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of Engineers®
St. Paul District

Design Documentation Report

Fargo Moorhead Metropolitan Area
Flood Risk Management Project

Reach 2

Engineering and Design Phase

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Design Documentation Report

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1 FARGO-MOORHEAD METROPOLITAN (FMM) PROJECT INTRODUCTION

1.1 Project Location

The cities of Fargo, North Dakota and Moorhead, Minnesota are located near the confluence of the Red River of the North and the Sheyenne River. The Fargo-Moorhead Metropolitan Area is located within an area from approximately 12 miles west to 5 miles east of the Red River of the North and from 20 miles north to 20 miles south of Interstate Highway 94. The metropolitan area is approximately 600 square miles, encompassing several smaller communities and has a population of approximately 200,000 people.

1.2 Project Setting

Because of the relatively flat terrain, the majority of the Fargo-Moorhead Metro area is located in the regulatory floodplain. The Red River of the North has exceeded the National Weather Service flood stage of 18 feet in 49 of the past 111 years (1902 through 2012), and recently every year from 1993 through 2011. During flood events, the Fargo-Moorhead Metro area relies on a number of emergency measures, including a series of emergency levees, to provide flood protection. Some permanent levees also exist within the metro area.

1.3 Project Purpose

The purpose of the project is to reduce flood risk for the Fargo-Moorhead Metro Area.

Flooding in Fargo-Moorhead typically occurs in late March and early April. The flood of record at Fargo-Moorhead was the 2009 spring flood with a stage of 40.8 feet on the Fargo gage. With an estimated peak flow of 29,200 cubic feet per second (CFS), the 2009 flood was approximately a 2-percent chance (50-year) event. Equivalent expected annual flood damages in the Fargo-Moorhead metropolitan area are estimated to be over $194.8 million in the future without project condition. Although emergency measures have been very successful, they may also contribute to an unwarranted sense of security that does not reflect the true flood risk in the area.

1.4 Project Authorization

The Fargo-Moorhead Metropolitan Area is part of the Red River of the North Basin. The Red River Reconnaissance Study was authorized by a September 30, 1974, Resolution of the Senate Committee on Public Works:

> *RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE UNITED STATES SENATE, That the Board of Engineers for Rivers and Harbors be, and is hereby, requested to review reports on the Red River of the North Drainage Basin, Minnesota, South Dakota and North Dakota, submitted in House Document Numbered 185, 81st Congress, 1st Session, and prior reports,*

> *with a view to determining if the recommendations contained therein should be modified at this time, with particular reference to flood control, water supply, waste water management and allied purposes.*

The Fargo-Moorhead metropolitan area was included in the Red River Basin Reconnaissance Study approved on September 19, 2002, but the level of detail in that report was insufficient to recommend a feasibility study specifically for measures in Fargo, North Dakota, and Moorhead, Minnesota. A supplemental Reconnaissance Study for Fargo-Moorhead was approved by the Mississippi Valley Division on April 08, 2008.

Based on the recommendations contained in the Reconnaissance Report, the city of Fargo, the city of Moorhead and the federal government entered into a Feasibility Cost Share Agreement on September 22, 2008. The study was cost shared 50/50 between the two non-federal sponsors and the Federal Government. The Corps of Engineers issued a notice of intent to prepare an environmental impact statement in the Federal Register on May 5, 2009. The Draft Feasibility Report and Environmental Impact Statement (DEIS) was published in the Federal Register for a 45 day public review period on June 11, 2010. The review period closed on August 9, 2010 after being extended by 14 days. In response to comments and to more fully study upstream and downstream impacts, the Corps made the decision to prepare a Supplemental DEIS. The notice of intent to prepare a Supplemental DEIS was published in the Federal Register on December 27, 2010. The Final Feasibility Report and Environmental Impact Statement were published in July 2011.

The Federal Water Project Recreation Act of 1965 (Public Law 89-72), as amended, requires an agency to fully consider recreational features that may be associated with Federal flood risk management projects.

1.5 Project Overview

Figure 1 shows the major features of the Fargo-Moorhead Metropolitan Flood Risk Management project. Figure 2 shows the inundation for a 1% chance exceedance flood with and without the project. The project consists of a diversion channel with low-flow channel, a connecting channel that diverts water from the Red and Wild Rice Rivers to the diversion channel, an upstream staging area, associated structures, non-structural features, recreation features, and environmental mitigation. Approximately 20,000 cfs is diverted into the diversion channel from the upstream staging area during the 1% and 0.2% chance flood events. Additional inflows from the Sheyenne River, Drain 21C, Drain 14, Maple River, Lower Rush River, Rush River, and other smaller drains may result in significantly higher discharges at the downstream end of the diversion channel.

The connecting channel starts on the Red River approximately three miles south of the confluence of the Red and Wild Rice Rivers and extends west, crossing the Wild Rice River, to the diversion inlet structure that is located just south of Horace. The diversion channel extends from its inlet, around the cities of Horace, Fargo, West Fargo and Harwood. It ultimately will re-enter the Red River north of the confluence of the Red and Sheyenne Rivers near the city of Georgetown, MN. The 36 mile path of the connecting channel and diversion channel will cross the Wild Rice, Sheyenne, Maple, Lower Rush and Rush rivers.

Two hydraulic structures will control the flows passing out of the staging area into the flood risk management area during larger flood events; one on the Red River and the other on the Wild Rice River. Flow into the diversion from the staging area will be controlled by a gated diversion inlet structure located at Cass County Highway 17 south of Horace, ND. The outlet structure is located where the diversion returns to the Red River of the North and will be a rock spillway with a low-flow channel capable of accommodating fish passage.

The main line of flood risk reduction at the south end of the project is a tieback embankment that extends about 12 miles west to east from the diversion inlet to high ground in Minnesota and ties into the Wild Rice River and Red River control structures along its path.

In order to eliminate downstream impacts, approximately 200,000 acre-feet of water will be staged immediately upstream of the tieback embankment. An overflow embankment approximately 4 miles in length along Cass County Road 17 (CR17) will be included to keep staged water from crossing overland into the Sheyenne River basin up through the 0.2% chance event.

At the Sheyenne and Maple rivers, aqueduct structures will allow base flows to follow the natural river channels to maintain habitat in the natural channels. Flows in excess of the channel forming discharge will be diverted into the diversion channel via a spillway. The Lower Rush River and Rush River inlet structures into the diversion will be drop structures that will direct the entire flow of those rivers into the diversion channel.

A wide variety of mitigation features are required to offset the impacts associated with construction and operation of the project. Measures required for aquatic habitat and connectivity mitigation could include stream restoration, riparian corridor restoration, a meandering low-flow channel in the diversion and providing fish passage. Fish passage will be provided at the diversion outlet, Rush River inlet, Maple River aqueduct, Sheyenne River aqueduct, and selected existing dams. Floodplain forest mitigation will be provided by re-establishing floodplain forest on approximately 220-250 acres of floodplain agricultural land or pastured land.

In accordance with the cultural resources programmatic agreement, construction in select reaches of the project will need to be monitored by a qualified professional archeologist. Areas requiring construction excavation monitoring include river floodplains, terraces and oxbows, which are locations with high potential to contain buried archaeological sites. Construction monitoring is required within 100 meters (328 feet) of the bank of the rivers affected by the diversion channel, including at the Red River outlet area, the Lower Rush River inlet area, the Rush River inlet area, the Maple River structure area, the Sheyenne River structure area, the Wild Rice River structure area, and the Red River inlet structure area, as well as where the diversion channel crosses through the Drain 14 oxbow area south of the Maple River.

