1.0 Executive Summary

This report details the assessment of Centerville Creek and outlines a plan for restoring the creek to a natural condition. A basic fluvial geomorphic assessment of Centerville Creek and regional streams was used with elementary hydraulic analysis to estimate stable stream planform and cross section geometry under restoration conditions. Existing water quality, fisheries and land use spatial data were incorporated to give a complete picture of the watershed and to assess the potential for restoration. A cost estimate of the restoration plan is provided, and alternatives for funding are discussed.

The Centerville Creek Dam was removed by the Wisconsin Department of Natural Resources (WDNR) in 1998. Sediment that accumulated behind the dam during its design life was not excavated at the time of dam removal. This has resulted in an incised channel with steep eroding banks and degraded in-stream and riparian habitat. The eroded sediment is transported directly into Lake Michigan. The restoration alternative proposed by Inter-Fluve Inc. involves the removal of large amounts of accumulated sediment behind the former dam site and stabilization of the stream channel using bioengineering methods. The proposed floodplain restoration will return the impoundment area to a forested riparian condition, reducing sediment load to Lake Michigan, improving fish habitat and increasing recreational opportunities.

2.0 Introduction

2.1 Purpose of Investigation

The Village of Cleveland, under a River Planning and Protection Grant from the Wisconsin Department of Natural Resources, contracted Inter-Fluve Inc. to investigate possible restoration alternatives for Centerville Creek. This report was prepared to assist the Village of Cleveland in the restoration process and to identify potential funding sources.

The parameters involved in restoring Centerville Creek in the former impoundment area was evaluated with regard to three primary factors: spatial (stream channel dimensions); geomorphic (ensuring proper channel grade, sinuosity, and stability); and habitat (improving conditions for fish and wildlife). Provided funding for full restoration is obtained in the future, this assessment provides valuable information that can be used in developing Final Design plans for the restoration of Centerville Creek.

2.2 Project Location and Site Description

Centerville Creek drains directly into Lake Michigan approximately 1.2 miles east of Cleveland, Wisconsin. The former dam site is located 600 feet upstream of Lake Michigan and the impoundment is approximately 1500 feet long and averages 120 feet wide, encompassing an area of approximately 7 acres (see Figure 1). The original Centerville Dam was built sometime prior to 1895 and a larger concrete structure was built in 1935 (Appendix A). A 1988 inspection of the dam revealed structural deterioration and after subsequent inspections, the WDNR ordered the dam to be repaired or removed. The dam remained in place until 1998, when the WDNR removed the dam. Impoundment sediment depths remain as much as 10 feet, and the stream has incised through the sediments to the former valley floor.

The project area is defined by steep bluffs that confine the former valley. Lincoln Avenue borders south side of the downstream end of the project site, and residential homes are common along the northern bluff above the impoundment. The Centerville Creek restoration site is free of structures such as home sites, bridges and other infrastructure. A bridge is located approximately 300 feet downstream of the former dam site but presents no grade control or other problems.

2.3 Limitations of Analysis

This report is designed to provide conceptual design plans and a preliminary cost estimate for restoration and should not be used for any construction activity. Final design plans will require detailed hydraulic analysis, flow modeling and detailed engineering specifications. This assessment does provide an excellent starting point for restoration, and addresses many of the issues surrounding stream restoration activities.

In addition, this report is based on site conditions for September of 2001, and any Final Design for restoration should incorporate changing land use and site.

Survey data was collected in August of 2001 and thick vegetation prevented adequate surveying of the upper reaches of the impoundment and of the slopes around the outside of the impoundment. However, some areas were surveyed and assumptions are made based on these measurements. These bluff slope areas are not critical to the concept design phase of the project, but additional surveying may be required for Final Design to further define project limits and construction access.

3.0 Methodology

3.1 Fluvial Geomorphology

Stable stream systems are in a delicate balance between the processes of erosion and deposition. Streams are continually moving sediment eroded from the bed and banks, and some of this material is deposited in the form of bars on the inside of meander bends. The process by which streams meander slowly within the confines of a floodplain is called ‘dynamic equilibrium’ and refers mainly to this balance of sediment erosion and deposition. Many factors can influence this equilibrium, including vegetation that holds soil in place, flashy flows that erode banks, and increased sediment pollution that deposits in the channel. Once a stream channel is in equilibrium, it may move across the floodplain, but several parameters remain relatively constant over time. Included among these are the average stream depth, stream width, belt width (generally the same as floodplain width), the meander wavelength (distance between bends) and the radius of curvature (the radius of a circle superimposed on a meander bend). Figure 2 gives a diagram of each of these measurements. Understanding these parameters and their relationship to each other is the first step in creating a stable stream restoration project.

The fluvial geomorphic assessment of Centerville Creek involved establishing several reference streams draining into Lake Michigan between Kewaunee and Cedar Grove, WI. These streams were used to obtain regional information regarding channel dimensions, planform geometry, riparian condition and stability. These reference streams were chosen based on the following criteria:

- Direct drainage to Lake Superior
- Perennial flow
- Proximity to Centerville Creek
- Watershed under 30 square miles
- Agricultural land use 50% or more
- Urban land use 20% or less
- Similar drainage pattern

Digital information was obtained from existing data, and field information was also collected. Based on the data collected, statistical equations were developed to better predict channel cross-section and planform dimensions such as bankfull width, mean bankfull depth, meander length and radius of curvature.

