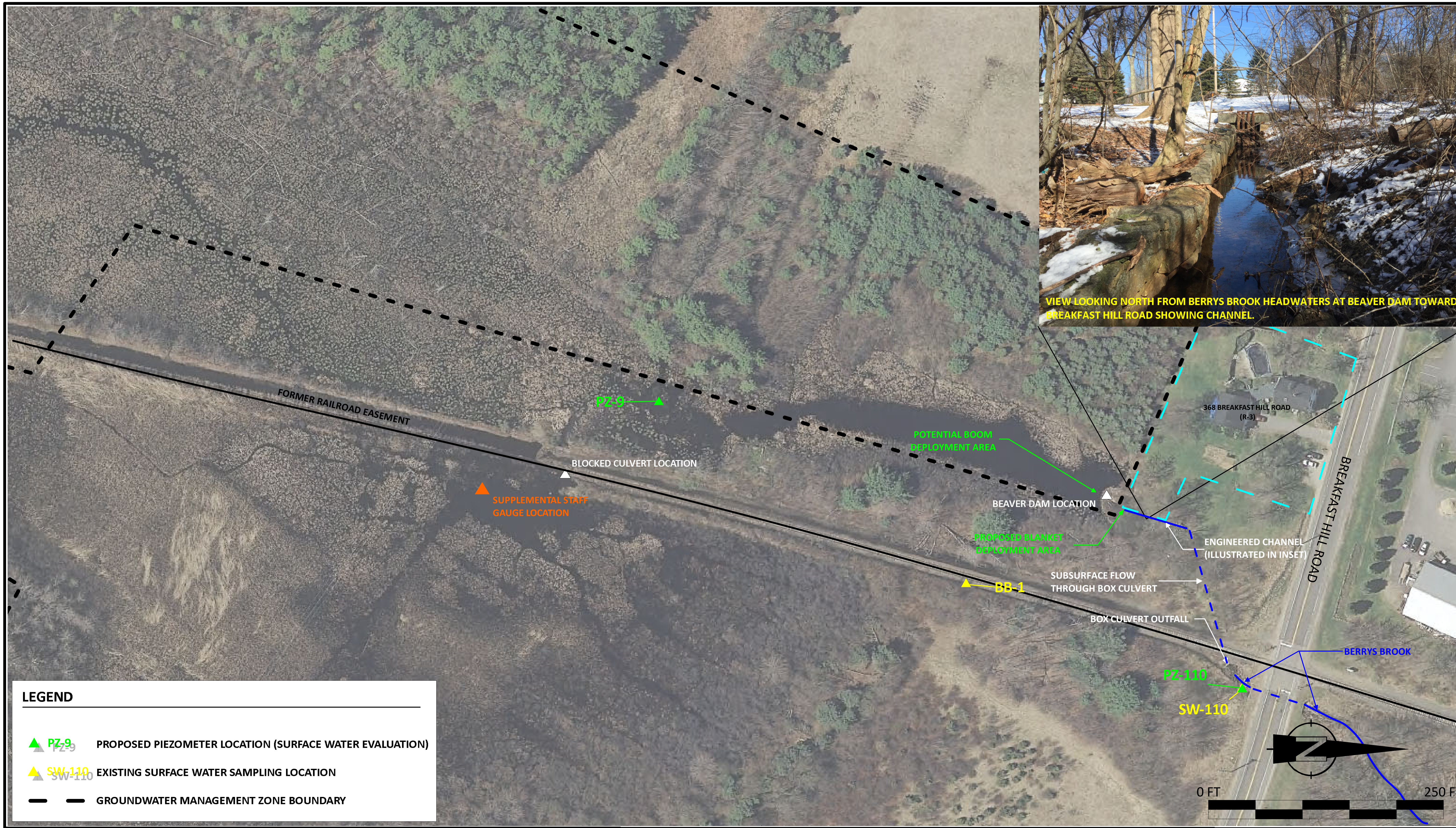
The selected remedy will be implemented during Fall 2020 following beaver mitigation efforts and dam removal. Beaver mitigation will be completed by the United States Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS), with dam removal completed by the CLG. It is anticipated that following dam removal, the equalization of water levels within the wetland complex (east and west of the easement) will be required and will be monitored through periodic visual observation of surface water levels and the gauging of water levels within piezometers located in each area. These piezometers will be installed in locations as proposed in the Surface Water Evaluation Scope of Work (CES, 2020) and include locations PZ-8 and PZ-9; however, may require the installation of a surface water gauging location between BB-1 and BB-2 to provide information on stabilized surface water levels.

