# Residual Solids Evaluation
# Summary Report
# Black River Dredged Material Reuse Facility

FINAL

October 2022

Prepared For:

City of Lorain Engineering Department
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October 11, 2022

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Ms. Golden,

Coldwater Consulting, LLC (Coldwater) and Geosyntec Consultants, Inc. (Geosyntec) have prepared the Summary Report for the Residual Solids Evaluation associated with the Black River Dredged Material Reuse Facility (BRDMRF) project.

The Residual Solids Evaluation was funding using two sources as below:

- Healthy Lake Erie Initiative grant to the City of Lorain (City), administered by Ohio Department of Natural Resources (ODNR), Office of Coastal Management (OCM). Generally, this grant funded the earthworks; field plots; pollutant, agronomic, and geotechnical laboratory analyses; engineering calculations; and, the majority of onsite measurements and observations.
- Project-specific supplemental grant to the City by the ODNR OCM. Generally, this grant funded the university professor-led greenhouse studies; analytical data reduction and interpretation of the pollutant, agronomic, and geotechnical laboratory results; interpretation of onsite measurements and observations; stakeholder engagement; and the majority of reporting.

Consistent with the Residual Solids Evaluation scope of work, this report does not differentiate the performed work between the individual grants. Rather, the report summarizes the work performed on the dredged material once it was contained within the GeoPool beginning in August 2020.

The work performed, observations, calculations, and interim conclusions over the 420 calendar days of the Residual Solids Evaluation were shared with the stakeholders during the Monthly Agency Meetings. Photographs and observations were shared monthly and topical PowerPoint slide decks were presented at milestones. The topical PowerPoint slide decks are appendices to this summary report.

Should any questions or feedback arise from your review of the documents presented, please contact Kristen Risch at kdrisch@coldwaterconsultants.com or 614-519-6062 or Corry Platt at corry.platt@geosyntec.com or 919.656.5799.

Sincerely,

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Black River Dredged Material Reuse Facility
City of Lorain
Lorain County, Ohio

**Prepared for:**

City of Lorain, Engineering Department
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**October 2022**

## ACKNOWLEDGMENTS

The Residual Solids Evaluation associated with the Black River Dredged Material Reuse Facility described in this report was funded through two grants issued to the City of Lorain and administered by the Ohio Department of Natural Resources, Office of Coastal Management. The Ohio Environmental Protection Agency (Ohio EPA); Ohio Department of Natural Resources (ODNR), Parks and Watercraft Division; and the US Army Corps of Engineers provided in-kind support and collaboration. The Residual Solids Evaluation grant funding sources were:

- Healthy Lake Erie Initiative grant to the City of Lorain (City), administered by ODNR, Office of Coastal Management (OCM). Generally, this grant funded the earthworks; field plots; pollutant, agronomic, and geotechnical laboratory analyses; engineering calculations; and, the majority of onsite measurements and observations.
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## EXECUTIVE SUMMARY

The Black River Dredged Material Reuse Facility (BRDMRF) design has developed since 2019 achieving several milestones including site selection and alternative site analyses, bench and pilot projects, series of iterative layouts, preliminary design, cost-conscious design and material selection, onsite investigations and mappings, and onsite work to prepare for construction. The base premise of the BRDMRF is to design a 50-year lifespan facility to annually process 75,000 cubic yards of fine-grained Black River sediments for beneficial reuse in the commercial market – an activity that has no local precedent and requires planning and engineering a facility capable to adapt without substantial capital investment or operational delays.

In 2019, the project began bench and pilot studies focused upon the dewatering of the hydraulically-delivered slurry. The project performed the GeoPool Pilot Study to evaluate this innovative textile-dewatering technology in its first global application for dewatering fine-grained dredged sediments. Upon filling the GeoPool in August 2020, the stakeholders agreed to increase the monitoring and evaluation of the GeoPool-contained dredged sediments above the original intention to observe dewatering and simply stockpile the residual solids. The increased monitoring and evaluation inspired the Residual Solids Evaluation which was initiated in August 2020 and extended to October 2021 when the GeoPool was disassembled and the remaining dewatered sediments were shaped into a conical stockpile for future reuse.

The Residual Solids Evaluation sought to answer seven primary questions, which it achieved as shown in Table ES-1.

**Table ES-1: Residual Solids Evaluation's Primary Questions**

| Question | Answer |
|---|---|
| Will the residual solids dewater to a cake-like consistency negating the common dredged material management requirement to rehandle to promote dewatering? | **Yes**<br>*The natural freeze-thaw cycles of the winter season accentuate the dewatering with no operational cost.* |
| How long does it take the solids to reach a suitable moisture content to be excavated, trucked, stockpiled, and blended to create marketable products? | **About 75 days.**<br>*Allowing the dewatering sediments to be exposed to the winter freeze-thaw and spring heat improves the handling and stockpiling.* |
| How do the residual solids characteristics compare to the pre-dredge sediment characteristics? | **No substantial pollutant, agronomic, or physical parameter changes.**<br>*The entrained water initially is greater than (bulks) pre-dredge in-situ yet is released as consolidation occurs resulting in an overall reduction in the moisture content and the volume the dredged sediment consumes. The in-situ volume after dewatering generally results in a 50% volumetric reduction; in short, the expected 75,000 insitu cyds dredged would become 37,500 dewatered loosely compacted cyds suitable for reuse applications.* |
| What blending is necessary to create suitable and marketable beneficial reuse products from typical Black River dredged material? | **Three passes with a rear-tine tiller provides a mechanically-blended 12-inch thick product.**<br>*Blending with placement site soils at various percentage rates yields suitable reuse in agricultural crop production, garden soil, growing turf grass (sod or seed), and ecological restoration.*<br>*Compacting without blending yields suitable cover for brownfield redevelopment and foundation soil for asphalt parking lots.*<br>*Compacting after incorporating a cement amendment yields suitable engineered fill for foundation soil for buildings and roadways.* |
| Can the GeoPool structure (e.g., fabric, wire mesh, frames) be disassembled while retaining a central/interior stockpile of residual solids? | **Yes** |

| Question | Answer |
| --- | --- |
| *Which structural components of the GeoPool warrant assessment between usages?* | **Toe-link and C-Channel** |
| *How does the solids handling, solids blending, and disassembly effect the operational financial forecast and schedule?* | **Single touch of the dewatered sediments was demonstrated feasible and practical.**<br>*Sequencing the hydraulic slurry filling to occur in late Summer/Fall and solids excavation to occur in late Spring/early Summer appears to minimize the necessity for double handling or windrowing.*<br>*Interim stockpiling of dewatered sediments onsite is likely due to the variable nature of the consumable market.*<br>*Partnering with brownfield redevelopment, ecological restoration, and park improvements to align these other projects' receipt of the dewatered sediments with the emptying of the GeoPools is practical, will reduce facility operating cost, and could yield additional grant funds to purchase the dewatered sediment from the City facility.*<br>*Application sites greater than 20 miles from the Facility are less likely to purchase the dewatered sediments due to the associated haul cost.* |

**Work Performed**

Implementing the Residual Solids Evaluation included the following actions:

1. Monitoring dewatering and consolidation of the solids within the GeoPool beginning on 26 August 2020.
2. Obtaining the Beneficial Reuse Exemption Approval from the Ohio EPA (BENU023820, issued 4 November 2020).
3. Collecting push cores to retrieve samples of the dewatering solids within the GeoPool over a period of 77 days.
4. Performing test pits to retrieve samples of the dewatering solids within the GeoPool at 28 and 86 elapsed days of dewatering.
5. Excavating about 700 cubic yards from the GeoPool and creating field plots of:
    a. Three 100 square feet plots where eight (8) inches of dredged material were placed. Within two, City leaf compost was blended in about a 67% dredged material to 33% compost ratio, one tiller mixed and one excavator bucket mixed.

   b. 2,500 square feet where subsequently blended with City leaf compost in a 1:1 ratio.
   c. 2,500 square feet where subsequently blended with manufactured sand in a 70% dredged material to 30% manufactured sand ratio.
   d. 10,000 square feet where placed 8 to 12 inches thick
   e. 10,000 square feet where placed in piles 12 to 24 inches thick
6. Submitting samples for pollutant, agronomic, and physical characteristics analyses of:
   a. Test pit excavated materials at 28 elapsed days of dewatering
   b. Test pit excavated materials at 86 elapsed days of dewatering
   c. Field plot laid solids before and after blending with compost and manufactured sand
   d. Dewatered solids supplied to the Universities for the greenhouse studies.
   e. Farm soils supplied to the Universities for the greenhouse studies.
7. Tracking moisture content changes using 27 laboratory analyses collected at various locations within the GeoPool over 84 elapsed days of dewatering indicating a decrease from about 130% to 80%, which generally corresponds with an increase in percent solids from about 45% to 65%.
8. Tracking moisture content changes of field plot over the five-month winter exposure to approximate the effect of windrowing the dredged sediments excavated at elapsed day 86, which indicated retention of moisture for compost-blended solids, about 40% moisture reduction of unaltered solids, and about a 50% moisture reduction of sand-blended solids.
9. Scoping and performing University-led greenhouse studies of various plants' growth in varying dredged material-based soil media, where:
   a. Bowling Green State University through Dr. Angelica Vazquez-Ortega, evaluated the response of corn and soybean germination, growth, and biomass to:
      i. 0, 5, 10, 20, and 100% dredged material blended with Lorain County farm soil.
      ii. 0, 5, 10, 20, and 100% dredged material blended with Lorain County farm soil and a soil acidifier treatment.
      iii. 5% leaf compost blended with 0, 5, 10, 20, and 95% dredged material blended with Lorain County farm soil.
   b. Bowling Green State University through Dr. Angelica Vazquez-Ortega, evaluated the response of sod growth and biomass to:
      i. 0, 30, 40, and 100% dredged material blended with farm soil with and without 5% compost.
   c. Wright State University through Dr. Megan Rua, evaluated the response of corn germination, growth, and biomass to:
      i. 0, 30, 50, 70, and 100% dredged material blended with Lorain County farm soil.

   d. Wright State University through Dr. Megan Rua, evaluated the response of canola, fescue seed, and ecological restoration seed germination, growth, and biomass to:
      i. 0, 30, 50, 70, and 100% dredged material blended with Lorain County farm soil.

10. Scoping and performing engineered fill soil testing through geotechnical laboratory analyses simulating various mixes of dredged material and Portland cement to identify the opportunities to improve the dredged materials' strength characteristics for reuse as:
    a. General site soil fill
    b. Structural soil
    c. Embankment core material
    d. Brownfield or landfill cover
    e. Roadway subgrade

### Top Take-Aways / Results

The results of the monitoring and studies performed are summarized in Table ES-2.

**Table ES-2 – Practical Applications of Beneficially Reused Dredged Material**

| Application | Finding |
|---|---|
| Brownfield Cap / Cover | When compacted meets CERCLA landfill cover and exceeds 1.00E-05 cm/s hydraulic conductivity. |
| General site fill | When compacted has suitable strength for beneath asphalt parking lots. |
| Engineered fill | With 3% cement added has suitable strength for single story building foundation soil.<br>With 7% cement added has suitable strength for multi-story building and general purpose roadways foundation soil.<br>With 10% cement added has suitable strength for interstate roadway foundation soil. |
| Turf grass | Blend site soil with 30 to 70% dewatered sediments for sod or seeding with fescue. |
| Ecological restoration | Blend site soil with 50 to 100% dewatered sediments for seeding with restoration seed mix. |
| Agricultural—Corn | Blend site soil with 10% dewatered sediments for corn. Amending typical farm soil with dredged material produced crop with increased biomass, increased yield (additional ears), and shorter time to reproductive stage. Growing corn in 100% dredged material reduced germination, height, survival, & no ears. |

| Application | Finding |
|---|---|
| Agricultural—Soybean | Blend site soil with 20% dewatered sediments for soybeans. Amending typical farm soil with dredged material produced crop with increased biomass and tallest average height. |
| Amendment—Compost | Blending with 5% compost tended to increase plant growth. |
| Amendment—Acidifier | Incorporating acidifier tended to reduce seed germination and plant growth. |
| Mechanical blending | Three passes with rear-tine tiller resulted in a uniform blend of sand, compost, and dewatered sediment initially laid in layers. |
| *Findings are laboratory study based—consult Engineer-of-Record, Agronomist, Agricultural Extension Office or other pertinent professional to tailor findings to specific application and individual site conditions.* | |

**Market Considerations**

The Residual Solids Evaluation scope of work included assessing Market Considerations for the dewatered sediments. This effort was approached after the monitoring and studies were performed so that market opportunities aligned with the findings. The Market Considerations are three-fold:

1. Quantity of dewatered sediment annually available.
    a. As dredged material dewaters and the entrained water is released, the volumetric space reduces. Extrapolating the observations over the duration of the Residual Solids Evaluation to the expected future annual 75,000 cyds of USACE dredged sediments (measured as cyds removed from in-river) results in about 37,500 cyds of dewatered sediments for entry into the market.
2. Opportunities within a reasonable hauling distance.
    a. Using nationally-based construction industry cost estimating guides for on-road hauling, there is a step-up between 15 and 20 mile haul distances. Therefore, restricting opportunities to within a 15-mile radius of the Black River Dredged Material Reuse Facility is recommended.
    b. While unsupported with comparative evidence, the 15-mile radius is consistent with the author's discussions and experience with earthwork's contractors and companies that recycle/reuse dredged material.
    c. Due to budgetary limits, additional effort is recommended to identify and quantify the market value and limits of 37,500 cyds of dewatered sediments within the 15-mile radius. Based on aerial photo review, land use mapping, and brownfield listings, there are reuse opportunities within the 15-mile radius as:
        i. Brownfield cover
        ii. Residential and non-structural fill
        iii. Structural fill

iv. Blending with farm soils on agricultural lands

v. Ecological restoration soil

3. Opportunistic Co-Dependent Projects.

   a. The data in-hand coupled with redevelopment initiatives within the City and County of Lorain open opportunities to align dewatered sediment reuse with publicly sponsored redevelopment projects. Specifically, the public agencies (project sponsors) would collaborate, align construction schedules, and specify that the dewatered sediments will be used rather than soils imported from borrow pits or other commercial stockpiles.

   b. Due to budgetary limits, additional effort is recommended to identify pertinent stakeholders, soil quantities, soil characteristics, and calendar year of future prospective projects to use dewatered sediments.

      i. Based on brownfield listings from a previous EPA grant to Port of Lorain, there were 34 brownfield sites identified within 5 miles of the BRDMRF.

      ii. For illustration, assuming each brownfield site requires two feet of compacted soil cover, the annual dewatered sediment quantity is consumed over 11 acres, which could be at a single or multiple sites.

   c. By identifying co-dependent project opportunities, grant funds could be sought emphasizing the reuse of the dewatered sediment, its sustainability, its maritime industry supportive function, and its grant-funded history over the commercially driven increase in extensive borrow pits.

   d. There are considerations and implications of co-dependent projects. Joining two projects require coordination, cooperation, and schedule alignment for optimum cost-savings, which is primarily driven by minimizing the dewatered sediment stockpiling and rehandling prior to hauling to the reuse location.

**Recommendations**

The Residual Solids Evaluation adds value to the operational considerations for the future Black River Dredged Material Reuse Facility. In addition to the market valuations and co-dependent projects mentioned above, there are various subsequent studies that can continue to advance and diversify the reuse opportunities, stakeholder and public acceptance, and diminish perceptions of dredged sediment as a waste that are recommended:

1. Support Ohio EPA's initiatives to streamline the beneficial use of dredged material authorizations, exemptions, and permits.
2. Encourage additional stakeholder participation with representatives of soil brokers, agriculture, parks, and brownfields.
3. Consider additional studies of:
    a. Amending commercial greenhouse growing media (horticulture and vegetable).
    b. Establish publicly accessible demonstration plots of 1 to 10 acres in size with available irrigation to perform scaled-up field demonstration of the University greenhouse successful plants and soil blends.
    c. Performing and monitoring a compacted cover at a brownfield site as a demonstration project.

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## Acronyms and Abbreviations

| | |
|---|---|
| AOC | Area of Concern |
| bgs | below ground surface |
| BRDMRF | Black River Dredged Material Reuse Facility |
| CDF | confined disposal facility |
| City | City of Lorain |
| Coldwater | Coldwater Consulting, LLC |
| CY or CYD | cubic yards |
| EDT | Ellicott Dredge Technologies |
| HLE | Healthy Lake Erie Initiative (grant funding) |
| LWD | low water datum |
| Ohio DNR | Ohio Department of Natural Resources |
| Ohio EPA | Ohio Environmental Protection Agency |
| SLFRF | State and Local Fiscal Recovery Fund (grant funding) |
| VAP | Voluntary Action Program |
| USACE | United States Army Corps of Engineers |
| USEPA | United States Environmental Protection Agency |

## Frequently Used Terminology

**Black River Dredged Material Reuse Facility (BRDMRF):** The to-be-constructed facility dedicated to the receipt of dredged sediment, dewatering, and shipment offsite for reuse in the commercial market. The facility will be substantially constructed on City owned lands identified as County Parcel Number 030 008 810 1024.

**Black River Reclamation Site:** Over 265 acres of City owned or controlled lands with street address of 2601 East 28th Street, Lorain. These lands were obtained in or around 2008-2010 from adjacent property owners – Republic Technologies International, LLC, and US Steel. Access to all these parcels is through a single gravel road that crosses lands owned or controlled by City of Lorain, Lorain County Metro Parks, US Steel, and Lake Terminal Railroad.

1. Parcel No. 030 008 810 1024 – 130 acres, within which a Ohio EPA Voluntary Action Program site (VAP site), a building used for City equipment storage, the City compost facility, areas of ecological restoration, subsurface piping leading to a river outfall monitored by adjacent property owner Republic Steel, and waterfront restrictive covenant administered by OEPA-Division of Environmental Financial Assistance. The VAP site is identified by OEPA as ID No. 247 002 290 011, 27.02 acres, named US Kobe Steel 15NFA626, with owner of City of Lorain, and contains land use restrictions.
2. Parcel No. 030 008 510 1022 – 103 acres
3. Parcel No. 03 008 400 0020 – 15.5 acres
4. Parcel No. 030 008 310 1045 – 5.9 acres
5. Parcel No. 030 009 010 1015 – 11.1 acres

**Bulking and Compaction Factors** – the ratio of volumetric change of earthen material as it is measured between natural / in-situ condition, when dredged / excavated, when handled / stockpiled, and when compacted. For dredged sediments, the bulking factor is generally measured relative to its in-situ / in-river volume and increases during dredging, handling, and stockpiling, with subsequent decreases when dewatered and compacted. In common terms, the volume of solid particles remains constant throughout the various stages but the entrained water and air increases the volume (bulks) and as the water and air are removed the volume decreases (compacts). For the facility design, bulking and compaction factors apply to sediments / dredged material, soils, aggregate, and slag and are material and state specific.

**Confined Disposal Facility (CDF)**: An upland site specifically constructed to retain dredged material. For example, a CDF can be a nearshore facility where dredged material is placed to create a marshland or an upland in open water.

**Dredged Material:** River sediment once actually separated from the river bottom by dredging or excavating.

**Dewatered Sediment:** Dredged material that has undergone some release of entrained water with the objective of eventual dewatering to a condition typical of landside soil.

**GeoPool:** An innovative material dewatering technology that assists with the rapid dewatering of large volumes of sediment in a relatively short period. The system consists of a steel frame, assembled in sections and bolted together at the toes of the frame. A polypropylene filter fabric secured along the interior of the pool filters out water and retains sediment.

**Residual Solids:** The material contained in the GeoPool.

**Sediment:** Geologic material that comprises the river bottom.

**Slurry:** A mixture of sediment and water typically mixed at a given solids content to more easily transport solid material long distances via pipeline.

**Upland Reuse:** Placement of dredged material for a defined end use.

**SuperHut:** A large steel framed structure located on the project Site used by the City primarily as storage. The structure will remain during construction of the BRDMRF.

# 1.0 INTRODUCTION

Through a Healthy Lake Erie Initiative grant administered by the Ohio Department of Natural Resources (Ohio DNR) in collaboration with the Ohio Environmental Protection Agency (Ohio EPA), the City of Lorain (City) is advancing the planning and design for future construction of the Black River Dredged Material Reuse Facility (BRDMRF). The purpose of the facility is to accept, dewater, and prepare the dredged sediment for reuse. The Black River sediments are dredged by the United States Army Corps of Engineers (USACE) and will be supplied to the BRDMRF on an annual dredge cycle.

The Residual Solids Evaluation associated with the BRDMRF described in this report was funded through two grants issued to the City of Lorain and administered by the Ohio Department of Natural Resources, Office of Coastal Management. The Ohio Environmental Protection Agency; Ohio Department of Natural Resource, Parks and Watercraft Division; and the US Army Corps of Engineers provided in-kind support and collaboration. The Residual Solids Evaluation grant funding sources were:

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- Project-specific supplemental grant to the City by the ODNR OCM. Generally, this grant funded the university professor-led greenhouse studies; analytical data reduction and interpretation of the pollutant, agronomic, and geotechnical laboratory results; interpretation of onsite measurements and observations; stakeholder engagement; and the majority of reporting.

The Residual Solids Evaluation builds upon and augments the GeoPool Pilot Study. The Residual Solids Evaluation was scoped after the dredged material was delivered and dewatering in the GeoPool. The Residual Solids Evaluation was performed largely coincidental and proximal to the existing GeoPool Pilot Study work, which reduced its cost.

The Residual Solids Evaluation has five phases, listed below, which occurred largely in parallel.

1. Scoping & Stakeholder Involvement
2. Residual Solids Characterization
3. Blended Beneficial Reuse Products Test Plots
4. Operational Function
5. Findings & Market Considerations

# 2.0 SCOPING AND STAKEHOLDER INVOLVEMENT

The Stakeholders involved represented the funding and cooperating agencies, the City, and its consultants. The individual participants that regularly participated were:

- Ohio Department of Natural Resources, Office of Coastal Management
  - Scudder Mackey, Steve Holland, Amanda Kovach
- Ohio Environmental Protection Agency
  - David Emerman, Vanessa Steigerwald Dick
- City of Lorain
  - Kathryn Golden
- City Consultants
  - Kristen Risch, Corry Platt, Brian Weyer, Jackson Caruso

As the Residual Solids Evaluation initiated, the City Consultants reached out to the Lorain Soil & Water Conservation District and the Lorain County office of the Ohio State University Extension. Individuals from these entities expressed interest in the study and responded to requests for information but reserved their availability for deeper participation at a future phase.

Monthly meetings were the primary method of stakeholder involvement. During the monthly meetings, recent and upcoming project activities were discussed, incremental achievements and interim presentations of data and calculations were shared, and scope adjustments were agreed upon.

Site visits were made by the individual Stakeholders to observe conditions and work activities.

Analytical data (discussed in Section 3) was provided to the US Army Corps of Engineers – Buffalo District and the Ohio EPA Area of Concern coordinator to support its evaluation of the river sediments.

# 3.0 RESIDUAL SOLIDS CHARACTERIZATION

The residual solids were characterized for multiple parameters and purposes.

## 3.1 Pollutant, Agronomic, and Physical Characteristics

Samples were collected at various times over the study duration.

1. Pollutant, agronomic, and physical characteristics analyses consistent with Table 1 were performed of:
    a. Test pit excavated materials at 28 elapsed days of dewatering
    b. Test pit excavated materials at 86 elapsed days of dewatering
    c. Field plot laid solids before and after blending with compost and manufactured sand
    d. Dewatered solids supplied to the Universities for the greenhouse studies.
    e. Farm soils supplied to the Universities for the greenhouse studies.
2. Tracking moisture content changes using 27 laboratory analyses collected at various locations within the GeoPool over 84 elapsed days of dewatering indicating a decrease in moisture content from about 130% to 80%, which generally corresponds with an increase in percent solids from about 45% to 65%.

**Table 1 – Pollutant, Agronomic, and Physical Analyses**

| Parameter | Pertinence | Method | Intended Use |
|---|---|---|---|
| **TAL Metals (23)** | Pollutants | EPA 6000/7000 | Ohio EPA Beneficial Use |
| **Polycyclic aromatic hydrocarbons (PAH 16)** | Pollutants | EPA 8270C, SIM low level | Ohio EPA Beneficial Use |
| **Total PCBs as Aroclors** | Pollutants | EPA 8082 | Ohio EPA Beneficial Use |
| **Pesticides** | Pollutants | EPA 8081A | Ohio EPA Beneficial Use |
| **TCLP RCRA Metals** | Pollutants | 6020A/6010B/7470A | Ohio EPA Beneficial Use |
| **TCLP Base Neutral Acids** | Pollutants | 8270C | Ohio EPA Beneficial Use |
| **Total Organic Carbon** | Pollutants | EPA 9060 | Bioavailable fraction |
| **USCS Soil Classification** | Engineering | ASTM D2487 | Geotechnical |
| **Particle Size Distribution** | Engineering | ASTM D6913 | Geotechnical |
| **Atterberg Limits** | Engineering | ASTM D4318 | Geotechnical |
| **Standard Proctor** | Engineering | ASTM D698 | Geotechnical |
| **Moisture Content** | Engineering | ASTM D2216 | Geotechnical |
| **Organic Matter @ 440 +750** | Engineering | ASTM D2974 | Geotechnical |
| **Specific Gravity** | Engineering | ASTM D854 | Geotechnical |

| Parameter | Pertinence | Method | Intended Use |
|---|---|---|---|
| **Available Phosphorus**[1] | Agronomy | Bray 1 Equiv | Nutrients |
| **Available Phosphorus** | Agronomy | Mehlich-3, NCR-13 No. 221, 2012 | Nutrients |
| **Cation Exchange Capacity** | Agronomy | Meq/100g | Nutrients |
| **Total Phosphorus** | Agronomy | EPA 365.3 | Nutrients |
| **Chloride** | Agronomy | EPA 9056A | Nutrients |
| **pH** | Agronomy | SM 9040C/9045C | Nutrients |
| **Nitrate-Nitrite** | Agronomy | EPA 353.2 | Nutrients |
| **Ammonia** | Agronomy | EPA 350.1 | Nutrients |
| **Total Kjeldahl Nitrogen (TKN)** | Agronomy | EPA 351.2 | Nutrients |
| **% Total Solids** | Agronomy | SM 2540G | Nutrients |

The analytical results of the pollutant, agronomic, and physical characterization were tabulated and did not show characteristics different than pre-dredging characteristics. The tables including context descriptions are contained in **Appendix A**.

## 3.2 Engineered Fill Testing

In Spring 2021, bulk sample of the residual solids contained within the GeoPool were collected and test samples prepared to examine the reuse potential as structural fill. The analyses performed included:

1. Index Testing for Soil Classification
    a. Standard soil classification tests by:
        i. ASTM D 6913 – Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis
        ii. ASTM D 4318 - Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
        iii. ASTM D 698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3))
    b. Tests were performed on:
        i. Untreated Dredged Material (DM)
        ii. DM + 3% Portland cement by dry mass; 2 samples total; 1 each cured 7-days and 28-days prior to testing
        iii. DM + 7% Portland cement by dry mass; 2 samples total; 1 each cured 7-days and 28-days prior to testing

[1] As Bray-1 equivalent and percent cation saturation (%K, %Mg, %Ca)

iv. DM + 10% Portland cement by dry mass; 2 samples total; 1 each cured 7-days and 28-days prior to testing

2. Unconfined Compressive Strength Testing in general accordance with ODOT Supplement 1120 with additional testing
3. Hydraulic Conductivity (Permeability) Testing in general accordance with ASTM D 5084 - Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter
    a. Tests performed on:
        i. Untreated DM
        ii. DM +3% Portland cement by dry mass; cured 14 days prior to testing
        iii. DM +7% Portland cement by dry mass; cured 14 days prior to testing
        iv. DM +10% Portland cement by dry mass; cured 14 days prior to testing

The analytical results of the engineered fill characterization were evaluated and showed characteristics suitable for brownfield / landfill cover, asphalt parking lot subbase, with various percentages of cement functions from building foundation soil to roadway subbase.  The analytical results, calculations, and conclusions are contained in **Appendix B**.

# 4.0 FIELD PLOTS & GREENHOUSE STUDIES

## 4.1 Beneficial Use Exemption Approval

Prior to initiating the field plots, authorization from Ohio EPA in accordance with Ohio Administrative Code Chapter 3745-599 was required. On 4 November 2020, Ohio EPA issued the Beneficial Use Exemption Approval (BENU023820) to the City of Lorain authorizing the initiation of the field plots, a copy of which is found as **Appendix C**. The necessary compliance submittals were submitted and/or communications to that effect were had with the Ohio EPA designated contact (Vanessa Steigerwald Dick).

## 4.1 Field Plots

Field plots were established on City property adjacent to the GeoPool in November 2020. Two of the field plots were mechanically blended using three passes of a tractor-mounted rear-tine tiller in December 2020. The work included:

1. Excavating about 700 cubic yards from the GeoPool and creating field plots of:
    a. Three 100 square feet plots where eight (8) inches of dredged material were placed. Within two, City leaf compost was blended in about a 67% dredged material to 33% compost ratio, one tiller mixed and one excavator bucket mixed.
    b. One plot measuring about 2,500 square feet where subsequently blended with City leaf compost in a 1:1 ratio intended to represent a residential garden.
    c. One plot measuring about 2,500 square feet where subsequently blended with manufactured sand in a 70% dredged material to 30% manufactured sand ratio intended to represent a typical Lorain County agricultural field.
    d. One plot measuring about 10,000 square feet where placed 8 to 12 inches thick and no blending occurred.
    e. One plot measuring about 10,000 square feet where placed in piles 12 to 24 inches thick and no blending occurred.
2. The moisture content was tracked within the field plots over five months (winter and early spring exposure) to track and extrapolate the effect of windrowing the dredged sediments. Table 2 shows the results that indicated retention of moisture for compost-blended solids, about 40% moisture reduction of unaltered solids, and about a 50% moisture reduction of sand-blended solids.

**Table 2 – Tracking Moisture Content of Field Plots- Representative Samples**

| Date | Sample ID | Representing | Moisture Content (%) | Percent Solids (%) |
|---|---|---|---|---|
| 12/9/2020 | RSE-P2.2_AG_20201209 | Sand blend | 84% | 54% |
| 12/9/2020 | RSE-P2.2_RES_20201209 | Compost blend | 78% | 56% |
| 12/9/2020 | RSE-P2.2_CNTL_20201210 | No blend | 64% | 61% |
| 1/12/2021 | RSE-P2.2_AGB_20210112 | Sand blend | 37% | 73% |
| 1/12/2021 | RSE-P2.2_RESB_20210112 | Compost blend | 105% | 49% |
| 1/12/2021 | RSE-P2.2_CNTL_20210112 | No blend | 74% | 58% |

| Date | Sample ID | Representing | Moisture Content (%) | Percent Solids (%) |
|---|---|---|---|---|
| 3/3/2021 | AG 0321 | Sand blend | | 76% |
| 3/3/2021 | RES 0321 | Compost blend | | 54% |
| 3/3/2021 | CNTL 0321 | No blend | | 64% |
| 3/24/2021 | RSE-P2.2_RES_20210324 | Compost blend | 58.5% | 63% |
| 3/24/2021 | RSE-P2.2_AG_20210324 | Sand blend | 18.9% | 84% |
| 3/24/2021 | RSE-P2.2_CNTL_20210324 | No blend | 33.6% | 75% |
| 4/28/2021 | RSE-P2.2_RES_20210428 | Compost blend | 68.5% | 59% |
| 4/28/2021 | RSE-P2.2_AG_20210428 | Sand blend | 12.5% | 89% |
| 4/28/2021 | RSE-P2.2_CNTL_20210428 | No blend | 33.6% | 75% |

The initial intent was to plant the field plots with seeds shown to be successful in the greenhouse studies. However, the absence of irrigation water and observation of soil moisture below germination and growth recommendations (25 percent minimum) and the labor and logistics required to water, weed, and generally tend to the field plots resulted in leaving the field plots to lay fallow and simply observe natural revegetation and general conditions over the summer months. Generally, weed seed germination and weed establishment did not occur on a uniform basis, rather occurred at random surface cracks.

