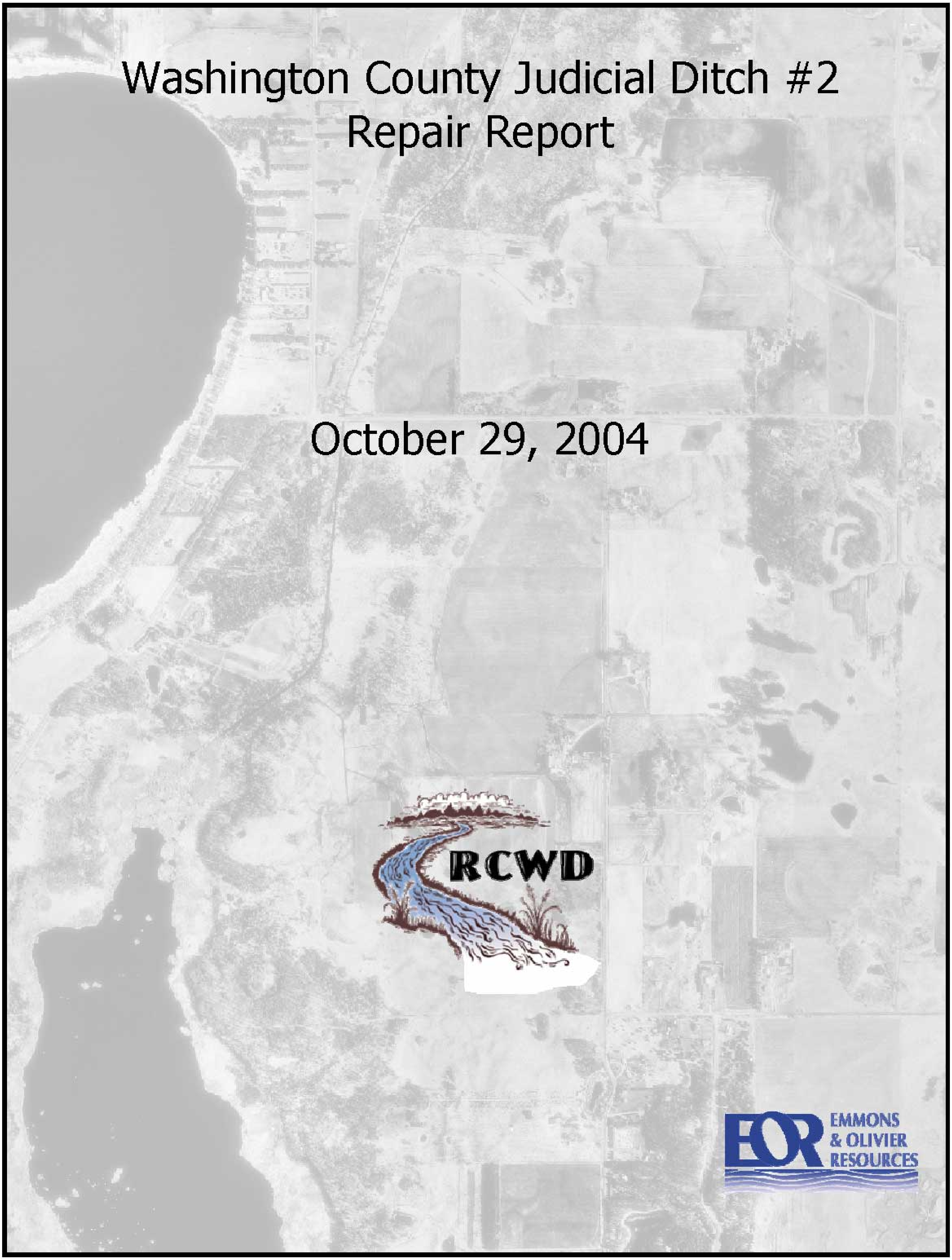

Washington County Judicial Ditch #2
Repair Report

October 29, 2004

RCWD

EMMONS
& OLIVIER
RESOURCES

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Goals for the Repair of Judicial Ditch 2

On April 10, 2002 the Rice Creek Watershed District (District) petitioned itself to repair Judicial Ditch 2 (JD2) in order to balance the District's diverse needs in this system, including:

- Drainage for adjacent property owners
- Stormwater conveyance for the Cities of Hugo and Forest Lake
- Protection of the resources of the District in accordance with the goals stated in its Water Resource Management Plan and Strategic Plan.

The goals of this project are to provide the District with a fiscally prudent repair design of JD2 that will:

- Mitigate flooding
- Improve the biological condition of Hardwood Creek
- Improve water quality downstream in the Rice Creek Chain of Lakes

Constraints

LANDSCAPE CONTEXT

The JD2 drainageway is a broad, low-lying swale in the landscape containing the narrow, slow-flowing JD2 channel that runs north from Rice Lake and west to Peltier Lake. The JD2 drainageway (corridor) also contains wetland communities of significant natural resource value, including tamarack swamp, sedge meadow, hardwood seepage swamp, and rich fen. Two State Wildlife Management Areas (WMAs) are in the corridor, one of which (Corrie's Swamp WMA) includes vegetation communities and species of statewide significance. The corridor is also identified in the Metro Greenways Regional Blueprint as part of the regionally significant natural area corridors.

Due to its unique setting there are many factors that constrain the JD2 design. These factors include both physical and social conditions, and present a significant challenge in designing, constructing, and maintaining a properly functioning drainage system. They include:

- Hydrology
- Soil Stability
- TMDL Listing
- Cost
- Timing

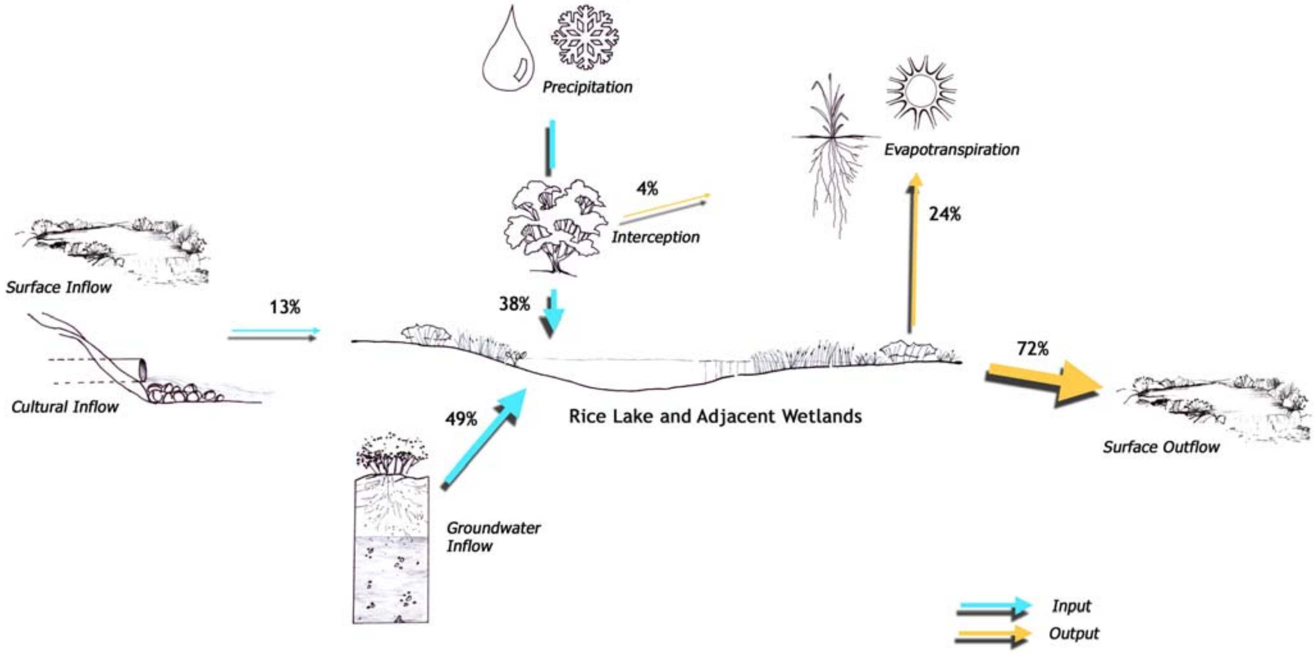
HYDROLOGY

Hydrologic measurements, water budget analysis, and floodplain modeling were used to characterize JD2 hydrology. During the 2004 growing season, data from *in situ* wells at several locations between Rice Lake and the Highway 61 crossing were used to assess the lateral dewatering adjacent to JD2. The results indicate that subsurface drainage or lateral movement of water towards the existing JD2 channel is occurring out 30 to 50 feet from the edge of the ditch (Appendix A). The water budget completed for JD2 as part of the Preliminary Draft Rehabilitation/Engineer's Repair Report (EOR, 2004) shows that approximately 50% of the annual water source is from groundwater and 13% is from surface runoff (Figure 1).

The results of floodplain modeling for both the 2-year (2.8 inches) and 100-year (5.9 inches) storms (Appendix B) show that in both cases the floodplain boundary is well within the boundary of the wetland corridor, which averages 1000 feet. These data along with the data on lateral dewatering in the upper portions of the JD2 corridor indicate that JD2 affects the hydrology of the corridor in a relatively narrow band. With respect to land use requiring somewhat drained conditions, the useable area is thus limited to the fringes of the broad floodplain and the narrow band spanning the JD2 channel.

Another key aspect of hydrology concerns the relationship of topography, slope, and velocity to water movement. The average slope from Rice Lake to the Highway 61 crossing is 0.03%. Based upon measured stream flows and stream modeling, JD2 is a relatively a low-velocity channel (EOR, 2004). The relationship of JD2 velocity to sediment transport and channel stability will be discussed in the next section.

Figure 1. Illustration of Water Budget for Rice Lake and Surrounding Wetlands



SOIL STABILITY

Soils in the JD2 corridor are mapped as Seelyeville, Rifle, Markey, and Cathro mucks (Viner, 1977). The descriptions of these soils include muck or mucky peat overlying water-saturated sands and loams. The soil data, along with the hydrology (previous section), can be used to describe the physical condition of the JD2 corridor as a groundwater-supported peatland system.

Peatland structure has been characterized in several investigations (Vardy, Warner, Aravena, 1998 and Vitt, 1994). There are two primary structural components: the structured peat within the root zone of the overlying herbaceous vegetation and the underlying unstructured and more highly decomposed mucky peat. The fibrous peat is also characterized by the nature of the herbaceous cover providing the organic ingredients for soil formation. Based upon the investigation of vegetation cover in the JD2 corridor (EOR, 2004), the peat is derived from sedge vegetation and is thus known as sedge peat. The root zone is limited in depth by environmental factors and consists of an interwoven mat of physiologically active root fibers within a matrix of fibrous peat (nonliving fibers in a range of states of decay).

The structured peat, limited to the root zone, provides the structural integrity within the peatland system (Wright, et al., 1992). As such, fiber content and the degree of decomposition are critical parameters in characterizing peat (Malterer et al., 1992) and understanding construction feasibility constraints. A standard field method of assessing the degree of peat decomposition is the von Post squeeze test (Malterer et al., 1992), and on September 16, 2004, a von Post analysis was conducted at multiple sample points along the JD2 corridor. The results showed that the structured peat is within three to four feet of the surface; this peat showed small to moderate levels of decomposition, while the peat was moderately decayed at depths below the root zone. The less decayed peat correlates well with observations of the root zone depth.