3.2 Digital Data

Digital Orthophotographic Quadrangles (DOQ) for Manitowoc and Sheboygan Counties were obtained from the United States Geological Survey (USGS) and from the Bay-Lake Regional Planning Commission. USGS topographic quadrangle maps were obtained from the Map Store (Milwaukee, WI). DOQ information was incorporated into ArcView™ Geographic Information Systems (GIS) software for manipulation.

Reference streams – Aerial photography was examined for each of the reference streams. This analysis yielded meander wavelength, radius of curvature, belt width, riparian cover, land use, watershed area, sinuosity and meander patterns.

3.3 Field Data

3.3.1 Survey

A topographic survey of the entire impoundment area was completed by Inter-Fluve Inc. and Robert E. Lee and Associates (Green Bay, WI). Global Positioning System survey equipment was used to establish true elevations and a total station survey level was used to map individual survey points. Approximately 1200 data points were surveyed to create a 1-foot interval contour map of existing conditions (Figure 3). Horizontal datum was obtained through the Manitowoc County Coordinate System and vertical datum was obtained with North American Vertical Datum (NAVD) 88. A base map was created using AutoCAD v.14.

3.3.2 Reconnaissance (Coastal streams)

Field geomorphic data was collected for each of the reference streams and for Centerville Creek. Parameters measured include bankfull width, mean depth, width of the floodplain and channel substrate size gradation. General observations were made regarding vegetative cover, erosion potential, and fish habitat quality. Observations were also made to determine overall channel stability. This process involves determining channel forming flow elevations from indicators such as woody vegetation growth, sediment deposition, watermarks and bank slope.

Planform geometry patterns were measured in the field for both the north and south branch of Centerville Creek upstream of the confluence.

3.3.3 Geologic controls

To determine the extent of channel incision into the impounded sediment, and to measure the depth of sediment deposition in the channel, the vertical distance to apparent historic bed was measured. Depth of sediment deposition was estimated by measuring the depth of refusal using a #4 iron rebar T-post.

Composition of impoundment sediments was measured by visual observation of erosion patterns, color and texture. Shovel samples were taken for close inspection.

3.4 Water Quality and Fisheries

As a part of the restoration plan, WDNR Fisheries biologists completed the Wisconsin DNR Wadeable Stream Survey Protocol on Centerville Creek in August of 2001. Three reaches were surveyed, one on the main stem and one on each of the two branches upstream of the impoundment area. The Wadeable Streams Protocol uses an Index of Biotic Integrity (IBI) to evaluate stream health based on the relative abundance of certain fish species. The IBI concept assumes a score for fish species based on each species' tolerance to pollutants. The total score for a stream reflects the overall water quality of the system.

3.5 Soil Testing

According to Wisconsin Statutes NR347 regulating sediment sampling and analysis, monitoring protocol and disposal criteria for dredging projects, some analysis of accumulated sediment may be necessary. The State Solid Waste Disposal Engineer and the local WDNR Water Management Specialist were contacted regarding the Centerville Creek Restoration. The Centerville Dam sediments are considered non-hazardous due to the agricultural nature of the watershed. Further soil testing will be required prior to disposal to determine proper disposal site methodology. This testing will be completed in accordance with WDNR requirements.

3.6 Geotechnical Conditions

A preliminary boring program has been developed.

3.7 Basemap and Planset

Conceptual drawings were completed for the proposed restoration site using ArcView and AutoCAD 2000.

4.0 Field Investigation Results

4.1 Fluvial Geomorphology

4.1.1 Former dam site and grade control

Portions of the dam structure still remain in place and may be providing some grade control throughout the project area (Figure 4). Removal of this portion of the dam may require replacement with a grade control structure. Typical grade control structures are made of natural rock and traverse the entire width of the floodplain, however only the portion in contact with the active channel bed would be visible as a rock riffle. See section 5.1.4 for further details.

4.1.2 Incision and erosion

The stream has incised through the sediments and appears to be reaching vertical equilibrium. Reconnaissance surveys show armored sections of gravel throughout the main channel area, suggesting a cessation of vertical migration. Both the north and south branch tributaries show active nickpoints (Figure 5), but these are cutting into extremely hard, cohesive clay lenses, again suggesting that the stream has reached its natural bed elevation. Point Creek, Fischer Creek and the upstream reaches of Centerville Creek all show stable, cohesive clay streambeds with some gravel bar and riffle formation.

The entire project area has extremely high vertical banks from five to 10 feet in height (Figure 6). Because of their sheer drop and the abundance of tall grasses, these banks represent a significant safety hazard. Spring sources have created deeply incised small gullies, some as much as 4 feet deep and completely obscured by vegetation, creating a trapping hazard. Floodplain excavation as called for in this restoration plan will eliminate these problems.