1.6 Reference Documents

Links to or copies of the following documents are on the project Extranet site at: https://extranet.dse.usace.army.mil/sites/Divisions/MVD/MVP/FargoMoorhead/ [accessible within USACE] or https://onecorps.usace.army.mil/sites/Divisions/MVD/MVP/FargoMoorhead/ [accessible outside of USACE]
Final Feasibility Study and Environmental Impact Statement, Fargo-Moorhead Metropolitan Area Flood Risk Management, July 2011
Reach Management Plan for Reach 2, Fargo-Moorhead Metropolitan Area Flood Risk Management Project,
Design Guidelines for the overall FMM Project and Reach-Specific Design Guidelines

Figure 1: Project Features

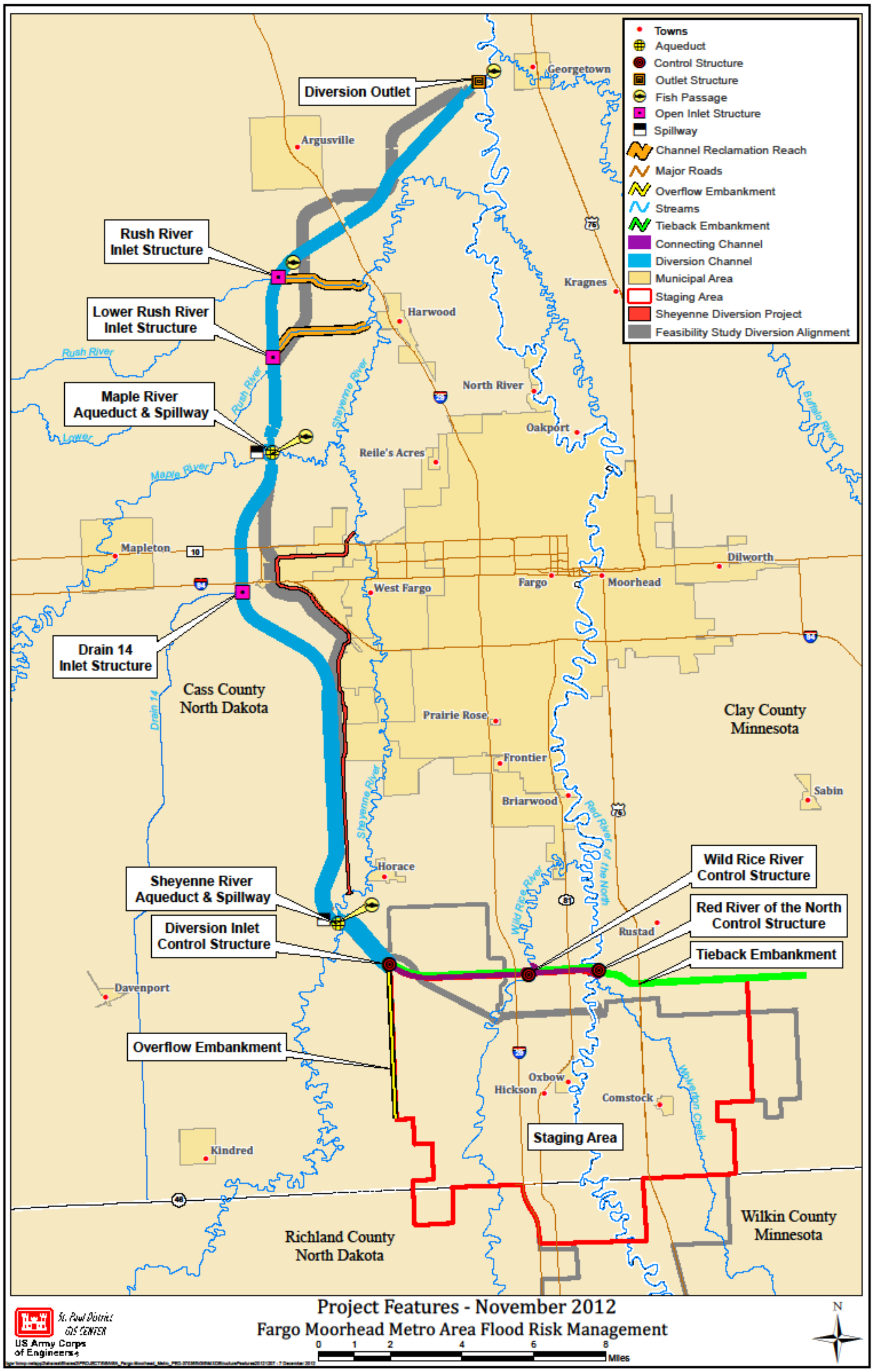
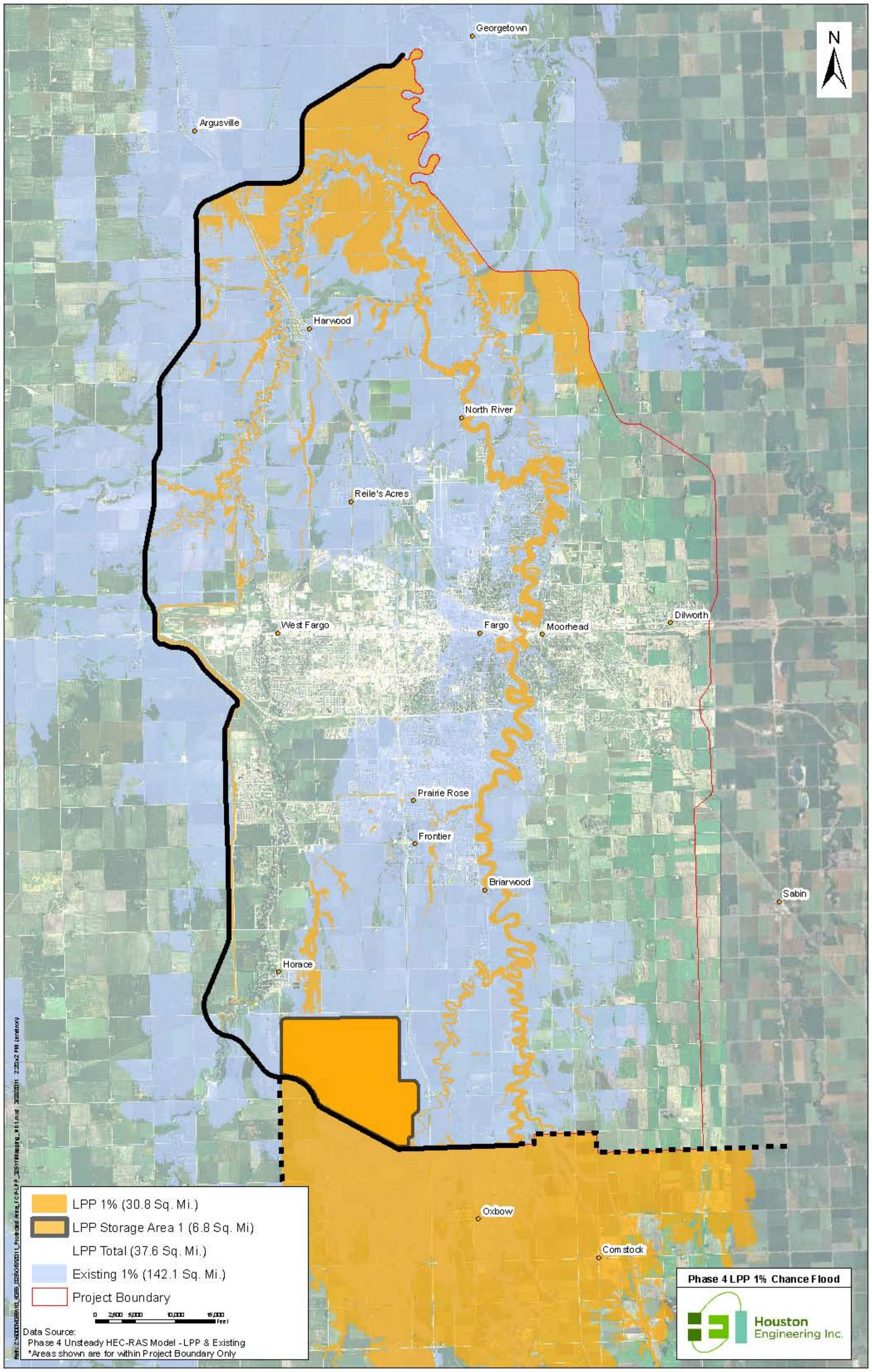