## 4.2 University Greenhouse Studies

Two university professors – one at Bowling Green State University and one at Wright State University - contributed to studies of dredged material from other harbors in Ohio. Because these professors had familiarity and research interest in beneficial use of dredged material, the project team opened discussions with these professors albeit after the field plots were established. Through these discussions, a flaw in the field plot approach was identified, namely that two blends were created but no preceding proof that either was suitable for the target plants. A scope modification occurred to initiate greenhouse studies with the intention to have data in-hand that would inform adaptations to the field plots. In March 2021, contracts with the universities were in-place, typical Lorain County farm soil courtesy of Shagbark Farms was collected, and the greenhouse studies initiated.

A summary presentation was provided to the Stakeholders in March 2022 and is found as **Appendix D-1**.

### 4.2.1 Bowling Green State University

Dr. Angelica Vazquez-Ortega led the greenhouse study performed at Bowling Green State University. The study was defined as a 45-day growth study. The work performed was:

1. Evaluated the response of corn and soybean germination, growth, and biomass to:
    a. 0, 5, 10, 20, and 100% dredged material blended with Lorain County farm soil.
    b. 0, 5, 10, 20, and 100% dredged material blended with Lorain County farm soil and a soil acidifier treatment.
    c. 5% leaf compost blended with 0, 5, 10, 20, and 95% dredged material blended with Lorain County farm soil.

2. Evaluated the response of sod growth and biomass to:
    a. 0, 30, 40, and 100% dredged material blended with farm soil with and without 5% compost.

The top take-aways from the greenhouse study pertinent to the Residual Solids Evaluation were:

1. Blends with dredged material improved growth in both corn and soybeans.
2. Treatments with compost tended to perform better but treatments with a soil acidifier tended to be less successful.
3. The dredged material did not hinder sod grass growth. The blend of 40% dredged material and 60% farm soil showed a marginal growth increase (5%) over the 100% farm soil.
4. The best blend for corn measured by tallest plant and greatest above and below ground biomass was 10% dredged material, 85% farm soil, and 5% compost.
5. The best blend for soybeans measured as the highest average height and greatest above & below ground biomass was 20% dredged material, 75% farm soil, and 5% compost.
6. Blends containing 30%, 50%, and 70% dredged material showed similar results for sod survival, growth, and biomass.

A data presentation prepared by the lead undergraduate researcher working under Dr. Vazquez-Ortega's direction is found in **Appendix D-2**.

### 4.2.2 Wright State University

Dr. Megan Rua led the greenhouse study performed at Wright State University. The study was initially defined as a 45-day growth study but due to the performance of the corn and restoration seed mix was extended to enable the plants to achieve its reproductive stage. The work performed was:

1. Evaluated the response of corn germination, growth, reproduction (ears), and biomass to:
    a. 0, 30, 50, 70, and 100% dredged material blended with Lorain County farm soil.
2. Evaluated the response of canola, fescue seed, and ecological restoration seed germination, growth, and biomass to:
    a. 0, 30, 40, and 100% dredged material blended with Lorain County farm soil.

The top take-aways from the greenhouse study pertinent to the Residual Solids Evaluation were:

1. Corn grown on dredged material and farm soil blends produced additional ears, suggesting higher yield (than commercial hybrids) and reached reproductive stages faster than corn grown on Toledo fresh or weathered dredged material blended with farm soil collected near the university.
2. 100% dredged material was not suitable for corn (reduced germination, height, survival, & no ears).
3. The best blend for ecological restoration seed mix was 50% dredged material and 50% farm soil, yet 70 & 100% dredged material yielded high diversity of sprouted seeds suggesting these ratios are suitable for restoration applications with limited or no blending.
4. The best blend for canola was 30% dredged material and 70% farm soil.
5. Blends containing 30%, 50%, and 70% dredged material showed similar results for fescue seed germination, growth, and biomass.

A data report prepared by Dr. Rua is found in **Appendix D-3**.

# 5.0 OPERATIONAL FUNCTION

In the initial scope of work for the Residual Solids Evaluation this phase was to focus upon the excavation and disassembly of the GeoPool structure. The measurement of consolidation and its implication upon the volume of dewatered sediments available for beneficial reuse is pertinent to and was measured over the duration of the Residual Solids Evaluation. This section summarizes the consolidation, excavation, and GeoPool disassembly.

## 5.1 BULKING AND CONSOLIDATION OF THE SOLIDS

Through the dredging and dewatering process, the volume (cyds) changes as a function of the amount of solid particles, entrained water, and entrained air. Simply, the often-cited dredging volume increases during handling and decreases during dewatering. The dredged volume is measured relative to in-situ conditions often through a comparative survey of the river bottom before and after dredging. The increase is most pertinent to sizing the receiving unit (e.g, scow, CDF, Basin, GeoPool) to have sufficient capacity to contain the solids+water+air volume. The decrease is most pertinent in beneficial reuse because it is the quantity of dewatered solids available. There are several factors that affect the bulking and consolidation, the basis of which is driven by the sediment type (e.g., sand, silt, clay) and age (e.g., recently deposited and largely unconsolidated maintenance dredging versus long-consolidated improvement or deepening dredging) along with the handling and delivery method (e.g., mechanically or hydraulicly dredged, percent solids in slurry), the ambient conditions in the dewatering structure (e.g., basin, CDF, GeoPool), the duration and effort of dewatering, and the resulting moisture content / percent solids of the dewatered product.

The contents of the GeoPool – the residual solids – initially increased (bulked) and eventually reduced in volume from the dredged volume. Generally, there was a rather rapid dewatering over the first 30 days resulting in about a no-increase from the in-river dredged volume. Attributed more to the impermeable pad and dry solids building up on the GeoPool textile, after 30 days the dewatering rate slowed. At about 75 days of dewatering (about half of which were at the diminished dewatering rate), some solids were excavated, off-road truck transported, and end-dumped to create the Field Plots. These excavated solids passed the Paint Filter Liquids Test, which is a requirement for on-road transport, indicating suitability for hauling offsite. The 75-day solids were visually saturated (albeit not releasing free water) but were not yet in the “cake-like” condition intended for full-scale excavation and stockpiling. The 75-day solids were able to self-stack in single lifts of up to 24 inches but lacked the strength to support heavy equipment or multiple incremental lifts. Extrapolating the rate of dewatering to full scale dewatering using GeoPools, it is reasonable to conclude that there would be little difference between excavating at 30 days or 75 days without modifications to the GeoPool pad to facilitate passage of entrained water. The bulking and consolidation observed through dewatering day 77 is found as **Appendix E-1**, with attention drawn to Slide 26.

At this stage in the Residual Solids Evaluation (December 2020), the Field Plot use was under reconsideration pending the University Greenhouse Studies. The Stakeholders agreed that it was opportunistic timing to expose the GeoPool structure and the residual solids to the winter freeze-thaw. The freeze-thaw cycle is a natural dewatering mechanism as the waters freeze inducing separation in the solids opening microchannels for the thawing waters to pass rather than remain entrained with the solids. The residual solids and the GeoPool structure were occasionally visually observed over the winter months. While a survey was not performed, it appeared that an additional 10% of consolidation occurred by early spring.

With the initial results of the University Greenhouse Studies available in early summer, the Stakeholders agreed to forego the Field Plots due to the favorable information obtained through the greenhouse studies, and the lack of budget to cover the labor, logistics, and equipment to irrigate and weed the Field Plots. The Field Plots laid fallow over the summer months with random vegetation establishing.

In October 2021, the GeoPool was disassembled. The surface of the residual solids within the GeoPool was heavily vegetated with air-dispersed herbaceous weeds. The residual solids were capable to support heavy equipment (e.g., hydraulic excavator, skid steer), maintain vertical cut edges, and stack in stockpiles. Due to the heavy vegetation a survey of the residual solids surface was not practical prior to machinery working and compacting the solids. All of excavation necessary to disassemble the GeoPool occurred within the GeoPool including stockpiling the residual solids within the GeoPool footprint; therefore, all residual solids remained within the footprint. After the GeoPool structure was disassembled, the residual solids were shaped into a convex stockpile. The volume of residual solids contained within the convex stockpile was estimated at 50% of the in-river dredged volume (subtracting for volumes excavated for the Field Plots). This dewatered reduction implies that the future forecasted 75,000 cyds of USACE dredged sediment will dewater to a dry lightly compacted soil of 37,500 cyds. The calculation basis is found in **Appendix E2**.

## 5.2 Excavating Solids coincidental to GeoPool Disassembly

The scope included assessing the ability to excavate, handle, stockpile, and truck load the residual solids coincidental to the GeoPool disassembly. The solids excavation work is pertinent to the "single touch" basis of the GeoPool to minimize rehandling costs. The following were to be assessed:

- Efficient and maximum truck cycling and load-out of residual solids to minimize bottlenecks and operational delays, and its change as the quantity of residual solids reduce.
- Practicality and schedule/efficiency considerations to disassemble the GeoPool structure while retaining a central/interior stockpile of residual solids. Depending upon the handling of the residual solids, measurements will be made of the efficient and minimum interior "ring" to be excavated/hauled or interior stockpiled.
- Duration of disassembly and the considerations for each disassembly task (e.g., dismantling safety cables, dismantling fabric, dismantling wire mesh, dismantling toe links, lifting and relocating individual frames.
- Ease and lashing multiple frame configurations on a flatbed trailer for on-road transport.
- Manufacturer inspection and identification of structural components warranting assessment or proactive replacement between usages.

The GeoPool was disassembled and the residual solids stockpile shaped in four days. No rain was encountered during disassembly. It was practical and efficient to pull back residual solids laid upon the GeoPool structure and swing to a stockpile behind the operating excavator. Excavation was not the bottleneck, rather the unbolting, dismantling wire mesh and toe links consumed the greatest duration. About 20 percent of the GeoPool frames were fully disassembled, the remainder were relocated in upright condition to the SuperHut for storage. Transport between the GeoPool pad and the SuperHut was without incident. The toe link and C-channel were identified as warranting further manufacturer assessment to resolve deformation.

# 6.0 MARKET CONSIDERATIONS

The scope included applying the results of the Residual Solids Evaluation to the Black River Dredged Material Reuse Facility operation. The most pertinent outcomes are the estimated quantity of dewatered sediment available for reuse and subsequent entry into the soil market as well as the prospective applications where the dewatered sediment can be a useful and competitive soil product.

This effort was approached after the monitoring and studies were performed so that market opportunities aligned with the findings. The Market Considerations are three-fold:

1. Quantity of dewatered sediment annually available.
    a. As dredged material dewaters and the entrained water is released, the volumetric space reduces. Extrapolating the observations over the duration of the Residual Solids Evaluation to the expected future annual 75,000 cyds of USACE dredged sediments (measured as cyds removed from in-river) results in about 37,500 cyds of dewatered sediments for annual entry into the market.
2. Opportunities within a reasonable hauling distance.
    a. Using nationally-based construction industry cost estimating guides for on-road hauling, there is a step-up between 15 and 20 mile haul distances. Therefore, restricting opportunities to within a 15-mile radius of the Black River Dredged Material Reuse Facility is recommended, which is supported by content found in **Appendix F**.
    b. While unsupported with comparative evidence, the 15-mile radius is consistent with the author's discussions and experience with earthwork's contractors and companies that recycle/reuse dredged material.
    c. Due to budgetary limits, additional effort is recommended to identify and quantify the market value and limits of 37,500 cyds of dewatered sediments within the 15-mile radius. Based on aerial photo review, land use mapping, and brownfield listings, there are reuse opportunities within the 15-mile radius as:
        i. Brownfield cover
        ii. Residential and non-structural fill
        iii. Structural fill
        iv. Blending with farm soils on agricultural lands
        v. Ecological restoration soil
3. Opportunistic Co-Dependent Projects.
    a. The data in-hand coupled with redevelopment initiatives within the City and County of Lorain open opportunities to align dewatered sediment reuse with publicly sponsored redevelopment projects. Specifically, the public agencies (project sponsors) would collaborate, align construction schedules, and specify that the dewatered sediments will be used rather than soils imported from borrow pits or other commercial stockpiles.
    b. Due to budgetary limits, additional effort is recommended to identify pertinent stakeholders, soil quantities, soil characteristics, and calendar year of future prospective projects to use dewatered sediments.

i. Based on brownfield listings from a previous EPA grant to Lorain Port and Finance Authority, there were 34 brownfield sites identified (Brownfields Post Clean-Up Development - Lorain Port and Finance Authority).

ii. For illustration, assuming each brownfield site requires two feet of compacted soil cover, the annual dewatered sediment quantity is consumed over 11 acres, which could be at a single or multiple sites.

c. By identifying co-dependent project opportunities, grant funds could be sought emphasizing the reuse of the dewatered sediment, its sustainability, its maritime industry supportive function, and its grant-funded history over the commercially driven increase in extensive borrow pits.

d. There are considerations and implications of co-dependent projects. Joining two projects require coordination, cooperation, and schedule alignment for optimum cost-savings, which is primarily driven by minimizing the dewatered sediment stockpiling and rehandling prior to hauling to the reuse location.

# 7.0 CONCLUSIONS & RECOMMENDATIONS

The Residual Solids Evaluation provided pertinent information to support identifying practical beneficial reuse opportunities for the dewatered sediments dredged from the Black River.

## 7.1 CONCLUSIONS

The most reasonable reuse opportunities are summarized in Table 3.

**Table 3 – Practical Applications of Beneficially Reused Dredged Material**

| Application | Finding |
|---|---|
| Brownfield Cap / Cover | When compacted meets CERCLA landfill cover and exceeds 1.00E-05 cm/s hydraulic conductivity. |
| General site fill | When compacted has suitable strength for beneath asphalt parking lots. |
| Engineered fill | With 3% cement added has suitable strength for single story building foundation soil.<br>With 7% cement added has suitable strength for multi-story building and general purpose roadways foundation soil.<br>With 10% cement added has suitable strength for interstate roadway foundation soil. |
| Turf grass | Blend site soil with 30 to 70% dewatered sediments for sod or seeding with fescue. |
| Ecological restoration | Blend site soil with 50 to 100% dewatered sediments for seeding with restoration seed mix. |
| Agricultural—Corn | Blend site soil with 10% dewatered sediments for corn. Amending typical farm soil with dredged material produced crop with increased biomass, increased yield (additional ears), and shorter time to reproductive stage. Growing corn in 100% dredged material reduced germination, height, survival, & no ears. |
| Agricultural—Soybean | Blend site soil with 20% dewatered sediments for soybeans. Amending typical farm soil with dredged material produced crop with increased biomass and tallest average height. |
| Amendment—Compost | Blending with 5% compost tended to increase plant growth. |
| Amendment—Acidifier | Incorporating acidifier tended to reduce seed germination and plant growth. |
| Mechanical blending | Three passes with rear-tine tiller resulted in a uniform blend of sand, compost, and dewatered sediment initially laid in layers. |
| *Findings are laboratory study based—consult Engineer-of-Record, Agronomist, Agricultural Extension Office or other pertinent professional to tailor findings to specific application and individual site conditions.* | |

## 7.2 Recommendations

The Residual Solids Evaluation adds value to the operational considerations for the future Black River Dredged Material Reuse Facility. In addition to the market valuations and co-dependent projects mentioned in Section 6, there are various subsequent studies that can continue to advance and diversify the reuse opportunities, stakeholder and public acceptance, and diminish perceptions of dredged sediment as a waste that are recommended:

1. Support Ohio EPA's initiatives to streamline the beneficial reuse of dredged material authorizations, exemptions, and permits.
2. Implore regulatory agencies to revisit the beneficial reuse terms, conditions, and landowner liabilities for accepting dewatered sediments as a resource rather than the terms implying it is a waste.
3. Encourage additional stakeholder participation with representatives of soil brokers, agriculture, parks, and brownfields.
4. Consider additional studies of:
    a. Amending commercial greenhouse growing media (horticulture and vegetable)
    b. Establish publicly accessible demonstration plots of 1 to 10 acres in size with available irrigation to perform scaled-up field demonstration of the University greenhouse successful plants and soil blends.
    c. Performing and monitoring a compacted cover at a brownfield site as a demonstration project.

# 8.0 RESOURCES CONSULTED

Analytical parameter listings used for multi-port dredged material comparison from V. Steigerwald Dick, Ohio EPA.

Disassembly considerations with T. Grabow, ODNR.

Market discussions with J. Ziss, Kurtz Brothers.

Marlin, John, 2018. *Beneficial Use of Illinois River Sediment for Agricultural and Landscaping Applications*, Illinois Sustainable Technology Center. http://hdl.handle.net/2142/99159

RS Means, 2021. *Site Work & Landscape Costs.* Gordian Group.

USACE. 2018. *Enclosure 3 – Sediment Evaluation, Discharges of Dredged Material Associated with the 2018 Maintenance Dredging of Lorain Harbor, Ohio. Buffalo District*. United States Army Corps of Engineers. July.

# Appendix A
# Ohio EPA Beneficial Use Exemption Approval

Ohio Environmental Protection Agency

**Mike DeWine,** Governor
**Jon Husted,** Lt. Governor
**Laurie A. Stevenson,** Director

November 4, 2020

Kathryn Golden, CPMSM, CFM
Storm Water Manager
City of Lorain Engineering Department
200 West Erie Avenue
Lorain, OH 44052

Re: Lorain Harbor GeoPool Pilot Study
Exemption
Approval
Beneficial Use
Lorain County
BENU023820

Dear Ms. Golden:

This letter is in response to the City of Lorain's proposal to conduct a pilot study to evaluate the potential beneficial use of soil blends created with dredged material dewatered in the GeoPool located on the City of Lorain's Black River Reclamation Site.

In 2019, through a Healthy Lake Erie grant administered by the Ohio Department of Natural Resources (ODNR) in consultation with the Ohio Environmental Protection Agency, the City of Lorain (City) began preparations for a pilot study to assess an innovative geotextile dewatering technology called a GeoPool for potential use in the design and construction of the Black River Dredged Material Reuse Facility. As part of that GeoPool Pilot Study, the GeoPool was filled in August 2020 with Lake Erie dredge as defined in Ohio Administrative Code (OAC) Rule 3745-599-02(L)(1). ODNR hydraulically dredged sediment from within the Lorain Harbor federal turning basin near Black River Mile 2.7 and delivered the dredge slurry into the GeoPool. Based on field measurements, the GeoPool contains approximately 4,500 cubic yards of dredged material.

Lorain Harbor sediment where the GeoPool dredged material was obtained was physically and chemically characterized previously by the United States Army Corps of Engineers (USACE) in 2013 and 2015. The material dredged for the GeoPool excluded deeper sediments within the federal turning basin that contain elevated concentrations of chemicals including polynuclear aromatic hydrocarbons. Both the USACE previous analytical results and recent preliminary chemical analytical results indicate that the GeoPool dredged material meet U.S. EPA residential soil screening levels and/or soil background levels contained in the July 2019 Ohio EPA *Evaluation of Background Metal Soil Concentrations in Lorain County*.

On October 2, 2020 the City provided Ohio EPA with a document titled *Black River Dredged Material Reuse Facility GeoPool Pilot Study Residual Solids Evaluation (RSE)*. This document includes a description of the City's proposal to conduct a pilot study to evaluate the potential beneficial use of soil blends created with dredged material excavated from within the GeoPool, which is included as Attachment 1 to this exemption. As part of this proposed pilot study, GeoPool dredged material will be transported to the City's adjoining Voluntary Action Program property located at 2601 East 28th Street in Lorain, Ohio (VAP Site). The VAP Site is fenced and is subject to a Covenant Not to Sue.

Specifically, the City proposes to land apply no more than 4,500 cubic yards of the dewatered GeoPool dredged material on the VAP Site in five test plots established and managed as described in Attachment 1. The GeoPool dredged material in four of the five test plots will be blended with material to create soil blends for agricultural soil, residential garden soil, structural soil, organic-rich feedstock, and a fifth test plot will include only GeoPool dredged material and be utilized as a control plot .

Ohio EPA has determined that the City's pilot study to evaluate the potential beneficial use of soil blends created with GeoPool dredged material as described in Attachment 1 is unlikely to adversely affect public health or safety or the environment as long as the following conditions are met:

1. Only dredged material that was placed into the GeoPool in August 2020 and is represented by the results of analytical testing performed by USACE in 2013 and 2015 may be used for this pilot study. No other dredged material may be brought to the VAP Site or placed into any of the test plots pursuant to this authorization. This authorization does not permit storage of GeoPool dredged material at any location.

2. All dredged material used for this pilot study shall be dewatered prior to creation of the soil blends at the VAP Site such that there are no free liquids as determined by Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (SW-846) Test Method 9095B- Paint Filter Liquids Test, as amended through July 2016. The City shall ensure that Ohio EPA is notified not less than 48 hours prior to placement of the GeoPool dredged material onto the VAP Site.

3. Only compost product that meets the distribution requirements in OAC Rule 3745-560-420 may be combined with the GeoPool dredged material for this pilot study.

4. The blending of material, including but not limited to the blending of GeoPool dredged material with compost product, Portland cement, or tree stump chippings/shreddings, shall occur only at the VAP Site. Unless otherwise provided in a permit issued under Chapter 6111 of the Ohio Revised Code (ORC), the City shall ensure that sediment control practices are implemented to catch any solids in runoff or to divert runoff away from all property lines, functional storm water catch basins, drainage ways, railroad rights of way, post construction water quality features, and surface waters of the state.

5. The City shall ensure that all activities related to this pilot study, including but not limited to all land application and blending activities, are conducted in such a manner that dust and odors are controlled so as not to cause a nuisance or a health hazard.

6. This approval expires on December 31, 2021. On January 15 and July 15 of each year, lasting for the duration of the pilot project, and not later than 30 days after the pilot project ends, the City shall submit a Technical Memorandum that includes all of the following to Ohio EPA at Vanessa.SteigerwaldDick@epa.ohio.gov or some other address specified in writing by Ohio EPA:

   a. The amount of dredged material used at each test plot in cubic yards;
   b. The amount and nature of material blended with the GeoPool dredged material within each test plot; and
   c. A detailed description of the City's current evaluation of the soil blends, using at a minimum the assessments, performance measurements, analyses, characterizations and other relevant criteria described in Attachment 1. This description shall at a minimum:
      i. Explain the specific tests and comparisons conducted;
      ii. Identify each standard, characteristic, and endpoint used in each test or comparison (including but not limited to the standards identified Attachment 1 for each test plot);
      iii. Report the results of the tests and comparisons conducted;
      iv. Identify any adjustments made to the test plots during implementation as provided in Attachment 1; and
      v. The address of each site used as a comparison site for any test plot in this pilot study.
   d. Time-stamped photographs documenting the pilot study results, including time-stamped photographs of the VAP Site and of any location used as a comparison site for this pilot study.

The City's use of dredged material from the Lorain Harbor GeoPool Pilot Study in order to evaluate the potential beneficial use of soil blends as described in Attachment 1 and in compliance with the conditions set forth above is unlikely to adversely impact the public health or safety or the environment. To the extent that the GeoPool dredged material is a solid waste, pursuant to ORC Section 3734.02(G) the City of Lorain is hereby exempted from the requirement to remit the state solid waste disposal fee set forth in ORC Section 3734.57(A) and from the requirements to obtain a permit and license before establishing a solid waste facility set forth in ORC Sections 3734.02(C), 3734.05(A)(1), and 3734.05(A)(2) and OAC Chapters 3745-27 and 3745-501.

Please note that this letter applies only to the City of Lorain's pilot program outlined above. Any future projects involving the use of dredged material may require a beneficial use permit.

The Director of Ohio EPA may revoke this authorization for any reason, including but not limited to the City's failure to comply with any of the conditions set forth herein or a determination by the Director that the activities performed pursuant to this authorization threaten or adversely affect public health or safety or the environment.

You are hereby notified that this action of the Director of Ohio EPA (Director) is final and may be appealed to the Environmental Review Appeals Commission pursuant to Section 3745.04 of the Ohio Revised Code. The appeal must be in writing and set forth the action complained of and the grounds upon which the appeal is based. The appeal must be filed with the Commission within thirty (30) days after notice of the Director's action. The appeal must be accompanied by a filing fee of $70.00 made payable to "Treasurer, State of Ohio." The Commission, in its discretion, may reduce the fee if by affidavit it is demonstrated that payment of the full amount of the fee would cause extreme hardship. Notice of the filing of the appeal shall be filed with the Director within three (3) days of filing with the Commission. Ohio EPA requests that a copy of the appeal be served upon the Ohio Attorney General's Office, Environmental Enforcement Section. An appeal may be filed with the Environmental Review Appeals Commission at the following address:

Environmental Review Appeals Commission
30 East Broad Street, 4th Floor
Columbus, Ohio 43215

If you have any questions concerning this letter, please contact Vanessa Steigerwald Dick of Ohio EPA, Northeast District Office, Division of Surface Water, at (330) 963-1219.

Sincerely,

Laurie A. Stevenson
Director
Ohio EPA

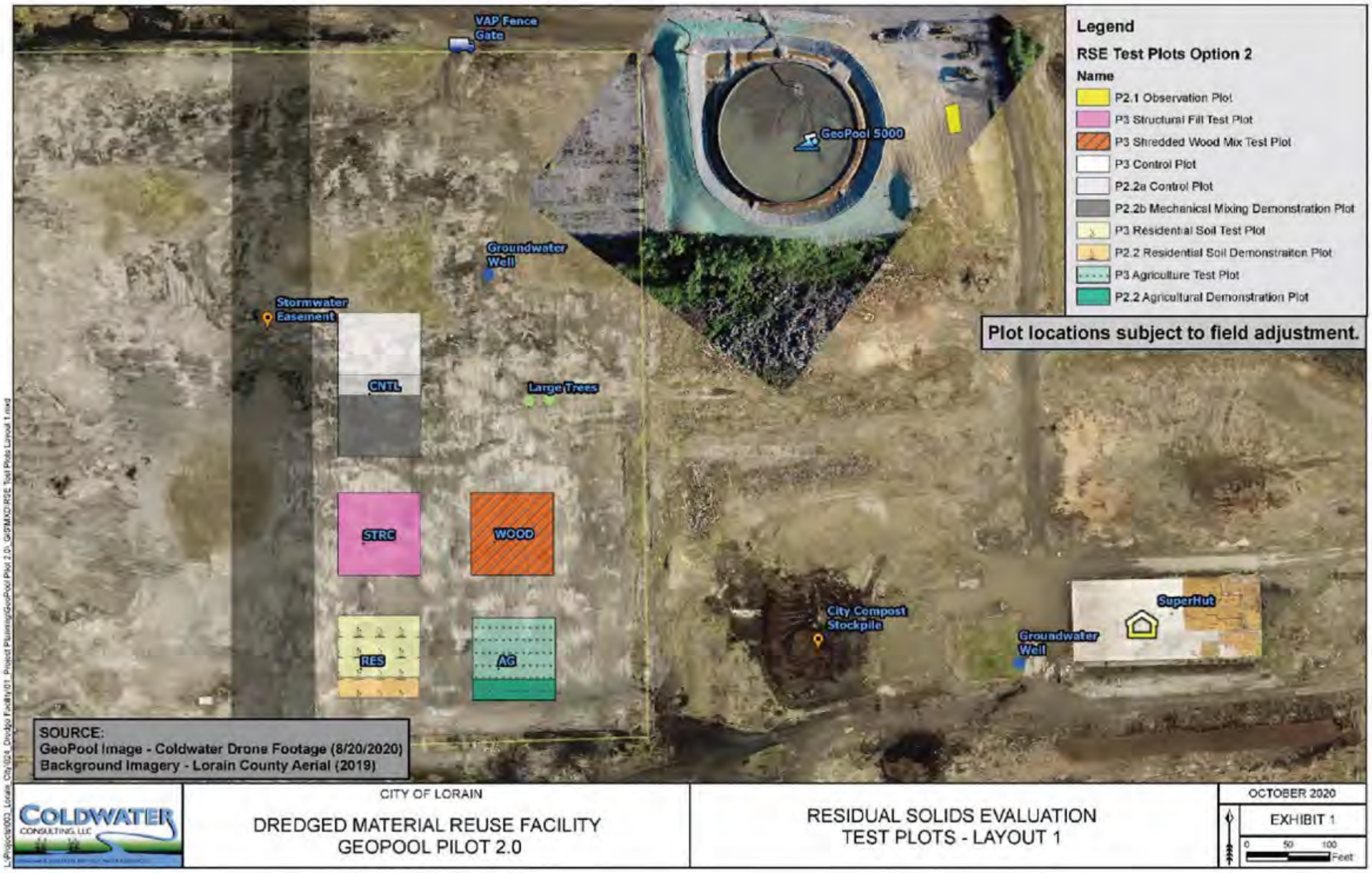
ec: Vlad Cica, Chief, DMWM
Harry Sarvis, Manager, DMWM
David Emerman, NEDO-DSW
Vanessa Steigerwald Dick, NEDO-DSW
Maera Flynn, DMWM
Robin M. Nichols, Legal
Kathryn Golden, City of Lorain (kathryn_golden@cityoflorain.org)
Corry Platt, Coldwater Consulting, LLC (ctplatt@coldwaterconsultants.com)

# Attachment 1

## Excerpts from the

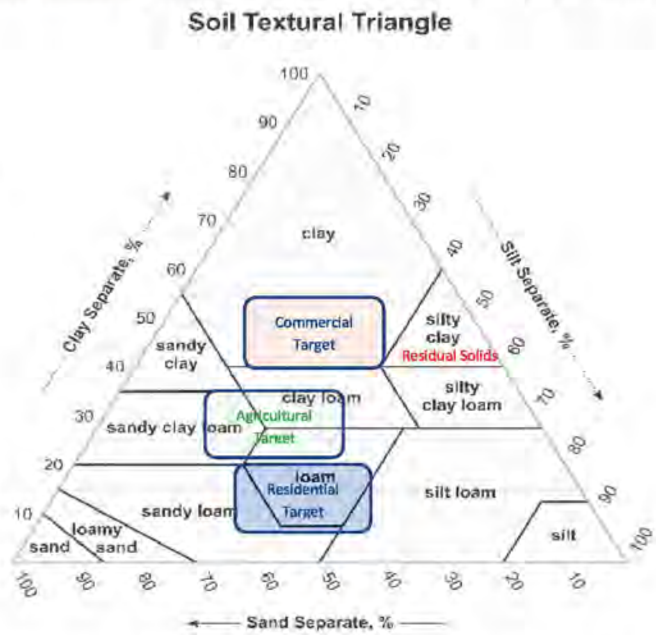
## *Black River Dredged Material Reuse Facility - GeoPool Pilot Study Residual Solids Evaluation*

## Figure 1 – Plot Locations – Phases 2.2 and 3



## Phase 3 – Blended Beneficial Reuse Test Plots

**Dredged material is commonly fine particles and requires blending with other soils, aggregate, or organics to be a market-suitable product. Pre-dredge characterization indicated the Black River sediments as 93 percent silts and clays with 7 percent fine sands. During dredging, abundant organic debris (leaf matter) were encountered and entrained with the sediments in the delivered slurry. Commonly, dredged material containing abundant fines and organic debris are the most difficult to dewater. Handling and blending the Black River dredged material has applicability beyond Lorain as the lessons learned from these commonly difficult dredged materials broadens capability and suitability for other Ohio fine-grained sediments.**




**The residual solids will be excavated from within the GeoPool, transported to the adjoining City-owned Voluntary Action Program fenced lot (VAP Site), laid on the ground surface surrounded with a straw waddle perimeter, and blended using spread & till methods[1] with imported material to "create" the market-appropriate beneficial reuse products.**

**The intention of the blending is to modify the residual solids texture to create a soil product as shown on the soil triangle figure.**

**Five test plots (one is control) will be installed, sampled, and monitored overtime as described individually below.**

**The progress, analytical results, and data interpretation of each test plot will be summarized individually in a Technical Memorandum with tabulated data and representative photographs.**

[1] Other common blending methods include mixing (pug) mills, mechanical mixing using excavator buckets, or excavator-mounted rotating blenders. The spread & till method was selected as it uses equipment commonly available in agriculture, soil blending facilities, and surface soil stabilization applications in Ohio.

