Assessment of Corrective Measures

RD Morrow Generating Station - Landfill CCR Unit
Purvis, Mississippi

Cooperative Energy, Inc.
Purvis, Mississippi

Submitted by:

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Certification

This Assessment of Corrective Measures, Cooperative Energy, RD Morrow Generating Station, has been prepared in compliance with applicable requirements of the CCR Final Rule. References to the appropriate 40 CFR § 257.96 rules are incorporated throughout this document.

Golder Associates Inc.

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I verify the information in this ACM is accurate and meets the applicable requirements of the CCR Final Rule. In consideration of the above, I certify to the best of my knowledge, information, and belief, that the ACM for the regulated CCR management unit referred to as the CCR Unit meets the applicable requirements of 40 CFR § 257.96

Brian Thomas, PE
Mississippi Registered Professional Engineer No. 18539

https://golderassociates.sharepoint.com/sites/104953/project files/5 technical work/200 reports/assessment of corrective measures/final acm/rd morrow acm_final_09_12_19.docx

1.0 INTRODUCTION

In accordance with the United States Environmental Protection Agency (US EPA) Coal Combustion Residuals (CCR) Rule 40 Code of Federal Regulations (CFR) 257 Subpart D, Golder Associates Inc. (Golder) has prepared this assessment of corrective measures (ACM) report for Cooperative Energy's (CoOp) RD Morrow Generating Station's (Morrow or Site) CCR Landfill unit. As required by § 257.96, this ACM evaluates potential corrective measures to address statistically significant levels (SSLs) of lithium at monitoring wells MW-03, MW-04, and MW-05 and molybdenum at MW-05 associated with the CCR Landfill.

CoOp began this ACM within 90 days of identifying the SSLs of groundwater quality data at the CCR Landfill on May 15, 2019. CoOp required a 60-day extension to complete the ACM. This ACM report will be placed in the Site's operating record in accordance with § 257.105(h)(10).

This ACM is the first step in identifying the most viable corrective measure(s) to address groundwater at the Site. Based on the results of the ACM, further evaluation may be performed, site-specific studies completed, and a final corrective action plan developed and implemented pursuant to § 257.97 and § 257.98.

1.1 Site and CCR Unit Description

Morrow is located in the community of Okahola, a rural area of Lamar County, approximately 4.5 miles north of the City of Purvis and 8 miles southwest of Hattiesburg (Figure 1). Old Okahola School Road bisects the property into a northern and southern parcel.

The generating plant and CCR surface impoundments are located on the north parcel. As shown in Figure 2, the Morrow CCR units include:

- **Surface Impoundments** - The surface impoundments are currently following a detection monitoring program in accordance with § 257.94.
- **Landfill Unit** – The CCR landfill unit is in Assessment Monitoring and is the focus of this ACM. Figure 2 presents the CCR monitoring well network for the CCR Landfill unit.

1.2 CCR Landfill Unit Monitoring Well Network

CoOp designed the monitoring network described herein to meet the performance standards specified in § 257.91 that will be protective of human health and the environment. The monitoring network was designed so that adequate monitoring coverage is provided to represent the quality of groundwater upgradient and downgradient of the landfill CCR unit. Table 1.2 summarizes the current background and downgradient monitoring well network as well as the current assessment monitoring well network (i.e., nature and extent) for Landfill CCR Unit.

Table 1.2: Landfill CCR Unit Monitoring Wells	
Background Monitoring Well	MW-02
Downgradient Monitoring Wells	MW-03, MW-04, MW-05, MW-06
Assessment Monitoring Wells	MW-10, MW-11, MW-12

2.0 SITE HYDROGEOLOGIC CONDITIONS

To adequately evaluate remedial options, the ACM considered site specific information and evaluated the conceptual site model (CSM). This subsection provides a high-level overview of the CSM and site hydrogeology.

Geological and hydrogeological units exposed at the surface and to a depth of a few hundred feet in this region of Mississippi, as described by Environmental Management Systems, Inc. (EMS) (EMS, 2003), are presented in the 2014 Site Permit Renewal Application. As it relates to the groundwater flow conditions, aquifers within the geologic units present at the site are continuously replenished from rainfall directly to the outcrop areas, which are located generally farther to the north. The rainfall also replenishes stream beds, lakes and ponds, which act as reservoirs that provide longer term sources of recharge. Leakage from these reservoirs percolates downward through the overlying formations to recharge shallow aquifers which in turn recharge adjacent and deeper aquifers.

At the Site, Black Creek Valley cuts through the terrace deposits and Citronelle Formation into the Miocene Hattiesburg (clay) formation. The geologic interpretation for the Site has been developed through analysis of boring data from this investigation as well as previous studies and is presented in cross-sectional views on Figures 3 and 4.

As presented by EMS (2003), the groundwater aquifer underlying the CCR landfill unit is located within the reworked Citronelle formation. Figures 3 and 4 present the uppermost aquifer as it relates to the subsurface strata across the site. Figure 5 shows that groundwater flows generally south towards Black Creek, which is consistent with historical observations (EMS, 2018). Hydraulic flow characteristics of the shallow aquifer were determined based on aquifer testing (i.e., rising- and falling-head slug tests) conducted by EMS (EMS 2018). Horizontal groundwater flow velocity is approximately 0.1 feet/day (approximately 35 to 50 feet/year) across the landfill unit. These calculated groundwater velocities are generally consistent with historical calculations. Observed groundwater velocities calculated for this monitoring event are also consistent with expected velocities in the upper aquifer and confirm the groundwater monitoring network is properly located to monitor the uppermost aquifer for the landfill at Morrow.

3.0 GROUNDWATER MONITORING SUMMARY

Following the installation of a groundwater monitoring system, CoOp collected background groundwater samples and performed detection monitoring for the CCR Units pursuant to the requirements of § 257.94. On May 16, 2018, CoOp initiated an assessment monitoring program for the CCR Landfill unit. CoOp completed assessment monitoring sampling events pursuant to the requirements of § 257.95 and developed the GWPS by selecting the larger value of the Maximum Contaminant Level (MCL) or the unit-specific background concentration for each analyte based on a tolerance/prediction limit statistical procedure. In August 2018, the U.S. EPA amended the CCR Final Rule (i.e., Phase 1 Part 1 amendment) and created health-based standards for cobalt, lead, lithium, and molybdenum, constituents that did not have MCLs, as of August 29, 2018. Pursuant to § 257.95(h)(2), the health-based standards can be used in place of background levels to calculate the GWPS.

Table 3.1 summarizes the GWPS used to evaluate the assessment monitoring results at the Site.

