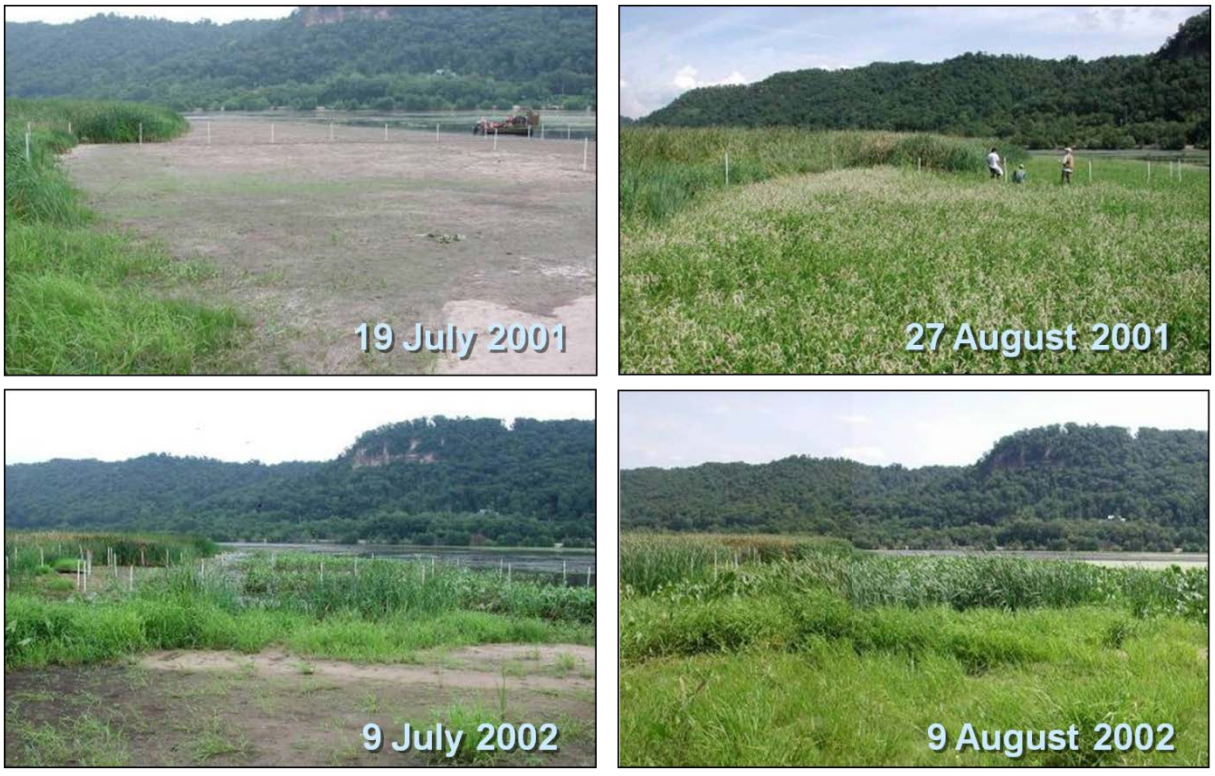
Preliminary Informational Assessment

Recurring Operational Drawdown
Pool 8, Upper Mississippi River

La Crosse and Vernon Counties, Wisconsin
Houston and Winona Counties, Minnesota



US Army Corps of Engineers
St. Paul District

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CHAPTER 1.

Introduction

1.1 Summary

The St. Paul District, Corps of Engineers, has prepared this preliminary assessment of routine water level drawdowns in Pool 8 for the purpose of improving habitat. This assessment relies on existing information gained from conducting previous drawdowns in this pool and other locations, and information from operating and maintaining the 9 foot navigation project. The intended purpose of the assessment was to provide information needed to plan and initiate a feasibility-type study and National Environmental Policy Act (NEPA) as required by Corps policy prior to the implementation of such a plan for Pool 8. The term "drawdown" used throughout this document means operating the gates at Lock and Dam 8 so that water levels are reduced below the current allowable water levels.

The environmental benefits of drawdowns have been well-established by previous work and were not addressed in detail here. Similarly, the adverse socio-economic effects have been addressed by previous works. What is not as well understood are the long-term annual costs, and authorities and processes to implement routine pool drawdowns on the Upper Mississippi River (UMR); these were the focus of this assessment.

Two alternative drawdown operating methods were reviewed: Alternative 1) Additional dredging once every five years and attempt up to a 1.5 foot drawdown on a five year cycle, but also in other years as depths allow; Alternative 2) Additional dredging once every three years and attempt up to a 1.5 foot drawdown on a three year cycle, but also in other years as depths allow. With each alternative the magnitude and duration of a drawdown may be affected by hydrologic conditions.

The results of this assessment concluded that the average annual cost (over 50 years) of Alternative 1 above and beyond the average annual cost of maintaining the 9 foot channel in Pool 8 would be about $244,000 or $575,000, and for Alternative 2 would be about $414,000 or $959,000 (depending on whether or not the potential savings to O&M can be credited as described in Chapter 3). These are the costs of the increased dredging to maintain the navigation channel and do not include any potential costs for recreational access dredging or the costs of a feasibility study. Furthermore, they are preliminary estimates that would require much refinement during a feasibility study.

Further development, evaluation, and coordination would be required prior to implementing a recurring drawdown operating plan on Pool 8. This would include a study and NEPA document that would cost an estimated $700,000 to $2,000,000. Such a study may be further pursued under one of the programs identified in this paper. Depending on the program, funding may need to be provided almost exclusively through non-Federal contributions.

1.2 Purpose of this Assessment

The purpose of this assessment is to provide the basic information that would be needed to conduct a detailed feasibility-level study of recurring operational drawdowns in Pool 8. Information is available regarding the environmental benefits of pool-wide drawdowns on the Mississippi River, and one-time drawdowns have proven successful (see Section 1.3). However, implementing these drawdowns on recurring basis as part of the normal operation of any given pool presents additional obstacles to address. First and foremost is the challenge of funding the increased dredging volumes and related management of increased dredged material. Second is the need to develop a flexible dam operating plan that can accommodate opportunities for drawdown as they become available annually. Finally, there is a need to identify the process and authorities that would allow the St. Paul District to further study and implement such a plan.

Pool 8 was selected as the pool within the St. Paul District that would best fit for the implementation of a recurring operational drawdown plan for several reasons. First, drawdowns conducted there in 2001 and 2002 were considered highly successful. Second, the successful implementation of those drawdowns increases the likelihood that a long-term plan would be accepted by the public. Third, the ability to support increased dredging needs through the beneficial use of dredged material is greater in Pool 8 than in many pools, potentially keeping long-term costs lower. Fourth, there was a great deal of physical, chemical, and biological data collected during the Pool 8 drawdown that would be useful for a feasibility study. Finally, Pool 8 is a trend pool and has been studied for almost 30 years through the long-term resource monitoring element of the Upper Mississippi River Restoration Program.