Figure 2: Inundation Map



2 DIVERSION CHANNEL DESIGN INFORMATION

2.1 Design Event

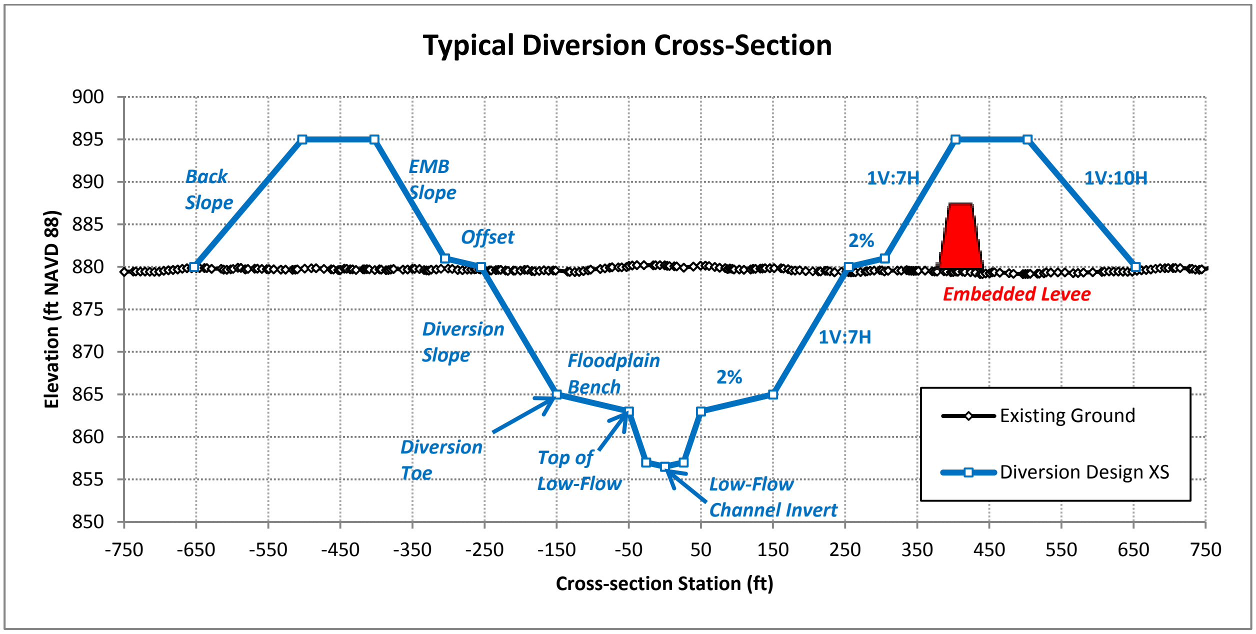
The diversion is designed for the 1% annual chance exceedance flood (1% flood), but the amount of excavation required to achieve the goals for the 1% flood design allows the diversion to function for much larger flood events. Flood events larger than the 1% flood are being investigated during the design effort to evaluate structure and levee resiliency. Design flows in the diversion were determined from the unsteady HEC-RAS modeling effort, which routes the Red River of the North balanced hydrographs and coincident tributary hydrographs described in Appendix A of the Final Feasibility Report and Environmental Impact Statement for the Fargo-Moorhead Metropolitan Area Flood Risk Management Project, dated July 2011.

2.2 Channel Size and Profile

The diversion size and profile were developed to: 1) keep the median 1% flood profile generally below existing ground for most of the diversion length to prevent making local flooding worse, 2) allow the Sheyenne River and the Maple River to pass over the diversion via aqueducts , and 3) have a slope similar to the natural streams in the area. To achieve these goals, the main diversion channel downstream of the Maple River Aqueduct Structure has been set at a longitudinal slope of 0.00017 ft/ft (0.9 ft/mile) with a 300 ft bottom width and 1V:7H diversion side slopes. To improve drainage, which facilitates maintenance, the bottom of the main diversion channel will be constructed with a 2% cross-slope toward the low-flow channel at the center of the diversion. These 2% portions above the low-flow channel will be referred to as the floodplain benches. The low-flow channel size increases in the downstream direction as more drainage enters the diversion.

The top of the diversion channel will be set at a point that is close to the average existing ground elevation. Beyond the top of the diversion channel, the EMB's will be offset 50 ft from the edge of the channel excavation. This offset will be constructed at a 2% slope to drain local runoff toward the channel. The interior slopes of the EMB's will be constructed at a 1V:7H slope. A typical diversion cross-section is provided as Figure 3.

Figure 3: Typical Diversion Cross-Section



The amount of flow to be let in to the diversion at the inlet for the 1% flood, which is 20,000 cfs, was determined by investigating downstream impacts and the amount of storage needed in the upstream staging area to essentially eliminate downstream impacts. Sediment transport, geomorphic, and geotechnical considerations determined the shape of the diversion (size of low-flow channel, bottom width, and side slopes). The 1% flood flows used to size the diversion and the higher flows investigated when considering structure and levee resiliency are presented in the following table. The gated diversion inlet structure will limit flow at the inlet to 20,000 cfs for floods up through the 0.2% flood. Flow in the downstream direction increases due to inflows from the tributaries and drains.

Based on modeling efforts completed so far, it is expected that flood fighting efforts will continue well beyond the 0.2% flood. While more work needs to be done regarding how the diversion inlet gates and the overflow spillway adjacent to the diversion inlet will operate during events larger than the 0.2% flood, the estimated maximum flood fight flow data provided in the table is an estimate of how much flow would be in the diversion while flood fighting efforts exist in the flood risk reduction area.