Cases of ditch channel excavation below the root zone elevation are related to lateral movement of the unstructured adjacent peat into the channel (Simon and Collison, 2002) until a new stable state is reached. Ditch excavation substantially lower than the elevation of the root zone results in an ‘unstable channel’ (Brookes, 1988). The excavation establishes a trajectory of events starting with the lateral movement of unstructured peat. Next a void space is created below the root zone of the adjacent peatland. This destabilizes the channel bank leading to collapse and slumping into the channel. In addition, the creation of a ‘spoil bank’ close to the channel bank sets up a second trajectory of change. This phenomenon, called rotational slumping, is commonly observed in association with spoil banks. The explanation is that the weight of the spoil bank can force bank failure of the ditch in a rotational motion. Both of these phenomena, lateral movement slumping and rotational slumping, are illustrated in Appendix C. This results in a channel configuration that is shallow and over-wide.

Channel configuration and water velocity are related to the ability of a channel to transport sediment (Brookes, 1987). The over-wide channel within a low-velocity reach does not have sufficient energy to transport the type of sediment load created by slumping phenomena. The sediment settles over time to create a new, stable configuration (Anon, 1977; Brookes, 1988; Corning, 1975) which does not meet the design expectations of the ditch for lateral dewatering and effects on the floodplain.

A model of channel metamorphosis from unstable to stable is shown below.

	Stage of Stable Channel Development	Time frame
1)	Deeper peat moves into the channel	Within weeks to one month
2)	Rooted peat zone collapses into channel (bank failure), leading to channel-widening	Months
3)	Sediment build up in over-wide channel	Months to years
4)	Re-establishment of naturally configured stable channel	Decades

The model suggests that the lateral and rotational slumping can be expected to occur very early and suggest that maintenance on a seasonal and annual basis would be needed to maintain a deep channel configuration.

The data on JD2 peat characteristics and channel configuration have been analyzed (Verry, 2004). These data suggest that the JD2 ditch channel is somewhere between stages three and four. The JD2 observations fit the prediction well in that it was initially excavated approximately 95 years ago. The naturally reconfigured stable channel would be reconnected to the existing floodplain wetland and result in a higher channel, translating into less benefit from a 'drainage' standpoint.

TMDL LISTING

In accordance with Section 303(d) of the Federal Clean Water Act (CWA), every two years the Minnesota Pollution Control Agency (MPCA) prepares a list of all impaired surface waters in the State of Minnesota. Listing under 303(d) requires the preparation of a total maximum daily load (TMDL) for the water body. Under the CWA and Minnesota Rule 7050.0150, further degradation of impaired waters is not allowed. If a TMDL is not prepared within 13 years of 303(d) listing, federal intervention to address the impairment could result.

Hardwood Creek Aquatic Biology

Hardwood Creek (HWC/JD2) is on the MPCA's 303(d) list of impaired waters for aquatic life impairment, as measured by a low fish Index of Biotic Integrity (IBI) and low dissolved oxygen. The District sought outside partnership and was awarded grant money by the MPCA to complete the Hardwood Creek TMDL study. The fish IBI TMDL study is currently underway, and preliminary results suggest that the primary impairment to the fish community is poor habitat caused by flashy flow and channel instability. The relationship between high quality physical habitat and a healthy fish community in other systems is well documented (Gorman and Karr, 1978; Allen and Flecker, 1993; Allen, et al., 1997; Saunders, et al, 2002; Rhoads et al., 2003).

Two independent habitat assessments were conducted using the QHEI (Qualitative Habitat Evaluation Index) and classified HWC/JD2 as a modified warm-water habitat (MWH). This classification describes streams with extensive physical habitat modifications indicating that the biological criteria for warm-water habitat are not attainable (Ohio EPA, 1998). The low fish IBI scores in HWC/JD2 are likely a result of the stream's poor-quality habitat.

Poor habitat in MWH streams is often caused by channelization, impoundment, or acid mine drainage (Ohio EPA, 1998). Since impoundment and acid mine drainage are not issues in this case, the channelization of HWC/JD2 is one of the likely causes of the low quality habitat. Ditching can produce more frequent higher peak flows downstream and increases in suspended sediments (Prévost et al., 1998), leading to poorer habitat quality. These phenomena have all been observed in HWC/JD2. Higher peak flows result from less flow being attenuated in a channelized ditch and from watershed runoff being directed to the channel more quickly. Ditching can decrease local storage, and water that would have spread out onto the floodplain remains in the channel and is passed downstream more quickly (Brookes, 1988; Saunders et al, 2002). These abrupt changes in flow regime in the downstream portions of HWC/JD2 have disturbed habitat and decreased habitat heterogeneity, which have directly impacted fish species richness and biodiversity, as verified through two fish IBIs conducted in 1999 and 2004.

In addition, high suspended solids contribute to poor habitat quality for fish communities (Gorman and Karr, 1978; Allen et al., 1997). Ditching activities can increase the amount of in-stream suspended solids. In a paired watershed study in a peatland of eastern Québec, the concentration of suspended sediments significantly increased during ditching and during peak flows in the weeks following ditching (Prévost et al., 1998). Suspended solids are high in HWC/JD2 and have been shown to increase following ditch maintenance activities (Appendix D).

Peltier Lake Water Quality

Hardwood Creek outlets into Peltier Lake, which is on the MPCA's 303(d) list of impaired waters due to excessive nutrients. The TMDL study for Peltier Lake has not yet begun, but nutrient budgets established from past District studies have estimated that HWC/JD2 contributes at least 30% (Table 1) of the total phosphorus load to Peltier Lake (Montgomery Watson, 1993, EOR, 2002).

Table 1. Proportional Phosphorus Loading into Peltier Lake

Hardwood Creek	Clearwater Creek	Upper Rice Creek	Internal Loading and Atmospheric Deposition
30%	12%	25%	33%

Recent monitoring data by the District has supported this finding. This percentage is substantial enough that changes in the load originating in HWC/JD2 can directly influence the in-lake water quality of Peltier Lake. An improvement in the water quality of Peltier Lake will require reductions in the nutrient load coming into the lake, including from HWC/JD2. Recent monitoring data by the District also indicate that the primary source of phosphorus is from anthropogenic sources coming into the system downstream of Harrow suggesting that the wetlands in the upper portions of the watershed are not significant phosphorus contributors (EOR, 2004). With the HWC/JD2 restoration project occurring in advance of the Peltier Lake TMDL study, it is reasonable that the restoration plan take the Peltier Lake TMDL into account.

COST

Costs are a driving constraint for any public infrastructure project or system. The District has three primary cost variables to consider in comparing the alternative JD2 repair designs. The primary cost variables and main issues for each are summarized in Table 2.

Table 2. Primary Cost Variables

Cost Variable	*Main Issue*
Construction	'Constructability' of peat soils in high water table; excavation material disposal locations
Maintenance	Magnitude of ongoing annual maintenance and material disposal costs
Environmental Protection Laws	Wetland impacts/mitigation, State Wildlife Management Area degradation

TIMING

Completing the project in a timely manner has been and continues to be an important issue to the District. Additional time often corresponds to additional costs and therefore a timely conclusion is consistent with the District's mandate to be fiscally responsible. A timely resolution of the situation at HWC/JD2 has been an important issue for some of the surrounding landowners as well as the City of Hugo and the District for several years. Construction of the project is contingent on completing the environmental review process, namely completing the EAW and (where necessary) an Environmental Impact Statement (EIS); obtaining permits from the U.S. Army Corps of Engineers (USACOE), the Minnesota Department of Natural Resources (DNR), the Minnesota Pollution Control Agency (MPCA), and the affected Cities; and complying with the District's own regulations applicable to the work. The project includes potential alteration of over five miles of channel through a large wetland complex that includes some areas of significant natural communities and state-owned lands. Due to this setting, the potential repair of JD2 has been the subject of scrutiny by reviewing agencies as well as environmental organizations for several years, and this can be a critical factor in selecting the repair alternative.

Design Alternatives

In the process of reviewing the traditional ditch repair and other alternatives that include additional restoration elements, four alternatives were selected for further review. The following sections describe the alternatives that were considered, along with how well they meet the goals of and benefit the District. Three alternatives call for active intervention in the channel and a fourth alternative consists primarily of ongoing maintenance activities, which could be considered the "no-build" alternative. The alternative names are as follows:

1) Traditional Repair
2) Meandered Channel at the Official Profile
3) Stable Stream Rehabilitation
4) Ongoing Minor Maintenance

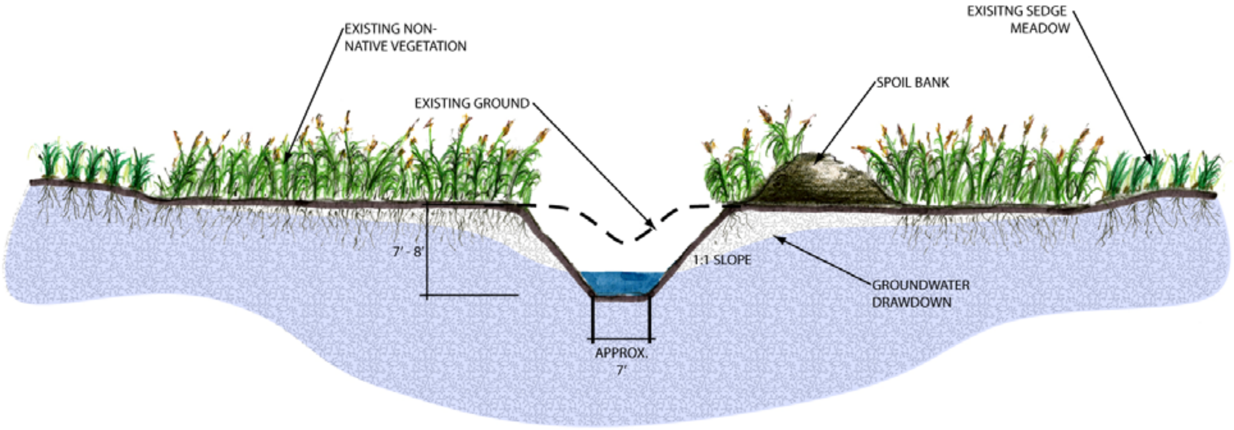
Building upon the conditions described in the preceding section and the goals of the project, the following criteria were identified for evaluating each alternative.

- Flood Mitigation
- Maintenance
- Future Storm Water Conveyance
- Biologic Condition
- Downstream Water Quality
- Wetland Impacts
- Cost

TRADITIONAL REPAIR

The traditional repair to the adopted profile would require excavating the existing channel bottom down three to five feet below the existing profile, with 1:1 side slopes consistent with the as-built design. In peatland systems such as JD2, vertical slopes of 1:1 are stable in the root zone. However, excavation below the root zone would result in an unstable ditch regardless of the vertical slope dimensions as discussed earlier in the soil stability section. Shallower side slopes, such as 2:1, where considered but would come with an increased construction cost and would not equate to a more stable channel. It is assumed that spoils would be placed adjacent to the ditch, as disposal in the wetlands beyond the existing spoil piles would trigger additional wetland regulations and potential impacts. The District could consider removing spoils offsite. This could reduce the rotational slumping that would occur along the ditch but would not reduce the lateral movement of decomposed peat into the channel. The result would be that the channel would still fill back in within a time of approximately 6 months to one year. The estimated cost of removing spoils offsite is estimated to be $300,000. Figure 2 shows a cross-section of this alternative.