Having established a vertical boundary, the stream has begun eroding laterally to establish a stable slope. This process will continue until the stream has established enough sinuosity to create a stable equilibrium. Unless the stream is restored, the high sediment input from eroding banks will continue to fill the channel bottom with fine silt and clay, and excess sediment will continue to pollute Lake Michigan for many years.

4.1.3 Fish habitat

The main channel of Centerville Creek contains very little fish habitat. Some large woody debris has drifted down from upstream or fallen from the eroding banks and has created scour pools with less than 2 feet of residual depth. Sedimentation of pools is preventing deep pool habitat from forming, and most gravels have a high degree of sedimentation.

No overhanging bank cover exists in the form of undercut banks, as large areas of mass wasting and slumps prevent any undercuts from forming. No woody vegetation is present and so there is little in the way of stream shading apart from that provided by the high vertical banks.

4.1.4 Stream classification and channel evolution

Currently, the main channel and lower portions of the two branches of Centerville Creek are designated as G5 under the Rosgen stream classification system. Highly unstable, incised, steeply eroding banks, no floodplain and sand dominated substrate characterize this stream type. As the banks erode laterally and the bed elevation rises to create a new floodplain, this stream would move toward an F5 stream type. Under the Schumm channel evolution model, Centerville Creek represents a Stage II channel progressing to a Stage III. This classification demonstrates that the initial incision is nearly complete and that the channel is now beginning to erode horizontally.

4.1.5 Floodplain function

A major factor in the physics of erosive processes is the depth of water, which relates directly to the weight or force of the water on an eroding bank. Floodplains dissipate the energy of large rainfall events by spreading the stream flow out over large areas, thereby decreasing the stress on any particular section of stream channel. These floodplains also serve as nurseries for riparian vegetation and provide critical wildlife habitat and green corridors between adjacent river systems.

The main stem of Centerville Creek has incised to the point where the stream is now completely cut off from its floodplain. This is misleading in this case since the actual historic floodplain is buried under several feet of deposited sediment. Large flood events are completely contained within the canyon-like walls of the stream, thereby increasing the forces that cause erosion.

4.1.6 Channel grade, length and sinuosity

According to existing survey data, the average grade of the valley from the confluence of the north and south branches to the dam site is 0.0062 (0.62 %). The channel slope in this reach is 0.0056 (0.56 %). The total stream length from the confluence to the dam site is 1280 ft. The south branch surveyed in the impoundment area has a thalweg, or mid-channel length of 260 ft, while the north branch section has a length of 470 ft.

Sinuosity is the ratio of channel, or thalweg, length to valley length. Sinuosity for the main channel is 1.12. Based on data obtained from regional reference streams, this low value represents lateral instability. Regional streams of similar drainage area demonstrate sinuosity in the range of 1.8 to 2.5.

4.1.7 Regional streams

Reconnaissance of reference streams revealed 13 streams that fit the proposed criteria for inclusion in the regional regression data set. Sandy Bay Creek, Little Sandy Bay Creek, Two Creeks South, Molash Creek, Silver Creek, Calvin Creek, Pine Creek, Point Creek, Fisher Creek, Centerville Creek, Centerville Tributary, the Black River, and Barr Creek were included in the data analysis. Using regression analysis of regional conditions, the suggested channel dimensions for the main stem restoration are a bankfull width of 17 feet with a mean depth of 1.7 feet. Predictions of planform geometry for the restored stream suggest an average meander wavelength of 120 feet with an average bend radius of 38 feet. Appendix B shows the distribution of values in a regional regression curve.

Upstream of the impoundment area, both branches show signs of increased channel incision. Current stream conditions show bankfull or channel forming flow depths approximately one foot deeper than some abandoned channel fragments. Centerville Creek upstream of the impoundment and some of the reference streams show a box-like channel with relatively few depositional bar features. Active erosion can be seen throughout these systems, and it is likely that these streams may have stabilized to accommodate the higher peak flows typical of agricultural streams in the Midwest. The stable stream is now deeper and wider than historic channels. As the watershed develops, increased urbanization will cause changes to the local hydrology. Final design plans should incorporate development effects on hydrology, and appropriate measures should be taken to prevent project failure.

4.2 Riparian Zone Conditions

4.2.1 Vegetative cover

Vegetation in the riparian zone and floodplain of the main stem currently consists mainly of aggressive exotic species including reed canarygrass (*Phalaris arundinacea*) and giant reed grass (*Phragmites australis*), two highly aggressive and nuisance exotic grass species. The area also has significant populations of cattail (*Typha latifolia*) and stinging nettle (*Urtica* *dioica*), two species common to disturbed areas. No woody vegetation currently exists and there are no bank stabilizing shrubs such as willow or dogwood.

