ABSTRACT

Overall Project Outcomes and Results:

[2014] Project Abstract

For the Period Ending June 30, 2019

PROJECT TITLE: Dredged Sediment for Forest Restoration on Unproductive Minelands

PROJECT MANAGER: Marsha Meinders Patelke
AFFILIATION: University of Minnesota Duluth – Natural Resources Research Institute (UMD-NRRI)
MAILING ADDRESS: 5013 Miller Trunk Highway
CITY/STATE/ZIP: Duluth/MN 55811-1442
PHONE: (218) 788-2642
E-MAIL: mpatelke@d.umn.edu
WEBSITE: https://www.nrri.umn.edu/
FUNDING SOURCE: Environment and Natural Resources Trust Fund
LEGAL CITATION: M.L. 2014, Chp. 226, Sec. 2, Subd. 06j, as extended by laws M.L. 2018, Chp. 214, Art. 4, Sec. 2, Subd. 20

APPROPRIATION AMOUNT: $300,000
AMOUNT SPENT: $280,335
AMOUNT REMAINING: $19,665

Erie Pier dredge sediment can provide benefits for both state mineland reclamation requirements as well as enhancement of revegetation and restoration of disturbed lands. Evaluation of potential economic advantages from purpose-grown trees was not observed due to the short project length and the slow growth rate of the trees.

Overall Project Outcome and Results

This project investigated using sediment dredged from the Duluth-Superior Harbor for enhancing mineland restoration, beyond what is required by state reclamation requirements, and to demonstrate potential economic gain from purpose-grown trees for biofuel. Funding was provided by ENRTF. The NRRI secured supplemental funding from the U.S. Army Corp of Engineers and the U.S. Department of Commerce to support transport of 4,500 cubic yards of dredge material to the Virginia, Minnesota landfill project site.

The Virginia Landfill property was cleared of existing vegetation in 2015 and three study plots were constructed, totaling approximately 4.5 acres. Dredge material was applied in two of the plots at 6-inch and 12-inch thicknesses; the remaining plot (control) did not receive sediment. Cottonwood, Tamarack, and White Pine were planted in 2017 and 2018.

Major project tasks included: counting surviving trees and measuring their heights; soil fertility sampling; and floristic inventories of all plants. For comparison purposes, tree-planting success at two sites previously treated with dredge sediment was also evaluated.

Tamarack had the lowest survival rate and White Pine had the highest, regardless of the plot. Cottonwood were more successful in the sediment plots than in the control. Average tree heights ranged from less than a foot to 2.5 feet at the project site, while high mortality and inconsistent growth rates were observed at the two comparison sites.

The economic potential from purpose-grown trees cannot be estimated with so short a growing time. Trees require 20 to 90 years' growth to attain a marketable height of 40 to 50 feet. Consequently, the greater near-term value of applying dredge material to disturbed or mined land is associated with shortening the time it takes to establish good vegetative cover. Based on the study results and observations, creating pollinator habitat could be another beneficial dredge material use.

Project Results Use and Dissemination

Results from this project, including soils and vegetation data were shared with St Louis County Environmental Services (2017), Minnesota Department of Natural Resources Mineland Reclamation program (2019), and United Taconite personnel (2019).

Environment and Natural Resources Trust Fund (ENRTF)
M.L. 2014 Work Plan Final Report

Date of Report: November 15, 2019

Final Report

Date of Work Plan Approval: June 4, 2014

Project Completion Date: June 30, 2019

Does this submission include an amendment request? No

PROJECT TITLE: Dredged Sediment for Forest Restoration on Unproductive Minelands

Project Manager: Marsha Patelke

Organization: University of Minnesota – Duluth, Natural Resources Research Institute (UMD - NRRI)

Mailing Address: 5013 Miller Trunk Highway

City/State/Zip Code: Duluth/MN/55811-1442

Telephone Number: (218)-788-2642

Email Address: mpatelke@d.umn.edu

Web Address: www.nrri.umn.edu/

Location: Saint Louis County Landfill Parcel/Acct 090-0193-00075 82249

Section 10 Township 58.0 Range 17; SW1/4 of NW1/4 LYING ELY OF A LINE BEG; ON W LINE N 1 DEG 21’26”W 174.09 FT FROM; W1/4 COR THENCE S30 DEG 44’17”E 376.05

Total ENRTF Project Budget: $300,000	
ENRTF Appropriation:	**$300,000**
Amount Spent:	**$ 280,335**
Balance:	**$19,665**

Legal Citation: M.L. 2014, Chp. 226, Sec. 2, Subd. 06j, as extended by laws M.L. 2018, Chp. 214, Art. 4, Sec. 2, Subd. 20

Appropriation Language:
$300,000 the second year is from the trust fund to the Board of Regents of the University of Minnesota–Duluth for the Natural Resources Research Institute to restore up to 136 acres of unproductive mine stockpile while improving the treatment of municipal sewage and biosolids near Virginia using clean Erie Pier dredged sediment and managed forestry techniques. This appropriation is available until June 30, 2018, by which time the project must be completed and final products delivered. Carryforward; Extension (a) The availability of the appropriations for the following projects are extended to June 30, 2019: (1) Laws 2014, chapter 226, section 2, subdivision 6, paragraph (j), Dredged Sediment for Forest Restoration on Unproductive Minelands

I. PROJECT TITLE: Dredged Sediment for Forest Restoration on Unproductive Minelands

II. PROJECT STATEMENT:

1. Intent of Project

The intent of this project is to demonstrate improved, sustainable, and best-practices methods of mineland restoration then transfer this methodology elsewhere, to perpetuate dual benefits to the environment and local commerce.

2. Justification and Impacts

Minnesota mining activities result in the removal of plant materials, depletion of soils, exposure of geologic formations and subsequent stockpiling of by-product rock. These disturbances reduce the biological productivity and biodiversity of a mine site, as well as impact the role of this land in the ecosystem. A reclamation permit for minelands required by State statute and enforced by the regulatory agencies addresses the practices designed to remedy these disturbances and fundamentally revegetate the site. This reclamation permit does not require revegetation with purpose grown plant species, for sustained economic benefit. This research takes the next step towards sustained economic benefit of mineland reclamation. The end results of this research are site restoration, effective plant succession, and economic sustainability. This research will therefore enable and demonstrate a higher use of these disturbed lands.

Presently mineland reclamation requirements do not include the higher goals of biodiversity and sustained economic development from resources disturbed by mining activities. Where ownership of such disturbed lands is transferred or conveyed, both biodiversity and sustained economic return are justified. This higher level of site restoration would provide economic return to the owner and stimulate local commerce, including tax revenues from the sale of products. This research site was reclaimed according to existing regulations prior to its conveyance to St. Louis County. In this specific case, the research site is owned by St. Louis County and NRRI was requested to demonstrate a higher use, specifically with purpose grown biomass species. St. Louis County based their request on the expertise and success of NRRI in site restoration at other locations. Based on ownership, no mining company is participating or contributing to this research. St. Louis County is providing land resources, equipment, operators and on-site facilities in support of this research. The goal of this research is to demonstrate a higher level of mineland reclamation with the benefits of biodiversity and sustained economic benefit, currently not required by regulatory agencies. No ENTRF funds are therefore used to meet regulatory requirement in the execution of this research.

This research is not intended for the revision of regulatory requirements. However, the results expected from this research will demonstrate the ecologic and economic benefits above basic revegetation, as required by existing regulations. All acreage included in this research (at the St. Louis County site) has been reclaimed according to existing regulations, but not resulting in economic activity (i.e. optimized biomass productivity).

The opportunity for purpose grown vegetation on minelands in Minnesota is significant. "Iron ore and taconite have been mined in Minnesota since the 1890s. Most lands disturbed by mining are on the Mesabi Iron Range in northeastern Minnesota. Currently, 256,000 acres are covered by Permits to Mine, 76,100 acres of which have been altered since 1980 when the Legislature established the DNR's permitting program. Of this acreage, about 33,100 are tailings basins, about 22,150 are mine pits, and about 18,300 are stockpiles (https://webapps8.dnr.state.mn.us/outcomes_reporting/conservation_agenda/detail/542). Lands disturbed by mining activities, requiring reclamation could benefit from this research, where a business could utilize the biomass (i.e. fiber related industry). In the case of the higher level of reclamation represented by this research, the owner of the land would incur the costs and then receive payment for the biomass.

A fundamental practice of harbor maintenance is dredging of sediment. In the Duluth Harbor, sediment is carried by the influx of water and settled into the harbor from the St. Louis River and surrounding landscape. The accumulation of sediment restricts ship traffic and commerce. Dredging ensures adequate depth for ship passage; an integral element of agricultural and industrial vitality in the region. In the case of the Duluth Harbor, the dredged sediment is lifted from the bottom of the channel, then barged to a containment facility owned by the Duluth Port Authority and managed by the US Army Corps of Engineers. The sediment from this facility is clean, classified and permitted for landscape use. This sediment has been successfully used in construction projects, landfill caps, sports turf substrate and a variety of land reclamation projects. The containment facility holds over two million cubic yards of dredging at full capacity, with annual additions of over one hundred thousand cubic yards of sediment.

The project affects the commercial sectors of shipping, forest products and biofuels production with other benefits to carbon sequestration, wildlife habitat, ecosystem beautification, recreational use, aesthetics, and biodiversity enhancement. The ecosystem management enabled by the use of sediment on unproductive minelands results in an enhanced, healthy root-zone, improvements to soil organic matter and maximizes biomass productivity.

3. Description of Activities

a. Research Site - The research site is located on lands owned and managed by St. Louis County Environmental Services adjacent to their landfill, leachate fields, recycling and recovery operations near Virginia. Maps of the research site, satellite images and the tax document (ownership) are available upon request.

The research site will include two general areas: staging and biomass production (i.e., research plots therein). Dredged sediment will be truck transported from the Erie Pier Containment Facility (Duluth Seaway Port Authority and US Army Corps of Engineers) in west Duluth to the staging area. NRRI personnel will monitor the shipments of dredged sediment from this facility, supported by ENTRF Funds. No ENTRF funds will be expended for the transport and handling of the dredged sediment; other funding sources will support this activity. The most cost-effective method of transporting the sediment from Duluth will be used and supported by funds other than ENTRF. The staging area is located at the St. Louis County Landfill site near the research plots. The staging area will be used to store dredged sediment intended for the substrate enhancement at the research plots. Since this staging area is not rail accessible, delivery trucks will deposit the sediment here, and samples will be retained for reference and analysis. Each delivery will be carefully monitored and recorded, with full compliance to regulatory permits. From the staging area the dredged sediment will be deployed to the prepared research plots. Site preparation is described in the following paragraph. The staging area and research plots are located within the 140 acre facility managed by St. Louis County Environmental Services (legal description previously provided as Location.)

b. Sequence of Activities – The research site and staging areas are currently covered with brush, saplings and a variety of emergent plants species. The productivity of this site is very low due to the deficient soils. This site was formerly a mine bench, where rock by-product was deposited and graded. The existing vegetation is the result of natural regeneration (i.e. little or no management).

Site preparation consists of floristic survey, baseline biomass productivity and in situ substrate analysis. The purpose of the floristic survey is to describe the present vegetation prior to research activities. Plants from seeds and fragments of this vegetation may regenerate at the sites, and this will require cultural management (mowing, removal and/or herbicide). Also baseline productivity will be quantified. Baseline biomass productivity is a weight measurement of vegetation collected from both staging and research areas before substrate enhancement. Also, the existing substrate will be classified and reported. These measurements and observations are important when compared to the improved conditions following sediment application.

The research plots in this project will receive substrate materials following site preparation, graded to a uniform surface and seeded with a temporary legume cover crop. Native seeds and plant species will be used in this project in accordance to BWSR guidelines for restoration. Plant materials from commercial sources, North Central Research and Outreach Center (NCROC, Grand Rapids) and NRRI's Greenhouse will be transported to the research site and deployed. Some plants species will be propagated at these facilities for specific deployment during this research project. Amendments (ex. nutrient, biological, mycorrhizae, bio-stimulants) will be applied to benefit the establishment and growth of the plant species. The sustainable succession of bio-diverse plant species of commercial importance is the goal of these activities.

As the plant species flourish within the research plots, growth and response will be monitored and documented to quantify effectiveness of treatment and measure biomass productivity (both standing and harvested). Research plots will be culturally managed to optimize survival and productivity. All practices will be carefully documented to enable thorough reporting and technology transfer. As biomass is harvested and quantified, stands will be maintained through replanting or coppicing to ensure re-growth.

Please Note: This research project will be conducted over a period of four years. Due to the timing of funding and seasonality of biomass productivity, we have proposed an extended period of monitoring. The results of biomass productivity can be better extrapolated with this extended timeline. The project status updates (below) will reflect this extend timeline.

c. Additional Impacts of Project - Technology transfer is an important goal of this project. Succession of plant species, building of soil organic matter and the perpetuation of purpose grown plant species are essential elements to the success of this project. The successful practices and materials used in this project have restoration potential for transfer to other disturbed and unproductive land resources in the region, while providing high quality biomass to the energy and bio-products industries.

III. PROJECT STATUS UPDATES:

Project Status as of October 1, 2014: Floristic survey contracted and conducted (baseline, existing vegetation, incidence by species) by Dr. Gerould Wilhelm, Conservation Research Forum. Research plot layout approved and confirmed with St. Louis County Environmental Services.

Project Status as of April 1, 2015: Floristic survey report received and discussed and discussed with contractor. Stockpile area prepared by St. Louis County. Initial deliveries of Erie Pier Sediment transported and delivered 1,960 cubic yards, 108 loads), with funds external to ENRTF. Initial stockpile shaped. Stocking plants monitored at nursery. Biomass protocols selected. Spring 2015 activities discussed and coordinated with project participants (planning).

Project Status as of July 1, 2015: The research plot reconnaissance was conducted and boundaries were approved by St. Louis County Environmental Services. This site is approximately 150' x 1452' south adjacent to the delivery road and directly across from the road from the stockpile area. A contractor for clearing the standing biomass was selected with the approval of St. Louis County. The nursery of planting stock located at the North Central Research and Outreach Center (Grand Rapids) was maintained; including removal of decadent materials, mowing, tilling and the application of pre-emergent herbicide. A local nursery was contacted to propagate and provide viable, native planting stock (trees and shrubs) for 2016 planting. The list of planting stock is in progress.

Amendment Request April 1, 2016:

Project Manager Tom Levar has retired. Request at this time is for Craig Maly to take over the responsibilities of project manager as amended above.
Amendment Approved: May 16, 2016

Project Status as of April 1, 2016: An additional 2,527 cubic yards (or approximately 140 truckloads) of Erie Pier dredged sediment were delivered to the site in September and October of 2015. Combined with the previous delivery of 1,960 cubic yards, the project site has received a total of nearly 4,500 cubic yards of Erie Pier dredged sediment. Funding external to ENTRF was used to support the entire movement of dredged material from Duluth to the project site, via a combination of funding secured by NRRI from the U.S Army Corps of Engineers and the U.S. Department of Commerce, Economic Development Administration. This portion of the project showed that dredged sediment could be loaded onto trucks at Erie Pier in Duluth and transported and delivered to the project site for $13.75 per cubic yard (2015 pricing).

The research plot area was reevaluated last fall and St. Louis County Environmental Services was in agreement to move the research area from across the delivery road to an area north of and adjacent to the 4,500 yard Erie Pier sediment stock pile. A local contractor-as selected and approved by St. Louis County Environmental Services, based on previous performance-was hired to remove the standing vegetation from this new area and establish three areas of treatment. One with one foot of Erie Pier sediment, one having six inches of Erie Pier sediment and one area left with existing soil for a control area. The following images show the project site relative to the city of Virginia (Fig. A); the dredged material stockpile (Fig. B); site preparation (Fig. C); and a schematic of the planned research area (Fig. D).

Figure A. Project location relative to the city of Virginia (image source: Google Earth)

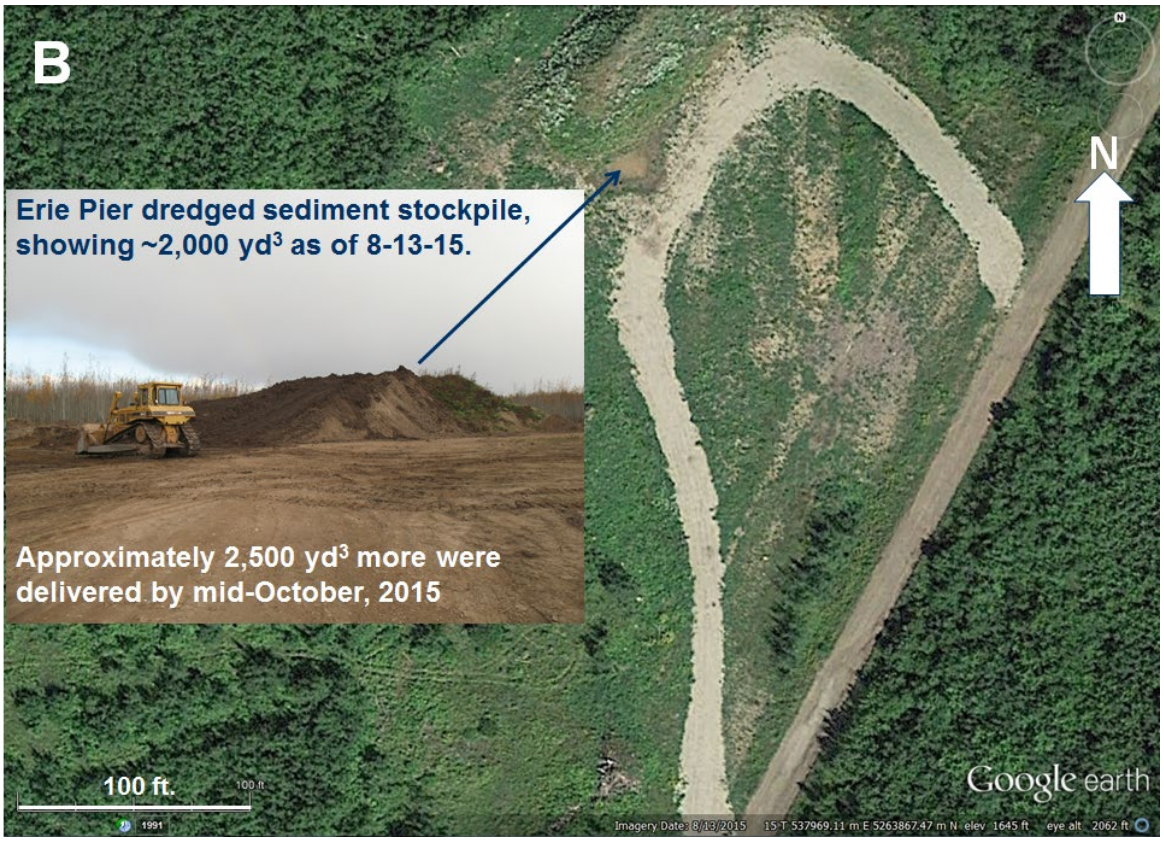


Figure B. Dredged material delivery site and stockpile development.

Figure C. Project site preparation.

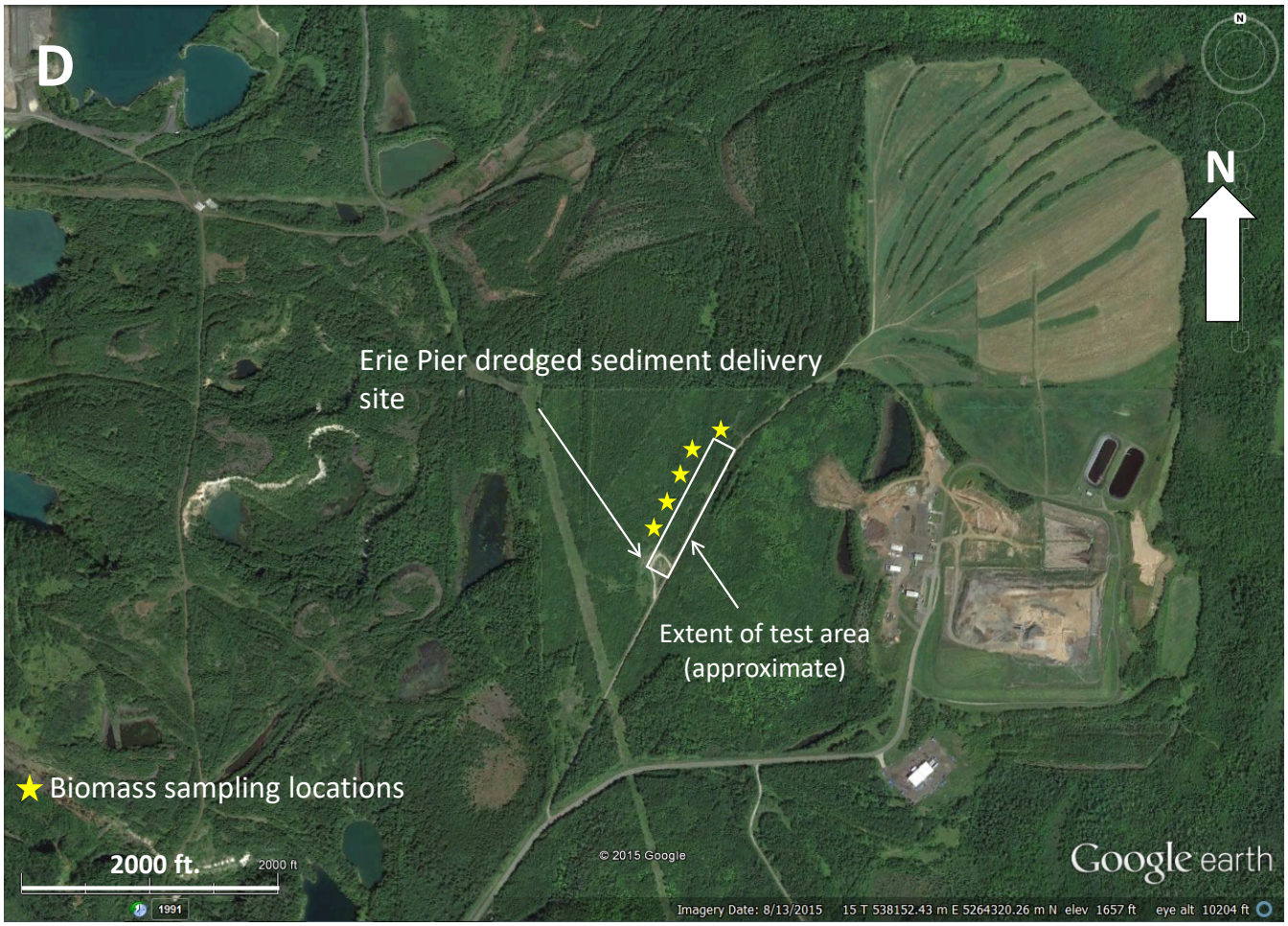


Figure D. Schematic of proposed test area, showing biomass sampling locations.