Figure 2. Traditional Ditch Repair Cross-section



Flood Mitigation

The traditional ditch would reduce surface flooding for both the 2-year (2.8-inch rainfall) and 100-year (5.9-inch rainfall) storms. For the 2-year storm, the theoretical flood profile drops approximately 2 to 3 feet (Figure 3), depending on the location along the channel, and for the 100-year storm (Figure 4), the flood profile drops approximately 1 to 2 feet. However, since it is likely that the ditch will become unstable within three to six months after excavation (Figure 5), these estimates would only apply for that limited time period and would be reduced following bank failure.

Since the wetland corridor extends far beyond the ditch, a traditional repair will not eliminate the adjacent wetland corridor, but rather will provide a small increase in pasture land and in the ability to cut hay. The areas that would be subject to slightly less wet conditions are summarized in Appendix E. This result assumes a clean and well-functioning ditch at the official profile. However, since it is unlikely that the ditch will be able to sustain the design configuration for any lengthy period of time, the improvement would likewise be limited.

Maintenance

The official profile channel bottom ranges from five and a half feet (5.5') to eight feet (8.0') below the adjacent vegetated floodplain. The District conducted minor maintenance at two locations along JD2 during February and March of 2004, to lower the channel elevation approximately six feet to the Official Profile (Figure 5).

The channel elevation was surveyed in February prior to construction and immediately following excavation (as-built). To gauge the success of the maintenance, surveying was again conducted one month after construction, in April, just after the thaw.

> MA 1: Maintenance occurred south of the 157th culvert to the cattail mat obstructing the outlet of Rice Lake. Material was excavated up to six feet below the existing ditch bottom elevation in some stretches. Spoils were deposited approximately 25 feet from the east side of the bank. The spoils were leveled and smoothed, seeded with temporary erosion control seed, and mulched.
>
> MA 2: Minor maintenance occurred approximately 1,400 feet north of the 170th culvert, resulting in a slight widening of the ditch. Material was excavated up to six feet below the existing ditch bottom elevation in some areas. Excavated material was placed approximately six feet from the east side of the bank.

Results of surveys (Figure 5) indicate that the channel was initially excavated roughly to the Official Profile, and that one month later, the channel bottom elevation had migrated approximately halfway back up to pre-excavation conditions. This is consistent with the failure mechanism described in the soil stability section and shown in Appendix C, which occurs when excavation is below the root zone.

Figure 3. 2-year Storm Water Surface Profile for the Traditional Repair

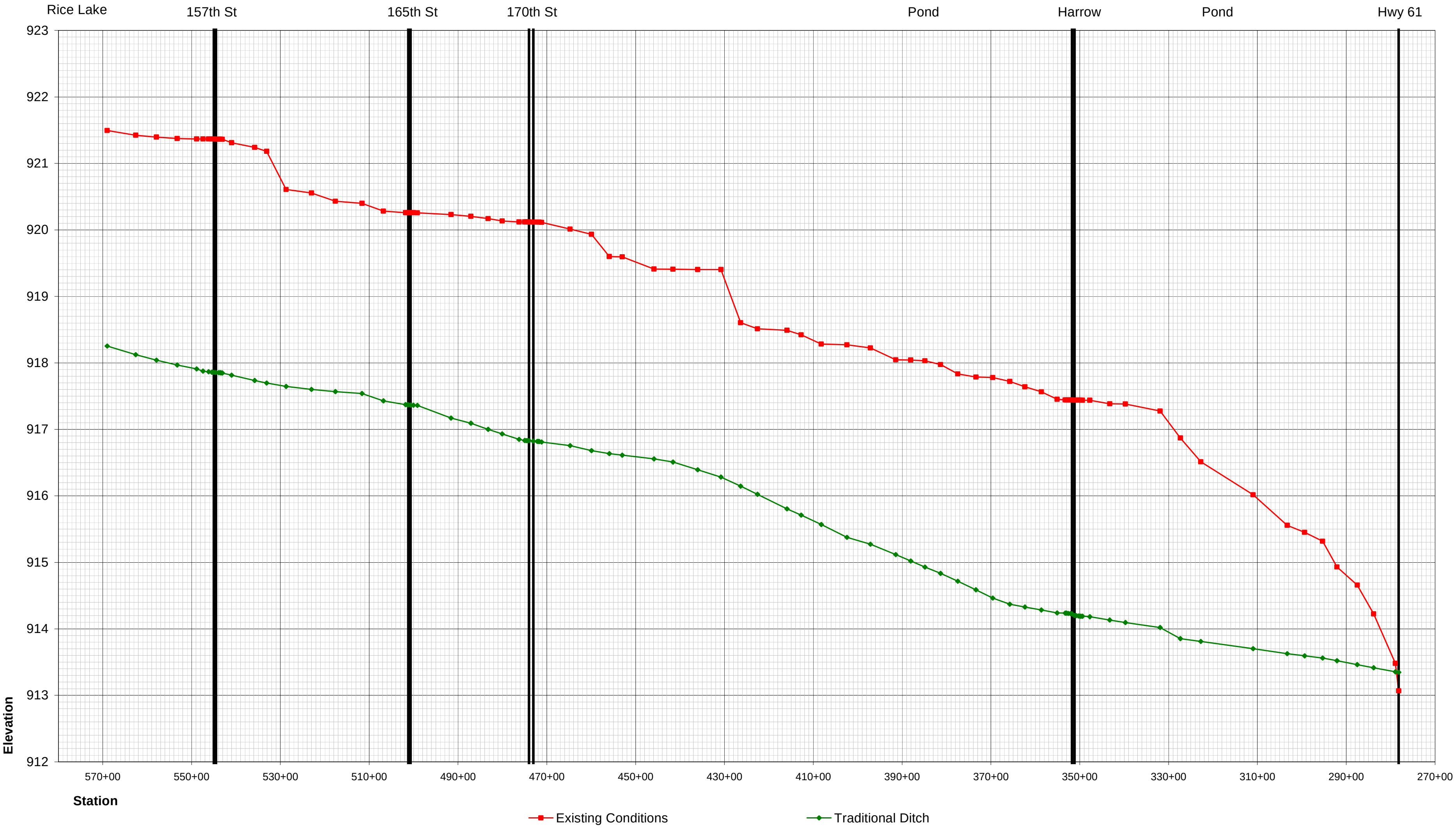
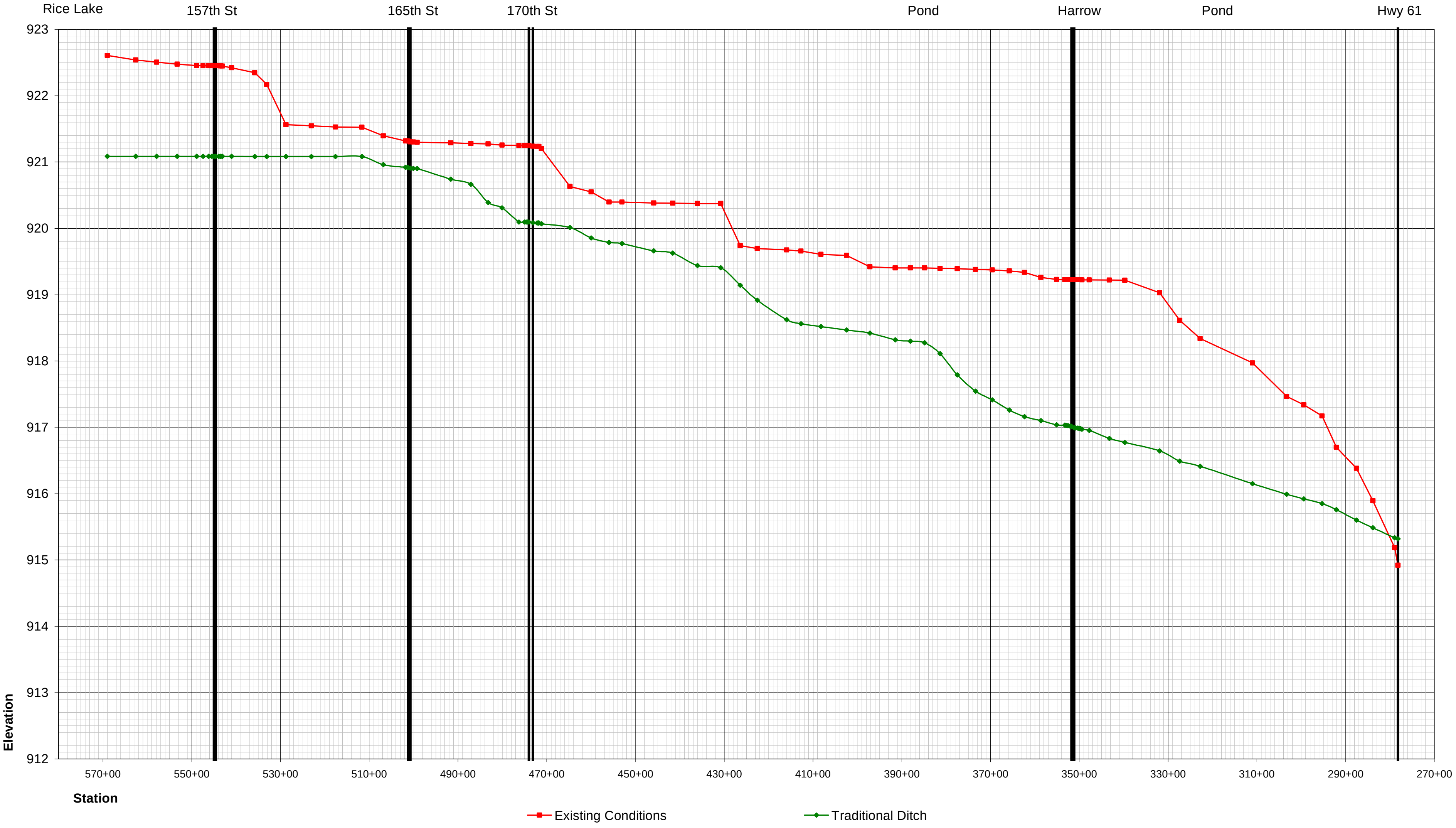
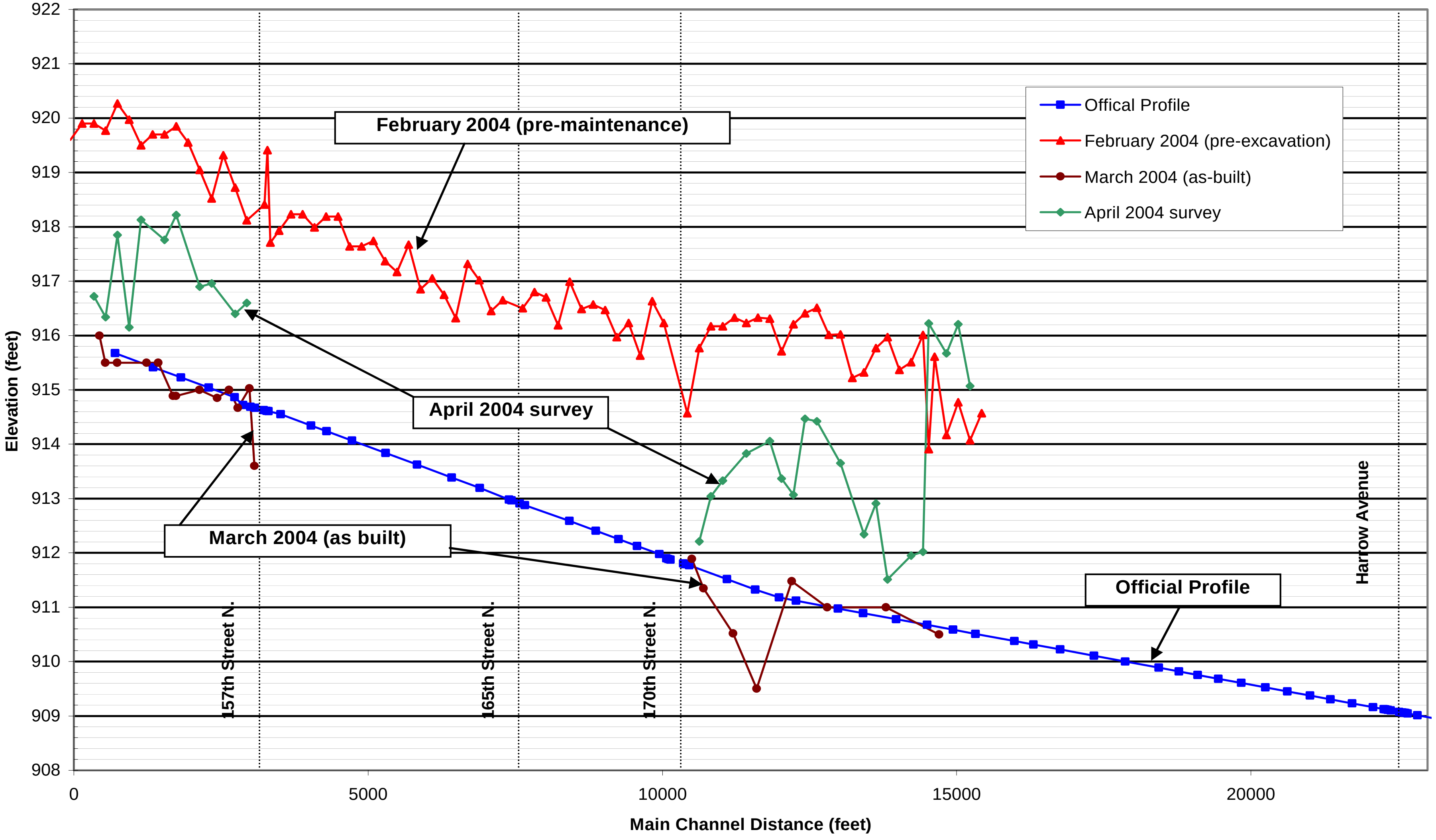