1.3 Related Reports and References

Many reports and peer-reviewed articles have been produced that evaluate drawdowns for habitat management in general and on the Mississippi River; just a few of the more relevant ones to this review are listed here:

Abraham D. D., Mark A. Cowen, Jon S. Hendrickson, William M. Katzenmeyer, Kevin J. Landwehr, and Thad C. Pratt (2006). Effects of Pool drawdown and Wing Dams (Pool 8), and Closure Dams (Pool 13), on Navigation Channel Sedimentation Processes, Upper Mississippi River. ERDC TR-06-2.

Great River Environmental Action Team (GREAT). 1980. Great River Environmental Action Team I Study of the Upper Mississippi River, Guttenberg, Iowa, to the Head of Navigation at Minneapolis, Minnesota (9 volumes).

Kenow, K.P., G.L. Benjamin, T.W. Schlagenhaft, R.A. Nissen, M. Stefanski, G.J. Wege, S.A. Jutila, and T.J. Newton. 2015. Process, policy, and implementation of pool-wide drawdowns on the Upper Mississippi River: A promising approach for ecological restoration of large impounded rivers. River Research and Applications 32:295-308

Landwehr, K.J., C.H. Theiling, T. R. Gambucci, D.R. Busse, D.B. Wilcox. 2004. Water Level Management Opportunities for Ecosystem Restoration on the Upper Mississippi River and Illinois Waterway. Upper Mississippi River – Illinois Waterway Navigation Study ENV Report 53.

Nissen, R.A., editor 2014. Habitat enhancement using water level management on the Upper Mississippi River. Water Level Management Task Force-River Resources Forum. May 2014. 87pp.

U.S. Army Corps of Engineers. 1981. Great River Environmental Action Team Study. St. Paul District, U.S. Army Corps of Engineers. St. Paul, Minnesota.

U.S. Army Corps of Engineers. 1996. Channel Maintenance Management Plan. Upper Mississippi River Navigation System, St. Paul District. St. Paul District, U.S. Army Corps of Engineers. St. Paul, Minnesota.

U.S. Army Corps of Engineers. 1997. Final Environmental Impact Statement. 9-Foot Navigation Channel Project. Channel Maintenance Management Plan. Upper Mississippi River, Head of Navigation to Guttenberg Iowa. St. Paul District, U.S. Army Corps of Engineers. St. Paul, Minnesota.

U.S. Army Corps of Engineers. 1999. Definite Project Report/Environmental Assessment. Pilot Pool Drawdown, Pool 8, Upper Mississippi River, Wisconsin and Minnesota. St. Paul District, U.S. Army Corps of Engineers.

1.4 Corps Contributing Team Members

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CHAPTER 2.

Background

2.1 Recent Coordination

The Water Level Management Task Force (WLMTF) is a sub-committee of the inter-agency River Resources Forum (RRF) partnership. The WLMTF has been focusing on developing a programmatic or operational approach to pool-wide drawdowns for several years. At the December 2008 RRF meeting, the WLMTF requested endorsement of the following recommendation:

"The River Resources Forum recommends the St. Paul District include pool-wide water level reductions (drawdowns) and other water management options as ecosystem restoration components of their Water Management Program."

The RRF was unable to endorse the recommendation without additional U.S. Army Corps of Engineers (Corps) input. In December 2010, the WLMTF received a letter from the Corps regarding the recommendation. In short, the letter stated that while the Corps is supportive of water level management on a pool-by-pool basis, there were numerous hurdles and short-comings with institutionalizing a broad-based WLM program. However, the Corps did encourage the WLMTF to continue "*finding a way forward for future planning and implementation of WLM activities in an era of constrained agency resources*."

The WLMTF has continued to work toward a programmatic strategy. With the support of the WLMTF, The Nature Conservancy and Audubon Minnesota jointly submitted a letter to the St. Paul District regarding the concept of using a private firm to complete a Problem Appraisal Report (PAR) addressing the selection and ultimate writing of a flexible water control manual for one pool in the St Paul District. This led to a meeting regarding this subject with both Colonel Koprowski and General Wehr (as reported at the December 2014 RRF 101 meeting).

The Nature Conservancy then worked with the firm CH2M HILL to develop a draft proposal titled "*Development of a Reconnaissance Report for Flexible Dam Operations in the Upper Mississippi River System*." The proposal outlined the steps needed to select and then alter the water control manual for one pool in the St Paul District. The steps included: conducting an existing conditions review, conducting workshops to develop the initial characterization and overall strategy, conducting a cost-benefit analysis workshop, and finally, preparing a PAR which could be used by the St Paul District to obtain permission to update a Water Control Manual (WCM) and subsequently implement flexible dam operations in one pool of the UMR.

This draft proposal was reviewed by the WLMTF at the January 8, 2015 meeting. After considerable discussion, Corps staff suggested that changing the WCM was not necessarily the goal. Instead, an assessment of all the impacts of changing water level management and

identifying appropriate solutions was needed; after which, changing the WCM would be merely procedural. Corps staff felt a reconnaissance study by CH2M HILL was not necessary; enough water level management work had been completed over the last 20 years to nominate Pool 8 as the best location for this action, and that the WLMTF should move to a feasibility-type study for the selected pool. All agency, partner and citizen representatives at the WLMTF meeting were in favor of this approach.

However, there is some information needed prior to the implementation of a feasibility study. Rather than using an outside AE firm, it was decided by the St. Paul District to commit up to $50,000 to the development of a white paper that would provide a rough plan and cost estimate for implementing routine drawdowns on Pool 8. This assessment is that white paper.

The WLMTF met again on March 9, 2015 to discuss the Corps recommendations and commitments in greater detail. This approach was recommended by the WLMTF to be followed up with review and support through the agency partnership with final endorsement by the RRF.

2.2 Pool 8 Drawdown History

A 1996 PAR led to the decision to pursue the implementation of a pilot drawdown of a navigation pool within the St. Paul District. A study completed in 1999 (USACE 1999; Section 1.3) recommended implementation of a 1.5-foot drawdown (beyond the current secondary control elevation of 630.0 MSL 1912) at Lock and Dam 8. A two-season drawdown was recommended to provide additional opportunity for emergent aquatic plant growth resulting from the drawdown to become established. The amount of drawdown that would occur at the La Crosse gage, which is the control point for Pool 8, was limited to 0.5 feet. If flow conditions on the river were reduced to a level that would cause the amount of drawdown to exceed 0.5 feet, then water levels would be raised at Lock and Dam 8.

The initial drawdown was scheduled for the summer of 2000, but was postponed because of predictions for unfavorable river discharge conditions. The drawdown was implemented during the summer of 2001, from the end of June until late September. The full 1.5-foot drawdown at Lock and Dam 8 was maintained only until mid-August. At that time, river discharges declined to the point where the drawdown limitation of 0.5 feet at the La Crosse gage required raising water levels at the dam. From mid-August until termination of the drawdown on 23 September 2001, the overall pool drawdown was about 0.5 foot.

A follow-up drawdown was implemented in 2002. The drawdown began in mid-June and extended until late September. River discharges during the summer of 2002 generally remained above 40,000 cubic feet per second (cfs) at Lock and Dam 8. Because of this, the full 1.5-foot drawdown was maintained at the dam for the entire drawdown period.