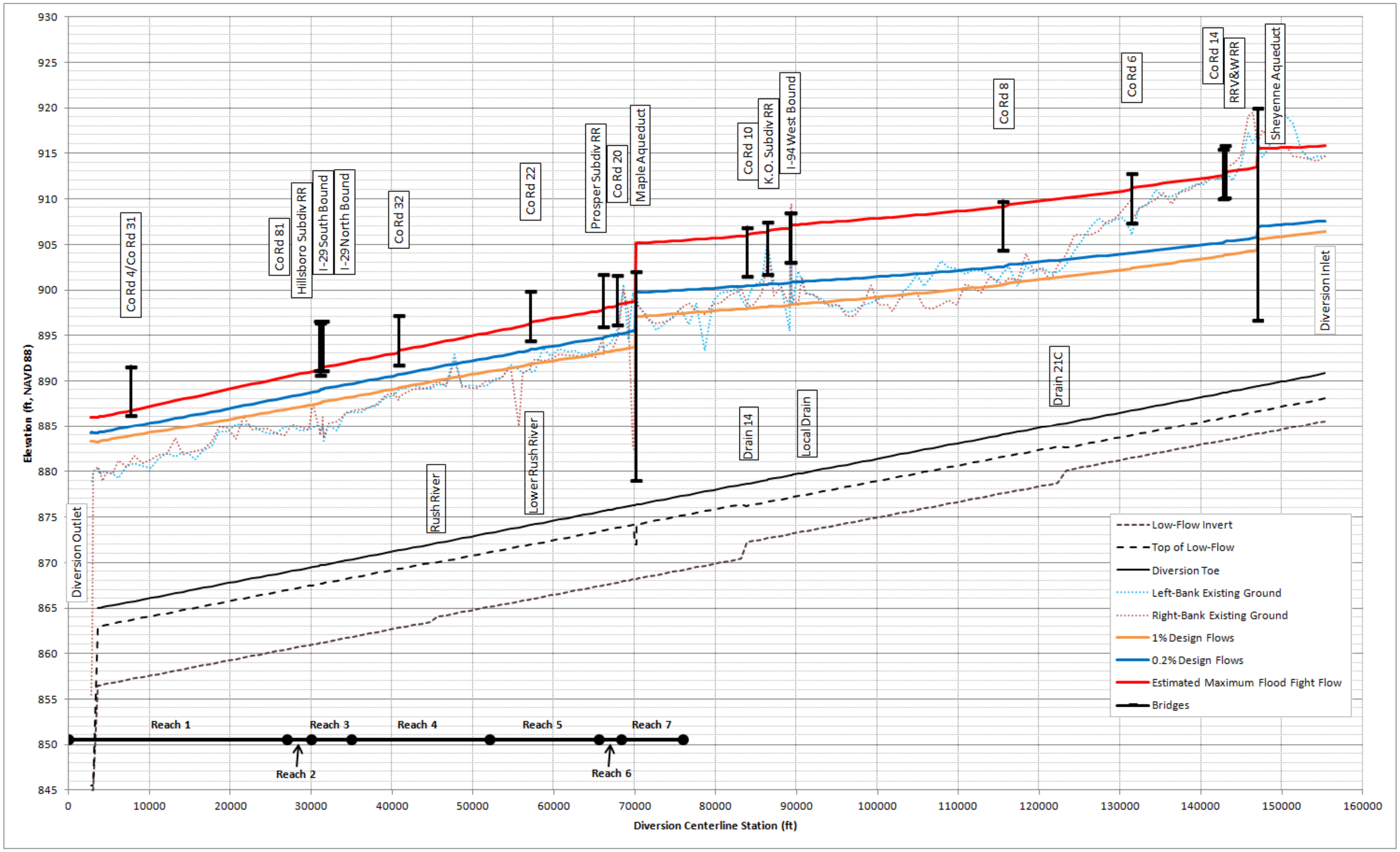
Table 1: Diversion Flows

DESCRIPTION	1% FLOW (cfs)	0.2% FLOW (cfs)	EST. MAX. FLOOD FIGHT FLOW (cfs)
Diversion Inlet to Sheyenne River Aqueduct	20,000	20,000	26,000
Sheyenne River Aqueduct to Cass CR 14	20,500	22,000	38,000
Cass CR 14 to Ditch 21C	20,500	22,000	40,000
Ditch 21C to Ditch Upstream of I-94	21,000	22,500	41,000
Ditch Upstream of I-94 to Drain 14	21,500	23,500	41,000
Drain 14 to Maple River Aqueduct	25,000	28,000	41,000
Maple River Aqueduct to Lower Rush River	29,000	34,000	41,000
Lower Rush River to Rush River	30,000	36,000	45,000
Rush River to Diversion Outlet	32,000	38,000	45,000

A Manning's n-value of 0.030 was selected for the entire diversion channel. This value was initially selected to model the diversion with enough conservatism for uncertainty. Recent calibration efforts of existing area diversions along the Sheyenne River indicate that the roughness values could be somewhat lower, around 0.027. These values of 0.030 for design and 0.027 for performance are similar to values considered for the Manitoba Floodway. For the Manitoba Floodway, an n-value of 0.028 was used for design and a value of 0.026 was estimated for historic events (Red River Floodway Operation Review Committee, 1999). Because of the complex nature of the Fargo-Moorhead diversion, with a meandering low-flow channel and shallow flow along the excavated material berms above existing ground, the conservative n-value of 0.030 is used for modeling purposes.

One additional concern for hydraulic roughness is the possibility of wetland vegetation and other vegetation specified in the planting plan, growing to a tall enough height to impact the channel roughness values. Through review of literature on the subject, there should be little to no impact from taller vegetation. Technical Report EL-9709 - Hydraulic Impacts of Riparian Vegetation (Fischenich 1997), indicates when the water depth is two to three times the height of the vegetation (even substantial woody vegetation), there is little to no required adjustment in the n-value. For major flood events, the depth of water in the channel will be well above three times the height of even unmaintained vegetation. Since the vegetation will be maintained regularly and the vegetation will tend to "lie down" during flood events, no adjustment to the n-value of 0.030 will be considered. Diversion feature profile and water surface profile information is provided in Figure 4.

Figure 4: Diversion Profile Information



2.3 Excavated Material Berms (EMBs) and Levee

The large volume of material that will be excavated to create the diversion channel will be placed along both sides of the diversion channel in linear features called Excavated Material Berms (EMBs). Given the size and profile of the diversion, the 1% floodplain would not increase over existing conditions even if the diversion channel did not have EMBs. For this reason and because the left-bank (looking downstream) EMB will have openings to accommodate tributary flow into the diversion, the left-bank EMB will not contain a levee. The right-bank (looking downstream) EMB will contain a levee.

At a minimum, the right-bank EMB must contain a levee section which contains the 1% flood with 90% assurance so that the levee is ultimately accredited by FEMA. If material was scarce, it would make sense to optimize the size of the levee, but less than 5% of the total excavated material will be needed to construct the levee. The excavated material is also good material for a levee. With good and abundant levee material, the Project Delivery Team (PDT) has determined that the cost of constructing a levee section within the right-bank EMB is relatively low. Given the relatively low levee cost and the uncertainty associated with the 1% flood with 90% assurance profile, the top elevation of the levee section located on the right bank of the diversion channel is being set at the expected water surface profile for the estimated maximum flood fight flow in the diversion channel, plus an allowance for settlement of the embankment.

This maximum flood fight flow condition has also been called the “diversion levee design event” in other project documents. The use of the term “design” when referring to the estimated maximum flood fight flow in the diversion is improper since the levee is not being designed for that flow condition. Setting the levee at the expected profile just prior to giving up on flood fighting efforts (just prior to opening up the Red and Wild Rice River control structures), plus an allowance for settlement, will assure that the levee is ultimately high enough to be accredited by FEMA and gives the local sponsor greater confidence that the right-bank EMB/levee will require minimal attention while flood fighting efforts are in effect.

Along the vast majority of its length, the levee will be embedded well within right-bank EMB in order to reduce maintenance requirements, but near road crossings and the aqueducts the levee will be not be fully embedded and therefore will require more maintenance.

2.3 Meandering Low-Flow Channel

A large meandering channel will be constructed within the diversion channel to completely re-route all flows from the Rush and Lower Rush Rivers. While the portions of these two rivers that are to be abandoned have been previously straightened as part of past water resources projects, the channel within the diversion will be designed with a slightly sinuous pattern to better represent a natural channel. This channel, while technically a *Channel-Forming-Discharge Channel* or *Effective Discharge Channel,* will be referred to as the *Low-Flow Channel* in the report documents. Typically, a low-flow channel is included in the design of a diversion project to convey runoff and ground water that occurs within the diversion channel. They are typically small in size and not designed to convey sediment or pass fish. It is important to note the distinction between the FMM diversion low-flow channel and typical diversion low-flow channels. The ability of this channel to effectively convey sediment is crucial for both fish passage and geotechnical stability. If the low-flow channel aggrades or degrades extensively, the connectivity of the channel could become interrupted and fish passage could be compromised. Similarly, significant channel aggradation, degradation, or lateral meandering could compromise the geotechnical stability of the entire diversion channel.