Figure 4. 100-year Storm Water Surface Profile for the Traditional Repair



In addition to monitoring the success of excavation using channel elevation data, following construction, channel water was sampled for suspended sediment and total phosphorus, and bank condition, sedimentation, and revegetation were evaluated on a bi-weekly basis from March through September 2004 (Appendix F). Immediately following construction, the concentration of suspended sediments and total phosphorus increased (Appendix D). Most excavated material was piled with a separation from the ditch bank, in order to prevent direct reentry of excavated material. It was observed that material moved into the channel via breaks in the ditch bank at several locations in MA2, but in MA1 no such movement of spoil material was observed. At both locations, the elevation profiles of April 2004 indicate that material rapidly reentered the channel and changed the bottom elevation soon after construction. In MA1, where no spoil material migration occurred, the most plausible explanation for additional channel material is side-slope slumping. The county soil survey describes this phenomenon for the soil types mapped at this location (Viner, 1977). In MA2, the elevation change may be attributed to observed spoil material movement as well as submerged bank sloughing. Over the course of the summer, additional slumping in both maintenance areas was observed (Appendix F).

Figure 5. Effects of Minor Maintenance on JD2 Channel Elevation



Future Stormwater Conveyance

Hydrologic parameters were calculated for the predicted future land use in this area, as it is presented in the City of Hugo Comprehensive Stormwater Management Plan. Where changes in land use are expected to occur, they do not translate into significant alterations to the hydrologic condition of the area. It should be noted that the Hugo plan contains a very general land use prediction, and that more detailed plans developed in the future may involve a larger change to area hydrologic parameters. However, using currently available information, the drainage performance of any of the featured repair alternatives under the predicted future land use would be comparable to its performance under current land use.

Assuming a clean and well-functioning ditch at the official profile, future stormwater conveyance would improve under the traditional repair relative to current conditions. However, since it is unlikely that the ditch will be stable for any lengthy period of time, to maintain this benefit would require continual ditch maintenance.

Biologic Condition

The traditional repair would not decrease the flashy flow regime downstream and would not address the likely recommendations from the Hardwood Creek TMDL study. In addition, a traditional ditch reduces the structural complexity of a stream channel further hindering the biological condition (Brookes, 1988). Research has identified a wide range of impacts resulting from channelization including uniform velocities, increases in temperature, homogenous substrate, and increases in dissolved substances (Patrick, 1971, Smith 1975).

Downstream Water Quality

The traditional repair would not improve water quality downstream and would be counterproductive to the Peltier Lake TMDL. The traditional repair would result in an unstable channel in which rates of sediment transport are expected to be higher due to bank failure, more frequent maintenance, and channelized flows. Due to phosphorus sorption (“sticking”) onto in-stream sediments, phosphorus export is highly correlated to sediment export and would also increase with an associated increase in sediment export (Astrom et al., 2001). The traditional ditch would reduce the connection of the in-stream flow to the floodplain where more settling and filtering of pollutants normally would occur (Brookes, 1988).

Wetland Impacts

For accounting purposes, the acreages of WCA and DNR regulated wetland impacts are tracked separately. Most impacts to Type 3, 4, and 5 wetlands are considered to be partial drainage because the surface water drawdown will not cause effective drainage. Any Type 3, 4, or 5 wetland that is intersected by the lateral effect is considered to be partially drained (EOR, 2004). Table 3 summarizes partial drainage of DNR and WCA regulated wetlands for the traditional repair scenario, and Table 4 summarizes the associated unregulated impacts.

Table 3. Traditional Ditch DNR and WCA Regulated Impacts

	Traditional Repair Impact (acres)		
DNR Regulated	**Rice Lake***	**Others**	**Total**
Type 3	17.6	35.8	53.4
Type 4	121.3	0	121.3
Type 5	146.0	0	146.0
Sub-Total	284.9	35.8	320.7
WCA Regulated			
Type 3			22.9
Type 4			0
Type 5			0.2
Sub-Total			23.1
Total			**343.8**

*Possible extent; actual impacts would need to be defined with DNR's input.

Table 4. Traditional Ditch Unregulated Wetland Drainage

Wetland Type	**Traditional Ditch Impact (acres)**
Type 1	6.6
Type 2	26.4
Type 6	34.8
Type 7	13.5
Type 8	20.8
Total	102.1

The traditional ditch repair would have the potential to impact Rice Lake and several public water wetlands, potentially triggering a mandatory EIS (See Meandered Channel at Official Profile Section). The District understands that it must provide replacement in accordance with DNR rules for any substantial impacts to public waters (Minnesota State Statues 103E.011, 103G.211, 103G.221, 103G.245). At the same time, the responsibility falls to the DNR to implement actual measures it deems warranted to protect specific public water wetlands, without impairing the function of the judicial ditch system. (Minnesota State Statue 103G.225). Rice Lake is designated as a Public Water, not a Public Water Wetland.

Cost

Overall cost estimates for the traditional ditch repair are shown in Table 5. The cost for channel construction and sediment control features, including contingencies, is estimated to be approximately $1.1 million. The cost of wetland mitigation is estimated to be $2.0 million for 1:1 replacement of WCA- and DNR-regulated wetlands along the JD2 system, not including the Rice Lake Basin. Additional mitigation costs may be incurred, depending on how the DNR would handle mitigation for type changes associated with lowering Rice Lake.

Table 5. Traditional Repair Cost Estimate

RCWD
HARDWOOD CREEK / JD2 TRADITIONAL REPAIR
COST SUMMARY TABLE

ITEM	DESCRIPTION	UNIT	QUANTITIES	UNIT PRICE	SUBHEADING SUBTOTAL	TOTAL	TOTAL+ 25% Conting., Engr., Legal, Admin.
Official Repair							
Ditch Excavation						$347,500	$434,375
Mobilization, Erosion Control, Access		Ea.	1	$90,000	$90,000		
Excavation of Main Channel	From Rice Lake to Hwy 61, Official profile & cross-section	C.Y.	80,000	$2	$160,000		
Excavation of Main Channel dn stream of 61**	From 61 to 170th, official profile & cross-section	C.Y.	15,000	$3	$45,000		
Excavation of Branch 2 Channel	Official profile & cross-section - 1:1 side slopes	C.Y.	1,100	$5	$5,500		
Excavation of Branch 1 Channel	Official profile & cross-section - 1:1 side slopes	C.Y.	1,400	$5	$7,000		
Excavation of Branch 3 & 4**	Minor Maintenance	C.Y.	1,000	$5	$5,000		
Revegetation	Seed and Mulch Disturbed Areas	Ac	35	$1,000	$35,000		
Water Quality/Sediment Control						$292,500	$365,625
Temporary Sedimentation Basins	7 Ac basin designed to reduce downstream impact to HWC and Peltier L.	C.Y.	65,000	$4.50	$292,500		
Wetland Mitigation*						$1,597,500	$1,996,875
WCA Regulated Wetland Mitigation	Required replacement for WCA regulated impacts	Ac	23.1	$25,000	$577,500		
DNR Regulated Public Water Wetlands***	Assumed a required 1:1 replacement	Ac	35.8	$25,000	$895,000		
Mitigation Management / Monitoring	Planning and Reports	year	5	$25,000	$125,000		
Other Misc. Structural Improvements		project	1	$200,000	$200,000	$200,000	$250,000
Remove Beaver Dams on Lake, Tile/Private Connections, Culverts							
Grand Total							**$3,046,875**

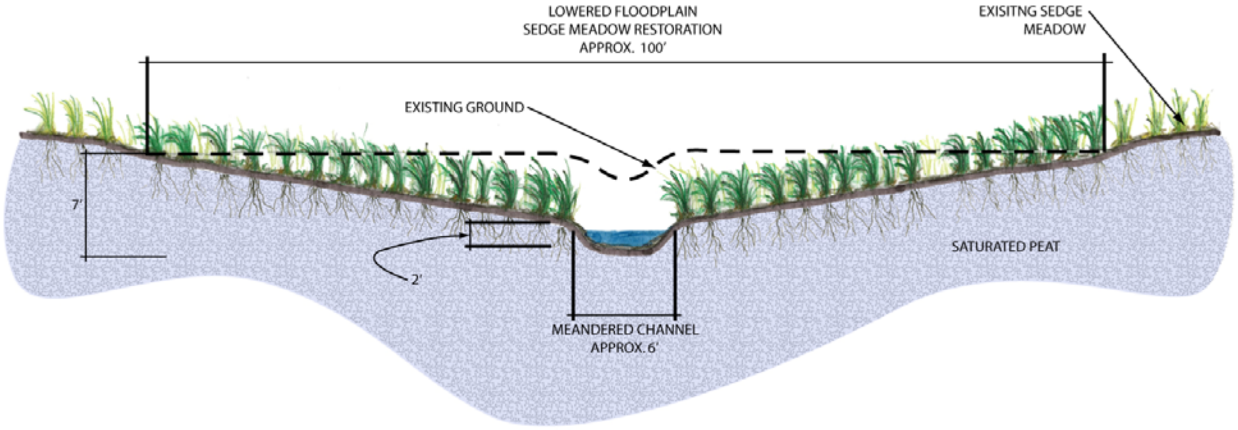
* =Mitigation costs reflect the lower end of purchasing wetland credits and is subject to change after coordination with regulatory agencies.
**=Will Require Additional Survey, Study and Establishment of Offical Profile for these areas
***=Impacts to DNR protected waters does not include the impacts to Rice Lake, DNR could require mitigation for all or part of the 285 acres of Type change that would occur.