The upstream areas of the south and north branches of Centerville Creek show overstory and understory vegetation typical of streams in this area. The South branch tributary is dominated by large trees, principally white cedar (*Thuja occidentalis*), basswood (*Tilia americana*), and black willow (*Salix nigra*), which form a nearly complete canopy. Because of the thick canopy in this reach, very little understory shrub species are present. The north branch of Centerville Creek upstream of the impoundment also contains some white cedar, but the riparian zone is dominated by large black willow of moderate density, resulting in canopy coverage of approximately 75%. The floodplain in this area is dominated by young sugar maple (*Acer saccharum*) and basswood, while the upper terraces are populated mainly by paper birch (*Betula papyrifera*). Understory shrubs are common in the north branch floodplain and near bank areas, and consist mainly of gray dogwood (*Cornus foemina*), box-elder (*Acer negunda*) and red osier dogwood (*Cornus stolinifera*).

4.3 Water Quality and Fisheries

The Wisconsin DNR survey of fish and habitat in the Centerville Creek system shows a degraded stream with water quality problems (Appendix C). In the main stem, 323 individuals from 16 different taxa were captured with a final IBI score of 35, indicating fair water quality. Site 2 on the south branch yielded 36 fish from 4 different taxa, indicating poor water quality. Site 3 on the north branch yielded 44 fish from 5 different taxa, indicating very poor water quality. It should be noted, however, that the IBI is based on a total of at least 100 fish captured per sample. Because fewer than 100 fish were captured in sites 2 and 3, conclusions based on these results should be made with caution. Regardless, it appears that water quality upstream of the impoundment area is poor. To assist in long-term management, further water quality data should be collected to determine actual amounts of pollutants.

Although this project focuses on restoring habitat in the impoundment area, an effort should be made to address watershed-scale problems that effect water quality. Some of these issues include water quality, runoff volumes and discharge rates. All restoration projects should consider these large-scale influences on water quality, hydrology and fisheries.

4.4 Soil Testing

Results of soil testing are pending further core sampling.

5.0 Performance Criteria

5.1 Introduction

The following criteria outline the level of performance desired for various elements within an acceptable level or risk. These criteria stipulate general requirements for design elements such as bank erosion protection, type and amount of fish habitat or densities for vegetation.

5.2 Flood Protection

This project have no adverse impact on the flood damage potential for the areas upstream, within or downstream of the project area.

5.3 Bank Stabilization

Dynamic equilibrium describes the migration of stream channels through cutting or erosion on outer banks and the deposition of eroded material on inside meander bends, or point bars. Streams migrate over time (years to decades), but have lateral stability over shorter temporal spacing (months to years). Lateral stability is accomplished through resistance to erosion and proper planform geometry. Natural channel design incorporates bioengineering methods and fluvial geomorphology analysis to impart initial stability until bank-stabilizing vegetation can fully establish. This method designs deformable banks that allow for minor changes in planform and bank shape, but retains overall lateral stability.

Design elements for erosion protection including biodegradable blankets, stakes and the associated design methods will protect the banks, bed and floodplain over the short-term until vegetation becomes established. Native grasses, shrubs and trees will provide long-term erosion protection and channel stability. The preferred design alternative presented here provides stable channel morphology up to the 100-year flood event.

5.4 Impacts to Lake Michigan

Because of the proposed bank restoration and stabilization, this project will reduce non-point source sediment loading to Lake Michigan. This project will have no effect on Lake Michigan water levels.

5.5 Fisheries Management

In-stream habitat structures, bank cover and vegetation will provide adequate cover based on all life stages of smallmouth bass (*Micropterus dolomieu*), northern pike (*Esox lucius*), and migratory Lake Michigan salmonids. Spawning size gravel will be incorporated into design where possible.

5.6 Floodplain Management

The majority of the project area will remain in public ownership and will be managed as wild riparian land and floodplain forest. The Village of Cleveland will pursue options for landowners such as conservation easements and land trust donations.

Recreational use will be limited to passive use, with a single non-paved walking trail on either the southern or northern edge of the newly constructed floodplain.

5.7 Hydrologic Conditions

Preliminary project design is based on existing hydrologic conditions. Final design components will consider future hydrologic conditions based on the Village of Cleveland Comprehensive Plan. Stormwater management by the Village of Cleveland will consider project success criteria in planning future watershed developments.

5.8 Safety

Grading of the floodplain and lowering streambank height will reduce the risk of injury from falling.

5.9 Maintenance

Maintenance of floodplain and riparian vegetation will be limited to watering and replanting where necessary. Once native vegetation has become established in approximately 5 years, further vegetation maintenance will not be required.

Minor repair and maintenance of structural impacts may be necessary until vegetation is established. Further maintenance following >100 year flood events may also be necessary.

5.10 Regulatory Requirements

This project requires adherence to permit conditions for permits according to Wisconsin State Statutes 30.12 (placement of structures), 30.19 (grading in excess of 10,000 square feet, and 30.195 (realignment of a navigable waterway). The Wisconsin DNR will complete any Environmental Assessment deemed necessary.

This project also requires adherence to Army Corps of Engineers General Permit GP-001-WI for specified activities permitted, authorized or approved by the Wisconsin DNR.

Disposal of impounded sediments is subject to permitting under Wisconsin Administrative Code 289.43(8) covering disposal of low-hazard waste.

6.0 Alternative Analysis

6.1 Introduction

A preliminary alternative analysis was performed as part of the concept design process. Three approaches were reviewed.