FIGURE 1

CESINC

ATTACHMENT A

ATTACHMENT B



PROJECT TITLE: COAKLEY LANDFILL SUPERFUND SITE NORTH HAMPTON & GREENLAND, NEW HAMPSHIRE	DWG: FIGURE 1	BY: CFB	REV:
		DATE: 2020-06-23	REV DATE:
SHEET TITLE: SURFACE WATER TREATMENT EVALUATION AREA	JN: 10424.020	APPROVED BY: SLY	ISSUE:
	SCALE: AS SHOWN	CHECKED BY: CFB	ISSUE DATE:

NOTE:

1. THIS SITE PLAN IS BASED ON EXISTING SAMPLING LOCATIONS AS PER THE COAKLEY LANDFILL SUPERFUND SITE REVISED SAMPLING AND ANALYSIS PLAN DATED JULY 18, 2018.
2. GMZ BOUNDARY IS BASED UPON "GMZ BOUNDARY PLAN" DATED MAY 9, 2008 INCLUDED IN THE 2008 GMP APPLICATION PREPARED BY HANCOCK ASSOCIATES AND 2013 GMZ EXPANSION AREA ESTABLISHED BY THE 2013 GMP DATED JANUARY 7, 2014.
3. GIS DATA COURTESY OF NEW HAMPSHIRE ONLINE GRANITE DATABASE.
4. MAP IS PROJECTED USING THE NEW HAMPSHIRE STATE PLANE PROJECTION, US FEET AND REFERENCES THE NORTH AMERICAN VERTICAL DATUM OF 1983.

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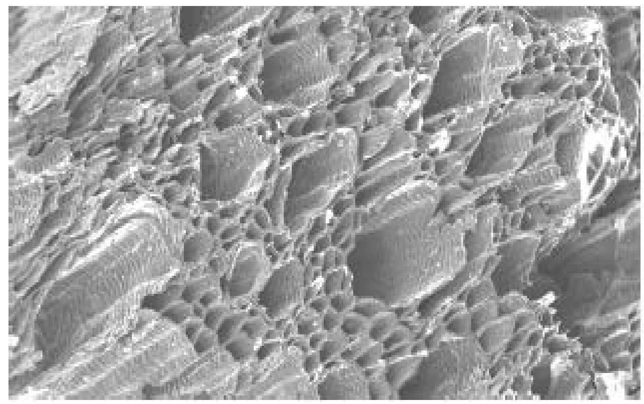
ORIN TECHNOLOGIES

Bioavailable Absorbent Media (BAM)

BAM is a sustainable, pyrolized, recycled cellulosic bio-mass product (>80% fixed carbon) derived from a proprietary blend of recycled organic materials with a high cation exchange and an estimated half-life of 500 years. BAM has diverse pore sizes with a minimum total surface area of up to 1,133 square meters per gram.

BAM has numerous synergistic qualities and is relatively affordable in large quantities for remediation purposes for both **soils and groundwater**. It has the ability to provide ample usable surface area for maximizing microbial colonization and thereby an active microbial community. Due to its unique 'honeycomb' structure, BAM has the ability to provide increased pore space for the different strains of microbes. Most importantly, BAM's honeycomb structure allows for maximum contact (bio-availability through high sorbency). This allows for complete degradation of the contaminant.



Example Honeycomb structure

Advantages

- **Immediate clean up of groundwater through absorption**
- **Treats both soils and groundwater**
- **Effective on wide range of hydrocarbons, chlorinated solvents, and some heavy metals**
- **Absorbed contaminants are treated biologically, and can be additionally treated through oxidation or chemical reduction**
- **Long lasting treatment with no additional costs after initial application**
- **Effective as a standalone and works simultaneously with various treatment chemistries**

The unique absorption capability of BAM prevents exterior surface microfilm buildup. This allows BAM to absorb contaminants for more productive bio-attenuation of contaminants over a longer period of time. Granular Activated Carbon (GAC) primarily adsorbs contamination to the surface of the media, which then is subject to bio-film development, preventing further adsorption. As a result, BAM has been proven to supply long term maintenance free remedial abilities over GAC. Laboratory tests have also shown that BAM has significantly more absorptive capacity than commercially available GAC products.