MEANDERED CHANNEL AT THE OFFICIAL PROFILE

In January, 2004, the RCWD made available for public review a draft Repair Report for JD2 presenting three design options. For all three options presented, the main channel of JD2 would be re-meandered in sections, and the side slopes would be laid back to reduce the wetland drainage resulting from the localized effect of lowered water levels in the ditch channel. The main difference between the three options were the final channel depth and the width of the adjacent floodplain.

On January 15, 2004, the District held a public open house to discuss current plans to rehabilitate JD2. The District then received a letter on January 26, 2004 from the City of Hugo stating their support of a hybrid JD2 restoration project that contained a blending of the key features of rehabilitation Options 1 and 2 at the official profile. On February 27, 2004 a joint meeting was held between the District Board and the City of Hugo Council, resulting in the pursuit of a hybrid restoration project incorporating Options 1 and 2, referred to here as the “meandered channel at the official profile” alternative. This alternative was presented as a two-track design, driven by the goal of constructing Track 1 within the existing District easement in the near future and completing the full corridor and channel meander pattern (Track 2) over time, as negotiations for expanded easements were finalized. Figure 6 shows a cross-section of this alternative.

Figure 6. Meandered Channel at the Official Profile Cross-section



On May 17, 2004, the District completed a discretionary Environmental Assessment Worksheet (EAW). The following comments were received in response to the EAW:

- The proposed project has the potential to eliminate public water wetland 82-205W.
- The extent of wetland impacts and the effect of groundwater on wetland hydrology within the project area were not adequately evaluated.
- The likelihood of the District to be able to count on wetland replacement/restoration activity intended to occur during Track 2 of the project as a means to compensate for wetland impacts accrued during Track 1 was called into question.
- A request was made to further evaluate the channel stability and stream morphology.

Due to these comments, the following actions were taken:

- The Board made a positive declaration on August 25, 2004 of the need to prepare an Environmental Impact Statement (EIS).
- The Board requested the District staff and Engineer to present an alternative that would reduce environmental impacts further and not require an EIS.

Flood Mitigation

This option was designed to have the same floodplain footprint as a fully functional traditional repair (Figures 2 and Figure 3). The wider cross sections were intended to provide bank stability and floodplain storage and to limit adjacent wetland dewatering.

Maintenance

The meandered channel at the official profile alternative has less risk of failure than a traditional ditch repair due to the wider cross section. However, since this alternative requires excavation into unconsolidated peat at the official profile, there is the risk that, just like the traditional repair, the resulting channel will not maintain its design configuration. Image 1 shows the problems associated with excavating an over-wide and deep channel.

Image 1. Root River at Stewartville, MN after excavation of an over-wide and over-deep channel.

Future Stormwater Conveyance

This option is designed to have the same stormwater conveyance as the traditional repair and therefore addresses future stormwater flows.

Biologic Condition

Once the full meandered channel is in place under Track 2, this option should provide improved flow regimes downstream, leading to improved habitat for the biota. However, this benefit will not be seen immediately, as some time will pass before Track 2 is fully implemented.

Downstream Water Quality

This option should provide an improvement in downstream water quality compared to existing conditions due to the connection of the channel with its floodplain and the associated sediment and nutrient removal. However, with stability problems a risk, the movement of sediment within the channel would lead to increased downstream sediment and nutrient transport.

Wetland Impacts

Predicted wetland impacts for the meandered channel at the official profile are included in Tables 6 and 7. The hydraulic conductivity has been refined since the EAW, and the lower field verified K values reduce the amount of effective drainage of unregulated wetlands (Appendix G). The impacts shown assume the use of berms and ditch blocks to avoid impacts to the majority of regulated wetlands.

Table 6. Meandered Channel at Official Profile DNR and WCA Regulated Impacts

	Meandered Channel at Official Profile (acres)
DNR Regulated	
Type 3	5.2
Type 4	
Type 5	
Sub-Total	5.2
WCA Regulated	
Type 3	
Type 4	
Type 5	
Sub-Total	
Total	**5.2**

Table 7. Meandered Channel at Official Profile Unregulated Wetland Drainage

Wetland Type	**Meandered Channel at Official Profile Impact (acres)**
Type 1	3.9
Type 2	8.5
Type 6	6.8
Type 7	5.3
Type 8	10.8
Total	**35.3**

Public water wetland 82-205W is of concern because the potential to eliminate it triggered a compulsory EIS. Further review of this wetland indicates that it consists of two sub-basins:

floating vascular plants to the south of the ditch and a cattail marsh with saturated soils to the north of the ditch. Subsequent field review indicates that the areas to the south were likely excavated in the past. The cattail area in the north did not have standing water when it was visited by the District Engineer in September, 2004. If the District feels that 205W may not meet the definition of a public water wetland, there is a means to attempt to remove it from the DNR's Public Waters Inventory list. Under Minnesota State Statue 103G.201, Subpart B, there are no formal guidelines for removing a public water wetland off the list. A second option would be requesting delegation of authority from the DNR to the LGU. Both avenues require approval from the DNR Commissioner. It should be noted that the de-listing of 82-205W from the public waters list would not likely dismiss the EIS currently underway for this design alternative.

Cost

Overall cost estimates are shown in Table 8, broken down into the two tracks. Portions of Track 2 could begin at the same time as or even before Track 1. The intent of the separation is to estimate the cost for a known project that would begin before easements were acquired throughout the corridor. Therefore, Track 1 was limited to the area contained within the existing 66-foot right-of-way along the ditch. The total cost for Track 1, including contingencies, is estimated to be $2.5 million.

Until the District is able to obtain conservation easements outside the 66-foot corridor, restoration efforts outside the existing right-of-way will be dependent on willing landowners. The total cost for Track 2 is approximately $1.5 million.

Table 8. Meandered Channel at Official Profile Cost Estimate

RCWD
HARDWOOD CREEK / JD2 MEANDERED CHANNEL AT THE OFFICIAL PROFILE
COST SUMMARY TABLE

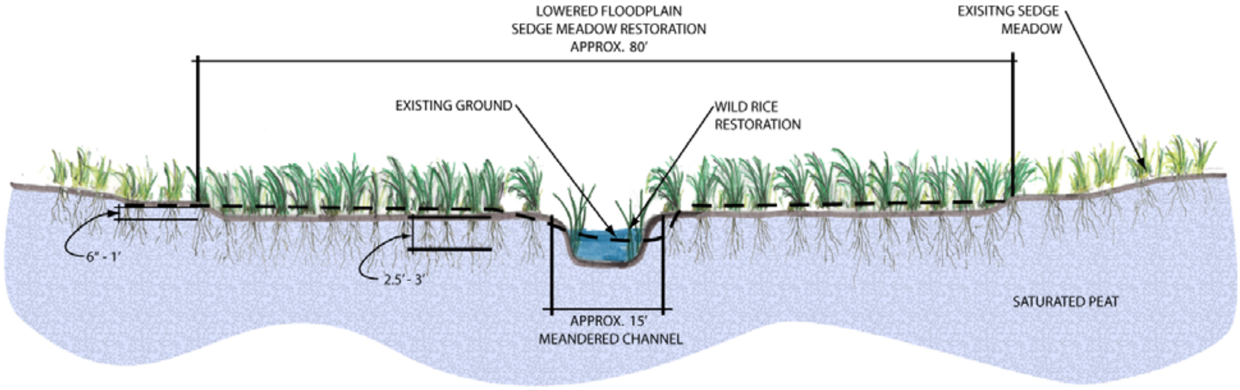
ITEM	DESCRIPTION	UNIT	QUANTITIES	UNIT PRICE	SUBHEADING SUBTOTAL	TOTAL	TOTAL+ 25% Conting., Engr., Legal, Admin.
Track I							
Main Channel Stream Restoration						$1,340,000	$1,675,000
Mobilization, Erosion Control, Access	Includes Building Haul Roads for Moving Equipment and Mate	Ea.	1	$200,000	$200,000		
Excavation of Channel		C.Y.	240,000	$4.50	$1,080,000		
Clear & Grub		Ac	20	$3,000	$60,000		
Branch 2 Repair						$10,500	$13,125
Excavation of Channel	Uses 2:1 Side Slopes for Stability	C.Y.	1,700	$5	$8,500		
Stabilize Channel@ existing elevation	Avoid Hydrologic Change in Regulated Wetlands	Ea.	1	$2,000	$2,000		
Water Quality/Sediment Control						$292,500	$365,625
Temporary Sedimentation Basins	7 Ac basin designed to reduce downstream impact to HWC and Peltier L.	C.Y.	65,000	$4.50	$292,500		
Wetland Restoration/Mitigation						$173,125	$216,406
Type 3 Regulated Wetland in the New Channel	Contingency Cost for Supplemental Planting	Ac	3.1	$500	$1,550		
Type 2 in the New Channel	Sedge Meadow Establishment	Ac	27	$1,725	$46,575		
Restoration Management / Monitoring	Field Actities & Reports	year	5	$25,000	$125,000		
Other Misc Structural Improvements		project	1	$200,000	$200,000	$200,000	$250,000
Remove Beaver Dams on Lake, Berms to prevent regulated drainage, Tile Connections, Culverts							
Track I Total (Does not include Rice Lake Outlet Structure)							**$2,520,156**
Track II						TOTAL	TOTAL+ 35% Conting., Engr., Legal, Admin.
Main Channel Stream Restoration						$800,000	$1,080,000
Excavation of Final Channel Configuration		C.Y.	150,000	$4.50	$675,000		
Mobilization, Erosion Control, Access		Ea.	1	$125,000	$125,000		
Wetland Restoration/Mitigation						$312,350	$421,673
Type 3 Regulated Wetland in the New Channel	Contingency Cost for Supplemental Planting	Ac	5.4	$500	$2,700		
Type 2 in the New Channel	Sedge Meadow Establishment	Ac	34	$1,725	$58,650		
Mixed Emergent Marsh Mitigation for Impacts	Fill Ditch, restore native emergant marsh vegetation	Ac	35	$3,600	$126,000		
Restoration Management/Monitoring	Field Activities and Reports	project	5	$25,000	$125,000		
Track II Total							**$1,501,673**
Grand Total							**$4,021,829**

Costs associated with placement of an outlet structure for Rice Lake are not included in this table.
Easement Costs are not included in this table. Easement Costs will vary widely depending on the situation. Much of the easement acquistion is intended to be funded through outside sources.