6.2 Alternative #1 - No Action

The implications of no action were considered. Lateral migration of Centerville Creek will eventually scour out the floodplain and become a stable system that is reflective of its geomorphic influences. However, this process will require a long time period for recovery. Exactly how long this recovery will take is unkown, but it is reasonable to assume that full geomorphic recovery will take several decades and vegetative recovery will take a century or more. The implications of no action are as follows:

- Continued excessive sediment release to Lake Michigan
- Continued safety concerns associated with the incised channel
- Limited recreational use
- Limited aesthetic value
- Limited fishing opportunities
- Limited fishery potential for the upstream reaches

Based upon these considerations, the no action or "do-nothing" alternative was rejected.

6.3 Alternative #2 - Channel Elevation

The second alternative examined was raising the channel bed elevation to reduce bank height and restore floodplain function. This would include the construction of multiple grade control structures across the valley width to provide a vertical transition between the channel invert downstream of the dam and the channel invert upstream of the dam's influence.

In effect this method would require constructing the historical grade control (dam) with multiple smaller grade control structures. These structures can be made of large rock material and designed to allow fish passage. A detailed cost estimate was not prepared for this alternative, but the construction cost would be significantly less than lowering the floodplain elevation.

However, construction of this type of system would not allow future lateral or vertical migrations that occur naturally and are an important part of functional riverine corridors. Raising the channel invert would give the appearance of a restored corridor but would not create a fully functioning riverine system. In addition, these grade control structures would require future maintenance effort and expense. Based on these considerations, this alternative was rejected.

6.4 Alternative #3 – Lowering Floodplain elevation

The third alternative involves the excavation of the impounded sediments and restoration of the channel. Interfluve Inc. believes that this plan mimics more closely the original, pre-dam stream condition and also represents the most geomorphically stable and environmentally sound restoration. This plan is the most expensive of the three alternatives, but this alternative eliminates sediment pollution, restores fish habitat and riparian function, allows for natural channel processes and provides aesthetic value. Based on these considerations, floodplain excavation and restoration is the selected alternative and is detailed in Section 7.0 below.

7.0 Selected Alternative Restoration Plan

7.1 Design and Construction

Interfluve Inc. recommends a plan based on floodplain establishment and removal of impoundment sediment. This restoration plan calls for the excavation of approximately 30,000 cubic yards of accumulated sediment from the impoundment area, establishment of a functioning floodplain and a stable stream channel with complex habitat features. The following paragraphs address potential issues and make recommendations for the Final Design phase of the project.

This preliminary design report is based on current development conditions. Future land use will play an important role in determining the evolution of the Centerville Creek stream channel, and attention should be paid to the effect of development in the watershed.

7.1.1 Floodplain restoration

Upon excavation of the bulk of accumulated sediment, a floodplain will be established. The stream will maintain an average bank height of 2.0 feet with a floodplain width averaging 100 feet. The planting plan for floodplain forest restoration is based on plant species data collected and outlined in Section 5.1.6. The constructed floodplain will slope up away from the stream banks at a 2% slope to ensure proper drainage and to minimize shear stress on the floodplain surface. In some areas plateaus 1-2 foot in height will be established to further minimize shear stress on the floodplain surface and thus prevent eroded pockets and chutes from forming. Erosion control of floodplain areas should include stabilization with erosion control fabric that is tied into bank stabilization measures. Figure 7 shows the general concept of floodplain excavation.

Floodplain borders will slope up from the floodplain to the terrace walls at an approximate 3:1 slope where possible. In some areas where there are geologic restraints, slopes may approach a 2:1 grade. These slopes will follow the floodplain erosion control and planting plans.

7.1.1.1 Disposal of floodplain sediments

The Wisconsin DNR has stated that the sediments accumulated upstream of the Centerville Creek dam are not to be considered hazardous, and can therefore be disposed of using methods and permitting for non-hazardous dredged material. The disposal procedure outlined below assumes non-hazardous waste. Disposal of more than 3,000 cubic yards of sediment in any one location will require the Village of Cleveland or its contractor to submit a request for a grant of exemption from solid waste regulations for a low hazard waste. The WDNR will review the proposed disposal site as well as contaminant concentrations of the sediments. The WDNR is required to hold a public meeting to solicit comments before making a decision on permitting. The application for the Grant of Exemption should be submitted well in advance of the project start date so that the project is not delayed.