Table 3.1 Summary of Background Concentrations and GWPS				
Analyte	**Units**	**MCL/RSL[1,4]**	**Site Specific Background August 2019[2]**	**Groundwater Protection Standard (GWPS)[3]**
Antimony	mg/L	0.006	0.025	0.025
Arsenic	mg/L	0.01	0.0101	0.01
Barium	mg/L	2	0.025	2
Beryllium	mg/L	0.004	0.009363	0.009
Cadmium	mg/L	0.005	0.005	0.005
Chromium	mg/L	0.1	0.025	0.1
Cobalt	mg/L	0.006	0.16	0.16
Fluoride	mg/L	4	0.9894	4
Lead	mg/L	0.015	0.008593	0.015
Lithium	mg/L	0.04	0.05	0.05
Mercury	mg/L	0.002	0.0015	0.002
Molybdenum	mg/L	0.1	0.005	0.1
Radium (226 + 228)	pCi/L	5	2.05	5
Selenium	mg/L	0.05	0.25	0.25
Thallium	mg/L	0.002	0.005	0.005

Notes:
Mg/L = milligrams per liter; pCi/L = picocuries per liter; NA = Not Available
[1] MCL = Maximum Contaminant Limit established by EPA. RSL = Risk-Based Screening Limit established by EPA.
[2] The background limits are used when determining the groundwater protection standard (GWPS) under 40 CFR §257.95(h). The established limits were based on available upgradient data through August 2019.
[3] Under 40 CFR §257(h)(1-3) the GWPS is: (i) the MCL/RBSL, (ii) where the MCL is not established, the background concentration, or (iii) background levels for constituents where the background level is higher than the MCL or rule-specified GWPS.
[4] Currently, there is no Environmental Protection Agency (EPA) MCL established for lead. The value listed as GWPS is the established EPA Action Level for drinking water.

A statistical analysis of the Appendix IV results from groundwater sampling/analysis of downgradient CCR monitoring wells (MW-02 through MW-06) was performed to evaluate if constituent concentrations detected in the samples are at SSLs relative to the GWPS established for the Site. The statistical analysis was conducted in accordance with the Site's statistical analysis plan. On May 15, 2019, CoOp initiated an assessment of corrective measures for the CCR Landfill unit based on the identification of certain constituents at concentrations (COCs) above the GWPS.

Table 3.2 presents the COCs identified above the GWPS.

Table 3.2: Landfill Unit Confidence Interval Statistically Significant Level (SSL) Exceedances	
Appendix IV Parameter	**Landfill CCR Unit Monitoring Well**
Lithium	MW-03, MW-04, MW-05
Molybdenum	MW-05

In accordance with the provisions of § 257.95(g)(1), CoOp has implemented a field investigation to define the nature and extent of the release associated with the CCR Units in the uppermost aquifer. The potential vertical migration and extent of groundwater impacts are limited by the low downward vertical component of groundwater flow because of the clay confining unit and the ability of this clay unit to attenuate metals, for instance through sorption.

CoOp has performed the actions required by § 257.95(g)(1)(i – iv), including the installation and development of assessment monitoring wells (MW-10, MW-11, and MW-12); collection of soil samples for a mineralogical assessment and chemical analysis; water-level data collection; and groundwater sampling and analysis. Figure 2 presents locations of soil borings and monitoring wells installed and sampled as part of further site characterization.

4.0 ASSESSMENT OF CORRECTIVE MEASURES

The ACM must include an analysis of the effectiveness of potential corrective measures in meeting the objectives of the remedy as described under 40 CFR § 257.97 and must include an evaluation of the following:

1) *The performance, reliability, ease of implementation, and potential impacts of appropriate potential remedies, including safety impacts, cross-media impacts, and control of exposure to any residual contamination*
2) *The time required to begin and complete the remedy*
3) *Institutional requirements, such as state or local permit requirements or other environmental or public health requirements that may substantially affect implementation of the remedy(s).*

Corrective measures objectives specified in §257.97(b), include:

1) *Be protective of human health and the environment;*
2) *Attain the groundwater protection standard as specified pursuant to § 257.95(h);*
3) *Control the source(s) of releases to reduce or eliminate, to the maximum extent feasible, further releases of constituents in appendix IV to this part into the environment;*
4) *Remove from the environment as much of the contaminated material that was released from the CCR unit as is feasible, considering factors such as avoiding inappropriate disturbance of sensitive ecosystems;*
5) *Comply with standards for management of wastes as specified in § 257.98(d).*

Potential response technologies were identified for Source Control (to reduce the potential for releases of constituents to groundwater) and Groundwater Response Actions (to reduce constituent concentrations below GWPS). The potential response technologies were then screened to identify options that are appropriate for further consideration in developing potential corrective measures alternatives for the Site. The results of the ACM are presented in this section.

4.1 Planned Source Control Measures

CoOp plans to close the CCR Unit by capping the landfill in accordance with § 257.102(d) and an approved MDEQ permit. To meet the requirements of § 257.97-98, CoOp's approach combines CCR source control, corrective remedy selection and groundwater monitoring to demonstrate achievement of applicable cleanup standards. The multi-part corrective action approach will be integrated, but may be sequenced, to allow for monitoring of results and optimization of subsequent steps following completion of the initial stages.

4.2 Groundwater Response Action Alternatives

As part of the response action screening process for groundwater, treatment technologies were eliminated if they were unlikely to perform satisfactorily or reliably, they were deemed difficult or impossible to implement, or they could not achieve corrective action objectives within a reasonable timeframe. The remaining technologies described in this ACM were retained for development as potential corrective measures. This section describes potentially applicable corrective measures for groundwater based on screening criteria specified in § 257.96(c) and § 257.97(b). Table 1 provides a summary of remedial evaluations. Potential groundwater corrective action remedies include:

- **Monitored Natural Attenuation and Enhanced Monitored Natural Attenuation** - The US EPA defines monitored natural attenuation (MNA) as the reliance on natural attenuation processes (within the context of a carefully controlled and monitored site clean-up approach) to achieve site-specific remediation objectives within a time frame that is reasonable compared to that offered by other more active methods (USEPA 1999). The natural attenuation processes that are at work in such a remediation approach include a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, bioavailability, mobility, volume, or concentration of constituents in soil or groundwater. These in-situ processes include biodegradation; dispersion; dilution; sorption; volatilization; radioactive decay; and chemical or biological stabilization, transformation, or destruction of constituents (USEPA, 1995).

  Attenuation mechanisms are either physical or chemical. Dilution and dispersion may be appropriate as a polishing step (e.g., at the boundaries of a plume, when source control is complete, an active remedy is being used at the site, and appropriate land use and groundwater controls are in place). Chemical attenuation of inorganic constituents may be possible through biogeochemical processes that lead to co-precipitation of metals with iron hydroxides or sequestration in sediments. Bacterial activity may occur in native groundwater but may also benefit from geochemical manipulation.