STABLE STREAM REHABILITATION

Drainage ditch construction often occurs without taking stream morphology into consideration. Most notably, ditches often lack a meander pattern and a two-stage relationship between a main channel and a floodplain. The Stable Stream Rehabilitation alternative would create a properly sized meandered base channel lower than the existing channel, a connected and properly sized floodplain also lower than the existing floodplain, and a stable meander pattern. Figure 7 shows a cross-section of this alternative.

Figure 7. Stable Stream Rehabilitation Cross-section



This design is based on stream morphology principles in order to establish equilibrium between the stream channel and the external forces shaping the channel, leading to a stable channel configuration. Field verified bankfull conditions were used to calculate design parameters. Dr. Sandy Verry, a peatland drainage and stream restoration expert, was contacted to provide design input. Dr. Verry recommended that a new channel be created off of the existing ditch and allowed to stabilize for one growing season before ditch flows are diverted. The reasons for this are:

- Reduced risk of channel block failures
- More stable peat for construction as verified through the von Post analysis
- Easier constructability without active ditch flows
- Significantly less water quality impact both during construction and long-term

Related to this alternative is the restoration of the Hardwood Creek corridor (Appendix H). This initiative is in accordance with the District goals of land and water conservation and wetlands management. The District sought partnership in applying these goals to JD2 and was awarded a grant by the Legislative Commission on Minnesota Resources (LCMR) of $800,000 for the purpose of creating a restored riparian corridor.

Flood Mitigation

The model results for the 2-year and 100-year storms for both existing and proposed conditions, as well as with the 100-year storm for projected future land use are shown on Figures 8 through 10. These figures illustrate that a moderate drop in maximum water levels (ranging from approximately 0-2 feet) along the corridor is expected under proposed conditions, relative to existing conditions, for the 2-year and 100-year storm events.

Maintenance

The overall approach with the stable stream design is to create a self maintaining system. However, it is expected for the first three to five years that minor repairs and maintenance will be required while the stream settles into equilibrium condition. This option will still require active beaver management and dam removal in order to maintain the desired drainage.

Future Stormwater Conveyance

The proposed channel design will provide the needed capacity for future needs based on the City of Hugo's land use plan. If the hydrology of the watershed changes significantly due to a change in the city's landuse plan, then the stream will need to be adjusted to establish a new equilibrium. However, this is an unlikely scenario due to the small portion of the watershed that is currently forecasted to experience more intensive urban development, specifically in the very southwestern portion of the watershed. The major change would be from agricultural (pasture with some row crop) to estate residential. Also, development will be subject to RCWD and Hugo regulation of peak and volume controls. From a hydrologic perspective, this does not imply a large change in runoff, and the channel as designed will accommodate these future flows for the 20-year planning horizon.

Biologic Condition

The meandered channel will be approximately 30% longer than the straight channel and will be connected with its floodplain. This will lead to improved flow regimes downstream and improved habitat for the biota by creating structural features such as pools and riffles (Karr, 2002).

Downstream Water Quality

This design will increase the interaction of the in-stream flow with the floodplain and will allow settling, storage, and recycling of in-stream nutrients in channel and on the floodplain. Additionally, the meandered channel will have more benthic, or stream bottom, surface area, which will improve in-stream water quality. Dissolved nutrients are primarily removed by sorption, or attachment, onto bottom sediments or through uptake by microbial communities on the stream bottom (Mulholland et al., 1985), and in-stream processes are important determinants of stream water nutrient concentrations (Mulholland and Hill, 1997). A greater surface area provides more substrate for microbial communities in addition to more attachment sites, and phosphorus retention has been related to stream bottom area (Doyle et al., 2003).

Figure 8. 2-year Storm Water Surface Profile for Stable Stream Design

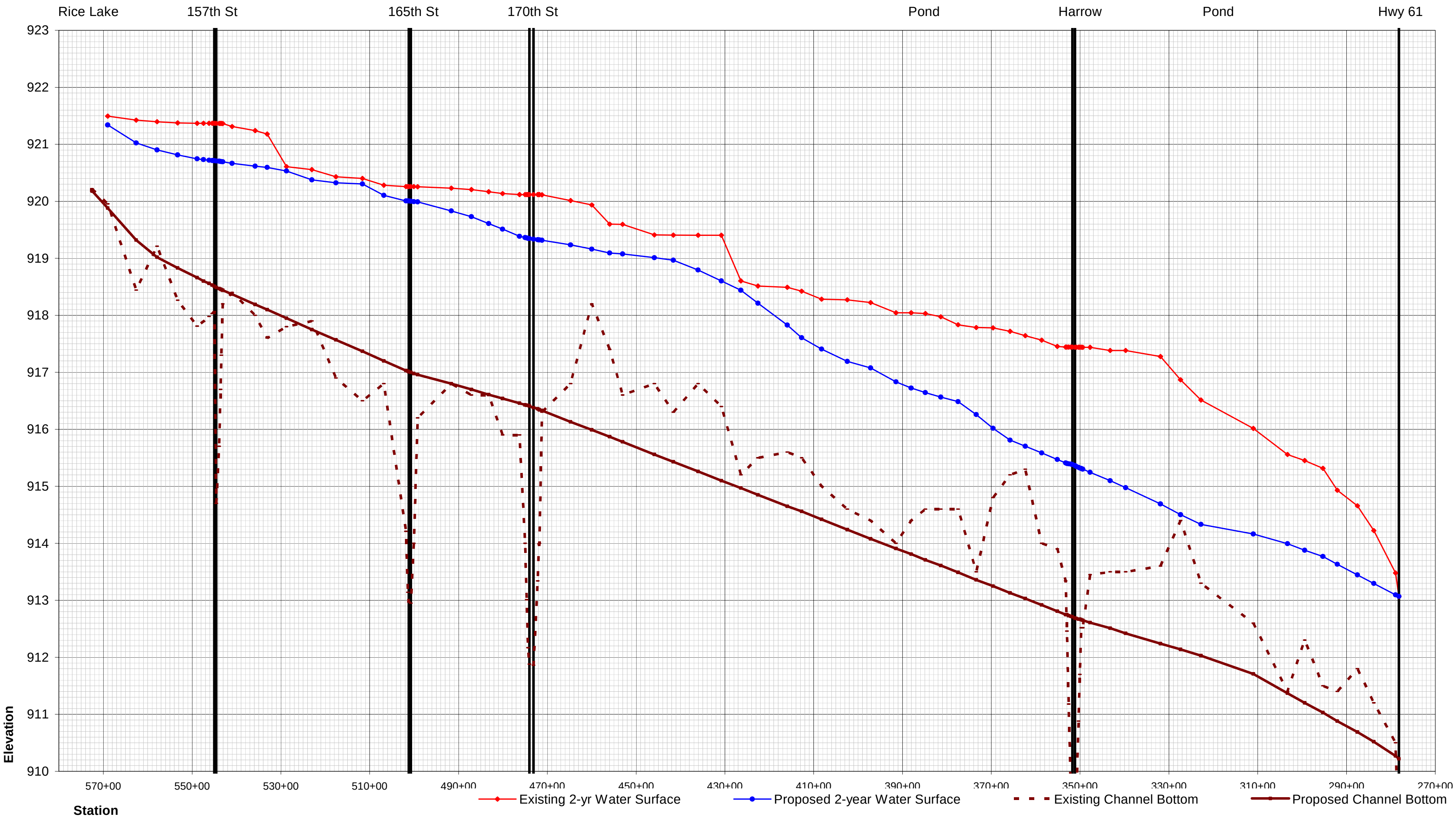


Figure 9. 100-year Storm Water Surface Profile for Existing Conditions, Stable Stream Design, and Traditional Ditch

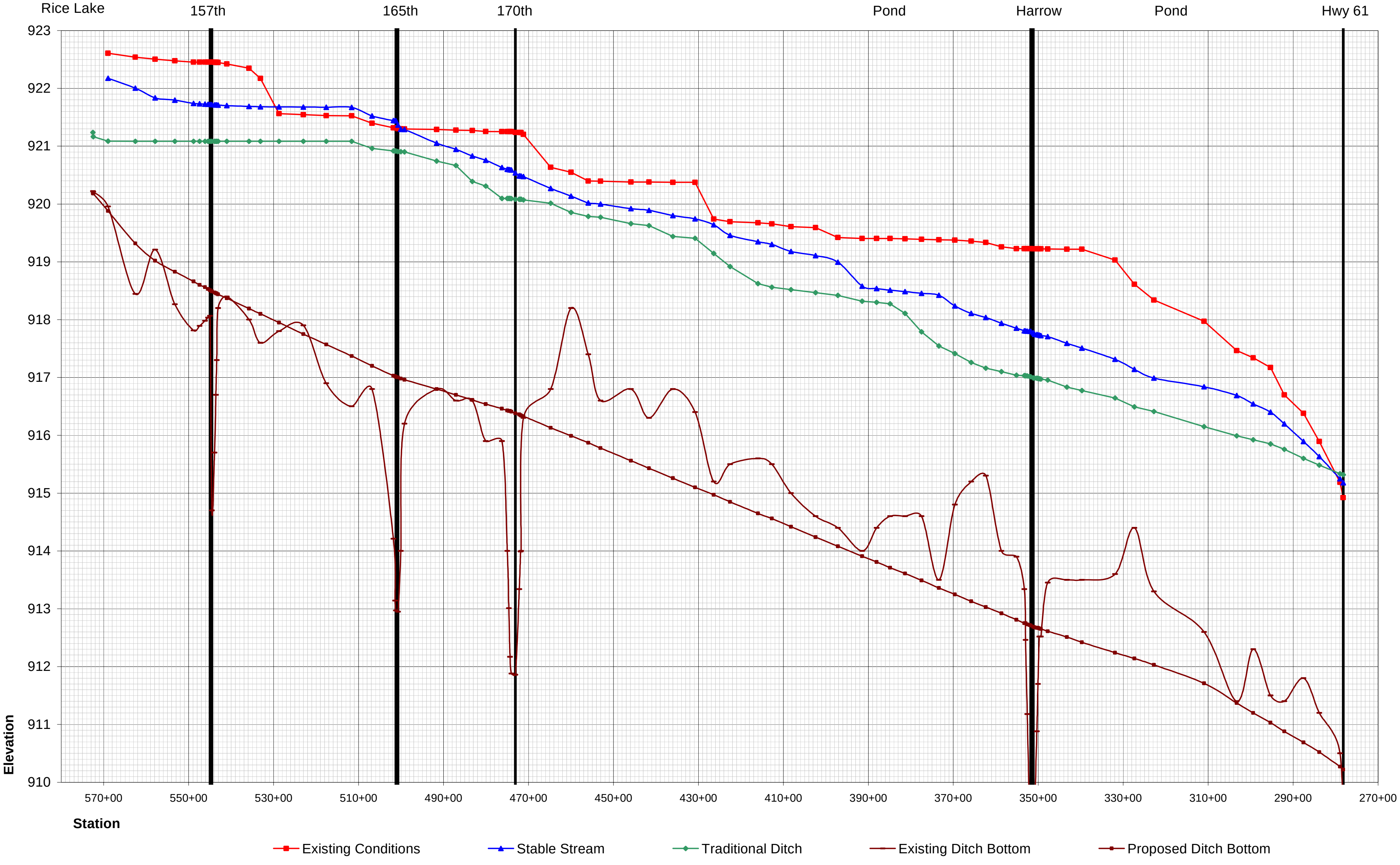
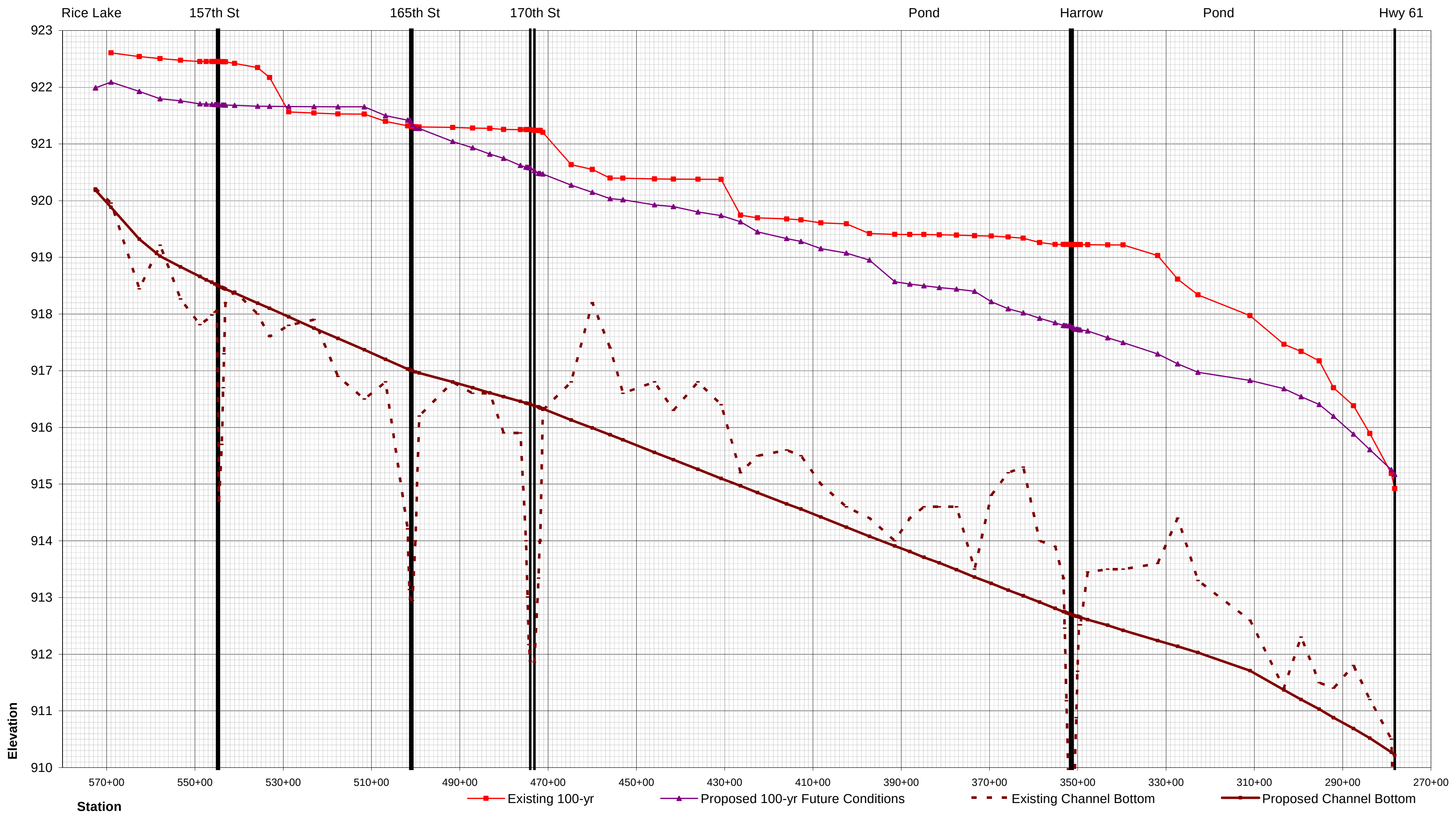