2.3 Navigation Channel Operation and Maintenance, Pool 8

2.3.1 Dredging, Drawdown Levels, and Hydrology Since inundation

The minimum water surface elevation at the La Crosse control point is 631.0 (MSL 1912) which corresponds to a reading of 4.7 at the La Crosse gage. For river flows up to 28,000 cfs this elevation is maintained by adjusting gates and reducing the water surface elevation at Lock and Dam 8. When the river flow reaches 28,000 cfs, the water level at Lock and Dam 8 has been reduced 1.0 feet and Pool 8 is at its lowest elevation, 630.0 at Lock and Dam 8 and 631.0 at the La Crosse gage. This condition is referred to as lowest control pool elevation. As river discharge exceeds 28,000 cfs, the water level at Lock 8 is held constant at elevation 630.0 and the water levels elsewhere in pool 8, including the La Crosse control point are allowed to rise. Once a discharge of 95,000 cfs is exceeded, the gates at Lock and Dam 8 are pulled clear of the water and open river conditions are in effect. This is the operating plan that has been in place since 1972. The term "drawdown" used throughout this document means operating the gates at Lock and Dam 8 so that water levels are reduced below the current allowable water level reductions. For example, the existing conditions allowable water level reduction at Lock and Dam 8 is 1.0 feet to elevation 630.0, and a 1.5 foot drawdown implies that the elevation at Lock and Dam 8 would be reduced to 628.5.

The dredging record in Pool 8, dating back to 1931, shows significant year to year variability and long-term heterogeneity with at least five different time periods distinguished by different average annual volumes of dredging (Figure 1). These time periods are listed in Table 1, along with the allowable water level reduction at Lock and Dam 8, average annual dredging in Pool 8, and average annual discharge associated with each time period. The allowable water level reduction at Lock and Dam 8 has been changed several times beginning with 3.5 feet right after Lock and Dam 8 was constructed to the current level of 1 foot. The average annual discharge at the USGS gage at Winona is provided to give perspective on hydrologic conditions and sediment transport potential for each time period.

Figure 1: Average Annual Dredging, and Average Annual Discharge

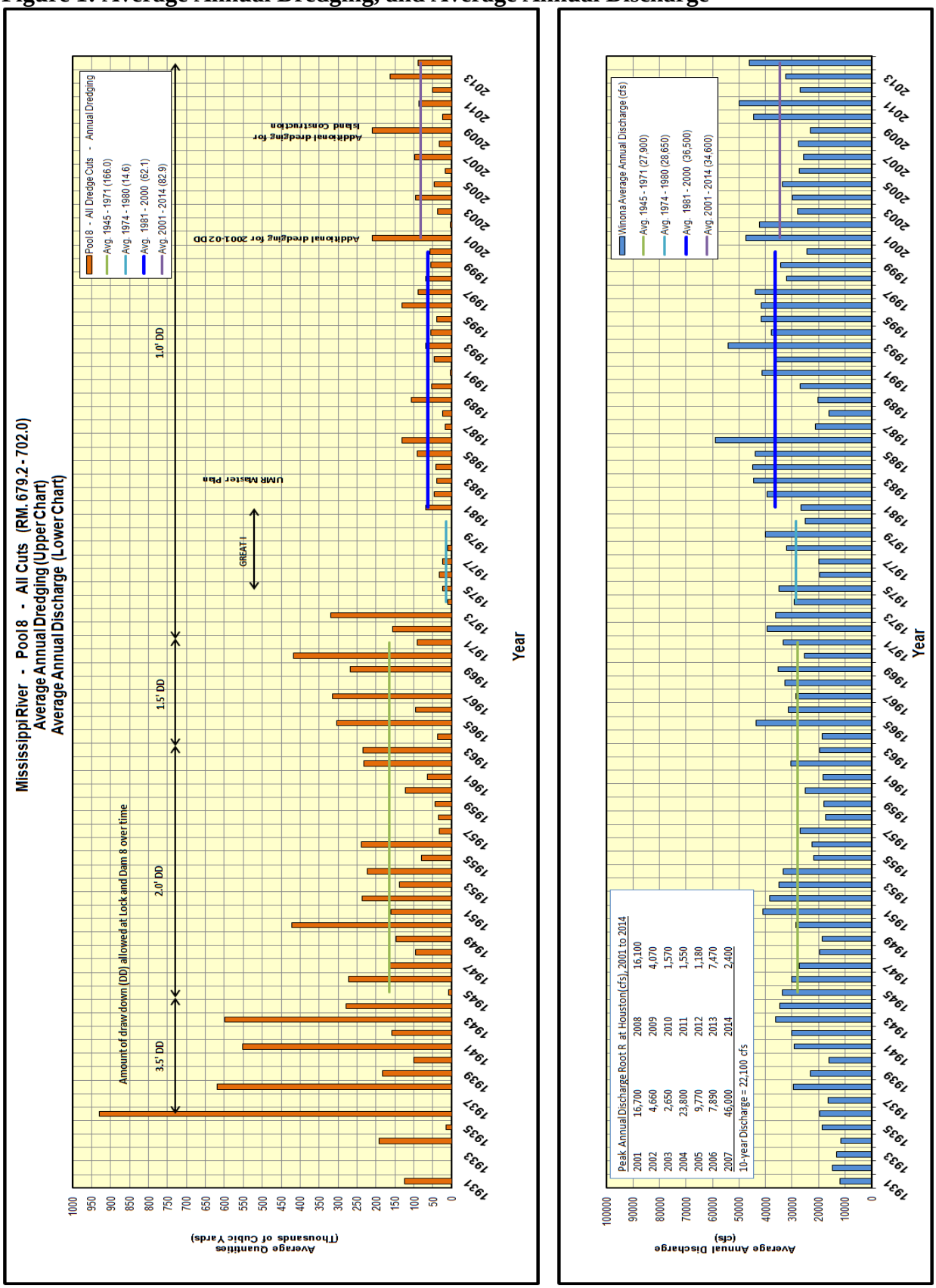


Table 1. Allowable Water Level Reduction, Average Annual Dredging and Discharge by Time Period

Time Period	Allowable Water Level Reduction at Lock and Dam 8 (feet)	Average Annual Dredging in Pool 8 (CY)	Average Annual Discharge at Winona USGS gage (cfs)	Explanation
1936 - 1944	3.5	380,000	26,050	Annual dredging volumes were extremely high during the establishment of the channel and due to large allowable water level reductions at Lock and Dam 8
1945 - 1971	2 & 1.5	171,000	27,900	Annual dredging was reduced compared to earlier years, but remained high.
1974 - 1980	1	14,600	28,650	An abrupt decrease in dredging occurred in response to environmental legislation
1981 - 2000	1	62,100	36,500	Annual dredging volumes varied significantly, but appeared to be stable
2001 - 2014	1	82,900	34,600	Annual dredging volumes increase due to over-dredging for drawdowns and islands

The high dredging volumes in the earlier time periods 1936 to 1944 and 1945 to 1971 are probably due to additional dredging required to establish the 9 foot navigation channel, greater water level reductions which required deeper and longer dredge cuts, lower hydraulic connectivity with backwaters resulting in more sediment transport in the main channel, and possibly elevated sources of sediment after the navigation pools were established. The average annual discharge at the USGS gage at Winona was much lower than in later time periods suggesting that hydrology was not a factor in introducing more sediment to the main channel.