2.4 Rock Ramp/Fish Passage Structures

Because the low-flow channel is required to pass fish from the Red River up to the Rush River during spawning, the Diversion Outlet Structure and the Rush River Inlet Structure to the Diversion will both incorporate fish passage elements. Structural fish ladders and other concrete fish passage elements have not been considered for this project due to cost, maintenance, and selective passage concerns. Rock ramp structures, whether full-channel-width or auxiliary channel structures, have been the preferred fish passage design considered for the project. Ensuring that rock elements can withstand ice and debris impacts will be crucial to limiting future O&M.

2.5 Inlet Structures

Agricultural ditches and legal drains that currently drain to Red River Basin streams and rivers will need to be re-routed and terminated in the diversion channel as the diversion alignment intersects their current paths. At each of the these inlets to the diversion, some type of culvert structure or drop structure will need to be included in the design to convey local drainage down to the low-flow channel of the diversion. The main hydraulic concerns with these structures include debris prevention at the upstream end, backflow prevention at the downstream end, energy dissipation at the downstream end to prevent scour, and proper water and sediment capacity of the drop structure for local drainage.

2.6 Bridges

The details of how the bridge hydraulic design criteria were developed are provided in Memorandum for Record 005, General Bridge Re-Assessment for the Diversion from Inlet to Outlet (MFR-005). Again, the 1% event is the primary design event, but when considering the availability of material and desire to avoid having to flood fight along the diversion while flood fighting efforts are occurring within the flood risk reduction area, the 0.2% event and the estimated maximum flood fight flow were used in developing the bridge hydraulic design criteria. A summary of the design criteria provided in MFR-005 is provided here (the term “diversion levee design profile” used in MFR-005 has been replaced with “estimated maximum flood fight profile”):

1. Low chord at least 1 ft above the 0.2 % event water surface.
2. Top of road deck or bottom of railroad ballast at least 1 foot above the estimated maximum flood fight profile at each abutment (assuring that the top of road deck or bottom of railroad ballast is at least 1 foot above the estimated maximum flood fight profile at each abutment means that flows within the diversion channel at or below the estimated maximum flood fight flow should not exceed a level at which they can flow down a roadway or railway and enter the interior of the project area).
3. Head-loss across a bridge or group of bridges is limited to less than 0.5 ft for events up to the estimated maximum flood fight profile.

4. Ensure that the on-center span widths between the piers are no less than 70 ft for ice and debris (the railroad bridge near I-29 will be allowed to have a minimum clear spacing of 50 ft so that the piers are aligned with adjacent highway bridges).
5. Ensure that the width for the middle span that extends across the low-flow channel is greater than the width of the low-flow channel for ice.

2.7 Aqueducts

The alignment of the project will require that the diversion cross underneath two existing river channels in the Sheyenne and the Maple Rivers. In order to convey channel forming discharges over the diversion to the natural river reaches within the project area, aqueduct crossing structures are included in the design. These aqueducts encourage the interior river reaches to retain their natural geomorphology through frequent channel forming processes. The structures allow for diversion flood flows to pass underneath the elevated river crossings through large box culverts. Detailed hydraulic studies will be conducted for both the Maple River and the Sheyenne River aqueducts. Flow splits, head loss and the effects of ice, debris, and sediment will be investigated. Head loss across the Maple River aqueduct will affect the hydraulic profiles upstream of the aqueduct; therefore the final height of the levee and bridges upstream of the Maple River aqueduct will not be set prior to having solid knowledge of the Maple River aqueduct design.

2.8 Vegetation

As part of environmental mitigation for wetland impacts, vegetation will be added across the full bottom width of the diversion channel to gain credit for wetland creation. This full bottom width includes the low-flow channel and the floodplain benches which are the portions of the diversion bottom on either side above the low-flow channel. This vegetation will provide an additional benefit to wetland creation in its ability to better resist possible channel erosion during high flows. If the vegetation cannot survive moderate periods of inundation, it could leave bare soil exposed to high shear stress, possibly leading to erosion of the low-flow channel or main diversion channel. This vegetation will, however, require a detailed O&M plan to ensure that the wetland quality is balanced with the hydraulic and sediment conveyance of the diversion channel during flood events.

2.9 Local Drainage Features

The orientation of the diversion inevitably causes the channel to intersect numerous ditches and drains. Project features will need to be added to ensure the agricultural and private land will not be adversely impacted as a result of the project. This local drainage plan will need to incorporate the design of additional drainage ditches along the EMB’s and along the re-routed roadways. These ditches will span the length of the project and eventually terminate as numerous culvert inlets at the bottom of the diversion channel. The responsibility for the design of the local drainage features will be shared between the Corps of Engineers and the Local Sponsor.

2.10 Previously Obtained Data

2.10.1 Existing Condition Data

Existing topographic data utilized for the design and drawings is from Aerial Light Detection and Ranging (LIDAR) and ground survey campaigns performed in May 2011 by Merrick and Company through contract with the local sponsors. Detailed ground and hydrographic survey campaigns were performed between October 2011 and March 2012 by the St. Paul District Corps of Engineers survey crew and Anderson Engineering of MN in order to enhance the accuracy of the surface models. The coordinate system and projection of the existing condition data is NAD83 (2007), North Dakota State Plane Coordinate System, South Zone (U.S. Survey Feet). The elevation datum of the existing condition data is NAVD88 (U.S. Survey Feet).

2.10.2 Cadastral Data

During the acquisition of rights-of-entry (ROE) for the project, the St. Paul District Corps of Engineers, Non-Federal sponsors, and Moore Engineering created a cadastral dataset for the project. The cadastral dataset is a geodatabase with parcel geometries and attributes, which will be used as the reference source for all property information. This dataset is incorporated into the base map for informational purposes only. The parcel geometries of the dataset have not been surveyed and should not be relied upon as such.

Detailed property surveys will be conducted by the non-federal sponsors during the final stages of the project.