## Test Plot 1 – Agricultural Soil

The silty clay nature of the dredged material is typically unsuitable for agricultural soil; rather, a loamy soil is preferred. The predominant soil type for the regional agriculture users is a silt loam underlain by a clay loam (Mahoning soil type). A silt loam is generally 65% silt, 15% clay, and 20% sand. The residual solids have balanced amount of silt and clay which can not be separated to support creating a silt loam; rather, a general loam, a clay loam, and a sandy loam appear reasonable to create/simulate.

*Figure 1 - Soil regions with area of interest circled*

The preferred test plot for the agricultural soil as a loam to clay loam comprised of generally equal parts of sand, silt, and clay as shown in Table 2. The test plot size will be 100 ft wide by 100 ft long by 2 ft thick[2] and be installed as:

- Lift 1
  - 9 inches of dewatered dredged material (excavated at 60 percent moisture, ~300 cyds)
  - 3 inches of imported medium grained sand (trucked, ~100 cyds/150 tons)
  - Lime as required pending analytical results (trucked, estimated at 0.25 inch thick – 7.75 cyds/5.5 tons)
  - Disc to blend
- Lift 2 - Repeat of Lift 1.
- Rake surface and dig planting trench appropriate to selected crop seed[3], install wooden stake at each end of the planting trench
- Sow selected crop seed in planting trench, cover seed by raking smooth

**Table 2 – Agricultural Test Plot Soil Creation**

| Item | Organic Matter % | % medium sand | % fine sand | % silt | % clay |
|---|---|---|---|---|---|
| **Residual Solids** | 5 | 0 | 6 | 47 | 47 |
| **Ag Plot Soil** | 5 | 30 | 4 | 33 | 33 |
| **Adjustment** | 0 change | +30% | -33% | -30% | -30% |
| **2 ft thick distribution** | | 30% ~6 inches | 70% ~18 inches | | |

The test plot will be visually assessed for seed germination, growth, and abundance initially on a weekly basis extending to monthly with stem counts, height, and other parameters of interest to stakeholders.

The test plot performance will be measured against regional and seasonal selected crop growth and abundance as measured by agricultural interests / cooperative extension.

[2] Plot dimensions may be adjusted pending target crop root depth.

[3] Seasonally and regionally appropriate crop seed will be selected with input from stakeholders.

## Test Plot 2 – Residential Garden Soil

The silty clay nature of the dredged material is typically unsuitable for residential garden soil; rather, an organic-rich loamy soil is preferred. The organic-rich loamy soil is generally one-third organic matter with the remaining two-thirds mineral soil as 50% sand, 25% silt, and 25% clay.

The preferred test plot for the residential garden soil as an organic-rich loamy soil created by blending organic matter (compost) with imported medium sand and residual solids as shown in Table 3

| Table 3 – Residential Garden Test Plot Soil Creation | | | | | |
|---|---|---|---|---|---|
| **Item** | **Organic Matter %** | **% medium sand** | **% fine sand** | **% silt** | **% clay** |
| **Residual Solids** | 5 | 0 | 6 | 47 | 47 |
| **Res Garden Plot Soil** | One-third | 50 | | 25 | 25 |
| **Adjustment** | +~8 inches<br>City-compost | +~8 inches<br>imported | No change<br>Residual Solids | | |
| **Blended distribution after amended** | 33% | 33% | 34% | | |

The test plot size will be 100 ft wide by 100 ft long by 2 ft thick and be installed as:

- Lift 1
  - 4 inches of dewatered dredged material (excavated at 80 percent moisture, ~125 cyds)
  - 4 inches of imported medium grained sand (trucked, ~125 cyds/185 tons)
  - 4 inches of City compost (~125 cyds, assumes includes onsite-generated wood chips, may require importing if City-available quantity insufficient)
  - Lime as required pending analytical results (trucked, estimated at 0.25 inch thick – 7.75 cyds/5.5 tons)
  - Disc to blend
- Lift 2
  - Repeat of Lift 1.
- Rake surface
- Broadcast Onsite Restoration Site seed mix consistent with manufacturer recommendations and cover with straw mat or equivalent as pertinent.

The test plot will be visually assessed for seed germination, growth, and abundance on a weekly basis extending to monthly with stem counts, height, and other parameters of interest to stakeholders.

The test plot performance will be measured against restoration plots under study at other locations within the same City-owned Reclamation Site against the restoration site's specification success criteria.

## Test Plot 3 – Commercial Fill / Structural Soil

The silty clay nature of the dredged material is typically low-strength and generally not suitable as structural soil until amended with Portland cement. However, stabilized dredged material (dewatered residuals amended with Portland cement) have been found suitable as commercial site fill, brownfield cover or cap, embankment core and stabilization, landfill cover, and soil-cement subgrades.

The preferred test plot for the structural soil created by blending imported Portland cement and residual solids as shown in Table 4

**Table 4 – Structural Soil Test Plot Soil Creation**

| Item | Organic Matter % | % medium sand | % fine sand | % silt | % clay |
|---|---|---|---|---|---|
| **Residual Solids** | 5 | 0 | 6 | 47 | 47 |
| **Structural Soil** | minimal | 15 | | 45 | 45 |
| **Adjustment** | No change | +10% | | No change | |
| **1 ft thick distribution** | ~0 inches | 10%<br>~1.25 inches | | 90%<br>~12 inches | |

The test plot size will be 100 ft wide by 100 ft long by 1 ft thick and be installed as:

- Lift 1
  - 12 inches of dewatered dredged material (excavated at 60-80 percent moisture, ~370 cyds)
  - 1.25 inches of imported Portland cement (trucked, ~38.5 cyds / 47 tons)
  - Disc to blend, Wait 24 hrs (initial curing), repeat disc to blend.
  - Compact to 96 +/-3 percent maximum dry density at optimum moisture, shape to drain.

The test plot will be divided into quadrants. Each quadrant will represent different curing and weather exposure durations based on number of elapsed days from completion of Lift 1 – 7, 14, 28 days. Bearing capacity will be field measured over the elapsed days using a Kessler Dynamic Cone Penetrometer (ASTM D6951). Aliquots of Lift 1 representing the curing duration (e.g., 7, 14, 28 days) will be collected or simulated using post-mixed, pre-compacted bulk sample in laboratory-cured samples for a total of up to 9 samples. Each sample will be analyzed for:

- Unconfined compressive strength (ASTM D2216)
- Standard Proctor (ASTM D698) – select samples
- Grain size (ASTM D6913) – select samples
- Atterberg Limits (ASTM 4318) – select samples
- Hydraulic Conductivity of Saturated Porous Materials using a Flexible Wall Permeameter – Falling Head (ASTM D5084) – select samples

The test plot performance / analyticals will be measured against geotechnical engineering standards, Ohio DOT standards, OEPA capping characteristics, and other pertinent endpoints agreed upon with the stakeholders.

## Test Plot 4 – Organic-rich Feedstock

The silty clay nature of the dredged material typically hardens as it dries into a hardened clay-like base. Incorporating woody organic pieces (e.g., stump shavings, wood chips) into a clay-laden soil is the initial and primary step to a common multi-year improvement process of clay-laden soils. Blending equal parts of residual solids and onsite-available tree stump chippings/shreddings with subsequent conical stockpiling and monthly texture assessments forms the basis for the Organic-rich Feedstock test plot as shown in Table 5.

| Table 5 – Organic-rich Feedstock Test Plot Soil Creation | | | | | |
|---|---|---|---|---|---|
| **Item** | **Organic Matter %** | **% medium sand** | **% fine sand** | **% silt** | **% clay** |
| **Residual Solids** | 5 | 0 | 6 | 47 | 47 |
| **Wood waste** | 100 | 0 | 0 | 0 | 0 |
| **Adjustment** | +50% | 0% | -3% | -24% | -24% |
| **2 ft thick distribution** | 50%<br>~12 inches | 0%<br>~0 inches | 50%<br>~12 inches | | |

The test plot size will be 100 ft wide by 100 ft long by 2 ft thick and be installed as:

- Lift 1
  - 6 inches of dewatered dredged material (excavated at 80 percent moisture, ~185 cyds)
  - 6 inches of City wood shavings (~185 cyds, assumes grinding of tree stump stockpile to generate)
  - Disc, doze, or excavator bucket rotations to blend
- Lift 2 - Repeat Lift 1.
- Doze or shape into conical stockpile

The test plot/stockpile will be assessed by visual-manual characterization (color, texture) on a monthly basis generally following ASTM D75 Sampling Aggregates – Sampling Stockpiles with Power Equipment. At quarterly intervals, a composite sample will be submitted for organic matter, soil pH, moisture content, and grain size distribution.

## Test Plot 5 – Control

Observation of solely the Residual Solids is the focus of this test plot. Observation of surface hardening, cracking, clumping, and soil characteristics when exposed to weather conditions combined with the ability for comparative analysis against the other test plots are the purposes of this test plot.

The test plot size will be 100 ft wide by 100 ft long by 1ft thick and be installed as:

- Lift 1
  - 12 inches of dewatered dredged material (excavated at 80 percent moisture, ~370 cyds)
  - Shape to drain – may require 1.5 ft high berm to contain.

The test plot will be divided into quadrants. Each quadrant will be used at common times for collection of comparison samples (e.g., quarterly); thereby, limiting disturbance (e.g., compression, rutting, seepage holes).

## Reporting

The observations, analytical results, and data interpretations will be summarized in Technical Memoranda with tabulated data and representative photographs as outlined in the individual phase descriptions.

END

# Appendix B
# Engineered Fill Testing Slide Deck

# GeoPool 2.0 Residual Solids Evaluation
# Engineered Fill Testing – August Update


## Black River Dredged Material Reuse Facility

Coldwater Consulting

# Engineered Fill Soil Testing

- RSE 2.2 Step 10 – Engineered Soil Laboratory Simulation

  - Fine-grained nature of the dredged material is typically low strength and not suitable for use as engineered fill on the commercial market
    - However, with "engineering", soil could be suitable for:
      - General Soil Fill (commercial construction, brownfield cap/cover, etc.)
      - Structural Fill (commercial or residential construction fill at foundation grades)
      - Embankment/dam core material (fine grained, high plasticity, good for dam cores)
      - Landfill cover
      - Stabilized road subgrade

  - It is commonplace to perform laboratory testing in lieu of field testing to determine optimal chemical additive for mix design

  - Purpose: To assess the potential for beneficially reusing dredged sediment in the civil earthwork's construction market for brownfield restoration/capping and commercial construction markets as general fill or structural fill where site specifications may limit the use of on-site materials.

# So what? What does it all mean?

Untreated dredged material (as-is)

3% cement additive

$$ 3% blended product = imported clay $$

7% cement additive

10% cement additive

*Final acceptance of soil for use on any type of project is at the discretion of the project Engineer of Record*

# RSE Chemically Stabilized Soils = Soil-Cement

- Chemically stabilized = soil amended with any of several admixtures
  - **Portland cement**
    - Portland cement typically used in coarse-grained soils or when looking for a quick, mix and dry scenario.  Adds compressive strength to soils in most situations.
  - Cement kiln dust
  - Lime (quicklime or hydrated lime)
    - Typically used in fine-grained soils.  Chemical reaction takes longer and does not add strength, but helps improve soil workability (lower plasticity, dries the soil, etc.)
  - Sodium silicate
  - Powdered slag
  - Bituminous materials
  - Resinous waterproofing materials
  - Many other options out there
- Soil-Cement Approval Gold standard = DOT specifications
  - Roadway subgrade most common use due to large volumes of soils requiring amendment
  - ODOT Supplement 1120 – Mix Design for Chemically Stabilized Soils
    - Followed in general accordance; more on that later.
- Using Type I Portland Cement additive
  - Readily available
  - Helps with drying sediments as well as adding strength = quicker turn from dewater to truck haul
  - Increases soil strength over time

# RSE Chemically Stabilized Soils Laboratory Testing Regimen

- Index Testing for Soil Classification
  - Standard soil classification tests
    - ASTM D 6913 – Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis
    - ASTM D 4318 - Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
    - ASTM D 698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3))
  - Tests performed on:
    - Untreated Dredged Material (DM)
    - DM + 3% Portland cement by dry mass; 2 samples total; 1 each cured 7-days and 28-days prior to testing
    - DM + 7% Portland cement by dry mass; 2 samples total; 1 each cured 7-days and 28-days prior to testing
    - DM + 10% Portland cement by dry mass; 2 samples total; 1 each cured 7-days and 28-days prior to testing
- Unconfined Compressive Strength Testing
  - ODOT Supplement 1120 with additional testing
- Hydraulic Conductivity (Permeability) Testing
  - ASTM D 5084 - Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter
  - Tests performed on:
    - Untreated DM
    - DM +3% Portland cement by dry mass; cured 14 days prior to testing
    - DM +7% Portland cement by dry mass; cured 14 days prior to testing
    - DM +10% Portland cement by dry mass; cured 14 days prior to testing

# RSE Chemically Stabilized Soils Laboratory Testing Regimen

- Index Testing for Soil Classification
  - Standard soil classification tests
    - ASTM D 6913 – Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis
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    - DM + 3% Portland cement by dry mass; 2 samples total; 1 each cured 7-days and 28-days prior to testing
    - DM + 7% Portland cement by dry mass; 2 samples total; 1 each cured 7-days and 28-days prior to testing
    - DM + 10% Portland cement by dry mass; 2 samples total; 1 each cured 7-days and 28-days prior to testing
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  - Tests performed on:
    - Untreated DM
    - DM +3% Portland cement by dry mass; cured 14 days prior to testing
    - DM +7% Portland cement by dry mass; cured 14 days prior to testing
    - DM +10% Portland cement by dry mass; cured 14 days prior to testing

# Soil-Cement Index Testing for Soil Classification Laboratory Testing Procedures

- Grain size analysis
- Atterberg Limits
- Natural moisture content
- Standard Proctor

Standard Proctor Test

Atterberg Limits (LL and PL)

Grain Size Analysis

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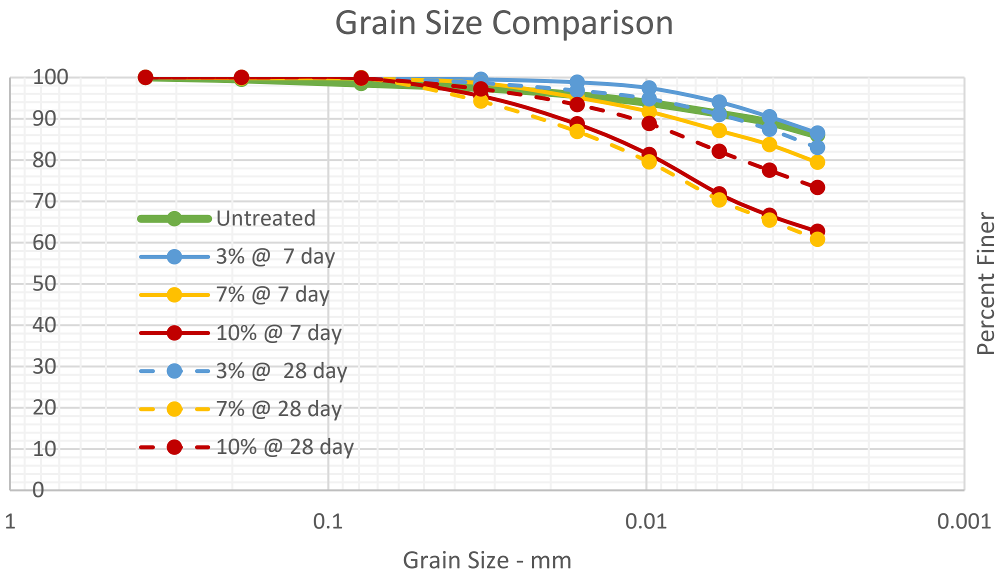
CONSULTING, LLC
of Sustainable Solutions

# Laboratory Index Testing Results

| Sample ID | USCS Classification | | Grain Size | | | Atterberg Limits | | | Standard Proctor | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Symbol | Name | % Gravel | % Sand | % Fines | LL | PL | PI | Maximum Dry Density (pcf) | Optimum Moisture Content (%) |
| Untreated Dredged Material (DM) | MH | ELASTIC SILT | 0.5 | 13.5 | 86.0 | 60 | 32 | 28 | 90.6 | 25.3 |
| 3% Cement Treated DM - 7 Day Cure | MH | ELASTIC SILT | 0.1 | 13.4 | 86.5 | 54 | 33 | 21 | 84.3 | 31.2 |
| 3% Cement Treated DM - 28 Day Cure | MH | ELASTIC SILT WITH SAND | 0.0 | 17.0 | 83 | 54 | 35 | 19 | 83.8 | 32.1 |
| 7% Cement Treated DM - 7 Day Cure | MH | SANDY ELASTIC SILT | 0.2 | 20.4 | 79.4 | 51 | 36 | 15 | 82.3 | 34.7 |
| 7% Cement Treated DM - 28 Day Cure | MH | SANDY ELASTIC SILT | 0.0 | 39.2 | 60.8 | 50 | 36 | 14 | 82.2 | 33.7 |
| 10% Cement Treated DM - 7 Day Cure | ML | SANDY SILT | 0.0 | 37.3 | 62.7 | 48 | 38 | 10 | 81.2 | 34.7 |
| 10% Cement Treated DM - 28 Day Cure | MH | ELASTIC SILT WITH SAND | 0.0 | 26.7 | 73.3 | 50 | 38 | 12 | 80.1 | 36.3 |




General Trend: Grain-size becomes more coarse-grained with increase in cement content

# Laboratory Index Testing Result Trends

| Sample ID | USCS Classification | | Grain Size | | | | | | | Atterberg Limits | | | Standard Proctor | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | % Gravel | | % Sand | | | % Fines | | | | | Maximum Dry Density (pcf) | Optimum Moisture Content (%) |
| | Symbol | Name | Coarse | Fine | Coarse | Medium | Fine | Silt | Clay | LL | PL | PI | | |
| Typical Earthwork Specification Requirements | SC, SM, ML, CL | | -- | -- | -- | -- | -- | -- | | ≤40 | -- | ≤15 | ≥100 | Varies |
| | | | | | | | | | | | | | | |
| Untreated Dredged Material | MH | ELASTIC SILT | 0.0 | 0.5 | 1.0 | 2.8 | 9.7 | 86.0 | | 60 | 32 | 28 | 90.6 | 25.3 |
| 3% Cement Treated DM - 7 Day Cure | MH | ELASTIC SILT | 0.0 | 0.1 | 0.0 | 1.1 | 12.3 | 86.5 | | 54 | 33 | 21 | 84.3 | 31.2 |
| 3% Cement Treated DM - 28 Day Cure | MH | ELASTIC SILT WITH SAND | 0.0 | 0.0 | 0.1 | 3.1 | 13.8 | 83 | | 54 | 35 | 19 | 83.8 | 32.1 |
| | | | | | | | | | | | | | | |
| Untreated Dredged Material | MH | ELASTIC SILT | 0.0 | 0.5 | 1.0 | 2.8 | 9.7 | 86.0 | | 60 | 32 | 28 | 90.6 | 25.3 |
| 7% Cement Treated DM - 7 Day Cure | MH | SANDY ELASTIC SILT | 0.0 | 0.2 | 0.1 | 4.6 | 15.7 | 79.4 | | 51 | 36 | 15 | 82.3 | 34.7 |
| 7% Cement Treated DM - 28 Day Cure | MH | SANDY ELASTIC SILT | 0.0 | 0.0 | 0.1 | 13.0 | 26.1 | 60.8 | | 50 | 36 | 14 | 82.2 | 33.7 |
| | | | | | | | | | | | | | | |
| Untreated Dredged Material | MH | ELASTIC SILT | 0.0 | 0.5 | 1.0 | 2.8 | 9.7 | 86.0 | | 60 | 32 | 28 | 90.6 | 25.3 |
| 10% Cement Treated DM - 7 Day Cure | ML | SANDY SILT | 0.0 | 0.0 | 0.2 | 11.1 | 26.0 | 62.7 | | 48 | 38 | 10 | 81.2 | 34.7 |
| 10% Cement Treated DM - 28 Day Cure | MH | ELASTIC SILT WITH SAND | 0.0 | 0.0 | 0.2 | 6.4 | 20.1 | 73.3 | | 50 | 38 | 12 | 80.1 | 36.3 |

## **Data Trends**

Positives:

- % coarse-grained material ↑ with ↑ in cement content
- Plasticity Index (PI) ↓ with ↑ cement content and ↑ curing time
- USCS classification of material nears or becomes low-plasticity soil

Counteractive:

- Maximum dry density ↓ (potential non-acceptance by Engineer of Record based on project specifications)
- Optimum moisture ↑ with ↑ in cement content (Potential increase in construction effort to achieve project compaction requirements)

*IT SHOULD BE NOTED, final acceptance of materials use on a project is at the discretion of the Engineer of Record*

# RSE Chemically Stabilized Soils Laboratory Testing Regimen

- Index Testing for Soil Classification
  - Standard soil classification tests typically performed to determine if soil meets specifications for project
    - ASTM D 6913 – Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis
    - ASTM D 4318 - Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
    - ASTM D 698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3))
  - Tests performed on:
    - Untreated Dredged Material (DM)
    - DM + 3% Portland cement by dry mass; 2 samples total; 1 each cured 7-days and 28-days prior to testing
    - DM + 7% Portland cement by dry mass; 2 samples total; 1 each cured 7-days and 28-days prior to testing
    - DM + 10% Portland cement by dry mass; 2 samples total; 1 each cured 7-days and 28-days prior to testing
- Unconfined Compressive Strength Testing
  - ODOT Supplement 1120 with additional testing
- Hydraulic Conductivity (Permeability) Testing
  - ASTM D 5084 - Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter
  - Tests performed on:
    - Untreated DM
    - DM +3% Portland cement by dry mass; cured X days prior to testing
    - DM +7% Portland cement by dry mass; cured X days prior to testing
    - DM +10% Portland cement by dry mass; cured X days prior to testing

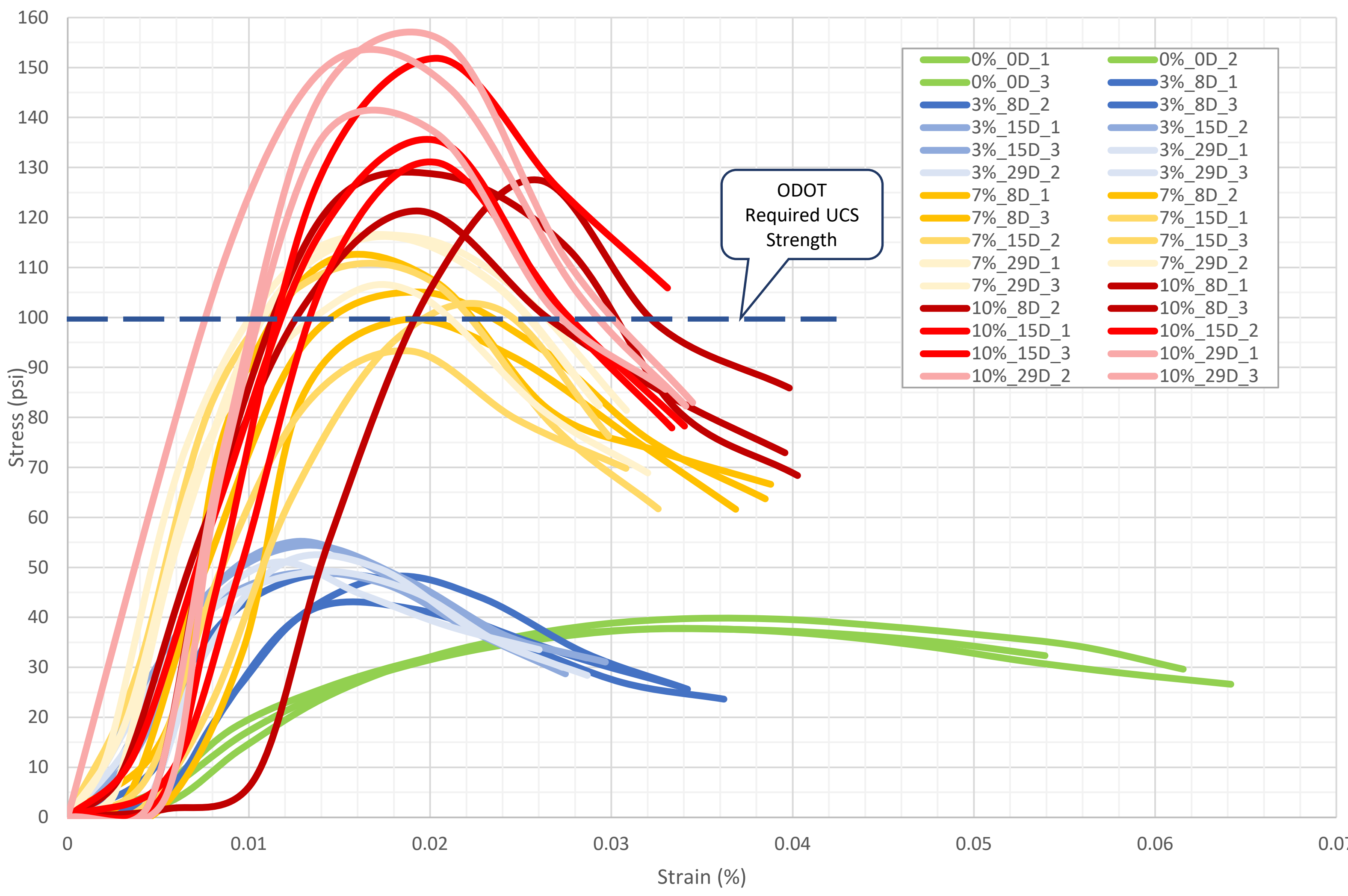
# Procedure Comparison – ODOT vs. GP 2.0 RSE

- ODOT Supplement 1120
  - Soil Classification Testing
    - Grain size analysis
    - Atterberg limits
    - Standard Proctor
  - Mix Design
    - 4 %'s of cement
      - 0%, 3%, 5%, 7%
      - 12 total samples
      - 3 samples molded per %
    - Unconfined Compressive Strength Testing
      - 0-day break of 3 untreated samples
      - 8-day break **ONLY**
      - Minimum compressive strength = 100 psi
      - Average across 3 specimens on 8-day break

- GeoPool 2.0 RSE Testing
  - Soil Classification Testing
    - Grain size analysis
    - Atterberg limits
    - Standard Proctor
  - Mix Design
    - 4 %'s of cement
      - 0%, 3%, 7%, 10%
      - 30 total samples
      - 3 samples per % per break day
    - Unconfined Compressive Strength Testing
      - 0-day break of 3 untreated samples
      - 8, 15 and 29-day breaks
      - Minimum compressive strength = 100 psi
      - Average across 3 specimens on each break day

# Unconfined Compressive Strength Curves

Each curve represents a single UCS test (30 total)

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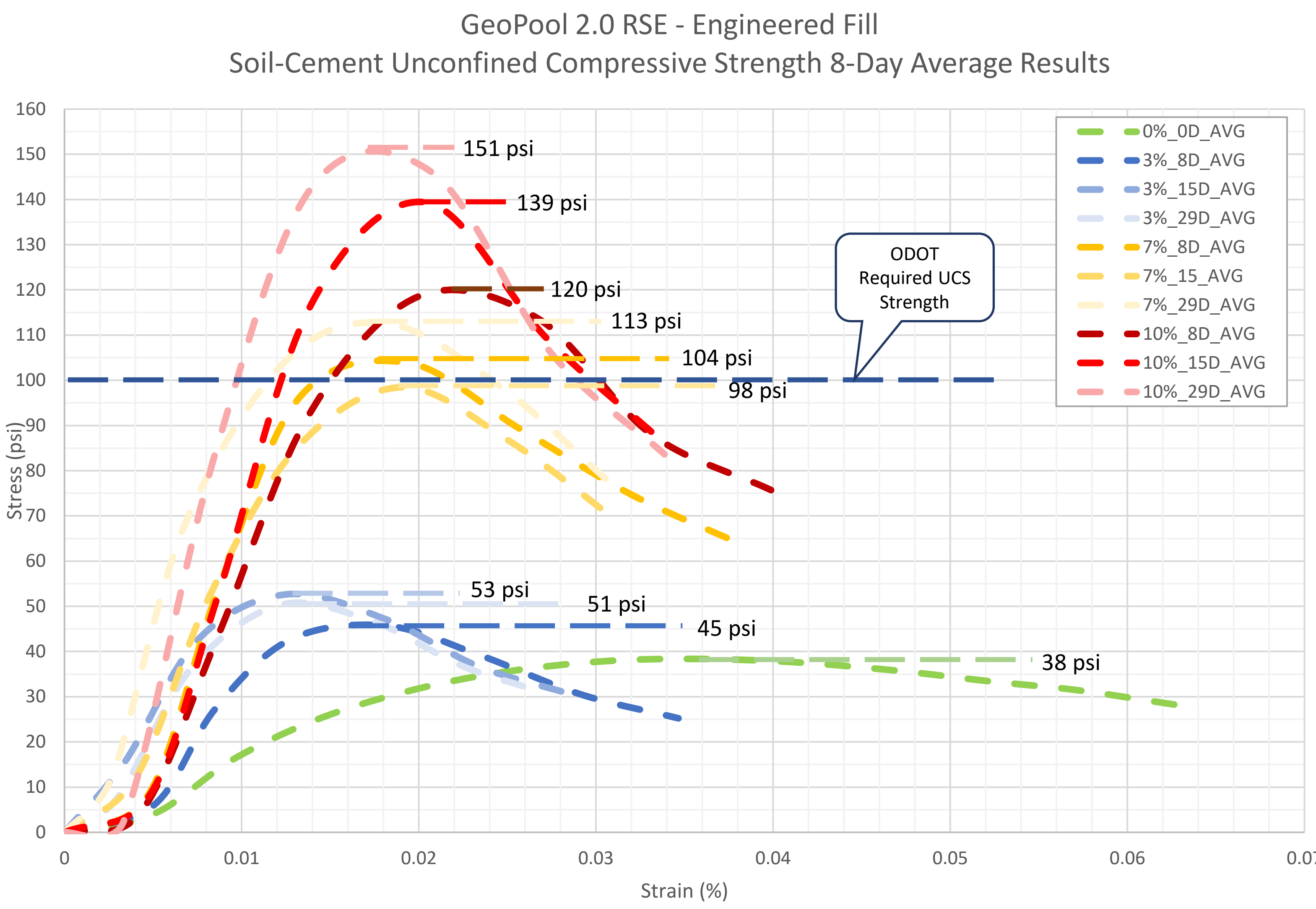
# What is the result of all this testing?