From 1974 to 1980, an abrupt reduction in annual dredging occurred because of a change in dredging protocols in the St. Paul District in response to new federal legislation and state environmental policy. The resulting protocols evolved from the GREAT Study (GREAT 1980; Section 1.3) and emphasized reduced depth dredging, improved channel surveys to minimize annual dredging volumes, placement of dredge material in designated dredge material placement sites, and beneficial use of dredge material. Low annual dredging volumes during this time period were probably due to larger dredging volumes in previous years, creating excess capacity in the navigation channel for sediment storage.

The years 1981 to 2000 should be used to represent pre-drawdown conditions in Pool 8. It is the time period following the abnormally low dredging volumes in the 1970s, but before the Pool 8 drawdown in 2001. This period should be used to represent pre-drawdown conditions. There was significant year to year variability, but no trend up or down. Annual dredging volumes were based on the requirement to provide a reliable navigation channel, but to reduce the amount of sediment dredged based on the new protocols established during the GREAT Study. The Channel Maintenance Management Plan (CMMP) was finalized in 1996 and provided the framework for channel maintenance and dredge material management that is still in use today in the St. Paul District of the Corps of Engineers

(http://www.mvp.usace.army.mil/Missions/Navigation/Channel-Maintenance/Channel-Maint-Mgmt/). Average annual discharges during this time period were significantly higher compared to earlier time periods. Normally higher river discharge results in higher sediment loads and more dredging, but that is clearly not the case when this time period is compared to earlier time periods. This suggests that there are other variables affecting dredging besides river flows.

Average annual dredging increased from 2001 to 2014. Several high dredging volume years occurred during this time period including: 2001 (for the 2001/02 drawdown), 2009 (when the navigation channel at the Head of Raft Channel was used as a borrow site for island construction), and 2013 (due to several imminent closure situations). All three of these high dredging volume events were followed by several years of below average dredging, however, the overall dredging during this time period was increased.

PRESENT DREDGING AND PLACEMENT METHODOLOGIES

To better understand what is being proposed it is important to look at what currently is happening in Pool 8 and similarly throughout the St. Paul District (District) as it relates to surveying, dredging and dredged material management.

The management of the navigation channel in the District is driven by risk management. There are several components of risk that need to be addressed:

1) Risk to commercial navigation customers: lock and dam operation and channel dredging are done to facilitate 9 foot navigation during low water times from St. Louis to St. Paul (Minneapolis was added later). The 9 foot navigation channel means that a vessel that drafts 9 feet under normal circumstances can safely transit. The steps in maintaining the navigation channel include:

    a. Surveying the navigation channels often from ice out in spring to freeze up in late fall. This helps gauge risk and measure changes due to river fluctuations.

    b. If the surveying shows shoaling then a dredge cut(s) is laid out. If urgent, a dredge plant is identified and dispatched. If not, the job is put in the queue for future scheduled dredging.

    c. Dredging is usually done to a depth of 12’ below the Lowest Controlled Pool (LCP) elevation to maintain a safe and reliable channel for commercial vessels. On rare occasions as a result of a restriction (time or placement site capacity as examples), we will dredge to 11’; however this is less efficient in terms of both the initial dredging and maintenance. For any given location it is more efficient to dredge deeper, removing the most amount of material from the system for the least amount of time and money. When dredging to 11’, less material is removed from the system, but in almost the same amount of time as when dredging to 12’ because the dredge has to cover most of the same area. In addition, because we try to dredge when locations become shallower than 10.5’, dredging to 11’ only gives a half-foot of capacity before the area would be targeted for dredging again. This means a dredge will need to return to that

location sooner than if it had been dredged to 12' However, when these depositional areas are dredged deeper, the tendency for sediment to deposit in that area increases (termed "sediment trap efficiency," discussed further in Chapter 3), which results in overall higher dredging volumes for that cut. Therefore, the St. Paul District has found it to be most efficient to opt to dredge to 12' in most locations, because it provides the best balance between maximizing cut longevity and minimizing sediment trap efficiency.

d. As with any dynamic system, there are exceptions to dredging depths. Small boat harbors are dredged to 6', approaches to locks and dams are dredged to 13' below LCP, and Betsy Slough dredge cut in Pool 5A is dredged to 13' because since 1970 it is the most frequently dredged location in the district and 13' helps prevent the Corps from having to dredge it 3+ times a season. It is not uncommon to have to dredge it twice in a navigation season.

2) Risk to the Environment

a. Emergency dredging has the potential for having a greater impact on the environment than routine or imminent closure dredging. Because of the urgency to open the navigation channel, certain planning and coordination is expedited and some placement site options may not be feasible due to the speed at which the channel needs to be cleared. A 12' dredging depth is more likely to prevent an emergency (as defined in the CMMP) dredging situation by increasing longevity from the time it was dredged until it will need to be dredged again.

3) Risk to Tax Payer / Budget consequences

a. Ultimately it costs more money to dredge in a hurry; it may be because of overtime, loss of production for dredging at night, or getting a dredge plant mobilized from a significant distance away. Placement site options may be reduced due to long push / pump distances effectively impacting placement site capacities. Risk is managed in a programmatic way so that the dredge plants can systematically dredge over the course of a season and take the material out of the system while not having to make sudden changes or moves for an emergency.

2.3.2 PLACEMENT SITES IN POOL 8

There are three placement sites currently identified in Pool 8. Other placement sites can be utilized if permits are obtained and cost considerations allow; however, for this white paper only the three existing placement sites will be explained:

1) Isle La Plume – A Permanent Upland placement site, owned by the city of La Crosse with agreement to place material there. However, capacity is limited and because it is not a Corps owned site, increasing capacity may be difficult. It is also a significant distance from all dredge cuts except the Root River dredge cuts.

2) Above Brownsville – A Temporary Island Site that is owned by the Corps and has a significant amount of capacity currently; all material would need to be removed at a later date.

3) Brownsville – A Permanent Upland Beneficial Use Placement Site that is owned by the Corps and has good capacity. The public removes material from this site beneficially on a regular basis. It may need to be expanded to the total CMMP footprint if used for extra dredging to accommodate both five and three year frequency drawdowns. It would need to be expanded if the annual drawdown alternative is pursued.

CHAPTER 3.