2.10.3 Utility Information

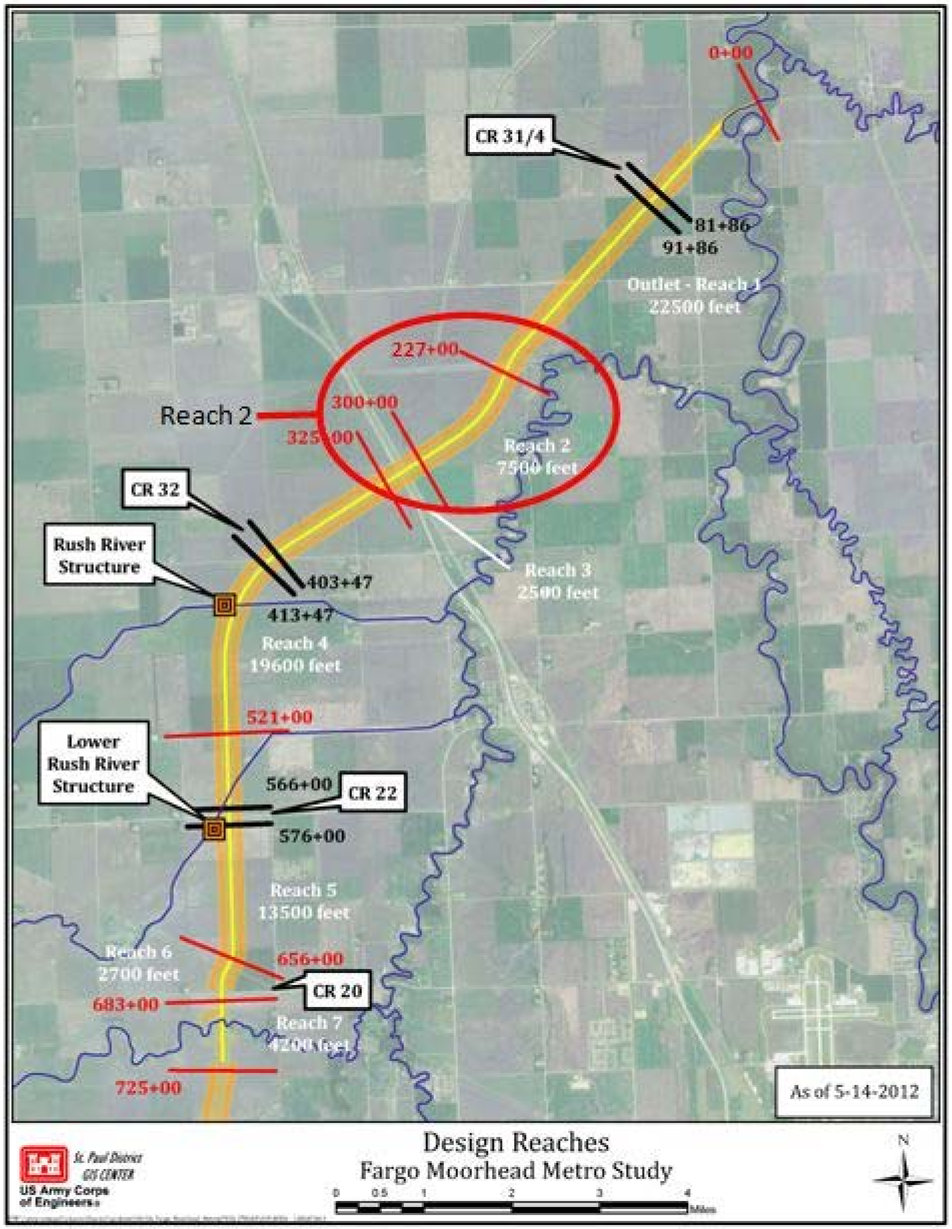
Utility information, including surveyed locations was obtained from Moore Engineering between December 2011 and April 2012 under contract with the non-federal sponsors. The utilities that are known to exist within Reach 2 are summarized in Appendix E: Civil-Site.

3 REACH 2 FEATURES

3.1 Description of Reach 2

As depicted in **Figure 3**, Reach 2 is located near the downstream (north) end of the diversion channel where it extends from station 227+00 upstream (south) to station 300+00. County Road 170th Avenue SE currently crosses the Reach 2 alignment, while 27th Street SE will be impacted by the extents of the right bank excavated material berm. At this time guidance is being developed by MVP in conjunction with the local sponsor as to how these roads will be re-routed or abandoned.

Figure 3: Location Map – Reach 2



3.1.1 Diversion Channel and Low Flow Channel

The diversion channel is 300 feet wide at the bottom with 1V:7H side slopes up to an elevation approximately 1 ft below existing ground to which the 50 ft stability bench shall slope at 2%. The bottom of the channel slopes at 2% toward the low flow channel. A meandering low flow channel is included within the main channel; see Hydrology and Hydraulics Appendix for details.

3.1.2 Excavated Material Berms (EMB) and Levees

The excavated material will be placed in berms located along the left and right banks of the diversion channel. The berms will extend from station 227+00 to station 300+00, and will be set back from the top of the excavated channel. For Reach 2, the right bank EMB separates the diversion from the risk reduction area and therefore a levee will be constructed so that it is embedded in the right bank EMB. The top of levee elevation will be set at the expected water surface profile in the diversion just prior to opening up the Red River and Wild Rice River control structures plus one foot. The purpose of opening the control structures is to prevent loss of minimum tieback embankment freeboard east of the Red River control structure in Minnesota.

3.1.3 Transportation System Modifications

The alignment of the channel will result in modifications to the local transportation system, including some modification to 27th Street SE and 170th Avenue SE. At this time guidance is being developed by MVP in conjunction with the local sponsor as to how these roads will be re-routed or abandoned.

3.1.4 Environmental Considerations

Environmental considerations which will be incorporated into the design of Reach 2 include the meandering low flow channel, and a planting plan that includes planting of native wetland species in the channel bottom and fringe of the side slopes.

4 HYDROLOGY AND HYDRAULICS

4.1 Introduction

The following paragraphs provide a summary of the Hydraulic Design considerations for the Fargo-Moorhead Metro Project. Detailed information related to the Hydrology and Hydraulic design of the FMM Project can be found in the Hydrology and Hydraulics Appendix. The design effort involves investigating a range of flow conditions, from low to moderate diversion flows with relatively low tailwater conditions on the Red River to extreme diversion flows that fortunately will occur with high tailwater stages at the outlet. The needs of other disciplines, (e.g. environmental and geotechnical) have been considered during the design process.

4.2 Technical Guidelines and References

The US Army Corps of Engineers is governed by engineering regulations (ER's), engineering manuals (EM's), engineering technical letters (ETL's) and engineering circulars (EC's). These Corps publications are available on line at the following web site: http://140.194.76.129/publications/.

The project design will comply with all civil works engineering regulations, circulars, technical letters and manuals (Corps publications). Industry standards shall apply when Corps guidelines are not applicable. The applicable guidelines and standards that will be used for hydrologic and hydraulic design can be found in the "Project Design Guidelines."

4.2.1 Diversion Channel

The diversion channel is designed so that the 1% flood profile is generally below existing ground from the diversion inlet downstream to the Lower Rush River. This was done to minimize impacts on local drainage outside the diversion channel. However, it is not practical to keep the 1% profile below existing ground at the downstream end of the diversion due to backwater effects from the Red River. Conveyance must be maintained in the diversion channel. The general design consists of a diversion channel with a 300 ft wide main channel bottom width, 2% cross slopes, and a profile slope of 0.9 ft/mile. The combination of increasing the bottom width while raising the toes of the channel for drainage generally balances the excavation material calculated in the Feasibility Phase. Increasing and cross-sloping the bottom of the diversion was needed to both provide adequate drainage toward the low-flow channel and to provide an adequate meander belt width to achieve the minimum required sinuosity for the low-flow channel. Increasing the channel slope from 0.8 ft/mile to 0.9 ft/mile by rotating it around the approximate halfway point, at the Maple River Aqueduct, allows for a more stable and sinuous low-flow channel. Also, by lowering the invert of the diversion at the outlet location, a costly concrete spillway outlet structure was able to be replaced by a less costly rock ramp structure. Adjusting the slope by maintaining the diversion channel invert elevation at the Maple River structure and adjusting the invert and outlet elevations also balances the excavated material quantity to approximately the quantity determined in Feasibility. The goal of the hydraulic design for the project is to create a diversion cross-section configuration that satisfies all engineering, environmental, safety, cost, and uncertainty constraints, all of which were considered in relation to this design change. It is important to note that this configuration of the diversion channel, when the Excavated Material Berms (EMBs) are included, allows for a capacity much greater than the 1% event. Each individual component (cross-slope, channel slope, side slope, bottom width, low-flow width, etc.) has not been perfectly optimized to bring the size of the diversion down to the minimum capacity. An optimization phase in the design process may be warranted, but it is important to consider this additional capacity allows for robustness of the project for events greater than the 1% event and allows the profile of the 1% event to remain below existing ground surface for a larger distance.