Tree propagating vegetation was collected out of the nursery at the North Central Research and Outreach Center (Grand Rapids). This material is currently being propagated in the NRRI greenhouse and will be available as planting stock for the project. With the retirement of the project manager and final delivery of dredged material to the project site delayed by over 6 months, discussions are being held to refine and develop a final research plot plan and a revised project schedule.

Project Status as of July 1, 2016: A final research plot plan for the site has been put together, and pending the results from the soil analysis, trees will be planted in the Spring of 2017. The project is one year behind schedule due to delays in other funding sources to support the transport of sediments to the site. The containerized Cottonwood (Populus deltoides) trees being grown in the NRRI greenhouse will be used and Tamarack (Larix laricina) and White Pine (Pinus strobus) seedlings will be purchased. The site will be monitored and maintained with herbicide for weeds this growing season. Samples were collected from the existing woody vegetation surrounding the site to estimate onsite biomass prior to clearing, as indicated by the yellow stars in Figure D. Figure E (upper photo) shows the type of small diameter woody vegetation that was present prior to clearing, while the lower photo of Figure E shows the site condition (post-clearing) as of June 28, 2016, and the three treatment areas. From left to right: control; 6” dredged sediment cover; and 12” dredged sediment cover.

E

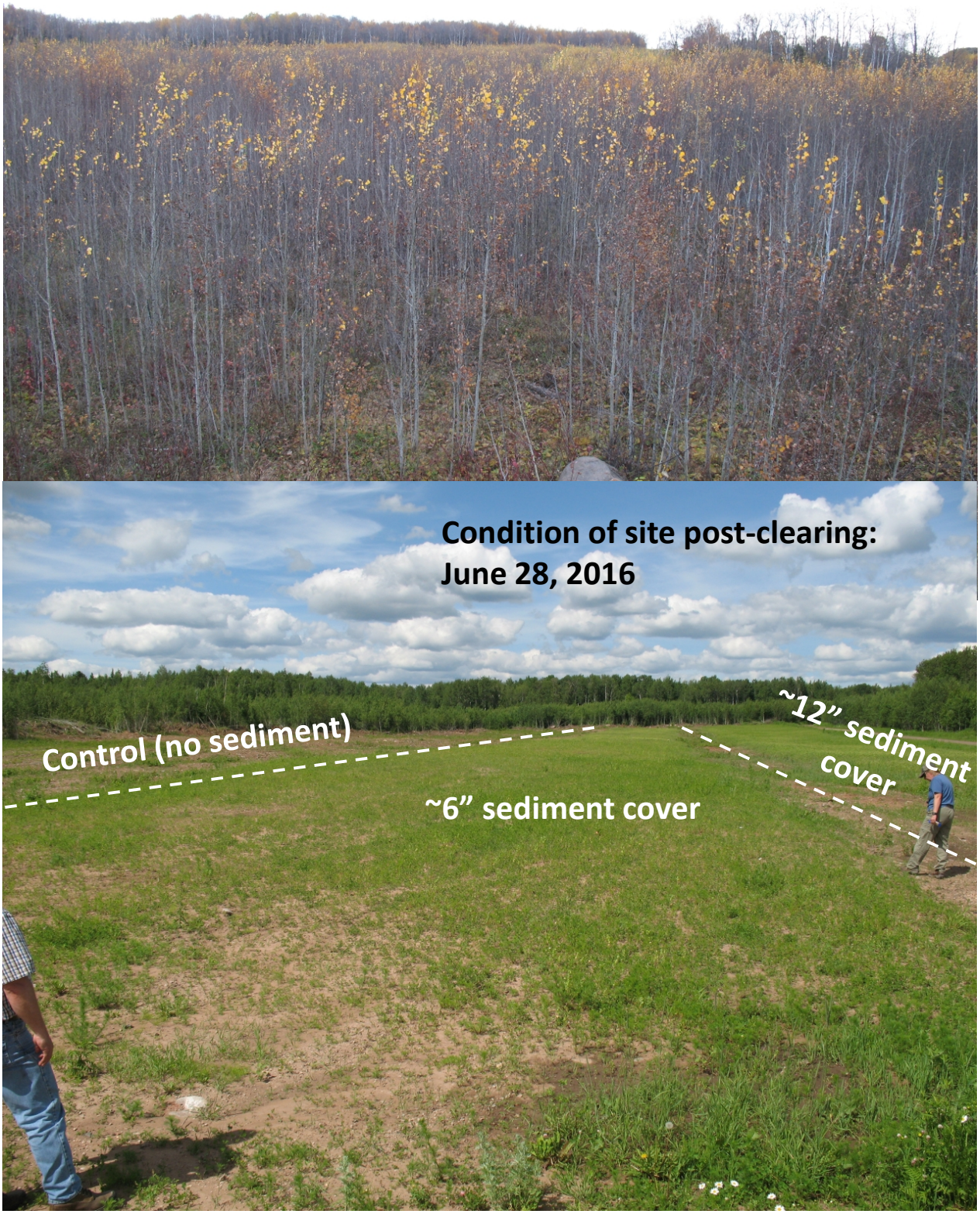


Figure E. (Upper photo): woody vegetation prior to clearing, October 15, 2015; (Lower photo): condition of site post-clearing, showing Control area (no sediment cover); ~6 in. sediment cover area; and ~12 inch sediment cover area, June 28, 2016, looking north.

Project Status as of December 1, 2016: The research site was monitored over the summer and treated with glyphosate herbicide to kill the weeds that grew on the site. An herbicide application will be applied again in the spring prior to tree planting. The results for the soil samples analysis were received from the University of Minnesota Research Analytical Laboratory and will be included in the final report. The containerized Cottonwood (Populus deltoides) tree seedlings were grown out over the summer in the NRRI greenhouse facility and will be part of the tree planting stock. Tamarack (Larix laricina) and White Pine (Pinus strobus) seedlings were ordered from Lakes States Evergreen Co LLC a local grower in Cohasset, MN. The site and the planting stock will be ready for planting Spring 2017. No floristic survey was performed this year. A final floristic survey will be done next year after the site is planted and a new plant community is allowed to reestablish.

Project Status as of July 1, 2017: The three treatment areas (12 inches sediment, 6 inches sediment and no sediment) were each divided into three replications of three plots. Each treatment area has nine plots as shown in Figure F. The plot size is a 7 X 10 row block with 8 ft x 8 ft spacing between all rows for a 70 tree plot per species. The three tree species White Pine (Pinus strobus), Tamarack (Larix laricina) and Cottonwood (Populus deltoides) are each represented in a 70 tree plot in each replication. The Tamarack and White Pine seedlings were planted on May 10th and the Cottonwood seedlings were planted on June 19th. Figures G and H show the site layout, seedlings, and seedling plantings. A site visit will be made in early July to assess survival of the planting. Depending on those results a fall replacement planting will be considered to get the plots fully stocked.

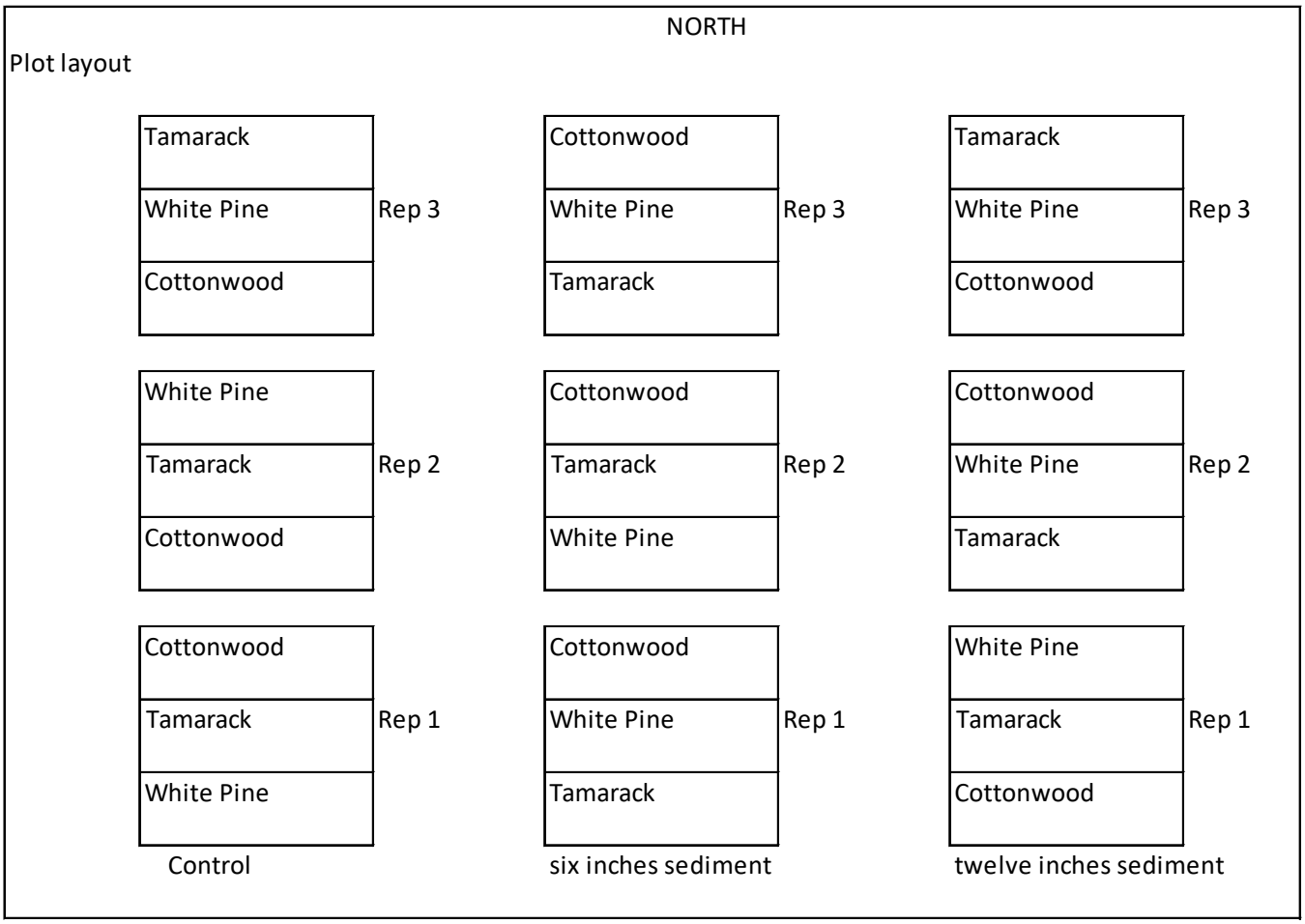


Figure F. Plot layouts for seedling plantings.

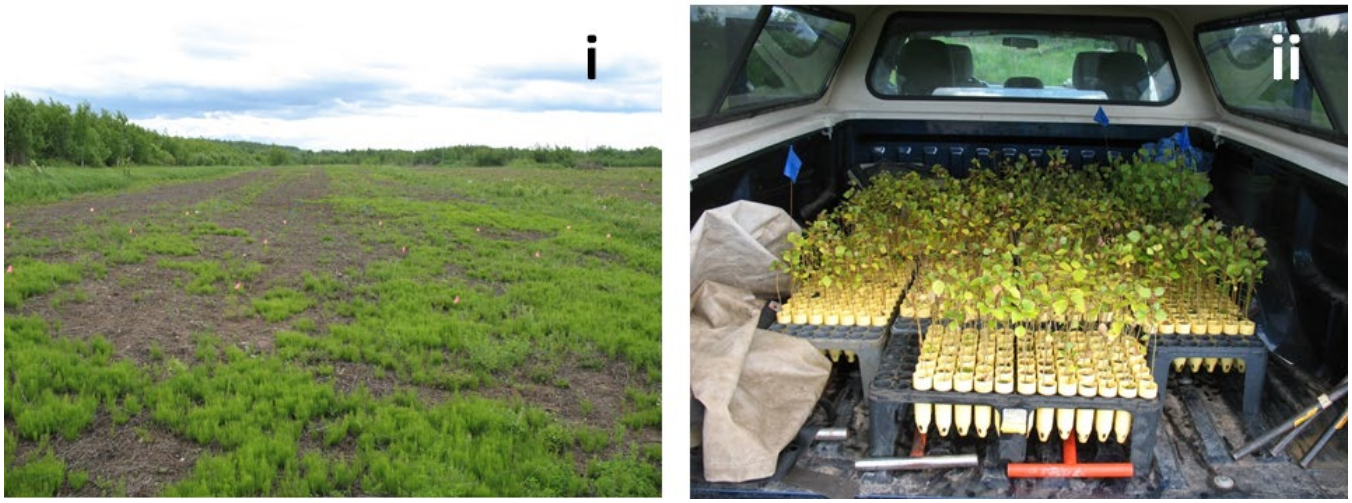


Figure G. (i) Plot layout overview – looking south, 12-inch sediment cover area; (ii) Cottonwood (Populus deltoides) seedlings ready for planting on June 19th, 2017.

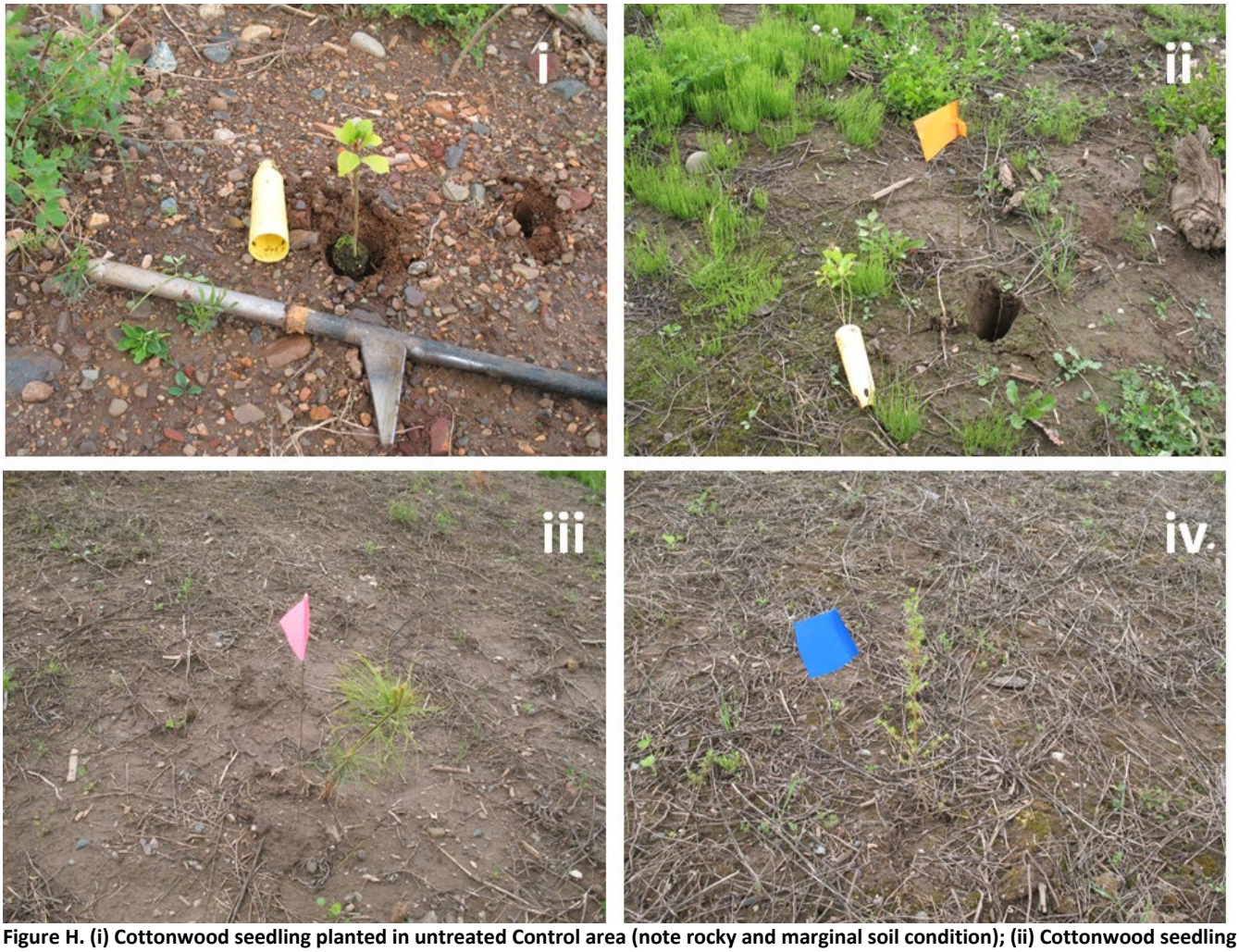


Figure H. (i) Cottonwood seedling planted in untreated Control area (note rocky and marginal soil condition); (ii) Cottonwood seedling ready for planting in area treated with dredged sediment; (iii) White Pine (Pinus strobus) seedling planted in sediment-treated area; (iv) Tamarack (Larix laricina) seedling planted in sediment-treated area. Plot and planting locations area flagged according to species: Orange=Cottonwood; Pink=White Pine; and Blue=Tamarack.

Amendment Request November 21, 2017: A request was submitted for a one year no cost extension to the project. The project was delayed by one year due to a delay from a federal funding source that was used to pay for the transportation of the sediment material from the Erie Pier site in Duluth, Minnesota to the research site near Eveleth, Minnesota. The delayed federal funding has the project timeline behind by one calendar year. Extending the project completion date to June 30, 2019 would allow us one more full growing season and enable us to complete the project as proposed.
Amendment Approved: May 30, 2018

Project Status as of December 1, 2017: Tree seedling survival was recorded in October. Overall Cottonwood (Populus deltoides) had the best first year survival at 90.8% over all treatments. The 12 inch sediment had the best Cottonwood survival at 93.3%. Tamarack (Larix laricina) had the worst survival over all at just 14.8%. Tamarack survival was highest on the control with 18.6%. White Pine (Pinus strobus) survival over all was 75.2% with the highest survival on the 12 inch sediment treatment at 81.4%. The results are reported in Table A.

Table A. First year seedling survival by species and treatment as a percent.

	Tamarack	White Pine	Cottonwood
Control	18.6	75.7	87.1
6 inches	13.3	68.6	91.9
12 inches	12.4	81.4	93.3
Over all	14.8	75.2	90.8

Cottonwood seedlings will be over wintered here at the NRRI greenhouse for replacement planting in the spring. Containerized White Pine seedlings have been ordered from Lakes States Evergreen Co LLC in Cohasset, MN for replacement planting. Unfortunately they don't have Tamarack seedlings available so we will be using a bareroot seedling from the MN DNR for replacement planting.

The research site and adjacent acreage of approximately 40 acres has been recently permitted for biosolids application by St Louis County. An application of biosolids was applied to the research area on November 28th under the supervision of the Mountain Iron Public Works Director (Figure I). The target rate was 60 lbs of nitrogen per acre as determined by them and the permit specifications. Due to circumstances beyond our control the entire research area had biosolids applied to it. Ideally we would have liked to have treated only half of the area to determine any difference the application has on the tree growth and soil conditions.

Figure I. Biosolids tractor and spreader wagon (left); biosolids after placement on test site (right): November 28, 2017

Please Note: This is a FOUR year project.

Project Status as of July 1, 2018:
Replacement seedlings were planted between May 19th and June 8th, 2018. The late planting date for the Tamaracks was due to weather and availability of trees from the MN DNR. Figure J shows the seedlings. Figure K shows the site and its vegetation in June.

White Pines (5/19/18)	Tamaracks (6/4/18)	Cottonwood 6/8/18)
200 seedlings	579 seedlings	75 seedlings

Figure J: Seedling prior to planting, Spring 2018.

Figure K: The Virginia Landfill Site as it appeared on June 8, 2018.

Amendment Request 07/03/2018

The purpose of this project is to assess: 1) the use dredge sediment for restoration on disturbed mineland; and 2) research the potential to use these sites for purpose-grown vegetation. Trees planted at this site have had either one or two years of growth. In order to better evaluate the potential benefit of sediment we want to also appraise two other project locations where sediment was applied for mineland reclamation and tree growth. In 2010-2011, approximately 30,000 cubic yards were applied for a tailings basin restoration project at the United States Steel Keewatin Taconite (USS KeeTac) operation. In 2013, 3,700 cubic yards of sediment were applied for borrow pit reclamation at the Cleveland-Cliffs Hibbing Taconite (HibTac) operation. In addition to the LCCMR Virginia Landfill sites, we want to evaluate reclamation at the KeeTac and HibTac sites to answer the following three questions:

1) Trees – Which tree species were most successful and which are least? (with a focus on species common to all three sites)
2) Site Soil Fertility – What is the soil fertility/chemistry at the three mineland sites and how could this have affected tree growth?
3) Topography – Is there a variation in site topography and does it influence tree growth success?

Topography variation will be mapped by drone flights at each of the sites. Vegetation health will also be mapped during the drone flight (Figure L).