In general, the process to request a grant of exemption includes the following:

A letter requesting an initial site inspection (ISI) of the proposed disposal site. ISI submittal requirements:

- Cover letter identifying the owner, location, and present land use
- Letter from DNR Bureau of Endangered Resources identifying any critical habitat areas
- Letter from State Archeology Office identifying the presence of any historical areas
- An enlarged 7.5 minute USGS map showing relief, surface waters, floodplains, existing land use conditions and all water supply wells and residences within 1200 ft of the disposal site.
- Any potential conflicts with wetlands, critical habitat, surface water, or groundwater

A proposal requesting a Grant of Exemption for low hazard waste under Wisconsin Statutes s. 289.43(8) for disposal of dredged sediments. There is a $500 plan review fee for this submittal that may be waived in the event that the State or the WDNR provides partial funding for the project. The proposal should include the following:

- Name, address, and telephone number of the owner and consultant
- Total acreage of property and disposal site.
- Life of disposal site, capacity, types and sources of sediments
- Depth to groundwater
- Boring logs identifying USCS classification of major soil units encountered at the disposal site. Analysis of USCS grain size distribution
- Proposed operation of the disposal site (hours of operation, etc.) The disposal site must be operated, maintained and closed in a nuisance free manner. The WDNR may require that the site be closed from view to residences within ¼ mile.
- Restricted access to site through use of gate (required) and fencing or equivalent
- Stormwater/runoff considerations.
- Results of sediment analyses. This would require that the collection of representative core samples of the proposed dredge site and have them analyzed for the RCRA metals (arsenic, barium, cadmium, lead, mercury, and selenium), pesticides, and PCBs.
- Closure plan. This plan details coverage of the site, and the WDNR may require that the site be final graded, seeded, fertilized and mulched. Under the right circumstances, this would be the responsibility of the contractor.

7.1.2 Channel restoration

Stable natural channel design requires design based on a multiple step, iterative process. The first step in this process is the determination of the design discharge based on either hydraulic modeling such as HEC-RAS or XPSWMM or empirical or analytical data analysis. Interfluve Inc. recommends the use of existing regional hydrology information and analog reaches to determine design discharge based on parameters such as watershed area. Regional data collected in this investigation is likely more accurate than any hydraulic model in this case. Sandy Bay Creek, Calvin Creek and some portions of Fisher Creek and Centerville Creek were determined to be relatively undisturbed and will serve as models for designing the riparian zone and in-stream restoration (Figure 8). These streams were characterized by thick canopy coverage, excellent large woody debris distribution, deep pool habitat, clean gravel riffles and overhanging vegetative cover, all desirable attributes for fish and wildlife habitat. Also common to these systems was a forested riparian at least 500 feet in width with large white cedar, cottonwood or willow trees dominating the near shore areas. It should be noted that although the lower portions of these streams remain undisturbed, the headwater areas of these systems are completely developed for row crop agriculture. Despite the excellent habitat conditions observed, these streams all suffer from excess sand deposition.

Data collected regarding substrate and flow conditions at particular sites will be used in the Final Design process to determine maximum scour depth and shear stress values for given flow conditions in the newly constructed channel. Scour analysis and incipient motion calculations determine the proper sizes of bed and bank particles, and determine the type of bank treatments allowed for the design discharge.

The next step in the design process is balancing the hydraulic and sediment size information with slope and planform geometry information to determine the cross-sectional geometry and planform geometry of the channel. Regional data again becomes valuable in determining the ultimate shape of the channel. Preliminary design data suggests the newly constructed Centerville Creek should maintain a variable bankfull top width between 15 and 17 ft, a bottom width of 5-6 ft with a mean depth at riffles of 1.5-1.7 ft. Maximum residual pool depth may vary from 2 to 4 ft. Regional planform geometry fitted to the Centerville Creek watershed predicts a stable planform with meander wavelengths between 100 and 110 ft, and a mean radius of curvature of 38 ft.

Following dewatering of the site, the new channel will be constructed in the following sequence. Pre-sorted and properly sized bed material, likely in the form of gravel and cobbles, will be installed to the determined maximum depth of scour (Figure 9). To ensure proper stability in the event of local lateral scour, this imported bed material will extend under the floodplain for approximately 0.5-1.0 * channel bottom width on either side of the stream. Pools and riffles will be constructed to final grade and woody debris structures will be installed (Figure 10). Bank stabilization with bioengineering methods and floodplain detailing will complete the restoration of the channel (Figure 11).

7.1.3 Grade Control

Unstable channel areas such as the former dam site may require the installation of grade control structures. Vertical instability is usually manifested in the form of nickpoints, or abrupt head changes (headcuts) that continue to erode and advance upstream until a stable channel grade is reached. To prevent the formation of a headcut at the former dam site, a rock weir would be buried just below the grade of the stream bottom and would extend across the entire width of the floodplain (Figure 12). Further grade controls may be installed in other reaches to add vertical stability to the newly constructed channel.

7.1.4 Bioengineering methods

Most of the bank restoration for this project involves the construction of new banks from deposited sediment. Construction of these banks is best accomplished using fabric-encapsulated soil (FES) in the form of 1.0-1.5 foot layers of soil enclosed in biodegradable erosion fabric. Fabric and live willow or dogwood stakes are placed and tied into the stream bed. A layer of soil is installed and compacted. The erosion control fabric is then wrapped around the soil and staked down with heavy-duty wooden stakes. The erosion control fabric prevents piping and erosion of the soil until the native vegetation becomes established. Figure 13 shows the general concept of FES lift construction following floodplain excavation.

Alternatively, soil can be compacted and erosion blanket can be used to secure slopes without the use of encapsulated lifts. This technique is useful with highly cohesive soils in segments with low banks (Figure 14). Again, live plants in the form of cuttings or mats can be used to stabilize newly constructed slopes.