Figure 10. 100-year Storm Water Surface Profile for Stable Stream Design under Future Land Use



Wetland Impacts

There are a total of 26.3 acres of Type 3 wetland that could potentially be converted to Type 2 in this scenario. Construction of the channel and wetland treatment basins would recreate 12.6 acres of Type 3 wetlands.

With the incorporation of avoidance measures (berming and lateral ditch stabilization at existing lateral outlet elevations) the total acres of impact could be reduced to 8.2 acres (Table 9). With the re-creation of Type 3 wetlands from the new channel and wetland treatment basins a net gain of 4.4 acres of Type 3 wetlands would be realized. Therefore, implementing these avoidance measures would ensure that no loss of regulated wetland type occurs.

Table 9. Stable Stream Rehabilitation DNR and WCA Regulated Impacts

	Stable Stream Rehabilitation (acres)	**With Avoidance (acres)**
DNR Regulated		
Type 3	10.8	5.3
Type 4	0	0
Type 5	0	0
Sub-Total	10.8	5.3
WCA Regulated		
Type 3	15.5	2.9
Type 4	0	0
Type 5	0	0
Sub-Total	15.5	2.9
Total	**26.3**	**8.2**

The calculated lateral effect is narrower than the designed floodplain channel and since the floodplain would be excavated, most of the effective drainage of adjacent wetlands would be avoided (Table 10).

Table 10. Stable Stream Rehabilitation Lateral Effect and Floodplain Channel Width.

Reach	Total width of dewatering (ft)	Total width of floodplain/belt width (ft)
157th	0.0	80.0
165th	31.0	80.0
170th	33.0	80.0
Corrie's Swamp	50.0	100.0
Harrow Ave	72.0	100.0
Hwy 61	46.0 (average)	50.0 (average)

Despite the narrow lateral effect and the excavation of the floodplain, there still are non-WCA regulated wetland impacts potentially resulting from the stable stream rehabilitation option (Table 11). Where the new meandered channel abuts the constructed floodplain, a small effective drainage impact could occur. In addition, lateral ditches connecting to the future channel have been determined to have an effect on existing wetlands. Total unregulated impacts are expected to be as low as 4.1 acres with avoidance measures in place.

Table 11. Stable Stream Rehabilitation Unregulated Wetland Drainage

Wetland Type	Stable Stream Rehabilitation (acres)	With Avoidance (acres)
Type 1	1.0	1.0
Type 2	5.3	0.6
Type 6	2.6	0.7
Type 7	2.8	0.1
Type 8	4.9	1.7
Total	**16.6**	**4.1**

Excavation is another wetland impact consideration. In order to construct the proposed new channel and water quality improvement ponds, existing wetlands will need to be excavated and restored (Table 12).

Table 12. Wetland Excavation Areas

	Stable Stream Rehabilitation
Wetland Type	**Acres**
Type 1	3.7
Type 2	16.3
Type 3	9.4
Type 4	0
Type 5	0
Type 6	13.5
Type 7	3.3
Type 8	17.3
Total	**63.5**

Cost

Overall cost estimates for the stable stream rehabilitation are outlined in Table 13. The total cost for channel restoration and construction of the water quality treatment features, including contingencies, is estimated to be $2.0 million. The costs could be spread over five years based on the sequencing of the construction. It should also be noted that this alternative would be eligible for 100% funding from the $800,000 LCMR grant.

Table 13. Stable Stream Cost Estimate

RCWD
HARDWOOD CREEK / JD2 STABLE STREAM REHABILITATION
COST SUMMARY TABLE

ITEM	DESCRIPTION	UNIT	QUANTITIES	UNIT PRICE	SUBHEADING SUBTOTAL	TOTAL	TOTAL+ 25% Conting., Engr., Legal, Admin.
Hardwook Creek Channel Restoration							
Main Channel Stream Restoration						$848,950	$1,061,188
Mobilization, Erosion Control, Access	Includes Building Haul Roads for Moving Equipment and Material	Ea.	1	$200,000	$200,000		
Excavation of Channel	Excavation only	C.Y.	173,100	$2	$346,200		
Offsite Disposal	Haul to offsite location, excavation paid separate	C.Y.	73,100	$2.50	$182,750		
Refill Old Ditch	Fill original channel after 2nd year, excavation paid separate	C.Y.	60,000	$1	$60,000		
Natural Decomposition	1-year of decomposition/dewatering	C.Y.	40,000	$0	$0		
Clear & Grub		Ac	20	$3,000	$60,000		
Branch 2 Repair						$10,500	$13,125
Excavation of Channel	Uses 2:1 Side Slopes for Stability	C.Y.	1,700	$5.00	$8,500		
Stabilize Channel @ existing elevation	Avoid Hydrologic Change in Regulated Wetlands	Ea.	1	$2,000	$2,000		
Water Quality/Sediment Control						$279,000	$348,750
Wetland Treatment Feature	first cell of larger scale potential futurewetland treatment feature	C.Y.	30,000	$4.50	$135,000		
Corrie Swamp pond	located on the Bredahl Property	C.Y.	21,000	$4.50	$94,500		
Pond North of 157th	located on the Malmstrom Property	C.Y.	11,000	$4.50	$49,500		
Wetland Restoration/Mitigation						$283,300	$354,125
Type 3 Wetland in the New Channel	Wild Rice Collection and Seeding	Ea.	10	$500	$5,000		
Type 2 in the New Channel	Sedge Meadow Establishment	Ac	58	$1,725	$100,050		
Type 2 Filled in Old Channel/Disturbed areas	Sedge Meadow Establishment	Ac	30	$1,725	$51,750		
Wetland Treatment and Ponds	Veg for Benches and floodplain	Ac	3	$500	$1,500		
Restoration Management / Monitoring	Planning and Reports	year	5	$25,000	$125,000		
Other Misc Structural Improvements		project	1	$200,000	$200,000	$200,000	$250,000
Remove Beaver Dams on Lake, Berms to prevent regulated drainage, Tile/Private Connections, Culverts							
Grand Total							**$2,027,188**

Easement costs are not included in this table. Easement costs would be approximately $1,500/acre. This is based upon previous appraisals in the area.
Much of the easement acquistion is intended to be funded through outside sources.

ONGOING MINOR MAINTENANCE

A fourth option that the District could consider is to continue to carry out minor maintenance on the system. For the purpose of benefits determination, it was necessary to clearly define the ongoing minor maintenance repair option. The assumption underlying the model of this scenario was that maintenance activities would remove all beaver dams and debris, as well as any obstructive sediment buildups in the channel. This would amount to removing any obstructions (e.g. beaver dams, limbs, bank failures, deltas created by inputs from tile lines) in the channel.

Flood Mitigation

This approach would provide some limited relief from flooding, but would not substantially mitigate flooding in the system over the current situation.

Maintenance

Maintenance would occur as needed.

Future Stormwater Conveyance

Stormwater conveyance would not be different than the current conditions.

Biologic Condition

The straightened channel that will be maintained in this alternative provides less attenuation of flows than a meandered channel, leading to poorer habitat quality for biological communities. Ongoing maintenance would not contribute to the habitat improvement needed to address the HWC/JD2 biotic impairment TMDL due to annual disturbance and excavation. However, this option would not be as detrimental to the biota as the traditional repair option, because less channel disruption would occur.

Downstream Water Quality

Ongoing maintenance would have a short term detrimental effect on downstream water quality. With annual disturbance and excavation in the channel, buoyant, organic sediment would be resuspended and transported downstream, similar to what was observed during and after the 2004 minor maintenance. In addition, the channel would remain separated from the floodplain, thus eliminating an opportunity for removal of suspended sediment and nutrients, which would instead continue to be transported downstream to the Rice Creek Chain of Lakes.