NRRI has saved ENRTF travel funds while still accomplishing outcomes for Project Activities 1 ($9316.00) and 4 ($8420.00), and both are completed, a total savings of $17,736.00. We are requesting a project amendment to apply these funds to Activities 5 and 6 to answer the three questions. The following amendments to the project budget are proposed:

A. Activity 1 is complete. $9316 will be transferred from Activity 1 budgets to Activity 3 for personnel, supplies, and travel associated with sampling, monitoring, site mapping, and drone at: 1) the LCCMR Virginia Landfill site; 2) HibTac reclamation gravel pit; and 3) KeeTac tailings site.
B. Activity 4 is complete. Remaining funds ($8420) for personnel, technical services, and travel will be transferred to Activity 5 ($5000) for personnel, sampling. $3420 will be used for Activity 6 personnel for final site visits.

In addition, Project Manager Craig Maly has new responsibilities at NRRI. Marsha Patelke is assigned to take over the responsibilities of project manager as amended above (see page 1).

This project is scheduled to conclude July 1, 2019. Because of the seasonal nature of plant growth and leaf out, the final field work including plant surveys and sample collection will need to be conducted through the end of June, 2019. The tree leaves need to be present and well-formed for identification purposes, and to tell if the tree is alive. We are requesting a three month extension to complete the final report by October 1, 2019. No funds will be expended after June 30, 2019.

Amendment Approved by LCCMR 3/1/2019

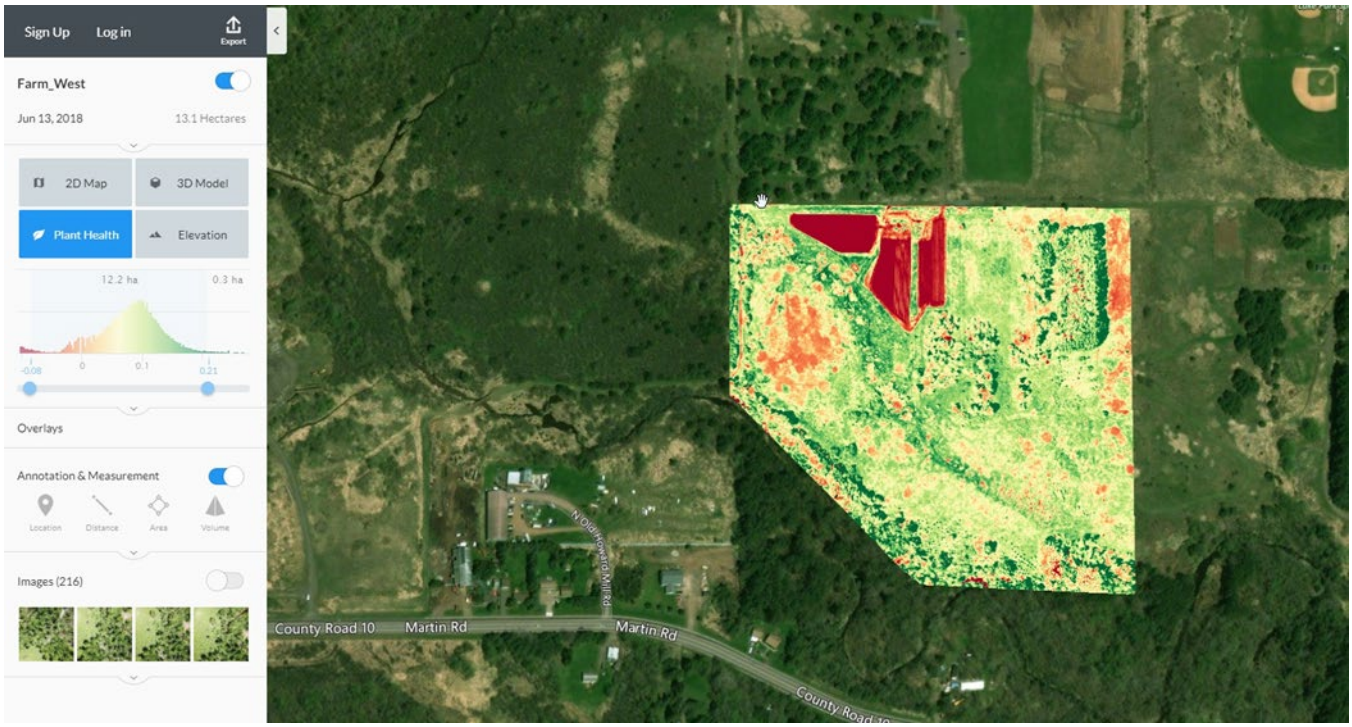


Figure L. This figure illustrates the results that can be obtained by use of a drone to assess plant health and site conditions. This figure is from a site in Duluth, Minnesota and shows plant health. Areas in red have poor plant health and areas in green are the healthiest.

Project Status as of December 1, 2018: Work completed for the project since July has included data collection and compilation from the tree survival survey completed in the fall, soil results, and the floristic inventory.

Project Status as of July 1, 2019 (Submitted November 15, 2019):
This is the final report for the *Dredged Sediment for Forest Restoration on Unproductive Minelands* project. The last round of field work was completed in May and June 2019 and included: 1) tree assessment including counting and measuring/or evaluation at the Virginia Landfill, Hibbing Taconite gravel pit, and USX Keewatin Taconite tailings basin, 2) collection of soil samples for soil fertility analyses, and 3) drone flights at the Virginia Landfill and Hibbing Taconite sites. Work at these sites was completed to evaluate tree growth, successful tree species, soil fertility, and other potential influences on tree growth and survival. Mr. Thomas Lee from the Minnesota Department of Natural Resources Mineland Reclamation group toured the Virginia site on June 26, 2019. We also tour the United Taconite facility to observe tree growth and wetlands creation at their tailings 1 basin reclamation site. Hybrid poplars were planted at this location in the 1990 and the dredge material was applied in 2002, giving a longer time period for revegetation and tree growth. It should be noted that the current biomass market economics have not supported this type of energy production. Drawbacks include potential environmental impacts and the need for subsidies in order to currently compete with fossil fuels (https://www.epa.gov/environmental-economics/economics-biofuels).

Amendment Request December 3, 2019

We are requesting that the following funds be shifted:

- Supplies budget under Activity 2 and 3 would be reduced by a total of $6,675 to a revised budget of $4,979

These changes are requested to cover additional personnel time required to complete field work, dissemination, and reporting. Savings were realized in the activities listed above, especially in travel and other expenses.

- Total personnel budget would increase by $6,675 to a revised budget of $253,359.

Spring was late in 2019 and additional staff was required in order to complete the spring 2019 field work by the project end date.

- Steven Monson Geerts
- George Host
- Kurt Johnson
- Kristina Nixon

Amendment Approved by LCCMR 2/28/20

Overall Project Outcomes and Results:
This project investigated using sediment dredged from the Duluth-Superior Harbor for enhancing mineland restoration, beyond what is required by state reclamation requirements, and to demonstrate potential economic gain from purpose-grown trees for biofuel. Funding was provided by ENRTF. The NRRI secured supplemental funding from the U.S. Army Corp of Engineers and the U.S. Department of Commerce to support transport of 4,500 cubic yards of dredge material to the Virginia, Minnesota landfill project site.

The Virginia Landfill property was cleared of existing vegetation in 2015 and three study plots were constructed, totaling approximately 4.5 acres. Dredge material was applied in two of the plots at 6-inch and 12-inch thicknesses; the remaining plot (control) did not receive sediment. Cottonwood, Tamarack, and White Pine were planted in 2017 and 2018.

Major project tasks included: counting surviving trees and measuring their heights; soil fertility sampling; and floristic inventories of all plants. For comparison purposes, tree-planting success at two sites previously treated with dredge sediment was also evaluated.

Tamarack had the lowest survival rate and White Pine had the highest, regardless of the plot. Cottonwood were more successful in the sediment plots than in the control. Average tree heights ranged from less than a foot to 2.5 feet at the project site, while high mortality and inconsistent growth rates were observed at the two comparison sites.

The economic potential from purpose-grown trees cannot be estimated with so short a growing time. Trees require 20 to 90 years' growth to attain a marketable height of 40 to 50 feet. Consequently, the greater near-term value of applying dredge material to disturbed or mined land is associated with shortening the time it takes to establish good vegetative cover. Based on the study results and observations, creating pollinator habitat could be another beneficial dredge material use.

IV. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1: Site Preparation and Baseline Productivity
Description: These activities prepare the staging and research plot areas for deployment of sediment to enhance the site prior to planting, including:

- Shearing and removal of standing biomass;
- Processing and transfer of biomass to user;
- Weighing of yield (load monitoring);
- Biofuels analysis (ash content and MBtu).

The research plot area is covered with emergent, volunteer plant species (i.e. brush and saplings) of low productivity, since the site is soil deficient. A contractor will be hired to remove (i.e. shear), transport, chip and ship the harvested biomass. Each load will be sampled and weighed to determine yield and baseline productivity. The samples will be split (one to be retained, one to be analyzed as fuel).

These activities also result in the following data/information from the research site:

- List and incidence of plant species, before site preparation;
- Cost to remove and process biofuels;
- Quantity, quality and value of biofuels.

The baseline floristic survey documents the species mix and relative incidence of these species on the site before further activities, including the placement of dredged sediment. Also, the value and quality of the biofuels removed from the site will be documented. This data will serve as a baseline and will be compared to the results of enhancements to the site (i.e. purpose grown species and their productivity when sediment is used).

Summary Budget Information for Activity 1:

ENRTF Budget: $ 41,180~~50,496~~
Amount Spent: $ 41,180
Balance: $ 0 ~~9316~~

Activity Completion Date: September 1, 2015

Outcome	Completion Date
1. Floristic survey DONE	Oct 31, 2014
2. Initial harvest DONE	Dec 31, 2014
3. Biofuels analysis DONE	Sept 1, 2016

Activity 1 is complete. ~~The remaining funds ($9316) are being transferred and applied to Activity 3.~~

Activity Status as of October 1, 2014: The Right of Entry documents were fully executed between the University and St. Louis County allowing research activities on lands owned and administered by the County (see Location

above for the legal description of this property). This document was executed after the appropriation was verified. The research site is described as Stockpile Area, Mine Bench and Biosolids Field. The Stockpile Area was prepared by a contractor selected by the County without financial impact to ENRTF funds. This area was leveled and driveways were installed for truck activities. This area will accommodate either end or side dump trucks. The size of the Stockpile Area is sufficient to store up to 20,000 cubic yards of Erie Pier Dredged Sediment. The initial loads will be delivered during the month of October. These activities are performed under the authority and agreement of St. Louis County.

All transport and delivery of Erie Pier Sediment will be documented and reported in the subsequent Status Report (April 1, 2015). ENRTF funds will not be used for transport or delivery of sediment. In addition, our efforts to secure additional funding for transport and delivery of sediment from Duluth to the Stockpile Area will be reported.

The Floristic Survey (conducted by Dr. Gerould Wilhelm on September 24, 2014) was completed for the research site but not billed to NRRI in time for this Status Report. The annual amount of $3,000 for this service will appear in the subsequent Status Report. This initial Floristic Survey depicting the species and incidence of vegetation is attached to this Status Report.

These activities required two round trips to the research site from NRRI and one trip to the Erie Pier Confinement and Disposal Facility in Duluth to coordinate the transport activities.

Activity status as of April 1, 2015: Initial biomass sampling to commence. Land surveying to be completed. Additional transport and delivery of sediment to be contracted with external funds. Biofuels analysis to be completed.

Activity status as of July 1, 2015: No activity.

Activity status as of April 1, 2016: Additional monies were awarded from the U.S. Department of Commerce, Economic Development Administration, to facilitate the delivery of additional 2,527 cubic yards (approximately 140) truckloads of Erie Pier Sediment to the stockpile for this project. Unfortunately, completion of this sediment work took place nearly a year later than originally planned, as the release of funding resources needed to complete the dredged sediment delivery was delayed by an excessively long bid review process, a process that took over 8 months to finalize following the submittal of University-approved competitive bids to the agency in early 2015. The standing biomass available on the site was determined to be uneconomical at this time to harvest for biomass. No commercial contractors were interested in harvesting the small diameter material available.

Activity status as of July 1, 2016: Biomass samples were collected from existing surrounding woody vegetation to estimate biomass that existed on site prior to clearing, results will be included in final report.

Activity status as of December 1, 2016: No floristic survey was done this year. Site has been sprayed with herbicide. A final floristic survey will be done next year after the site is planted and a new plant community is allowed to reestablish.

Activity status as of July 1, 2017: No activity.

Activity status as of December 1, 2017: No activity.

Activity status as of July 1, 2018: No activity.
Review of Outcomes completed:

In 2014, Gerould Wilhelm from Conservation Institute completed a floristic quality survey at Erie Pier (where the dredge sediment was stored) and the Virginia Landfill study site, prior to site preparation for this study in 2015. Results from this inventory were previously submitted with the October 2014 progress report. Sediment was then moved to the site and stockpiled until placement in 2016. A floristic inventory of the project site is scheduled for late August 2018. We will also be utilizing a drone, if the amendment is approved, for an overview of plant health and site conditions. Results from both of the surveys will be presented in the next progress report.

In May, 2016, samples were collected for biomass assessment from the five stared locations on Figure D. Five one hundredth acre circular plots were established at the Virginia landfill site to collect initial biomass data from the existing woody vegetation at the site. Tree diameters were measured at DBH (diameter breast height) on all plot trees before felling. All plot trees were cut down and weighed on a hanging scale. Sub samples were taken from the stems and branches of the cut down trees. The sub samples were brought back to the lab and weighed for initial wet weight and then oven dried and 105°C until a stable weight was achieved to determine moisture content. From this calculation a dry tons per acre estimate can be made with the field information collected. See Table 1.

Table 1-1.
Biomass Estimate of Original Vegetation
Virginia Landfill Project Site

	Aspen				
	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5
Avg DBH (in)	1.15	0.97	1.07	1.04	1.08
stems/acre	4900	5300	5100	7700	5300
Basal Area	0.369749	0.303472	0.357178	0.390756	0.382725
Harvest wet wt (lbs)	305	260	305	390	330
Wet wt (g)	881	1103.4	1258.4	1467.9	932.7
Oven dry wt (g)	381	481.1	561.7	607.3	395
% moisture	0.568	0.564	0.554	0.586	0.576
Harvest dry wt (lbs)	131.90	113.36	136.14	161.35	139.76
Dry tons/acre	6.60	5.67	6.81	8.07	6.99

No biomass evaluation of the current vegetation has been made. This will be completed during work for Activity 5, Outcome 2.

Activity status as of December 1, 2018: No Activity

Activity status as of July 1, 2019: No Activity

Final Report Summary:
Sediment transport from the Erie Pier facility in Duluth to the Virginia Landfill study site was funded by monies awarded by the U.S. Department of Commerce, Economic Development Administration and the U.S. Army Corps of Engineers. A total of 4,500 cubic yards of dredge material was stockpiled at the project site by the fall of 2015. Loading and transportation costs from Erie Pier to the project site were $13.75 per cubic yard.

Dr. Gerould Wilhelm completed a floristic assessment of the study site in 2014, prior to site clearing and construction (Tables 3 and 4). Dr. Wilhelm applied a coefficient of conservatism (C) – developed by Dr. Wilhelm and others (Wilhelm and Masters, 1995) – to species found at the study site. This coefficient is an estimated likelihood that a plant would occur in a relatively unaltered landscape from what is believed to be pre-European

settlement condition. The scale used for this estimate ranges from 0 (not likely) to 10 (very likely). Table 3 lists the higher-ranked plants observed at the site. The mean C value for the Virginia Landfill site is 2.6 and means that the site is not considered to be natural quality and would require mitigation to be considered a natural area. This is not surprising, due to the historic use of the site as a waste rock stockpile constructed and disturbed by mining activities. Wilhelm identified 67% native species and 33% adventive plants. Adventives are plants that may have been introduced by human activities. Three invasive species were identified and included *Cirsium arvense* (Canada thistle), *Cirsium vulgare* (Bull thistle), and *Lotus corniculata* (Bird's-foot trefoil).

Table 1-2. Plants Identified at the site by Wilhelm in 2014

C	**Scientific Name**	**Common Name**
3	*Agrimonia Striate*	agrimony
3	*Anaphalis margaritacea*	pearly everlasting
3	*Anemone virginiana*	thimbleweed
3	*Clinopodium vulgare*	wild basil
3	*Epilobium angustifolium*	fireweed
3	*Hieracium kalmii*	kalm's hawkweed
3	*Solidago gigantea*	late golden rod
4	*Argrostis hyemalis*	ticklegrass
4	*Aster macrophyllus*	big leaved aster
4	*Danthonia spicata*	poverty grass, oatgrass
4	*Galium triflorum*	fragrent bedstraw
4	*Lysimachia ciliata*	fringed loosestrife
4	*Maianthemum canadense*	canada mayflower
4	*Rosa acicularis*	wild rose
4	*Salix humlis*	prairie willow
5	*Amelanchier sanguinea*	round leaved serviceberry
5	*Carex normalis*	sedge
5	*Cinna latifolia*	wood reedgrass
5	*Corylus americana*	hazel nut
8	*Lathyrus ochroleucus*	pale vetchling

Table 1-3. Summary of 2014 floristic inventory

43	Native Species
64	Total Species
2.6	Native Mean C
1.8	w/Adventives

In the spring of 2016, commercial contractors evaluated the existing vegetation and determined the small trees that occupied the site were not of commercial value. Biomass samples were then collected to assess the existing biomass prior to site clearing. As mentioned in July 2018, biomass assessment is completed by measuring tree diameters at breast height (DBH) and in the U.S., at about 130 centimeters (cm). Trees across the project site were about 1 inch in diameter. A second measurement of biomass was planned for the end of the project as part of Activity 5.

Reference

Wilhelm, G., and L.A. Masters. 1995. Floristic quality assessment in the Chicago Region and application computer programs. Morton Arboretum, Lisle, IL. 17 p.

ACTIVITY 2: Erie Pier CDF Activities and Stockpiling of Sediment

Description: These activities involve the monitoring of the loading of Erie Pier Sediment from the Duluth Containment Facility (CDF), then the monitoring of the shipment of sediment to the prepared staging area on the Landfill Property, including:

- Loading and monitoring of sediment from CDF at Erie Pier (samples and load out data);
- Monitoring of deliveries (load received and quantities at research site);
- Sampling of delivered sediment (representative samples from loads as received at research site);
- Bioassay of sediment samples (potted study to provide purity/weed-free data);
- Management of sediment stockpile (spray and cover as needed, then monitor).

ENRTF funds will be expended only in the sampling and monitoring of activities at the Containment Facility, jointly operated by the Duluth Seaway Port Authority and US Army Corps of Engineers (i.e. not for transport costs). Loading and transport of the sediment will be supported by other funds. A composite sample of each load will be taken and each load will be monitored. Load tickets will be retained. As loads are delivered to the staging area near the research plots, the sediment will be bulldozed and the stockpile will be sloped and tended. A contractor will be hired when St. Louis County personnel and equipment are not available. NRRI has established a bioassay protocol for determining the presence of viable seed and plant fragments in sediment samples. Retained sediment samples will be used for these bioassays. Before sediment is deployed from this staging area, emergent weeds will be controlled by spray and/or cover, as needed. This will ensure weed control prior to deployment of sediment onto the research plots. Special emphasis will be placed on the control of invasive weed species, such as Purple Loosestrife.

Please Note: ENRTF monies will not be used for the transport of the sediment from the Erie Pier CDF to the staging area.

Summary Budget Information for Activity 2:

ENRTF Budget: $ ~~48,546~~ 45,803
Amount Spent: $ 39,845
Balance: $ ~~8,701~~ 5,958

Activity Completion Date: September 1, 2015

Outcome	Completion Date
1. CDF activities DONE	Dec 31, 2015
2. Receipt of deliveries DONE	Dec 31, 2015
3. Sampling and bioassay DONE	June 30, 2019
4. Stockpile management DONE	June 30, 2015

Activity status as of October 1, 2014: No activity.

Activity status as of April 1, 2015: Initial deliveries of sediment completed. Biomass sampling, bioassay and estimation to be completed. Additional shipments of sediment to be contracted with external funds. Stockpile to be managed. Preparation of research sites to be completed.

Activity status as of July 1, 2015: The biofuels assessment of standing biomass has been delayed until after leaf fall. The contractor for shearing (initial harvest) has been selected and initial contact with Laurentian Energy for the use of the biofuels has been made. The shearing will be performed as the contractor is available and occur after leaf fall. Biofuels analysis will also be conducted after leaf fall. The perimeter of the research plot was determined by cut lines and approved by St. Louis County. Based on site assessment, biomass observations and literature review, we have delayed sampling and bioassay until Fall of 2015 (after leaf drop). Supplemental funding for additional deliveries of sediment has not be secured, however Federal Economic Development

Administration and St. Louis County have indicated willingness to provide monies for this purpose. Weeds emerging on the stockpile will be sprayed with a herbicide during the coming weeks.

Activity status as of April 1, 2016: Final delivery of 2527 cubic yards 140 truckloads of Erie Pier Sediments were completed with external funds. Stock pile was managed and deployed on research site in November 2015. Current stock pile of sediment has been depleted.

Activity status as of July 1, 2016: Stock pile site will be maintained by St. Louis County as a stock pile area for potential future deliveries of sediment for other projects.

Activity status as of December 1, 2016: No activity

Activity status as of July 1, 2017: No activity.

Activity status as of December 1, 2017: No activity.

Activity status as of July 1, 2018: No activity.

In 2016 nine soils samples were collected from the site, both sediment and existing soils, for nutrient analyses and 27 element ICP chemical analyses. The table below provides the results of the 2016 nutrient testing. Remaining results will be provided in the final report.

Table 2-1. 2016 Soil Analyses Results

7/12/2016 Sample Number	Bray P (ppm)	Olsen P (ppm)	NH_4OAc-K (ppm)	LOI OM (%)	Water pH	SO_4-S (ppm)	1:1 Elec. Conductivity (mmhos/cm)	TOC (% C)
1	12 / 13	16 / 16	56 / 61	2.8 / 2.7	7.5 / 7.5	54 / 52	0.5 / 0.5	1.82 / 1.93
2	13	15	67	2.7	7.6	27	0.3	1.82
3	12	16	70	2.6	7.7	27	0.3	1.96
4	13	13	64	2.2	7.6	43	0.4	1.70
5	12	16	77	2.7	7.7	31	0.4	2.05
6	14	15	87	3.2	7.6	23	0.3	2.14
7	3		75	1.7	6.7	2	0.1	0.99
8	5		155	3.0	6.7	3	0.1	1.94
9	5		148	2.8	7.0	4	0.2	1.65

Note: Samples 1, 2, 3 are from the 12 inch sediment plots, 4, 5, and 6 from the 6 inch sediment plots, and 7, 8, and 9 from the control plot.