Alternative Development

3.1 Introduction

Channel maintenance and dredged material management protocols implemented in the mid - 1970s have resulted in practices that provide a reliable navigation channel with a reduced amount of annual dredging. Reduced dredging depth and improved channel surveys are the two tools most commonly used to minimize dredging. By not over-dredging the channel, additional sand-size sediment is transported through the dredge cut rather than depositing in it, reducing overall dredging in the reach. One of the primary costs associated with water level drawdowns is the additional dredging (deeper and longer dredge cuts) which is necessary for a drawdown, and the fact that the deeper dredge cut has a higher sediment trap efficiency ratio (TE) resulting in increased sediment deposition instead of downstream transport. The trap efficiency ratio describes the amount of the annual bed material load (sand load) that deposits in a reach of river. Dredging patterns associated with the 2001 Pool 8 drawdown and the 2005 Pool 5 drawdown can be described as:

- Increased dredging during the initial year due to the additional dredging depth needed to accommodate the lowered water surface

- Reduced dredging for ensuing years until sediment deposition has filled the additional dredging depth

- An overall increase in the amount of material dredged over the time period starting with the initial year due to the increased sediment trap efficiency

The ecological benefits of water level drawdowns are well documented (e.g., Landwehr et al., 2004, Nissen 2014, Kenow et al, 2016) and can be estimated to determine habitat benefits used in the Corps planning process. However, a method is also needed to estimate the costs associated with increased dredging. This method must be able to 1) estimate dredging volumes for different drawdown frequencies (i.e., annual drawdowns or intermittent), 2) estimate dredging volumes for different amounts of drawdown, and 3) reasonably reproduce the observed dredging volumes from the Pool 8 and Pool 5 drawdowns. During feasibility a sediment transport model with better predictive capabilities may be developed to simulate the effects of additional dredging.

Initially, three water level management alternatives were considered for evaluation here. Alternatives 1 and 2 would involve additional dredging in the navigation channel and attempting drawdowns on 5 year and 3 year cycles respectively. Alternative 3 would involve additional dredging and drawdowns on an annual cycle. For all three alternatives, the assumption was made that the water level would be drawn down 1.5’ below the lowest controlled pool elevation at the dam for the current operating plan. If navigation channel depths allow, a drawdown of some level

would be attempted in ensuing years for Alternatives 1 and 2. While there is no guarantee that this would be possible, second year drawdowns were attempted in 2002 in Pool 8 and in 2006 in Pool 5 with minimal dredging.

Alternative 3, however, was removed from further evaluation here. Reasons for this included its high cost and the uncertain biological need (benefit) to attempt annual drawdowns. This alternative would likely be revisited under a future feasibility study for more in-depth evaluation. The following sections describe analyses for the two remaining alternatives.

3.2 Estimating Future Dredging Volume With Drawdowns

Inter-annual hydrologic conditions on the UMR vary significantly and will have an impact on sediment transport, dredging volumes, and the ability to do a drawdown. For instance, the five year time period starting with the 2001 drawdown in Pool 8 included annual discharges near average and reduced dredging for 2 years (2002 and 2003) after the initial year. On the other hand, annual discharges associated with the Pool 5 drawdown in 2005 were below average from 2006 to 2009 and dredging was below average all four years. Because there is no way of predicting whether wet or dry hydrologic conditions will occur once a drawdown cycle is initiated, a sediment budget was developed using estimated sediment loads and average annual dredging volumes in Pool 8 for the pre-drawdown time period (1981 to 2000). The existing conditions trap efficiency ratio (TE) was set equal to the average annual dredging volume divided by the bed material load. With existing conditions TE established, the annual dredging volumes that result for the three scenarios were estimated by adjusting the trap efficiency and calibrating it to the actual dredging volumes associated with the 2001 drawdown in Pool 8 and the 2005 drawdown in Pool 5. The additional channel volume created during the initial year of the drawdown will be reduced by the amount of sediment trapped in future years and will be used to estimate dredging requirements in years 2 and 3.

Figure 2 illustrates this concept using data related to the 2001/02 drawdown in Pool 8. The average annual dredging volume for the years 1981 to 2000 was 62,000 CY/year (cubic yards/year) and the estimated average annual bed material load in lower Pool 8 is 218,000 CY/year, resulting in a trap efficiency ratio (TE) of 0.284 (62,000/218,000). In 2001, 209,000 CY of dredging was done in Pool 8 in advance of the drawdown. This could be split up as routine and additional dredging. Routine dredging will be assumed to equal the average annual dredging, 62,000 CY/year with the additional dredging set equal to 147,000 CY. Through trial and error, TE values of 0.5 in 2002 and 0.35 in 2003 seemed to produce reasonable and physically correct results. This results in sediment deposition of 109,000 CY in 2002, which uses up a large amount of the additional depth, leaving only 38,000 CY of additional channel volume. In 2003, 76,300 CY deposited and at this point all of the additional depth created in 2001 has been used up and sediment encroachment into the navigation channel had occurred resulting in 38,000 CY of dredging necessary in 2003. By 2004, pre-drawdown channel conditions have been re-established and TE has returned to 0.284 resulting in channel dredging of 62,000 CY. Figure 3 shows the estimated annual dredging using the method described above versus the actual annual dredging that was done in Pool 8 for the five year time period starting in 2001. Although there is some variability in years 4 and 5, the results appear reasonable.