  Enhanced MNA is the use of low-energy, in-situ techniques to stimulate or increase the attenuation of contaminants or reduce contaminant loading. Enhancements options include increasing the attenuation capacity of aquifer, decreasing the mobility of contaminants, and/or increasing the stability of immobilized contaminants (ITRC 2010). These options involve increasing the ability of aquifer solids to remove contaminants from groundwater and/or manipulating the geochemistry to reduce remobilization of contaminants by desorption or dissolution of precipitates.

  MNA is retained as a potentially effective means of remediating the affected aquifer; however, the estimated time to achieve GWPS for the target Appendix IV constituents is dependent on site-specific conditions and groundwater modeling is needed to evaluate remedial timeframes.

- **Hydraulic Containment (Groundwater Pump and Treat)** – Hydraulic Containment may control potential hazards by eliminating risk pathways or reducing the rate of exposure to acceptable risk levels through containment of impacted groundwater. Hydraulic containment can be achieved by extraction wells and/or subsurface drains. After impacted groundwater is extracted, the water may be treated, discharged, or beneficially reused. Hydraulic containment requires periodic monitoring to evaluate effectiveness.

The effluent may require treatment for compliance with regulatory requirements. Permits may be required for the withdrawal and re-injection (if elected) of water, and the chemistry of the effluent after treatment would need to be compatible with the site NPDES permit. Options for treatment of effluent may include pH adjustment, precipitation technologies, adsorption on reactive media, ion exchange, membrane filtration, or biological treatment.

Regulatory requirements and institutional controls may be greater for hydraulic containment than some of the other corrective measures. Hydraulic containment would be anticipated to become effective within a short period following construction (2-4 years).

- **Subsurface Barrier Wall (Containment/Hydraulic Barrier)** - Containment actions include physical barriers that contain the source material such as caps, slurry walls, and sheet piles. They are designed to isolate the source material and prevent migration of the source water beyond the area of control. The benefits to containment actions are they are relatively simple to design, can be implemented quickly, and can address large areas and volumes of waste. However, there can be uncertainty with verifying their connection with natural subsurface barriers (e.g., low permeability layers, bedrock, etc.) and their long-term effectiveness.

  Barrier walls could be used to improve the subsurface hydraulic (flow) conditions for other technologies (i.e., PRB walls and pump-and-treat). Impermeable barrier walls can be used to direct groundwater to the treatment gates containing reactive media or to direct groundwater toward pumping wells in a pump-and-treat system. Since this is a physical corrective action it could become more effective within a short period following construction. However, since it would likely need to be used in conjunction with another remedy, time to completion would be based on the other corrective measure.

- **In-Situ Injection (geochemical manipulation)** – Chemical injection can be utilized to alter groundwater conditions to lower metal solubility. Reactive chemicals are introduced into groundwater and soil for the primary purpose of rapid and complete metal precipitation. This may involve adjustment of pH to higher levels while maintaining adequate buffering capacity in groundwater to limit the upward extent of the pH range (i.e., at levels above 10 S.U. solubility begins to increase).

  Some additional routine data collection (e.g. alkalinity) would be desirable post-treatment to ensure conditions remain favorable for low COC solubility. Adjustment of pH would be anticipated to occur relatively quickly, with long term monitoring (i.e., similar considerations as monitored natural attenuation).

- **Permeable Reactive Barrier** - A permeable reactive barrier (PRB) "is an in situ, permeable treatment zone designed to intercept and remediate a contaminant plume."[1] "The primary use of a PRB is to eliminate or substantially reduce the mass discharge of contaminant(s) downgradient of the barrier. The PRB is not typically used as a source remediation technology; however, it may be used as a source control technology depending on the placement of the PRB relative to the location of the contaminant source."[2] Inorganics have shown to be amendable to remediation using PRB technology with the appropriate reactive media. Potential

[1] Pg. 2, Permeable Reactive Barrier: Technology Update, The Interstate Technology & Regulatory Council (ITRC), June 2011.
[2] Pg 12, Permeable Reactive Barrier: Technology Update, The Interstate Technology & Regulatory Council (ITRC), June 2011.

reactive media include zero valent iron, zeolites, and granular activated carbon and COCs are removed by precipitation and/or adsorption. A PRB can be installed through trenching or soil excavation.

A PRB is a passive treatment system that acts as a barrier to groundwater contamination but not to groundwater flow. PRBs can be used to remediate groundwater impacted with inorganic contaminants. A PRB must intercept the flow if impacted groundwater and to be effective it must be designed and constructed such that impacted groundwater cannot bypass the reactive media by flowing over, under or around the PRB. A PRB must include the appropriate reactive media and the residence time with the PRB needs to be sufficient to allow for effective treatment. Reactive media options are being explored for molybdenum and lithium.

- **In-Situ Stabilization/Solidification** – In Situ Stabilization/Solidification, also referred to as single auger mixing or deep soil mixing, uses a crane-mounted auger system to drill into affected soils and uniformly mix the soils with cement to create a monolith (stabilization) or other appropriate chemical additives to chemically bind constituents within the solid matrix (stabilization). This remedy can also be achieved by a cutter head on an excavator if treatment depths do not exceed the reach of the excavator. Additional equipment utilized for treatment primarily consists of a grout mixing plant, a grout pump and a mixing rig designed to capsulate constituents in a monolithic solid of high structural integrity, thereby minimizing constituent migration. This corrective measure would be anticipated to become effective within a short period following construction (2 – 4 years). However, in situ stabilization is not directly effective if the source of the COCs is naturally occurring in aquifer materials. Some indirect benefit may still occur if pH is increased in the vadose zone soils. Due to the high percentage of fine-grained soil in the aquifer material, as documented in previous site investigations (EMS, 2003), the ability to distribute media used to solidify/stabilize in heterogeneous porous media may be limited.

Following identification of these potential response actions, Golder prepared a preliminary comparative evaluation of the retained groundwater remediation technologies for the respective corrective measure areas. The potential remedial technology type is a general category of technology, while the process options are specific methods within each remedial technology type. The general response actions developed for further consideration for each of the corrective measure areas identified above are summarized in Table 1. Consistent with the approach outlined for the Source Control Measures, the groundwater remedy may include a multi-phase approach, which is sequenced to allow for monitoring of results and optimization of subsequent remedial actions for affected groundwater.

Information regarding potential remediation technologies that may be applicable based on contaminant groups is available on EPA's clean-up information website at www.clu-in.org. Information available on the website has been used as a guide for screening technologies based on the COCs and its location at the site.

5.0 REMEDY SELECTION PROCESS

The purpose of this ACM is to begin the process of selecting corrective measures for groundwater impacts based on further evaluation using the criteria outlined in § 257.96(c).

Additional data collection is ongoing. CoOp will prepare semi-annual reports to discuss the progress in selecting and designing the remedy in accordance with § 257.97(a). At least 30 days prior to the selection of remedy or remedies, a public meeting to discuss the results of the corrective measures assessment will be held pursuant to

§ 257.96(e). The final remedy selection report will be developed as outlined in § 257.97(a). Once the remedy has been selected, the implementation of the remedy will be initiated in accordance with § 257.98.