Activity status as of December 1, 2018 (submitted November 15, 2019):

Four sediment samples were collected from the site on October, 24, 2018 for soil nutrient analyses. Composite samples were collected from the remaining stockpiled sediment as well as from the three test plots. Samples were collected from all three tree type zones for the control, 6 inch thick, and 12 inch thick plots. The samples were submitted to the University of Minnesota Soils Laboratory for testing. The results are presented at the bottom of the table below

Table 2-2. 2018 Soil Analyses Results

Sample Number	Bray P (ppm)	Olsen P (ppm)	NO3_n (ppm)	LOI OM (%)	K (ppm)	Water pH	SO_4-S (ppm)	Conductivity (mmhos/cm)
2018 Sediment Sampling Results								
2018-12	7	nr	10.6	2.7	62	7.3	9	0.2

Sample	Bray P	Olsen P	NO3_n	LOI OM	K	Water	SO_4-S	Conductivity
2018-6	8	11	8.6	2.2	41	7.5	8	0.2
2018-C	1	nr	4.3	3.0	107	6.6	8.0	0.10
2018-Sed	11	14	5.9	2.2	93	7.5	9	0.2

Note: 12 = plot with 12-inch-thick sediment, 6 = plot with 6-inch-thick sediment, C = control plot, Sed = remaining sediment pile.

Figure 2-1: Sediment Fall 2018. 12 inch plot

Activity status as of July 1, 2019 (submitted November 15, 2019)

Ten soil samples were collected from the Virginia Landfill site in June 2019 and submitted to the University of Minnesota Soils Laboratory for testing. Analyses included ICP 27 element EPA method 3051, total organic carbon, and regular soil testing for mineral soils (P, pH, salts, sulfate). Composite samples consisted of sediment collected from three locations associated with each tree type within each plot. Samples were placed in a bucket and mixed before packaging for testing. Results are provided in Table 2.3.

Table 2-3 2019 Soil Analyses Results

Sample Number	Bray P (ppm)	Olsen P (ppm)	NH_4OAc-K (ppm)	LOI OM (%)	Water pH	SO_4-S (ppm)	Soluble Salts Conductivity (mmhos/cm)	TOC (% C)
2019 Sediment Sampling Results								

Sample	Bray P	Olsen P	NH_4OAc-K	LOI OM	Water	SO_4-S	Soluble Salts Conductivity	TOC
2019-T-1	16 / 17	9 / 9	71 / 69	2.5 / 2.4	7.8 / 7.8	7 / 9	0.2 / 0.2	1.434 / 1.498
2019-T-2	15	10	59	2.7	7.8	7	0.1	1.543
2019-T-3	14	9	48	2.3	7.8	7	0.1	1.415
2019-S-1	19	9	41	2.0	7.8	6	0.1	1.213
2019-S-2	15	9	62	2.6	7.8	7	0.2	1.450
2019-S-3	19	12	75	2.5	7.8	8	0.2	1.525
2019-C-1	3		85	1.7	6.8	5	0.1	1.004
2019-C-2	2		100	2.5	6.7	4	0.1	2.340
2019-C-3	4		110	1.6	7.0	4	0.1	1.073
2019-U-1	9		48	1.4	7.3	4	0.1	0.420

2019-T = 12-inch-thick sediment plot, 2019-S = 6-inch-thick sediment plot, 2019-C = control plot, no sediment
2019-U = untreated mining waste material.

Figure 2-2: Soil sampling 2019.

Final Report Summary:
Erie Pier sediment was delivered to the Virginia Landfill site between April 2015 and April 2016. A total of 4,500 cubic yards of material was delivered. The NRRI facilitated securing funding for sediment transportation, which was provided by the U.S. Army Corp of Engineers and the U.S. Department of Commerce, not from ENRTF monies.

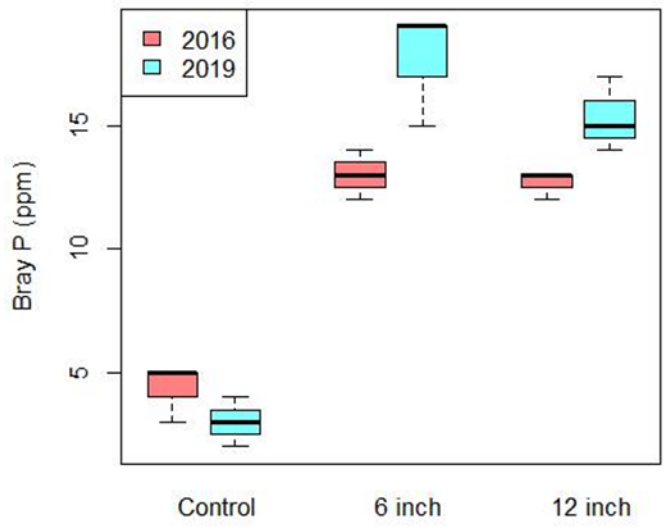
Initial biomass assessment was completed on woody vegetation in the fall of 2015, and initial soil sampling was completed in 2016. To evaluate the difference in soil/sediment fertility between plots and changes over time, data from soil samples were collected in 2016, 2018, and 2019. The table below summarizes these 2016 and 2019 results.

Table 2-4. Soil Analytical Results 2016 and 2019.

Sample Number	Bray P (ppm)	Olsen P (ppm)	NH4OAc-K (ppm)	LOI OM (%)	Water pH	SO4-S (ppm)	Soluble Salts Conductivity (mmhos/cm)	TOC (% C)
Twelve inch sediment plot								
2016-1-T	12 / 13	16 / 16	56 / 61	2.8 / 2.7	7.5 / 7.5	54 / 52	0.5 / 0.5	1.82 / 1.93
2016-2-T	13	15	67	2.7	7.6	27	0.3	1.82
2016-3-T	12	16	70	2.6	7.7	27	0.3	1.96
2019-T-1	16 / 17	9 / 9	71 / 69	2.5 / 2.4	7.8 / 7.8	7 / 9	0.2 / 0.2	1.434 / 1.498
2019-T-2	15	10	59	2.7	7.8	7	0.1	1.543
2019-T-3	14	9	48	2.3	7.8	7	0.1	1.415
Six inch sediment plot								
2016-4-S	13	13	64	2.2	7.6	43	0.4	1.7
2016-5-S	12	16	77	2.7	7.7	31	0.4	2.05
2016-6-S	14	15	87	3.2	7.6	23	0.3	2.14
2019-S-1	19	9	41	2	7.8	6	0.1	1.213
2019-S-2	15	9	62	2.6	7.8	7	0.2	1.45
2019-S-3	19	12	75	2.5	7.8	8	0.2	1.525
Control Plot								
2016-7 -C	3		75	1.7	6.7	2	0.1	0.99
2016-8-C	5		155	3.0	6.7	3	0.1	1.94
2016-9-C	5		148	2.8	7	4	0.2	1.65
2019-C-1	3		85	1.7	6.8	5	0.1	1.004
2019-C-2	2		100	2.5	6.7	4	0.1	2.34
2019-C-3	4		110	1.6	7	4	0.1	1.073

The 2016 and 2019 results are compared to the University of Minnesota Extension Service 2008 document, *Soil Test Interpretations and Fertilizer Management for Lawns, Turf, Gardens, and Landscape Plants* (U of M Extension, 2008), in order to evaluate the results for specific nutrients. The nutrient relative levels are in relation to site use and can be influenced by soil texture as well as pH.

- Phosphorous (P)



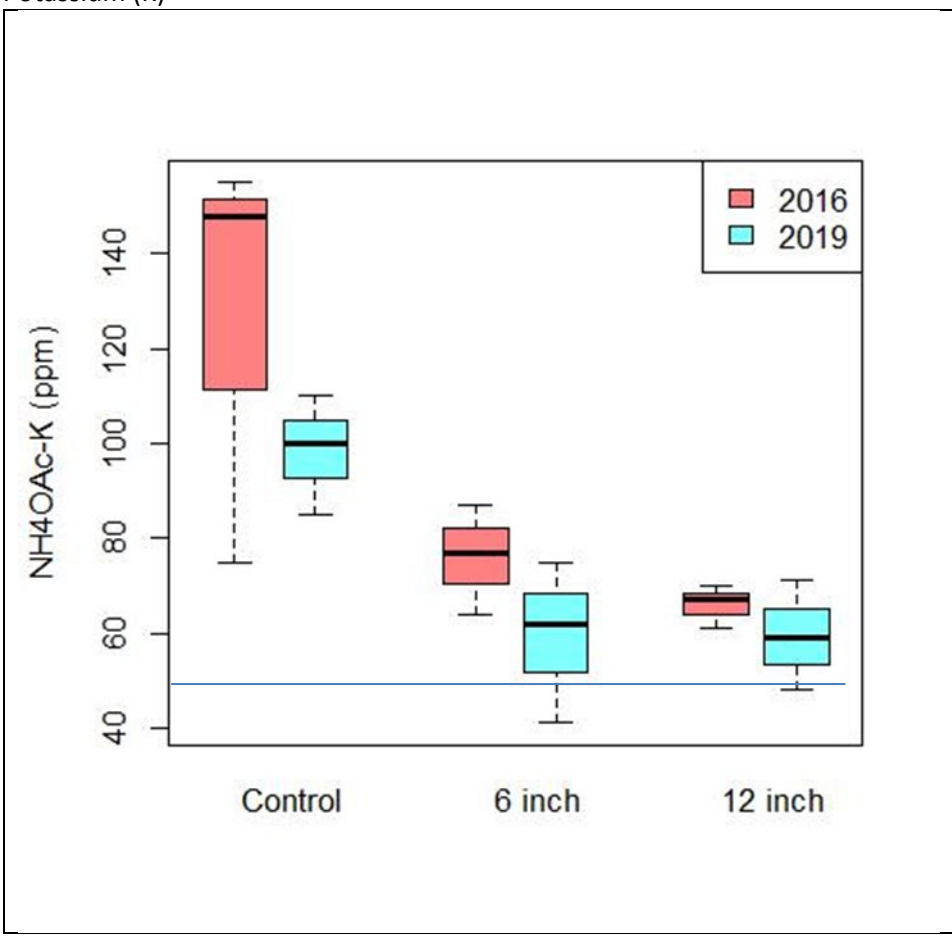
Bray (p) relative levels for soil

Low = 0 – 5 ppm
Medium = 6 – 10 ppm
High = 11 – 25 ppm
Very High = over 25 ppm

Figure 2-3: Range and average of P results from 2016 and 2019

Phosphorous content of a soil is determined by two different tests and is based on pH. Bray (P) determines the level of phosphorous available to plants in soils with a pH of 7.4 or less. For soils with a pH greater than 7.4, the Olsen P test procedure is used to determine the level of plant available phosphorus. Phosphorous results for soils samples collected at the project site are low in the control plot and medium to high in the sediment test plots. Concentration of P decreased in the control plot and increased in the 6- and 12-inch plots over time.

- Potassium (K)



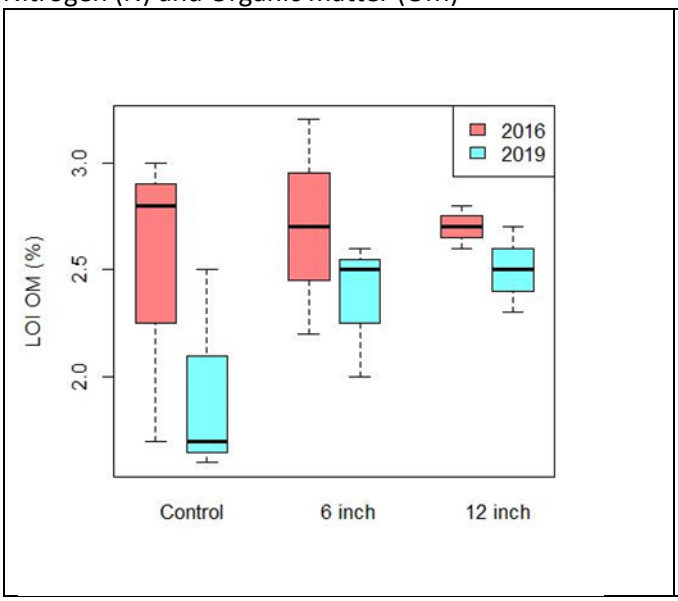
K relative levels in soil

Low = 0 – 50 ppm
Medium = 51 – 100 ppm
High = 101 – 150 ppm
Very High = over 150

Figure 2-4: Range and average of K results from 2016 and 2019

Potassium was analyzed by two different methods, and they give different results. The test method NH_4OAc-K provides the amount of available K for plant use. Potassium values in the graph above indicate K is higher in the control plot than the 6-inch and 12-inch plot and decreased through time. In 2019, results are considered medium to high for the control plot and medium in the sediment plots.

- Nitrogen (N) and Organic matter (OM)



U of M Extension Classification of OM
Low = less than 3.1%
Medium = 3.1 to 4.5 %
High = 4.5% to 19%

Figure 2-5: Range and average of nitrogen results from 2016 and 2019

Nitrogen is mobile in soils and can be bound to the organic matter in the soil. The 2008 U of M Extension document makes recommendations for nitrogen fertilization based on Organic Matter (OM) test results. The study site OM concentrations are considered low results, ranging from 3.2% to 1.6%. The control plot has the lowest OM.

- Total organic carbon (TOC)

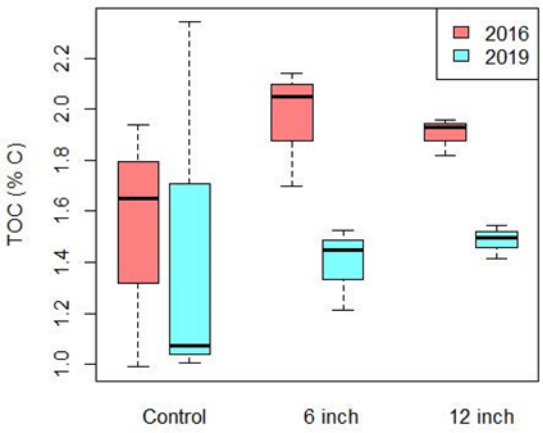


Figure 2-6: Range and average of TOC results from 2016 and 2019

Total organic carbon is stored in organic matter. Analyses results for all samples range between 1% and 2.34%. Each of the plots shows a decrease in TOC between 2016 and 2019. The sediment plots contain more TOC in 2016 and less in 2019.

- pH - water

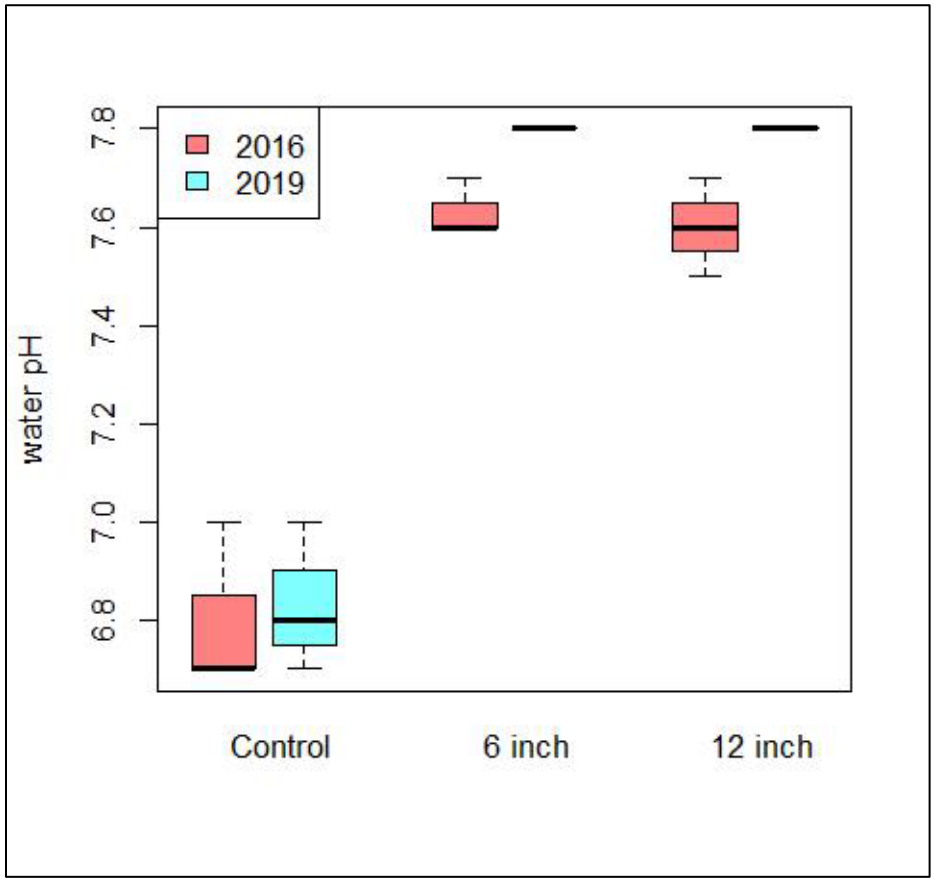


Figure 2-7: Range and average of pH results from 2016 and 2019.

Soil fertility analyses indicate that pH levels are higher in the sediment plots (Figure 2-7), which could negatively impact the growth of some tree species, like the Tamaracks.

Table 2-6: Site tree species and pH ranges for best growth

Tree species	Preferred pH range
Tamarack	5.5 – 6.5
White Pines	6.0 – 7.5
Cottonwoods	4.5 – 8.0

Biosolids were spread across the whole site instead of only a portion of the site in November 2017. Because of this mistake, any influence on the soils cannot be determined from the testing results (see Activity 3, December 1, 2017 activity status. It is common for biosolids to be higher in Nitrogen, which in sufficient quantities could be detrimental to trees. In 2018, a sample was collected from the remaining stockpile of sediment leftover from site construction. In general, the sediment alone had higher P, lower N, and higher K than the two sediment test plots where biosolids were applied. Organic matter and water pH were similar.

References:

University of Minnesota Extension. 2008. Soil Test Interpretations and Fertilizer Management for Lawns, Turf, Gardens, and Landscape Plants.

South, D.B. 2017. Optimum pH for Growing Pine Seedlings, Tee Planters' Notes, Vol. 60, Number 2, Fall 2017.

Minnesota Pollution Control Agency, Minnesota Stormwater Manual, Tree species list – pH and moisture ranges, https://stormwater.pca.state.mn.us/index.php/Tree_species_list_-_pH_and_moisture_ranges.

United States Department of Agriculture Natural Resources Conservation Service. 2002. Plant Fact Sheet Eastern Cottonwood, https://plants.usda.gov/factsheet/pdf/fs_pode3.pdf.

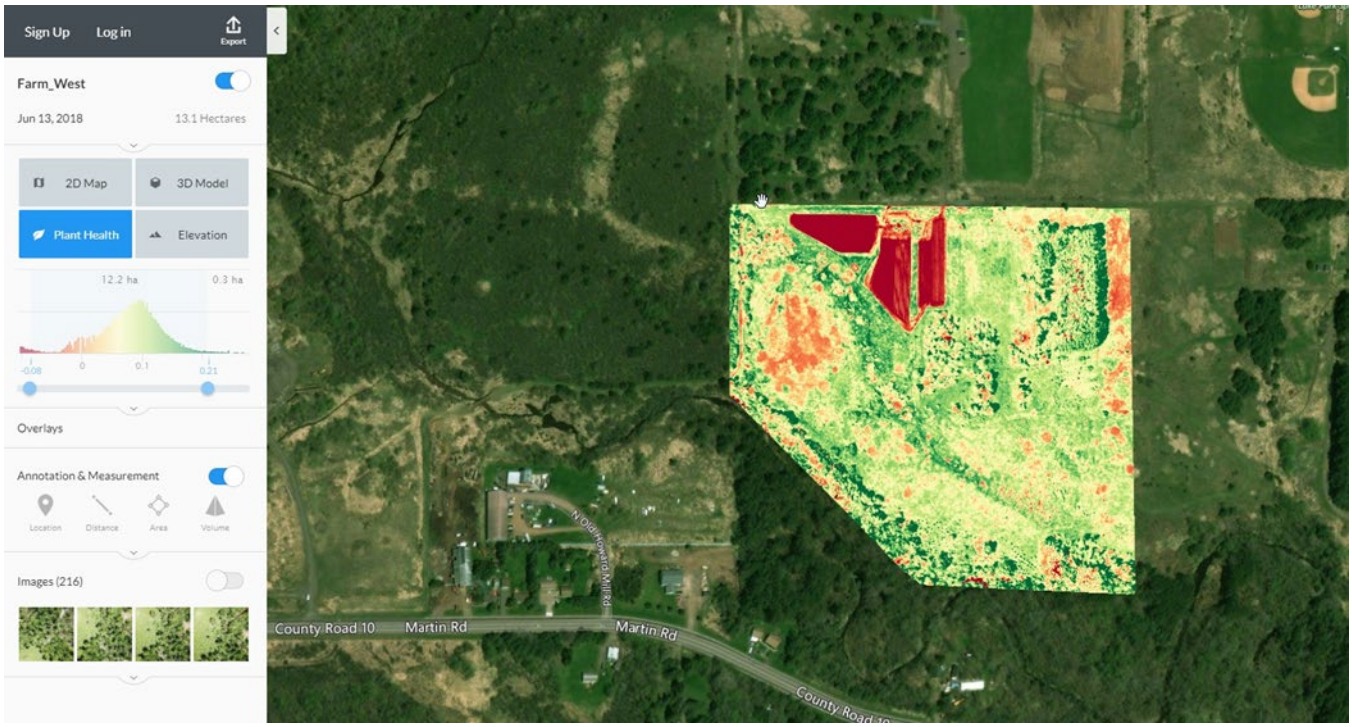
ACTIVITY 3: Sediment Deployment and Substrate Management
Description: These activities involve the initial placement and management of the substrate from the stockpile to the research plots, including:

- Deployment, grading and surface preparation (prepare research plots for purpose grown plants);
- Weed control (monitor and eliminate unwanted vegetation);
- Nutrient and stimulant application (fertilizer and biological products for the benefit of plant growth);
- Seeding with cover crop (green manure and organic matter building);
- Monitoring of vegetation (data on success or per cent of cover);
- Research plot layout (map of purpose grown species).