# Tabulated Average Unconfined Compressive Strength (UCS) Results

| Sample ID | Cure Period (days) | Average Unconfined Compressive Strength (psi) |
|---|---|---|
| ODOT Stabilized Subgrade Requirement | 8 | 100 |
| | | |
| Untreated Dredged Material (DM) | 0 | 38 |
| 3% Cement Treated DM | 8 | 45 |
| | 15 | 51 |
| | 29 | 53 |
| 7% Cement Treated DM | 8 | 98 |
| | 15 | 104 |
| | 29 | 113 |
| 10% Cement Treated DM | 8 | 120 |
| | 15 | 139 |
| | 29 | 151 |

**Take-Aways**

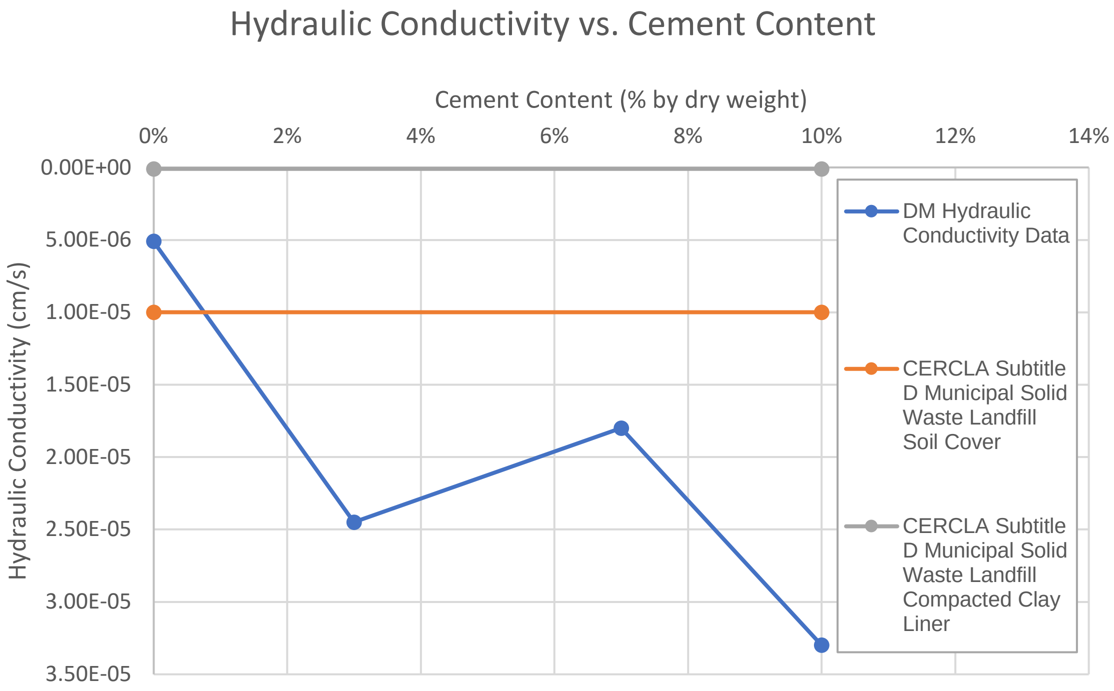
- UCS increase with increase in both cement content and cure time
- Between 7% and 8% Portland cement by dry weight would be required to meet ODOT specification for UCS strength of roadway subgrade (UCS>100psi)

# RSE Chemically Stabilized Soils Laboratory Testing Regimen

- Index Testing for Soil Classification
  - Standard soil classification tests typically performed to determine if soil meets specifications for project
    - ASTM D 6913 – Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis
    - ASTM D 4318 - Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
    - ASTM D 698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3))
  - Tests performed on:
    - Untreated Dredged Material (DM)
    - DM + 3% Portland cement by dry mass; 2 samples total; 1 each cured 7-days and 28-days prior to testing
    - DM + 7% Portland cement by dry mass; 2 samples total; 1 each cured 7-days and 28-days prior to testing
    - DM + 10% Portland cement by dry mass; 2 samples total; 1 each cured 7-days and 28-days prior to testing
- Unconfined Compressive Strength Testing
  - ODOT Supplement 1120 with additional testing
- Hydraulic Conductivity (Permeability) Testing
  - ASTM D 5084 - Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter
  - Tests performed on:
    - Untreated DM
    - DM +3% Portland cement by dry mass; cured X days prior to testing
    - DM +7% Portland cement by dry mass; cured X days prior to testing
    - DM +10% Portland cement by dry mass; cured X days prior to testing

# Hydraulic Conductivity (Permeability) Testing Results

| Cement Content | Average Hydraulic Conductivity (cm/s) |
|---|---|
| CERCLA Subtitle D Solid Waste Landfill Cover | $1.00 \times 10^{-5}$ |
| CERCLA Subtitle D Solid Waste Landfill Compacted Clay Liner | $1.00 \times 10^{-7}$ |
| 0% | $5.00 \times 10^{-6}$ |
| 3% | $2.45 \times 10^{-5}$ |
| 7% | $1.80 \times 10^{-5}$ |
| 10% | $3.30 \times 10^{-5}$ |




**Take-aways**

- Untreated DM has permeability to meet CERCLA requirements for cover soil
- As cement content ↑, permeability ↑
- Cement-treated DM likely won't meet criteria for use in landfill liner or cover; however, typical specifications for these layers may accept untreated material for use

# So what? What does it all mean?

Untreated dredged material (as-is)

3% cement additive

7% cement additive

10% cement additive

*Final acceptance of soil for use on any type of project is at the discretion of the project Engineer of Record*

# Can locally available manufactured sand save $$$ versus soil-cement?

- Manufactured sand readily available in NW Ohio
  - Quarries typically consider it a waste…….. WASTE + WASTE = PRODUCT?

- Results from RSE Agricultural test plot (70% DM + 30% manufactured Sand by volume; 20% by dry weight)
  - USCS Classification: SC (Clayey Sand)
    - 43.2 % Fine Grained
    - 56.8 % Coarse Grained
    - LL = 52, PL = 28, PI = 24; fine-grained constituent still high plasticity

- Conclusion: Need a minimum of 30% manufactured sand by volume to achieve coarse-grained soil classification to amend soil for suitable use by typical project specs

  - ??? is DM-sand cheaper than DM-cement ???

# Sand additive versus cement treated

- Volume/cost comparison exercise: 3% Portland cement vs. 20% Manufactured Sand both by dry weight

- Commodity $$$
  - Cement =$200/ton vs Sand = $15/ton…..sand wins, right? WRONG!!!
- Blended Product $$$
  - DM-cement and DM-sand mix ~ EQUAL in price…..BUT!
    - Sand = **<u>10x</u>** TRUCKS to haul in
    - Sand mix = **<u>1.2x</u>** VOLUME of material to haul out/store
  - *<u>Blended Product versus imported clay = equivalent $$$</u>*
- Community/Transportation Implication
  - 1.2x TRUCK trips to haul out product
    - *7,900 trucks for DM-sand versus 6,600 trucks for DM-cement*
  - *10x TRUCK trips to import sand vs Portland cement*

Imported PC Truckloads

Imported Sand Truckloads

# Discussion and Conclusions

- Treated DM = marketable engineered fill
- The receiving project Engineer of Record must be cognizant of DM properties
- *Two perceived waste streams (dredge material and manufactured sand) can make a marketable, beneficial reuse product comparable in price to imported natural soil*

Brian Weyer, PE (OH)
Senior Project Engineer
Coldwater Consulting, LLC
3079 East Erie Ave, Lorain OH 44052
201 West Chatham St., #220, Cary NC 27511
bjweyer@coldwaterconsultants.com
Cell: 704-654-1133

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Celebrating 10 Years COLDWATER CONSULTING, LLC of Sustainable Solutions

# Appendix C
# Letter Report containing Residual Solids Analytical Results

**COLDWATER CONSULTING, LLC**
3079 East Erie Avenue
Lorain, OH 44052

23 April 2021

Vanessa Steigerwald-Dick, PhD (330.963.1219)
Standards and Technical Support and Dredge Program
Ohio Environmental Protection Agency, Division of Surface Water
Northeast District Office

Columbus, OH 43215

Sent via Email Correspondence

Subject: City of Lorain Black River Dredged Material Reuse Facility (BRDMRF)
Data Request Response in support of OEPA AOC BUI evaluation
Coldwater Project Number 03-024.7

Dear Vanessa,

As you are aware, the City of Lorain (City) is working with the Ohio Department of Natural Resources (Ohio DNR) and the Ohio Environmental Protection Agency (Ohio EPA) under a Healthy Lake Erie Fund (HLEF) grant to design and construct a dredged material receiving facility for the Black River. In August 2020, the City performed a pilot study where about 3,000 cyds of sediments were hydraulically dredged from the Federal Middle Turning Basin and Upper Turning Basins. The dredged slurry was pumped about one mile to an innovative dewatering technology called a GeoPool. The dredged slurry was dewatered leaving the residual solids within the GeoPool. These residual solids have been sampled and analyzed for pollutants, physical/engineering properties, and agronomic parameters at various points between September 2020 and March 2021. The pilot project was performed under permits from the USACE, OEPA, and ODNR.

This letter is submitted on behalf of the City of Lorain in response to a data request initiated by Melanie Barbis, NE-AOC Coordinator, OEPA with supplemental clarifications by yourself and Karen Keil, USACE-Buffalo. We understand that the provided analytical results will be used to supplement data collected by others for evaluation of in-river sediment conditions. If the provided analytical results are used for other purposes, we request the ability to authorize the re-use on an individual case basis.

The remainder of this letter provides the following requested information:

1. In-river locations of the dredged sediment represented by the analytical results.
2. General description of the sample collection and handling.
3. Listing of analytical laboratories that performed the analyses.
4. Tabulation of the analytical results.
5. Electronic data deliverables of the pollutant analytical results.
6. Laboratory reports for the pollutant analytical results.

**Request 1: In-River Locations of the Dredged Sediment**

Dredging occurred at two locations in August 2020 – one dredging footprint was in the Federal Middle Turning Basin and one in the Federal Upper Turning Basin. The dredged sediments were mixed in the GeoPool so the provided analytical results represent a composite sample of the about 3,000 cubic yards of dredged sediment across these two footprints. Both dredging footprints extended from about -7 ft to -12 ft LWD. The dredging footprints are shown on the attached Figure 1. The representative coordinates of these dredging footprints are:

- Middle Turning Basin
  - Latitude: 41.453064
  - Longitude: -82.150166
- Upper Turning Basin
  - Latitude: 41.454003
  - Longitude: -82.148324

**Request 2: Sample Collection & Handling**

Samples were collected and handled using environmental sampling procedures. The following procedures were employed: disposable or decontaminated tools, gloved hands, laboratory-provided bottleware, wet ice for temperature control, chain-of-custodies, and laboratory couriers and/or overnight shipping.

Individual samples were collected as follows:

| Sample ID | Collection Date | Description | EDD |
|---|---|---|---|
| **RSE P2 0-6 20200922** | 22 Sept 2020 | Sourced from GeoPool Northeast quadrant, scrape of surface (0 to 6 inches), using long reach excavator. Sample collected from excavator bucket. | 20092102 |
| **RSE P2 +10 20200922** | 22 Sept 2020 | Sourced from GeoPool Northeast quadrant, test pit located 10 feet into the GeoPool from exterior circumference about 3 feet deep (mid to lower depth) using long reach excavator. Sample collected from excavator bucket. | 20092102 |
| **RSE P2 +45 20200922** | 22 Sept 2020 | Sourced from GeoPool Northeast quadrant, test pit located 45 feet into the GeoPool from exterior circumference about 3 feet deep (mid to lower depth) using long reach excavator. Sample collected from excavator bucket. | 20092102 |

| Sample ID | Collection Date | Description | EDD |
|---|---|---|---|
| **RSE P2.2 AG 20201119** | 19 Nov 2020 | Sourced from GeoPool Northwest quadrant that was excavated to full depth (about 6 feet) and truck hauled to nearby 25 ft x 100 ft test plot and dumped creating an undisturbed 12 inch thick lift. Sample composited from three grab locations within test plot. Sample represented the agricultural test plot pre-blending with amendments. | 20111967 |
| **RSE P2.2 RES 20201119** | 19 Nov 2020 | Sourced from GeoPool Northwest quadrant that was excavated to full depth (about 6 feet) and truck hauled to nearby 25 ft x 100 ft test plot and dumped creating an undisturbed 12 inch thick lift. Sample composited from three grab locations within test plot. Sample represented the residential test plot pre-blending with amendments. | 20111967 |
| **RSE P2.2 CNTL 20201119** | 19 Nov 2020 | Sourced from GeoPool Northwest quadrant that was excavated to full depth (about 6 feet) and truck hauled to nearby 25 ft x 100 ft test plot and dumped creating an undisturbed 12 inch thick lift. Sample composited from three grab locations within test plot. Sample represented the control test plot pre-blending with amendments. | 20111967 |
| **RSE P2.2 DM 20210322** | 22 March 2021 | Sourced from surface (0-1 ft) in GeoPool Northeast quadrant. | 21032772 |

**Request 3: Analytical Laboratories**

The laboratories that performed the analyses were:

- Agronomic analyses: A&L Great Lakes, Fort Wayne, Indiana
- Physical / Engineering: Wood Environment & Infrastructure Solutions, Durham, North Carolina
- Pollutant: ALS Environmental, Holland, Michigan

**Request 4: Tabulation of Analytical Results**

Tabulated analytical results are shown on Table 1.

______________________________

**Request 5: Electronic Data Deliverables**

The EDD in flat file format for the pollutant analyses are contained in an electronically-transferred ZIP folder containing the following files:

- 20092102 EDD flat file_OEPA issued – excel format
- 20111967 EDD flat file_OEPA issued – excel format
- 21032772 EDD flat file_OEPA issued – excel format

**Request 6: Analytical Laboratory Reports**

The laboratory issued data reports inclusive of the respective batch quality control documentation and case narratives are contained in an electronically-transferred ZIP folder containing the following files:

- 20092102 (Coldwater – RSE P2) Final Report from ALS – PDF format
- 20111967 (Coldwater – RSE P2) Final Report from ALS – PDF format
- 21032772 (Coldwater – BRDMRF) Report from ALS – PDF format

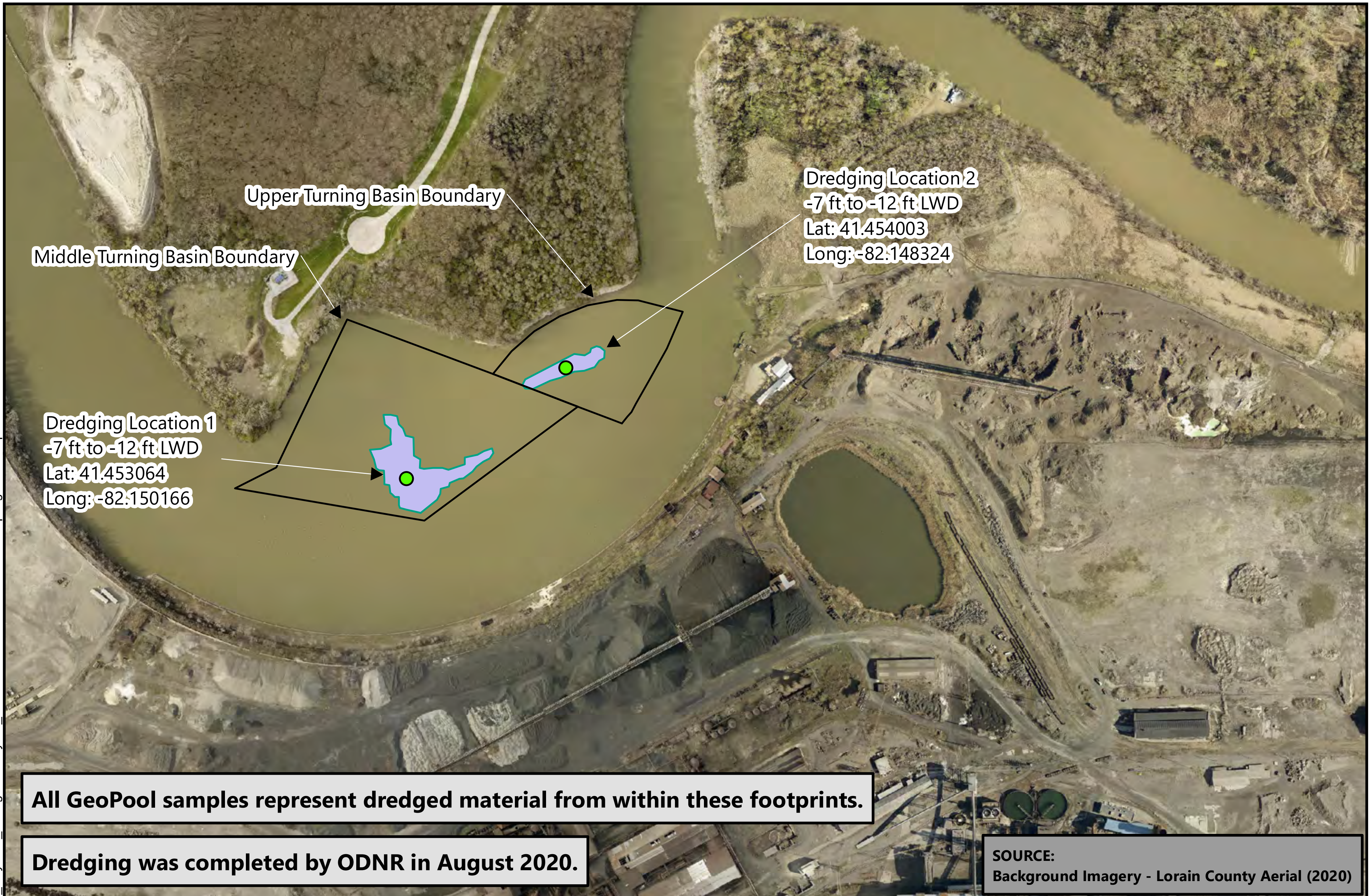
**Closing**

In closing, we trust the materials provided satisfy the data request. If additional information or discussion is necessary, please contact me at 919.656.5799 or by email.

Cordially,

Corry Platt, CEP
Project Manager/Technical Director
ctplatt@coldwaterconsultants.com

Attachments:
Figure 1 – Dredging Footprints
Table 1 – Analytical Results Representing Sediments Dredged from Middle and Upper Turning Basins
Electronic ZIP folder containing:
Table 1 in excel format
Pollutant electronic data deliverable flat files from ALS (20092102, 20111967, 21037772)
Pollutant laboratory reports / case narratives from ALS (20092102, 20111967, 21037772)
Copies to:
Kate Golden, City of Lorain – with attachments
OEPA – David Emerman, Melanie Barbis – with attachments
ODNR – Scudder Mackey – with attachments
USACE – Karen Keil – with attachments
END

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| | | | |
|---|---|---|---|
| COLDWATER CONSULTING, LLC<br>SUSTAINABLE SOLUTIONS FOR YOUR WATER RESOURCES | CITY OF LORAIN<br>BLACK RIVER DREDGED MATERIAL REUSE FACILITY | DREDGING FOOTPRINTS AND GEOPOOL SEDIMENT SOURCES LOCATION MAP | APRIL 2021<br>FIGURE 1<br>0 240 480 Feet |

**Black River Dredged Material Reuse Facility**
**GeoPool Pilot Study / Residual Solids Evaluation**
**OEPA Data Request**
**Table 1 - Analytical Results Representing Sediments Dredged from Middle and Upper Turning Basins**
*Samples collected from GeoPool-contained solids*

Supplied to OEPA in response to Data Request in support of Black River AOC BUI evaluation, April 2021.
Not authorized for any other use, reproduction, or dissemination without written consent from Coldwater Consulting, LLC.
U = Analyzed but not detected above the Method Detection Limit, value shown is Reporting Limit.
J = Analyte is present at an estimated concentration between the Method Detection Limit and Report Limit.

| AGRONOMY | | | P2.1 Scoops (9/22/2020) | | | P2.2 Plot Creation (11/19/2020) | | | P2.2 BGSU/WSU Studies (3/22/2021) |
|---|---|---|---|---|---|---|---|---|---|
| | | Description | Surface Solids (Top 0-6") | Solids 10' From Frame | Solids 45' From Frame | Pre-Blend Agricultural Plot | Pre-Blend Residential Plot | Pre-Blend Control Plot | GeoPool Surface (0-1 ft) |
| | Unit | Analytical Method | RSE P2.1 0-6 | RSE P2.1 +10 | RSE P2.1 +45 | RSE_P2.2_AG_ 20201119 | RSE_P2.2_RES_20201119 | RSE_P2.2_CNTL_20201119 | RSE_P2.2_DM_20210322 |
| Soil pH | | SM 9040C | 7.7 | 7.6 | 7.8 | 7.9 | 7.8 | 7.8 | 7.7 |
| Organic Matter (%) | % | | 5.1 | 3.7 | 3.4 | 3.5 | 3.6 | 3.9 | 3.6 |
| CEC(meq/100g) | | | 19 | 18.2 | 19.2 | 20.2 | 19.3 | 20.7 | 21.1 |
| CEC by NH4-Sat (meq/100g) | meq/100g | MSA Part 3 | 17.1 | 14.64 | 12.96 | 15.4 | 13.95 | 18.5 | 11.71 |
| Phosphorus, Mehlich 3 (ppm-P) | ppm | Mehlich-3 | 41 | 37 | 37 | 31 | 29 | 28 | 22 |
| Phosphorus, Bray-1 Equiv (ppm-P) | ppm | Bray 1 | 30 | 27 | 28 | 20 | 23 | 21 | |
| Phosphorus, Bray-2 Equiv (ppm-P) | ppm | Bray 2 | 125 | 118 | 108 | 77 | 90 | 70 | 105 |
| Phosphate (ppm) | ppm | calculated | | | | | | | 49 |
| Bicarb-P (ppm) | ppm | | 28 | 30 | 25 | 44 | 49 | 42 | 42 |
| Exchangeable Potassium (ppm) | meq/100g | | 104 | 103 | 111 | 119 | 114 | 121 | 95 |
| Exchangeable Magnesium (ppm) | ppm | | 252 | 214 | 232 | 260 | 248 | 245 | 249 |
| Exchangeable Calcium (ppm) | ppm | | 3324 | 3232 | 3401 | 3550 | 3393 | 3674 | 3679 |
| Exchangle Aluminum (ppm) | ppm | MSE Part 3 (1996) | | | | | | | <1 |
| %K - CEC | % | | 1.4 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.2 |
| %Mg - CEC | % | | 11.1 | 9.8 | 10.1 | 10.7 | 10.7 | 9.9 | 9.8 |
| %Ca - CEC | % | | 87.5 | 88.8 | 88.5 | 87.8 | 87.8 | 88.7 | 87.2 |
| %Na - CEC | % | | | | | | | | 1.8 |
| %H - CEC | % | | | | | | | | |
| Nitrate (ppm) | ppm | EPA 353.2 | 1 | 1 | 1 | 1 | 1 | 1 | 56 |
| Ammonium (ppm) | ppm | | 95 | 99 | 95 | 98 | 88 | 99 | 3 |
| Chloride (ppm) | ppm | EPA 9056A | 75 | 73 | M | 68 | 91 | 66 | 85 |
| Sodium | | | | | | | | | 85 |
| Soluble Salt Concentration (mmho/cm) | mmho/cm | | | | | | | | 0.9 |
| Pyritic Sulfur (%) | % | EPA 600 | | | | | | | <.01 |
| Potential Acidity (T CaCO3/ 1000 T Soil) | | EPA 600 | | | | | | | <.3 |
| Net Neutralization Potential (T CaCO3/ 1000 T Soil) | | EPA 600 | | | | | | | 26.64 |
| Neutralization Potential (T CaCO3/ 1000 T Soil) | | EPA 600 | | | | | | | 26.64 |
| Total Nitrogen | % | Dumas | | | | | | | 0.17 |
| Total Kjeldalh Nitrogen (%) | % | MSA Part 3 | 0.185 | 0.19 | 0.197 | 0.204 | 0.211 | 0.196 | 0.182 |
| Total Phosphorous (%) | | EPA 365.3 | 0.093 | 0.091 | 0.08 | 0.091 | 0.092 | 0.091 | 0.068 |

| AGRONOMY - Micronutrients | | | P2.1 Scoops (9/22/2020) | | | P2.2 Plot Creation (11/19/2020) | | | P2.2 BGSU/WSU Studies (3/22/2021) |
|---|---|---|---|---|---|---|---|---|---|
| | | Description | Surface Solids (Top 0-6") | Solids 10' From Frame | Solids 45' From Frame | Pre-Blend Agricultural Plot | Pre-Blend Residential Plot | Pre-Blend Control Plot | GeoPool Surface (0-1 ft) |
| | Unit | Analytical Method | RSE P2.1 0-6 | RSE P2.1 +10 | RSE P2.1 +45 | RSE_P2.2_AG_ 20201119 | RSE_P2.2_RES_20201119 | RSE_P2.2_CNTL_20201119 | RSE_P2.2_DM_20210322 |
| Sulfur | ppm | | | | | 35 | 38 | 36 | 225 |
| Zinc | ppm | | | | | 10 | 9.1 | 9.4 | 28 |
| Manganese | ppm | | | | | 93 | 86 | 104 | 64 |
| Iron | ppm | | | | | 1242 | 1279 | 1237 | 875 |
| Copper | ppm | | | | | 2.3 | 2.2 | 2.2 | 3.1 |
| Boron | ppm | | | | | 0.9 | 0.8 | 0.8 | 0.9 |

| ENGINEERING | | | P2.1 Scoops (9/22/2020) | | | P2.2 Plot Creation (11/19/2020) | | | P2.2 BGSU/WSU Studies (3/22/2021) |
|---|---|---|---|---|---|---|---|---|---|
| | | Description | Surface Solids (Top 0-6") | Solids 10' From Frame | Solids 45' From Frame | Pre-Blend Agricultural Plot | Pre-Blend Residential Plot | Pre-Blend Control Plot | GeoPool Surface (0-1 ft) |
| | Unit | Analytical Method | RSE P2.1 0-6 | RSE P2.1 +10 | RSE P2.1 +45 | RSE_P2.2_AG_ 20201119 | RSE_P2.2_RES_20201119 | RSE_P2.2_CNTL_20201119 | RSE_P2.2_DM_20210322 |
| **Particle Size** | | | | | | | | | |
| Clay (%) | % | ASTM D6913 | 34.9 | | | 30.9 | 33.7 | 32.1 | pending |
| Silt (%) | % | ASTM D6913 | 53.1 | | | 59.2 | 59.1 | 61.3 | pending |
| Sand (%) | % | ASTM D6913 | 12 | | | 9.9 | 7.2 | 6.6 | pending |
| Gravel (%) | % | ASTM D6913 | 0 | | | 0 | 0 | 0 | pending |
| USCS Classification | | ASTM D2487 | Silt (ML) | | | Elastic Silt (MH) | Elastic Silt (MH) | Elastic Silt (MH) | pending |
| **Atterberg Limits** | | | | | | | | | |
| Liquid Limit | | ASTM D4318 | 46 | | | 60 | 59 | 58 | |
| Plastic Limit | | ASTM D4318 | 29 | | | 33 | 35 | 31 | |
| Plasticity Index | | ASTM D4318 | 17 | | | 27 | 34 | 27 | |
| Specfic Gravity | | ASTM D854 | 2.611 | | | 2.624 | 2.659 | 2.656 | |
| Organic Content @ 450C (%) | % | ASTM D2974 | 4.4 | | | 5 | 4.7 | 5.2 | |
| Organic Content @ 750C (%) | % | ASTM D2974 | 8.2 | | | 8.1 | 8.8 | 9.2 | |
| **Standard Proctor** | | | | | | | | | |
| Maximum Dry Density (pcf) | pcf | ASTM D698 | 91 | | | 88.7 | 87.8 | 86.4 | |
| Optimum Moisture Content (%) | % | ASTM D698 | 24 | | | 25.2 | 25.4 | 26.1 | |

**Black River Dredged Material Reuse Facility**
**GeoPool Pilot Study / Residual Solids Evaluation**
**OEPA Data Request**
**Table 1 - Analytical Results Representing Sediments Dredged from Middle and Upper Turning Basins**

*Samples collected from GeoPool-contained solids*



U = Analyzed but not detected above the Method Detection Limit, value shown is Reporting Limit.
J = Analyte is present at an estimated concentration between the Method Detection Limit and Report Limit.