6.0 REFERENCES

Code of Federal Regulations, 2015 April. Chapter 40, Part 257, Subpart D.

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TABLE & FIGURES

TABLE 1.
EVALUATION OF CORRECTIVE MEASURES ALTERNATIVES
COOPERATIVE ENERGY - RD MORROW GENERATING STATION
PURVIS, MISSISSIPPI

Corrective Measure	Description	Ease of Implementation 40 CFR 257.96(c)(1)	Performance 40 CFR 257.96(c)(1)	Potential Impacts 40 CFR 257.96(c)(1)	Reliability 40 CFR 257.96(c)(1)
Monitored Natural Attenuation & Enhanced Monitored Natural Attenuation	A remedial solution that takes advantage of natural attenuation processes to attenuate constituents in soil and groundwater. This option may meet the GWPS given sufficient time and favorable conditions. Engineering controls should be evaluated along with this option.	This process is not limited by implementation.	This process provides ongoing effectiveness and is well documented as an effective measure for remediating groundwater	This process is effective in reducing toxicity, mobility, and concentrations of COCs via natural processes.	This process will likely have overall reliability in achieving GWPS goals where impacted area remains internal to the site and is adequately monitored.
Hydraulic Containment (Pump and Treat)	Combines a groundwater extraction system with a surface treatment system to remove target analytes from the subsurface and/or to control/prevent constituent migration.	Relative ease in implementation compared to other technologies.	Groundwater Pump & Treat is an effective corrective measure for dissolved constituents provided regular maintenance is performed throughout the operational life. Not typically immediately effective for trace level metals. Rebounding can occur as water levels return to normal once the pumping system is turned off post-remediation. Generally, requires disposal of treated water and sludges.	Groundwater Pump & Treat is more effective with constituents that are easily oxidized (low boiling point) and less effective with inorganic compounds (metals).	This technology provides moderate reliability by hydraulically controlling migration of the COCs groundwater plume.
Subsurface Vertical Barrier Walls	Used to physically control the migration of impacted groundwater. They may be used to either directly contain impacted groundwater by isolating it or to manipulate the flow direction of groundwater.	Ideally the lower depth would achieve a low permeability zone. Additional subsurface investigation would be required to confirm and define the lower confining unit.	May need to be used in conjunction with an additional technology such as a permeable reactive barrier or pump- and-treat.	Potential mounding of groundwater, creating possible changes in flow direction or daylighting of seepage.	The reliability of this technology is limited by the ability to manage changes in the flow direction and hydraulic head of groundwater.
In-Situ Injection (Geochemical Manipulation)	Injection of a chemical or organic substrate to alter geochemical conditions to those more favorable for stabilization of COCs. In this case an injection that would increase the pH to the 6-8 range is desirable.	This process is not substantially limited by implementation. Bench testing and pilot testing can be used to optimize implementation.	This process has the potential to alter conditions rapidly but requires ongoing monitoring to ensure conditions remain favorable.	Non-hazardous chemicals used for pH adjustment will not create undesirable byproducts. High pH conditions (> 10) must be avoided due to increased solubility of COCs at higher pH levels.	This process will likely have overall reliability in achieving GWPS goals when adequate volume and subsurface distribution are achieved. Ongoing monitoring is necessary to ensure favorable conditions are maintained once achieved.
Permeable Reactive Barrier	A permeable reactive barrier is a zone of reactive material that extends below the water table to intercept and treat groundwater.	Additional investigation is necessary to confirm the lower confining unit. Depth to this unit may make this technology challenging to implement.	This technology may have a limited reactive lifespan and is only effective for specific constituents. Marginally effective over long periods of time without replacement of PRB material. The approach is expected to achieve GWPS for both constituents as impacted groundwater passes through the reactive barrier.	This technology may reduce the toxicity, mobility or volume of metals in groundwater through precipitation of the metal(s) as oxides in the reactive media.	This technology is expected to be reliable in the site-specific lithology due to ease of interception of groundwater flow though shallow sand aquifer.

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Corrective Measure	Description	Ease of Implementation 40 CFR 257.96(c)(1)	Performance 40 CFR 257.96(c)(1)	Potential Impacts 40 CFR 257.96(c)(1)	Reliability 40 CFR 257.96(c)(1)
In-Situ Stabilization/Solidification	In situ stabilization is achieved by creating reactive zones in the subsurface through chemical injection to intercept constituents and permanently immobilize or degrade them into harmless end products. In-situ solidification is the process by which constituent mobility in a solid matrix is decreased through physical and/or chemical means. Grout or other chemical additives are mixed with aquifer materials to reduce permeability. The resulting lower aquifer permeability limits the flow of impacted groundwater.	Relative ease in implementation compared to other technologies; however, stabilization may not be suitable due to high percentage of fine-grained materials in aquifer.	Performance would need to be assessed through pilot testing. May need to be used in conjunction with an additional technology. This treatment may reduce the permeability of the aquifer with precipitation of COCs hydroxides.	Treatment may result in the stabilization of COCs, however, increases in the solubility of non-target metals need to be considered. Can result in undesirably high pH levels if geochemical buffering system is not maintained.	The reliability of this technology is limited by the ability to distribute media used to solidify/stabilize in heterogeneous porous media. Fine-grained materials limit viability of stabilization.

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COOPERATIVE ENERGY - RD MORROW GENERATING STATION
PURVIS, MISSISSIPPI