These activities describe the preparation of the research plots, the transport of sediment from the staging area located at the research site, the placement of the sediment onto the research plot areas and the initial management of the substrate (i.e. blanket of sediment in place). Based on the initial sample analysis of the sediment, the fertility and biology of the sediment will be amended in place. Products will be applied to the surface of the sediment and incorporated. Seeds of native species approved as cover crops by BWSR and MN DNR will be applied to the research plots. The success of the establishment of this cover will be monitored and reported. The position and placement of purpose grown shrubs and trees will be marked. A detailed map of these plots will be made available for review.

Vegetation monitoring and plot mapping will be completed by traditional field work and augmented with drone flights. We will complete additional site mapping, topography, conditions, and plant health with a drone. This type of vegetation assessment will be completed at a USS (KeeTac) tailings basin and a Cleveland-Cliffs (HibTac) gravel pit, where Erie Pier sediment was applied and trees were planted in 2014 and 2011, respectively. Data collected from the Virginia Landfill and the two additional sites will be used for Activity 5. The additional work will be funded by the $9316.00 transferred from Activity 1. Topography variation will be mapped by drone flights at each of the sites. Vegetation health will also be mapped during the drone flight (Figure L).

Several tree species were also planted at these sites, including species common to each, such as tamarack (Larix laricina). Results will compare and evaluate tree growth and survival as well as site conditions these three sites



Summary Budget Information for Activity 3:

ENRTF Budget: $ ~~47,250~~ 46,521

Amount Spent: $ ~~37,805~~42,280

Balance: $ ~~18,761~~ 4,241

Activity Start Date: June 1, 2015

Please Note: We have accelerated the timeline of this activity (specifically plot layout) to accommodate discussions and planning with St. Louis County managers and contractors. This is necessary to schedule Fall 2015 activities.

Outcome	Completion Date
1. Deployment of sediment DONE	June 30, 2016
2. Sampling and analyses DONE	June 30, 2019
3. Cultural applications of products and seed DONE	June 30, 2016
4. Monitoring of vegetation DONE	Sept 30, 2019
5. Plot layout DONE	Oct 31, 2018

~~*Budget NOTE:* $9316 from Activity 1 is being transferred and applied to Activity 3 for vegetation monitoring and plot layout (mapping) as presented in the revised Activity 3 description.~~

Activity status as of October 1, 2014: No activity.

Activity status as of April 1, 2015: No activity.

Activity status as of July 1, 2015: Activities during this period focused on research plot layout, coordination with St. Louis County, nursery maintenance, selection of a contractor for shearing the standing biomass and procurement of planting stock. Planting stock located at the University nursery (facility: North Central Research and Outreach Center, Grand Rapids) was maintained and the purchase of native trees and shrubs were

discussed with Itasca Greenhouse of Cohasset. The research plot has been selected and approved. Monitoring of standing biomass at the research site is in progress.

Activity status as of April 1, 2016: Research area was established late last fall standing vegetation was removed and sediment was placed. Two different depths of sediments were spread. One area has 12 inches of sediment on top of existing soil, the other area has six inches of sediment on top of existing soil. An area with no sediment will be part of the study for a control area.

Activity status as of July 1, 2016: Replicated plot boundaries were established on site and soil samples were collected and have been submitted for soil analysis. Site is being managed for emergent weeds with herbicide.

Activity status as of December 1, 2016: The research site was monitored over the summer and treated with glyphosate herbicide to kill emergent vegetation. An herbicide application will be applied again in the spring prior to tree planting. The analysis results for the soil samples were received from the University of Minnesota Research Analytical Laboratory and will be included in the final report.

Activity status as of July 1, 2017: An application of glyphosate herbicide was applied to the site this spring after green up and prior to planting. The replicated 7 x 10 row tree blocks were measured and flagged out prior to tree planting.

Activity status as of December 1, 2017: The research site and adjacent acreage of approximately 40 acres has been recently permitted for biosolids application by St Louis County. The site will be utilized by the Quad Cities (Virginia, Mountain Iron, Gilbert and Eveleth) municipalities. An application of biosolids was applied to the research area November 28th under the supervision of the Mountain Iron Public Works Director. The target rate was 60 lbs of nitrogen per acre as determined by them and the permit specifications. We had communicated our preference to have only half of each of the three treatment areas receive biosolids to determine any benefit of the application to the trees and any soil differences. Unfortunately due to circumstance beyond our control the contractor applying the biosolids on the site treated the entire research area. When there is another biosolids application there will be an opportunity to do this type of assessment.

Activity status as of July 1, 2018: A manure spreader had been used last year to apply the biosolids. Casual observation and photo documentation of the distribution of biosolids was made at the time of 2018 spring planting. The quantity and coverage varied across the site. Piles of material of varying sizes and thicknesses were observed. This application completes Outcome 3. Note that future applications should use an alternate method of spreading to achieve a more uniform and consistent application. Figure M provides photos of the application. No other activities occurred.

Figure 3-1. Biosolids application. Both photos show sporadic piles of biosolids surrounded by areas with no biosolids applied.

Upcoming additional soil sampling will be conducted at the site in August/September 2018 for nutrient analyses to evaluate the sediment quality since the biosolids were applied, and from the remaining stockpiled soil as an untreated comparison. In addition to analyses at the University of Minnesota Soils Lab, NRRI will evaluate leachate produced by several of the soil samples to complete Outcome 2.

Activity status as of December 1, 2018:
Four tasks were completed for Activity 3 between August and October, 2018 at the Virginia Landfill study site:

- A floristic assessment of the study site was completed by Gary Walton, a Minnesota Field Botanist, on August 27, 2018 to assess the floristic composition and quality.
- The site and its plots were mapped using a drone mid-October.
- A count of surviving trees was completed at the end of October.
- Four sediment samples were collected from the site near the end of October for soil nutrient analyses. Composite samples were collected from the remaining stockpiled sediment and from the three test plots. The samples were submitted to the University of Minnesota Soils Laboratory for testing.

Results from these activities will be provided in the next report.

Activity status as of July 1, 2019 (submitted November 15, 2019):

Gary Walton conducted a floristic assessment of the Virginia Landfill site on August 27, 2018, using a time random meander method on each of the three site plots. In addition to determining an estimated native versus introduced plant species, his method provides an estimate of the quantity of a given plant cover in the area observed (Tables 3-1, 3-2, and 3-3). A slightly greater number of native plants was observed in the control plot. Seven invasive species observed included *Bromus inermis* (Smooth brome grass), *Chrysanthemum leucanthemum* (Ox-eye daisy), *Cirsium arvense* (Canada thistle), *Cirsium vulgare* (Bull thistle), *Linaria vulgare* (Butter and eggs), *Lotus corniculata* (Bird's-foot trefoil), *Melilotus officinalis* (Yellow sweetclover), and *Phalaris arundinace* (Reed canary grass). Table R lists the plot and the invasive species observed.

Table3-1. Native and Introduced Plant species, 2018.

	Control	6-Inch Plot	12-Inch Plot
Native Richness – species	42	37	35
Introduced Richness – species	25	50	34

	Control	6-Inch Plot	12-Inch Plot
Native Cover (%)	184	165	191
Non-native Cover (%)	177	218	281.5

Table 3-2. Invasive species observed listed by plot.

Control Plot	6 Inch Plot	12 Inch Plot
Cirsium arvense	*Bromus inermis*	*Chrysanthemum leucanthemum*
Cirsium vulgare	*Cirsium arvense*	*Cirsium arvense*
Lotus corniculata	*Cirsium vulgare*	*Cirsium vulgare*
Phalaris arundinacea	*Linaria vulgare*	*Linaria vulgare*
	Lotus cornicullata	*Lotus cornicullata*
	Melilotus officinalis	*Melilotus officinalis*
	Phalaris arundinace	*Phalaris arundinacea*
Total Species 4	Total Species 7	Total Species 7

The Daubenmire cover class method was developed to determine cover at a site. A Cover Class indicates a range of the amount of cover by a plant as a percentage. This method uses six separate cover classes (Daubenmire 1959). The higher the Cover Class number, the higher percentage of a given plant cover a defined area, as illustrated in Table 3-3 (Bureau of Land Management, 1996).

Table 3-3. Cover Class Classifications.

Cover Class	**Range of Coverage**	**Midpoint of Range**
1	0 - 5%	2.5%
2	5 - 25%	15.0%
3	25 - 50%	37.5%
4	50 - 75%	62.5%
5	75 - 95%	85.0%
6	95 - 100%	97.5%

The tables below list the plants that were observed to cover between 5% and 75% for each test plot at the Virginia Landfill.

Table 3-4. Cover classes between 5 and 3 for each plot.

Control Plot	**Common Name**	**Percent Cover Class**	**Percent Midpoint**
Agrostis gigantea	Black Bent/Redtop	5	62.5
Fragaria vesca	Wild strawberry	4	37.5
Tanacetum vulgare	Tansy	4	37.5
Equisetum arvense	Field Horsetail	3	15
Populus balsamifera	Balsam poplar	3	15
Populus tremuloides	Quaking aspen	3	15
Cornus sericea	Red osier dogwood	3	15
Rubus strigosus	American red raspberry	3	15
Danthonia spicata	Poverty oatgrass	3	15
Rosa blanda	Smooth rose	3	15
Artemisia absinthe	Common wormwood	3	15
Trifolium pratense	Red clover	3	15
Trifolium repens	White clover	3	15
Salix sp.	Willow	3	15
6-Inch Plot	**Common Name**	**Percent Cover Class**	**Percent Midpoint**
Erigeron canadense	Horseweed	4	37.5
Agrostis gigantea	Black Bent/Redtop	4	37.5
Artimesia absinthe	Common wormwood	4	37.5
Hordeum jubatum	Foxtail barley	3	15
Equisetum arvense	Field Horsetail	3	15
Potentilla norvegica	Rough cinquefoil	3	15
Anemone canadensis	Canada anemone	3	15
Cornus sericea	Red osier dogwood	3	15
Lotus cornicullata	Bird's foot Trefoil	3	15
Phalaris arundinace	Reed canary grass	3	15
Plantago major	Broadleaf plantain	3	15
Sonchus arvensis	Perennial sow thistle	3	15
Tanacetum vulgare	Tansy	3	15
Trifolium hybridum	Alsike clover	3	15
Trifolium pratense	Red clover	3	15
12-Inch Plot	**Common Name**	**Percent Cover Class**	**Percent Midpoint**
Erigeron canadense	Horseweed	5	85
Equisetum arvense	Field Horsetail	5	62.5
Agrostis gigantea	Black Bent/Redtop	5	62.5
Artimesia absinthe	Common wormwood	4	37.5
Trifolium pratense	Red Clover	4	37.5

Solidago gigantea	Giant Goldenrod	3	15
Anthemis cotula	Stinking chamomile	3	15
Cirsium arvense	Creeping Thistle	3	15
Lotus corniculatus	Bird's foot Trefoil	3	15
Medicago sativa	Alfalfa	3	15
Phalaris arundinacea	Reed canary grass	3	15
Phleum pratense	Timothy grass	3	15
Taraxacum officinale	Common Dandelion	3	15
Trifolium hybridum	Alsike clover	3	15

References:
Bureau of Land Management. 1996. Sampling Vegetation Attributes, Interagency Technical Reference: *Revised in 1997, and 1999*. BLM/RS/ST-96/002+1730, 171 p.

Daubenmire, R. 1959. A Canopy-coverage method of vegetational analysis. Northwest Science 33:43-64.

Site Mapping – Drone
A drone was used to produce site maps for the Virginia Landfill site and the Hibbing Taconite Kelly Lake gravel pit in June of 2019 (Figures 3-2 and 3-4).

In addition to site maps, the data collected during the drone flights were used to produce a general overview of plant health at both sites. The RGB approximates a true-color aerial photograph of the site. The Normalized Difference Vegetation Index (NDVI) uses visible Red light and Near-Infrared (NIR) to calculate vegetation cover, based on the fact that plant leaves reflect NIR wavelengths and absorb visible Red wavelengths. The Soil-Adjusted Vegetation Index (SAVI) is used in areas with higher amounts of exposed soil than the NDVI but requires that a soil brightness correction factor be calculated or estimated. The Modified Soil-Adjusted Vegetation Index (MSAVI) and the revision MSAVI2 were created to eliminate the need for estimating the soil brightness correction factor.

Generally, the index values range from -1 to 1. Positive values indicate vegetation, with higher values correlating to more vegetation or better vegetation health. Negative values indicate soil, water, rocks, etc.

NDVI Virginia Landfill Site 1 mean = 0.87; Site 2 mean = 0.88; Site 3 mean = 0.89
MSAVI Virginia Landfill Site 1 mean = 0.70; Site 2 mean = 0.73; Site 3 mean = 0.76

NDVI Kelly Lake Site 1 mean = 0.56; Site 2 mean = 0.45; Site 3 mean = 0.56
MSAVI2 Kelly Lake Site 1 mean = 0.32; Site 2 mean = 0.21; Site 3 mean = 0.26

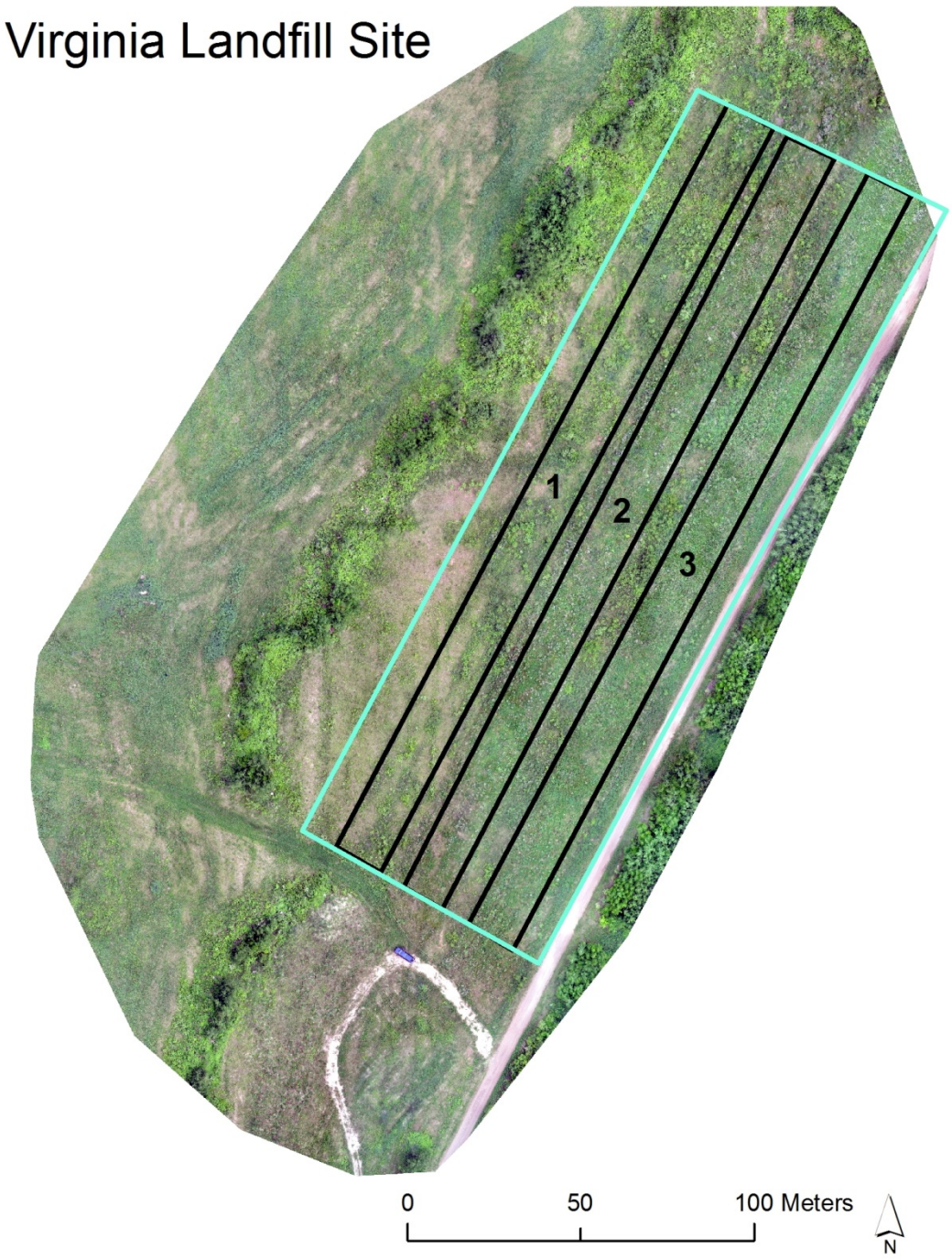


Figure 3-2: – Drone Site Map - Virginia Landfill site. 1 = control plot, 2 = 6-inch sediment plot, 3 = 12-inch sediment plot.

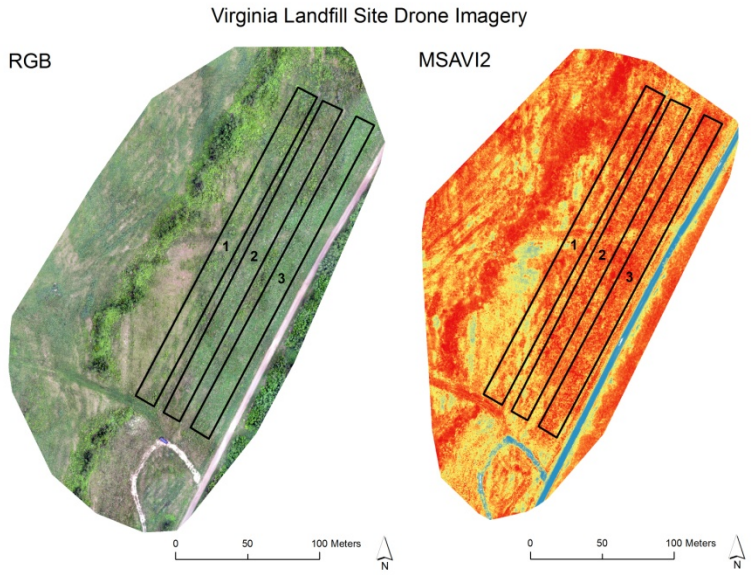


Figure 3-3: Drone figures at Virginia Landfill. 1 = control plot, 2 = 6-inch sediment plot, 3 = 12-inch sediment plot.

Figure 3-4: Drone Kelly Lake Site Map

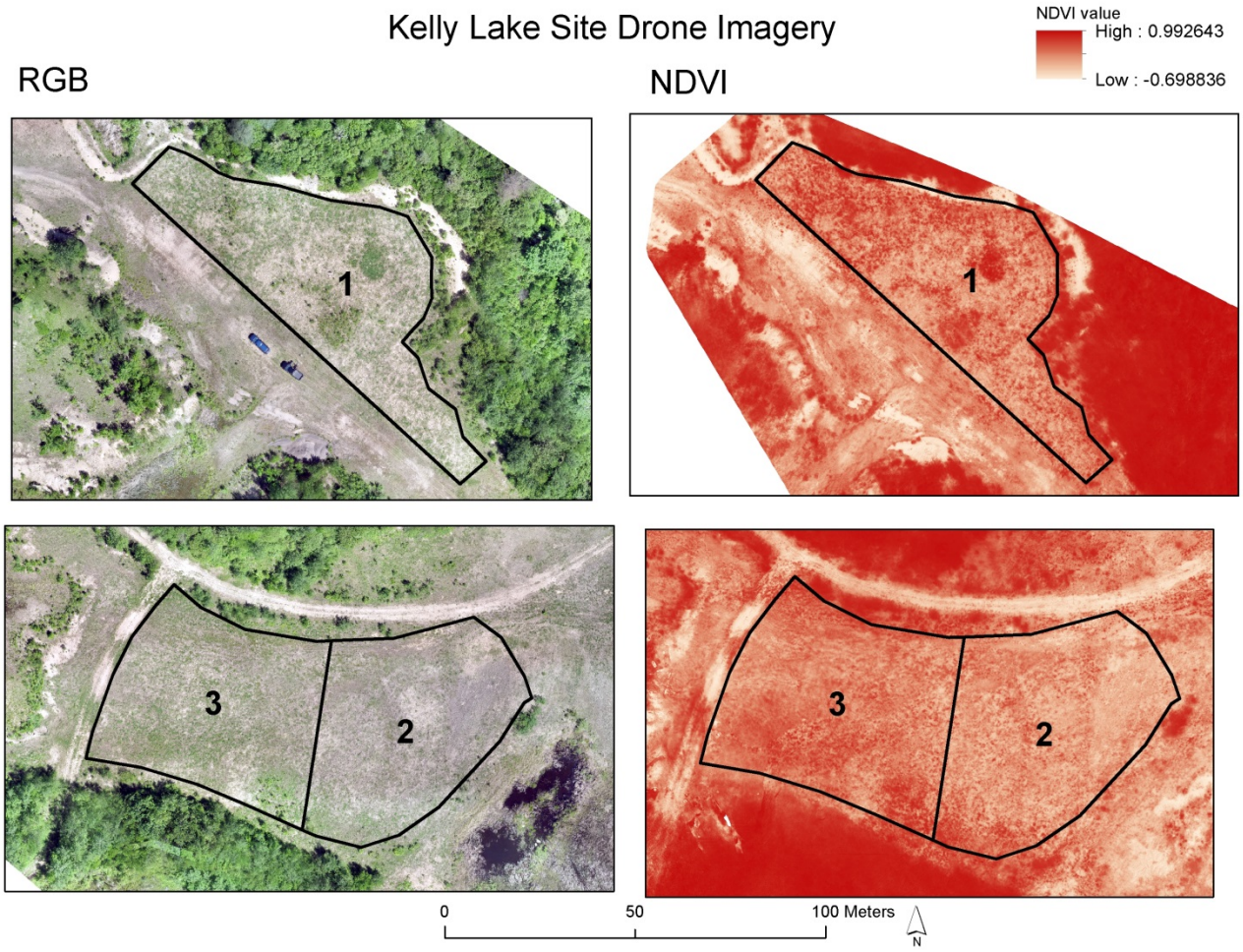


Figure 3-5: Kelly Lake Site Drone Imagery. Site 1 – 1.7 ft; Site 2 – 0.5 ft; Site 3 – 0.5 ft, tilled in.