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ORIN TECHNOLOGIES

Application

The diverse honeycomb structure has various size pore openings. This variation in pore size enables BAM to be efficient at storing CO2, treatment chemistries, and absorbing multiple contaminants from large chain structures to small chemical compounds. The greater storage capacity allows for favorable environments for the long-term destruction of contaminants. In recent years, the focus at TCA contaminated sites deepened to also investigate 1, 4-Dioxane. Also, Per and Polyfluoroalkyl Substances (PFASs) are also being investigated, especially at site where PFA containing fire retardants were used. Research for their adverse health effects of these emerging contaminants led to the EPA establishing new Minimal Risk Levels for both of the contaminants, and treatment solutions will need to be employed. Through ORIN's continued research, BAM has been successful at treating 1, 4-Dioxane, PFASs, and other listed contaminants.

BAM's exceptional ability to work alone in both aerobic and anaerobic conditions with numerous other treatment chemistries makes it a flexible treatment choice. This characteristic follows ORIN's belief of choosing the right treatment option for the contaminant based on the sites specific parameters. Chemical oxidation or chemical reduction work more effectively than traditional methods due to the increased contact between the treatment chemistry and the absorbed contaminant. In addition to contaminant degradation on the absorption site, chemical treatment addresses residual contaminant that is bound to the soil. Again, this approach treats soils and groundwater for both in-situ and ex-situ applications.

BAM can be utilized in conjunction with the following chemistries:

- Peroxy Compounds
- Carbon Sources
- Zero Valent Metals

<u>Some Examples of Treated Contaminants</u>

Total Petroleum Hydrocarbons
- DRO
- GRO
- ORO

Aromatic Hydrocarbon Compounds
- BTEX

Chlorinated - VOCs
- 1-4,-Dioxane
- Carbon Tetrachloride
- -ethenes(PCE/TCE)
- -ethanes(DCA/PCA)

Semi Volatile Organic Compounds
- Naphthalene
- Pyrene's
- Phenol's

Pesticides
- BHC's
- DDT
- Toxaphene

Per/Polyfluoroalkyl Substances (PFASs)
- Perfluoroctane Sulfonate (PFOS)
- Perfluorooctanoic Acid (PFOA)

And More!


Boom with float
Curtain with BAM fill
BAM filled boom

Attachment A
EXPANDED PFAS ANALYTE LIST

ANALYTE		CAS No.
PFPeA	Perfluoropentanoic Acid	2706903
PFBS	Perfluorobutane Sulfonic Acid	375735
PFBA	Perfluorobutanoic Acid	375224
PFUnA	Perfluoroundecanoic Acid	2058948
PFTrDA	Perfluorotridecanoate	862374876
PFTeDA	Perfluorotetradecanoic Acid	376067
PFOSA	Perfluorooctane Sulfonamide	754916
PFOS	Perfluorooctane Sulfonate	1763231
PFOA	Pentadecafluorooctanoic Acid	335671
PFNA	Perfluorononanoic Acid	375951
PFHxS	Perfluorohexane Sulfonate	355464
PFHxDA	Perfluorohexadecanoic Acid	67905195
PFHxA	Perfluorohexanoic Acid	307244
PFHpS	Perfluoroheptane Sulfonic Acid	375928
PFHpA	Perfluoroheptanoic Acid	375859
PFDS	Perfluorodecane Sulfonate	67906427
PFDoA	Perfluorododecanoic Acid	307551
PFDA	Perfluorodecanoic Acid	335762
MeFOSE	N-Methyl Perfluorooctane Sulfonamidoethanol	24448097
MeFOSAA	N-Methyl Perfluorooctane Sulfonamidoacetic Acid	2355319
MeFOSA	N-Methyl Perfluorooctane Sulfonamide	31506328
EtFOSE	N-Ethyl Perfluorooctane Sulfonamidoethanol	1691992
EtFOSAA	N-Ethyl Perfluorooctane Sulfonamidoacetic Acid	2991506
EtFOSA	N-Ethyl Perfluorooctane Sulfonamide	4151502
8:2 FTS	8:2 Fluorotelomer Sulfonate	39108344
6:2 FTS	6:2 Fluorotelomer Sulfonic Acid	27619972