4.2.2 Sinuous Low Flow Channel

Based on the most recent hydrology and hydraulics for the project, the low-flow channel for all of Reach 2 is currently sized with 1V:4H side slopes and a 52 foot bottom width. The low-flow channel will be designed to meander across a 200 ft wide meander belt with a variable meander wavelength for an overall sinuosity of 1.127. With at a slope of 0.9 ft/mile, the sinuosity results in the low-flow channel having a slope of 0.8 ft/mile. This 0.8 ft/mile slope replicates the average slope of the nearby Maple River. This mild slope and slight sinuosity should allow for environmental variability and closer conditions to a natural river channel. It is important to note that the size of the low-flow channel could change as more data collection and analysis becomes available. Sediment transport modeling, soil erosion rate testing, further hydrologic analysis, and further consideration of Devils Lake outflows could all lead to changes in the size and meander of the low-flow channel.

5 GEOTECHNICAL ENGINEERING

5.1 General

The geotechnical engineering and geology work completed for this Design Documentation Report was associated with the stability, settlement, and rebound along the diversion channel. Detailed information related to the geotechnical design criteria, design cases, and other information related to geotechnical design can be found in "Appendix D: Geotechnical Engineering and Geology".

5.2 Technical Guidelines and References

A list of technical guidelines associated with the geotechnical design can be found in the "Project Design Guidelines."

5.3 Geotechnical Design Features/Analysis

A brief summary of the features and analyses completed is provided below.

5.3.1 Diversion Channel

The slopes of the diversion channel were analyzed to evaluate the stability of the hydraulic cross section provided. At this time the diversion channel side slopes of 1V:7H have been found to be stable in Reach 2. Verification of the assumptions being used in the current analysis is being completed and may require minor changes to the models as the design evolves. It is not anticipated that these changes will result in drastic changes to the diversion channel geometry. As the design progresses, additional information will be obtained. If the information suggests that the assumptions are incorrect, the modeling will be updated.

5.3.2 Excavated Material Berms and Levees

The excavated material berms (EMBs) are located offset 50 feet from the top of the diversion channel and have a maximum height of 15 feet on the left bank and 14 feet on the right bank. The EMBs have been taken into consideration when analyzing the stability of the diversion channel slopes. The configuration of the EMB will need to be updated when additional information is received regarding the recreation and grading plan for the EMBs, which is being developed by the Local Sponsor. Additional information is available in Appendix E.

5.3.3 Settlement and Rebound

The excavation of the diversion channel will lead to rebound of the invert. Construction of the EMBs will lead to settlement. Both settlement and rebound were analyzed and accounted for in the design (see Appendix D - Geotechnical Engineering and Geology). Ultimate levee settlement is expected to be approximately 1.5 feet, and the levee will be overbuilt by that amount. Ultimate channel rebound is expected to be approximately 1.5 feet.

5.3.4 Constructability

The topsoil thickness along the alignment is estimated to be 1.5 to 2 feet thick. Local variations could be encountered along the alignment.

Different techniques may be required to excavate the diversion channel and outlet structure. It is likely that scrapers can be used to excavate the upper soils (Alluvium and Sherack formations). As the excavation increases with depth, the soils will become wetter and weaker. These weaker soils will have a reduced capacity to support construction equipment and therefore it is likely an excavator will be used and material hauled away using off-road trucks.

Due to the impervious nature of the soils, dewatering of the site prior to excavation is not required as flow into the excavation will be minimal. A slope will need to be maintained in the excavation to allow precipitation to drain to a low area. Depending on amount of precipitation, this low area may need to be pumped out.

5.4 Phase 1 Environmental Site Assessment

A Phase I Environmental Site Assessment (ESA) was conducted along the project area to identify the presence and/or potential presence of hazardous, toxic, and radioactive wastes (HTRW). The ESA identifies past or present HTRW issues term Recognized Environmental Conditions (RECs) which is defined as the presence or likely presence of any hazardous substances or petroleum products on a property under conditions that indicate an existing release, a past release, or a material threat of a release of any hazardous substances or petroleum products into structures on the property or into the ground, groundwater, or surface water of the property.

The initial PI ESA was completed during the feasibility study in 2010 by Stanley Consultants (**Error! Reference source not found.**). A supplemental investigation was completed in 2012 by the St. Louis District Corps of Engineers (**Error! Reference source not found.**) to cover the areas of the shifted alignment at the north end of the project. The ESAs were completed in conformance with the scope and limitations of American Society for Testing and Materials (ASTM) Practice E 1527-05 and Engineering Regulation ER-1165-2-132 *Water Resource Policies and Authorities Hazardous, Toxic and Radioactive Waste (HTRW) Guidance for Civil Works Projects*.

Within the Reach 2 footprint , no properties were identified that have recognized environmental conditions (RECs).

6 CIVIL-SITE ENGINEERING

6.1 General

Civil design for this project will include demolition, levee and Excavated Material Berm (EMB) layout, access road layout, utility relocations, general grading, and storm water pollution prevention. This section summarizes the proposed layout, method of analyses, and support for preparation of the civil-site plans.

6.2 Technical Guidelines and References

A list of technical guidelines associated with the civil-site design can be found in the "Project Design Guidelines."

6.3 Programs and Standards for Design and Drawings

The computer-aided drafting and design (CADD) program used for the drawings utilized MicroStation V8i (Version 8.11, October 2008) and topographic data with InRoads generated Digital Terrain Model (DTM) files, profiles, and cross sections. All drawings adhere to national, Mississippi Valley Division, and St. Paul District CAD standards as referenced in the current Design Guidelines.

6.3.1 Geometric Design – Channel and Excavated Material Berms

The alignment and configuration of the channel and EMBs are based on Hydraulic and Geotechnical considerations. Final layout of the EMB's will take into account balance of cut and fill, local drainage, real estate acquisition, and other considerations.

6.3.2 Vegetation Free Zone/Vegetation Management Zone

The Vegetation Free Zone (VFZ)/Vegetation Management Zone (VMZ) will comply with the requirements in ETL 1110-2-571, as well as the criteria set forth in project specific guidance documents such as the Memo For Record (MFR) Levees and Excavated Material Berms along the Diversion Channel (provided in Appendix E Civil-Site, Attachment 1). The VFZ will be a minimum of 15' from the toe of stand-alone levees and partially embedded levees. The VMZ will extend 15' from the landside crown of the levees embedded within EMB's.

6.3.3 Utility Relocations

Utility relocations will comply with the MVP MFR for Utility Relocation Requirements and local/state requirements. The utilities that are known to exist within Reach 2 are summarized in Appendix E: Civil-Site.

6.4 Engineering Drawings for Civil Features and Site Work

Drawings produced for this document utilized the following information:

- LIDAR Topographic Survey Data
- Corps of Engineers Field Survey Data (topographic and hydrographic)

- MicroStation V8i model and sheet seed files
- Design files including cross-sections, alignment, and DTM files

Civil engineering drawings and plans prepared concurrent with this report are included in Appendix B.

7 STRUCTURAL ENGINEERING

7.1 General

There are no structural features within Reach 2.

8 MECHANICAL ENGINEERING

8.1 General

There are no mechanical features within Reach 2.

9 ELECTRICAL ENGINEERING

9.1 General

There are no electrical features within Reach 2.