Wetland Impacts

When minor maintenance is performed, it would be limited to avoid wetland impacts to avoid wetland regulatory issues and in keeping with the RCWD's definition of ditch maintenance as stated in their Water Resource Management Plan. Therefore no wetland impacts would result from this option.

Cost

The cost for ongoing minor maintenance is estimated to be $75,000 per year. This is based upon costs incurred by the RCWD for similar kinds of maintenance, albeit on a smaller-scale, over the past three years.

Recommendations

COMPARISON OF ALTERNATIVES

The effectiveness of each alternative in meeting the objectives of the project is presented below. The effectiveness was scored qualitatively as good *(better than existing)*, *neutral*, or *poor (worse than existing).*

Table 14. Comparison of JD2 Alternatives Based on Project Goals and Benefits

Project Issue	Traditional Repair	Meandered Channel at Official Profile	Stable Stream Rehabilitation (recommended)	Ongoing Minor Maintenance
Flood Mitigation	good	good	neutral/good	neutral
Maintenance	poor	neutral/poor	good	neutral
Future Stormwater Conveyance	poor	neutral	neutral/good	poor
Biologic Condition	poor	neutral	good	neutral/poor
Downstream Water Quality	poor	neutral	good	poor/neutral
Wetland Impacts	poor	poor/neutral	neutral/good	good
Cost	poor/neutral	poor	neutral/good	good
Timing – Implement in 2004	poor	poor	neutral	good

Table 15 summarizes the overall costs of each option. For each option, the cost estimates include preliminary contingency costs for combinations of cross drains and floodplain culverts at 157th, 165th, and 170th Streets. These structures will allow for shallow everyday flow through the upper one and one half feet of peat near these road crossings in addition to improving flood flows (Appendix I). While the floodplain culverts would be most helpful at 157th Street and 170th Street, the cross drains would primarily be for 170th Street and 165th Street, with 170th Street being the top priority. It is important to note that, while the cross drains likely should be justified under the WCA incidental wetland exemption, the USCOE does not have that exemption and may have permitting issues.

Table 15. Summary of Cost Estimates

HWC / JD-2 Cost Summary		
Options	**Construction Cost**	**Estimated Annual Maintenance Cost**
Traditional Repair	$3.0 Million*	$150,000
Meandered Channel at the Official Profile	$4.0 Million*	$100,000
Stable Stream Rehabilitation	$2.0 Million	$20,000
On-going Minor Maintenance	$200,000	$75,000

* Does not include any Rice Lake mitigation

A breakdown of maintenance costs are provided in Appendix J. The Stable Stream Rehabilitation design provides the District with an option that best meets all of the project goals. Merging stream morphology principles with site-specific data and applying them to channel design provides the District with a low-maintenance outcome suited to local conditions. The main benefits of a Stable Stream Rehabilitation option are summarized in Table 16:

Table 16. Summary of Stable Stream Rehabilitation Benefits

Issue	Benefit
Flood mitigation	Good long-term flood mitigation due to in-stream storage and connection between channel and floodplain
Maintenance	Least amount of long term maintenance due to stable channel design
Future stormwater conveyance	Improved stormwater conveyance due to in-stream storage and connection between channel and lowered floodplain
Biologic condition	Helps achieve goals of HWC/JD2 biotic impairment TMDL
Downstream water quality	Greatest downstream water quality benefits, due to least amount of sediment transport.
Wetland impacts	Least amount of wetlands impacted except for the no-build alternative
Cost	Lowest cost except for no-build, and lowest long-term maintenance cost

In addition to Dr. Verry’s consultation, the District has sought the contribution of other experts in the field for a technical peer review of the proposed design. The specialists that have been contacted for their input, along with their affiliation and role, are listed in Table 17. Comments received to date from these specialists are found in Appendix I.

Table 17. Peer Review Contributions

Name	Expertise	Entity	Area of Review	Role
Sandy Verry, PhD	Peatland Hydrology and Stream Morphology	Ellen River Partners (Retired U.S. Forest Service-Hydrologist)	Stream Design, Ditch Stability in Peatlands	Design Contribution
David Grigal, PhD	Soils and Peatlands	University of Minnesota, Prof. Emeritus	Hydraulic Conductivity in Peatlands, Stability in Peatland	Peer Review
Bruce Wilson, PhD	Biosystems and Agricultural Eng.	University of Minnesota, Professor	Stream Design	Peer Review
Joe Magner	Hydrology	MPCA, Senior Hydrologist	Stream Design	Peer Review/Agency Comments
Ed Matthieson	Water Resource Engineering	Wenck & Associates	Water Resources Engineering	Peer Review

DESIGN DETAIL – CHANNEL CONSTRUCTION AND SEQUENCING TIMELINE

It would be preferred to construct the channel during the winter, since construction would be facilitated by frozen ground conditions. The frozen ground construction provides several benefits:

- Allows access to otherwise unstable peat areas that may be difficult to access during other portions of the year, except with specialized equipment.
- Allows for work under low flow conditions.
- Provides water quality benefits – exposed soils during construction would not be eroded by rain events nor would the channel be subject to high flow events.
- Reduces the destruction of wetland plants by equipment movement.

The majority of the new channel excavation would be done “off-line” during this first year and would not be connected to the existing channel. After a growing season has passed, the new channel would be connected to the existing channel at the various cross-over or connection points and would start carrying all the flow.

Postponing channel connection would allow the newly created channel to establish vegetation, which will help maintain channel stability and limit repairs. It would also allow the suspended solids (released during the excavation) to settle out of the water column during the first growing season. By allowing the excavated material to settle in the channels and the exposed soil/peat to re-vegetate, there would be significantly less water quality impact downstream due to the construction.

This delay of the connection of the new channel to the existing channel would require that some spoils material be stored on-site adjacent to the existing ditch during the first growing season. The material would then be placed in the old channel once the new channel is connected. Filling in the old channel avoids the need to move the material off-site and reduces the risk of the flows “jumping” out of the young, new channel and back into the old channel during higher flows. The problem of flows migrating back to a blocked-off channel is a relatively common problem in stream restoration (Shields, et al, 2003). The filled-in old channel would then be re-vegetated to stabilize the material and restore it to a quality wetland. In order to prevent flow migration, stable ditch blocks of mineral soils would be placed at the point where the old channel is diverted into the new channel.

There are three water quality wetlands/ponds designed into the system to help uptake soluble nutrients and settle material that has been eroded and carried downstream. The locations of the water quality wetlands were driven by three factors:

- The need to treat several reaches of the channel.
- The feasibility of obtaining rights from landowners to construct wetlands.
- The removal of invasive species and the avoidance of high quality vegetation.

These basins should be completed and stabilized before the new system is connected to the waterway. For larger events, the new floodplain would function as a sediment trap and filter as floodplains naturally do, improving water quality downstream.

MONITORING OF CHANNEL REPAIR AND ADAPTIVE MANAGEMENT

On-going monitoring and management would be needed in the first few years to address vegetation problems and/or to control invasive plants. There may be a need for periodic repair or reshaping of the channel as the new channel adjusts to the flows of the system.

Vegetation Monitoring

All channel areas would be monitored in concert with adaptive management (repeated seeding and both weeding and herbicide treatment of invasives). Channel reconstruction areas with no existing reed canary grass are expected to require less effort to ensure complete coverage with the desired native species; these areas would be monitored closely for how adjacent sedge-dominated stands expand into the disturbed area. The channel areas with nearby reed canary grass are expected to require more aggressive management to inhibit clonal and seed expansion of reed canary grass into the unoccupied soil. Aggressive adaptive management is expected to ensure the desired outcome within five years of initial seeding. Wetland permit conditions are expected to clarify specific vegetation outcomes. This was included in the construction cost for this stable stream alternative.

Hydrologic Monitoring

The hydrologic monitoring plan for determining changes associated with channel reconstruction has been partially implemented. Pre-construction data has been collected this year and can be compared to post-construction data to be used for impact analysis. Post-construction data would be used in vegetation management and in decisions on seeding augmentation to meet the prevailing hydrologic regime.

Water Quality Monitoring

Water quality monitoring would continue after channel reconstruction. Pre-construction data can be compared to post-construction data to assess the impacts. In addition, a fish survey and macroinvertebrate sampling would be conducted post-construction and coordinated with the TMDL study.

Mosquito Monitoring

Due to the extent of wetlands in the JD2 corridor, mosquito species that have the potential to transmit diseases are a human health concern. Of recent concern are the vectors carrying the West Nile Virus. Historically, malaria was of concern, but is no longer a major issue in the United States due to medical advances (Willott, 2004).

In Minnesota, *Culex tarsalis* is suspected as being the primary vector of West Nile virus to humans (Appendix K). According to the Metropolitan Mosquito Control District (MMCD), at survey locations in Hugo approximately 25 species of mosquitoes have been identified. *Culex tarsalis* has not been one of the species identified. The two most common species, the vexans mosquito and the cattail mosquito, have not proven to be effective transmitters of West Nile virus. The MMCD monitoring sites in Hugo do not include wetlands in the JD2 corridor. The MMCD estimates that 5-25% of *Culex tarsalis* found in Minnesota have been found in temporary to semi-permanent wetlands (personal communication with Nancy Reed, MMCD).

The likelihood of *Culex tarsalis* habitat in the JD2 corridor can be estimated by examining the standing water areas associated with the corridor. The areas of standing water are primarily in the wetlands of the floodplain and the open water ditch channel. The floodplain wetland hydrology is characterized as saturated to the surface on a broad scale. During the spring there may be pools of standing water as a result of spring runoff. During the summer and fall the hydrology persists to at or just below the surface without large expanses of open water (EOR, 2004). The main exceptions are the few created duck ponds excavated into the saturated wetland. In general, the corridor wetlands would not be considered preferred breeding habitat because of the lack of persistent standing water.

The proposed ditch channel designs have been compared in terms of standing water for breeding habitat. Using low stream velocity as the indicator for potential breeding habitat, the stream rehabilitation alternative provides the lowest potential of the three alternatives for *Culex tarsalis* breeding habitat. Primarily this is due to the fact that the properly sized base flow channel will have higher velocities of flow and will be self-maintaining meaning that there is little opportunity for water to pool and become stagnant as with the traditional ditch or the meandered channel at the official profile option (Brookes, 1988; Rosgen, 1996). In addition, the meandered channel will have variable velocity along the channel bed, allowing for zones of faster and slower-moving water and associated coarser to finer substrate materials. This in turn increases the vitality of the biological community and increases the natural predators of mosquitoes (Allen and Flecker, 1993; Karr, 2002; Willott, 2004; EPA, 2004). Ponds proposed within the channel have been designed to be greater than four feet in depth which is the depth threshold recommended by the MMCD to minimize mosquito habitat.

Because the project is outside the current MMCD monitoring area, as part of this project, the District could integrate mosquito awareness education, monitoring, and control into the project. This work would be coordinated with the MMCD.

Conclusion

The multiple goals of the HWC/JD2 repair and the physical and social constraints of the system make this project a unique and complex undertaking. The traditional ditch, meandered channel at the official profile, and ongoing minor maintenance options all achieve some, but not all, of the District's goals for this system. At a technical level, the stable stream rehabilitation design is the best at meeting all project goals given the system constraints.

References

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