Figure 2: Sediment Budget Conceptual Model

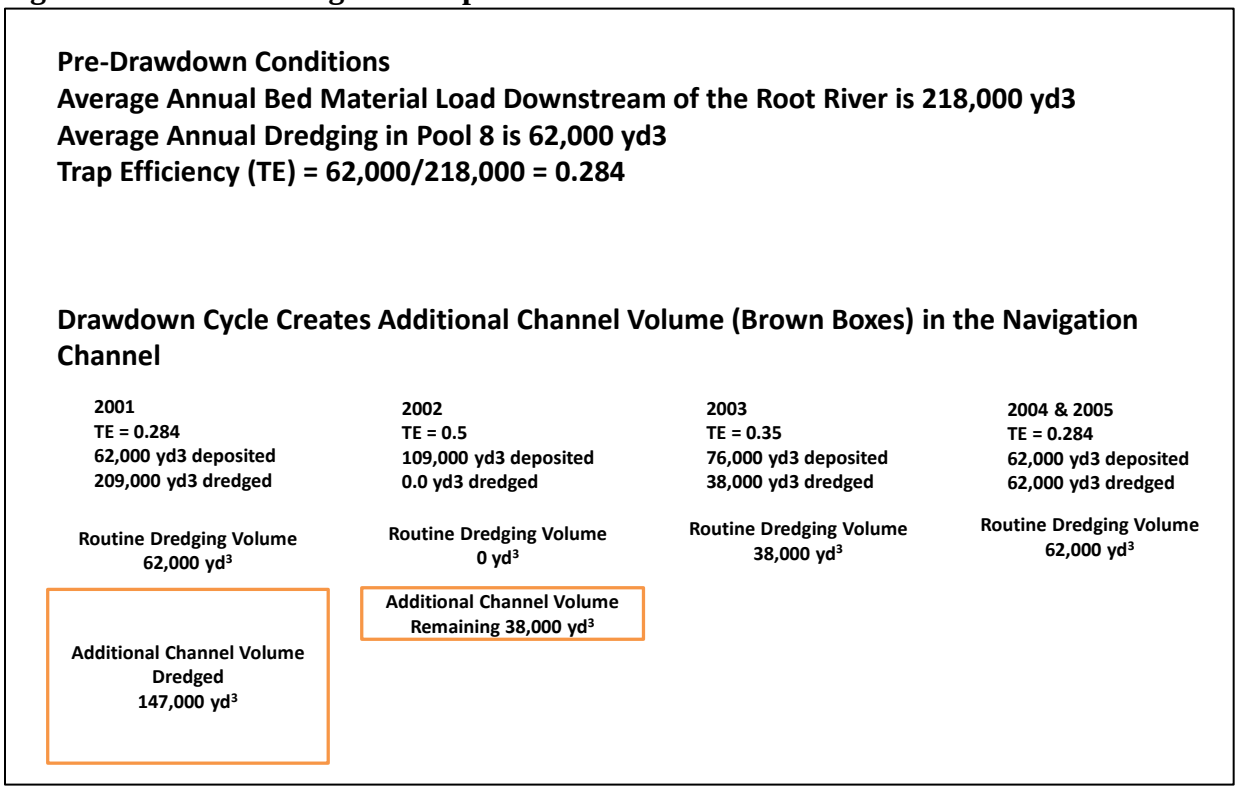
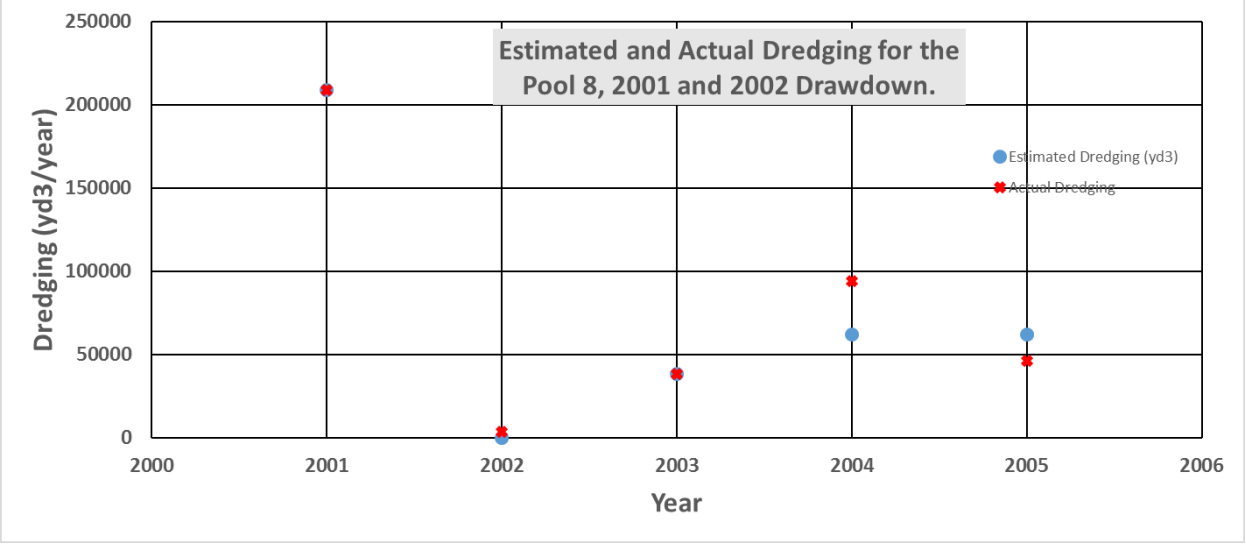


Figure 3: Estimated and actual dredging in Pool 8 for the 2001 and 2002 drawdowns



Using trap efficiency as a surrogate for sediment transport and keeping track of the additional dredging depth and volume following the initial year of a drawdown did a reasonable job producing results observed in Pool 8. A similar type of analysis was done in Pool 5 with acceptable results. For the purposes of this white paper, this method should be adequate; however, numerical sediment transport modeling should be considered during feasibility.

3.3 Quantities for Alternatives

Dredging costs associated with drawdowns include the increase in navigation channel dredging and in some cases, the cost of unloading dredge material placement sites. The increase in dredging occurs due to the large volume of additional dredging that is done during the initial year of the drawdown, and the subsequent increase in trap efficiency which results in more sediment deposition in dredge cuts for 1 to 2 years after the drawdown. The change in annual dredging and in the amount of dredge material placed at the Above Brownsville Placement Site that occurs for the two alternatives based on the sediment budget is summarized in table 2.

Negative numbers in table 2 that occur during the second and third year for Alternatives 1 and 2 indicate a decrease in dredging volumes for those years. This occurs after the initial year of the drawdown when the navigation channel has added depth and sediment can accumulate without impeding navigation. Negative numbers represent potential cost savings in subsequent years. Depending on how a programmatic drawdown is authorized and funded, the first-year higher dredging costs and subsequent-year potential cost savings will need to be precisely accounted for to ensure that the navigation channel authority is separate from whatever authority is used for a drawdown. How this will be done will be identified during a feasibility study.

Table 2. Change in annual dredging and the volume of dredge material placed at the Above Brownsville Placement Site for the two alternatives.

		Alternative 1 - Five Year Cycle			Alternative 2 - Three Year Cycle		
Assumed Year	Average Annual Dredging Based on the 1981 - 2000 time period (CY)	Annual Dredging (CY)	Change in Annual Dredging (CY)	Change in Material Placed at Abv Brownsville (CY)	Annual Dredging (CY)	Change in Annual Dredging (CY)	Change in Material Placed at Abv Brownsville (CY)
Initial year 2017	62,000	209,000	147,000	40,093	209,000	147,000	40,093
2018	62,000	0	-62,000	-16,910	0	-62,000	-16,910
2019	62,000	38,180	-23,820	-6,497	38,180	-23,820	-6,497
2020	62,000	62,000	0	0	209,000	147,000	40,093
2021	62,000	62,000	0	0	0	-62,000	-16,910

Second year drawdowns were attempted in Pool 8 in 2002 and in Pool 5 in 2006 with minimal amounts of navigation channel dredging. This was very successful in Pool 8 with over 75 days of maximum drawdown achieved; however, the second year drawdown in Pool 5 was cut short because of low flow conditions that triggered other constraints. The benefit of these second year drawdowns was a shift in the plant community from annuals to perennials (Nissen 2014). While second year drawdowns may be considered for Alternatives 1 and 2, this will depend on navigation channel depths. If enough sediment deposition occurred between the first and second

years such that navigation would be impacted under drawdown conditions, then additional dredging would be needed prior to the second year drawdown.

3.4 Costs for Alternatives

For cost calculations in this report, the increase in dredging is based on the sediment budget described in section 3.2. The cost per cubic yard of dredging is based on year 2016 numbers with adjustments for inflation over a 50 year drawdown program.

For Alternatives 1 and 2, additional dredging to support a drawdown would be conducted every five or three years respectively. This would involve increasing the dimensions of dredge cuts from the Root River downstream to lower Pool 8 early during the year scheduled for the drawdown, thereby increasing the amount of material dredged significantly. Dredging volumes are reduced for the next two years, as the extra dredge cut depth fills in, but by the fourth year dredging has returned to routine levels similar to those experienced prior to the drawdown. For Alternative 1, this means that routine dredging would be done in years four and five before another drawdown cycle is initiated. For Alternative 2, another drawdown cycle would be initiated with additional dredging done in year four.

Even though the reduced dredging volumes in years two and three in either cycle represent a potential cost savings, existing Corps policy limits the ability to combine channel maintenance funds with funds from other programs or sources. Finding alternative implementation options (some of which are summarized in chapter 5) will be investigated further during feasibility. If an implementation option can't be identified to account for potential future savings, then the costs of a drawdown are the costs of the additional dredging over normal maintenance in the first year for either alternative. These costs are shown in the "without credit" column in Table 3. Drawdown costs shown in the "with credit" column are those expected if the savings to channel maintenance could be credited.