10 LANDSCAPE AND RECREATION

10.1 General

The Local Sponsor is responsible for the design and construction of any proposed recreational features of the Fargo-Moorhead Flood Risk Management Project. A draft report, Fargo-Moorhead (FM) Area Diversion, Recreation and Use Master Plan, as well as the Technical Memorandum, Fargo-Moorhead Area Diversion Channel EMB Grading Guidelines for Reaches 1 and 2, have been developed for the local sponsor which detail the current plan for recreation features. Included in the Master Plan is the concept of an undulating landscape on the right bank EMB that will provide varying landscape and separation between equestrian and pedestrian trails. The COE and the Sponsor have agreed that the most cost effective way to construct these undulations would be to include them in the Diversion Reach Plans and Specifications. The undulations were designed by the Sponsor and were incorporated into the Reach 2 plans by the COE design team (see further discussion in Paragraph 11.2). In addition, Reach 2 includes a turf establishment plan that was developed in compliance with mitigation and NPDES requirements (see further discussion in Paragraph 11.3). All additional recreation features, such as trails and permanent landscape plantings, will be designed by the Sponsor and constructed at a later date under a separate contract.

10.2 Proposed Recreation Features

It was the Sponsors responsibility to determine the end use of each EMB. The concept proposed in the draft Master Plan was to incorporate recreation features, including trails, plantings, and an undulating landscape, into the EMB on the right bank of the channel. The left bank EMB concept was to grade and place topsoil so that the EMB may be used for agricultural purposes. However, after the Master Plan was submitted, MVP developed more detailed design for Reach 2 and the associated EMB's. The top width of the EMB's is now in the range of 200-250', The draft Master Plan was based on 400' as defined in the Feasibility Report for the project.

Because of the width reduction, the end use of the left bank EMB was revisited. The current concept proposed by the Local Sponsor is to abandon the concept of agricultural use on the left bank EMB. The Sponsor has requested that the footprint of the left bank EMB be minimized by slightly increasing the EMB height away from the channel. This footprint reduction will help preserve existing agricultural land outside the EMB footprint for continued use. For the left bank EMB the Sponsor provided grading, slope, and topsoil depth information and the COE incorporated this into the design plans. Vegetation, such as wind breaks, has been discussed but has not been finalized by the Sponsor. Topsoil depths on the land side of the maintenance road are 1' to accommodate future plantings, or perhaps minimal agricultural use.

For the right bank EMB, the undulating landscape requires a detailed grading design that will ultimately accommodate future muli-use and equestrian trails. As previously discussed, the Sponsor is responsible for the design of the undulations. The COE will provide the "base EMB" design to the Sponsor, with the top graded at 2% to shed drainage away from the channel. COE also will provide design guidance including geotechnical grading requirements and Guidance Memo-001 "Construction Heights of EMB's" to the Sponsor. The Sponsor will design the undulations a certain height above and below the "Base EMB" top, based on COE guidance, and deliver a design surface (DTM) to the COE for incorporation into the COE construction documents (COE will review this submittal and determine if it is acceptable prior to incorporation). The COE will develop the plan views, details and cross sections for the undulating landscape that will be included in the Reach 2 plan set.

10.3 Landscape

Any planting plan will be coordinated with the environmental mitigation plan for the project. Planting plans proposed in the FM-M Area Diversion Recreation and Use Master Plan will follow USACE design guidance.

Seeding for the Reach 2 construction contract will consist of temporary seed mixes. There will be two basic zones for the temporary seed mixes, one wet zone for riparian species and one dry zone for upland grasses and forbs. These temporary mixes will include a few native species and a cover crop of oats for seeding in the spring and early summer or winter wheat if seeding in the fall. Establishment and maintenance of native plant species will be accomplished through a separate contract or possibly establishment of a workforce by the local sponsor. Once the Reach 2 construction contract is complete and the temporary seed is established, the site will be mowed and herbicide will be applied to kill weeds within the seeded area for a period of one year. After one year of herbicide application, the site will be seeded with native plant species. Once planted, the native grasses will take approximately three years to become established under good growing conditions. Guidance for seed mixes and planting zones will be in accordance with MFR-003, Vegetation within the Fargo-Moorhead Metro Diversion and MFR-017, Turf Establishment with Native Species via Construction Contract and the Sponsors Involvement within the Fargo-Moorhead Metro Diversion.

11 ENVIRONMENTAL CONSIDERATIONS

11.1 Introduction

The environmental consideration for this reach includes providing planting guidance to facilitate wetlands in the bottom of the diversion channel and to ensure the low flow channel is designed to meander. These efforts are discussed in the Feasibility Report and Environmental Impact Statement (EIS).

11.2 Planting Guidelines

Vegetation establishment guidelines for the diversion channel have been developed with the goal of a planting plan that will limit the potential for the establishment of undesirable species (such as cattails, willow, etc.), compatible with Conveyance criteria (resulting in a Manning’s roughness n value of .03 or less), and resilient to maintenance activities. In consultation with a variety of experts, planting guidelines and initial seed mixes for various zones of the channel cross section have been identified that will ensure we meet overall objectives (Appendix K).

11.3 Cultural Resources

Reach 2 was surveyed for cultural resources in June and October 2011. The alignment for Reach 2 was adjusted for a number of reasons in 2011. The new portions of the adjusted Reach 2 alignment were surveyed in May and June 2012. The adjusted Reach 2 alignment contains no farmsteads or historic archeological sites and one prehistoric isolated artifact (32CSX382), a Knife River Flint scraper. Isolated find spot site 32CSX382 is not eligible to the National Register of Historic Places and no further cultural resources work needs to be done at its location.

11.4 NEPA Compliance

The proposed plan for the diversion channel was discussed in the 2011 Fargo-Moorhead Metropolitan Area Flood Risk Management Final Feasibility Report and Environmental Impact Statement. Changes to the original layout for Reach 2 consisted of an optimization of the diversion alignment.   The optimizing of the diversion channel would impact less wetland acres than was identified in the EIS. Overall there is no appreciable effects caused by changes, therefore no further NEPA documentation is required for Reach 2.

12 PROJECT DELIVERY TEAM

The Project Delivery Team (PDT) is an inclusive term that is meant to include all parties involved in the design, review, and approval of the products produced by a definable work effort; this includes USACE personnel, non-federal sponsor personnel, and in some instances key stakeholders. The members assigned have extensive professional and technical experience in their assigned areas of responsibility.

12.1 Project Delivery Team

Table 2: Project Delivery Team

Project Delivery Team				
NAME	**DISTRICT / ORG**	**DISCIPLINE/ROLE**	**PHONE**	**EMAIL**
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12.2 Technical Leads and Functional POCs

Table 3: Technical Leads and Functional POC's

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12.3 District Quality Control (DQC) Team

Table 4: DQC Team

DQC Team				
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DQC Team				
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12.4 Biddability Constructability Operability & Environmental (BCOE) Team

Table 5: BCOE Team

BCOE Team				
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TBD	CEMVP-EC-C	TBD		
TBD	CEMVP-EC-C	TBD		

12.5 Agency Technical Review (ATR) Team

Table 6: ATR Team

ATR Team				
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ATR Team				
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12.6 Sponsor Representatives

Table 7: Sponsor Representatives

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12.7 State Agency Representatives

Table 8: State Agency Representatives

State Agency Representatives				
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13 REVIEW DOCUMENTATION

13.1 District Quality Control (DQC) Review

The DQC review started on 8 March 2013 and ended on 014 March 2013. Formal comments were entered into ProjNet (Dr. Checks). Informal comments on minor items were provided directly to the designers. Documentation of the DQC Review can be found in Appendix L: Quality Control Documentation.

13.2 Agency Technical Review (ATR)

Documentation will be added after the ATR has been completed.