Corrective Measure	Begin/Complete 40 CFR 257.96(c)(2)	Institutional Requirements 40 CFR 257.96(c)(3)	Other Env or Public Health Requirements 40 CFR 257.96(c)(3)	Relative Costs
Monitored Natural Attenuation & Enhanced Monitored Natural Attenuation	Can begin immediately. Long-term monitoring and reporting likely required.	MNA may require the implementation of institutional controls, such as deed restrictions, to preclude potential exposure to groundwater within the footprint of impacted groundwater until GWPS are achieved.	Little to no physical disruption to remediation areas and no adverse construction-related impacts are expected on the surrounding community. Further evaluation of downgradient receptor pathways should be considered.	Relatively lower capital costs are associated with this technology.
Hydraulic Containment (Pump and Treat)	Time needed to model and design may take up to 24 months; variable time for construction depending on scale, generally can be accomplished in 6 months.	Depending on the effluent management strategy, modifications to the existing NPDES permit may be required, or obtaining a new underground injection control (UIC) permit may be needed if groundwater reinjection is chosen. In addition, deed restrictions may be required if groundwater conditions are above regulatory standards for unrestricted use.	Depending on the effluent management strategy, modifications to the existing NPDES permit may be required, or obtaining a new underground injection control (UIC) permit may be needed if groundwater reinjection is chosen. In addition, deed restrictions may be required if groundwater conditions are above regulatory standards for unrestricted use.	High costs are associated with this technology (O&M and groundwater disposal).
Subsurface Vertical Barrier Walls	Time needed to model and design may take up to 24 months. Variable time for construction depending on scale, generally can be accomplished relatively quickly between 6 and 12 months.	Deed restrictions may be necessary for groundwater areas downgradient of the barrier wall until remedial goals are met. No other institutional requirements are expected at this time.	Additional investigation near adjacent waterbodies should be evaluated to confirm there are no potential receptors downgradient of the unit. Due to the need for groundwater extraction associated with barrier walls, above-ground treatment components may need to be present for an extended period, creating carbon emissions and generating residuals requiring management and disposal.	High capital costs are associated with this technology.
In-Situ Injection (Geochemical Manipulation)	Can begin immediately upon completion of pilot testing and/or bench scale testing, which may take up to 24 months. Long-term monitoring and reporting likely required.	Deed restrictions may be necessary until in-situ treatment has achieved GWPS. A new UIC permit (for in-situ injections) would be required to implement this corrective measure. No other institutional requirements are expected at this time.	None expected at this point. Additional investigation to confirm no downgradient receptors is necessary. Following installation, the remedy is passive.	Moderate costs are associated with this technology.
Permeable Reactive Barrier	Time needed to model and design may take up to 24 months; variable time for construction depending on scale, generally can be accomplished in 6 to 12 months.	Deed restrictions may be necessary for groundwater areas upgradient of the PRB (if not installed along the waste boundary). No other institutional requirements are expected at this time.	None expected at this point. Based on downgradient sampling results near adjacent waterbodies, additional investigation is necessary to evaluate receptor pathways downgradient of the unit. Following installation, the remedy is passive. However, certain treatment media have the potential to mobilize naturally occurring constituents downgradient of the PRB.	High capital costs are associated with this technology.

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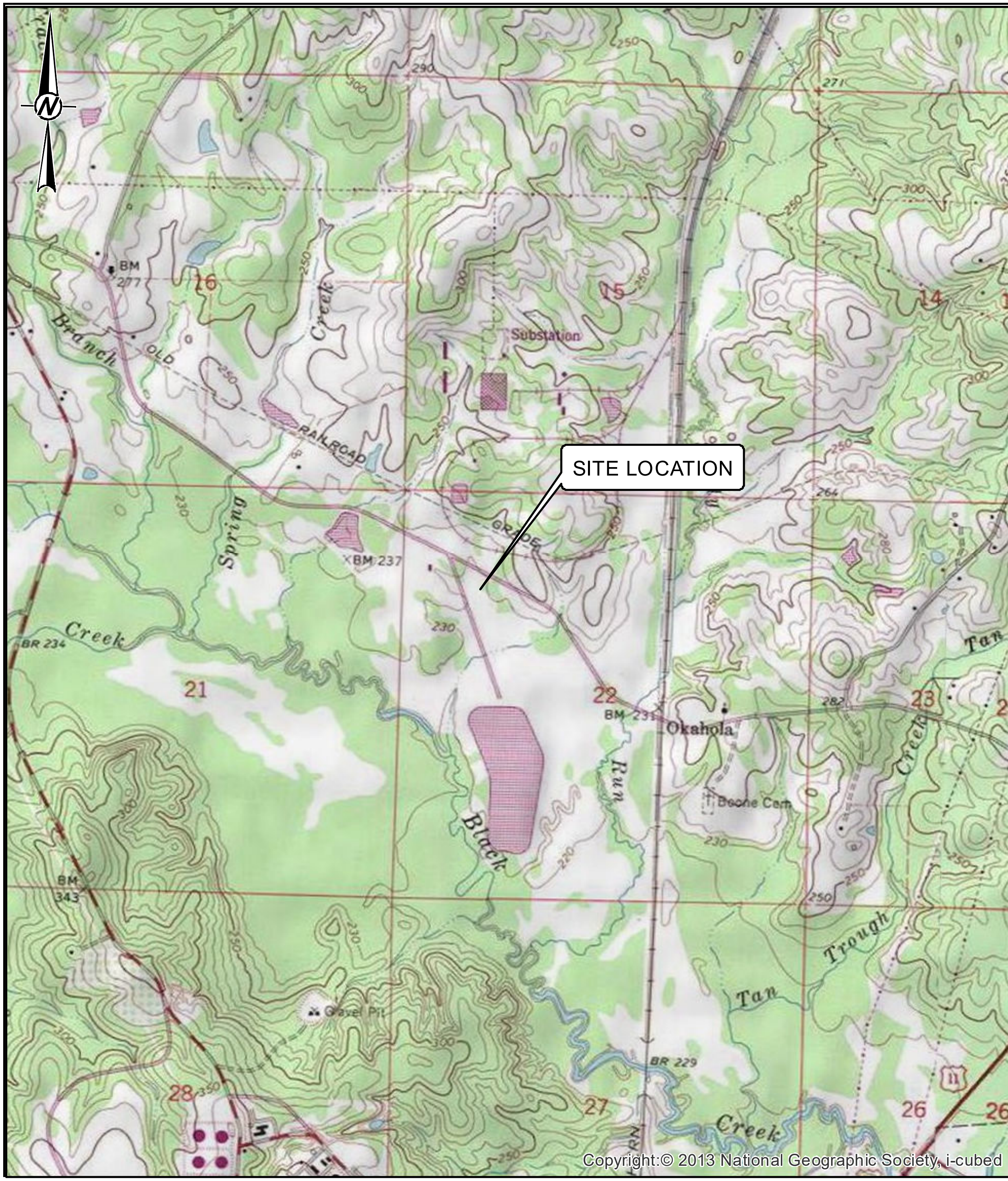
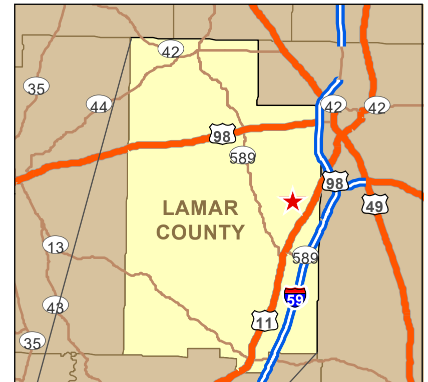
PURVIS MISSISSIPPI

Corrective Measure	Begin/Complete 40 CFR 257.96(c)(2)	Institutional Requirements 40 CFR 257.96(c)(3)	Other Env or Public Health Requirements 40 CFR 257.96(c)(3)	Relative Costs
In-Situ Stabilization/Solidification	Time needed to model and design may take up to 24 months; variable time for construction depending on scale, generally can be accomplished relatively quickly between 6 and 12 months. Solidification is likely not suitable due to high percentage of fine-grained materials in aquifer.	Deed restrictions may be necessary for groundwater areas downgradient of the stabilized and/or solidified areas. No other institutional requirements are expected at this time.	None expected at this point. Further investigation is needed downgradient, near adjacent waterbodies to evaluate potential receptors downgradient of the unit. Following implementation of ISS, this source control remedy is passive, does not create carbon emissions, and preserves groundwater resources.	Moderate costs are associated with this technology (repeat injections if there is a rebound in concentrations).