| METALS (mg/Kg-dry) | | | P2.1 Scoops (9/22/2020) | | | P2.2 Plot Creation (11/19/2020) | | | P2.2 BGSU/WSU Studies (3/22/2021) |
|---|---|---|---|---|---|---|---|---|---|
| | | Description | Surface Solids (Top 0-6") | Solids 10' From Frame | Solids 45' From Frame | Pre-Blend Agricultural Plot | Pre-Blend Residential Plot | Pre-Blend Control Plot | GeoPool Surface (0-1 ft) |
| | Unit | Analytical Method | RSE P2.1 0-6 | RSE P2.1 +10 | RSE P2.1 +45 | RSE_P2.2_AG_ 20201119 | RSE_P2.2_RES_20201119 | RSE_P2.2_CNTL_20201119 | RSE_P2.2_DM_20210322 |
| Aluminum | mg/Kg | SW6020B | 9,300 | 9,900 | 9,600 | 9,800 | 9,600 | 9,000 | 11000 |
| Antimony | mg/Kg | SW6020B | 1.0 | 1.0 | 0.9 | 0.78 J | 0.75 J | 0.62 J | 0.94 |
| Arsenic | mg/Kg | SW6020B | 11.00 | 12.00 | 12.00 | 12 | 11 | 12 | 13 |
| Barium | mg/Kg | SW6020B | 61 | 68 | 64 | 74 | 70 | 70 | 75 |
| Beryllium | mg/Kg | SW6020B | 0.64 | 0.63 | 0.63 | 0.64 | 0.61 | 0.63 | 0.62 |
| Cadmium | mg/Kg | SW6020B | 2.5 | 2.3 | 2.1 | 2.4 | 2.5 | 2.4 | 3.4 |
| Calcium | mg/Kg | SW6020B | 9,000 | 9,200 | 9,100 | 10,000 | 9,300 | 9,700 | 9,800 |
| Chromium | mg/Kg | SW6020B | 26 | 24 | 24 | 24 | 24 | 20 | 28 |
| Cobalt | mg/Kg | SW6020B | 10.0 | 11.0 | 11.0 | 11 | 10 | 11 | 11 |
| Copper | mg/Kg | SW6020B | 52 | 47 | 48 | 34 | 34 | 32 | 45 |
| Iron | mg/Kg | SW6020B | 25,000 | 26,000 | 31,000 | 25,000 | 23,000 | 23,000 | 31,000 |
| Lead | mg/Kg | SW6020B | 30 | 31 | 26 | 29 | 28 | 27 | 34 |
| Magnesium | mg/Kg | SW6020B | 4,100 | 4,300 | 4,400 | 4,600 | 4,200 | 4,400 | 4,500 |
| Manganese | mg/Kg | SW6020B | 450 | 480 | 490 | 480 | 470 | 430 | 490 |
| Mercury (mg/kg-dry) | mg/Kg | SW7471B | 0.09 | 0.08 | 0.08 | 0.086 | 0.085 | 0.092 | 0.087 |
| Nickel | mg/Kg | SW6020B | 29 | 35 | 33 | 29 | 27 | 28 | 33 |
| Potassium | mg/Kg | SW6020B | 1,300 | 1,300 | 1,300 | 1,500 | 1,500 | 1,400 | 1600 |
| Selenium | mg/Kg | SW6020B | 0.9 | 1.1 | 1.0 | 0.82 | 1.1 | 1.1 | 1.5 |
| Silver | mg/Kg | SW6020B | 0.2 J | 0.1 J | 0.1 J | 0.15 J | 0.15 J | 0.14 J | 0.23 J |
| Sodium | mg/Kg | SW6020B | 180 | 180 | 170 | 170 | 180 | 160 | 190 |
| Thallium | mg/Kg | SW6020B | 0.52 J | 0.52 J | 0.52 J | 0.57 J | 0.56 J | 0.59 J | 0.64 |
| Vanadium | mg/Kg | SW6020B | 24 | 25 | 25 | 27 | 26 | 26 | 25 |
| Zinc | mg/Kg | SW6020B | 140 | 130 | 120 | 130 | 130 | 140 | 170 |
| Total Organic Carbon (% by wt-dry) | | Walkley-Black | 2.3 | 2.3 | 1.7 | 1.8 | 4.1 | 2.9 | |

| PCBs (µg/Kg-dry) | | | P2.1 Scoops (9/22/2020) | | | P2.2 Plot Creation (11/19/2020) | | | P2.2 BGSU/WSU Studies (3/22/2021) |
|---|---|---|---|---|---|---|---|---|---|
| | | Description | Surface Solids (Top 0-6") | Solids 10' From Frame | Solids 45' From Frame | Pre-Blend Agricultural Plot | Pre-Blend Residential Plot | Pre-Blend Control Plot | GeoPool Surface (0-1 ft) |
| | Unit | Analytical Method | RSE P2.1 0-6 | RSE P2.1 +10 | RSE P2.1 +45 | RSE_P2.2_AG_ 20201119 | RSE_P2.2_RES_20201119 | RSE_P2.2_CNTL_20201119 | RSE_P2.2_DM_20210322 |
| Aroclor 1016 | ug/Kg | SW8082 | 400 U | 400 U | 420 U | 410 U | 370 U | 400 U | 110 U |
| Aroclor 1221 | ug/Kg | SW8082 | 400 U | 400 U | 420 U | 410 U | 370 U | 400 U | 110 U |
| Aroclor 1232 | ug/Kg | SW8082 | 400 U | 400 U | 420 U | 410 U | 370 U | 400 U | 110 U |
| Aroclor 1242 | ug/Kg | SW8082 | 400 U | 400 U | 420 U | 410 U | 370 U | 400 U | 110 U |
| Aroclor 1248 | ug/Kg | SW8082 | 400 U | 400 U | 420 U | 410 U | 370 U | 400 U | 110 U |
| Aroclor 1254 | ug/Kg | SW8082 | 400 U | 400 U | 420 U | 410 U | 370 U | 400 U | 110 U |
| Aroclor 1260 | ug/Kg | SW8082 | 400 U | 400 U | 420 U | 410 U | 370 U | 400 U | 110 U |
| Aroclor 1262 | ug/Kg | SW8082 | 400 U | 400 U | 420 U | 410 U | 370 U | 400 U | 110 U |
| Aroclor 1268 | ug/Kg | SW8082 | 400 U | 400 U | 420 U | 410 U | 370 U | 400 U | 110 U |
| PCBs, Total | ug/Kg | SW8082 | 400 U | 400 U | 420 U | 410 U | 370 U | 400 U | 110 U |

| Pesticides (µg/Kg-dry) | | | P2.1 Scoops (9/22/2020) | | | P2.2 Plot Creation (11/19/2020) | | | P2.2 BGSU/WSU Studies (3/22/2021) |
|---|---|---|---|---|---|---|---|---|---|
| | | Description | Surface Solids (Top 0-6") | Solids 10' From Frame | Solids 45' From Frame | Pre-Blend Agricultural Plot | Pre-Blend Residential Plot | Pre-Blend Control Plot | GeoPool Surface (0-1 ft) |
| | Unit | Analytical Method | RSE P2.1 0-6 | RSE P2.1 +10 | RSE P2.1 +45 | RSE_P2.2_AG_ 20201119 | RSE_P2.2_RES_20201119 | RSE_P2.2_CNTL_20201119 | RSE_P2.2_DM_20210322 |
| 4,4´-DDD | ug/Kg | SW8081A | 300 U | 59 U | 63 U | 62 U | 56 U | 59 U | 17 U |
| 4,4´-DDE | ug/Kg | SW8081A | 300 U | 59 U | 63 U | 62 U | 56 U | 59 U | 17 U |
| 4,4´-DDT | ug/Kg | SW8081A | 300 U | 59 U | 63 U | 62 U | 56 U | 59 U | 17 U |
| Aldrin | ug/Kg | SW8081A | 300 U | 59 U | 63 U | 62 U | 56 U | 59 U | 17 U |
| alpha-BHC | ug/Kg | SW8081A | 300 U | 59 U | 63 U | 62 U | 56 U | 59 U | 17 U |
| alpha-Chlordane | ug/Kg | SW8081A | 300 U | 59 U | 63 U | 62 U | 56 U | 59 U | 17 U |
| beta-BHC | ug/Kg | SW8081A | 300 U | 59 U | 63 U | 62 U | 56 U | 59 U | 17 U |
| Chlordane, Technical | ug/Kg | SW8081A | 740 U | 150 U | 160 U | 150 U | 140 U | 150 U | 41 U |
| delta-BHC | ug/Kg | SW8081A | 300 U | 59 U | 63 U | 62 U | 56 U | 59 U | 17 U |
| Dieldrin | ug/Kg | SW8081A | 300 U | 59 U | 63 U | 62 U | 56 U | 59 U | 17 U |
| Endosulfan I | ug/Kg | SW8081A | 300 U | 59 U | 63 U | 62 U | 56 U | 59 U | 17 U |
| Endosulfan II | ug/Kg | SW8081A | 300 U | 59 U | 63 U | 62 U | 56 U | 59 U | 17 U |
| Endosulfan sulfate | ug/Kg | SW8081A | 300 U | 59 U | 63 U | 62 U | 56 U | 59 U | 17 U |
| Endrin | ug/Kg | SW8081A | 300 U | 59 U | 63 U | 62 U | 56 U | 59 U | 17 U |
| Endrin aldehyde | ug/Kg | SW8081A | 300 U | 59 U | 63 U | 62 U | 56 U | 59 U | 17 U |
| Endrin ketone | ug/Kg | SW8081A | 300 U | 59 U | 63 U | 62 U | 56 U | 59 U | 17 U |
| gamma-BHC (Lindane) | ug/Kg | SW8081A | 300 U | 59 U | 63 U | 62 U | 56 U | 59 U | 17 U |
| gamma-Chlordane | ug/Kg | SW8081A | 300 U | 59 U | 63 U | 62 U | 56 U | 59 U | 17 U |
| Heptachlor | ug/Kg | SW8081A | 300 U | 59 U | 63 U | 62 U | 56 U | 59 U | 17 U |
| Heptachlor epoxide | ug/Kg | SW8081A | 300 U | 59 U | 63 U | 62 U | 56 U | 59 U | 17 U |
| Methoxychlor | ug/Kg | SW8081A | 300 U | 59 U | 63 U | 62 U | 56 U | 59 U | 17 U |
| Toxaphene | ug/Kg | SW8081A | 1,800 U | 360 U | 380 U | 370 U | 340 U | 360 U | 99 U |

**Black River Dredged Material Reuse Facility**
**GeoPool Pilot Study / Residual Solids Evaluation**
**OEPA Data Request**
**Table 1 - Analytical Results Representing Sediments Dredged from Middle and Upper Turning Basins**

*Samples collected from GeoPool-contained solids*

Supplied to OEPA in response to Data Request in support of Black River AOC BUI evaluation, April 2021.
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U = Analyzed but not detected above the Method Detection Limit, value shown is Reporting Limit.
J = Analyte is present at an estimated concentration between the Method Detection Limit and Report Limit.

| PAHs (µg/Kg-dry) | | | P2.1 Scoops (9/22/2020) | | | | | | P2.2 Plot Creation (11/19/2020) | | | | | | P2.2 BGSU/WSU Studies (3/22/2021) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Description | Surface Solids (Top 0-6") | | Solids 10' From Frame | | Solids 45' From Frame | | Pre-Blend Agricultural Plot | | Pre-Blend Residential Plot | | Pre-Blend Control Plot | | GeoPool Surface (0-1 ft) | |
| | Unit | Analytical Method | RSE P2.1 0-6 | | RSE P2.1 +10 | | RSE P2.1 +45 | | RSE_P2.2_AG_ 20201119 | | RSE_P2.2_RES_20201119 | | RSE_P2.2_CNTL_20201119 | | RSE_P2.2_DM_20210322 | |
| 1-Methylnaphthalene | ug/Kg | SW8270E | 25 | | 21 | J | 24 | J | 25 | U | 14 | J | 25 | U | 8.9 | |
| 2-Chloronaphthalene | ug/Kg | SW8270E | 25 | U | 25 | U | 25 | U | 25 | U | 22 | U | 25 | U | 6.9 | U |
| 2-Methylnaphthalene | ug/Kg | SW8270E | 28 | | 24 | J | 27 | J | 25 | U | 22 | U | 25 | U | 15 | |
| Acenaphthene | ug/Kg | SW8270E | 59 | | 83 | | 69 | | 60 | | 100 | | 36 | | 120 | |
| Acenaphthylene | ug/Kg | SW8270E | 25 | U | 25 | U | 25 | J | 25 | U | 22 | U | 25 | U | 6.9 | U |
| Anthracene | ug/Kg | SW8270E | 53 | | 77 | | 74 | | 31 | | 64 | | 25 | U | 73 | |
| Benzo(a)anthracene | ug/Kg | SW8270E | 46 | | 59 | | 85 | | 34 | | 53 | | 43 | | 32 | |
| Benzo(a)pyrene | ug/Kg | SW8270E | 37 | | 57 | | 64 | | 25 | U | 39 | | 31 | | 27 | |
| Benzo(b)fluoranthene | ug/Kg | SW8270E | 58 | | 92 | | 100 | | 25 | | 55 | | 39 | | 39 | |
| Benzo(g,h,i)perylene | ug/Kg | SW8270E | 24 | | 40 | | 45 | | 25 | U | 31 | | 22 | J | 15 | |
| Benzo(k)fluoranthene | ug/Kg | SW8270E | 16.00 | J | 26.00 | | 31.00 | | 25 | U | 23 | | 25 | U | 13 | |
| Chrysene | ug/Kg | SW8270E | 45 | | 87 | | 77 | | 30 | | 77 | | 37 | | 56 | |
| Dibenzo(a,h)anthracene | ug/Kg | SW8270E | 25 | U | 10 | J | 11 | J | 25 | U | 22 | U | 25 | U | 6.9 | U |
| Fluoranthene | ug/Kg | SW8270E | 180.0 | | 250.0 | | 280.0 | | 100 | | 210 | | 91 | | 200 | |
| Fluorene | ug/Kg | SW8270E | 76.0 | | 100.0 | | 83.0 | | 54 | | 100 | | 32 | | 110 | |
| Indeno(1,2,3-cd)pyrene | ug/Kg | SW8270E | 32 | | 49 | | 58 | | 25 | U | 59 | | 44 | | 21 | |
| Naphthalene | ug/Kg | SW8270E | 20.00 | J | 28.00 | | 19.00 | J | 25 | U | 22 | U | 25 | U | 70 | |
| Phenanthrene | ug/Kg | SW8270E | 200 | | 270 | | 260 | | 150 | | 280 | | 96 | | 290 | |
| Pyrene | ug/Kg | SW8270E | 180 | | 250 | | 280 | | 82 | | 180 | | 79 | | 140 | |

| TCLP Metals (mg/L) | | | P2.1 Scoops (9/22/2020) | | | | | | P2.2 Plot Creation (11/19/2020) | | | | | | P2.2 BGSU/WSU Studies (3/22/2021) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Description | Surface Solids (Top 0-6") | | Solids 10' From Frame | | Solids 45' From Frame | | Pre-Blend Agricultural Plot | | Pre-Blend Residential Plot | | Pre-Blend Control Plot | | GeoPool Surface (0-1 ft) | |
| | Unit | Analytical Method | RSE P2.1 0-6 | | RSE P2.1 +10 | | RSE P2.1 +45 | | RSE_P2.2_AG_ 20201119 | | RSE_P2.2_RES_20201119 | | RSE_P2.2_CNTL_20201119 | | RSE_P2.2_DM_20210322 | |
| Arsenic | mg/L | SW6020B | 0.009 | J | 0.010 | J | 0.010 | J | 0.009 | J | 0.010 | J | 0.008 | J | 0.0036 | J |
| Barium | mg/L | SW6020B | 0.410 | | 0.390 | | 0.410 | | 0.400 | | 0.390 | | 0.410 | | 0.47 | |
| Cadmium | mg/L | SW6020B | 0.022 | | 0.022 | | 0.021 | | 0.024 | | 0.024 | | 0.023 | | 0.038 | |
| Chromium | mg/L | SW6020B | 0.050 | U | 0.050 | U | 0.050 | U | 0.050 | U | 0.050 | U | 0.050 | U | 0.050 | U |
| Lead | mg/L | SW6020B | 0.012 | J | 0.009 | J | 0.011 | J | 0.008 | J | 0.008 | J | 0.050 | U | 0.041 | J |
| Mercury | mg/L | SW7470A | 0.002 | U | 0.002 | U | 0.050 | U | 0.002 | U | 0.002 | U | 0.002 | U | 0.002 | U |
| Selenium | mg/L | SW6020B | 0.050 | U | 0.050 | U | 0.005 | J | 0.050 | U | 0.050 | U | 0.050 | U | 0.050 | U |
| Silver | mg/L | SW6020B | 0.050 | U | 0.050 | U | 0.000 | | 0.050 | U | 0.050 | U | 0.050 | U | 0.050 | U |

| TCLP Semi-Volatile Organics (µg/L) | | | P2.1 Scoops (9/22/2020) | | | | | | P2.2 Plot Creation (11/19/2020) | | | | | | P2.2 BGSU/WSU Studies (3/22/2021) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Description | Surface Solids (Top 0-6") | | Solids 10' From Frame | | Solids 45' From Frame | | Pre-Blend Agricultural Plot | | Pre-Blend Residential Plot | | Pre-Blend Control Plot | | GeoPool Surface (0-1 ft) | |
| | Unit | Analytical Method | RSE P2.1 0-6 | | RSE P2.1 +10 | | RSE P2.1 +45 | | RSE_P2.2_AG_ 20201119 | | RSE_P2.2_RES_20201119 | | RSE_P2.2_CNTL_20201119 | | RSE_P2.2_DM_20210322 | |
| 1,4-Dichlorobenzene | ug/L | SW8270D | 100 | U | 100 | U | 100 | U | 100 | U | 100 | U | 100 | U | 100 | U |
| 2,4,5-Trichlorophenol | ug/L | SW8270D | 100 | U | 100 | U | 100 | U | 100 | U | 100 | U | 100 | U | 100 | U |
| 2,4,6-Trichlorophenol | ug/L | SW8270D | 100 | U | 100 | U | 100 | U | 100 | U | 100 | U | 100 | U | 100 | U |
| 2,4-Dinitrotoluene | ug/L | SW8270D | 100 | U | 100 | U | 100 | U | 100 | U | 100 | U | 100 | U | 100 | U |
| Hexachloro-1,3-butadiene | ug/L | SW8270D | 100 | U | 100 | U | 100 | U | 100 | U | 100 | U | 100 | U | 100 | U |
| Hexachlorobenzene | ug/L | SW8270D | 100 | U | 100 | U | 100 | U | 100 | U | 100 | U | 100 | U | 100 | U |
| Hexachloroethane | ug/L | SW8270D | 100 | U | 100 | U | 100 | U | 100 | U | 100 | U | 100 | U | 100 | U |
| m-Cresol | ug/L | SW8270D | 100 | U | 100 | U | 100 | U | 100 | U | 100 | U | 100 | U | 100 | U |
| Nitrobenzene | ug/L | SW8270D | 100 | U | 100 | U | 100 | U | 100 | U | 100 | U | 100 | U | 100 | U |
| o-Cresol | ug/L | SW8270D | 100 | U | 100 | U | 100 | U | 100 | U | 100 | U | 100 | U | 100 | U |
| p-Cresol | ug/L | SW8270D | 100 | U | 100 | U | 100 | U | 100 | U | 100 | U | 100 | U | 100 | U |
| Pentachlorophenol | ug/L | SW8270D | 100 | U | 100 | U | 100 | U | 100 | U | 100 | U | 100 | U | 100 | U |
| Pyridine | ug/L | SW8270D | 200 | U | 200 | U | 200 | U | 200 | U | 200 | U | 200 | U | 200 | U |

# Appendix D-1
# Greenhouse Studies Slide Deck

# Residual Solids Evaluation – Greenhouse Studies

BGSU

WRIGHT STATE UNIVERSITY

## Black River Dredged Material Reuse Facility

Coldwater Consulting

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THE CITY OF LORAIN OHIO

Celebrating 10 Years COLDWATER CONSULTING, LLC of Sustainable Solutions

# University Studies Overview

BGSU
- Investigators
  - Dr. Angelica Vazquez-Ortega
  - Margaret Rettig (undergrad research)
- DM & FS ratios
- Compost amendment
- pH adjustment / soil acidifier
- Corn, soybean, sod grass
- Germination & Growth
- Aboveground & below ground Biomass – three test species

WSU
- Investigators
  - Dr. Megan Rua
  - Maureen Roddy (undergrad research)
- DM & FS ratios
- Plant-based soil prep (canola)
- Corn, fescue, restoration mix
- Germination & Growth
- Aboveground & below ground Biomass
- Corn lifecycle (ears)
- Restoration mix diversity

# BGSU Blends

| | Corn & Soybean Ratios | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dredged Material | 0 | 5 | 10 | 20 | 100 | 0 | 5 | 10 | 20 | 100 | 0 | 5 | 10 | 20 | 95 |
| Farm Soil | 100 | 95 | 90 | 80 | 0 | 100 | 95 | 90 | 80 | 0 | 95 | 90 | 85 | 75 | 0 |
| Compost | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 5 | 5 | 5 | 5 |
| Soil Acidifier | 0 | 0 | 0 | 0 | 0 | X | X | X | X | X | 0 | 0 | 0 | 0 | 0 |

| | Sod Ratios | | | | |
|---|---|---|---|---|---|
| Dredged Material | 0 | 0 | 30 | 40 | 100 |
| Farm Soil | 100 | 60 | 40 | 60 | 0 |
| Compost | 0 | 40 | 30 | 0 | 0 |

# BGSU Top Take-Aways

- DM improved growth in both corn and soybeans
- Treatments with compost tended to perform better…ones with acidifier tended to be less successful.
- DM did not hinder sod grass growth

- 10 DM : 85 FS : 5 Compost
  - best for corn…tallest and greatest above & below ground biomass
- 20 DM : 75 FS : 5 Compost
  - Best for soybeans…highest average height and greatest above & below ground biomass
- 70, 50, & 30 DM are similar for sod survival, growth, biomass

# WSU Blends

| | Corn Ratios | | | | |
|---|---|---|---|---|---|
| Dredged Material | 0 | 50 | 70 | 90 | 100 |
| Farm Soil | 100 | 50 | 30 | 10 | 0 |

| | Canola, Tall Fescue, & Restoration Mix Ratios | | | | |
|---|---|---|---|---|---|
| Dredged Material | 0 | 30 | 50 | 70 | 100 |
| Farm Soil | 100 | 70 | 50 | 30 | 0 |

# WSU Top Take-Aways

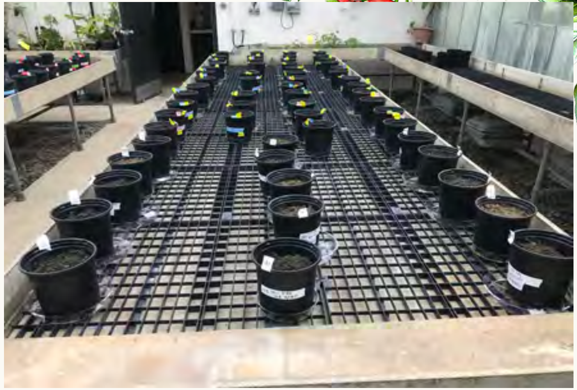
- Corn grown on DM+FS produced additional ears suggesting higher yield (than commercial hybrids)
- Corn grown on Lorain DM+FS reached reproductive stages **faster than** Toledo fresh or weathered DM + FS.
- 100% DM was not suitable for corn (reduced germination, height, survival, & no ears)
- 50 DM : 50 FS yields greatest diversity for restoration purposes, yet 70 & 100% yielded high diversity suggesting these ratios are suitable for restoration applications with limited or no blending
- 30 DM : 70 FS ideal for canola
- 70, 50, & 30 DM are similar for fescue

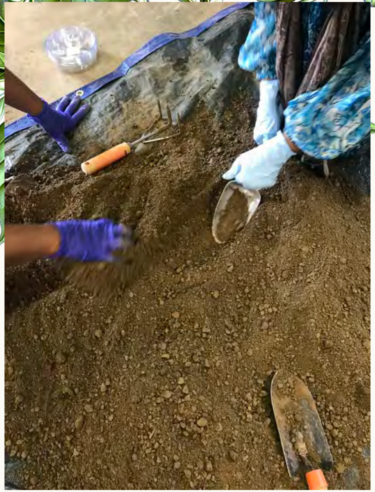
# Appendix D-2
# BGSU – Investigating the Feasibility of Black River Dredged Sediment Blends as a Farm Soil Amendment

# Investigating the Feasibility of Black River Dredged Sediment Blends as a Farm Soil Amendment

# Setup Photos

Randomized corn and sod grass pots (right)





Dredged Material (above)

Field Soil (below)

Compost (below)

Randomized soybean pots (below)

Mixing the soils (above)

Soils Pre-Mixing (below)

# Hypothesis

- We hypothesize that plants grown in the blended soils that include higher amounts of Black River Dredged Sediments will have a higher aboveground and belowground mass then those grown with lower amounts of the Dredged Sediments.

# Germination Rates

- 39/45 or 86% of the corn plantings germinated and sprouted.
- Preliminarily, it appears that the soil acidifier may make it difficult for the corn to sprout.

- 20/45 or 44% of the soybean plantings germinated and sprouted.
- Preliminarily, it seems like the treatments containing compost germinated at a higher rate then the rest of the soybeans.

- All of samples the Sod Grass survived planting and there are no noticeable differences in the growth of the sod grass between treatments at this point in the experiment.

# Preliminary Data - Corn

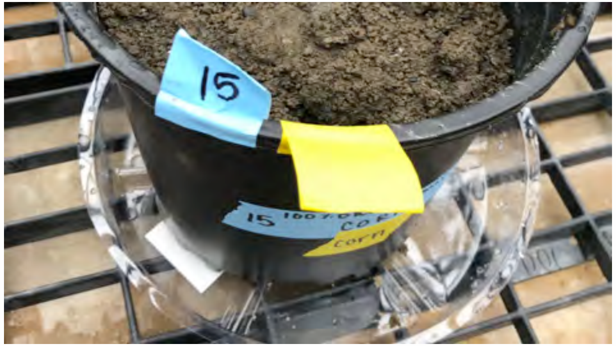
## Corn Weekly Growth Averages

| | |
|---|---|
| Week 1 | 0.612 CM per Week |
| Week 2 | 9.145 CM per Week |
| Week 3 | 19.074 CM per Week |
| Week 4 | 14.215 CM per Week |
| Week 5 | 10.116 CM per Week |

## Overall Growth Average Weeks 1– 5

| |
|---|
| 10.633 CM per Week |

# Corn Images




Video of Growth Progress,
press to play the video

Sample 23 (left) + 29 (above)
Week 5

Sample 41
(left)

Sample 45
Week 2
(left)

Sample 19 Week 4
(right)

# Preliminary Data - Soybeans

## Soybean Weekly Growth Averages

| | |
|---|---|
| Week 1 | 0 CM per Week |
| Week 2 | 0.264 CM per Week |
| Week 3 | 2.589 CM per Week |
| Week 4 | 5.465 CM per Week |
| Week 5 | 2.978 CM per Week |

## Overall Growth Average

| |
|---|
| 2.259 CM per Week |

# Soybean Images

Sample 85 Growth Video





Left: Sample 15 week 5
Right:Sample 64 Week 4


Sample 90 week 2 (above left)
Sample 79 week 2 (above right)
Sample 75 week 3 (below right)

# Preliminary Data – Sod Grass

## Sod Grass Weekly Growth Averages

| | |
|---|---|
| Week 1 | 0 CM per Week |
| Week 2 | 0.1 CM per Week |
| Week 3 | 0.14 CM per Week |
| Week 4 | 0.12 CM per Week |
| Week 5 | 0.17 CM per Week |

## Overall Growth

| |
|---|
| 0.106 CM per Week |

# Sod Grass Images

Sod Grass Growth
Sample 102



Left: Sample 95 week 5
Right: Sample 105 Week 1



Left: Sample 94 Week 3

Right: Sample 98 Week 4

# Sod Grass Conclusions

- Based on the measurements taken thus far, the treatments with higher concentrations of compost and some dredged material promoted more growth of the sod grass.
- The highest average width by treatment was 14.167 CM for the 40% dredged material, 60% soil mixture, followed by 14.10 the 40% compost, 60% soil

| Treatment | Average Width |
|---|---|
| 100% Soil | 13.467 CM |
| 40% Compost, 60% Soil | 14.100 CM |
| 30% Dredge, 30% Compost, 40% Soil | 12.533 CM |
| 40% Dredge, 60% Soil | 14.167 CM |
| 100% Dredge | 13.733 CM |

# Corn Conclusions

- Based on the measurements, the treatments containing soil acidifier had the lowest average heights overall, at 44.147 CM across the treatments. The soil acidifier treatments also had the lowest average treatment height of 29.467 CM for the 100% soil with soil acidifier.
- The treatments containing compost had the highest overall average height of 70.527 CM. The compost treatments also had the highest treatment height of 79.7 CM.

| Amendment Type | Overall Average Height Across Treatments |
|---|---|
| No Amendment | 54.887 CM |
| Soil Acidifier | 44.147 CM |
| Compost | 70.527 CM |

# Soybean Conclusions

- Overall, the soybeans did not germinate very well, with an overall germination rate of 44% across all treatments.
- The soil acidifier treatments appear to have the lowest germination rates, as well as the lowest overall average height of 7.520 CM.
- The compost has the highest treatment average of 12.486 CM overall and the highest individual treatment average of 20.367 CM for the 20% Dredged Material, 5% compost, and 75% soil treatment.
- The 20% Dredged Material, 80% Soil treatments with and without the soil acidifier failed to germinate entirely, having an average treatment height of 0 CM.

| Amendment | Overall Average Height Across Treatments |
|---|---|
| No Amendment | 9.247 CM |
| Soil Acidifier | 7.520 CM |
| Compost | 12.486 CM |

# Appendix D-3
# WSU – Evaluating Plant Growth on Sediments Dredged from the Black River

**Evaluating plant growth on sediments dredged from the Black River**

Final Report for Coldwater Consulting LLC

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February 2022

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## INTRODUCTION

Agriculture is the largest industry in Ohio, bringing over $2.07 billion to Ohio's economy annually from corn production alone (USDA: Economic Research Service). While agriculture continues to expand to maintain the demands of an increasing human population, there continues to be shortages of crop production largely due to lack of suitable land caused by urbanization, industrialization, and degradation (Pennington 1986, Averett et al. 1990). This shortage leads to more intensive practices, often creating large mono-cropping ecosystems, which changes soil structure, vegetation, and alters community structures of microorganisms, insects, and animals (Villamil et al. 2006). These changes can have detrimental effects on the surrounding environment including soil erosion and fertilizer run-off, releasing sediments and nutrients into nearby waterways (Averett et al. 1990).

To maintain both ecological and economic function of waterways, including lakes, ponds, rivers, streams, canals, channels, agriculture ditches/barriers, the built-up sediments must be removed (Sigua 2005). This removal, through mechanical digging and scooping, also known as dredging, results in 1.5 million tons of dredged sediments removed from Ohio shores each year (Averett et al. 1990). In the Great Lakes region of the US, dredging projects costs up to $20 million annually (Ouyang et al. 2005). Currently, the large amount of dredged sediments removed from waterways are disposed of two different ways: redistribution into deeper waters, called open-water disposal, which returns all the sediments back to the original source, and land disposal sites, which are similar to landfills (Pennington 1986). With the large amounts of dredged sediments produced each year, and the recent ban on open-water disposal by the Ohio State Senate, there is a need for upland uses of these sediments for projects in reclamation, conservation and habitat restoration, and agriculture.

It is necessary to determine the ratio of dredged sediments to agricultural soil to create suitable and marketable beneficial reuse products from typical Black River dredged sediment. To address this goal, we are conducting a greenhouse experiment manipulating the ratio of dredged sediments to agricultural soil and growing four focal species. Two of those focal species (canola and tall fescue) were grown for 45 days. An additional focal species, corn, was allowed to complete its lifecycle and grew for 21 weeks (~145 days). Finally, a planting with a mixture of prairie species is still growing. For all focal plants, we recorded germination and measured relative growth rate using height as a proxy for plant growth, tillering (tall fescue only), and above- and below-ground biomass. We assessed species diversity for the prairie mix for two timepoints, approximately 45 days after germination of the first species and 140 days after germination. Outcomes from this greenhouse experiment will inform a larger field demonstration using dredged material from the Lorain Harbor, OH.

## METHODS

*Experiment Description and Preparation*

To investigate the use of a sediments from the Black River as a beneficial soil amendment for agricultural soils, we factorially manipulated the ratio of agricultural soil to dredged sediments consistent with the following treatments: 100:0, 10:90, 30:70, 50:50, and 0:100 for corn, and 100:0, 30:70, 50:50, 70:30, 0:100 for three seed sources (canola, tall fescue and the prairie mix). Each treatment was replicated five times for a total of 100 experimental pots (5 soil mixes x 4 focal seed sources x 5 replicates). Dredged sediments sourced from the GeoPool maintained at Lorain Harbor, OH and agricultural soil sourced from a conventionally farmed field in northern OH were collected by Coldwater Consulting LLC and transported to Dayton via car on 4 April 2021. Materials were stored in the greenhouse for immediate use. Soil ratios were homogenized by hand prior to planting (Figure 1).

*Figure 1.* Hand mixing agricultural soils and dredged sediments. Undergraduate students Maureen Roddy and Emily Kahlert. Photo credit: Ashley Julian.