7.1.5 Planting

7.1.5.1 Near bank

Installation of bioengineered bank stabilization will require the installation of live cuttings of various native willow species, usually black willow, sandbar willow or pussy willow. Dogwood shrubs in cutting, bare root stock, potted plants or live mat form can also be incorporated into bank stabilization (Figure 15).

7.1.5.2 Riparian zone

A buffer will be established along the entire project length, and will serve to provide overhead cover and stream shading as well as erosion control. The buffer will be approximately 20 feet wide on either side of the stream channel and will be composed mainly of potted understory shrubs, basswood, white cedar and black willow trees.

7.1.5.3 Floodplain

Floodplain planting will incorporate a variety of local native trees and shrubs. Trees and shrubs of varying sizes will be planted in randomly assigned clumps to encourage shading. All areas will be seeded with a mixture of native grasses to create temporary erosion protection. Seed and plant species are listed below:

Native seed

Dropseed prairie grass	*Sporobolus*
Red top grass	*Agrostis alba*
Seed oats	*Avena sativa*
Annual rye	*Lolium multiflorum*
Indian grass	*Sorghastrum nutans*
Little bluestem	*Andropogon scoparius*
Sideoats Grama	*Bouteloua curtipendula*
Switch grass	*Panicum virgatum*
Timothy	*Phleum pratense*

Native Wisconsin Shrubs and Trees

Black Cherry	*Prunus serotina*
Black Walnut	*Junglans nigra*
Bur Oak	*Quercus macrocarpa*
Dwarf bush honeysuckle	*Diervilla lonicera*
Elderberry	*Sambucus canadensis*
Gray Dogwood	*Cornus racemosa*
Green Ash	*Fraxinus pennsylvanica*
Hazelnut	*Corylus americana*
Highbush cranberry	*Viburnum trilobum*
Northern Pin Oak	*Quercus palustris*
Sand serviceberry	*Amelanchier sanguinea*
Shagbark Hickory	*Carya ovata*
Silver Maple	*Acer saccharinum*
Sugar Maple	*Acer saccharum*
White Oak	*Quercus alba*
Willow	*Salix spp.*

7.1.5.4 Timing

Seeding should take place immediately following construction, to provide temporary erosion protection. Shrubs and trees should be planted in Fall or late Spring. A watering plan must be established to ensure that grasses and trees have adequate moisture in dry periods. Bare root stock and potted plants should be protected with either tubing or wrap to prevent rodent and ungulate damage.

7.1.6 Other design issues

Other design parameters include dewatering, walking trail and staging area design. Dewatering design will be the responsibility of the contractor, but that the consulting engineer must approve any dewatering design, and that the plan must be prior approved by the Wisconsin DNR.

7.1.7 Other Construction Issues

7.1.7.1 Staging

Due to the amount of excavation required, large equipment such as front-end loaders, scrapers, bulldozers and excavators will be required on site. The existing floodplain near the dam site may be used for staging, and the high terrace near the former boat launch may also be a good staging area and headquarter location. The wastewater treatment facility parking lot and shed should also be considered as the main staging area, but traffic issues should be considered when using this area. Access using residential lots may be a requirement, but will need to be arranged between the Village of Cleveland and participating landowners.

7.1.7.2 Utilities

Utilities such as fiber optic cable, electric lines, gas mains and sanitary sewers will need to be located and marked prior to construction. Utility location would be included in the design phase of the Final Design and Construction process.

7.1.7.3 Haul roads

The designation of haul roads depends on the location of the disposal site. A disposal site north of the project area would require the use of North Avenue. Disposal of material south of the project site would require the use of North Avenue, County LS, and South Cleveland Road.

7.1.7.4 Traffic

During the floodplain excavation portion of the project, approximately 1200 truckloads of sediment will travel haul roads near the project. Depending on the number of trucks used, this trucking could take between 20 and 30 days of constant hauling. Proper signage will be required and detours may be suggested for through-traffic, restricting traffic near the project site to local residents only.

7.1.7.5 Erosion control

With proper dewatering techniques, loss of sediment into the stream and into Lake Michigan can be minimized. Silt fencing will be used to contain runoff events and a combination of erosion control fabric and cover crop seed will be used to stabilize bare areas.

7.1.8 Additional data needs

To complete a Final Design for the Centerville Creek project, additional survey data will be required. The Wisconsin State Historical Society has determined that there are no archeological or architectural properties within the area of potential effect of the restoration work. In accordance with Section 106 of the National Historic Preservation Act and 36 CFR Part 800, any sediment disposal sites will need to be surveyed and approved by a qualified archeologist.