Table 3. Costs of Alternatives

Alternative	Average Annual Total Cost	Average Annual Drawdown Cost Without Credit for Savings to O&M	Average Annual Drawdown Cost With Credit for Savings to O&M
No Action (regular O&M)	$1,183,233	$0	$0
1 (5 year cycle)	$1,427,705	$574,652	$244,472
2 (3 year cycle)	$1,596,864	$959,030	$413,631

The magnitude and duration of a drawdown that can be done in any given year depends on hydrology. High discharges may result in elevated tailwater elevations at Lock and Dam 8 that may reduce or even make it impossible to lower the water surface in Pool 8. Low discharges may trigger constraints related to commercial and recreational navigation in the upstream reach of Pool 8. Considering only the tailwater limitation, the probability of being able to do drawdowns of 1

and 2 feet at Lock and Dam 8 for a continuous period of 60 days is estimated at 74% and 50%, respectively (Landwehr et al., 2004). Assuming the probability of achieving a 1.5 foot drawdown is 65% in any given year when adequate depths are available, and assuming that adequate depths are only available each year dredging occurs, then over the span of 50 years about 7 drawdowns may be possible for Alternative 1, and 11 drawdowns would be possible for Alternative 2. If a future drawdown program has scheduling flexibility (e.g. defer a planned drawdown if the forecasted hydrologic conditions are unfavorable) the number of drawdowns that can be done would increase. In addition it is possible that during some cycles, a drawdown or partial drawdown may be possible during the second year after initial dredging, providing additional ecological benefits.

CHAPTER 4.

Potential Environmental Effects

Much has been written regarding the effects of drawdowns and two such examples referenced in Section 1.3 are U.S. Army Corps of Engineers, 1999; Nissen, 2014; and Kenow et al., 2016. The positive effects of drawdowns and natural flow regimes in particular are well-documented and would be the desired and expected outcome of implementing recurring drawdowns in Pool 8. However, there are several potential adverse effects, many of which are socioeconomic, that must be addressed if such a plan were to be successfully implemented. Furthermore, many of these effects would change in magnitude relative to those that occurred under the past one-time planned drawdowns. All of these effects would need to be fully addressed in the feasibility phase and are discussed below.

4.1 Socioeconomic

4.1.1 Boat access, including marinas.

There are (as of 2011) 18 public boat ramps and 14 commercial recreation facilities located in Pool 8, the same as listed in the 1999 Pilot Pool Drawdown DPR/EA for Pool 8. Recreation access dredging was conducted at nine sites in Pool 8 in support of the pilot drawdown, and cost approximately $245,000.

Adverse effects to recreational boat access are a major concern for the general public. Under past single drawdowns, the public may have been more willing to accept the temporary inconvenience of limited boat access. A programmatic drawdown will certainly draw more concern from the public and likely a demand for funding recreational access dredging. This cost has not been included in the costs presented above.

4.1.2 Commercial Navigation

Commercial tow pilots were surveyed about their experiences during the Pool 8 Drawdown. The overall response indicated that navigating was more difficult, but still navigable. It was also learned later that the tows must operate slower during a drawdown. There were no reports of groundings.

The Pool 8 letter report estimated that dredging would be required at 14 commercial facilities identified in Pool 8 in 1998. However, the WLMTF summary report did not mention this, so it is unknown if any of the dredging was actually needed or occurred.

Effects to commercial navigation would likely be a major concern under any of the alternatives considered here. Issues with access, similar to those discussed for recreational boat access, would likely require a substantial effort to resolve during the feasibility study.

4.2 Natural Resources

4.2.1 AQUATIC VEGETATION

Of course the most notable effect of the drawdown, and the objective, was a substantial increased growth of aquatic vegetation. Aquatic vegetation provides food and cover for many species of fish and wildlife. This beneficial effect has been described in numerous reports for the single-event drawdowns that have been performed in the past. This beneficial effect would be expected to be greater under the alternatives reviewed here. During the feasibility phase, it will be critical to determine which alternative would provide the greatest benefit at a reasonable cost.

4.2.2 FRESHWATER MUSSELS

Drawdowns have been shown to impact freshwater mussels by stranding. Years of stable water levels have led to the colonization by mussels of areas of the floodplain that would otherwise have been dewatered frequently enough to preclude this. Impacts to mussels in the first year of drawdowns would cause the greatest impact. Effects on mussels due to drawdowns in subsequent years would be minimal, because the increased frequency of low water levels in these areas would preclude the colonization of the areas by substantial numbers of mussels. In the long-term, however, a programmatic drawdown may reduce the quantity of habitat suitable for freshwater mussels throughout the pool. The quality of remaining habitat could possibly be improved.

Some mussel species are state- or federally-listed as threatened or endangered. Effects to listed mussel species would need to be addressed prior to implementing a drawdown. Addressing such effects could require substantial effort and coordination.

4.3 Cultural Resources

There are approximately 240 known cultural resource sites recorded within the floodplain and along the terraces and uplands in Wisconsin and Minnesota in Pool 8. Thirty-three archaeological sites were monitored during the Pool 8 Drawdown in 2001. Fifteen of these sites had a high probability of impact from shoreline erosion or looting that could occur during a drawdown.

Under a programmatic drawdown schedule, the recurring exposure of these sites could increase their susceptibility of erosion and looting. Monitoring or protection may be recommended.

CHAPTER 5.

Implementation Options

Several paths for the implementation of a programmatic drawdown are presented below, highlighting the processes that may be needed for each. Within any of the options below, the Corps would need to further study the alternatives and impacts in order to make an informed decision and to comply with NEPA. In addition, a formal feasibility study is required for many of the options below. The NEPA documentation and a feasibility study may require extensive modeling and analysis, and could cost $700,000 to $2,000,000.

Implementation under any plan would require that the WCM be updated and revised before the current water level management practices could be modified. Revision of the WCM would be conducted by the District, and approved by the Mississippi Valley Division upon completion of a detailed review process. Full implementation of a new water level operation plan would likely begin with an initial trial period of possibly three to five years, and transition as the permanent operation after that. A WCM update would likely be procedural and straight-forward after the completion of the other steps in an implementation process and, therefore, is not discussed in further detail here.

5.1 Existing 9-Foot Channel Project

The Corps of Engineers is responsible for maintaining a navigable channel on the Mississippi River. Authority for continued operation and maintenance of the Mississippi River Nine-Foot Channel Project is provided in the River and Harbor Acts of 1930 and 1932. Although navigation was the initial purpose of the 9-foot channel project, Congress has since authorized the development of recreational facilities, protection of forest resources, and required the consideration of fish and wildlife conservation at water resources projects. In 1960, Congress enacted the Forest Cover Act (PL 86-717; 16 USC § 580n) providing the authority for the Corps to manage project lands and waters for conservation purposes, including fish and wildlife conservation. The Corps must coordinate its program with the Secretary of Agriculture and appropriate state agencies.