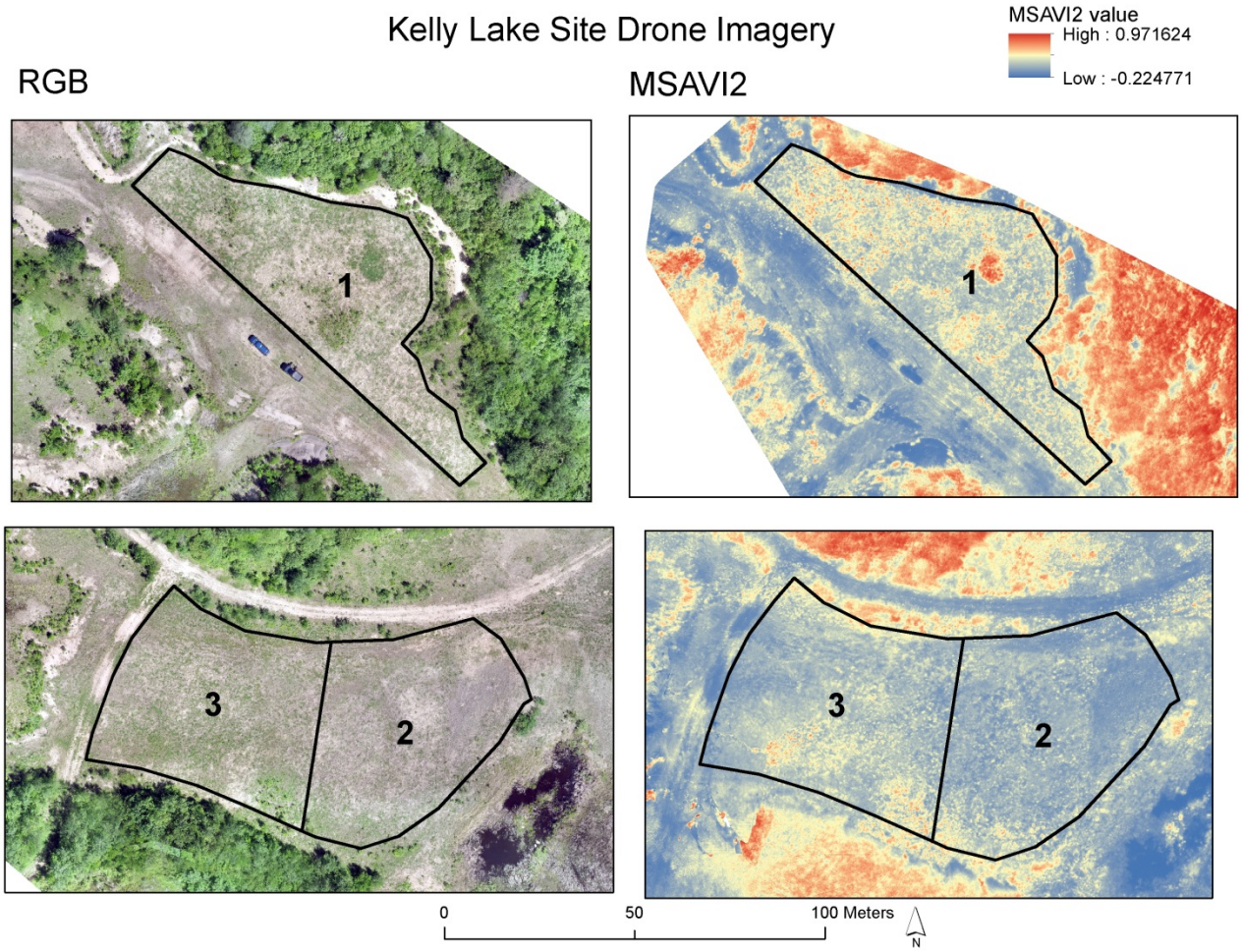


Figure 3-6: Kelly Lake Site Drone Imagery. Site 1 – 1.7 ft; Site 2 – 0.5 ft; Site 3 – 0.5 ft, tilled in.

Tree Survey 2019

Tree surveys of live trees were conducted in the fall of 2018 and again in the spring of 2019. Table 3-5 provides the results by study plot and tree type for both events.

Table 3-5. Percent Tree Survival for 2018 and 2019: Virginia Landfill (ENRTF) project site.

Control	**Tamarack**	**White Pine**	**Cottonwood**
2018	40	96	61
2019	37	90	31
6 inch	**Tamarack**	**White Pine**	**Cottonwood**
2018	45	95	77
2019	27	88	76
12 inch	**Tamarack**	**White Pine**	**Cottonwood**
2018	56	94	80
2019	46	96	63

Kelly Lake and KeeTac Comparison Sites

For comparison purposes, tree-planting success at two sites previously treated with dredge sediment (Kelly Lake and KeeTac) was also evaluated. The U.S. Army Corps of Engineers supported the transport of the dredge sediment to both sites.

Kelly Lake

Dredge sediment was placed in three plots at the Hibbing Taconite Kelly Lake site in the fall of 2012 (Table 3-6).Sediment was placed directly on top of the existing ground surface in Sites 1 and 2. In Site 3, the sediment was tilled into the underlying material. Eight types of trees and shrubs were in the spring of 2013. The location for each plant was recorded. No growth monitoring work was completed at the site after planting due to expiration of project funding. In June 2019 we conducted a tree count to determine survival rates. Table 3-6 provides survival data as a percentage of the trees planted and is arranged by site and vegetation type.

Table 3-6. Kelly Lake Tree Survival Rates

Kelly Lake - Hibbing Taconite –Tree Survival (%) 2019

Species	**Oak**	**Hazel**	**Birch**	**Spruce**	**B. Chokeberry**	**Tamarack**	**Chokecherry**	**Alder**
SITE 1 – 1.7 ft	47.4	44.1	0.0	25.0	**66.7**	30.0	**71.4**	**78.4**
SITE 2 – 0.8 ft	19.4	2.9	2.9	10.3	33.3	0.0	60.5	4.9
SITE 3 – 0.6 ft tilled	35.7	0.0	0.0	3.8	30.8	0.0	35.3	4.8

Figure 3-7: Kelly Lake Site 1 as of 2019. Trees in the foreground were planted in 2013, note size of trees and sparseness. Tall trees at the back were original to the site. Note sparseness of trees.

Figure 3-8: Kelly Lake former gravel pit looking north, Site 2 foreground and Site 3 in the background, as of 2019. Flagging indicates where trees should be located.

KeeTac

Sediment was placed on an unproductive area of a tailings basin (Figure 3-9 b) at Keewatin Taconite (KeeTac) in 2010 and 2011. Seedlings were planted after the sediment was spread. All 2010 and 2011 site activities were organized and completed by KeeTac.

The NRRI project team was unable to do a tree count since the tree type and quantities data were not available. However, during our site visit on June 27, 2019, the success of this project was clearly visible, as indicated by a sharp line where vegetation coincided with sediment application (Figure 3-10). Where the sediment application stopped, so did the vegetation. Site observations on June 27, 2019 include the following:

- Rows of trees were planted parallel to the service road.
- Tree quantities and quality decrease from the thicker layer of sediment near the service road to the thinner areas further into the basin.
- Tamarack and Scotch Pine were present, with heights up to 9 feet, and average height estimated to be 5 feet.
- Birch average height 4 to 6 feet.
- White Spruce smaller and some missing, average height 1 – 2 feet tall.
- Red Pines observed near service road.

- Aspen average height 4 to 5 feet toward basin (wetter conditions) and up to 12 feet near road (drier conditions).
- Black Willow height 4 – 5 feet toward basin (possible volunteers) and up to 12 – 15 feet near service road (drier area).
- A clear line in vegetation density is observed along the edge of sediment placement toward the basin.

Photographs in the figures below present the site conditions in 2010 prior to sediment placement, after sediment placement, and as of June 2019. Photographs were provided to NRRI by USX – Keewatin Taconite.

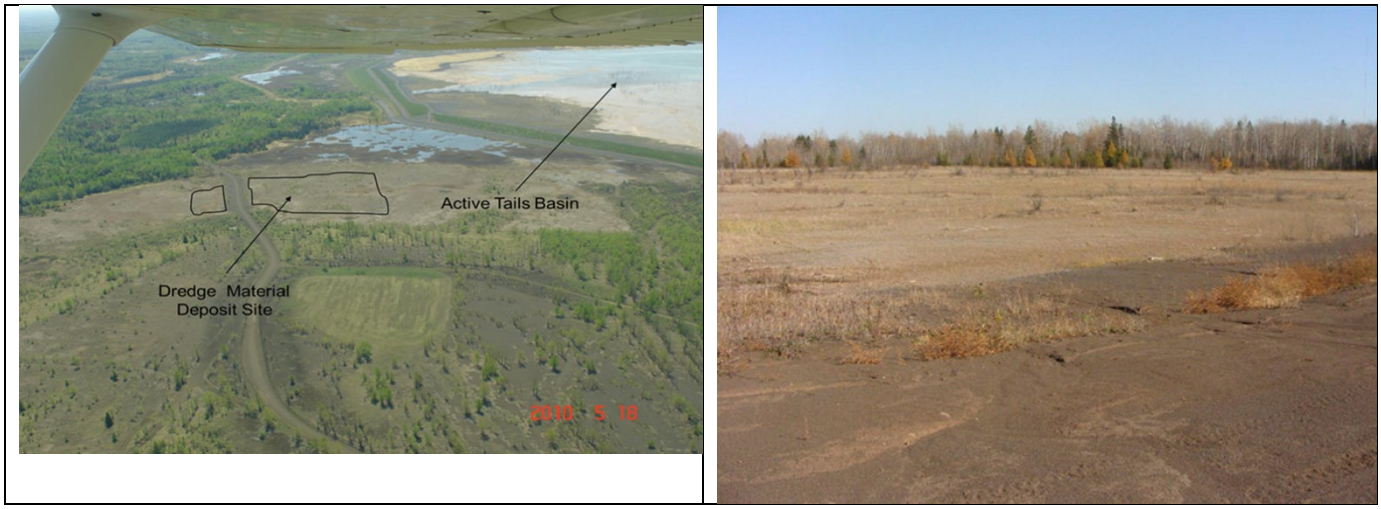


Figure 3-9. 2010 KeeTac Tailings Basin project site, prior to sediment application.

Figure 3-10: 2019 KeeTac project site about 8 years after sediment application. Green edge of the vegetation is associated with the extent of sediment application.

Final Report Summary:
The project's research plots were constructed at the Virginia Landfill Site and began in the summer of 2015 with removal of the existing vegetation. Sediment was placed on top of existing soil in two of the three plots at a thickness of 6 inches and 12 inches. The third plot was the control; no sediment was used in this area. Tree

replicate boundaries were established in 2016, and soil samples were collected for soil fertility analyses. Emergent weeds were managed with herbicide three times before the tree seedlings were planted in 2017. Biosolids were applied over the entire site in 2017 prior to planting.

In 2014, prior to site clearing for this project, Gerald Wilhelm completed a floristic assessment at the Virginia Landfill site. Floristic data collected by Walton in 2019 indicate a different plant population at the site. Using only the number of native and introduced (adventive) species to evaluate change from application of dredge sediment, the following are observed: the ratio on the control is similar to pre-treatment, and the 6-inch and 12-inch plots are about half native and half introduced species. The number of invasive species is similar for the 2014 pre-construction survey and the 2019 control. As reported previously, seven invasive species were observed in the plots that received Erie Pier sediment: *Bromus inermis* (Smooth brome grass), *Chrysanthemum leucanthemum* (Ox-eye daisy), *Cirsium arvense* (Canada thistle), *Cirsium vulgare* (Bull thistle), *Linaria vulgare* (Butter and eggs), *Lotus corniculata* (Bird's-foot trefoil), *Melilotus officinalis* (Yellow sweetclover), and *Phalaris arundinace* (Reed canary grass).

Table 3-7. Virginia Landfill Site Vegetation 2014 and 2018.

	2014 Whole Site	Control 2018	6 inch Plot 2018	12 Inch Plot 2018
Native Species (%)	67	63	43	51
Introduced Species(%)	33	37	57	49
Invasive Species	3	4	7	7

Walton identified 7 invasive plant species in the 6-inch and 12-inch plots. Four invasive species were observed in the control plot. Canada Thistle, Bull thistle, and Bird's-foot trefoil were identified in all three plots in 2019 as well as in 2014.

Drone flight for site mapping

A drone was used to produce site maps for the Virginia Landfill site and the Hibbing Taconite Kelly Lake gravel pit in June 2019. In addition to site maps, the data collected during the drone flights were used to produce a general overview of plant health at both sites. We found that the MSAVI2 results for both sites correlated well with the conditions we observed on the ground. At the Virginia Landfill site, the NDVI and the MSAVI2 results are fairly similar, probably due to the fact that there is not a lot of bare ground at this site. At Kelly Lake, the two indices are much more different, most likely due to the greater amount of bare ground present at this site. At both sites, we find that the index values are slightly higher for the plots with the most sediment coverage, though the difference is, again, greater at Kelly Lake than at the Virginia Landfill.

Possible explanations for these differences between the sites include substrate type and soil moisture. We have observed that the pre-existing substrate at Kelly Lake was a gravel pit, and wet areas are present nearby, but the site itself is upland and appears to drain freely (sandy and gravelly soil). The substrate at the Virginia Landfill site is a finer grained soil, and supported a fair amount of vegetation growth prior to being cleared for this project, suggesting that sufficient moisture and nutrients were present for at least some tree growth.

Table 3-9 NDVI Virginia Landfill Site 1 mean = 0.87; Site 2 mean = 0.88; Site 3 mean = 0.89
MSAVI Virginia Landfill Site 1 mean = 0.70; Site 2 mean = 0.73; Site 3 mean = 0.76

Site	MSAVI, mean
Virginia Landfill Site 1	0.70
Virginia Landfill Site 2	0.73
Virginia Landfill Site 3	0.76

Table 3-10. NDVI Kelly Lake Site 1 mean = 0.56; Site 2 mean = 0.45; Site 3 mean = 0.56
MSAVI2 Kelly Lake Site 1 mean = 0.32; Site 2 mean = 0.21; Site 3 mean = 0.26

Site	NDVI, mean	MSAVI2, mean
Kelly Lake Site 1	0.56	0.32
Kelly Lake Site 2	0.45	0.21
Kelly Lake Site 3	0.56	0.26

The Normalized Difference Vegetation Index (NDVI) uses visible Red light and Near-Infrared (NIR) to calculate vegetation cover, based on the fact that plant leaves reflect NIR wavelengths and absorb visible Red wavelengths. The Soil-Adjusted Vegetation Index (SAVI) is used in areas with higher amounts of exposed soil than the NDVI, but requires that a soil brightness correction factor be calculated or estimated. The Modified Soil-Adjusted Vegetation Index (MSAVI) and the revision MSAVI2 were created to eliminate the need for estimating the soil brightness correction factor. Generally, the index values range from -1 to 1. Positive values indicate vegetation, with higher values correlating to more vegetation or better vegetation health. Negative values indicate soil, water, rocks, etc.

Results of tree survival surveys
Tree survival data were collected at the Virginia Landfill and Kelly Lake sites. At the project site, White Pines have the highest survival rates of the three tree species, regardless of the dredge sediment thickness. Cottonwood trees may do better in the plots containing sediment. Tamarack trees did poorly on all three plots.

Table 3-11. Tree survival rates 2017, 2018, and 2019.

Control	**Tamarack**	**White Pine**	**Cottonwood**
2017	19	76	87
2018	40	96	61
2019	37	90	31
Average	*32*	*87*	*60*
6 inch	**Tamarack**	**White Pine**	**Cottonwood**
2017	13	69	92
2018	45	95	77
2019	27	88	76
Average	*28*	*84*	*82*
12 inch	**Tamarack**	**White Pine**	**Cottonwood**
2017	12	81	75
2018	56	94	80
2019	46	96	63
Average	*38*	*90*	*73*

The most successful trees at the Kelly Lake site were observed in Site 1, which received the thickest sediment application. Alders, B. chokeberry, and Chokecherry have the best survival rates, over 50%. Survival rates for 7 of the 8 trees species in Site 2 were below 20% survival rates. All survival rates in Site 3 were 35% or less. Tamarack is the only tree species common to the Virginia Landfill site. Its survival rates were 30% in Site 1 (1.7 ft sediment) and 0% in Sites 2 and 3.

ACTIVITY 4: Propagation and Sourcing of Plant Materials

Description: These activities involve the purchase, storage and propagation of the plant materials, such as greenhouse and nursery operations. (Please Note: These activities are redundant until all research plots are fully stocked; final projected planting including restocking by June 30, 2016), resulting in:

- Sufficient planting stock (dormant and/or live containerized) for research plots;
- Purchased planting stock;
- Fully stocked (populated) research plots;
- Managed nursery plots for successive plantings and re-plantings;
- Additional (propagated in greenhouse) planting stock.

The planting stock for this project will be containerized, rooted material based on our previous forestry research. Both dormant and actively growing stock will be used, depending on the specie and timing. The goal is to have a live, measurable plant at each position for shrub and tree species (i.e. fully stocked plots). When planting stock cannot be propagated, it will be purchased from local source. In the case of herbaceous cover, seeds will be used. The North Central Research and Outreach Center in Grand Rapids is used to hold planting and propagation stock for this research. NRRI's greenhouse facility is also used in the indoor propagation of materials. The NRRI staff scientists have over twenty years of experience in the propagation of plant materials for site restoration. Please note: native and approved species will be used in this activity, in accordance to State guidelines.

Summary Budget Information for Activity 4:

ENRTF Budget: $ 41,033
Amount Spent: $ 41,033
Balance: $ ~~8,420~~ 0

Activity Start Date: Oct 31, 2015

Outcome	Completion Date
1. Propagation of plant materials DONE	June 30, 2018
2. Purchase of planting stock DONE	June 30, 2018
3. Direct Plantings DONE	June 30, 2018
4. Nursery Management DONE	June 30, 2018
5. Additional propagation DONE	June 30, 2018

~~*Budget NOTE:* Activity 4 is complete. The remaining $8,420 is being transferred and applied to Activity 5 ($5,000) and Activity 6 ($3,420).~~

Activity status as of October 1, 2014: No activity.

Activity status as of April 1, 2015: No activity.

Activity status as of July 1, 2015: No activity.

Activity status as of April 1, 2016: Cutting material was collected this winter, from the North Central Research and Outreach Center nursery in Grand Rapids, to propagate some of the tree planting stock for this project. The material was recently planted in containers and is being grown in the NRRI greenhouse.

Activity status as of July 1, 2016: Propagation of Cottonwood seedlings will continue through summer to generate planting stock for Spring of 2017 planting. Tamarack and White Pine seedlings will be purchased for Spring 2017 planting.

Activity status as of December 1, 2016: The containerized Cottonwood (Populus deltoides) seedlings were grown out over the summer in the NRRI greenhouse facility and will be part of the tree planting stock. Tamarack

(Larix laricina) and White Pine (Pinus strobus) seedlings were ordered from Lakes States Evergreen Co LLC a local grower in Cohasset, MN. and will be available in the Spring for planting.

Activity status as of July 1, 2017: Tamarack and White Pine containerized planting stock was picked up from Lakes States Evergreen Co. LLC and hand-planted on the site May 10th. The Cottonwood planting stock was hand-planted on the site June 19th after any reasonable chance of frost. We were not able to hold the Cottonwoods in dormancy as planned. The trees were very succulent and susceptible to frost damage.

Activity status as of December 1, 2017: Cottonwood (Populus deltoides) planting stock has been maintained and will be overwintered at the NRRI greenhouse and used for replacement planting stock in the spring of 2018. Replacement White Pine (Pinus strobus) seedlings have been order from Lake States Evergreen Co LLC for replacement planting in the spring. A different source for the Tamarack (Larix laricina) seedlings will have to be used as Lake States Evergreen Co LLC doesn't have any available for next spring planting. A bare root seedling from the MN DNR will be used for replacement.

Activity status as of July 1, 2018: White Pine (Pinus strobus) seedlings were picked up from Lake States Evergreen Co LLC for replacement planting in May 2018. The Tamarack (Larix laricina) bare root seedlings were obtained from the MN DNR for replacement planting in late May, 2018. Cottonwood (Populus deltoides) planting stock for replacement planting was maintained at the NRRI greenhouse and available for planting in early June. This planting completes the Outcomes for Activity 4.

Activity status as of December 1, 2018: No Activity

Activity status as of July 1, 2019 (Submitted November 15, 2019): No Activity

Final Report Summary:
In April 2016, cuttings of Cottonwood trees were collected from North Central Research and Outreach Center in Grand Rapids and transported to NRRI's greenhouse to generate seedlings for planting at the site. Tamaracks and White Pines were purchased from Lake States Evergreen Company in May 2017. All seedlings were planted at the Virginia Landfill site. Tamarack trees were observed to have a high mortality rate in the fall of 2017. Based on the tree survival survey, additional trees were both grown and purchased for planting in the spring of 2018. Based on results from two plantings, it would be advised that any future projects assume at least two rounds of seedling planting.

ACTIVITY 5: Research Plot Management and Monitoring of Biomass Productivity
Description: These activities involve cultural practices, monitoring of growth and measurement of productivity within research plots, including sampling to project harvest yields, resulting in:

- Recommended methods of measuring stand productivity;
- Data (destructive and non-destructive evaluation) of productivity of purpose grown plants;
- Data (proof) from test methods (non-destructive);
- Yield projections and verification.