The following additional survey data will be collected as part of the Final Design phase of the project and can be tied into the existing base map:

- Roads
- Utilities
- Disposal site
- Project limits (define ownership)
- Staking
- As-built survey
- Boring locations

Soil borings will be required to determine parameters such as compaction, cohesion and the potential for seepage and slope failure due to soil composition. Borings taken with a hollow stem auger will be analyzed using standard ASTM methods including:

- In-situ standard penetration test (ASTM D 1586)
- Grain size (ASTM D422)
- USCS Classification of Soils (ASTM D2487)
- Water content (ASTM D2216)
- Moisture / Density relationship (ASTM D1557)
- Atterburg limits (ASTM D4318)

7.2 Cost

The total cost for this project is broken down in Appendix D, and is summarized here. The total cost for the project including design and construction is $800,700. This estimate includes additional surveying, data collection, staking, permitting, design, plans and specifications and construction supervision. Oversight of the construction process is critical in river restoration, where complex biological habitat features are often changed in the field during installation. This estimate also includes floodplain excavation, dewatering and stream restoration. See Appendix D for further details.

Several assumptions are necessary during this stage of design, and these assumptions can greatly effect project cost. First among these is the assumption of a nearby disposal site for excavated materials. Any hauling of excavated sediment beyond 0.5 miles from the project site will increase the cost of construction. Other assumptions include:

- Project will be let as one bid package.
- Construction will occur in 2002.
- No special requirements for material handling or disposal due to contaminants.
- No historical or archeological investigations or associated design considerations.
- Disposal site is within Village of Cleveland city limits.
- Excavation and stream restoration occur simultaneously.
- No rock or muck excavation required.
- No easement acquisition costs associated with design or construction.
- No off-road construction vehicles such as scrapers may be used. Large, multi-axle dump trucks will be used for sediment hauling.
- A haul road will be not be necessary for trucking material off-site.
- No topsoil dressing of the site prior to seeding. It should be verified that the material will have adequate organic content and nutrients to support plant growth.

7.3 Permitting issues

This project will require a Wisconsin DNR "Chapter 30" permit for the relocation and restoration of a navigable waterway. As part of this permitting process, the Wisconsin DNR will forward the permit application to the U.S. Army Corps of Engineers for consideration under the Section 404. As part of this process, it may be determined that an Environmental Assessment will be necessary. Removal and disposal of impoundment sediments requires a non-hazardous waste permit as detailed in Section 5.1.2.1. Because the stream is within Village of Cleveland city limits, Manitowoc County does not require any zoning or permits. Questions regarding zoning can be directed to the Manitowoc County Code Administrator.

Once a disposal plan is in place, the Manitowoc County Highway Department should be contacted regarding any transportation permits or restrictions. Questions regarding permitting, weight restrictions and routing should be directed to Manitowoc County Highway Commissioner.

7.4 Construction limitations

Ownership of the impoundment area should be resolved before construction begins. Construction easements can be acquired, but landowners should be made aware of the eventual result of restoration and of the importance of keeping the area wild. If the Village of Cleveland acquires land, this area should be designated as parkland, eliminating the potential problems associated with development and active recreational use.

If public ownership is not an option, landowners may consider Conservation Easements. These easements are written into the title specifying the restrictions for development, building and vegetation management. A landowner may assist in writing the easement language, thereby affording some flexibility with regard to personal management of the property. Most land trusts that manage easements, however, require perpetual easements that contain restrictive clauses limiting any cutting or trimming of vegetation. In most cases it is recommended that no additional buildings be allowed on the property. Landowners need not place the entire property in an easement, but can designate certain portions, such as the impoundment area and surrounding slopes, as protected. Conservation Easements are legal title documents and help protect wild lands well into the future. More information can be obtained by calling the University of Wisconsin Extension Basin Educator at 920-388-4313.

Donating or selling land to a group such as the Northeast Wisconsin Land Trust also ensures proper management and protection of wild lands. The Northeast Wisconsin Land Trust can be contacted at 920-738-7265.

8.0 Additional Funding

See the attatched file for links to grant information.

9.0 Schedule

(see attached)

10.0 Glossary

The following fluvial geomorphology terms are commonly used in this document:

Aggradation – the vertical buildup of channel bed elevation due to excessive sediment deposition.

Bankfull capacity – the amount of flow contained by banks during a bankfull event. The bankfull channel must be appropriately sized to accommodate anticipated flows. Undersized channels can result in degradation and frequent flooding, while undersized channels can aggrade (Rosgen 1996).

Belt width - describes the maximum boundary within which a stream meanders back and forth across its floodplain. The belt width of a stream often completely confines the floodplain.

Degradation – the lowering of channel bed elevation due to excessive erosion of bottom sediment.

Lateral stability – the resistance of a channel to excessive bank erosion or deposition

Meander wavelength – the distance between the apexes of two meanders.

Radius of curvature (R_c) - describes the degree of curvature of a meander, and is equivalent to the radius of a circle that matches the meander curvature when superimposed on the meander.

Shear stress – the force of moving acting on channel bed and banks that can entrain and move substrate particles. Shear stress is commonly measured in pounds per square foot, and is dependent on channel slope and water depth.

Sinuosity – the degree of meandering or lateral channel migration typically seen in natural stream channels. Sinuosity aids in the dissipation of energy in the stream system, as increased sinuosity decreases channel slope.

Vertical stability – the resistance of a channel to both downcutting or degradation of the bed and aggradation or sediment accumulation.

Width to depth ratio – equal to the bankfull width divided by the mean depth of the bankfull channel.