Path: H:\19x-Projects\19117989-Coop Energy\figures\A-\19117989A000-GIS.mxd





0 1000 2000
Feet

CLIENT
COOPERATIVE ENERGY LLC

PROJECT
RD MORROW GENERATING STATION
PURVIS, MISSISSIPPI

TITLE
SITE LOCATION MAP

CONSULTANT

GOLDER

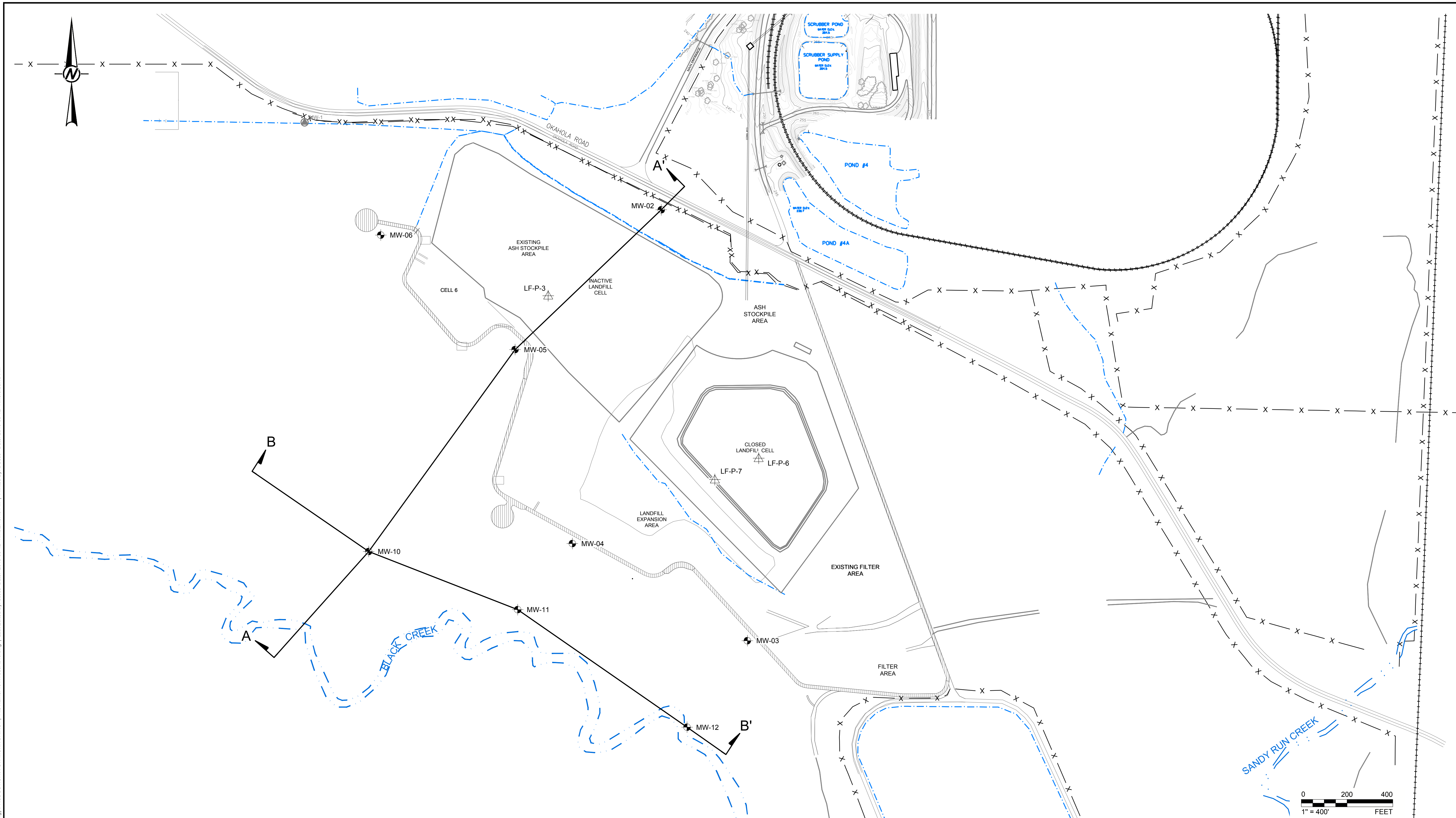
YYYY-MM-DD	2019-09-12
PREPARED	DJC
DESIGN	DLP
REVIEW	DLP
APPROVED	TIR

PROJECT No.	CONTROL	Rev.	FIGURE
19117989	19117989A000-GIS.mxd	0	1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET HAS BEEN MODIFIED FROM: ANSI A

1 in

0



LEGEND

MW-XX	MONITORING WELL LOCATION
LF-P-X	PIEZOMETER LOCATION
	CROSS SECTION LOCATION

REFERENCE

BASE MAP TAKEN FROM ENVIRONMENTAL MANAGEMENT SERVICES, INC., MONITORING WELL LOCATIONS, DATED 2017-02-17 DELIVERED IN .DWG FORMAT.