Experimental plants are currently grown in one-gallon pots (corn, canola, restoration seed mix) or D20 Stuewe & Sons pots (tall fescue) in the Wright State University greenhouse. Three seeds were planted for canola (*Brassica napus*; Gardens Alive!, Inc., Lawrenceburg, IN) and tall fescue KY 31 (*Festuca arundinacea*; The Scotts Company LLC., Marysville, OH), two seeds for corn (Pioneer ®, Corteva Agriscience™, Wilmington, DE), and approximately 1 tablespoon of prairie mix (Ernst Seeds, Meadville, PA). Germination was recorded and plants were thinned to a single plant per pot approximately 2 weeks after germination for canola and corn and 4 weeks after germination for tall fescue. Prairie mix pots were allowed to grow unimpeded.

Two focal plant species (canola and tall fescue) were monitored for 45 days before being destructively harvested (see Figure 2 for a photo of the status of the plants at harvest). Corn was allowed to complete its lifecycle and grew for 21 weeks (~145 days). Finally, a planting with a sponsor-provided restoration seed mix mixture of prairie species is still growing. We recorded germination and measured relative growth rate (all plants), tillering (tall fescue only), species diversity (restoration seed mix only) and above- and below-ground biomass (all plants). These measurements are consistent with prior work performed in the Rúa lab examining performance of corn and soybean grown in dredged sediments originating from the Toledo harbor in both greenhouse and field settings. This consistency will allow us to compare growth patterns between the two dredged sediment sources. The treatments that are more successful in producing healthy plants will be tested in a field demonstration.

*Figure 2.* Status of the plants in the greenhouse on 27 May 2021. Photo credit: Dr. Megan Rúa.

<u>Plant Responses</u>

We have measured several traits related to plant growth including growth indicators of plant height and leaf count, reproduction status, total, above and below ground, biomass and final yield (if applicable). For the growth indicators of leaf count and plant height, measurements were taken weekly throughout the growing season, starting from plant emergence on 3 May 2021, eight days after planting and continued until harvest. Plant performance was assessed following USDA recommended protocols. For corn height (cm), we used a tape measure from the bottom of the plant even with the ground, to the top of the arch of the highest fully formed leaf (Nafziger

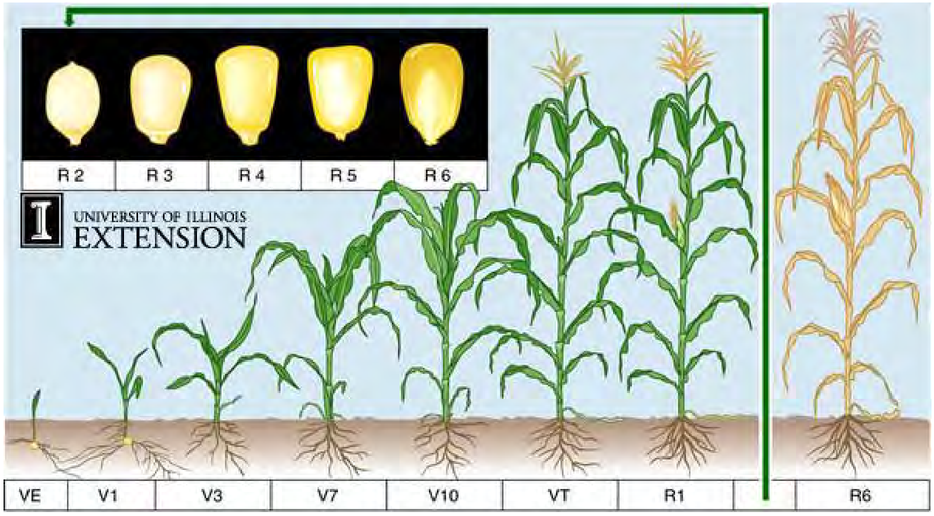


*Figure 3.* Corn growth stages as a function of vegetative (V) and reproductive (R) stages. Adapted from the University of Illinois Extension Service.

2017). Similarly, leaf count was measured by counting only the fully formed leaves with an arch. Leaf count was used to indicate growth stages of vegetation (*i.e.*, for V6, the corn plant had six fully developed leaves; Figure 3) along with reproduction status (*i.e.*, tassel/pollen production, silking, and ear development) when applicable (Nafziger 2017).

Height and leaf count for canola were measured in a similar fashion. For tall fescue, height is measured from the bottom of the plant even with the ground until the tip of the tallest blade and leaf count is measured based on the production of new nodes which give rise to fully formed leaf blades (Fribourg et al. 2009). Daughter tillers develop from leaf axillary adventitious buds and are counted as indicators of overall plant health (*i.e.*, more tillers are indicative of a healthier plant).

Species diversity from the prairie mix has been assessed twice, at 45 days and 140 days. Each pot was assessed to determine the number of species present. This number will be compared to the number of species present in the seed mix to determine a proportion of overall species present in the pot compared to what should be present in the pot. Upon completion of the experiment, I will calculate Simpson's and Shannon Diversity for each pot by determining the number of species present in the pot as a function of the number of species present in all pots.

After harvest, plants will be sorted by species and weighed. Each species' weight will be divided by the total weight of all plants in the pot to determine the proportion of the pot devoted to each species.

Above and below ground biomass were measured twice during the experiment, once shortly after emergence, and once for final harvest. Since germination was nearly 100% for all treatments for canola, corn and tall fescue, pots were thinned to one plant approximately 22 days (corn, canola) or 28 days (tall fescue) after planting. Biomass measurements were taken from these extra plants to provide an understanding of initial growth while final measurements provide a better overall understanding of the effect of growth conditions (ag:dredge ratio) on plant growth. Once the plants were harvested (initial or final), the roots were disconnected from the stalk and cleaned to remove excess soil. All roots and plant material dried for 48 hours at 105 $^{o}$C, and the biomass (g) was recorded.

**PRELIMINARY RESULTS**

***Plant health: Lorain Harbor only***

There was no significant effect of the ratio of agricultural soil to dredged sediments on seed germination for corn, canola, or tall fescue (Table 1).

**Table 1.** Number of seeds planted, germinated, and the percent germinated for canola, corn, and tall fescue by treatment.

| Seed Source | Ratio (Ag:Dredge) | Number Seeds Planted | Number Seeds Germinated | Percent Germinated |
|---|---|---|---|---|
| **Canola** | 100:0 | 15 | 15 | 100% |
| | 70:30 | 15 | 14 | 93% |
| | 50:50 | 15 | 15 | 100% |
| | 30:70 | 15 | 15 | 100% |
| | 0:100 | 15 | 13 | 87% |
| **Corn** | 100:0 | 10 | 10 | 100% |

| | | | | |
|---|---|---|---|---|
| | 50:50 | 10 | 10 | 100% |
| | 30:70 | 10 | 10 | 100% |
| | 10:90 | 10 | 8 | 80% |
| | 0:100 | 10 | 10 | 100% |
| **Tall Fescue** | 100:0 | 15 | 15 | 100% |
| | 70:30 | 15 | 12 | 80% |
| | 50:50 | 15 | 12 | 80% |
| | 30:70 | 15 | 12 | 80% |
| | 0:100 | 15 | 13 | 87% |

There were no significant differences in overall plant growth as proxied by biomass for total biomass for either corn ($P=0.275$, $F_{4,14}=1.432$) or canola ($P = 0.4169$, $F_{4,38} = 1.005$) 22 days after planting (Figure 4).

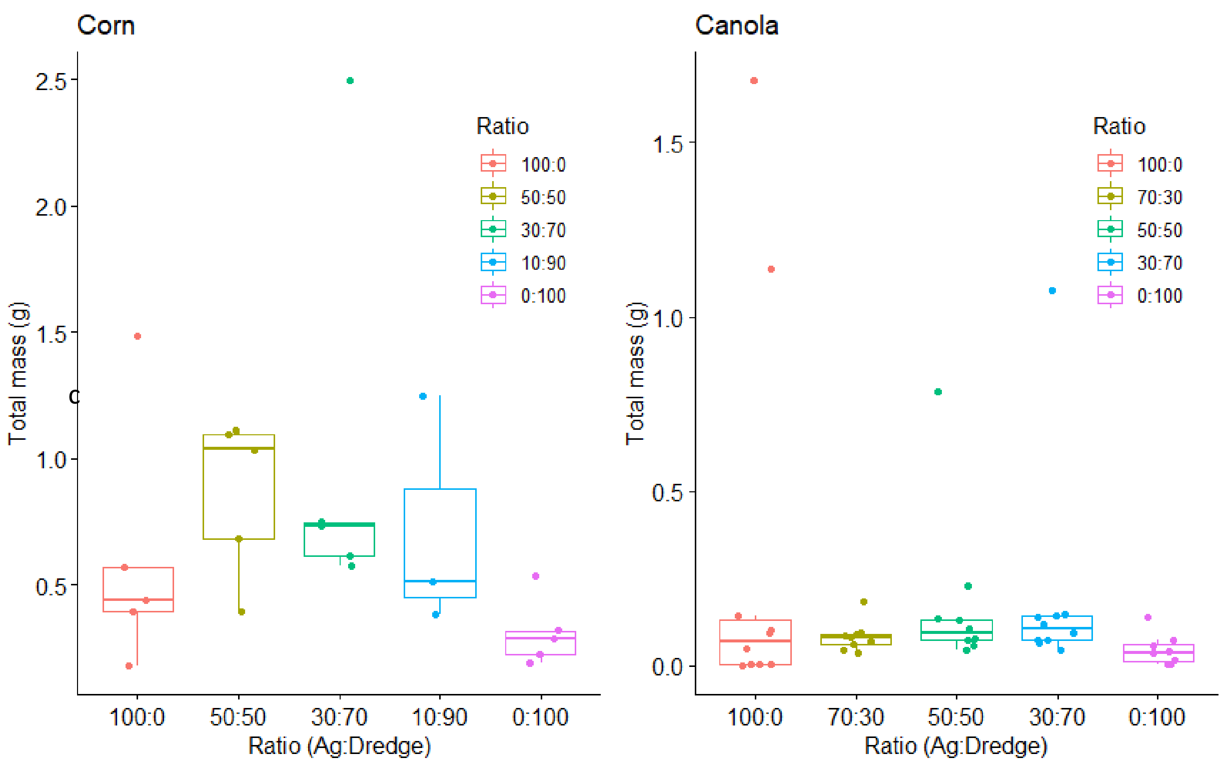


*Figure 4.* Total biomass for corn (a) and canola (b) for plants collected 22 days after planting. Points represent single plants and are jittered to not plot on top of one another.

There were significant differences in final plant mass (g) among treatment groups for corn (P=0.0102, $F_{4,16}$=4.755) and canola (P<0.0001, $F_{4,16}$=9.718) but not for tall fescue (P=0.1056, $F_{4,16}$=2.282; Figure 5). For corn, plants grown in 100% agricultural soil were smaller than all plants grown in dredged sediments even though that relationship was only significant for plants grown on agricultural soils supplemented with 90% dredged (Figure 5a). For canola, plants grown in the 70% dredged sediments with 30% agricultural soil were significantly larger than all other treatments (Figure 5b).  Unsurprisingly, there were no significant differences in final mass at harvest among treatments for tall fescue plants (Figure 5c).

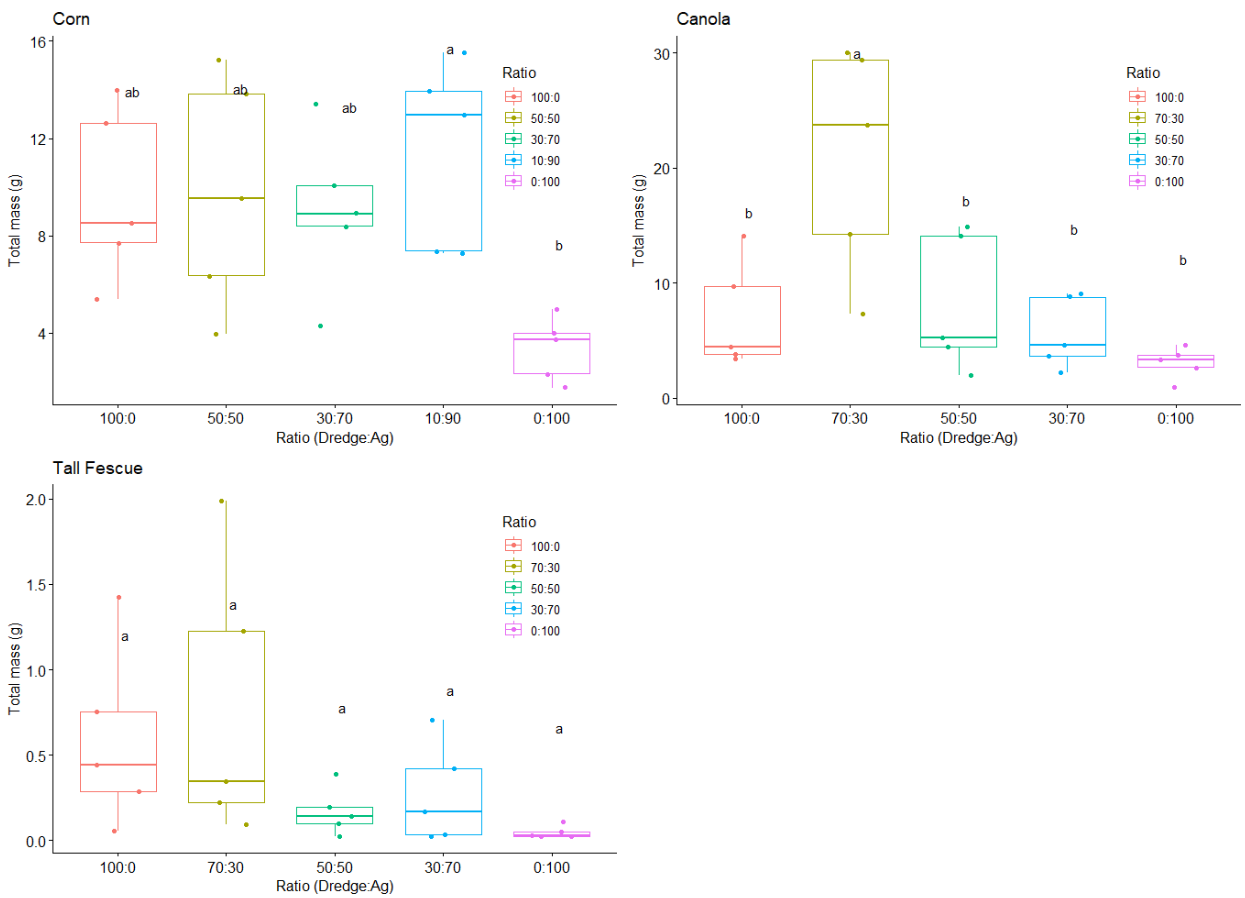


*Figure 5*. Plant mass (g) at harvest for corn, canola, and tall fescue when grown on different ratios of dredged sediments to agricultural soil. Letters indicate significant differences in means as evaluated by Tukeys HSD. Points represent single plants and are jittered to not plot on top of one another.

Corn grew significantly shorter in the 100% agricultural soil compared to any of the dredge treatments starting at 43 days post germination and continuing throughout most sampling dates (P=0.0001, $F_{4,463}$=6.385; Figure 6).

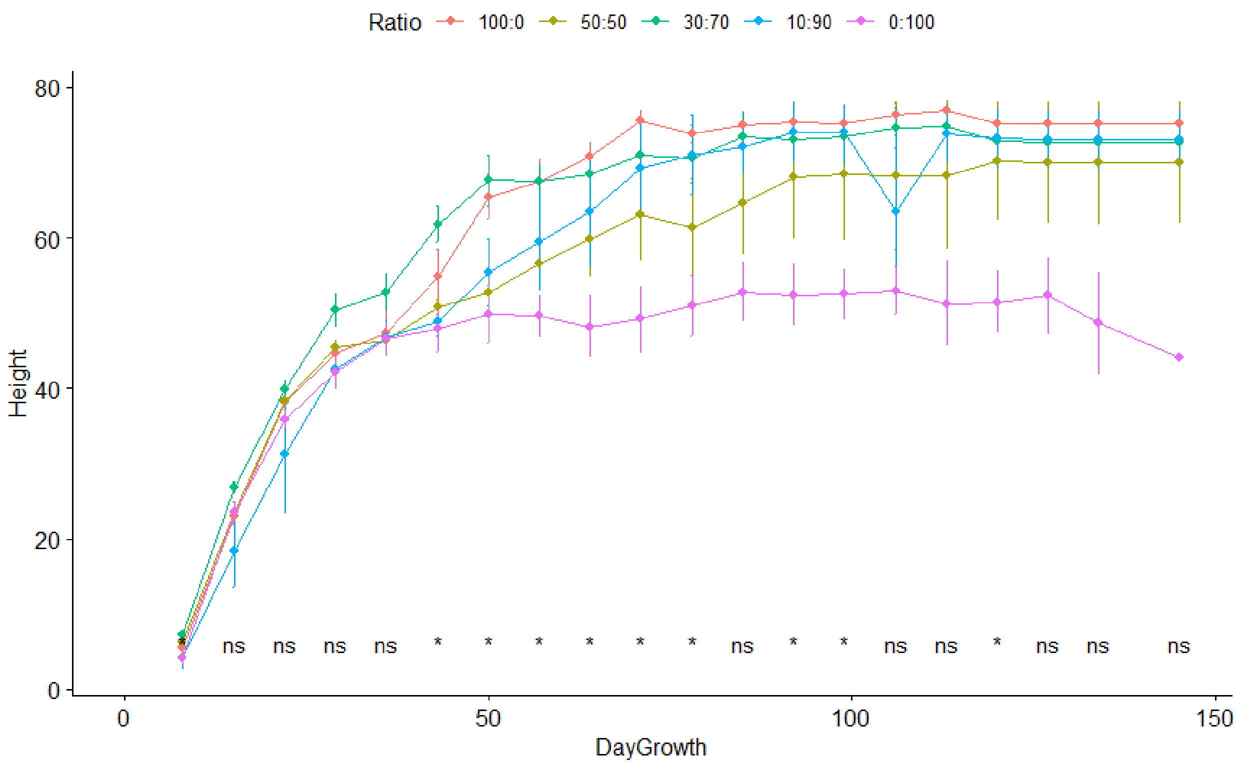


*Figure 6.* Plant height (cm) for corn by days of growth since planting when grown on different ratios of dredged sediments to agricultural soil. * P < 0.05, ** P <0.01, *** P <0.001, **** P <0.0001, ns = non-significant.

Although not significant (P=0.1635, $F_{4,16}$= 1.878), this pattern was particularly striking for the final heights of the plants since only a single plant from the 100% agricultural soil survived the experiment (Figure 7).

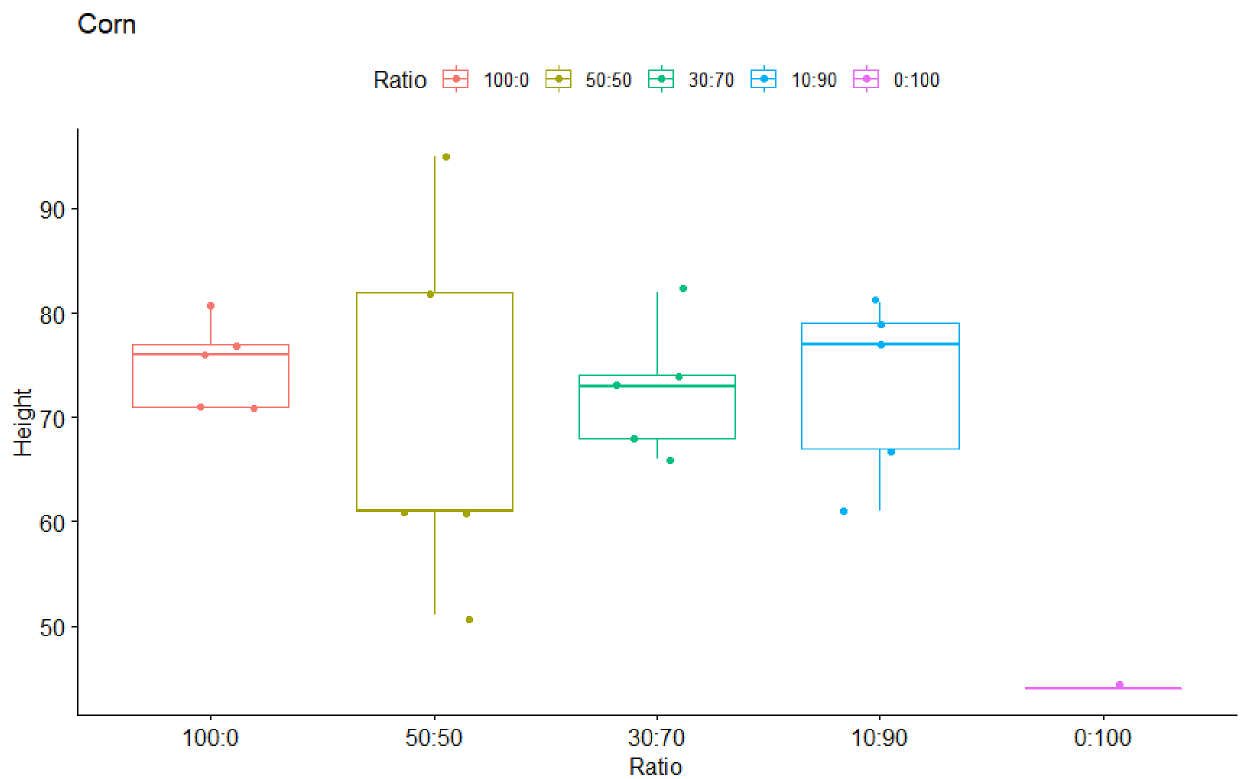


*Figure 7.* Plant height (cm) for corn measured during final harvest at 145 days when grown on different ratios of dredged sediments to agricultural soil. Points represent single plants and are jittered to not plot on top of one another.

Similarly, plant height was significantly different among the treatments for tall fescue ($P = 0.0056$, $F_{4,145} = 3.8115$) and canola plants ($P = 0.0102$, $F_{4,145} = 3.4385$) but patterns differed. Canola plants were tallest in the 30% agricultural soils to 70% dredged material starting at 29 days after planting until their harvest but tall fescue plants were tallest in the 100% dredged material treatment (Figure 8). Both species were the shortest throughout their growth period in the 100% agricultural soil.

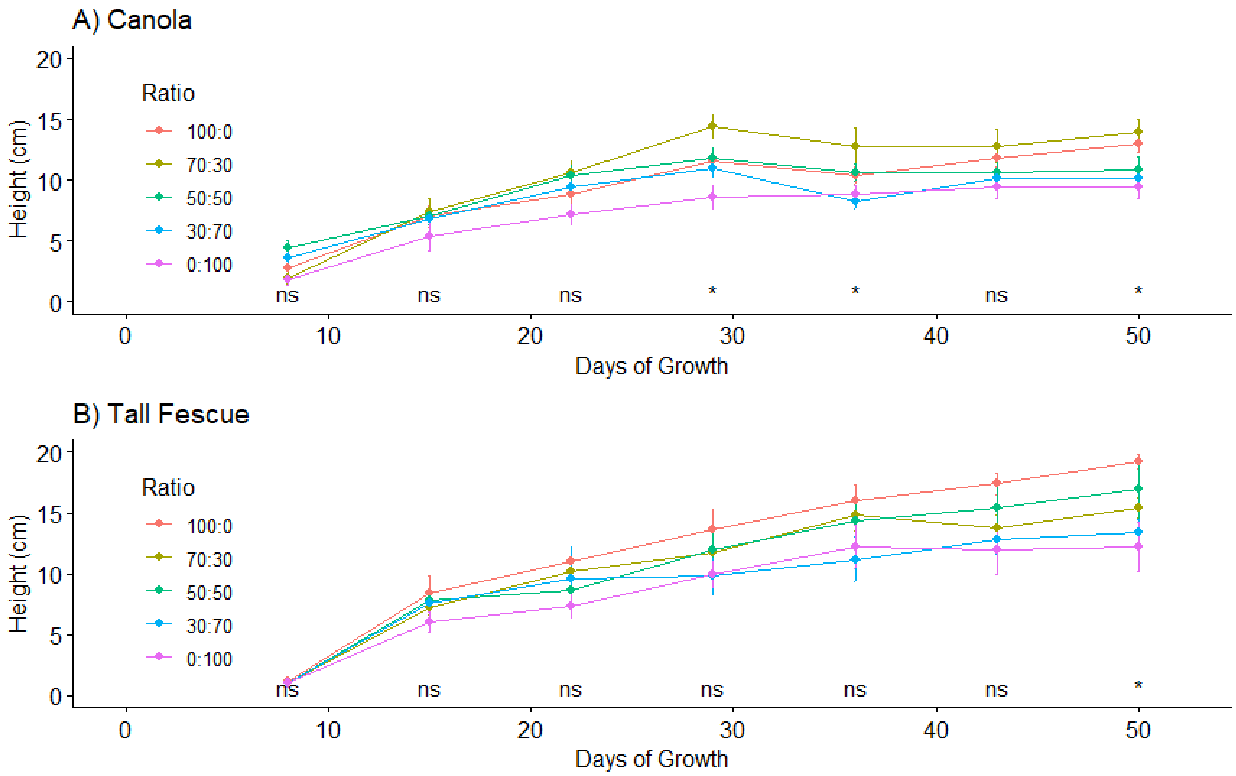


*Figure 8.* Plant height for canola (a), and tall fescue (b) by days of growth since planting when grown on different ratios of dredged sediments to agricultural soil. * P < 0.05, ** P <0.01, *** P <0.001, **** P <0.0001, ns = non-significant.

Finally, the number of ears produced from corn grown on dredged sediments from the Lorain Harbor Geopool varied significantly by treatment (P<0.0001). For corn grown on the Lorain Harbor Geopool sediments, plants achieved between 1 and 3 ears for all treatments, including 100% dredged sediments, while corn grown on the 100% agricultural soil produced 0 to 1 ear (Figure 9).

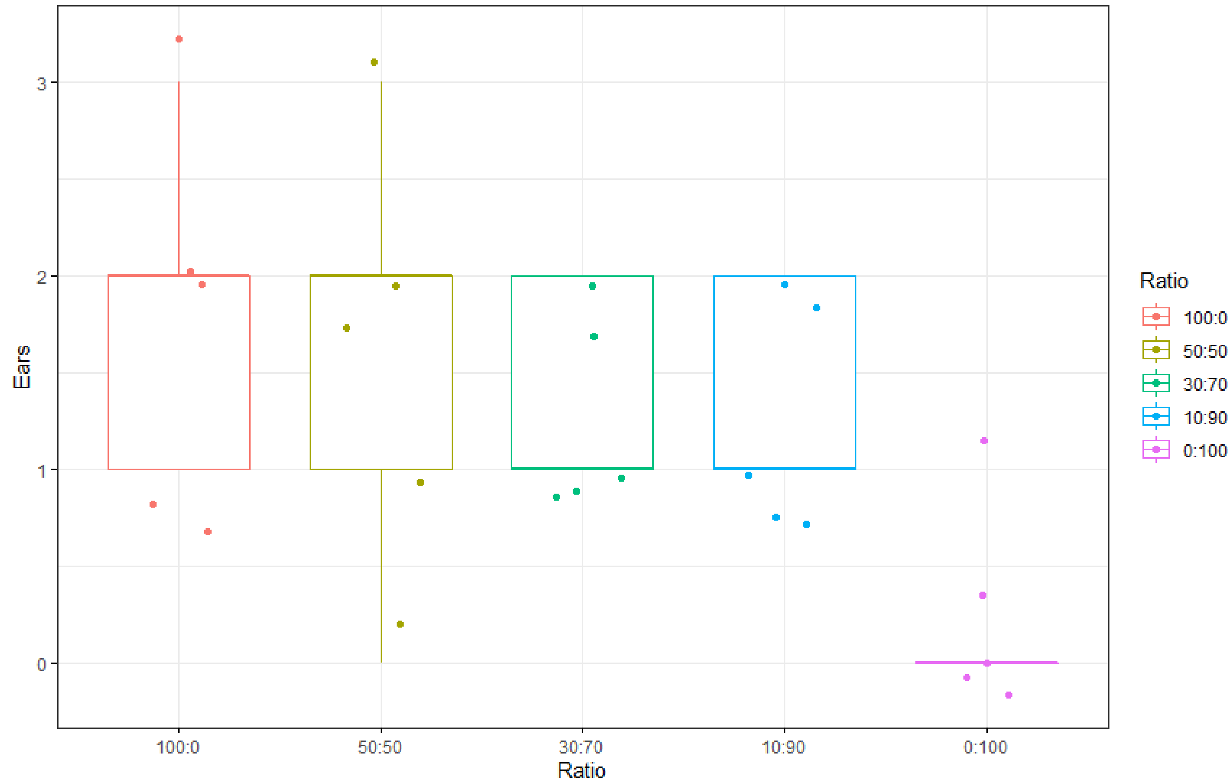


*Figure 9.* Number of ears for corn when grown on different ratios of dredged sediments to agricultural soils. Points represent single plants and are jittered to not plot on top of one another.

***Plant health: comparison of corn growth across dredged sediment sources***

Corn grown on dredged sediments from the GeoPool progressed through the vegetative growth stages faster than corn grown on fresh dredged sediments from the Toledo Harbor ('Dredge – Fresh'), weathered dredged sediments from the Center for Dredge Innovation ('Dredge – Weathered'), and agricultural soil (Figure 11; $P < 0.0001$, $F_{48, 4838} = 4.383$). Plants grown on dredged sediments from the GeoPool also achieved an additional vegetative stage (R2

*Figure 10.* Ear of corn for a plant grown in dredged sediments from the GeoPool. Photo credit: Maureen Roddy

– meaning the cob for seed development has started to form with initial kernel production) than plants grown on dredged sediments from the Toledo Harbor.

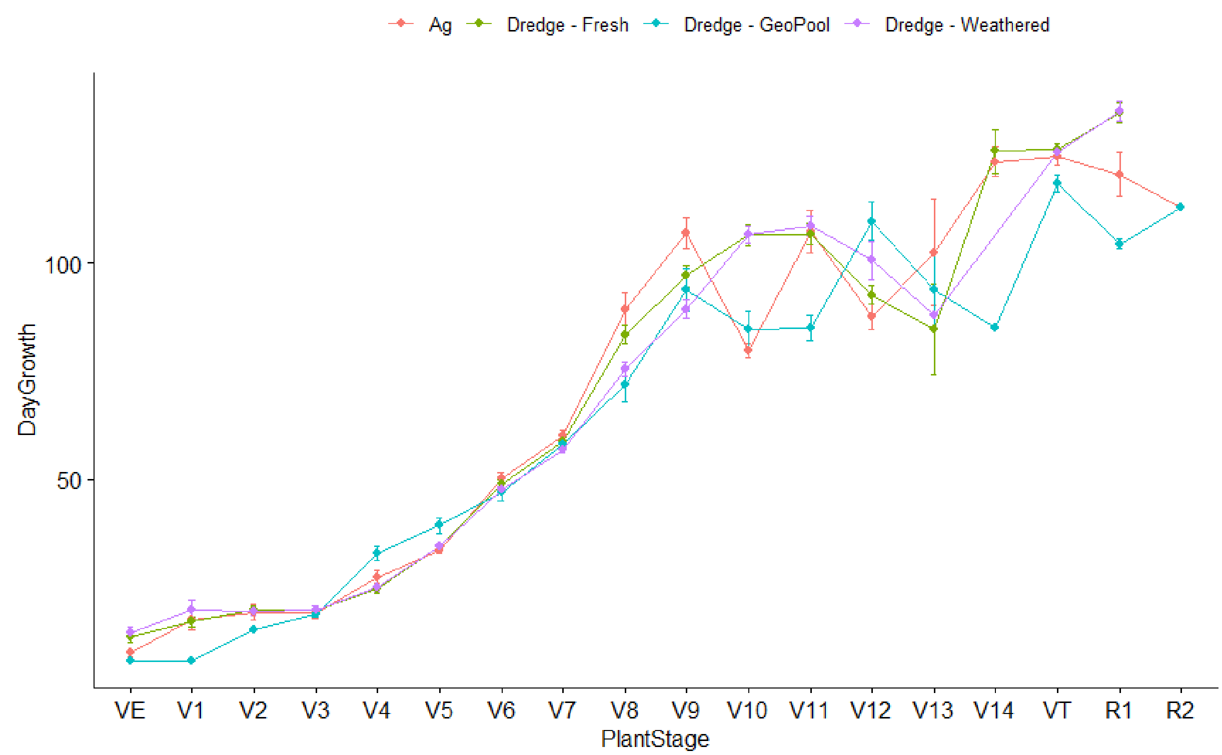


*Figure 11.* Plant stage corn by days of growth since planting when grown on fresh dredged sediments from the Toledo Harbor ('Dredge – Fresh'), weathered dredged sediments from the Center for Dredge Innovation ('Dredge – Weathered') and Geopool dredged sediments from Lorain Harbor ('Dredge – GeoPool').