Biomass yield estimates are based on measurement data (i.e. caliber, height and weight). This data will be collected within the research plots and equations will be developed for standing biomass. Yield projections will be verified, again by harvesting. Where destructive data is gathered, research plots will be replanted. Yield projection equations from this project are specific to the specie mix and age class of the stock within plots. The methodology and equations can be used for similar plantations for yield estimates and as a management tool to maximize productivity.

Data collected from the Virginia Landfill, HibTac gravel pit, and KeeTac tailings site in Activity 3 will be used in estimating future biomass and yield for Activity 5. Tree type, tree survival rates, and biomass measurements,

where possible, will be used in the projection. This additional work will be funded by the $8,420 transferred from Activity 4.

Summary Budget Information for Activity 5:	**ENRTF Budget:**	**$ ~~50,774~~ 62,668**
	Amount Spent:	**$ ~~14,547~~ 58,629**
	Balance:	**$ ~~36,227~~ 4,039**

Activity Start Date: June 30, 2017

Outcome	Completion Date
1. Cultural management of plots DONE	June 30, 2017
2. Sampling of biomass DONE	June 30, 2017
3. Yield projections DONE	June 30, 2017

~~*Budget NOTE*: $5000 is being transferred from Activity 4 to Activity 5.~~

Activity status as of October 1, 2014: No activity.

Activity status as of April 1, 2015: No activity.

Activity status as of July 1, 2015: No activity.

Activity status as of April 1, 2016: No activity.

Activity status as of July 1, 2016: No activity.

Activity status as of December 1, 2016: University of Minnesota Analytical Lab charges for soil sample analysis were charged to this activity as set up in the budget worksheet.

Activity status as of July 1, 2017: No activity.

Activity status as of December 1, 2017: Tree seedling survival data was collected in October. Over all Cottonwood had the best overall survival at 90.1 % on the site with high survival of 93.3 % on the 12 inch sediment treatment and low survival of 87.1 % on the no sediment treatment. Tamarack had the lowest overall survival of 14.8 % with high survival of 18.6 % on the no sediment treatment and low survival of 12.4% on the 12 inch sediment treatment. White Pine had 75.2 % survival over all with the high survival of 81.4 % on the 12 inch sediment treatment and low survival 68.6 % on the 6 inch sediment treatment. We are unsure why there was such low survival of the Tamarack. The planting stock was of good quality and soil moisture was adequate at time of planting. Bud break had already occurred before they were planted and it may have been a stress issue as survival was low across all treatments compared to the other species.

Activity status as of July 1, 2018: No activity. Outcome 1 will be completed by end of fall 2018.

The biomass assessment for the purpose planted trees will be an estimate at best given the short growing time and slow growth rate for the planted trees. They may be made based on survival rates and tree height. The trees will be too small to complete Diameter at Breast Height (DBH) measurements as was done for the trees on the site prior to beginning this project. A more informative evaluation could be done once the trees are 5 to 10 years old. Tree and sediment/soil data will be collected from a 2014 Hibbing Taconite (HibTac) gravel pit and 2011 Keewatin Taconite (KeeTac) sediment treatment projects (Activity 3) to assist in projecting potential biomass production from purpose-grown trees.

Activity status as of December 1, 2018: No Activity

Activity status as of July 1, 2019 (submitted November 15, 2019): In July 2018, LCCMR approved adding evaluating tree survival at two other sites where dredge sediment had been applied and trees planted. In 2010-2011, 30,000 cubic yards of dredge sediment were applied at a tailings basin at Keewatin Taconite via a project supported by the U.S. Army Corps of Engineers. Records associated with tree planting were not available for the Keewatin Taconite tailings basin site, so general observations of the trees and site were recorded. Three plots were established at a Hibbing Taconite gravel (borrow) pit near Kelly Lake, and 3,700 cubic yards of sediment were applied in 2013. Tree survival counts and tree height measurements were completed at the Virginia Landfill site and the Hibbing Taconite Kelly Lake site in May and June 2019. Results on survival rates are discussed in Activity 3, Final Report Summary. Soil samples were collected from the Virginia Landfill site in 2019 and submitted to the University of Minnesota Soils lab for analyses. Results from the analyses were discussed in Activity 2.

Final Report Summary:
At a minimum, tree survival as well as tree heights must be considered when trying to estimate the biomass production for the woody vegetation. Tree seedling survival surveys were completed in 2017, 2018, and 2019 (Activity 3) at the project site. The results of the 2017 survey indicated very poor survival of the Tamaracks. Based on the results, a second round of tree planting was completed in 2018. Subsequent tree survival surveys continue to indicate unacceptable survival rates for Tamaracks, moderate survival rates for Cottonwood, and good survival for White Pines.

As mentioned in the July 2018 status report, biomass assessment for the project using the tree seedlings requires the trees to be at a minimum 130 cm tall. Tree seedlings were planted at the Virginia Landfill site in the spring of 2017. A second planting was completed in the spring of 2018. Tree heights were measured and recorded in June 2019. Tamarack tree heights ranged from 17 cm to 99 cm, White Pine from 2 cm to 70 cm, and Cottonwood ranged between 2 cm and 191cm across the site and plots. The average tree height for all three tree species are below in Table 5-1. Diameter at breast height (DBH) biomass measurements could not be collected with only one to two years of tree growth. The trees are too short, below the minimum 130 cm height requirement. The photo below shows the site in June 2019. The site is primarily covered in grassy, weedy-type vegetation. The trees are no taller than the surrounding vegetation. Trees on the right are across the road from the site and not part of the project.

Table 5-1. Virginia Landfill Tree Types and Average Height – cm.

	White Pine	Tamarack	Cottonwood
Control	27	42	52
6 inch	26	43	66
12 inch	29	44	77

Figure 5-1: Virginia Landfill site 2019. Planted trees are surrounded by grassy, weed-type vegetation.

Heights of the trees at the Kelly Lake site were recorded at the same time as the tree survival count. These trees have had six years of growth. The mean height for each species planted is provided below. Alder were the only trees that were taller than 120 cm. Tamarack is the only tree common to the landfill site, and they are still below 130 cm in height. An estimation of biomass could be not completed for this site.

Table 5-2. Kelly Lake Tree Types and Mean Height – 6 years' growth.

Kelly Lake - HibTac - Mean Tree Growth - cm

	Oak	Hazel	Birch	Spruce	B. Chokeberry	Tamarack	Chokecherry	Alder
SITE 1: 1.7 ft	48	37	0	56	49	**96**	27	**171**
SITE 2: 0.8 ft	27	26	41	63	29	NA	26	**115**
SITE 3: 0.6 ft tilled	29	NA	NA	91	48	NA	23	21

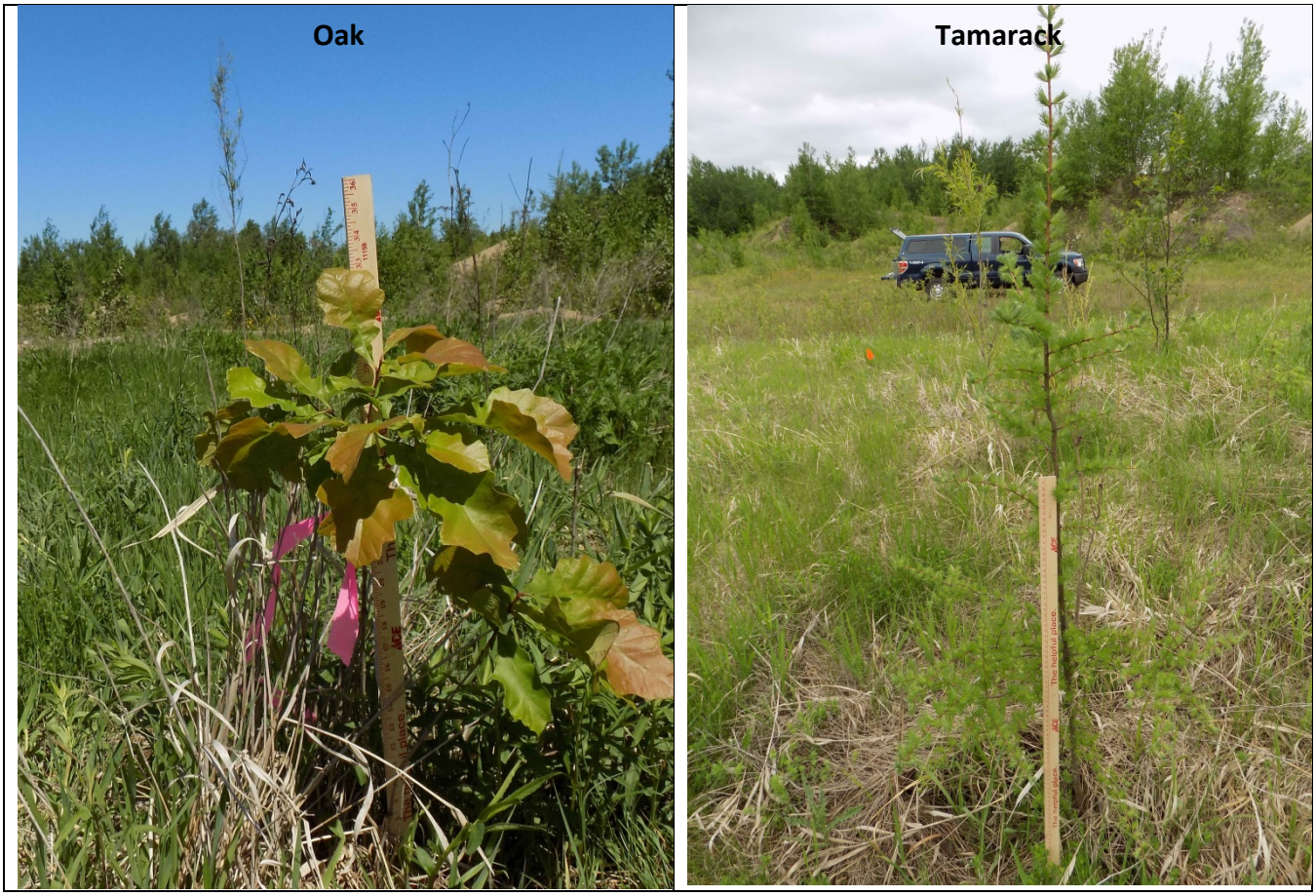


Figure 5-2: Hibbing Taconite Kelly Lake - Site 1 – Oak and Tamarack after 6 years of growth.

A third mining site received Erie Pier sediment to enhance revegetation and tree growth. Over 30,000 cubic yards of sediment were placed on an unproductive area of the tailings basin at Keewatin Taconite (KeeTac) in 2010 and 2011 via a project supported by the U.S. Army Corps of Engineers (Patelke et al., 2013). Seedlings were planted after the sediment was spread. All site activities were organized and completed by KeeTac. We were unable to conduct a tree count or make measurements since the tree type, locations, and quantities data were not available.

Biomass predictions – based on survival, height, and time.
To attempt to predict the woody biomass potential at the Virginia Landfill site, the NRRI silviculturist estimated a potential height of each tree type at 3, 4, and 5 years. At the 5 year mark, only Cottonwood is significantly above the 130 cm measurement (Table 5-3). Given that Tamaracks, White Pines, and Cottonwoods (species selected for this study) can require 20 to 90 plus years to reach a marketable size, it is unrealistic to estimate biomass at the Virginia Landfill site based on survival rates determined after only 1 to 2 years of growth.

Table 5-3. Average tree heights 2019 and projected height in centimeters at 5 years.

Virginia Landfill	**White Pine**	**Tamarack**	**Cottonwood**
Control	27	42	52
6 inch	26	43	66
12 inch	29	44	77
Projected Height at 5 years	131	137	408
Note: height estimates for 5 years growth derived by John Duplisiss from formulas provided in Carmean, et al 1989.			

References:
Carmean, W.H., Hahn, J.T., and Jacobs, R.D. 1989. Site index curves for forest species in the eastern United States. Gen. Tech. Rep. NC-128. St. Paul, MN: US. Department of Agriculture, Forest Service North Central Forest Experiment Station. 142 p.

Patelke, M.M., Levar, T.E., Zanko, L.M., Oreskovich, J.A., and Maly, C. 2013. Erie Pier Dredge Material Beneficial Use Study – Final Report: Natural Resources Research Institute, University of Minnesota Duluth, Technical Summary Report NRRI/TSR-2013/03. 60 p.

ACTIVITY 6: Final Analysis and Site Visits
Description: These activities involve the final sampling, analysis and site visits to enable the promotion, education and transfer of these practices to other sites, including the following results:

- Comparative changes in substrate properties (organic matter and nutrient changes);
- Growth curves projected yields;
- Tutorials, video and literature enabling technology transfer.

Summary Budget Information for Activity 6:

ENRTF Budget: $ ~~53,481~~ 62,795
Amount Spent: $ ~~0~~ 57,369
Balance: $ ~~53,481~~ 5,426

Activity Start Date: APRIL/MAY 30, 2019

Outcome	Completion Date
1. Final sampling	June 30, 2019
2. Final measurements	June 30, 2019
3. Final site visits	June 30, 2019

~~*Budget Note:* $3420 is being transferred from Activity 4 to Activity 6.~~

Activity status as of October 1, 2014: No activity.

Activity status as of April 1, 2015: No activity.

Activity status as of July 1, 2015: No activity.

Activity status as of April 1, 2016: No activity.

Activity status as of July 1, 2016: No activity.

Activity status as of December 1, 2016: No activity.

Activity status as of July 1, 2017: No activity.

Activity status as of December 1, 2017: No activity.

Activity status as of July 1, 2018: No activity.

These outcomes will be completed between fall 2018 and spring 2019. Given the short project duration relative to typical growth rates of trees, projected yields will be very general. In order to evaluate potential projected yields, we will use literature and comparison with trees planted in sediment at another site (HibTac) in 2014, and potentially another site planted in 2011 (KeeTac). At this point, it would be suggested that annual follow-ups take place over the next 5 to 10 years to assess and document tree growth and survival, as well as that of other

vegetation. This time frame would be more appropriate for trees that take 50+ years or more to reach a useful size for biofuels.

Activity status as of December 1, 2018: No Activity

Activity status as of July 1, 2019 (submitted November 15, 2019):
The data and results from the final sampling and field work completed in May and June 2019 are presented in Activities 2, 3, and 5. NRRI included the Virginia Landfill ENRTF site with a reclamation tour in order to review the site with Thomas Lee from the Minnesota Department of Natural Resources Mineland Reclamation Program on June 26, 2019. While it is premature to consider the project a success for biomass production, the use of dredge sediments to enhance establishment of a vegetation cover on land disturbed by mining or other activities could be beneficial, an outcome worth sharing with the MnDNR.

Final Report Summary:

This project was originally designed to assess the use of dredge sediment for purpose-grown vegetation, improved reforestation, and improved biodiversity when placed on disturbed mineland. Tree survival data from both the Virginia Landfill and Kelly Lake sites do not provide definitive evidence to support this idea. In the 2018 amendment, additional work was approved in order to attempt to answer three questions:

1) Which tree species were most successful and which are least?
2) How could soil fertility affect tree growth?
3) Is there a variation in topography that could influence tree growth?

Tree Species Success
In order to assess whether or not the current tree survival rates suggest potential success (strictly based on the number of trees) we divided the percentages into four groups.

75% - 100% Good,
50% - 75% Poor,
25% - 50% Unacceptable,
and 0% – 25% Failure.

At the Virginia Landfill site, Tamarack survival rates were lowest of the three tree types and in all test plots, with UNACCEPTABLE survival rates. White Pine had the highest survival rates in all three plots and was considered GOOD. Cottonwoods showed a little more variation by plot and time in their success, ranging from GOOD to UNACCEPTABLE. However, the Cottonwood results suggest that application of dredge material was beneficial for improving its survival and growth relative to the untreated control. If this species is to be used for similar mine site restoration and reclamation purposes (for example, for establishing a windbreak to reduce dust takeoff), then dredge material could provide an adequate growth substrate.

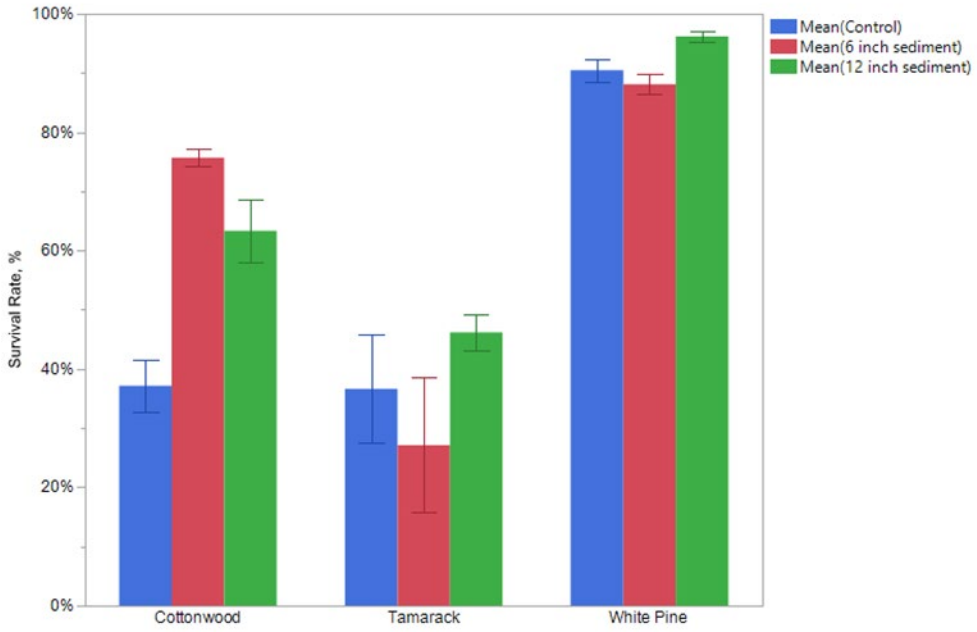


Figure 6-1: The average survival rates of three types of trees in the three plots. The error bar is the standard error calculated by three replicates.

At the Kelly Lake site, the most successful trees were observed in Site 1, the thickest sediment layer. Alders and Chokecherry have the highest survival rate in this test plot and are considered GOOD. Survival rates for Oak, Hazel, Birch, and Spruce are POOR to UNACCEPTABLE. Tamaracks are rated as UNACCEPTABLE to FAILURE.

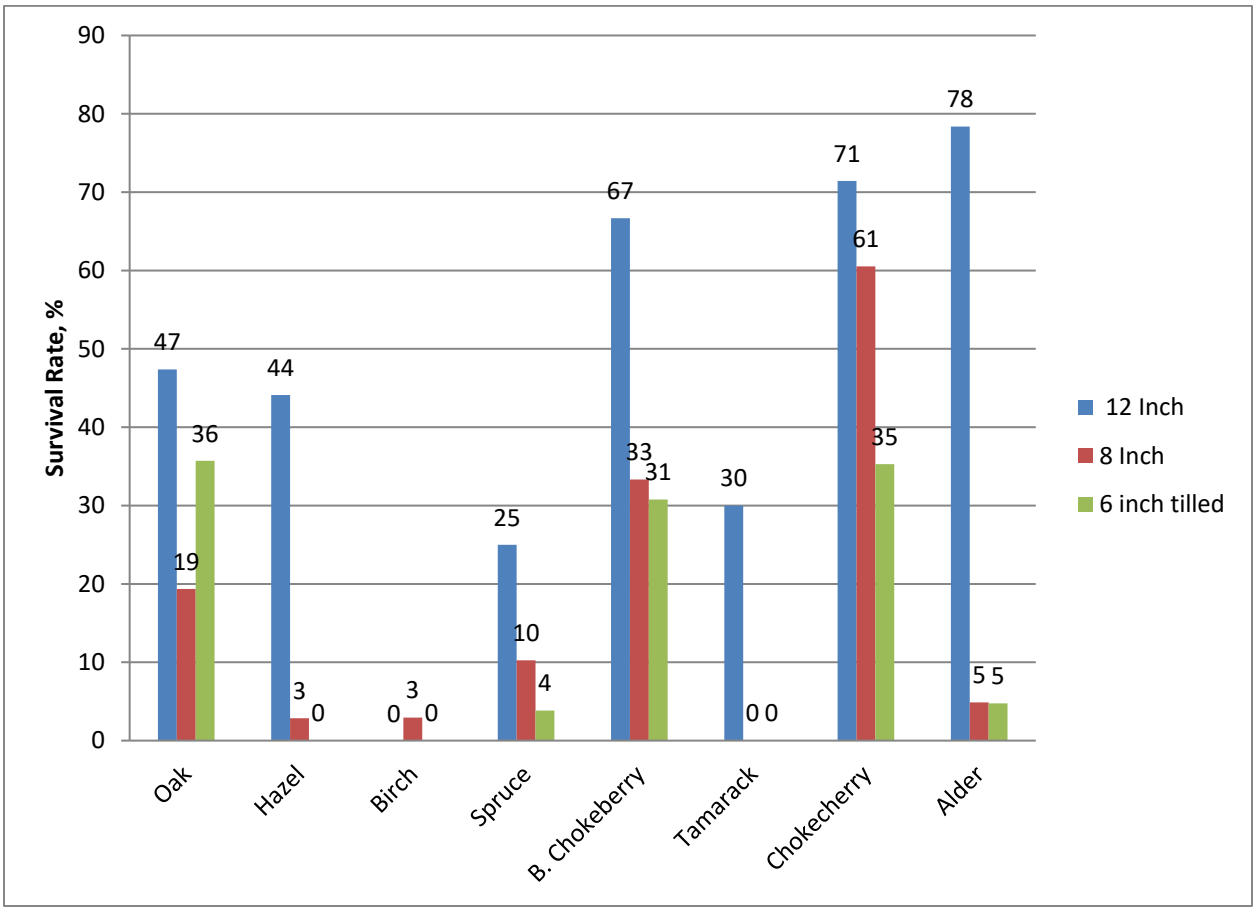


Figure 6-2: 2019 Survival rates by tree type at each of the sites.