CLIENT
COOPERATIVE ENERGY LLC

PROJECT
RD MORROW GENERATING STATION
PURVIS, MISSISSIPPI

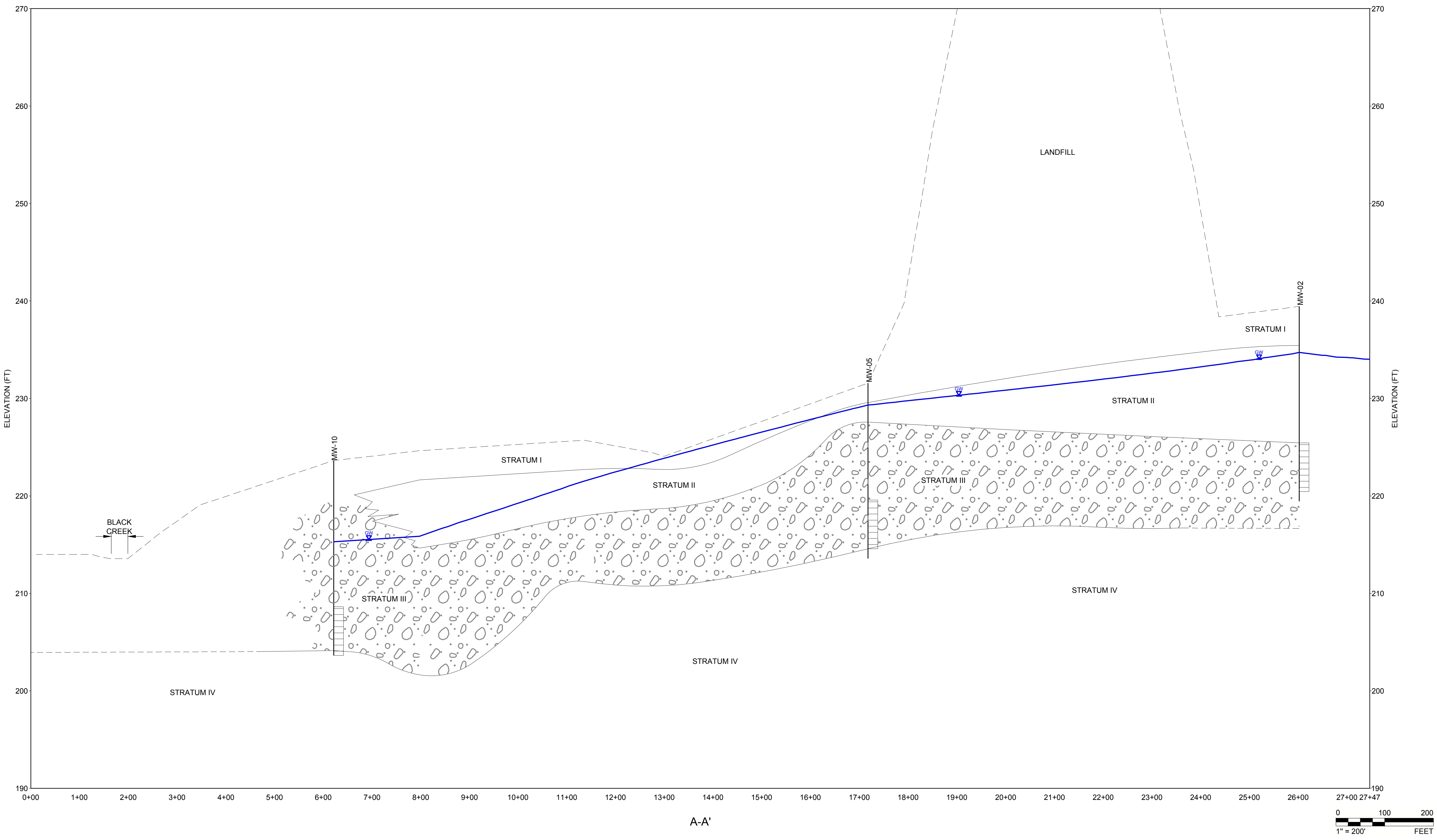
CONSULTANT

GOLDER

YYYY-MM-DD	2019-09-09
DESIGNED	DLP
PREPARED	DJC
REVIEWED	DLP
APPROVED	TIR

TITLE
CCR LANDFILL UNIT MONITORING WELL NETWORK & CROSS SECTION LOCATION MAP

PROJECT NO.	CONTROL	REV.	FIGURE
19117989	19117989A010.dwg	0	2



LEGEND

- APPROXIMATE GROUND SURFACE
- GROUNDWATER ELEVATION BASED ON DATA COLLECTED IN AUGUST, 2019
- WELL SCREEN

STRATA KEY

STRATA I: SILTY SAND

STRATA II: SILTY CLAY

STRATA III: SAND AND SILTY SAND AND GRAVEL (AQUIFER UNIT)

STRATA IV: BLUE-GREEN CLAY (HATTIESBURG FORMATION)

CLIENT
COOPERATIVE ENERGY LLC

CONSULTANT

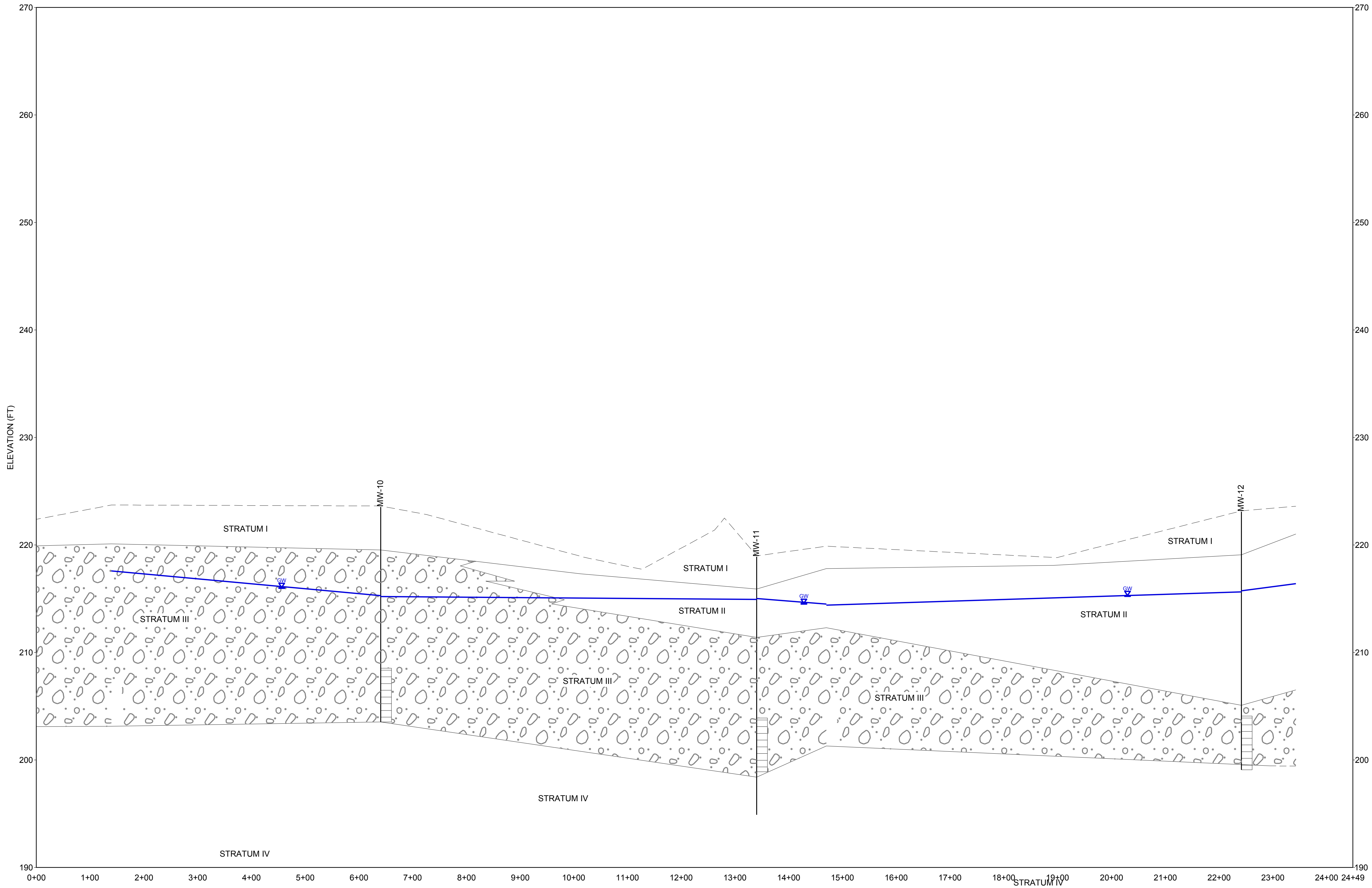
GOLDER

YYYY-MM-DD	2019-09-05
DESIGNED	DLP
PREPARED	DJC
REVIEWED	DLP
APPROVED	TIR

PROJECT
RD MORROW GENERATING STATION
PURVIS, MISSISSIPPI

TITLE
SUBSURFACE GEOLOGIC CROSS SECTION A-A'