***Plant health: species diversity for restoration mixes***

The number of species which germinated in each mix was assessed twice prior to placing the pots outside to overwinter. The number of species significantly differed by ratio of dredged sediment to agricultural soil (Figure 11, P = 0.0292, $F_{4, 20}$ = 3.366) with the 50:50 ratio having the greatest number of species followed by the 30% dredged sediment : 70% agricultural soil and 100% agricultural soil (Figure 12).

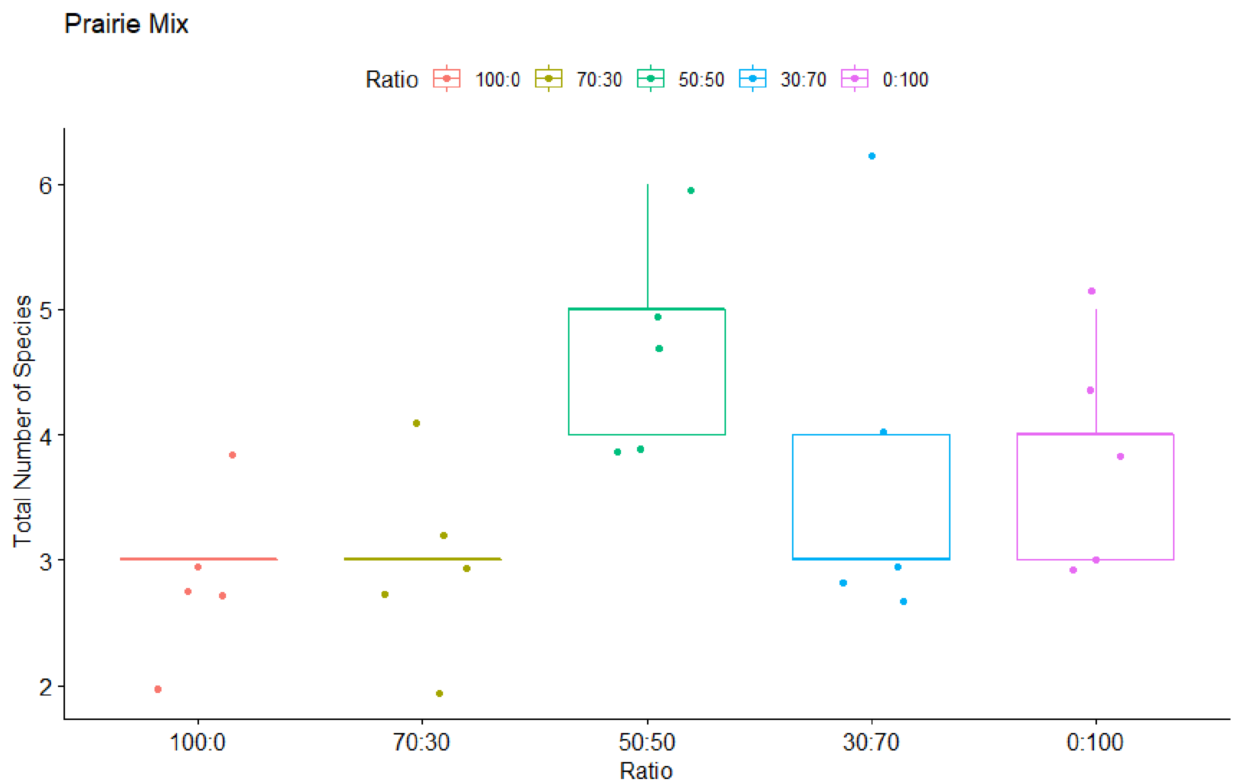


*Figure 12.* Number of species present in pots planted with a prairie restoration mix as assessed in September 2021 when grown on different ratios of dredged sediments to agricultural soil. Points are individual pots and a jittered so as to not lay on top of one another.

Finally, there were no statistically significant differences between the species present in one ratio compared to another, suggesting that each species had equal likelihood of being found in any of the treatments (Figure 13, P=0.398). A full species list of what germinated from the prairie mix can be found in Table 2 along with the percentage of pots for which those species germinated by ratio of dredged sediments to agricultural soil.

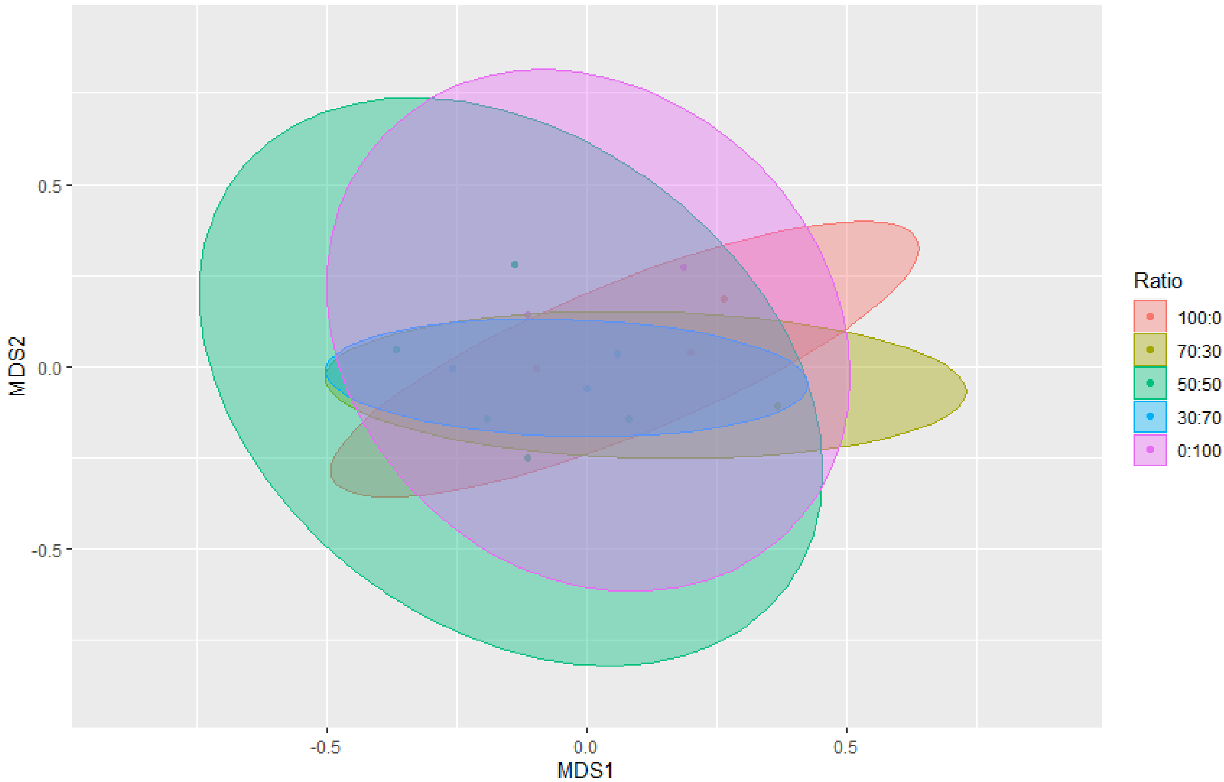


*Figure 13.* NMDS plot of plant species present in pots planted with agricultural soil and dredged sediments with Jaccard distances which are appropriate for presence / absence data. Spheres represent 95% confidence intervals and points represent individual pots. Overlapping circles suggest no clear differences.

**Table 2.** Percent of pots with each species from the prairie mix for pots grown in different ratios of dredged sediments to agricultural soil.

| ***Ratio*** | **Partridge Pea** | **Clover** | **Little Bluestem** | **Smooth Blue Aster** | **Maximillian's Sunflower** | **Mustard** | **Wrinkleleaf Goldenrod** |
|---|---|---|---|---|---|---|---|
| *100:0* | 60% | 100% | 100% | 20% | 0% | 20% | 0% |
| *70:30* | 60% | 100% | 100% | 0% | 0% | 0% | 0% |
| *50:50* | 80% | 100% | 100% | 40% | 40% | 0% | 20% |
| *30:70* | 100% | 100% | 100% | 20% | 20% | 20% | 0% |
| *0:100* | 60% | 100% | 100% | 20% | 0% | 0% | 0% |

| ***Ratio*** | **Common Milkweed** | **Rye** | **Blue Aster** | **Plains Coreiopsis** | **Ragweed** | **Unknown** |
|---|---|---|---|---|---|---|
| *100:0* | 0% | 0% | 0% | 0% | 0% | 0% |
| *70:30* | 20% | 0% | 0% | 0% | 0% | 20% |
| *50:50* | 20% | 0% | 20% | 40% | 20% | 0% |
| *30:70* | 0% | 0% | 0% | 20% | 0% | 0% |

| | | | | | | |
|---|---|---|---|---|---|---|
| *0:100* | 20% | 40% | 0% | 40% | 0% | 0% |

**CONCLUSIONS FROM RESEARCH TO DATE**

Overall dredged sediments from the Lorain Harbor Geopool project provided an excellent media for plant growth, consistently out-performing the 100% agricultural soil treatments. Additionally, corn grown in the Geopool sediments also reached reproductive stages faster (suggest the plants grew faster) then corn grown on either fresh or weathered dredged sediments from Toledo Harbor.

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# Appendix E-1
# Bulking Factor Presentation Slide Deck

# GeoPool Quantity & Bulking Factor

Black River Dredged Material Reuse Facility

GeoPool 2.0 Pilot Project

Jackson Caruso, Coldwater Consulting

Celebrating 10 Years COLDWATER CONSULTING, LLC of Sustainable Solutions

# Bulking Factor

- Ratio of volume before dredging/volume after dredging

- 1 $yd^3$ in the river ≠ 1 $yd^3$ on site ≠ 1 $yd^3$ in a truck
  - Interaction with water and air changes volume

- Affects storage capacity of dredge facility

# Quantity Calculation Methods

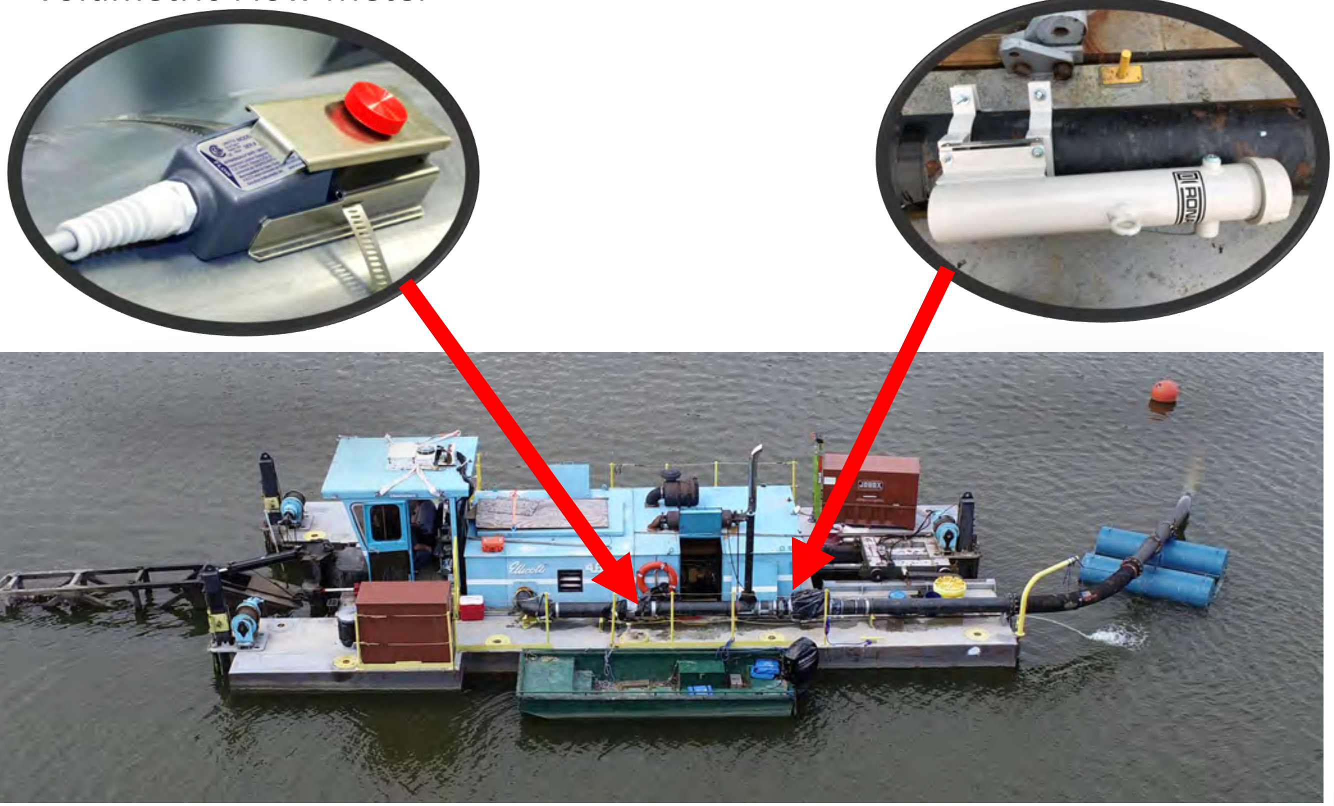
- In Situ Quantity – before dredge volume in the river
  - Suspended Solids & Flow Meter Data (on-dredge)
  - Bathymetric Survey Comparison
- In Pool Quantity – after dredge volume in the GeoPool
  - Capacity Interval Table
  - 3D Surface Models

# In Situ Method 1: Meter Data

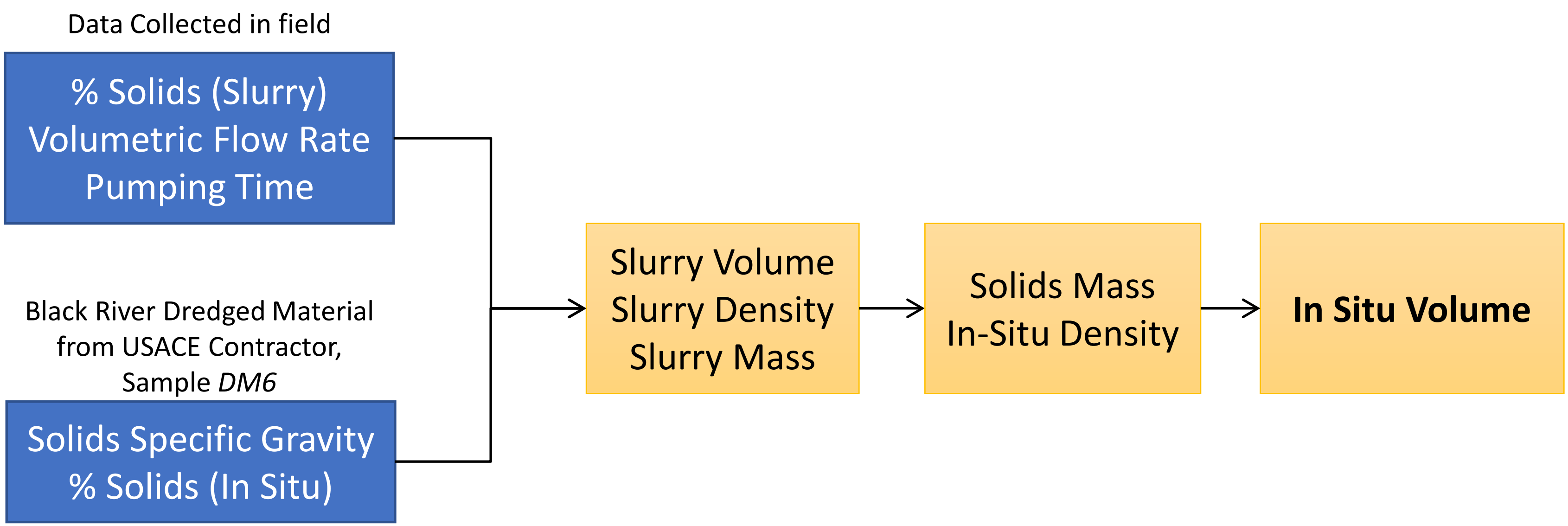
- Utilize data from slurry pipe meters to find in-situ

Volumetric Flow Meter

Nuclear Density Meter



# In Situ Method 1: Meter Data



# In Situ Method 1: Meter Data

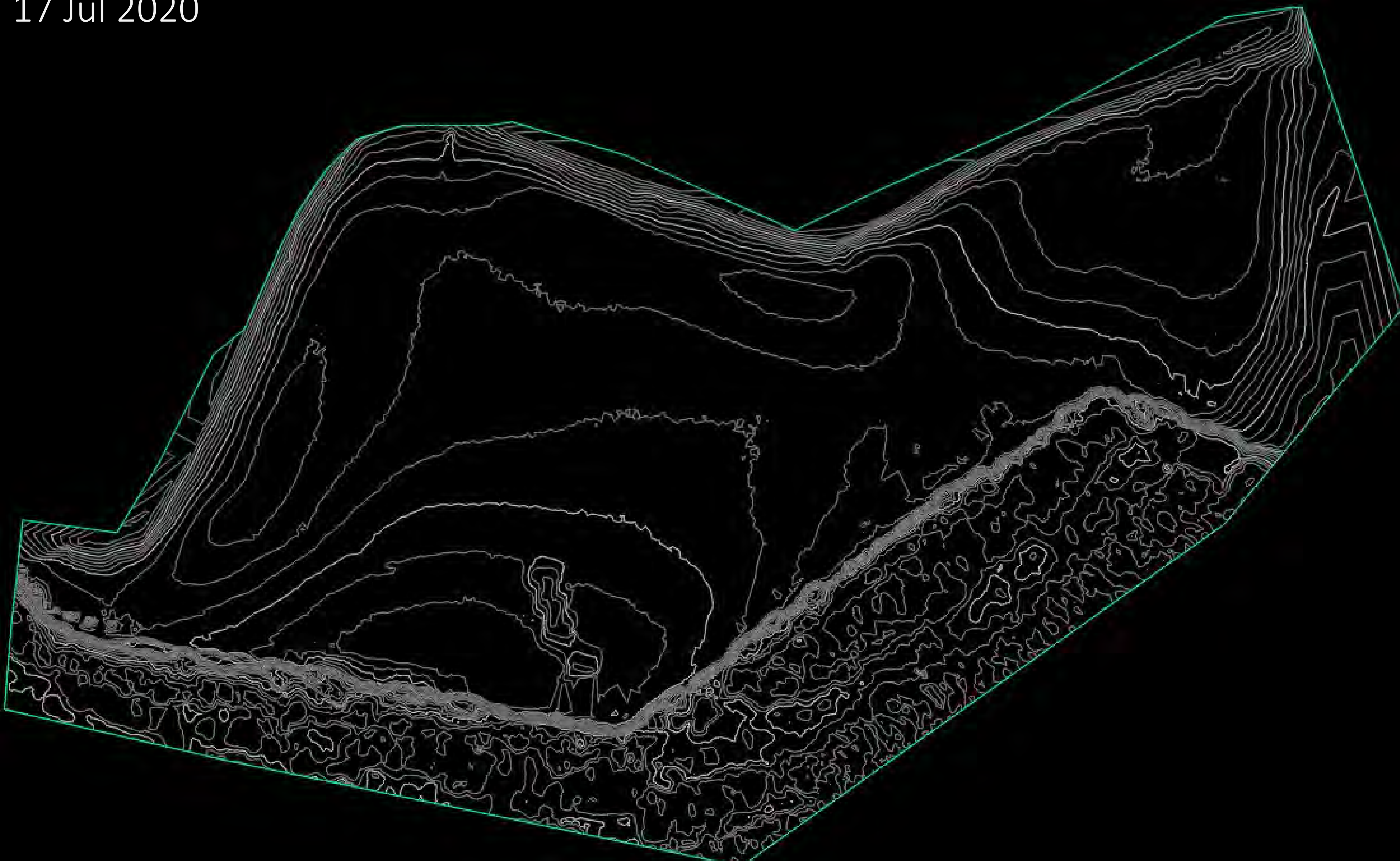
| Source | In Situ % Solids, (w/w) | In Situ Density (lb/CY) | In Situ Volume (CY) |
|---|---|---|---|
| USACE Pre-Dredge Surface Grabs and Cores (2013) | 51.55% | 2496 | **3440** |
| Black River Dredged Material from USACE Contractor, Sample ***DM6*** (2019) | 55.63% | 2595 | **3066** |

# In Situ Method 2: Bathymetric Surveys

- Comparison of Before Dredge (BD) and After Dredge (AD) surveys
  - Using *AutoCAD Civil 3D*
- Surveyor: Affiliated Researchers, LLC

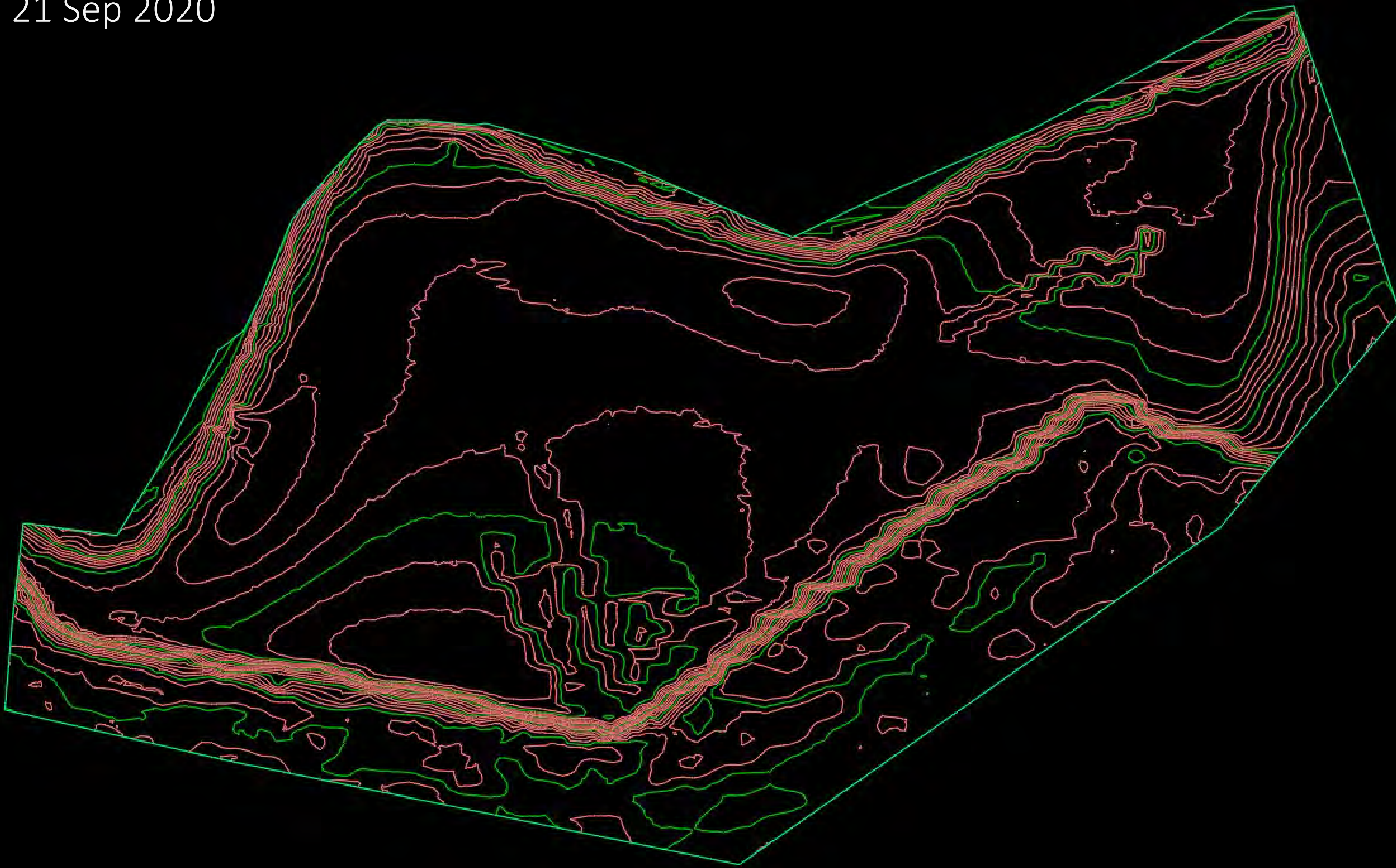
# Before Dredge Bathymetric Survey
17 Jul 2020

# Before Dredge Bathymetric Survey
17 Jul 2020

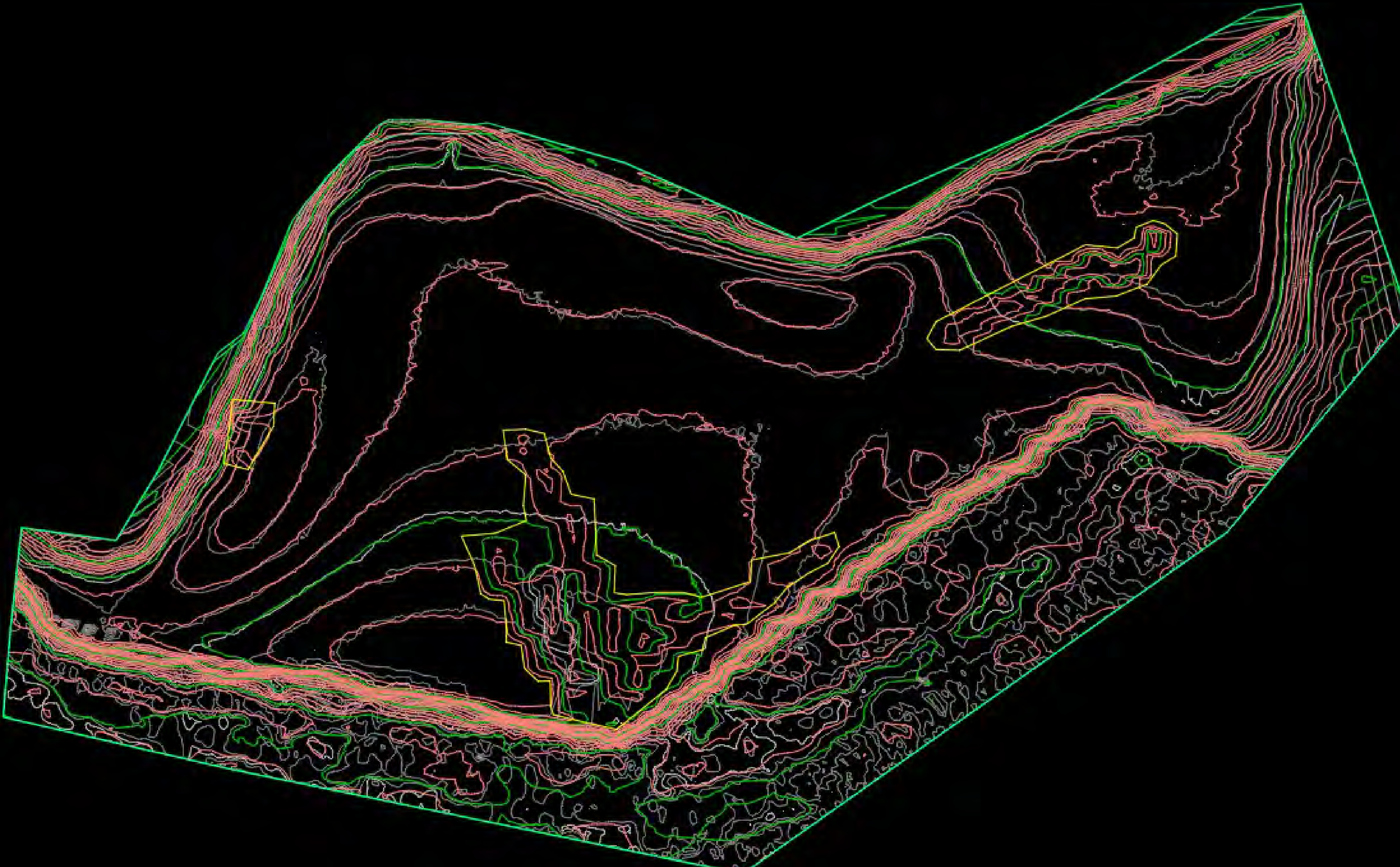


# After Dredge Bathymetric Survey

21 Sep 2020



# Survey Comparison

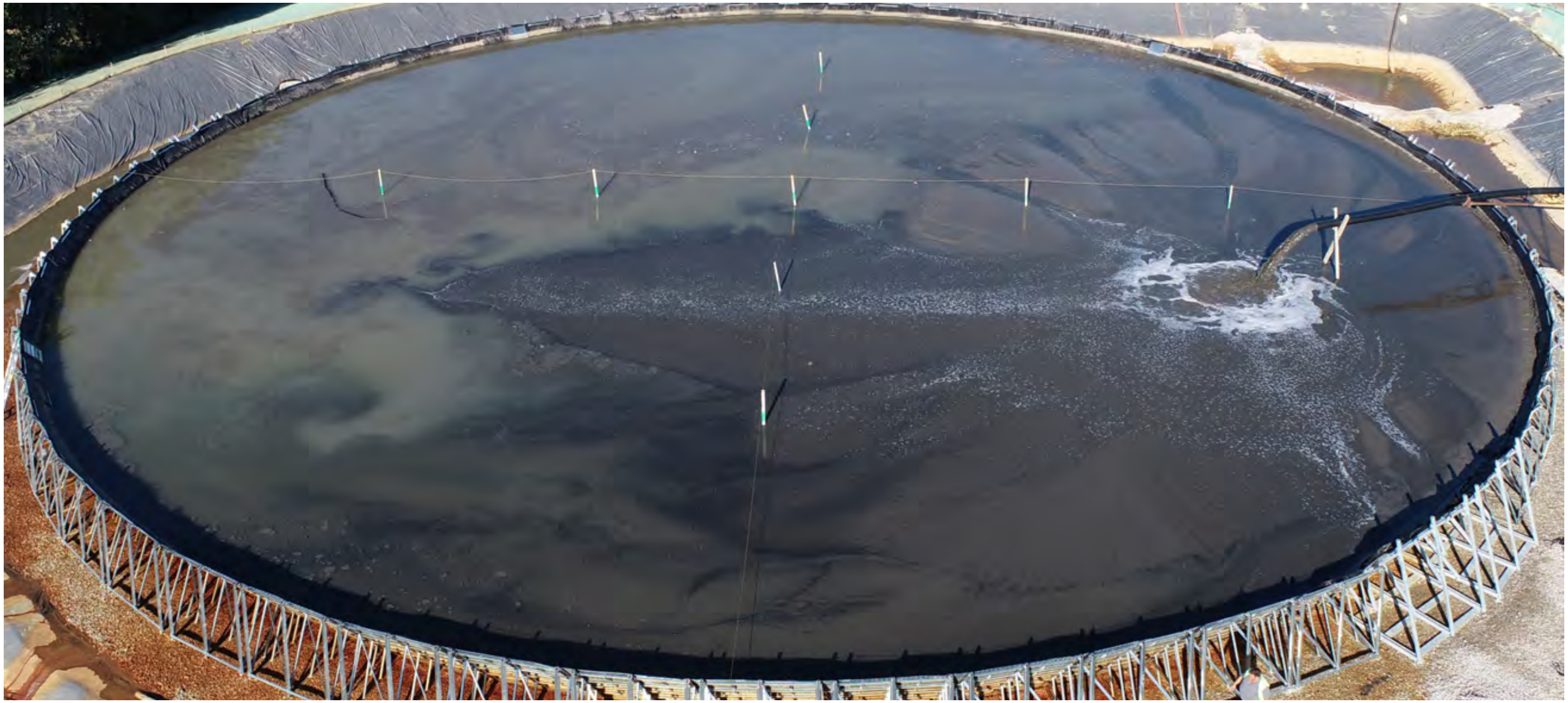


# In Situ Method 2: Bathymetric Surveys

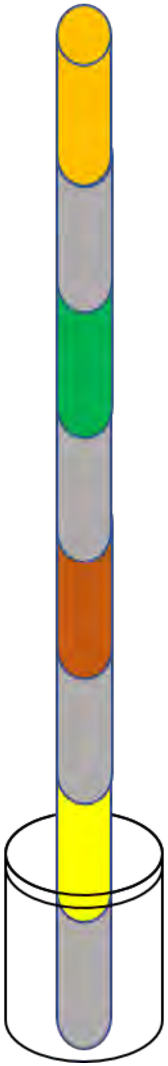
- Mathematical Difference **= 2616.59 CY**
- Variables/Uncertainties
  - Inherent vertical accuracy = +160 CY
  - Fluid Mud = ?
  - Transect survey points vs dredge cut = ?
    - Single beam @ 25 ft separation vs multi-beam