Each year, the St. Paul District receives a budget for operating and maintaining the channel. In general, funds are directed towards dredging and dredged material management, infrastructure maintenance, planning, water control, environmental compliance, and project lands management. Operation and maintenance of the project is funded annually under the Corps Civil Works Operation and Maintenance appropriation, and each year's budget is submitted for funding two years in advance, with specific types of work activities outlined for the requested funds. Mississippi River funding allocated to the St. Paul District in recent fiscal years has ranged from $50 to $60 million. This level of funding has generally remained static for several years, while

operation and maintenance costs continue to climb. As a result, current funding levels are not available to cover all maintenance needs in any given year and some needs are deferred to future years. At current funding levels, rerouting funds from other Environmental Stewardship activities to Water Level Management would come at an expense of failing to accomplish other environmental programs such as forestry and shoreline management, which the District is currently tasked with. While dredging for environmental purposes has been continually submitted for funding consideration under the Environmental Stewardship program, it has not been funded due to competition from other Environmental Stewardship request packages nationally.

The Federal Standard for the disposal of dredged material (defined in 33 CFR §335.7) is the least costly alternative that is consistent with sound engineering practices and meets the environmental standards established by the Clean Water Act section 404(b)(1) evaluation process. The principle of the Federal Standard drives how operation and maintenance of the navigation channel is carried out. While environmental standards must be met, it does not mean that additional cost can be incurred to benefit the environment.

Because of the current and expected future funding levels for operation and maintenance of the navigation channel, and the principle of the Federal Standard, it is highly unlikely that Operation and Maintenance funding would be available for dredging for environmental purposes.

However, the Corps has the authority to accept contributions of funds from states and political subdivisions, as well as other non-Federal interests, for the study, design, construction, and operation and maintenance of Federally authorized water resources development studies and projects under 33 U.S.C. 701h.[1] This contributions authority can be a vehicle for studying and implementing a recurring drawdown operating plan for Pool 8. The use of this authority would require notification to Congress and the execution of a Memorandum of Agreement (MOA) between the Corps and the non-federal sponsor. A standard model MOA is not available for this use of contributed funds, and a new MOA would have to be drafted and approved within the Corps if an entity is interested in contributing funds.

5.2 UMRR Program

The Upper Mississippi River Restoration Program (UMRR) (formerly known as the Environmental Management Program) was authorized by section 1103 of WRDA 86 (P.L. 99-662) to help address ecological needs of the Upper Mississippi River System (UMRS). Under the UMRR, several habitat projects have been constructed. Major components of these projects typically include island construction and backwater dredging. While a drawdown has not been conducted under the UMRR, the authority and funding to do so would be available under this program. It is likely that construction of islands would be included in a drawdown project under

[1] Contributions Authority 33 U.S.C. § 2328 was initially explored for the Corps to accept contributions of funds, materials, and services, to share the cost of managing recreation facilities and natural resources. This Authority however, was determined to be intended for small contributions only, and is not deemed appropriate for the scale of recurring water drawdowns. Authority 33 U.S.C. 701h was found to be a more appropriate authority for consideration.

this program to provide additional habitat benefits and to provide a placement site for the dredged material.

The UMRR is a continuing authority receiving roughly $20 million a year, and St. Paul District's total annual funding equates to approximately $3.5M. Up to the present, this funding level has typically supported efforts to continually plan and construct high-priority projects in the District. However, it has also been necessary to thoughtfully prioritize these projects in coordination with agency partners because the number of potential projects exceeds the funding needed to plan and construct them. Therefore, while the authority and funding to conduct the drawdown evaluated here would be available under the UMRR, it is unknown whether or not conducting drawdowns under the UMRR would be acceptable to the agencies or the Corps; such a proposal would have to be discussed with the UMRR partners and fully assessed to determine an effective and sustainable path forward.

5.3 NESP

The Navigation & Ecosystem Sustainability Program (NESP) is a long-term program of ecosystem restoration and navigation improvements for the UMRS. From 1993 to 2004, the Corps initiated the Upper Mississippi River - Illinois Waterway System Navigation Feasibility Study to determine the best way to manage the UMRS, where economic, environmental, social, and political needs are balanced. This study took a systems approach, since changes in one part of the system may have an impact elsewhere in the system.

Congress authorized NESP in the WRDA 2007 at $2.2 billion for navigation improvements and $1.72 billion for ecosystem restoration, with an additional $10 million per year for monitoring. NESP was last included in the President's budget in 2004 for completion of the feasibility study. Funding was appropriated from 2005 to 2010 by Congressional action and was used to conduct preconstruction engineering and design work on navigation and ecosystem projects. The latest cost estimate and economic analysis were prepared in 2008; however, NESP has not been included in the President's budget for construction funding due to economic uncertainty. NESP has been suspended since June 2011 due to lack of appropriations (funding) by Congress, and funding was not included in the President's 2017 Budget. No construction funds for any NESP project have ever been appropriated. Drawdowns could be conducted under the NESP program, but Congress would first have to appropriate funds to do so.

5.4 Continuing Authorities Program Sections 1135 and 206

Section 1135 of WRDA 1986 and Section 206 of WRDA 1996 allow the Corps to participate in qualified environmental and aquatic ecosystem restoration projects. Under these authorities the Corps may participate in cost-shared studies and implement projects geared towards environmental purposes. Projects under both authorities require a non-Federal sponsor that would sign a Feasibility Cost Share Agreement for the feasibility phase, and a Project Partnership Agreement (PPA) if the project moves to construction. The non-Federal sponsor may be a legal

public entity (including a federally recognized tribe), or a nonprofit entity with full authority and capability to perform the terms of its agreement. One of the requirements of the PPA is that the non-Federal sponsor must hold and save the Federal government harmless. The non-Federal sponsor is also responsible for all Operation, Maintenance, Repair, Rehabilitation & Replacement (OMRR&R) associated with the ecosystem restoration project; however, it is unlikely a drawdown would be considered to require operation and maintenance.

The feasibility study under these authorities is cost-shared 50-50 between the Federal and non-Federal sponsors, and the design and implementation cost-share varies based on each authority. Furthermore, the non-Federal sponsor's required share determined per each authority could increase if the Federal costs of planning, design, and implementation for the project exceed the statutory Federal participation limits. Available Corps' funding for projects under these authorities is limited, and potential projects are prioritized nationwide based on availability of funding, project cost-benefit ratio, and needs. Projects approved under these authorities would allow for only a limited number of drawdowns, and cannot be extended for an indefinite amount of time. New PPAs would need to be executed for all subsequent drawdown projects under the Continuing Authorities Program.

Section 206 of WRDA 1996 allows the development of aquatic ecosystem restoration and protection projects that improve the quality of the environment. Under this authority, the non-Federal sponsor is responsible for 35% of the total project costs during the design and implementation period.

Section 1135 of WRDA 1986 provides for the review and modification of water resources projects constructed by the Corps for the purpose of improving the quality of the environment, when feasible and consistent with the authorized project purposes. Under this authority, the project must either be modification of an existing Corps project, or restoration of an existing Corps project where the project contributed to the degradation of the quality of environment. The non-Federal sponsor is responsible for 25% of the total project costs during design and implementation period.