The only common tree species between the two sites were the Tamaracks. Both had UNACCEPTABLE survival rates. Cottonwood and White Pine have higher survival rates, outperforming all other tree species.

In general, a thicker sediment layer can have a positive effect on survival rates for some tree species. However, other potential influences on tree survival at both Virginia Landfill and Kelly Lake include browsing by deer, insect and small mammal predation, moisture variation due to topography, the quality of the seedlings, and smothering by herbaceous species (e.g., grasses and weeds). Evidence of overgrowth of grasses and weeds was observed at both sites. Trees were found “buried” by the vegetation and had to be uncovered to count and measure (Figure 6-3). Competition from other vegetation likely affected the survival and growth of tree seedlings at all three sites. Any future project completed with dredge sediment and planted tree seedlings should be managed for the competitive grassy type vegetation.

At the Virginia Landfill site it is also possible that the method of biosolid application contributed to some tree mortality from elevated nitrogen.

Figure 6-3: Grasses buried trees at Kelly Lake. Left photo Site 2. Right photo Site 1.

As mentioned in the Activity summary, tree heights at both sites were less than 130 cm and too short to complete a biomass assessment. Growth rates for the three tree species at the Virginia study site are illustrated below. Only one measurement of a Cottonwood was above 130 cm.

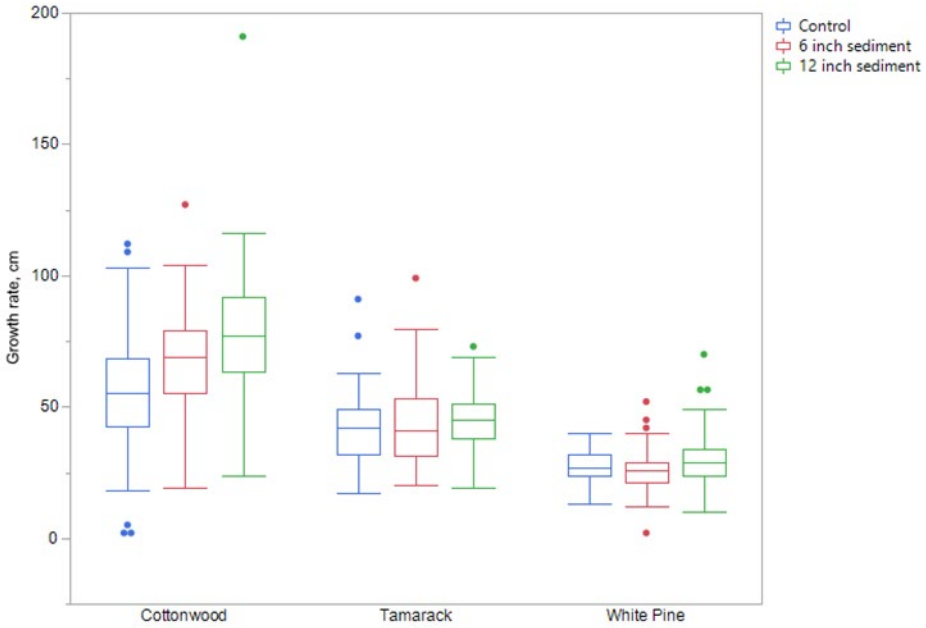


Figure 6-4: The boxplot of tree growth rates for living trees in three soil types – Virginia Landfill.

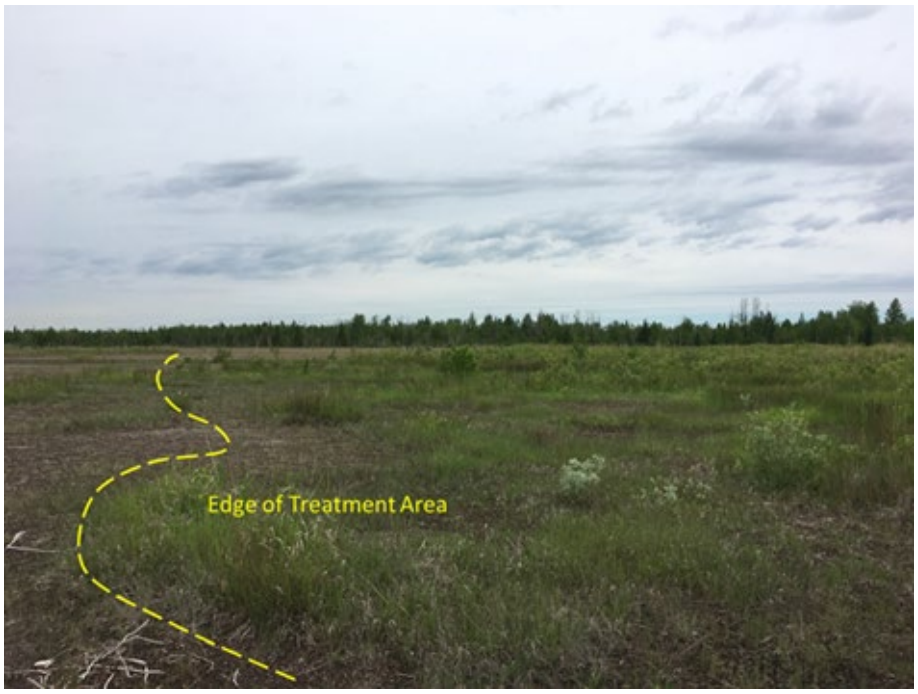
Soil Fertility and Tree Growth

The Final Report Summary for Activity 2 provides soil fertility testing data and results. The results from the nutrient testing indicates that the 6-inch and 12-inch sediment test plots have higher concentrations of phosphorus, organic matter, and total carbon when compared to the control plot. Potassium is higher in the control plot soils. Results also indicate that pH levels are higher in the sediment plots, which could negatively impact tree growth. For example, White pines prefer a pH of 5.5 to 6.5 (South, 2017) while Tamaracks prefer a pH of 5.5-6.5, and Cottonwood 4.6 – 6.5 (Minnesota Pollution Control Agency Stormwater Manual). In the

sediment samples pH ranged from 7.5 to 7.8. Result for pH from control samples were between 6.7 and 7. The sediment's higher pH suggests it may be useful for capping (or blending with) geological materials that have lower pH (acidic) generating potential.

Note: The number of soil samples collected from the test plots subplots is low and natural variability for each nutrient is not established.

Results for the survival and growth of trees on sediment plots range from good to failure, however all three sediment demonstration projects have developed a heavy cover of grasses and weeds. The best illustration of the value of sediment fertility for vegetative regrowth on disturbed land is at Keewatin Taconite's tailings basin. Sediment was placed on an unproductive area of the tailings basin in 2010 and 2011. A definitive easily visible line is observed where vegetation and sediment application stopped as seen in the 2019 photos in Figure 6-5.



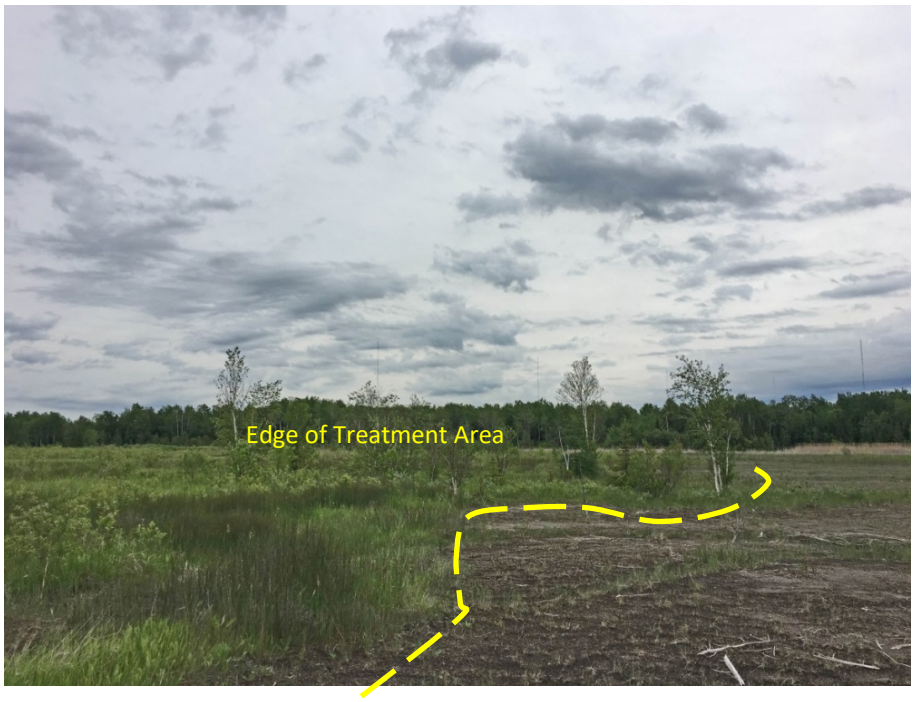


Figure 6-5: Keewatin Taconite Tailings Basin. Sediment placed on vegetated side of yellow line. Photographs provided to NRRI by USX – Keewatin Taconite.


Figure 6-6: Keewatin Taconite - Trees planted 2011 near service road where sediment layer is thickest.

Topography and other potential influences
Undulation across the site surface that may influence soil moisture is at a scale smaller than could be detected by the drone flight.

The MSAVI2 drone imaging certainly appears to agree with what we observed on the ground – that sediment application appears to assist with overall vegetation growth. It's a much more time-effective way to assess the vegetative cover but cannot be used for counting or measuring individual trees. In future studies, it could provide seasonal snapshots and documentation of the rate of cover growth over time and would be useful when combined with annual floristic surveys to document plant species.

Potential benefits of dredge sediment use on unproductive mineland and other disturbed properties

Other Potential Benefits from Project Results
This project has demonstrated that Erie Pier Dredge Sediment can promote vegetation growth on disturbed land. The success of purpose-grown trees using the sediment is not consistent between the three sites we observed. However, the re-establishment of grassy type vegetation can be enhanced with use of the sediment. This suggests that sediment could be used to grow pollinator habitat on disturbed lands. Bees were observed across the site during field work in June 2019 (Figure 6-7). Another possibly would be to select plants to provide carbon sequestration. If projects are pursued for these purposes, we recommend a long project time table, 5 to 10 years, to provide more realistic survival and growth of the shrubs and tree.

Figure 6-7: Bee and flower at ENRTF Virginia Landfill Site June 2019

Reference:

South, D.B. 2017. Optimum pH for Growing Pine Seedlings, Tee Planters' Notes, Vol. 60, Number 2, Fall 2017.
Minnesota Pollution Control Agency, Minnesota Stormwater Manual, Tree species list – pH and moisture ranges, https://stormwater.pca.state.mn.us/index.php/Tree_species_list_-_pH_and_moisture_ranges.

V. DISSEMINATION:

Description: In addition to the above reporting, site visits will be made available as requested featuring the activities at the NRRI facilities and St. Louis County research site. Annual fall tours will be scheduled and promoted. Participants will be invited from mining companies, land managers and regulatory agencies. Annual fall tours will be publicized through the NRRI website, local media and Laurentian Vision Partnership. A final tour of the research site will be scheduled and reported in the final report.

Each tour will begin at NRRI or be otherwise coordinated. Each tour will be preceded with a promotional mailing to highlight and describe the features of the activity or otherwise publicized through local media, the NRRI website or Laurentian Vision Partnership. The tours will be videotaped for future use and made available on request. In addition, the progress of this research will be photo-archived for reporting and dissemination.

Since this project is supported by County, State and Federal monies, all reported information will be made available to the funding sources, corresponding to the reporting schedule. Presentations will be made available to cooperators, especially the forum represented by Laurentian Vision Partnership.

All reported information will be archived and referenced in the NRRI Library and promoted as NRRI documents, with attribution to the funding sources.

Please Note: This is a FOUR year project.

The dissemination of data and reports will be accomplished through the NRRI website, in cooperation with the Laurentian Vision Partnership Meetings (quarterly), through progress reports to Commission Members and regulatory agencies (specifically MN DNR Hibbing Mineland Reclamation contacts) as status is reported. This will coincide with the above Item III. Project Status Updates, as follows:

Status as of October 1, 2014:

No dissemination of data and/or reports was performed during this period.

Status as of April 1, 2015:

No dissemination of data and/or reports was performed during this period.

Status as of July 1, 2015:

No dissemination of data and/or reports was performed during this period.

Status as of April 1, 2016:

No dissemination of data and/or reports was performed during this period.

Status as of July 1, 2016:

No dissemination of data and/or reports was performed during this period.

Status as of December 1, 2016:

No dissemination of data and/or reports was performed during this period.

Status as of July 1, 2017:

No dissemination of data and/or reports was performed during this period.

Status as of December 1, 2017: The analysis data from the soil samples collected at the site was shared with St Louis County Environmental Services staff for their own internal information on the Erie Pier sediments.

Status as of June 30, 2018: No dissemination of data and/or reports was performed during this period.

Status as of December 1, 2018: No dissemination of data and/or reports was performed during this period.

Status as of July 1, 2019 (submitted November 15, 2019): During the Reclamation Tour completed on June 26, 2019, a handout was provided to Mr. Thomas Lee, Reclamation Specialist, from the Mineland Reclamation program with the Minnesota Department of Natural Resources. The tour included a visit to the United Taconite facility to observe tree growth and wetlands creation at their Tailings 1 Basin reclamation site. A copy of the handout was also provided to the contact from the mine. A copy of this handout is attached to this report. It was completed prior to review and compilation of all the project data collected in May and June 2019.

Final report summary:
Results from this project, including soils and vegetation data, were shared with:

- **St Louis County Environmental Services (2017),**
- **Minnesota Department of Natural Resources Mineland Reclamation program (2019)**
- **and United Taconite personnel (2019)**

VI. Project Budget SUMMARY:

Please Note: Itemized details of this budget are included in a separate document.

A. ENRTF Budget Overview: See attached budget spreadsheet

Explanation of Use of Classified Staff: University employees are not classified.

Explanation of Capital Expenditures Greater Than $5,000: No capital expenditures greater than $5,000 for this project.

Number of Full-time Equivalents (FTE) Directly Funded with this ENRTF Appropriation: 3.0 FTE total for UMD NRRI Staff for the four year project

Number of Full-time Equivalents (FTE) Estimated to Be Funded through Contracts with this ENRTF Appropriation: 0.3 FTE total for contractors for the four year project

B. Other Funds: Please Note – PROJECTED FUNDS (not verified as January 2014)

Source of Funds	$ Amount Proposed	$ Amount Spent	Use of Other Funds
Non-state			
	$ 352,500	$ 352,500	US ACOE and US EDA MMC TOTAL allocated and spent on research projects related to the transport and use of Erie Pier Sediment for site restoration (through 2014)
	$ 250,000		Federal monies through US ACOE (pending request for transport monies) Please Note: Not ENRTF. Covering all forms of transport to the research site
State			
	$ 125,000		IRRRB LVP (pending request for transport monies) Please Note: Not ENRTF. Covering all forms of transport to the research site.
TOTAL OTHER FUNDS:	**$ 727,500**	**$ 352,500**	

VII. PROJECT STRATEGY:

The long term vision for this project is:

- To substantiate the most cost effective system for the transport of sediment from Duluth to minelands within the Mesabi Range (i.e. establish parameters of cost effectiveness);
- To provide protocols for quality control and quality assurance for the sediment relative to site restoration;
- To prove best management practices in the use of the sediment for mineland site restoration;
- To demonstrate long term economic benefits of site restoration, with emphasis on biomass productivity;
- To establish transferrable, technical practices for the use of sediment for other sites, such as brownfields, landfills and spill sites.

A. Project Partners: All of these Project Partners are funded without ENRTF monies - US ACOE, Duluth Port Authority, St. Louis County Environmental Services, IRRRB (Laurentian Vision Partnership – LVP), UMD-NRRI (indirect and PUTF). All are partnering without ENRTF funds.

B. Project Impact and Long-term Strategy: Transfer proven technology and methods to other sites, including public lands, industrial properties, brownfield and disturbed sites for the purpose of restoration and sustained, benefitical use.

C. Spending History:

Please Note: No ENRTF funds have supported this research to date.

Please Note: No specific Minnesota Legislative appropriations have been expended on research related to Erie Pier Sediment by UMD- NRRI. Internal NRRI monies, Federal funds and PUTF monies have been expended in support of related research (US ACOE and EDA MMC) since 2010. Previous research sites are located at tailings basins, superfund sites, one local golf course, landfill and borrow pit. For reports on these activities please contact the NRRI research team.

Funding Source	M.L. 2008 or FY09	M.L. 2009 or FY10	M.L. 2010 or FY11	M.L. 2011 or FY12-13	M.L. 2013 or FY14

VIII. ACQUISITION/RESTORATION LIST: None

IX. VISUAL ELEMENT or MAP(S):

A map of the research site, as originally submitted to LCCMR is attached and included in XI. Research Addendum

X. ACQUISITION/RESTORATION REQUIREMENTS WORKSHEET: None

XI. RESEARCH ADDENUM/EXHIBIT:

Purpose: If more information is required to explain the geography and logistics of the overall project and Research Site specifically, please contact the NRRI research team.

Title (format)	Description/Purpose
Landfill Area Gray (jpg)	gray scale visual of landfill, submitted with initial proposal, research plot within

XII. REPORTING REQUIREMENTS:

Project Status as of October 1, 2014:

Project Status as of April 1, 2015:

Project Status as of July 1, 2015:

Project Status as of April 1, 2016:

Project Status as of July 1, 2016:

Project Status as of December 1, 2016:

Project Status as of July 1, 2017:

Project Status as of December 1, 2017:

Project Status as of July 1, 2018:

Project Status as of December 1, 2018:

Project Status as of July 1, 2019: Final Report

Environment and Natural Resources Trust Fund
M.L. 2014 Project Budget

Project Title: Dredged Sediment for Forest Restoration on Unproductive Minelands
Legal Citation: M.L. 2014, Chp. 226, Sec. 2, Subd. 06j
Project Manager: Marsha M Patelke
Organization: University of Minnesota - Duluth, Natural Resources Research Institute (UMD-NRRI)
M.L. 2014 ENRTF Appropriation: $ 300,000
Project Length and Completion Date: 4 Years, June 30, 2019
Date of Report: Feb 28, 2020

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Activity 1 Budget	Amount Spent	Activity 1 Balance	Activity 2 Budget	Amount Spent	Activity 2 Balance	Activity 3 Budget	Amount Spent	Activity 3 Balance	Activity 4 Budget	Amount Spent	Activity 4 Balance	Activity 5 Budget	Amount Spent	Activity 5 Balance	Activity 6 Budget	Amount Spent	Actvity 6 Balance	TOTAL BUDGET	TOTAL Expenses	TOTAL BALANCE
BUDGET ITEM																					
Personnel (including Wages and Benefits) (07/01/2018)	$32,880	$32,880	$0	$33,046	$33,046	$0	$37,162	$37,162	$0	$39,948	$39,948	$0	$54,776	$54,776	$0	$55,547	$55,547	$0	$253,359	$253,359	$0
All UMD-NRRI Staff: Marsha Patelke - salary and benefits, ($55,346) Tom Levar - salary and benefits, 20% time per year for four years ($76,495) Larry Zanko - salary and benefits, 10% time per year for four years ($41,271) Craig Maly - salary and benefits, 20% time per year for four years ($53,331) Sara Post - salary and benefits, 20% time per year for four years (13,228) Steven Monson Geerts - salary and benefits, ($6,386) George Host - salary and benefits, ($3,386) Kurt Johnson - salary and benefits, ($401) Kristina Nixon - salary and benefits, ($3,515)						$0			$0						$0			$0			
Professional/Technical/Service Contracts Contract #1: Floristic Survey (Dr. Gerould Wilhelm at Conservation Forum) Annual Events (four) each at $3,000 Project Total $ 12,000	$3,000	$3,000	$0			$0	$3,000	$3,000	$0	$0		$0	$3,000	$840	$2,160	$3,000	$0	$3,000	$12,000	$6,840	$5,160
Professional/Technical/Service Contracts Contract #2: Site Preparation and Equipment Operations Annual for Two Years $ 5,000 Project Total $ 10,000	$5,000	$5,000	$0	$5,000	$4,630	$370			$0						$0			$0	$10,000	$9,630	$370
Equipment/Tools/Supplies $ 11,654 Project Total Tractor and implement rental (seasonal) Trailer rental (seasonal) Planting supplies (seasonal, field) Soil and substrate materials sampling supplies Water sampling supplies Hydrologic monitoring supplies Plant tissue sampling supplies Seed sampling supplies Plant propagation, greenhouse and nursery supplies Planting stock (field and propagation) Agrichemicals and fertilizers (seasonal, field and greenhouse)	$0		$0	$3,207	$669	$2,538	$1,772	$1,772	$0						$0			$0	$4,979	$2,441	$2,538
Travel expenses in Minnesota Round trips, one leased vehicle, 120 mile each trip seasonal at twice per week (3,840 miles per four months per year or 15,360 seasonal plus 1,920 miles per year off season (two round trips per month for eight months) = 17,280 per year or 69,120 total miles for four year project X $0.56 per mile = $38,707; travel is needed for site establishment, site maintenance, monitoring, sample collection, coordination of activities and technical outreach	$300	$300	$0	$4,550	$1,500	$3,050	$1,387	$346	$1,041	$1,085	$1,085	$0	$572	$572	$0	$728	$728	$0	$8,622	$4,530	$4,092
Other Evaluating Aerial site assessment using a drone ~ $1200 for the Virginia Landfill Site and ~$1200 to assess a similar site to compare results for this new method of to survey plant health and site conditions. Funds are transferred from Activity 1.						$0	$3,200	$0	$3,200				$4,320	$2,441	$1,879	$3,520	$1,094	$2,426	$11,040	$3,535	$7,505
COLUMN TOTAL	$41,180	$41,180	$0	$45,803	$39,845	$5,958	$46,521	$42,280	$4,241	$41,033	$41,033	$0	$62,668	$58,629	$4,039	$62,795	$57,369	$5,426	$300,000	$280,335	$19,665