# In Pool Volume Calculation

- Both methods rely on measuring post data, collected in the field by Coldwater staff



# In Pool Volume Calculation

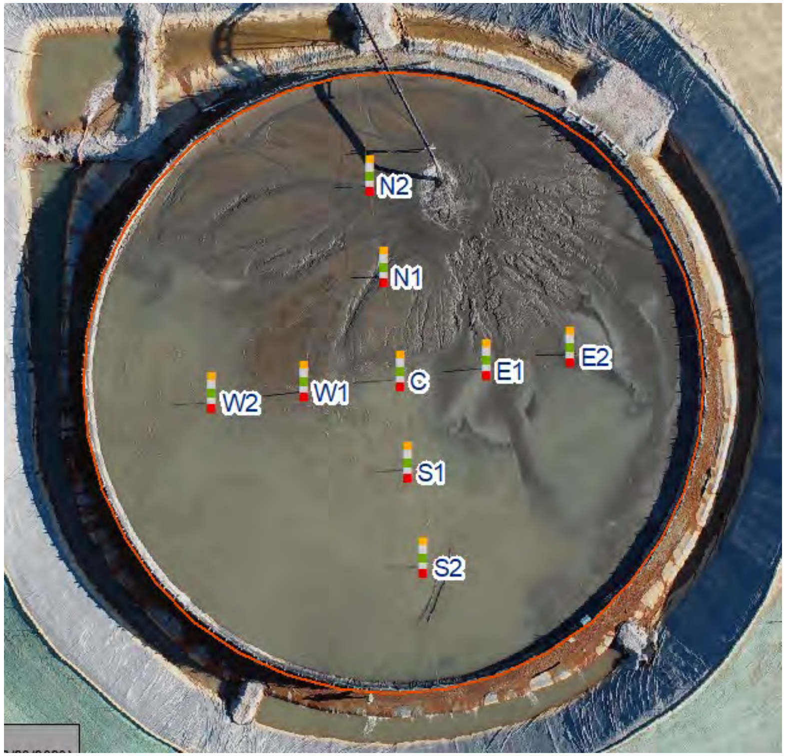


| Color | Location | Code | Height |
|---|---|---|---|
| Top of Pole | | TOP | 8.2 |
| Orange | Top | Ot | 8.0 |
| | Middle | Om | 7.7 |
| | Bottom | Ob | 7.4 |
| 3rd Gray | Top | 3Gt | 7.0 |
| | Middle | 3Gm | 6.7 |
| | Bottom | 3Gb | 6.4 |
| Green | Top | Gt | 6.0 |
| | Middle | Gm | 5.7 |
| | Bottom | Gb | 5.4 |
| 2nd Gray | Top | 2Gt | 5.0 |
| | Middle | 2Gm | 4.7 |
| | Bottom | 2Gb | 4.4 |
| Red | Top | Rt | 4.0 |
| | Middle | Rm | 3.7 |
| | Bottom | Rb | 3.4 |
| 1st Gray | Top | 1Gt | 3.0 |
| | Middle | 1Gm | 2.7 |
| | Bottom | 1Gb | 2.4 |
| Yellow | Top | Yt | 2.0 |
| | Middle | Ym | 1.7 |
| | Bottom | Yb | 1.4 |
| Bucket | Top | Bt | 1.0 |
| | Middle | Bm | 0.7 |
| | Bottom | Bb | 0.4 |

# In Pool Volume Calculation

26 Aug 2020, Post-Fill Day 0

| Measuring Post | Post | Height (ft) |
|---|---|---|
| N2 | Gm | **5.99** |
| N1 | Gl | **5.90** |
| C | Gl | **6.16** |
| S1 | 2Gm | **5.24** |
| S2 | 2Gm | **4.99** |
| W1 | Gl | **5.90** |
| W2 | 2Gt | **5.32** |
| E1 | Gl | **5.90** |
| E2 | Gl | **5.65** |



# In Pool Method 1: Capacity Interval Tables

| Level (ft) | Vol (CY) |
|---|---|
| 1 | 575 |
| 1.5 | 925 |
| 2 | 1300 |
| 2.5 | 1675 |
| 3 | 2050 |
| 3.5 | 2425 |
| 4 | 2800 |
| 4.5 | 3200 |
| 5 | 3600 |
| 5.5 | 3975 |
| 6 | 4400 |
| 6.5 | 4800 |
| 7 | 5200 |

- Table supplied by EDT (GeoPool Manufacturer)
- Level = height from base of frame to sediment
- Level = average of measuring post height data

# In Pool Method 1: Capacity Interval Tables

| Level (ft) | Vol (CY) |
|---|---|
| 1 | 575 |
| 1.5 | 925 |
| 2 | 1300 |
| 2.5 | 1675 |
| 3 | 2050 |
| 3.5 | 2425 |
| 4 | 2800 |
| 4.5 | 3200 |
| 5 | 3600 |
| 5.5 | 3975 |
| 6 | 4400 |
| 6.5 | 4800 |
| 7 | 5200 |

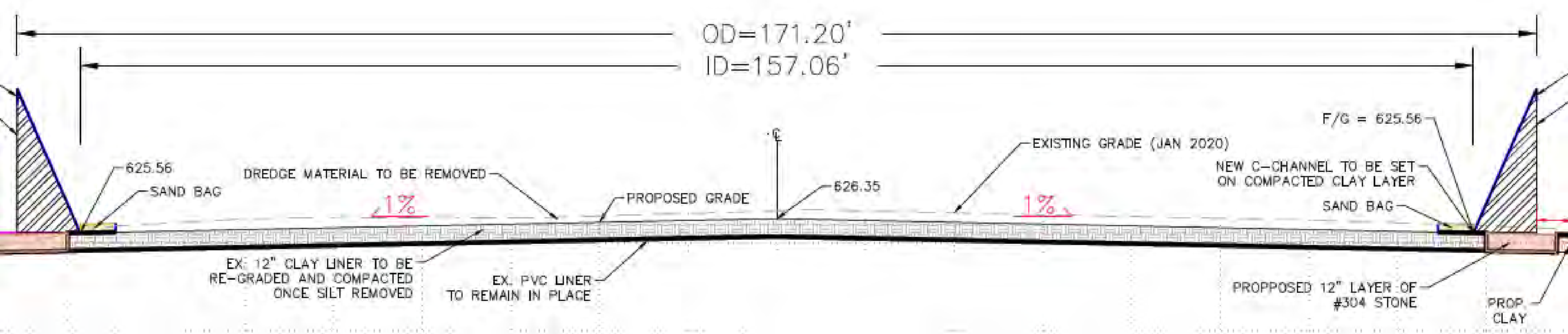
26 Aug 2020, Post-Fill Day 0

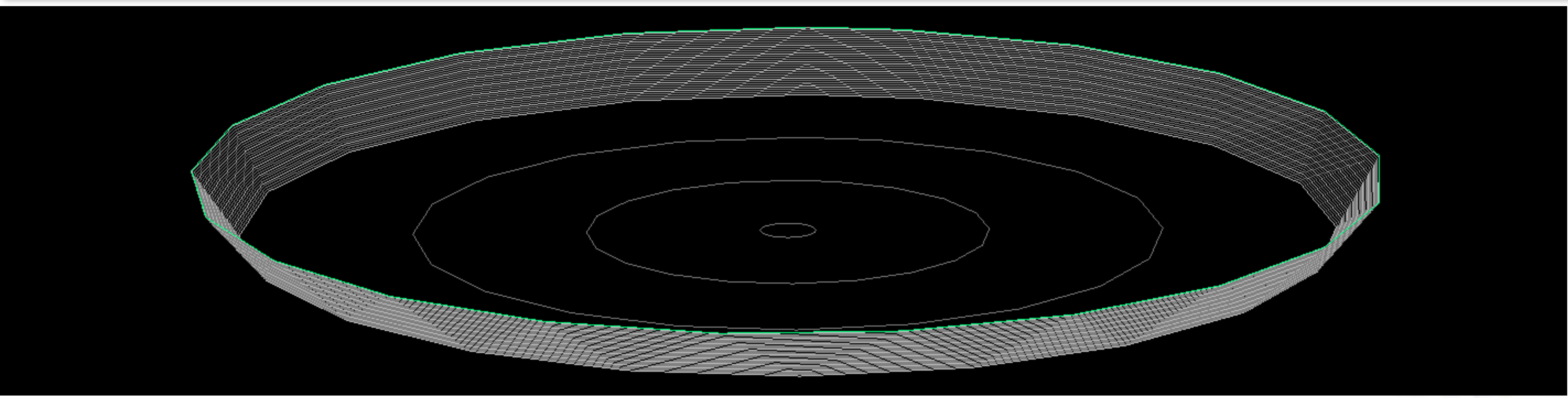
| Measuring Post | Post | Height (ft) |
|---|---|---|
| N2 | Gm | 5.99 |
| N1 | Gl | 5.90 |
| C | Gl | 6.16 |
| S1 | 2Gm | 5.24 |
| S2 | 2Gm | 4.99 |
| W1 | Gl | 5.90 |
| W2 | 2Gt | 5.32 |
| E1 | Gl | 5.90 |
| E2 | Gl | 5.65 |
| **Average** | | 5.67 |
| **Volume** | | **4120** |

# In Pool Method 2:
# 3D Surface Models

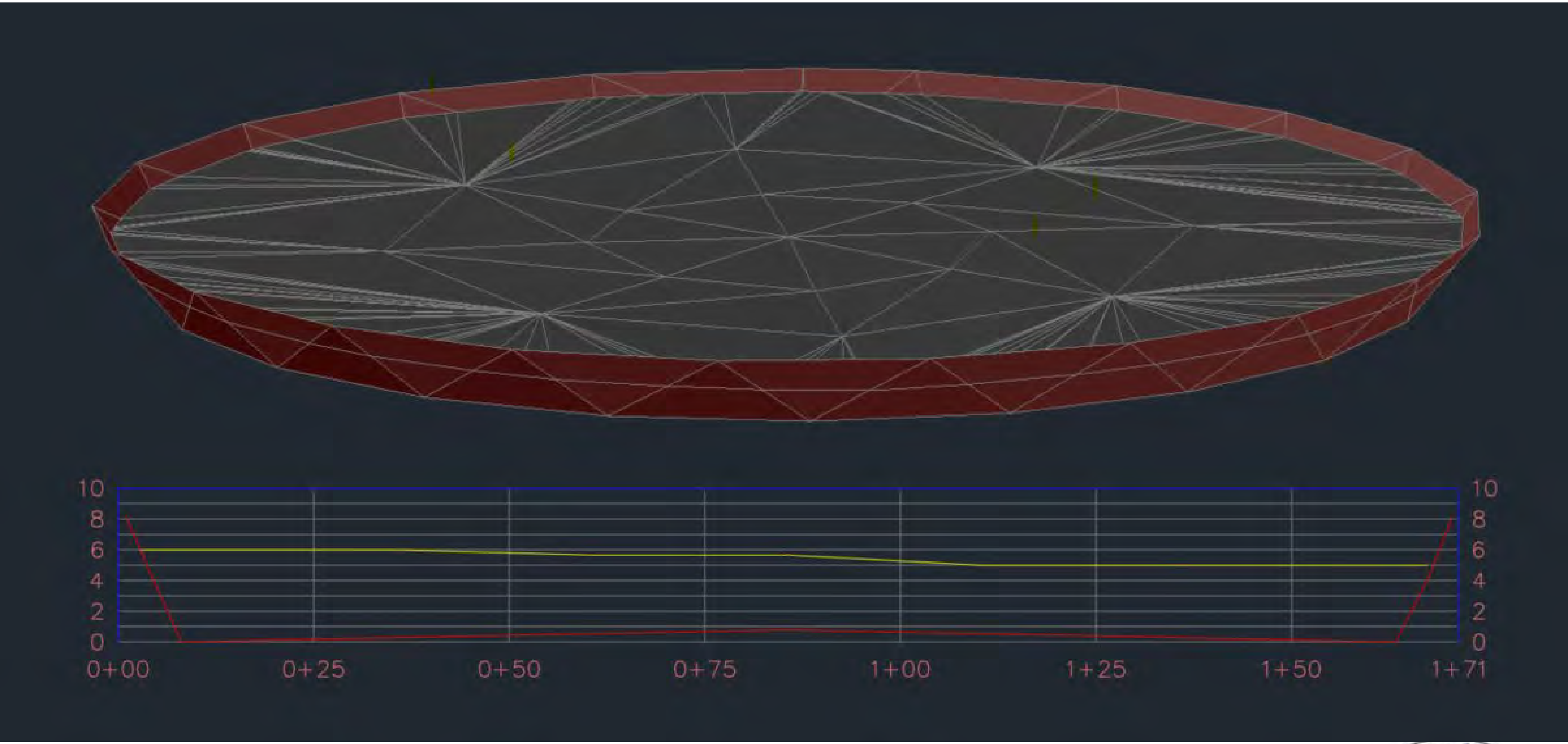
- Using *AutoCAD Civil 3D,* create 3D surface models of sediment level and GeoPool base.
- Program calculates volumetric difference between surface models

# In Pool Method 2:
# 3D Surface Models



# In Pool Method 2: 3D Surface Models



# In Pool Method 2:
# 3D Surface Models

- Using *AutoCAD Civil 3D,* create 3D surface models of sediment level and GeoPool base.
- Program calculates volumetric difference

- Post-Fill Day 0 (26 Aug 2020) Volume = **3989.35 CY**

# Quantity Summary

| Location | Method | Quantity (CY) |
|---|---|---|
| **In situ** | 2013 USACE Data, 51% solids in situ | **3440** |
| | 2019 *DM6* Data, 56% solids in situ | 3066 |
| | Bathymetric Survey Comparison | **2617** |
| **In pool** | Capacity Table | 4120 |
| | 3D Surface Models | **3989** |

# Post-Fill Day 0
# Bulking Factor Range

- In situ quantity = range of values
- In pool quantity = 3D surface quantity, due to accuracy

| In Pool (CY) | | In Situ (CY) | | Bulking Factor |
|---|---|---|---|---|
| 3989 | ÷ | 2616 | = | **1.52** |
| 3989 | ÷ | 3440 | = | **1.16** |

Day 0 Range = 1.16 to 1.52

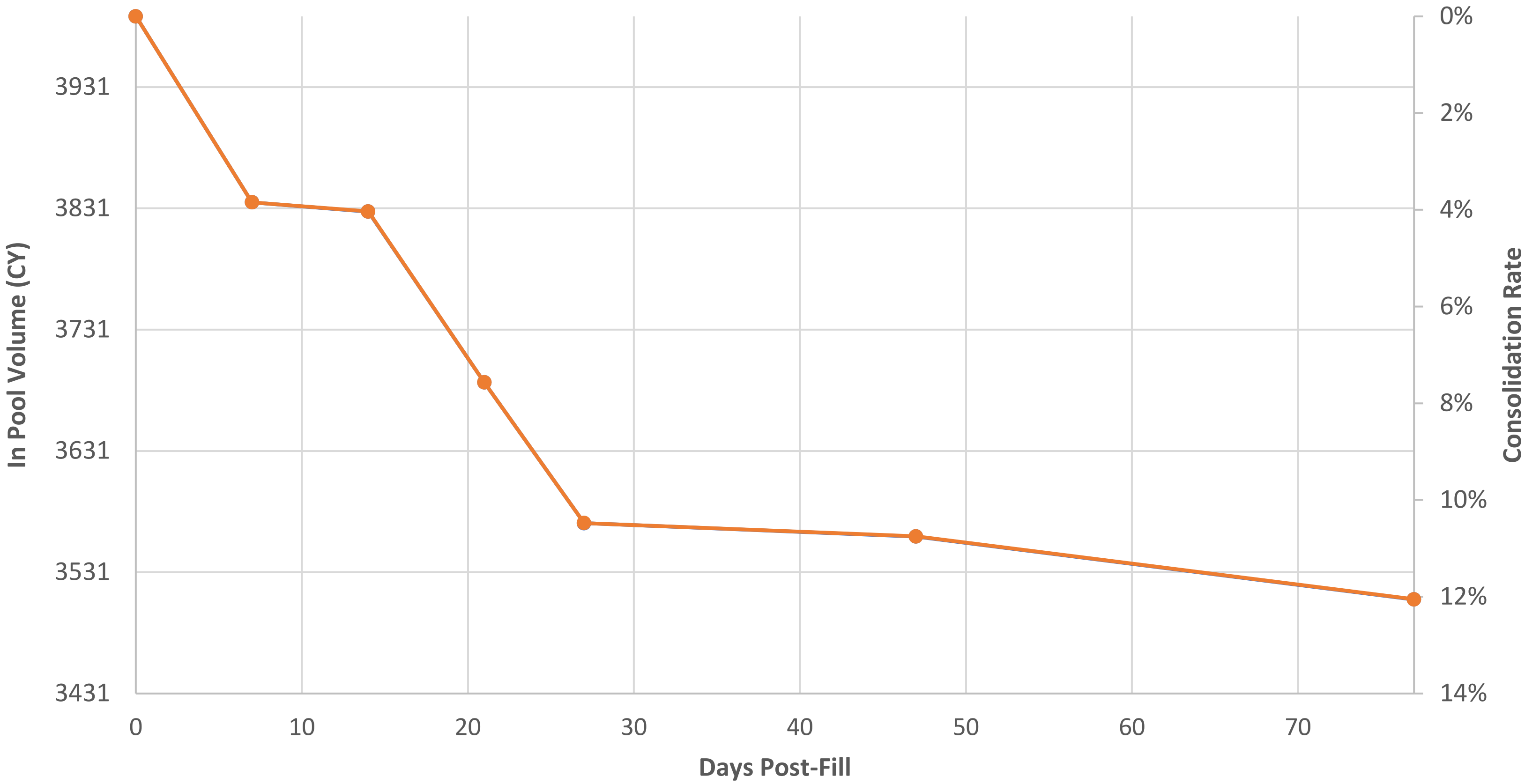
# GeoPool Solids Consolidation

- In pool quantities from 26 Aug 2020 to 11 Nov 2020
  - Using the 3D Surface Model Method

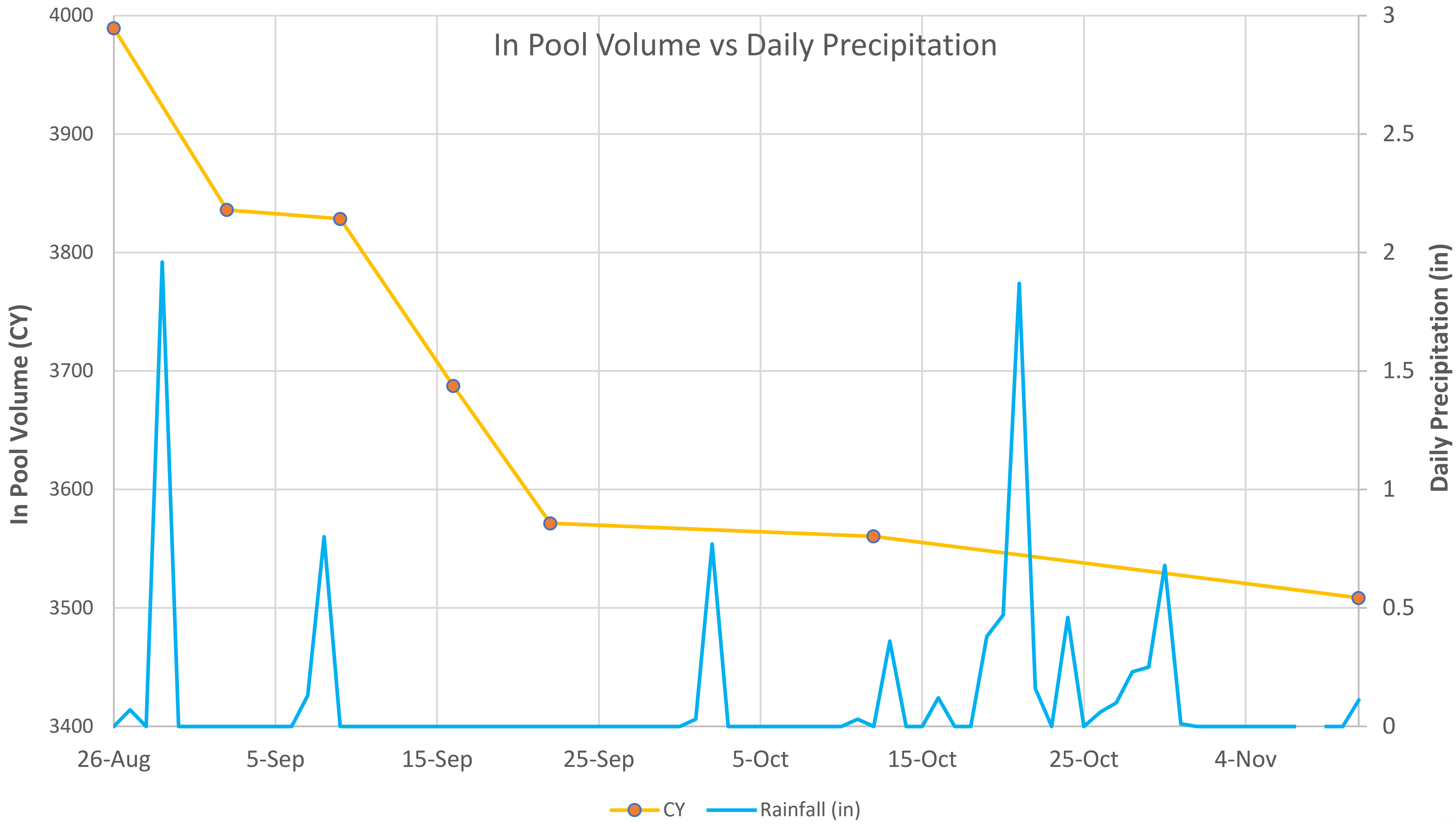
# GeoPool Solids Consolidation

| Date | Post Fill Days | In Pool Volume (CY) | Consolidation % | High BF | Low BF |
|---|---|---|---|---|---|
| **26-Aug** | 0 Days | 3989 | | **1.52** | **1.16** |
| **2-Sep** | 7 Days | 3836 | 3.8% | 1.47 | 1.12 |
| **9-Sep** | 14 Days | 3828 | 4.0% | 1.46 | 1.11 |
| **16-Sep** | 21 Days | 3687 | 7.6% | 1.41 | 1.07 |
| **22-Sep** | 27 Days | 3571 | 10.5% | **1.36** | **1.04** |
| **12-Oct** | 47 Days | 3560 | 10.8% | 1.36 | 1.04 |
| **11-Nov** | 77 Days | 3508 | 12.0% | 1.34 | 1.02 |

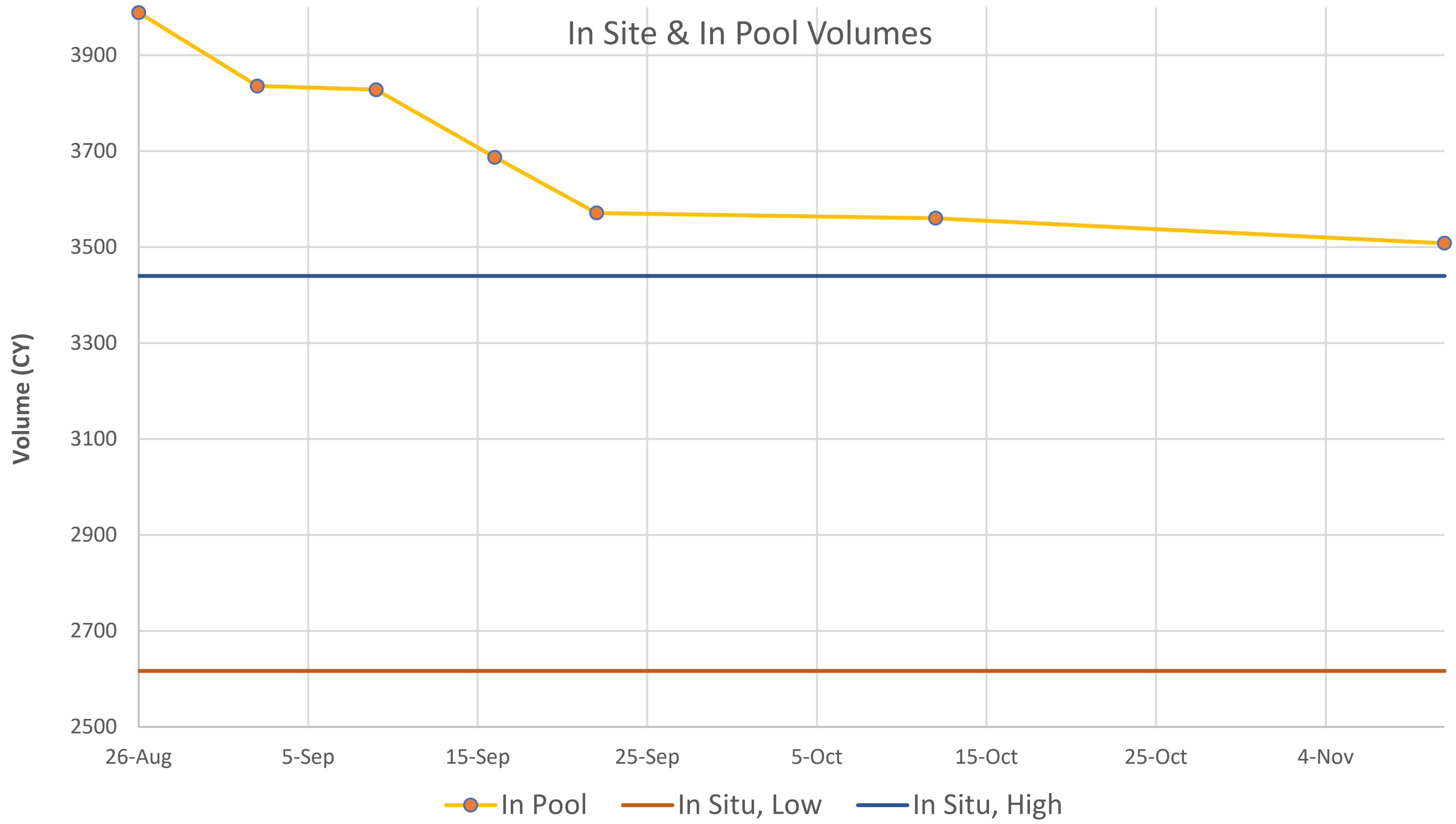
# GeoPool Solids Consolidation



# GeoPool Solids Consolidation



# GeoPool Solids Consolidation



# Bulking Factor Range

| Dewatering System | Bulking Factor Range |
|---|---|
| GeoPool,<br>Post-Fill Day 0 | **1.52 – 1.16** |
| GeoPool,<br>Post-Fill Day 27 | **1.36 – 1.04** |
| Solids Basins,<br>with polymer (bench tests) | **2.6 – 2.3** |
| ~~Solids Basins,~~<br>~~without polymer~~ | **~~>2.6~~** |

# Appendix E-2
# Calculation of Convex Stockpile

Geosyntec consultants

Written by: CT Platt Date: 15 Jun 22 (DD MM YY) Reviewed by: B Woyer Date: 16 06 22 (DD MM YY)

Client: Lorain Project: BRDMRF Project/Proposal No. GN8848 Task No. —

Purpose: Estimate volumetric change between dredged volume and lightly compacted dewatered sediments using GeoTool contained solids over time.

I. Spherical Cap Volume using omnicalculator.com

Inputs Cap height 4 feet

Cap base radius 76 ft.

Output Volume = 1354 cyds

if increased to 5 ft height and 80 ft radius yields 1864 cyds.

II. Bulking Factor presentation (January 2021) cited Day 0 of 3989 cyds

Day 77 of 3508 cyds, which is about same as 80/90 volume.

after Day 77, 700 cyds were excavated for the test plots. Therefore the GeoTool quantity reduced to 2808 cyds.

Assuming an additional 10% consolidation over the freeze-thaw winter exposure, which is based solely on professional observation, yields about 2508 cyds in the GeoTool in Summer 2021.

III. Using the Summer 2021 estimated quantity of 2,508 cyd compared to the estimated stockpile of Fall 2021 (Spherical Cap above) quantity of 1354 indicates that the dewatered sediments are 46% of the dredged volume when lightly compacted.

$$\frac{2508 - 1354}{2508} = 46\%$$

IV. Use 50% of dredged volume yields dewatered volume.

# Appendix F
# Calculation of Market Haul Distance

Geosyntec consultants

Page 1 of 1

Written by: CT Platt Date: 15 / Jun / 22 (DD MM YY) Reviewed by: B. WEYER Date: 16 / 06 / '22 (DD MM YY)

Client: Lorain Project: BROMRF Project/Proposal No. GN8848 Task No. —

## Haul Distance Limit - Approximate