PROJECT NO.	CONTROL	REV.	FIGURE
19117989	19117989B001.dwg	0	3



B-B'

0 100 200
1" = 200' FEET
20x VERTICAL EXAGGERATION

LEGEND

- APPROXIMATE GROUND SURFACE
- GROUNDWATER ELEVATION BASED ON DATA COLLECTED IN AUGUST, 2019
- WELL SCREEN

STRATA KEY

STRATA I: SILTY SAND

STRATA II: SILTY CLAY

STRATA III: SAND AND SILTY SAND AND GRAVEL (AQUIFER UNIT)

STRATA IV: BLUE-GREEN CLAY (HATTIESBURG FORMATION)

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RD MORROW GENERATING STATION
PURVIS, MISSISSIPPI

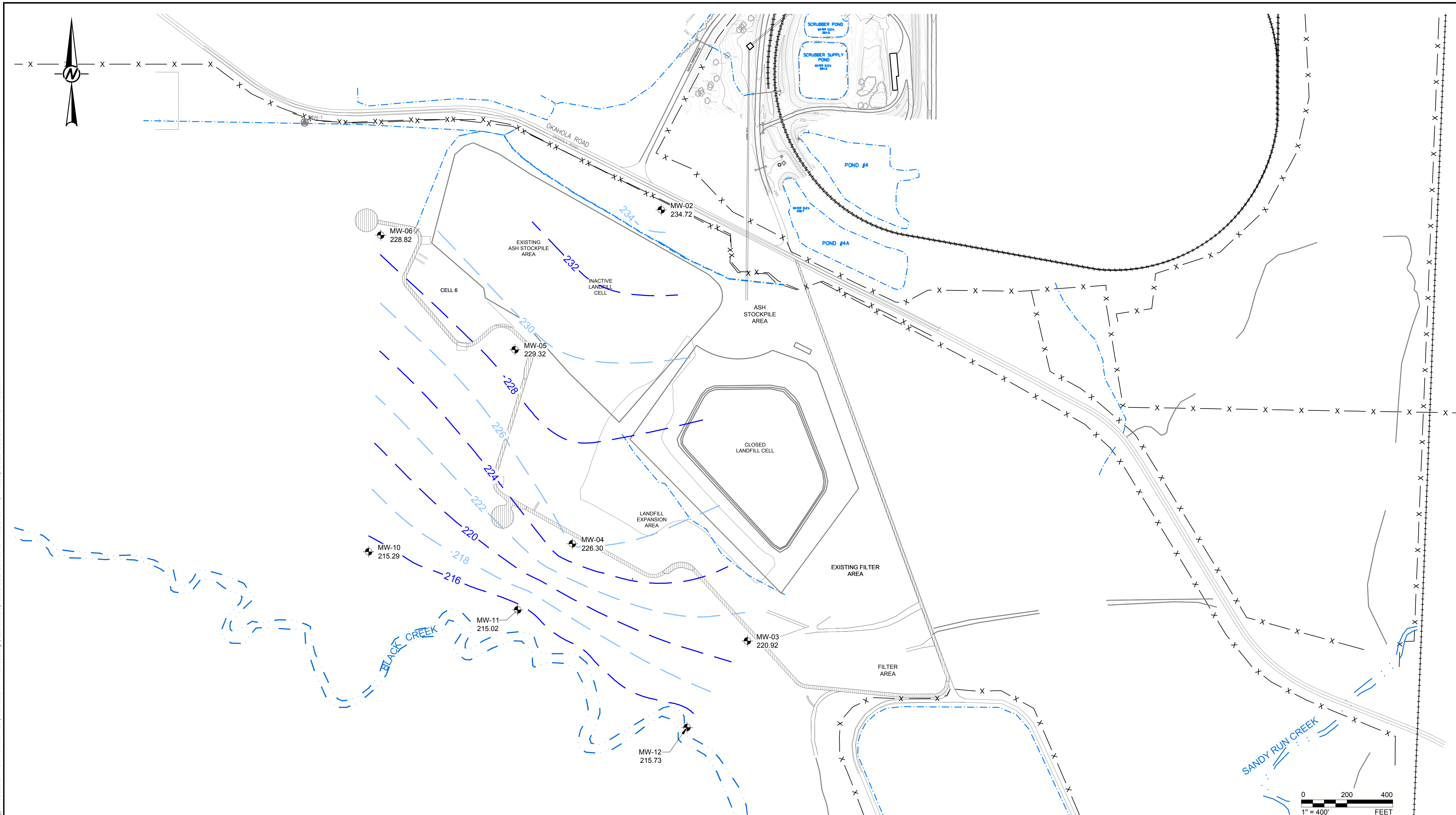
CONSULTANT

GOLDER

YYYY-MM-DD	2019-09-05
DESIGNED	DLP
PREPARED	DJC
REVIEWED	DLP
APPROVED	TIR

TITLE
SUBSURFACE GEOLOGIC CROSS SECTION B-B'

PROJECT NO.	CONTROL	REV.	FIGURE
19117989	19117989B002.dwg	0	4



LEGEND

MW-XX MONITORING WELL LOCATION WITH GROUNDWATER ELEVATION

220 / 218 GROUNDWATER ELEVATION CONTOUR

REFERENCE

BASE MAP TAKEN FROM ENVIRONMENTAL MANAGEMENT SERVICES, INC., MONITORING WELL LOCATIONS, DATED 2017-02-17 DELIVERED IN .DWG FORMAT.

CLIENT COOPERATIVE ENERGY LLC		PROJECT RD MORROW GENERATING STATION PURVIS, MISSISSIPPI	
CONSULTANT GOLDER	YYYY-MM-DD 2019-09-05 DESIGNED DLP PREPARED DJC REVIEWED DLP APPROVED TIR	TITLE **POTENTIOMETRIC SURFACE ELEVATION CONTOUR MAP** *AUGUST 13, 2019*	
PROJECT NO. 19117989	CONTROL 19117989A006.dwg	REV. 0	FIGURE 5

GOLDER

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